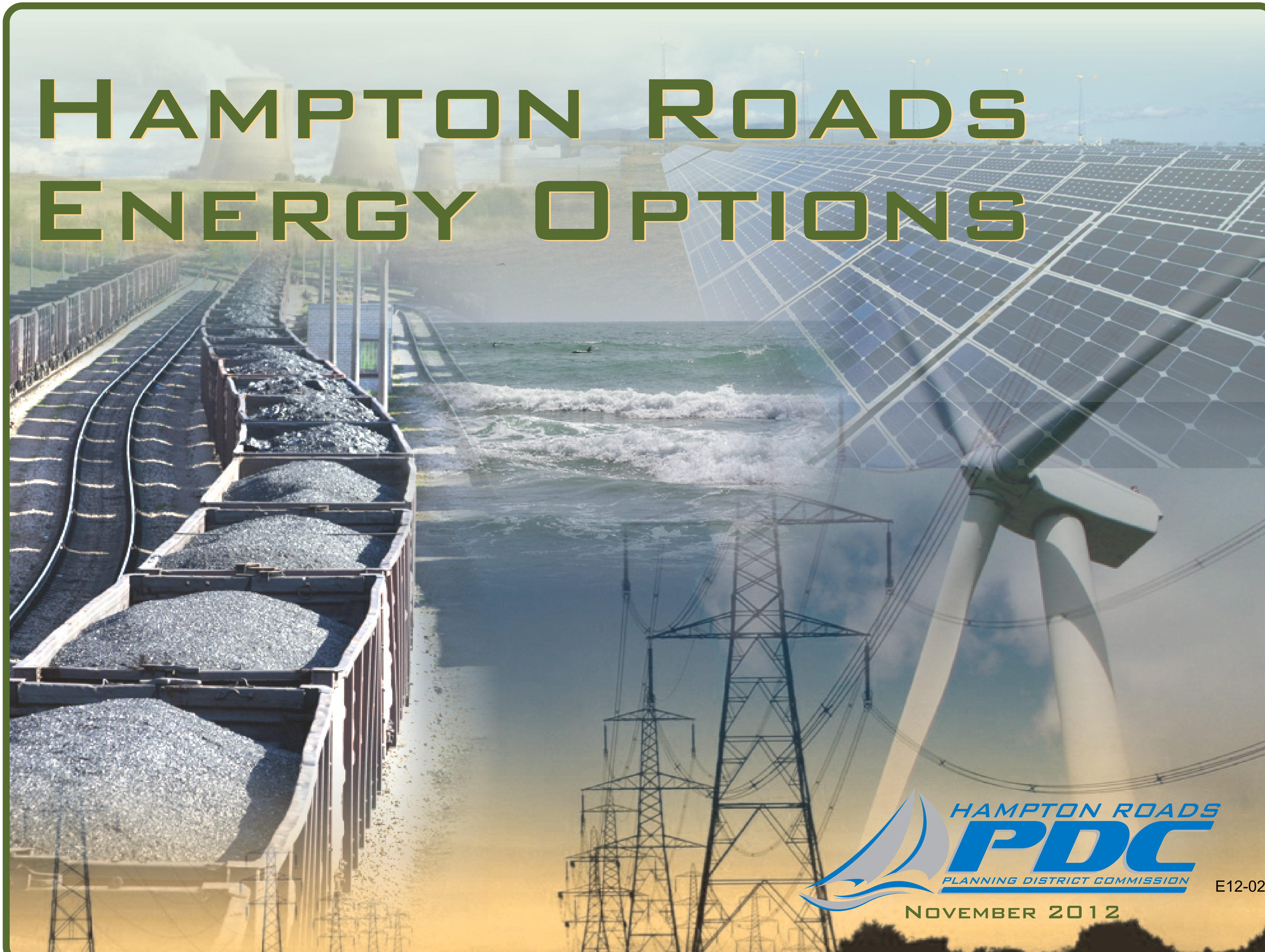
Hampton Roads Energy Options



Hampton Roads PDC
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HAMPTON ROADS ENERGY OPTIONS

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ABSTRACT

The Hampton Roads Energy Options report provides a high level overview of energy technologies either currently deployed in the region, or which have the potential to be deployed in Hampton Roads. Emphasis has been given to the role of path dependence, and the potential for economic benefit to the region. Regional planning should focus on 1) Energy Surety, 2) Low Energy Cost, and 3) The development of energy jobs. Currently, energy efficiency efforts are the best route to achieve these goals.

ACKNOWLEDGMENTS

The Report was prepared by the Economics staff of the Hampton Roads Planning District Commission.

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I. Introduction and Summary

Despite energy production being a relatively minor component of total employment, energy policy can and does shape national employment opportunities. As an example, the U.S. ethanol mandate increases the demand for ethanol, providing incentives for farming and ethanol refining which would not exist otherwise.

Energy has been a focal point of discussion in Hampton Roads for the past several years, particularly on topics such as coal plants, green jobs, offshore wind, and offshore drilling. Much of the regional discussion on energy has focused on the technology, viability, and employment opportunities in Hampton Roads as related to the energy industry. The purpose of this document is to review energy topics as they relate to Hampton Roads, evaluating potential obstacles and opportunities in developing the region's energy industry.

Particular interest in energy in the region has focused on its role as a job creator, especially in light of the financial crisis and ensuing recession that began in December 2007. Despite claims by the proponents of various energy sectors, energy generation and plant construction are capital intensive rather than labor intensive activities, and thus create relatively fewer jobs than an equivalent investment might generate in another endeavor. This is not to suggest that there are no valid reasons to invest in higher cost energy technologies, merely that energy policy has proven to be a relatively weak tool for job creation. While energy policy can play an important role in regional economic development, the discussion of jobs and energy tends to focus around the politics of energy and environmental policy rather than pure economics.

Three Goals of Energy Policy

1. *Energy Surety*
2. *Low Energy Prices*
3. *Energy Jobs*

Additionally, the federal installations in Hampton Roads require a high level of energy security.

GOALS OF REGIONAL ENERGY POLICY

Generally, there are three important goals for local energy policy regarding economics.

Energy Surety: Ensure that businesses and residences have access to energy on demand to allow them to conduct affairs. This would contrast with areas that have brown-outs, frequent black-outs, or power rationing.

Low Energy Prices: Provide low energy prices. If the energy sources (primary or generated electricity) come from outside the region, the money spent on energy drags down economic activity; however, even if the region produces its own energy, high energy prices crowd out investment in all other economic activity, which is especially damaging to other capital intensive industries.

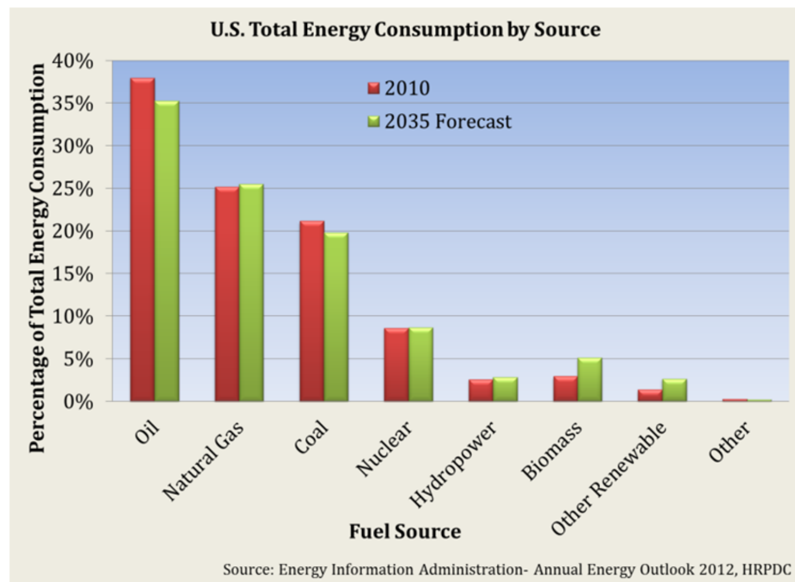
Energy Jobs: Expand the energy workforce in the region as part of having a resilient infrastructure and enhanced business opportunities. Growth in energy employment would benefit the region, all else being equal.

Lastly, this region has an additional goal of energy security, and this remains a key issue for federal and particularly defense installations to have a robust energy supply.

LONG TERM ENERGY OUTLOOK

The long term energy outlook is uncertain. Natural gas prices remain at historically low levels, and have driven investment in this technology, but they have varied greatly over the past 40 years. Twice the country has been close to "running out" of natural gas and twice (including currently) has had "a century" of natural gas. reserves Oil and coal have seen similar swings in fortune over the same period of time. Even with nuclear energy there have been discussions of risks to the long term supply of uranium, which would vastly change the operating costs of plants.

The Energy Information Administration's projections for future energy usage are not dramatically different than the current mix of energy consumption. This is not because energy will not change, but merely because forecasts are extremely difficult, especially in an environment of rapidly changing technology and resource prices. Natural gas's share of electricity generation has increased by 10% over the past decade as coal's share has declined by 10%, because of the shifting economics of the technologies and changing environmental regulation. Cost projections for electricity production have shifted rapidly; just between 2011 and 2012 the costs of utility scale solar have declined by 25%.



SHORT TERM ENERGY OUTLOOK

Low natural gas prices currently drive energy development, and while installations in renewable electricity generation are occurring at extremely high rates, renewables remain a very small share of the overall energy supply. Onshore wind, the most cost effective of renewable electricity would require natural gas prices to more than double for wind to be cost competitive.

In Hampton Roads, Dominion Resources plans to shut down a tremendous amount of coal capacity, and the planned Cypress Creek Power Station awaits litigation of Environmental Protection Agency rules in Federal Court. While the Surry Nuclear power plant still generates a tremendous amount of energy, new nuclear development has slowed down significantly because of both high regulatory and capital hurdles for plant construction, as well as cheap natural gas delaying economic justifications for nuclear plant construction. While offshore wind and drilling have proponents, there remains little chance that any development will occur until after 2018, and most analyst projections indicate that 2021-2022 are more likely dates for either offshore oil or wind.

POLICY RECOMMENDATIONS

- Avoid the temptations to pick winners. Given the long-term uncertainty around energy it will be very difficult to choose correctly.
- Energy efficiency is the most cost effective way to meet energy needs. Energy, despite moderately high petroleum prices, has been extremely cheap because of weak demand in the wake of the recession, and because it is almost impossible to build new generation capacity for less than the current cost of wholesale energy. Energy efficiency remains the best way for both energy companies and localities to plan for the future. The region should consider efforts to develop higher energy efficiency standards for buildings, as well as working with Dominion to strengthen energy efficiency initiatives for existing structures.
- Maintain simple permitting processes for distributed energy technologies. Though rooftop solar panels and residential wind are not economically competitive given Virginia's current energy prices and policies, localities should maintain low hurdles to distributed technology investment. Distributed energy installation and energy efficiency retrofits have the highest labor to capital ratios, and thus generate more energy jobs per dollar spent.
- Recognize that some questions are policy questions and not economic or energy questions. Many of the questions revolve around environmental issues as well as planning decisions, many of which were made decades ago.
- Continue to support the Hampton Roads Energy Corridor Efforts. Federal facilities are working to meet the goal that all federal buildings lower their CO_2 emissions 28% by 2020. They are exploring a variety of methods to achieve this goal, as well as maintain energy security and surety. The region should continue to support these efforts.

II. Current State of Energy: Nationally, In the Commonwealth, and Regionally

Energy captures the imagination, and thus many people discuss energy policy and production by framing the development path for which they advocate as laudable in its own right, both in its method of energy production and as a superior job creator. While this excitement and imagination serves a role in shaping the future of the world and this region, real world considerations require that planners understand energy is a constraint. These constraints are not just about sufficient energy 'production', but also about the form of the energy, the energy infrastructure, and the timing/reliability of the energy supply.

Society has formed around human beings' quest for energy. This started with the shape of hunter-gatherer interactions as they worked to find the most efficient way to get energy (food), but extends to the formation of towns around waterwheels, and later, the development and enrichment of areas near the extraction of raw materials.

All too often those who advocate for a particular energy source forget the importance of path dependence. This path dependence results from both previous investment in infrastructure as well as previous investment in developing the 'habits' of a region. While these habits do constrain imagination and planning, they are very real- as real as the location of home and businesses throughout a region that necessitate automobile travel, and just as real as transmission cables that were designed and located for the technology of energy production in the middle of the 20th century, not the technology of the 21st.

Thus it is important to understand the current energy landscape before attempting to elaborate on the energy alternatives of the future.

BRIEF HISTORY OF ENERGY

Early humans only had access to renewable energy sources: the sun for warmth and the most basic chemical energy in the form of food. As the species evolved, it tamed fire and animals, thereby greatly expanding the potential living spaces, and fundamentally changing the desirability of locations. This trend accelerated with the deployment of waterwheels during the middle ages, and where previously towns only formed for trade, now they began to form around areas with cheap energy and greater potential productivity.

Food calories are actually 1000 calories(kCal) in energy terms 1 kCal = 1.162 watt-hours

This means a 2000 calorie a day diet is equivalent to 2324 watt hours.

This is sufficient energy to power a laptop for 30-41 hours, a bandsaw for 2 hours, or a ½ horse power sump pump for 3 hours.

II. CURRENT ISSUES IN ENERGY

Coal was used for heating and by artisans (metal workers) throughout the Middle Ages, but after the turn of the 19th century when steam engines were placed in textile mills, the demand for coal exploded. Now a level of work and productivity that before was restricted to fast moving rivers could be brought to where it was desired. This led to the industrial age as productivity skyrocketed, and for the first time economic growth began to rapidly outpace population growth. Another key use of coal was for steam transport, and this rapidly shrank the world and expanded trade.

Electricity allowed the productivity enhancements of energy to be brought into the home.[1] While coal dominated electrical production through the 1950's, hydroelectric, oil (on the west coast), and eventually nuclear energy also arrived through a combination of economics and government action.

USES OF ENERGY

There are three major categories of use for energy: Industry, Residential & Commercial, and Transportation. The use of energy, along with cost, determines which energy resources will be utilized to fill that energy need.

Industrial

Industry uses 31% of all energy consumed in the United States. This includes everything from smelting aluminum to making paper to making fertilizer. Often the energy is used for direct heating during the production process, such as metallurgic coal used in blast furnaces.[2] Energy is also used to water making steam for the production process particularly in food industries. Some industries also use the primary energy resource as an input in the production process, including plastics and chemicals which are made out of oil and some biofuels, and fertilizer which is often produced using natural gas. The majority of industrial energy is used in the chemical, refining, aluminum, and steel industries. While oil and natural gas provide a large amount of the energy used by industry, electricity is also crucial for many industrial functions.

Supply of Industrial Energy Use in the United States: 2010

Petroleum 8.110 qBTUs (34.85%)
Natural Gas 8.013 (34.44%)
Coal 1.618 (6.95%)
Electricity 3.283 (14.11%)
Biomass 2.229 (9.58%)
Total used energy- 23.267
Energy System losses attributed to Industry by EIA -6.872

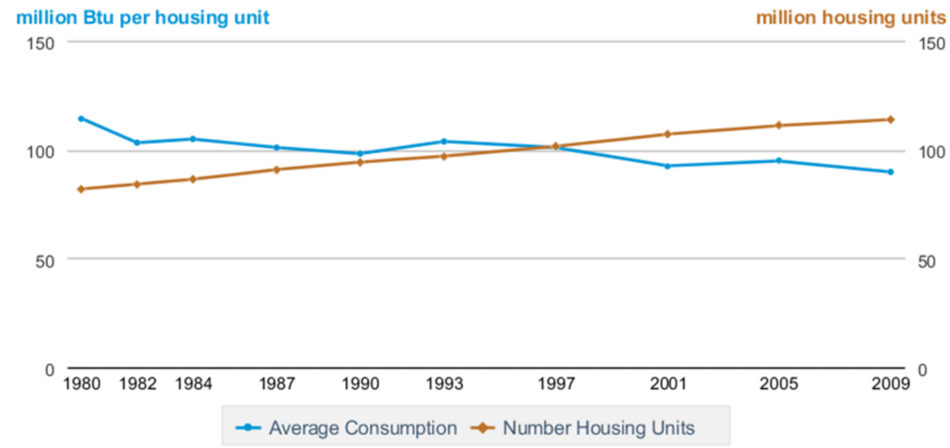
[1] Electricity production allowed different kinds of work in the home and moved primary energy out of the home almost entirely, leading to a centralized power system.
[2] Coal in steel production also provides necessary carbon to the iron ore.

II. CURRENT ISSUES IN ENERGY

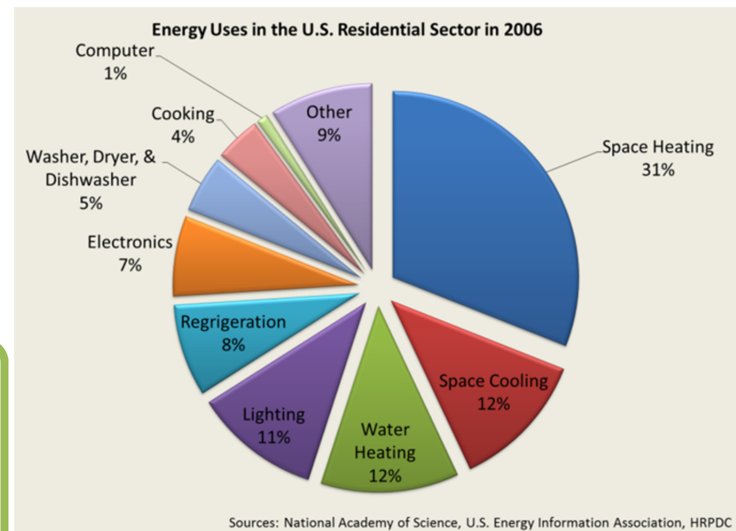
Residential and Commercial

Roughly 41% of energy use goes to powering homes and businesses. This use typically uses electricity rather than primary energy, though oil and natural gas are used for some space and water heating needs. Energy usage for residential can be split into pure electricity use, and into heating uses (space heating 31%, water heating 12%, and cooking 4%). Homes and businesses use natural gas extensively for heating, 4.99 quadrillion BTUs and 3.20 quadrillion BTUs respectively. Energy usage per household has declined over the past years, as more energy efficient construction and appliances have balanced increased home sizes, but total residential energy use continues to grow because of the growing number of housing units.

Figure 1. Average energy consumption per home and number of housing units, 1980-2009



Source: Residential Energy Consumption Survey. Includes occupied primary housing units only.



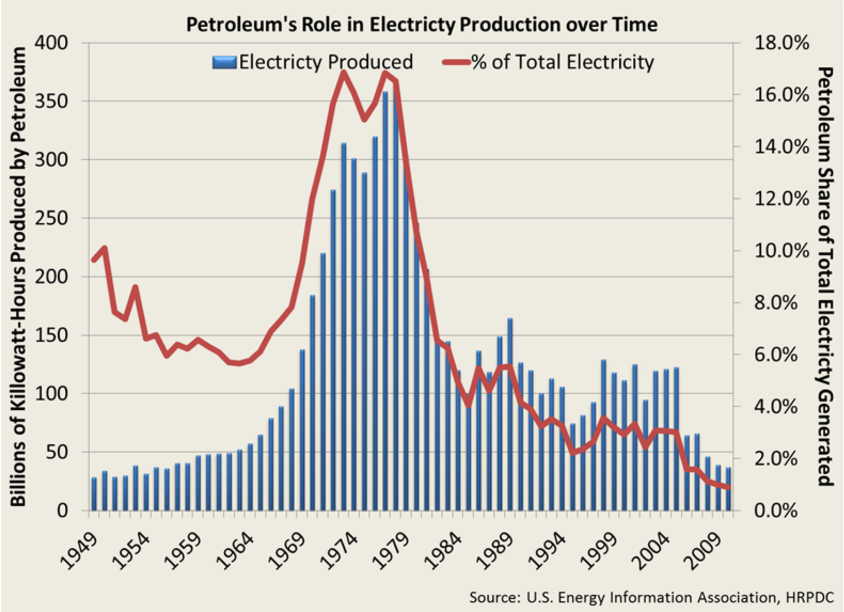
Transportation

Transportation of goods and people accounts for 28% of U.S. energy consumption, including all modes of transportation. While aircrafts use a tremendous amount of fuel, they only account for 9% of transportation energy usage, while personal vehicles consume more than 60% of all transportation energy. Approximately 93% of all transportation fuel is either gasoline or diesel with the rest of the energy in this sector being produced by a mixture of biofuels, natural gas, and

Transportation Energy Usage in 2010
Petroleum 25.646 qBTU (93.42%)
Natural Gas 682 (2.48%)
Biomass 1.098 (4.00%)
Total 27.452

electric vehicles.

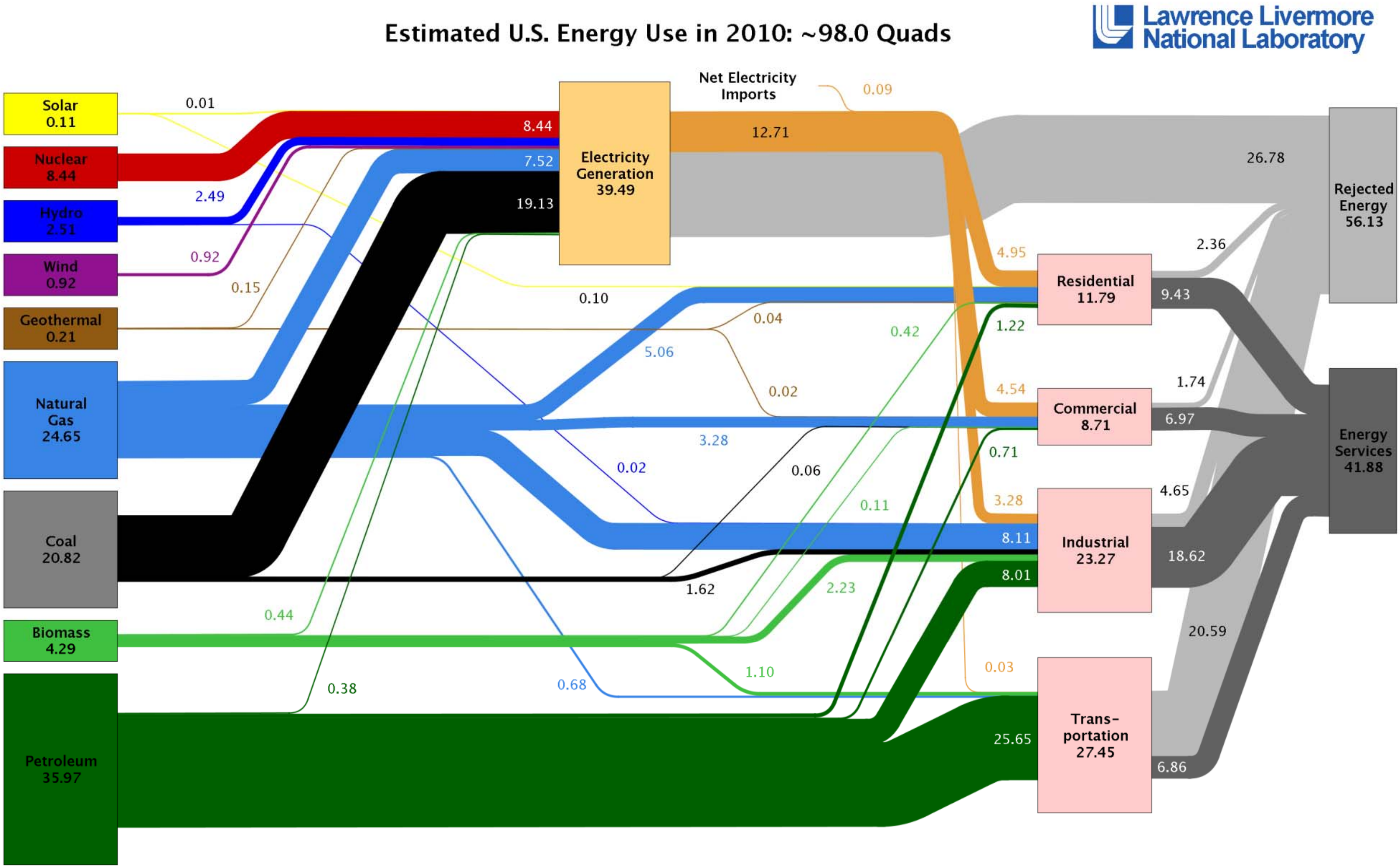
CURRENT STATE OF ENERGY IN THE U.S.



The U.S. energy landscape continues to undergo extreme changes. This country never confronted a sharp contraction (or even an escalating decline) in energy supplies until OPEC restricted the oil supply in 1973. The U.S. economy proved unprepared for the change, and took more than a decade to recover from the pressure of rapidly increasing oil prices. Since that time, the U.S. has continually tried to adjust and adapt its energy future to protect itself economically from changes in energy prices. Petroleum imports, as a percentage of consumption, peaked in 2005 (imported oil was 60.3% of the total consumed), but in 2010 the U.S. imported 49.2% of its petroleum. This have yet to change oil's dominant role in transportation, though there has been significant efforts to push the development of biofuels, hydrogen fuel cells, and electric cars.

The biggest change in the U.S. energy sector over the past five years has been the rapid development and deployment of the natural gas hydraulic fracturing (fracking) techniques which have dramatically increased the production of natural gas from shale formations. The combination of existing horizontal drilling and fracking techniques allowed access to natural gas resources that were previously thought undevelopable. Natural gas production has increased 24% between 2006 and 2011, and virtually all of this increase was the result of shale gas. The EIA projects that the U.S. will produce more natural gas than it consumes by 2022, and already natural gas production is straining the current storage technology in the United States. As a result of both the low price of natural gas and the increased Enviromental Protection Agency (EPA) regulation of carbon dioxide, mercury, and fine particulate emmissions associated with coal, natural gas generators produced the same amount of electricity as coal generators for the first time.

Solar has grown by 156% between 2006 and 2010, but only generates 0.03% of U.S. Electricity.



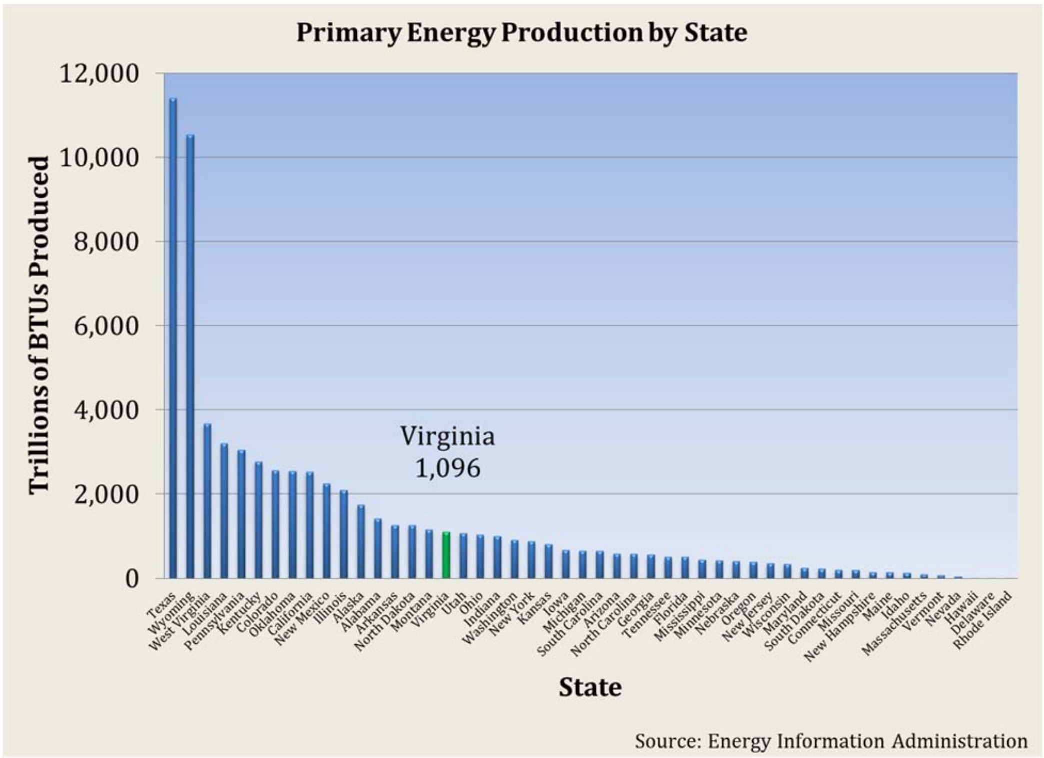
Source: LLNL 2011. Data is based on DOE/EIA-0384(2010), October 2011. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for hydro, wind, solar and geothermal in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." (see EIA report for explanation of change to geothermal in 2010). The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

II. CURRENT ISSUES IN ENERGY

A variety of targets, standards, and goals for renewable energy generation have been established by various states and federal entites, and greater investment in wind, solar, and offshore wind has followed these policies. While the installed capacity has increased rapidly in the United States, energy production from these technologies still represents a modest share of total energy produced in America. Even with several programs in place to encourage the use of renewable power, choices on energy usage in this country typically reflect the private/direct costs of energy consumption.

The energy flow picture created by the Lawrence Livermore National Laboratory using the U.S. Energy Information Administration data shows the relative importance of primary energy sources in the U.S. economy and society in 2010. The dominating role of traditional fossil fuels in current energy consumption is readily apparent, with petroleum, coal, and natural gas dominating primary energy in the country (69.9%).

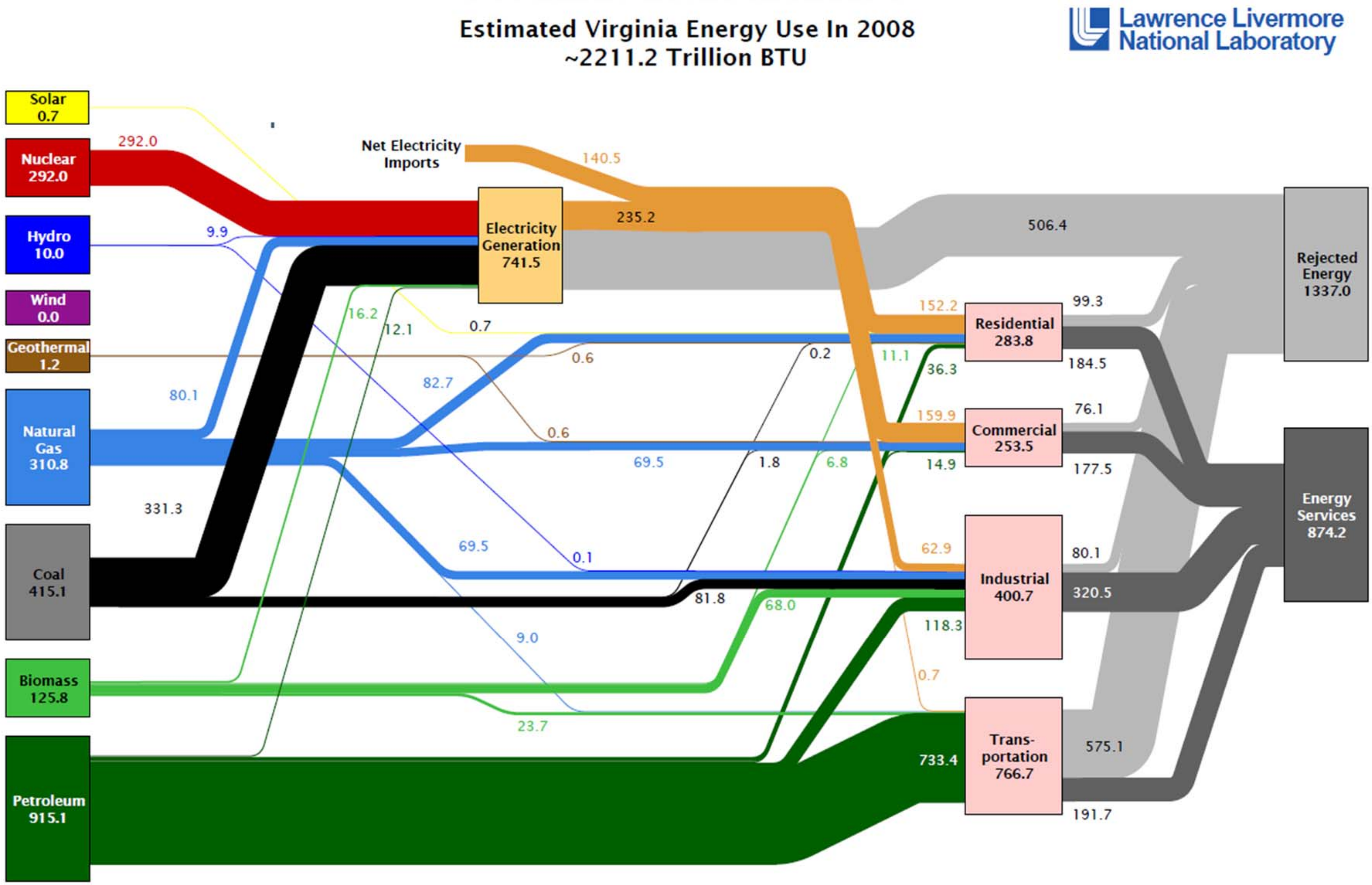
It is also instructive to see how the impact of lost energy, labeled in the graphic rejected energy, plays in the overall energy space. Some of that is energy which is lost through inefficiency in transmission and at production facilities; some of it is a result of lost energy at residences and places of businesses, and a large share of the losses occurs due to the relative inefficiencies of the internal combustion engine for transportation. More than half the energy that is produced or imported into this country is wasted, and when considering new energy production, improving that efficiency is a key concern.



CURRENT STATE OF ENERGY IN VIRGINIA

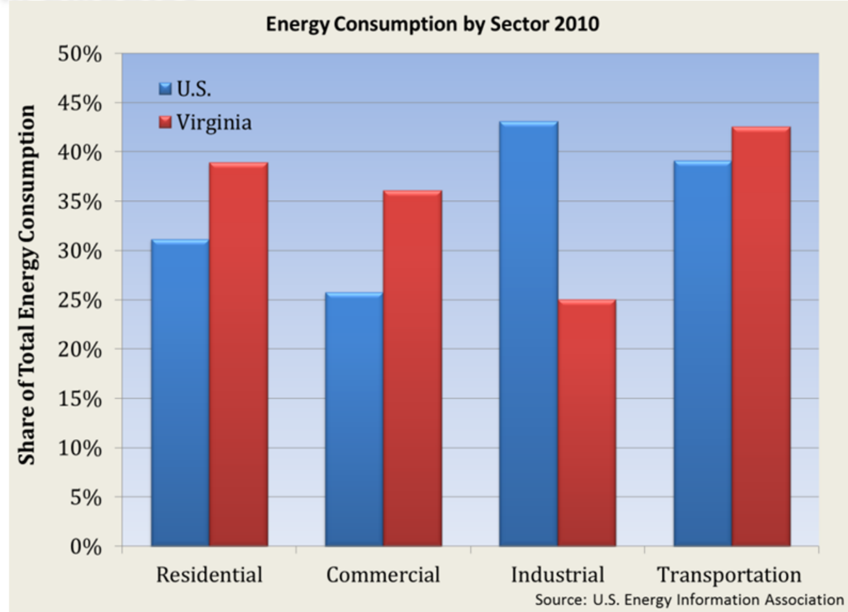
Despite the push to become the energy capital of America, it is true that Virginia must rely on energy from outside the state for most of its energy needs.

II. CURRENT ISSUES IN ENERGY



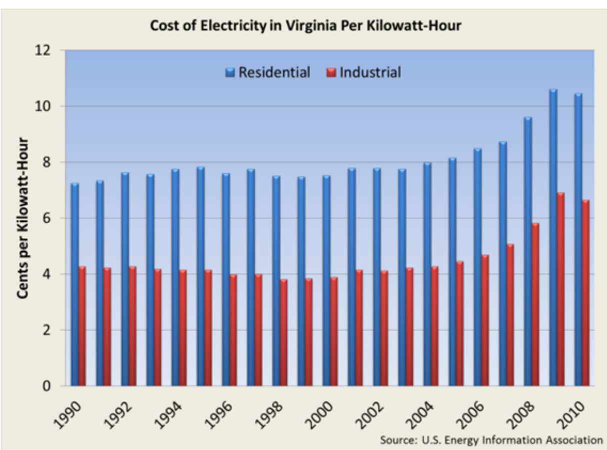
Source: LLNL 2010. Data is based on DOE/EIA-0214(2008), June 2010. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. Interstate and international electricity trade are lumped into net imports or exports and are calculated using a system-wide generation efficiency. End use efficiency is estimated as 65% for the residential, 70% for the commercial, 80% for the industrial sector, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

II. CURRENT ISSUES IN ENERGY



Current proven reserves of natural gas (3.091 billion cubic feet, 1.1% of U.S. reserves) and recoverable coal (337 million short tons, 1.9% of U.S. Reserves) in Virginia are small, relative to Virginia's share of the country's population and economy. There are no proven crude oil reserves in the state currently. Virginia ranked 17th out of the 50 states in total energy production in 2010.

Primary energy production[3] in Virginia was approximately 1.096 QBTUs in 2010, with 51.5% of the production derived from coal, 13.5% from natural gas, and 25.3% from nuclear. This constitutes only 43.8% of the 2.502 QBTUs of energy consumed in the state. Energy in the state tends to be used to a greater extent in the residential and commercial sectors than in the U.S. as a whole, and this relates to a lack of the most energy intensive industries (extensive chemical refining, petroleum refining, or smelting industries). On a per capita basis, Virginia consumes 312 million BTUs, which is just below the national average of 316 million BTUs and ranks 27th out of the 50 states in per capita consumption, but only produces 137 million BTUs of primary energy per capita.



Electricity in Virginia

The average retail price of electricity in Virginia is 8.69 cents/kilowatt-hour (c/kWh), which is below the U.S. total average of electricity supplied of 9.83 c/kWh, and places Virginia 27th in terms of state electricity price.[4] The price of electricity changes based on which sector is being supplied. Industry typically pays a lower rate than residential and commercial users, and that has been the case in Virginia

[3] While typically Nuclear is considered a primary energy resource of its own category, Virginia imports Uranium from outside the state to run its significant nuclear power stations.

[4] The highest state is Hawaii at 25.12 c/kWh, but in the continental U.S. it is New York at a cost of 16.41 c/kWh. The lowest cost currently is Wyoming where prices average 6.20 c/kWh; Wyoming is a major producer of primary energy resources.

where the gap was 3 c/kWh in 1990 and is now 3.79c/kWh. While electricity prices in Virginia have increased in nominal terms, in real terms prices were just as high in 1990 as they are currently.

Electricity production capacity has grown by 42.2% between 1990 and 2010, or at an annualized rate of 1.78% a year. Much of this growth has come from natural gas plants, which now represent 21% of state energy production, versus the 1% it represented in 1990 or the 10.7% it constituted in 2000. Nuclear and coal energy generation have increased at annualized rates of 0.17% and 0.42% respectively, a result in the difficult regulatory hurdles in building plants associated with both energy technologies. The only technology that has declined in the amount of energy it produces over those two decades has been petroleum, which results from the economics of producing electricity from a very expensive resource. Virginia only produces 64% of the electricity it consumes each year, and thus had to import 50,746 million kilowatt-hours (mkWh) in 2010, up from 28,205 mkWh in 1990.

CURRENT STATE OF ENERGY IN HAMPTON ROADS

Currently, other than very small renewable energy generators at the individual company or homeowner level, almost no primary energy production occurs in Hampton Roads. One interesting exception to this is the Enviva plant being built in Southampton County, which provides wood pellets for home heating to consumers (mainly in Europe). Enviva also purchased a terminal in Chesapeake with the intention of using it to export wood pellets. This is typical with Hampton Roads' relation to most primary energy resources. The Yorktown refinery was shut down for not being cost effective, and now operates as a storage terminal for refined gasoline for regional retail sales. Hampton Roads is also a major thoroughfare for international coal exports, with three major coal terminals that are supported by the region's railroad network.

Hampton Roads has several plants which produce electricity, most notably Surry Nuclear power plant with a net summer capacity of 1,638 MW produced by the two reactors on site (there is space for four reactors at the plant). Another large energy producing facility in the region is the Yorktown coal plant which has a summertime capacity of 1,141 MW, but it is scheduled to be shut down as a coal plant by 2016, with one of the coal fired units shut down and the other announced as a conversion natural gas fired unit (Dominion Virginia's Integrated Resource Plan does not indicate a conversion). The Chesapeake Energy Center coal plant is also planned to be shut down by 2016, with its capacity of 650 MW, and it is not scheduled to be used for other power generation. There are two smaller coal plants in the region with capacities of 115 MW (Congentrix Portsmouth Facility) and 71.1 MW (Southampton Power Station); Dominion Virginia Power has announced plans to shift Southampton

Power Station to biomass power which will drop its capacity to 50 MW. This is one of three plants undergoing this conversion in Virginia.

There is also a natural gas and oil plant at Gravel Neck Power Station in Surry Virginia, but this plant has typically been used for peak capacity rather than baseload power. It has four turbines that run primarily on natural gas with a capacity of 92 MW each (totaling 368 MW), and an additional two turbines that are fueled by oil alone with a combined capacity of 40 MW. There is another natural gas power station in Chesapeake, the Elizabeth River Power Station, with three units and a total capacity of 354 MW also used for peak demand. Natural gas has been a preferred fuel for peak demand even when it has been expensive because of the ability to quickly and cheaply operate a natural gas plant at full capacity.

Another facility is the waste-to-energy (WTE) facility owned by Wheelabrator (formerly owned by SPSA) with a generating capacity of 60 MW. The primary function of this WTE plant is to generates steam used by the Naval Shipyard. Several other biomass plants are located in this region, including one at the International Paper Franklin Mill, one in NASA Langley in Hampton, and two land fill gas plants (one in Suffolk and one in Gloucester).

III. Natural Resource Analysis of Petroleum

Gas prices are probably the one energy price that consumers are most familiar with, and may even be the only price to which consumers regularly react. Even though coal and natural gas combined supply a larger share of U.S. energy consumption, oil generally has a far greater impact on the U.S. economy.

Quick Facts about Oil

- In the average year, half of U.S. oil is domestically sourced, and half of it is imported
- Oil represents 37% of U.S. energy usage
- Oil supplies 94% of the energy for the transportation sector
- A negligible amount of oil is used for electricity production, used almost exclusively for meeting periods of peak demand
- U.S. is the #3 oil producer in the world at 10.1 million barrels per day, but consumes 18.8 million barrels per day

HISTORY OF OIL

Also known as crude oil or just oil, petroleum formed from the remains of microscopic animals and plant life that accumulated on the ocean floor. As these biological remains were covered with sediment and subject to heat and pressure for an extended period of time, they began to change in both physical and chemical composition forming what is now known as oil.

Oil experienced widespread adoption in the West as a substitute for whale oil lamps in the middle to late 19th century. Kerosene, which was first developed for lighting in the Middle East during the 9th century, quickly overtook whale oil in popularity leading to the decline of that industry.[1] It was the invention of the automobile that led to the desirability of gasoline (until the 1908 Model T, gasoline was an undesirable byproduct of kerosene production), and the eventual explosion of the oil production industry. Diesel fuel also began to be adopted around 1910, primarily for heavy vehicles, though increasingly for automobiles beginning in the 1930s.

Oil became the most important form of energy in the mid-1950s, though it played an important role in strategic decisions during World War II. World oil product ion has tripled since the 1960s, and while U.S. oil production declined in the 1970s, world production more than compensated for the shortfall. Even during the period of increasing U.S. domestic oil production, the U.S. had been a net importer of oil since 1949. The 1970s did feature two events that forever changed the U.S. relationship

[1] While the rise of cheap Kerosene helped to speed the decline of the whale oil industry, it was already in decline in the U.S. due to this country's higher labor costs.

with oil: the peak of U.S. oil production and the increasing political and economic strength of the Organization of Petroleum Exporting Countries (OPEC). These two events shocked the United States with respect to energy supplies and energy efficiency; eventually these efforts led to the creation of the Department of Energy in 1977. Even with efforts to constrain oil consumption, U.S. oil imports increased from 7 million barrels per day (Mbpd) in 1976 to 10 Mbpd in 2004, and since 2004 imports have supplied half of U.S. oil consumption.

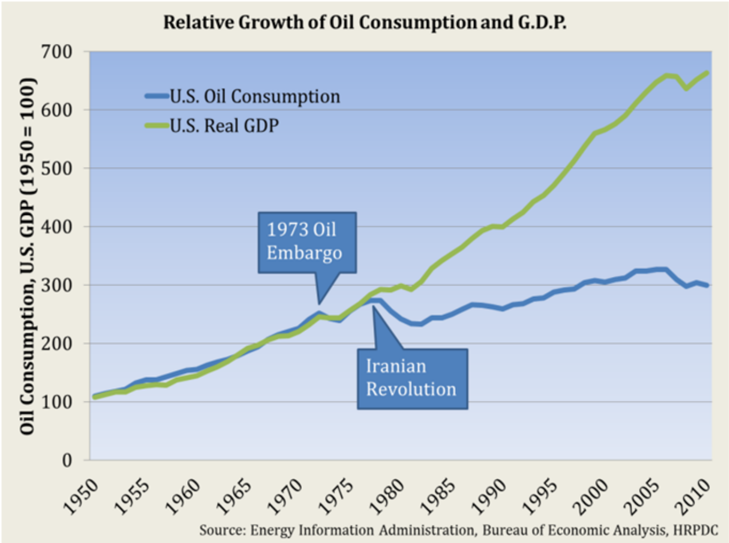
From the 1950s to 1970, U.S. economic growth and energy consumption grew at roughly the same rate. After the 1970s economic growth far surpassed the growth in the nation's energy consumption

U.S. AND WORLD OIL OUTLOOK

Top 5 Oil Producers-

Country	Share
Saudi Arabia	13%
Russia	12%
United States	12%
China	5%
Iran	5%
Rest of World	54%

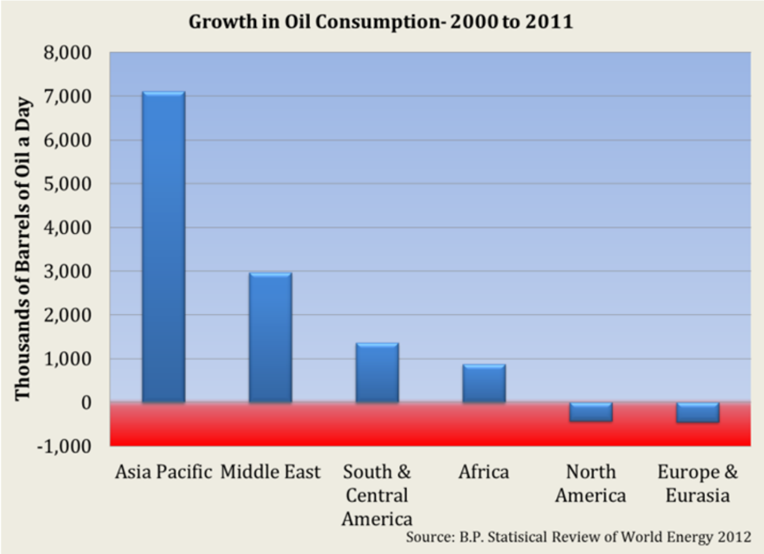
As noted, the U.S. experienced its peak oil production in 1970. The peak in the U.S. production, as well as observations that the production from oil wells decreases exponentially after its production peak has been reached led to fears that U.S. oil production would collapse.[2] This country's experience with the 1973 OPEC oil crisis and then the Iranian revolution had a devastating impact on employment and economic growth during the 1970s. Since that time, the U.S. has grown more efficient in its oil consumption, but in some ways this leaves the nation even more susceptible to supply disruption, as the nation has adapted away from oil



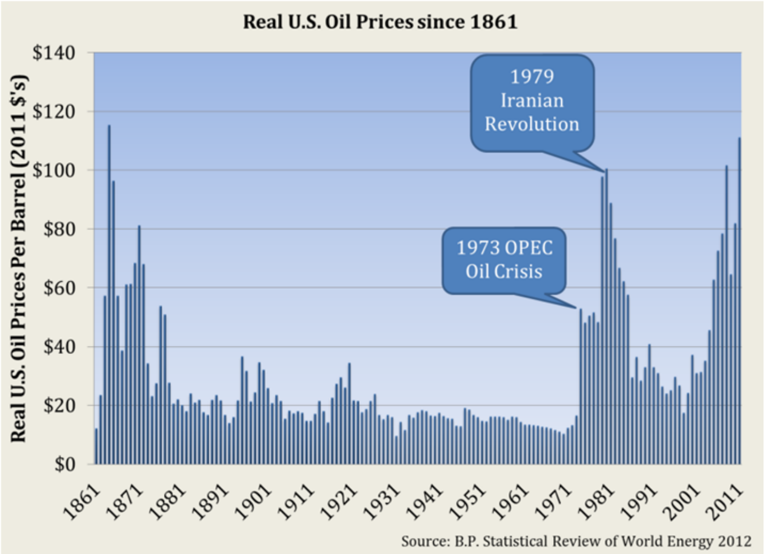
[2] This concept of peak oil was derived from the work of a geophysicist at Shell, M. King Hubbert. In a 1956 paper he predicited that oil production in a region would approximate a bell curve, and applied this reasoning to the nation. He intitially expected peak oil production to occur in the U.S. between 1965 and 1975, which occurred. Hubbert used significantly lower estimates for both world and U.S. reserves than have proven to be the case, but his basic theories and analysis continue to be applied to world oil production.

consumption to the extent that has been economically feasible.

The U.S. has continued to withdraw significant amounts of oil over the last 30 years, without significantly depleting the U.S. oil reserves. In 1979, U.S. oil reserves were estimated at 29.8 billion barrels, and had declined by 6.5 barrels by 2010; over that timeframe the United States extracted 74.4 billion barrels, almost two and a half times the original estimate of proved reserves in 1979. These improved production techniques for existing wells, along with higher oil prices, made previously undesirable oil deposits profitable, and a combination of the two allowed new resources (such as oil sands) to be developed.



As of 2008, Energy Information Administration (EIA) estimates that world oil reserves stand at 1,341 billion barrels, of which North American supplies constitute 15% (the lion's share is in Canada). World reserves have more than doubled over the past 20 years (108%), but 90% of this growth has been driven by OPEC nations, and there are concerns that their data is not entirely accurate. One issue is that the amount of oil members are allowed to sell on the world market has been closely tied to their proven reserves which have led to a significant overstatement in said reserves, particularly during the high reserve growth period of the 1980s. Another example of possibly overstated reserves comes from Venezuela, which has increased its stated reserves three fold between 2007 and



2011. This is because Venezuela has moved heavy oil sands from a 'resource' to a 'reserve'.[3]

Oil Production and Refining

The first step in oil production comes from discovering an oil reservoir. Typically this results from the propagation of seismic waves into the earth to determine if the geological formation might contain oil. Once a potential formation has been identified, than an exploratory (often called a wildcat) well is drilled to the petroleum deposit. If this indicates an economically viable formation, the oil company develops the find (or play).[4]

Oil Production Stages

1) Primary- natural pressure from the oil and gas drives out 10% of the play's content.
2) Secondary- artificial pressure as a result of pumped water or natural gas brings production to 20-40% of the play.
3) Tertiary or Enhanced Oil Recovery can allow up to 60% of a play's oil to be recovered.

Once the oil has been extracted, often using advanced techniques, including hydraulic fracturing and enhanced recovery methods, it needs to be refined into final products. There are a continuum of products that are produced from a barrel of oil, including gasoline, diesel, kerosene, jet fuel, and fuel oil; the characteristics of the particular oil and the design of the refinery process can change the proportions of each refined product produced. Additionally, the amount of refining required for a particular end product will depend on how heavy or light the oil supplied (heavy and light refers to the oil's specific weight, with heavier oils requiring more refining and producing less refined product), as well as how much sulfur the oil contains (oil with high sulfur content is sour, while oil with light sulfur content is sweet, and the different types of oil fetch different prices on the world market).

Henry Ford experimented with both electric motors and biofuels before the petroleum engine took hold.

Women preferred the early electric cars because of the ease of starting them, while Henry Ford felt biofuels made the most sense.

The most valuable crude oils are sweet and light, while heavier and sourer crudes require additional processing (and energy demands) that drives down the price of heavy crudes. While the total amount of world reserves has increased, more of those reserves are heavier (like oil

[3] A resource indicates that oil is known to exist in an area with an associated estimate of quantity. A reserve is the amount of oil resources that are both technologically and economically judged to be recoverable.
[4] A play is a group of petroleum fields that are in the same region and have the same geology, and thus are developed using the same techniques. The term can be used speculatively or for an area than contains producing wells.

sands) and have a lower amount of energy that can effectively be produced with more of the oil from the refining process lost. It is unknown at this time whether the oil reserves off the Atlantic Coast are light or heavy.

Oil as a Transportation Fuel

Oil gained its current importance in the world energy mix because of its use as a transportation fuel.[5] Oil's rise to prominence as a transportation fuel was driven by three key reasons: cost, convenience, and abundance. In many places in the world, oil bubbled to the surface of the earth and proved a nuisance, and thus the abundance and cost was very low. Also, liquid petroleum possesses many ideal characteristics for internal combustion engines, including portability and high energy density. As a result, petroleum experienced widespread adoption for motor fuels, and ushered in an age of widespread mobility.

Over time these characteristics that initially made oil desirable have changed as oil supplies have been depleted. Since Henry Ford's time, several oil substitutes have developed a share of the characteristics which made oil attractive, but all still suffer from a high cost basis and from a lack of delivery infrastructure.

OIL AS ENERGY IN HAMPTON ROADS

Hampton Roads Oil Generators

Hampton Roads currently has two power stations that can produce electricity from oil, though both of the plants are used to meet periods of peak demand during the height of winter and summer, rather than for baseload power.

Dominion Gravel Neck Power Station

Gravel Neck Power Station in Surry County, Virginia has six units, two units (totaling 28 megawatts of capacity) which are designed for oil only, and four units (totaling 340 megawatts of capacity) that run primarily on natural gas but have the capability to use oil as a backup fuel source. This plant only produced 67 gigawatt-hours in 2009, operating at 1.9% of its total

[5] While transportation usage has driven oil's rise, there are also very important uses of oil including plastics, petro-chemicals, and in particular its use as a feedstock for many of the chemicals that allowed for the huge jumps in agricultural productivity.

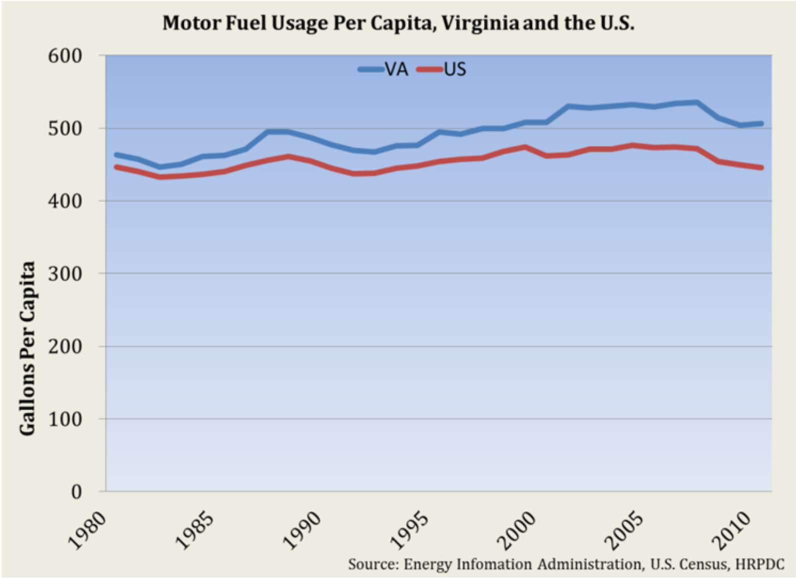
capacity. While previously this plant produced half its energy from oil when the price was relatively low, 73.8% of the energy produced came from natural gas in 2009.[6]

Dominion Yorktown

Unit #3 at the Yorktown Plant also runs on refined fuel oil, and has a nameplate capacity of 818 megawatts. Dominion only uses this unit for peak demand, and thus it only generates 2.9% of its theoretical capacity, producing 12% of all the electricity produced at the Yorktown Plant. The Dominion Resources 2012 Integrated Resources Plan indicates the company will retrofit Unit #3 with additional pollution controls for Nitrous Oxides in 2018.

Oil for Transportation Usage in Hampton Roads

The answer to how many gallons of gas and diesel are used in Hampton Roads remains elusive. To estimate this number, the Hampton Roads Planning District Commission has used the Virginia per capita motor fuel consumption and applied it to the region's population. Usage per capita peaked both nationally and locally in 2004, and has declined subsequently because of higher fuel prices, greater fuel efficiency in cars, and declines in travel as a result of the economic recession. In 2010, the per capita fuel consumption figure for Hampton Roads was 506 gallons per year, and thus the region used an estimated 845 million gallons of fuel that year.



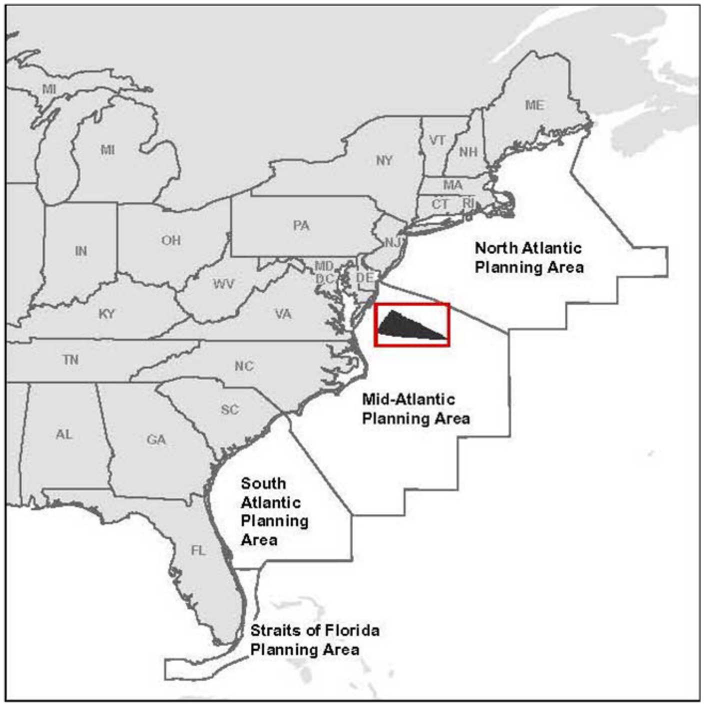
This leaves the region sensitive to increases in gasoline prices, as a 10 cent increase in the price of gasoline would remove $85 million dollars from the regional economy, a decline of 0 .11% of the gross regional product. This would be equivalent to the region losing 1,000 jobs.

[6] Energy Information Administration data From eGrid2012

Yorktown Refinery

Built in 1956, the Yorktown Refinery was a relatively small refinery with the capacity to refine up to 70,000 barrels per day into the usual blend of refined petroleum products. The refinery was acquired by Western Refining in 2007 as part of its purchase of another oil company; however, the combination of the highly competitive refining on the east coast and expensive crude caused it to be a money losing operation. It stopped refining operations in 2010, and was sold to Plains All American Pipeline at the end of 2011. Part of this agreement was for Plains to sell the remaining refinery equipment and split the proceeds with Western Refining.

While the initial shutdown of the Yorktown Refinery cost 230 jobs and the machinery and tools tax revenue from the refining equipment, the overall impact to the economy has been much more modest. The cost to bring fuel to Hampton Roads from Texas and the Gulf Coast through the Colonial pipeline is only 3-4 cents per gallon. The Yorktown refinery is now operated as a fuel distribution terminal rather than a refinery. [7]



Offshore Drilling

While the Hampton Roads region has essentially no primary resource fossil fuels, much has been made of the possibility for development of oil and gas resources on the Continental Shelf. The U.S. Outer Continental Shelf (OCS) is the submerged seabed whose mineral estate is subject to Federal jurisdiction. Currently Bureau of Ocean Energy Management (BOEM) estimates that there are 0.91 billion barrels of oil and 8.9 trillion cubic feet of natural gas in the entire Mid-Atlantic OCS area. The Mid-Atlantic OCS only contains 1.3% of the oil and 3.5% of the natural gas available on all Federal OCS territory at

[7] Refining rarely is a profitable business as it is squeezed between high capital costs of equipment, high variable costs in terms of oil prices, and sales of a product that is priced competitively in the regional market. East Coast refiners have been particularly squeezed because while Gulf Coast and Midwest refiners are typically buying oil using West Texas prices and bringing it in by pipeline. East Coast refiners typically use Brent Crude which is brought in by ship and has had a higher cost since the beginning of the recession.

moderate price points. The estimate of total technically recoverable resources for the Mid-Atlantic OCS is higher in both absolute and percentage terms, with a mean estimate of 1.42 billion barrels and 19.36 trillion cubic feet respectively.

The proposed call for information and notice to prepare an environmental impact statement were both released in November 12, 2008 for Virginia Lease Sale 220 (this lease covers 2.9 million acres that are 50 miles offshore). The Bureau of Ocean and Mineral Management (now BOEM) estimates that this area specifically may contain 130 million barrels of oil and 1.14 trillion cubic feet of natural gas. On March 27, 2010, President Obama announced Secretary of the Interior Salazar's decision to cancel this lease sale, and on May 7, 2010, BOEM released a notice of indefinite postponement for the environmental impact statement. Currently, the area off Virginia is not included in the Five Year Lease program from 2012-2017, which would indicate that no sale could take place before 2017 without an act of Congress.

While the impact on the world and the national price of oil would be relatively small, the benefit of that oil going to domestic rather than foreign production would accrue to the United States. It is unclear that offshore drilling would have a significant impact on regional employment, as many of the laborers on offshore rigs stay on the rigs when they are working, and fly back to their homes when they are not scheduled to serve the rig. The economic benefit to the state would be through the federal royalties and initial lease payment which the federal government would share with the State of Virginia. On Gulf Coast oil fields the government collects an 18.7% royalty on offshore oil and natural gas production, and shares 37.5% of that money with the Gulf Coast states. While the initial lease sale would produce some money for the State, between the Environmental Impact Statement, public comment, conducting the lease sale, updated seismic testing, digging a test well, and finally building an operating oil rig, it seems unlikely any significant drilling royalties would be achieved before 2020.

CONCLUSION

There are two separate issues with petroleum in Hampton Roads, the issues of future costs, and the potential benefits from future offshore development.

Hampton Roads is a price taker in terms of petroleum and gasoline prices, and offshore drilling in this state would have a negligible impact on the market.[8] While oil produces electricity for peak demand, it is primarily used as a transportation fuel in

[8] An energy economist, James Hamilton, estimated in 2008 that the impact of opening up all offshore drilling would have an impact of approximately $0.165 per barrel, or less than 1 cent per gallon.

Back of the Envelope
Offshore Royalties

130 billion barrels of oil, at an EIA estimated $125 barrel in 2035 (2009 $'s) equals $16.25 billion in oil, with total royalties equaling $3 billion and potential Virginia share equal to $1.14 billion.

If only 50% of that is accessible, Virginia's share would be $571 million, or if the price of oil proved to be $85 in current value, then Virginia's share would be $777 million if the full resource could be developed.

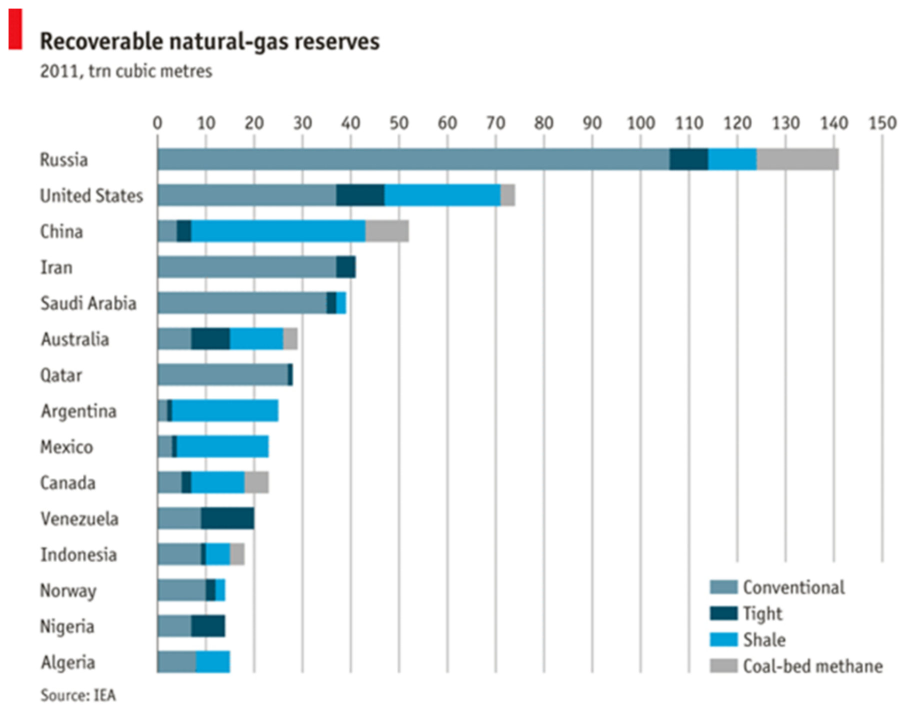
this region and it is through that channel that higher oil prices would impact the region. A 10 cent per gallon increase in the price of gasoline is equivalent to an $85 million loss in regional income, or the loss of 1,000 jobs.

The employment benefits from offshore development of oil and natural gas resources are difficult to quantify. The estimate of 18,000 jobs by 2030 comes from a Wood Mackenzie Study in 2011 conducted for the American Petroleum Institute. Without access to many of the assumptions made in that analysis, it is difficult to assess the validity of the numbers, but this assumes an employment multiplier of 3.5, which is high but not unreasonable for a capital intensive industry. It is notable while this employment would technically be in Virginia, the income from many of these jobs might not be spent in Virginia because of the nature of oil platform work. Employment and income that would support the Hampton Roads economy would likely be related to support services for the offshore platforms. It is possible that the Yorktown Refinery could be re-equipped, but that would require significant environmental reviews.

IV. Natural Resource Analysis of Natural Gas

Natural gas, over the course of time, has had an interesting role in U.S. energy production and consumption. In the 19th and early 20th century, natural gas was an unwanted byproduct of active oil fields, and would be burned off at the field. There was little transportation infrastructure (piping) developed, and thus burning was the quickest way to dispose of it (now it is often injected back into the ground for later extraction).

Very recently, it was thought that the U.S. would need to start importing natural gas for electricity generation and chemical production because of dwindling domestic



Source: The Economist

Quick Facts about Natural Gas

- Cleanest burning of all fossil fuels.
- Supply and prices have been inconsistent over time.
- Must either be compressed or liquefied to allow for transport through techniques other than pipelines.
- Shale Gas estimates for the U.S. are between 423 and 1,230 trillion cubic feet according to EIA. Current U.S. usage is 24 trillion cubic feet.
- Price was $1.89 per thousand cubic feet in April 2012, which is unsustainable ($2.59 by July of this year).
- Cost to develop shale gas wells estimated to be between $6 and $7 per thousand cubic feet of production.

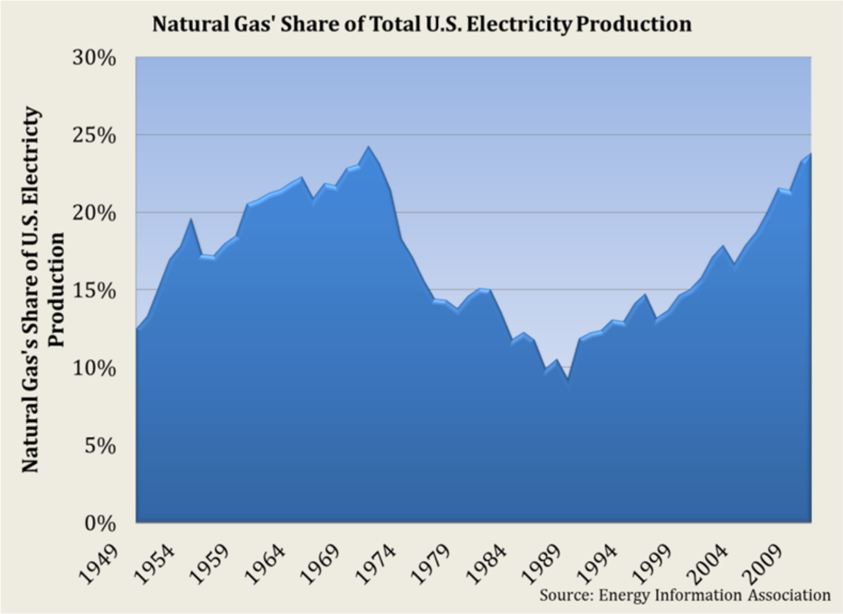
production, but because of technological advances in horizontal drilling and hydraulic fracturing of shale, large supplies of natural gas in the United States have become economically viable. The development of shale fields in Texas and the Eastern United States occurred rapidly, and just as rapidly outstripped demand driving the price of natural gas well below the cost of production, and leading to the reassessment of natural gas' role in meeting the nation's energy demands. There have been efforts to develop facilities to export liquified natural gas, as well as to increase the role of gas in both the transportation and energy generation sectors.

WHAT IS NATURAL GAS

Natural gas is a fossil fuel that occurs in gaseous form. Natural gas is composed primarily of methane, the simplest of all hydrocarbons (each molecule is composed of four hydrogen atoms to one carbon atom). When natural gas combusts (i.e. combines with oxygen), it forms two molecules of water and one molecule of carbon dioxide, making it the cleanest burning of all fossil fuels. It also produces the least amount of CO_2 per unit of energy, and requires minimal processing after extraction (unlike oil).

Natural gas forms from a variety of organic materials and under the same pressure and heat conditions as both coal and oil, and thus often is colocated with those deposits. Early on, these natural gas deposits represented a major risk of explosion for coal mines, and later, for oil wells.

While briefly used as a source of lighting, it was quickly displaced by electric lights, and saw minimal use until reliable pipelines were built in developed countries. It quickly became a highly sought after source of energy for both heating and cooking, because of the ease of scaling up and down the level of heat produced by the fuel source. Natural gas pipelines were considered a natural monopoly and were treated as such by the federal government, and this framework allowed for rapid growth in natural gas usage between 1950 and 1978.



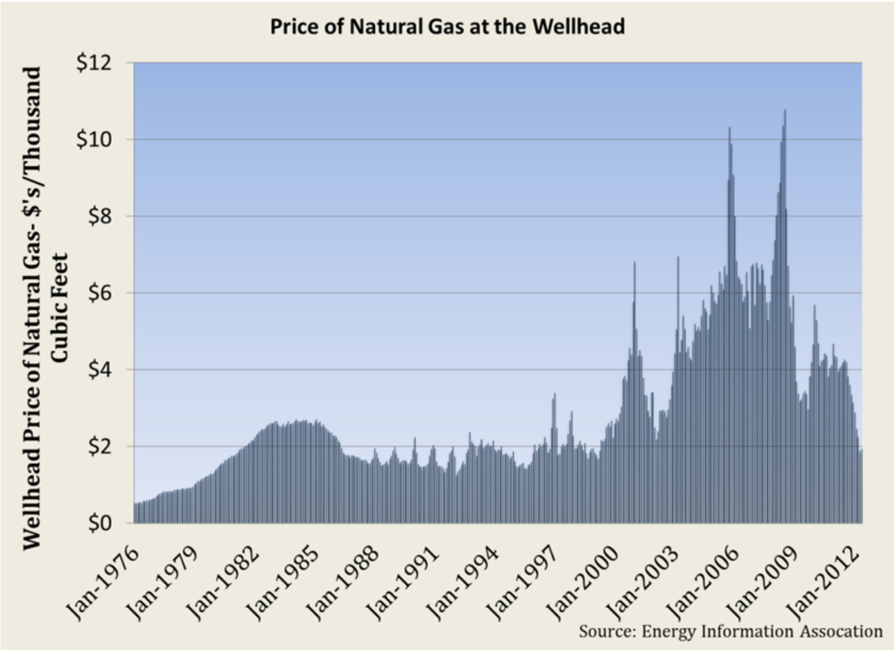
IV. NATURAL RESOURCE ANALYSIS OF NATURAL GAS

There were concerns about the natural gas supply as a result of increased use after the oil embargo in 1973, and construction of new natural gas electric plants was constrained by the 1978 Power Plant and Industrial Fuel Use Act. Almost half of all electric generating capacity added by the U.S. over the next decade was coal plants (81 out of 172 GW of capacity). New technology which allowed for greater access to gas resources, encouraged the repeal of the 1978 Act, and since then almost 88% of new capacity has been natural gas plants.[1]

Natural gas' low energy density presents a major impediment to its widespread adoption; this results from its simple molecular form (less chemical energy per molecule) and because of the low molecule per volume associated with gases. Also, transmission outside of pipelines is relatively expensive due to those features of natural gas. Transmission costs represent a much higher proportion of gas prices, and result in the market for gas being regional rather than global. While the development of liquified natural gas has introduced additional flexibility, the infrastructure to support trade in natural gas remains underdeveloped.

NATURAL GAS IN THE U.S.

Natural gas represents approximately 25% of total energy usage in the U.S., with almost all of that produced domestically. Gas plays a major role in supplying energy for all the various demand sources, except for a marginal role in the transportation network (there are only 115,000 natural gas vehicles in the U.S. out of a fleet of 250 million, versus 1.7 million natural gas vehicles in Brazil). The use of natural gas supplies is split into thirds between three sectors, industrial, residential & commercial, and electric power generation, with only 3% going to transportation (mainly to powering oil and gas pipelines).



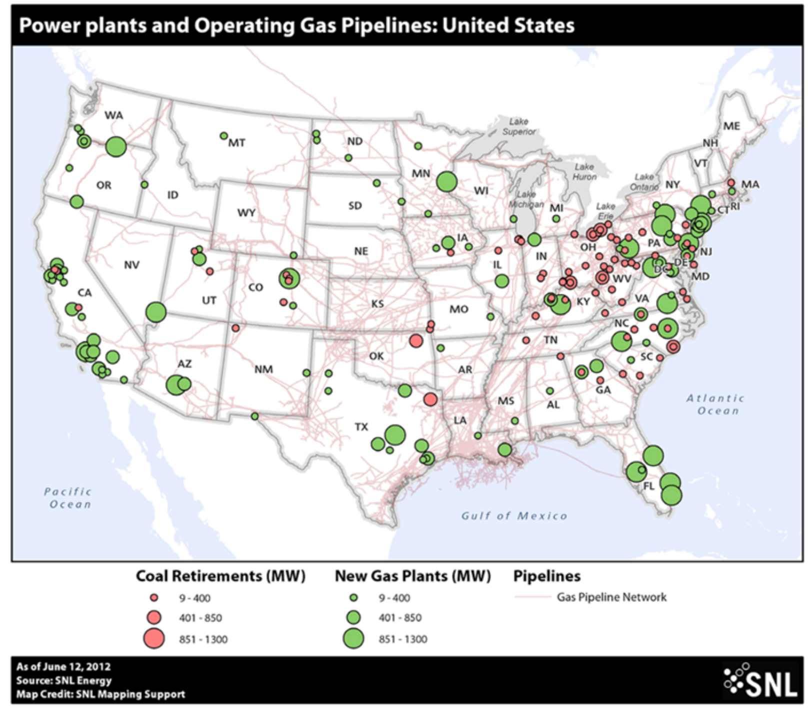
[1] Greenstone (2012)

IV. NATURAL RESOURCE ANALYSIS OF NATURAL GAS

Hydraulic Fracturing (Fracking)

Over the past several years, vast caches of natural gas trapped in deeply buried rock have been made accessible by advances in two key technologies: horizontal drilling, which allows vertical wells to turn and snake more than a mile sideways through the earth, and hydraulic fracturing, or fracking.

Fracking involves pumping millions of gallons of chemically treated water into deep shale formations at pressures of 9000 pounds per square inch or more. This fluid cracks the shale or widens existing cracks, freeing hydrocarbons to flow toward the well.



As noted previously, expectations of natural gas supply have vacillated rapidly over time. At first, natural gas was a waste byproduct of coal and oil production. As transportation infrastructure developed, it became the most utilized primary energy source for residential and commercial users. After the OPEC oil embargo increased the development of natural gas utilities, real fears developed of natural gas shortages which led to the 1978 legislation which significantly reduced the installation of gas fired utilities. Technology in the late 1980s opened up new natural gas fields, but again in 2000, fears developed about natural gas shortages, and North America greatly expanded its import facilities for liquefied natural gas. In the past five years the U.S. has experienced the shale gas boom and again supply has skyrocketed. This feast or famine nature of both gas supplies and prices has shown the difficulty in forecasting the future of gas. Furthermore, this uncertainty has prevented the adoption of natural gas technology for transportation and other uses, because of the wild swings in gas prices.

One of the greatest uncertainties for the natural gas industry is regulatory uncertainty. The Power Plant and Industrial Fuel Use Act chose the coal industry over the natural gas industry because of concern over the long term stability of natural gas supplies. Recent Environmental Protection Agency (EPA) regulations over both particulate pollution and CO_2 emissions have changed the regulatory environment to strongly favor natural gas; particularly the rules preventing any new power plant that produces more than 1,000 tons of carbon per megawatt-hour of electricity favors natural gas plants (new plants produce ~950 tons per megawatt-hour) over coal plants.[2] While not discussing the merits of either government action, these regulations, as well as a permitting system that allows potential 'vetoes' at many decision points, tend to constrain investment. The economics of extremely cheap natural gas and the EPA regulations have created an environment where there has been rapid expansion in plans for gas powered utilities, as well as a massive transition away from coal fired ones. This combination, along with a relatively mild winter in 2011, has led natural gas electric power generation to surpass coal power generation for the first time.

NATURAL GAS IN HAMPTON ROADS

Hampton Roads has no on-land natural gas resources to develop at this time. It is believed there might be both natural gas and petroleum resources on the Continental Shelf under the Atlantic Ocean, but the extent of these resources and their capacity to be developed currently is uncertain. After the Deepwater Horizon spill in May 2010, plans to auction leases off the coast of Virginia were halted, and currently there is a ban on drilling in federal waters in the Atlantic (3 miles to 200 miles offshore) until 2017. A 2012 study by the Bureau of Ocean Energy Management (BOEM) estimates there are significant technically recoverable oil and gas resources in Atlantic federal waters of approximately 3.30 billion barrels of oil (4% of current recoverable U.S. oil) and 31.28 Trillion cubic feet of gas (8% of total estimated recoverable gas resources).[3]

Hampton Roads is served by both Columbia Gas and Virginia Natural Gas which supply businesses and residences in the region with natural gas for both cooking and space heating.

There is currently one natural gas plant in Hampton Roads, the Gravel Neck Power Station in Surry County, Virginia which is operated by Dominion Virginia Power. There are six combustion turbines at the plant, and it has a capacity of 408 megawatts. The plant is currently used to serve during peak demand, and only operates at 34% of its annual capacity. Hampton Roads was

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[2] Greenhouse Gas New Source Performance Standards (NSPS)

[3] The concept of recoverable resources and what qualifies are worthy of their own paper. The methodology used by US Bureau of Ocean Energy Management (BOEM) is extremely conservative. That said, the resources off the Atlantic Coast have several questions that need to be answered before development could be proposed, and currently energy analysts with CitiBank do not anticipate any Atlantic or Pacific drilling will occur until after 2020 at the earliest.

slated to have an additional natural gas plant when Unit 2 of Yorktown Power Station was to be converted to natural gas, but that plant has not been included in Dominion Resources most recent integrated resource plan (2012).

Old Dominion Electric Cooperative (ODEC) examined the possibility of having the Cypress Creek Power Station be a natural gas plant, but at the time the original assessment was completed, it was determined that the pipeline infrastructure to Surry was insufficient to support a new gas plant of the size ODEC required. Any cost savings achieved by using natural gas and having less pollution control technology in place was overwhelmed by the cost of permitting and building new natural gas infrastructure.

CONCLUSION

Currently, there are very few natural gas options in Hampton Roads, outside of adoption for fleet vehicles in several of the region's jurisdictions. While there is the possibility of widespread adoption of natural gas vehicles in the future, there exist few avenues for local governments to accelerate this process (in this region only three U-Haul locations sell natural gas such that it is available for privately owned cars). While offshore natural gas development could bring jobs to the region, offshore gas exploration currently is not economically viable without accompanying oil exploration given the low current natural gas prices. Continued adoption of natural gas plants in other parts of the state and the Mid-Atlantic region will continue to ensure cheap electricity for Hampton Roads, assuming that natural gas fracking continues at current paces.

V. Natural Resource Analysis of Coal

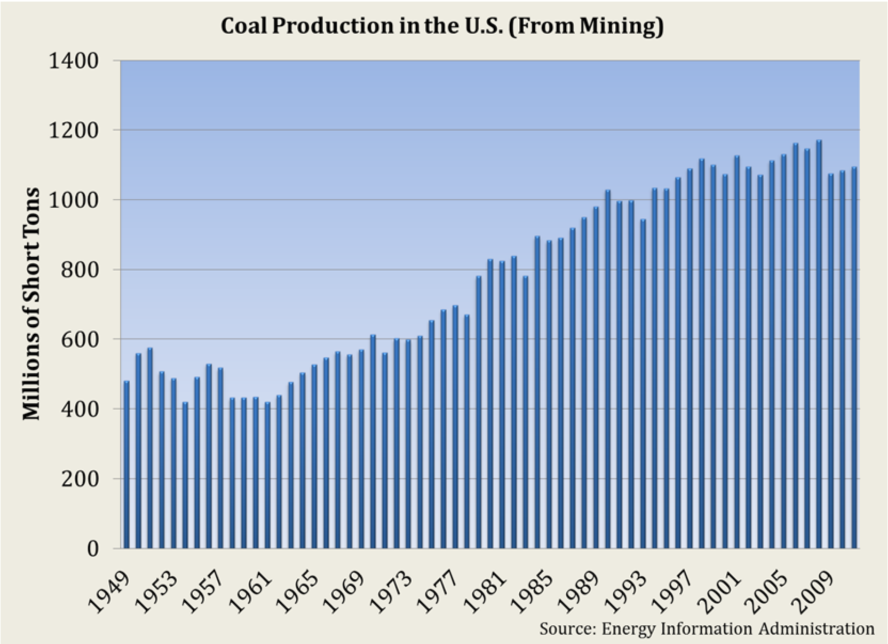
For almost 350 years, coal served as the primary energy resource. Even today coal provides a significant portion of the nation's and state's energy needs, particularly with relation to electricity and industrial uses.

Quick Facts about Coal

- The use of coal in electric power has decreased.
- The U.S. mines over 1 billion short tons of coal each year.
- In 2010, coal plants produced 44.9% of all U.S. energy vs. 22.8% from natural gas.
- The U.S. consumed 14.8% of the total world coal consumed in 2010 (China consumed 48.2%)

HISTORY OF COAL

Like all sources of industry, the story of coal is the story of tradeoffs. Power derived from coal drove the industrial revolution in both England and the United States. Although coal was overtaken by petroleum as the major source of energy in the middle of the 20th Century, the average American still consumes the equivalent of 20 lbs. of coal per day.[1] Coal has many virtues, including the fact that it is easily transportable by ships and railroads, easily storable, and easily transformed into energy. In addition, it has consistently been the cheapest form of energy, with much less price volatility than either oil or natural gas.



These positive traits are balanced by the many environmental questions that coal has posed society since it gained widespread use as a fuel. As early as the 1300s, England tried to control the noxious fumes that were produced by artisans burning coal in London workshops. Issues with pollution can be seen in many other countries that burn coal intensively but have neither the environmental regulations nor the efficient plants that are here in America. There are numerous pollutants (including sulfur-dioxide and particulate emissions) that come from the burning of coal which have to be mitigated through either purchasing coal from a

[1] Goodell 2006

Types of Coal

Lignite or Brown Coal

Low Energy Density similar to many types of wood, and is used almost exclusively in power plants

Sub-bituminous and bituminous coal

Have a higher energy density and lower water content than lignite. While sub-bituminous is also used primarily for energy production, bituminous coal is used to produce coke for steel production.

- Bituminous coal also categorize by volatility

Coal with low volatility is difficult to ignite, while high volatility is easy to ignite. Coals with a middle level of volatility are usually preferred.

Anthracite

Contains fewer impurities and has a higher energy density than other coals. Used primarily for heating purposes.

different location or by putting new and more expensive pollution controls on energy plants and industries that burn coal.

The Environmental Protection Agency (EPA), coal mining interests, and energy companies (as well as many others) continue to negotiate and litigate around the optimal level of pollution/environmental integrity; in many ways, this is a policy tradeoff for which there is no absolute answer.

Coal drove the industrial revolution, and still plays a dominant role in both U.S. and worldwide energy production. Coal is formed from the remains of complex plant matter such as trees in swampy areas. As the plant matter accumulated, it first formed peat; and later as even more material accumulated on top of the peat, the heat and pressure transformed the peat into coal. Thus, as with other fossil fuels, coal is actually derived from plant matter.

Comparing coal to biofuels does obscure several key differences. One, coal compresses centuries of plant growth into one rock, and thus serves as a much denser source of energy than burning logs. To put it another way, coal has generations of stored sunlight in the rock, while a log may only have one generation of solar energy stored. One author described it this way, "For billions of years, almost every life form on earth depended for its existence on energy fresh from the sun, on the 'solar income' arriving daily ...temporarily stored in living things."[2] This is why coal is not considered a renewable resource, because burning coal that took millennia to create cannot be sustained indefinitely at the current consumption rates. Also, not only does burning coal release particulate matter in much the same way that burning logs would, but it also releases other chemicals that have accumulated in the coal deposits.

[2] Freese 2003

V. NATURAL RESOURCE ANALYSIS OF COAL

This energy density of coal was instrumental in the development of industrialized society, through enabling the smelting of higher qualities of metals, powering factories, and eventually powering railroads. As greater industrialization occurred it fed the demand for coal. It is easy to undersell the importance of industrialization to increasing the quality of life of humans, in particular increasing their incomes; these rising incomes fed the demands for additional manufactured products again driving the demand for coal.

In the second half of the 19th century, coal found a new use as a source for electric generation and this grew rapidly. Coal was the fuel of choice because of its price and easy portability, and today supplies 42% of the world's electricity.

Major Pollutants from Coal-

SO_2- Sulfar Dioxide

A contributor to acid rain.

NOx- Nitrogen Oxides

Class of gases that when exposed to sunshine creates ground level ozone.

Mercury-

Causes water pollution and accumulates in the food chain leading to contaminated fish dangerous for humans to consume. It is classified as a neurotoxin.

Particulates-

Tiny floating particles, so small that they pass through many of the body's defenses and can accumulate in the lungs.

CO_2- Carbon Dioxide

Greenhouse gas that increase the acidity of water when absorbed.

CURRENT ROLE OF COAL

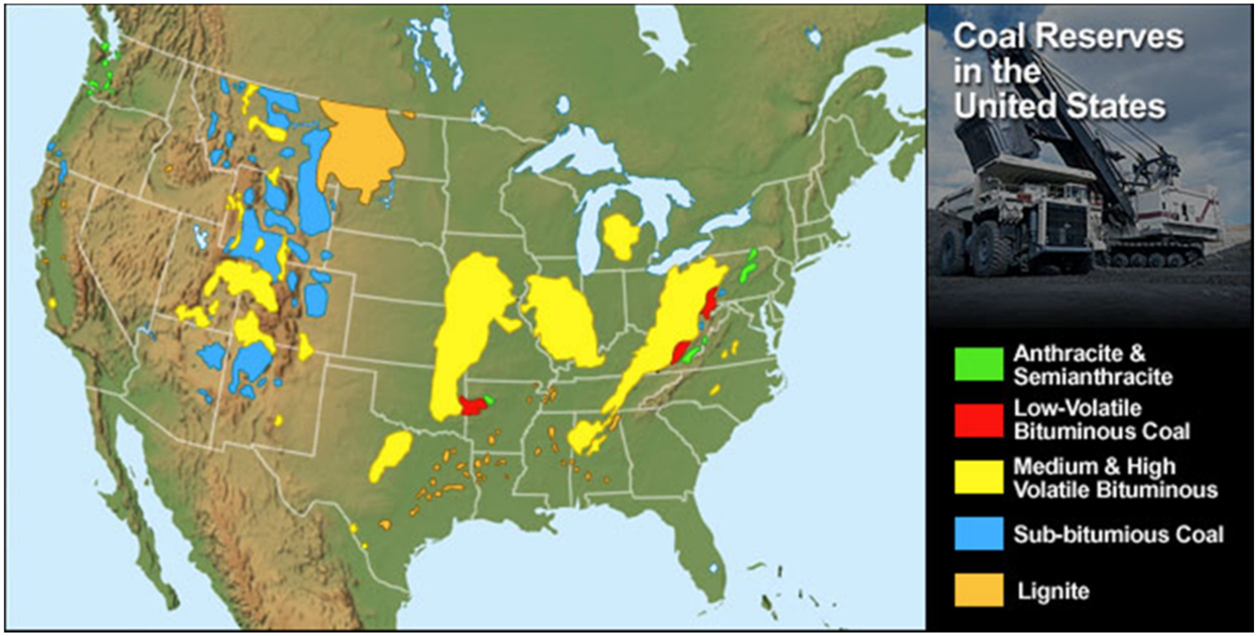
Despite the current narrative about China's investments into green and renewable energy, China is also the largest producer and consumer of coal in the world. China produced 3.5 billion metric tons of coal, versus 993 million metric tons in the United States (2011)[3]. China both produces and consumes 48% of the world's coal versus the Unites States which accounts for 15% in both[4]. It is also important to note that while coal consumption has been flat in developed nations for more than a decade[5], the developing nations of the Pacific Rim have been using more and more coal as they aspire to higher levels of economic growth. In many ways, coal is powering the Asian industrial revolution.

Coal has a higher carbon content than oil or natural gas per unit of energy. The U.S. Environmental Protection Agency (EPA) estimates that per megawatt-hour of electricity produced by coal plants emits significantly more carbon dioxide than petroleum plants and almost double the carbon output

[3] BP Statisical Review of World Energy 2012
[4] Rapier 2012
[5] An important caveat to this is Japan, which after the Earthquake/Tsunami and the subsequent Fukushima Daiiachi nuclear meltdown, shut down all of its nuclear plants for safety reviews. During that time, Japan has imported coal to cover its energy shortfall. Germany has also begun importing more energy made from coal as it has backed away from nuclear power.

of natural gas plants. This resulted in recent regulations by the EPA to effectively ban the permitting of any new power plant (not already under construction) that emits more than 1,000 tons of carbon dioxide per megawatt-hour of energy produced. While natural gas plants are able to meet this standard, no coal electric plant has been constructed at this time that is able to produce electricity at that level of carbon emissions. Partly, this reacts to the issue that nearly 40% of U.S. annual CO_2 emissions are the result of coal plants.[6]

Currently the world produces a total of 7 billion metric tons of coal per year, which accounts for 30% of the world's primary energy production. This production has increased 90% over the past three decades. China, which produces 48% of the world's coal, employs 5 million out of a total of 7 million employed in coal production around the world.



Source: American Coal Foundation

Coal resources in the United States have a particular geography, as can be seen in the graphic above. Production comes mainly from the upper mid-west and to a lesser extent the Appalachian Mountains. While coal is used for electricity production throughout the country except the west coast and the northeast (California does import a significant amount of coal-produced electricity from other states), these states rely primarily on nuclear, hydroelectric, and natural gas.

[6] Goodell 2006

V. NATURAL RESOURCE ANALYSIS OF COAL

It is hard to overstate the coal resources in America, with approximately 25% of the world's recoverable reserves, about 270 billion tons under the United States.[7] This is sufficient fuel to match America's consumption of coal for the next 250 years, if this country so desires. China, which currently produces three times the coal that the U.S. does, has only an estimated 126 billion tons of recoverable coal, and Russia is the next closest to the U.S. with 176 billion tons. Western Europe only has 36 billion tons of recoverable coal.[8] Western coal is softer than most of the coal found in the Eastern U.S., having a lower energy density. Because the coal in the Western U.S. formed in freshwater swamps, it has a much lower sulfur content which has given it an advantage in the marketplace as air quality rules have been tightened.

COAL IN HAMPTON ROADS

There are two major ways that Hampton Roads interacts with coal as an energy source. One, it is the primary baseload fuel for several power plants in the region. Two, coal is exported through the terminals in Hampton Roads and provides not only jobs, but also serves as a major source of revenue for a Fortune 500 company headquartered in this region.

Coal Plants in Hampton Roads

There are four utility scale coal-fired plants operating within Hampton Roads, but several of them are scheduled for total closure or conversion to other fuel sources. Dominion Resources announced on September 1, 2011 that in response to changes in environmental regulations, Dominion planned to significantly modify its operations in Hampton Roads. This included closing one of the coal-fired units at the Yorktown Power Station, and converting the other to natural gas.[9] It also included shutting down the Chesapeake Energy Center entirely. Dominion indicated that it reviewed installing additional emissions controls while continuing to utilize coal, but determined that those controls were not the most cost effective method of complying with regulations and meeting future energy demand.

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[7] BP 2012

[8] Ibid

[9] The integrated resource plan for Dominion now indicates that they plan to shut down both units, converting neither one to natural gas.

V. NATURAL RESOURCE ANALYSIS OF COAL

Yorktown Power Station

Yorktown Power Station Emissions in 2010

- Mercury Compounds Onsite 275 lbs., Offsite 48 lbs.
- CO_2 1,392.8 thousand metric tons
- Methane 4.3 thousand metric tons (CO_2 equivalent)
- Nitrous Oxide 9.4 thousand metric tons (CO_2 equivalent)

Yorktown Power Station is the sixth largest site of energy production in Virginia, and generates energy largely through coal. It is owned exclusively by Dominion Virginia Power, and has a nameplate capacity of 323 megawatts. It was constructed under two phases, with half its production coming online in 1957, and the other half in 1958. On September 1, 2011, Dominion announced plans to close down one of the two coal-fired units at the Yorktown Power Station (2014) and convert the other unit from coal-fired to natural gas (the integrated resource plan does not mention this conversion). Additionally there is a large oil-fired unit on site which has a generating capacity of 818 megawatts (more than the two coal-fired units combined), but is only utilized during periods of high demand. The power station employs approximately 100 workers currently, and uses an average of 2,200 tons of coal for its two coal-fired units per day.

Above- Yorktown Power Station

Below- Chesapeake Energy Center

Source: Dominion Resources, Inc.

Chesapeake Energy Center

The Chesapeake Energy Center consists of four coal-fired generating units along with eight gas turbines. This power station is owned and operated by Dominion Power, and was a coal-only facility until the late 1960s. The facility was converted to an oil facility at that point because of the falling price of oil and federal regulations, but then re-converted to coal generation in the early 1980s as a result of the rising price of oil. It currently has 595 megawatts of capacity in four coal-fired units which consume 4,500 tons of coal per day. The facility is slated for decommissioning by Dominion, with two units shutting down in 2015 and the other two in 2016.

Southampton Power Station in 2010

- Mercury Compounds Onsite 1 lbs., Offsite 17 lbs.
- CO_2 251.0 thousands of metric tons
- Methane 0.6 thousand metric tons (CO_2 equivalent)
- Nitrous Oxide 1.3 thousand metric tons (CO_2 equivalent)

Southampton Power Station

Southampton Power Station is a 63 megawatt coal-fired unit located on 24 acres which opened in 1992. It currently employs approximately 30 workers, and is one of three plants in Virginia that Dominion Power has scheduled for conversion to biomass. After the conversion, Southampton will have a nameplate capacity of 51 megawatts and produce energy through a renewable process, by using waste wood as its fuel source.

Chesapeake Energy Center in 2010

- Mercury Compounds Onsite 160 lbs., Offsite 0 lbs.
- CO_2 3,348.9 thousand metric tons
- Methane 8.0 thousand metric tons (CO_2 equivalent)
- Nitrous Oxide 17.2 thousand metric tons (CO_2 equivalent)

Portsmouth Genco LLC

The Portsmouth Genco LLC is 50% owned by Cogentrix. Constructed in 1998, it is a two unit, 110 megawatt cogeneration facility, though it no longer has a customer for the steam it produces. The plant output is now dedicated solely to the production of electricity which is delivered to the Northern Virginia Electric Cooperative. Originally it used coke (processed coal) as a fuel source, but changed technologies in its plant in 2007 to allow for broader sourcing of its coal.

Portsmouth Genco, LLC Station in 2010

- Mercury Compounds Onsite 1 lbs., Offsite 50 lbs.
- CO_2 479.4 thousand metric tons
- Methane 1.2 thousand metric tons (CO_2 equivalent)
- Nitrous Oxide 2.6 thousand metric tons (CO_2 equivalent)

Proposed Cypress Creek Power Station

While the proposed Old Dominion Electric Cooperative (ODEC) power station in Surry County is designed to run on both biomass and coal, 1,470 out of the 1,500 megawatts of generating capacity would be supplied by coal under the current plans. ODEC purchased the 1,600 acre site in 2009 located within the Town of Dendron. Construction of the plant would create an estimated 3,000 jobs during construction and 225 operation jobs once the plant began producing electricity. ODEC estimates the plant would produce approximately $3 million in tax revenue each year to

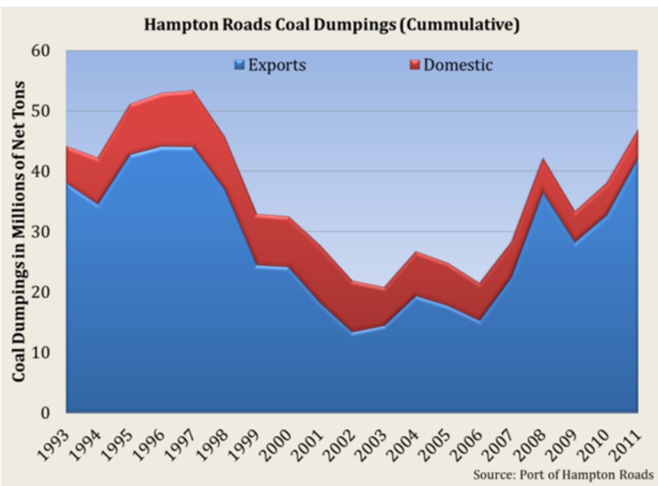
Surry County. While local permitting has been completed for the plant, ODEC has suspended applications for state and federal permits as it awaits the outcome of court cases related to new EPA rules. The process has also met a considerable amount of resistance from other local governments and environmental groups who are concerned over the cost of pollution in terms of health, air, and water quality. Additionally, the lower energy demand that has resulted from the economic crisis and the lower natural gas prices that have emerged from the shale gas boom have changed the economics of the project. Still, coal has been historically the cheapest of all primary energy resources (in terms of price to energy content) and ODEC indicates that it intends to continue moving forward with this project.

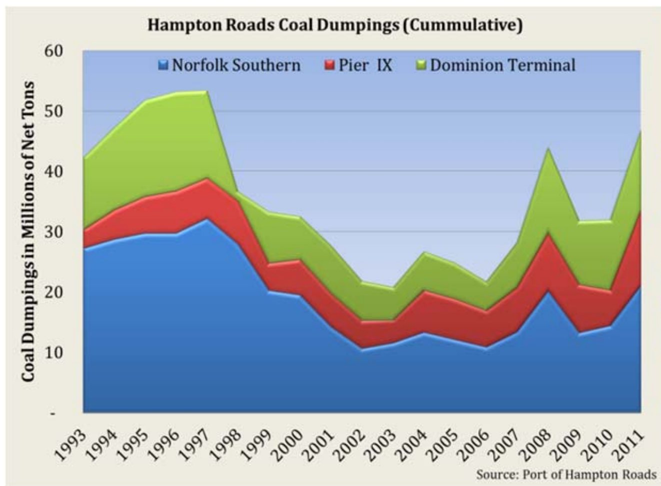
Coal Terminals in Hampton Roads

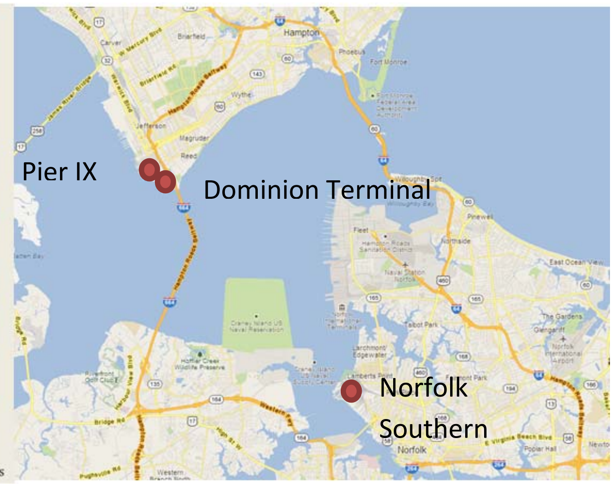
One of the major ways that Hampton Roads interacts with the coal industry is as a hub where Appalachian coal is removed from CSX and Norfolk Southern trains and is shipped around the world.

In January 2012, Norfolk Southern delivered the largest single coal-load in the 30-year history of the Lambert's Point Terminal, loading nearly 160,000 net tons of metallurgical coal (sufficient to make 207,000 tons of steel).

Norfolk had been one of the leading coal exporters on the east coast since the Norfolk & Western tracks were extended directly to the coal piers at Lamberts Point in Norfolk in 1886. The Chesapeake and Ohio Railway began operating on the Virginia





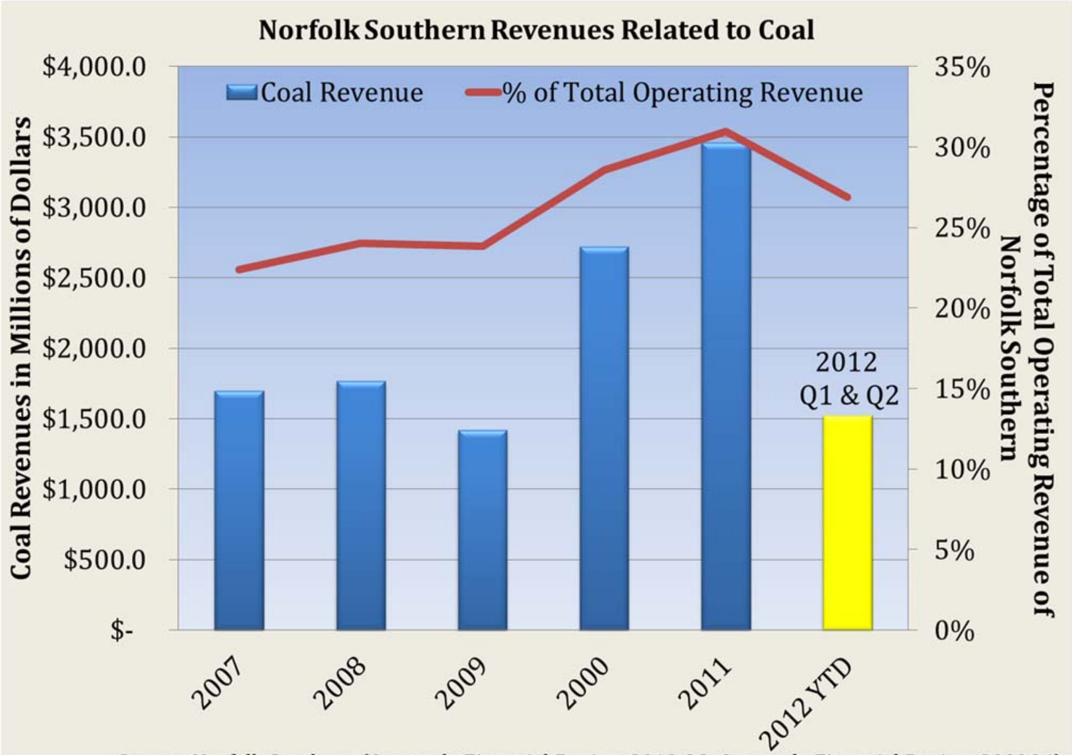


Source: Google Maps, HRPDC

Peninsula in 1881. Originally, the terminal on the Peninsula served to transport the coal to the Northeast. West Virginia coal helped to create the City of Newport News though the economic benefits of the railroad built for those coal shipments. As time has gone on, foreign markets have played an increasing role in this region's coal exports, and now dominate coal loadings in this region. While the Environmental Protection Agency's regulations could shrink the domestic market for coal, there seems to be an aggressively growing foreign market, which has been revitalized by the abandonment of nuclear power in Germany, and the slow return of nuclear power in Japan.

Even with advances in renewable technologies, and particularly the dropping prices of solar panels, Wood Mackenzie Research and Consulting projects that world demand for coal will almost double by 2025, with especially robust demand growth coming from Southeast Asia. One threat to regional coal shipments is the possible development of coal piers on the West Coast which would export the thermal coal from the Powder River Basin. Fortunately, the shipment time for coal is not a large priority, versus the price and the quality of the coal, as evidenced by the coal ships parked at the mouth of the Lynnhaven.

Norfolk Southern, which is based in Hampton Roads, and is one of the region's Fortune 500 companies, still derives a significant portion of its profits from coal. Norfolk Southern typically exports the Appalachian bituminous coal which can be used for both thermal and metallurgic purposes. Coal revenues for Norfolk Southern are extremely sensitive to energy demand (which varies with temperature and economic growth) and the price of coal versus other natural resources. Coal has accounted for between 20% and 30% of Norfolk Southern's revenue over the last five years, and is very important to the economic health of the company. While the majority of that coal is delivered



Source: Norfolk Southern (Quarterly Financial Review 2012 Q2, Quarterly Financial Review 2009Q4) domestically, and both environmental regulation and the current economic of coal power generation threaten these shipments, it appears that international shipments will absorb any declines in domestic demand.

CSX Transportation also serves coal piers in this region, and coal provided roughly 32% of the company's revenue in 2012. Like Norfolk Southern, weak coal demand domestically has put pressure on CSX's coal revenues, but the company indicates ir expects strong export growth, particularly to Europe, in 2013.

CONCLUSIONS

Coal remains an important source of energy for the country, but current trends will see a sharp contraction in the coal produced electricity in Hampton Roads. This will have almost no impact on electricity prices however. The shuttering of plants does impact a city's tax base, but it has a relatively minor impact on overall employment because coal plants are not particularly labor intensive,.

Coal terminals also are not particularly labor intensive, but the healthy revenues from coal are very important for both CSX and locally headquartered Norfolk Southern. This particularly relates to domestic coal consumption, but if natural gas continues to maintain its current low relative price levels, coal exports will become increasingly important.

VI. Nuclear Power

A controlled fission reactor creates heat, and this thermal energy superheats water to drive a steam turbine and create "nuclear energy". While initial development of nuclear power focused on creating a power source for submarines and aircraft carriers in both the U.S. and the U.S.S.R., the technology was quickly adapted for civilian/commercial purposes. The first two nuclear reactors to produce commercial energy were small; a 5 megawatt reactor in the U.S.S.R. which began operation in 1954, and the 50 megawatt Calder Hall nuclear power plant in England which began operation in 1956. The first U.S. plant was commissioned in 1957 at Shippingport Atomic Power Station in Pennsylvania.

Quick Facts about Nuclear

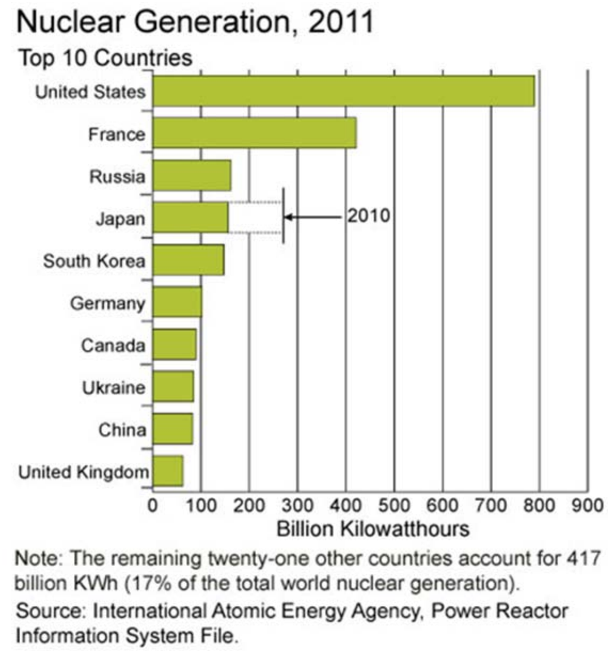
- Produces no greenhouse gases
- Does produce nuclear waste, which remains radioactive for thousands of years, and currently there are no long term storage solutions in the U.S.
- There are three different sites that are currently building, or permitted to build, new reactors (5 total new reactors will come on line by 2022).
- 20% of U.S. electricity currently is produced by nuclear power, as a result of both its low operating cost and its high capacity factor.

CURRENT STATE OF NUCLEAR POWER

There are approximately 440 nuclear plants currently operating in 30 countries, and nuclear power produced 14% of the world's electricity in 2010. However, big changes have come and are coming for nuclear power. Nuclear power was experiencing a renaissance before March of 2011, and broad enthusiasm existed for the expansion of nuclear power. Businesses were attracted to the high level of reliability and capacity usage. Security experts see it as a quick way to establish energy independence. Even some environmentally friendly organizations believed that the lack of carbon (or any other) emissions outweighed the problem of nuclear waste. This represented a major turnaround from the 25 year period since the 1986 Chernobyl Nuclear Accident. The Chernobyl accident caused numerous deaths and rendered more than 1,600 square miles uninhabitable due to heavy levels of radiation contamination. In 1987 Italy shut down all four of its nuclear plants as a result of antinuclear sentiment that emanated from the Chernobyl disaster.

VI. NUCLEAR POWER

> To replace Japan's nuclear reactors with solar panels would take an installed solar capacity of approximately 432 gigawatts, at a cost of $1.296 trillion and would cover 110% of Japan's land area. Alternatively they could install 152 gigawatts of wind capacity, at a cost of $375 billion, and this would cover 50% of Japan's total land area. Coal and Liquid Natural Gas (LNG) plants could be built for much less, but Japan would need to import all of the coal or LNG to run these plants, and significantly increase its greenhouse gas emissions.



The lack of accidents and the natural gas disputes in Europe led both Europe and the U.S. to reconsider the role of Nuclear in their energy mix. Italy which had decommissioned four fully functional nuclear plants in 1987 was considering building new plants in 2009, turning to France to build four new reactors and signaling a 180 degree shift in policy. Germany, the last remaining country in the G8[1] with anti-nuclear positions, also reassessed its policies. Germany had adopted a plan in 2000 to decommission all 17 of its nuclear plants, but following a 2007 gas dispute between Belarus and Russia, began to argue that it was impossible to achieve climate change goals without nuclear.

The international nuclear renaissance was derailed by the disaster at Fukishima Japan. The 11th largest nuclear power plant in the world, the Fukishima plant was designed to withstand major earthquakes and tsunami waves of up to 5.7 meters (18.7 feet). Unfortunately, on March 11, 2011 there was a 9.0 magnitude earthquake and a tsunami estimated to be 15 meters high, almost twice what the plant had been designed to withstand. This led to the worst nuclear incident since Chernobyl and the full environmental impacts of this disaster have yet to be tallied.

The disaster caused Germany to yet again reverse its direction on nuclear energy, and announce all 17 of its reactors would be closed by 2022. In Japan, which had the fourth most nuclear generation in the world, polls showed that 74% of the population favored a complete phasing out of nuclear power. U.S. polls in the immediate aftermath of Fukishima showed that only 43% of the population favored building new nuclear plants, when as many as 57% favored building new plants in 2008.

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[1] The Group of Eight, or G8, is a forum of the world's eight largest economies.

VI. NUCLEAR POWER

Nuclear facilities also remain very difficult to build because the upfront regulatory hurdles and capital costs are extremely high. This is particularly problematic because of the long lifespan of nuclear plants. Present value calculations render the large amount of electricity produced 30+ years in the future as almost valueless, despite the fact it is produced at minimal costs.

U.S. NUCLEAR PLANTS

Nuclear plants in the United States are used more intensively than any other form of electric power generation. Nuclear Power only has 9% of the nation's generating capacity, but produced 19% of its energy output in 2011. This is related to both cost and technical considerations. While other countries generate a greater share of their electricity from nuclear (notably France, which generates 80% of its power from nuclear), the U.S. generates by far the greatest amount of nuclear energy.

In February 2012, the U.S. Nuclear Regulatory Commission voted to approve Southern Company's application to build and operate two new nuclear reactors at its nuclear plant in Georgia. These are the first new nuclear units to be approved in over 30 years. These reactors are expected to come online in 2016 and 2017. The last new reactor built in the United States was in Tennessee in 1996, though one reactor was recommissioned in 2002 (it had been shut down since 1985) and another which was partially built has had construction resumed.

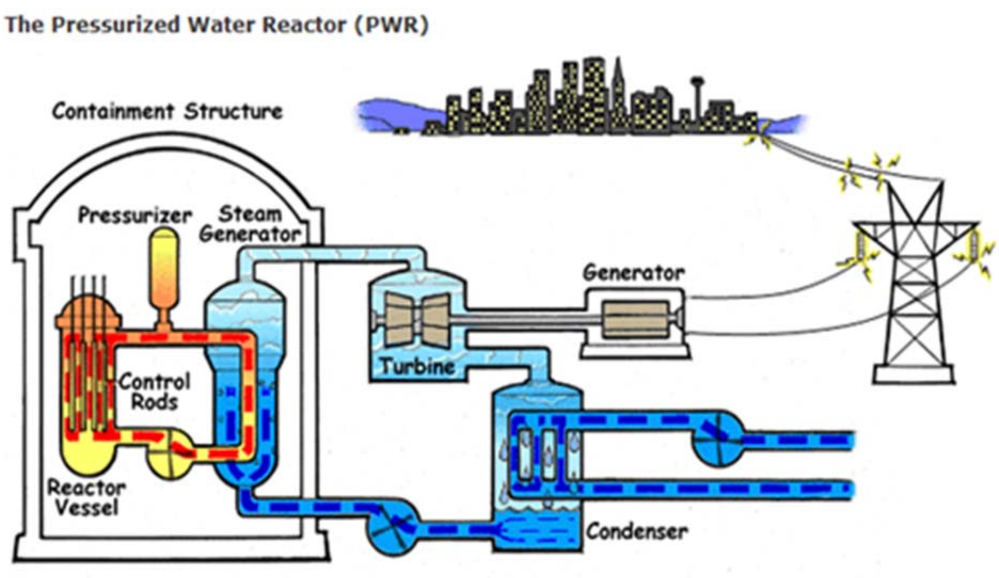
Although five nuclear plants were retired in 1997 and 1998, nuclear capacity is about the same as in 1996 when the Watts Bar 1 plant came on line. Technical modifications to increase capacity (called uprates) at existing plants have made this possible. These uprates, combined with high utilization, have enabled nuclear to consistently maintain a share of about 20% of total electricity output. With many nuclear plants operating at or near capacity, even maintaining the current share will depend on new reactors being built as electricity demand increases. However, four new reactors are expected to come online between 2016 and 2017. As of early 2012, the United States Nuclear Regulatory Commission (NRC) has active applications for a total of 28 new reactors, although it is unknown how many of the proposed reactors will be built. The NRC application review process is a detailed review that takes 30 to 60 months. The U.S. Energy Information Administration (EIA) projects that the industry will add approximately 15.8 gigawatts (15,800 megawatts) of new nuclear capacity during the period 2010 to 2035, with 8.5 gigawatts coming from new reactors and 7.3 gigawatts coming from uprates of existing plants.

VI. NUCLEAR POWER

SURRY POWER STATION

Surry Power Station is a nuclear power plant operated by Dominion Generation and owned by Dominion Resources. Its site was designed and has been approved for four units. It currently houses two pressurized water reactors which are capable of producing approximately 799 megawatts each, or a combined 1.58 gigawatts. It draws its water directly from the James River (and discharges its water directly to the James) which removes the need for the iconic water cooling towers often associated with nuclear plants. While the original operating license for the plants was 40 years, it was extended to 60 years in 2003 (the units which opened in 1972 and 1973 would be in the process of decommissioning otherwise).

Source: Dominion Resources



The Surry Plant has a sister plant in the North Anna Nuclear Generating Station (outside of Hampton Roads) which is jointly owned by Dominion Virginia Power and the Old Dominion Electric Cooperative (ODEC). The North Anna plant went online at the end of the 70s (Unit 1 in 1978 and Unit 2 in 1980). It uses a similar pressurized water technology as Surry, though its reactors have a slightly higher capacity of 895 megawatts per unit. Unlike the Surry Plant, Dominion currently has started the process of putting a third reactor at the plant which is planned to have over 1,500 megawatts of capacity. ODEC which originally was to continue to partner with Dominion Resources determined that it believed the capital costs of the new plant were prohibitive and has withdrawn from the planning and permitting process.

Source: U.S. Nuclear Regulatory Commission

VI. NUCLEAR POWER

FUTURE NUCLEAR TECHNOLOGIES

Many new nuclear technologies are being explored. Currently, the United States has many reactors that are considered generation 2 reactors, and there are plans to build several generation 3 reactors (or Generation 3+ as they are a refinement of generation 3 reactors). These are refinements of existing technologies used in nuclear plants, with greater emphasis on passive safety measures. These represent a step forward in efficiency and safety, and many nuclear proponents champion the benefits of further investment in nuclear technology.

One major technology that has been proposed is use of thorium, which utilizes the far more common element thorium rather than uranium as its feed stock. The plants have almost no risk of melting down because rising temperatures actually lower the energy output removing the chance of a runaway reaction present with uranium reactors. Unfortunately, while there have been several thorium reactors in U.S. history, this technology still remains in the experimental stage with regards to commercial development. An advanced heavy water reactor has been planned to open in India. This 300 megawatt reactor will derive 75% of its power from thorium, and is currently scheduled to open in 2013. This is part of India's current research efforts to develop thorium fuel (India has approximately 25% of the world thorium supply).

Generation 4 reactors have also been discussed. These reactors would be able to harness current nuclear waste as a source of fuel, powering the reactors and dealing with a significant issue with current nuclear power technology. These new reactors would produce nuclear waste, but the waste would be radioactive for a few hundred years rather than millennia. There are several different technologies discussed for these reactors, but even nuclear proponents do not expect these technologies to be available until 2030.

Another technology that has recently been popularized is Small Modular Reactors (SMRs). These reactors generate less than 300 megawatts and build on the experience of the Navy in building small reactors. These designs could be pre-approved, assembled offsite, and then shipped to the location of the plant. The modular nature would allow companies that build nuclear plants to lower the cost, and allow new plants to begin generating revenue before all of the reactors were in place. The Department of Energy will spend $452 million with matching funds from the energy industry to guide two SMRs through the regulatory process by 2022. They will be tested on a site in South Carolina next to the Savannah River Plant. While their proponents talk about the ability to use the SMR for particular needs like military bases, safety because of their relative smaller size (and proposal to bury the reactors underground), and speed of deployment, crtics have discussed these reactors as a risk for nuclear weapons proliferation as a result of widespread deployment and of licensing/regulatory issues.

AREVA AND NEWPORT NEWS SHIPBUILDING

AREVA Newport News LLC was announced in 2008 as a joint venture between AREVA, a French Nuclear Company and Northrup Grumman, which at that time owned Newport News Shipbuilding. The plan revolved around utilizing AREVA's experience building reactors and Newport News' skilled engineers with experience building nuclear aircraft carriers to form a company to take advantage of the worldwide nuclear renaissance that occurred with spiking gas prices. In July 2009 the firm broke ground in Newport News on a factory promising $360 million dollars of investment and over 400 employees (who would be highly qualified and well paid engineers and technicians). In early 2011, this joint venture had completed preparing the site for this factory, but the 300,000 square foot nuclear component factory had already been put on hold.

The original plan had anticipated building components as early as January 2012, but changes in U.S. energy policy and the Fukishima incident slowed that plan down considerably. Approval of new nuclear power plants and particularly loan guarantees slowed down considerably after the disaster in Japan, but the economic downturn had already forced AREVA Newport News to delay manufacturing until at least 2013. While AREVA has indicated that it remains committed to this project and has already invested $25 million here, internationally they have started to experience pressure due to Germany's new policies concerning nuclear power. This may hamper the firm's ability to invest in the United States. The long term health of this partnership will probably rest on the successful completion of the Generation 3+ reactors currently being built by other companies, and the possible adoption of one of several SMR designs that AREVA has participated in the engineering design (particularly the NP-300 which is modeled after submarine power plants).

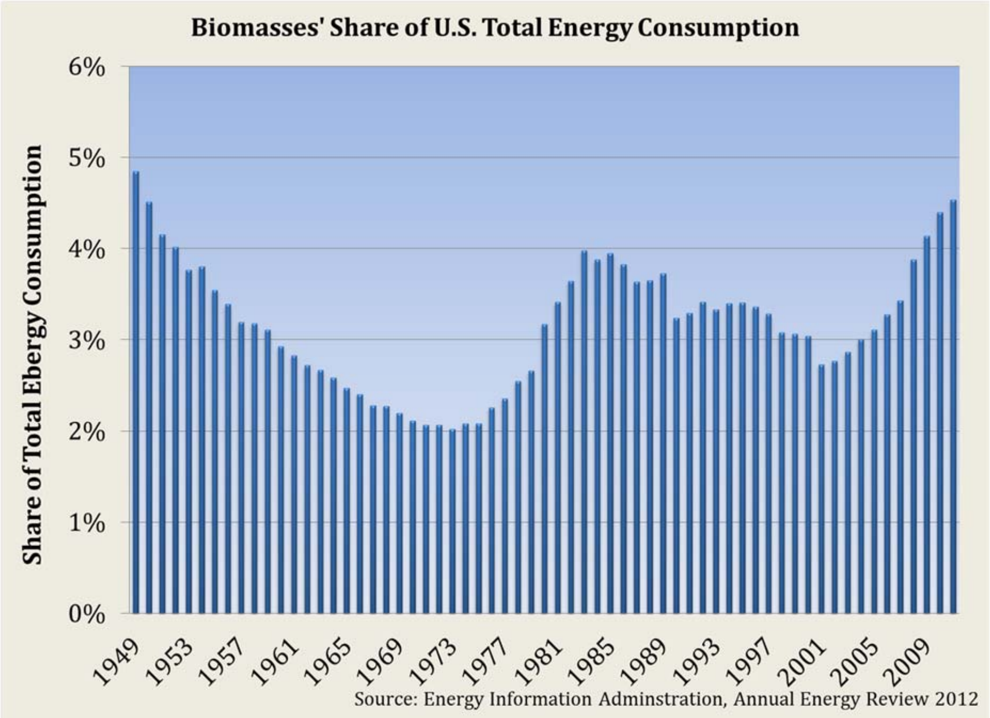
CONCLUSSION

Nuclear generation confronts three issues, two old and one new. The issue of radioactive waste and its disposal continues to be one the industry has yet to solve (for a variety of issues), and serves as a major wedge between a technology that produces zero greenhouse gases and the environmental movement. The industry also confronts the fear of a nuclear meltdown, which captures the imagination in a negative light. The new challenge the nuclear industry faces is the same with which all energy technologies currently grapple; given the low price of natural gas it is hard to justify investing in any other technology at this time. While the too cheap to meter slogan (never adopted by the industry) was proved a fallacy, nuclear continues to be one of the cheapest sources of energy even with today's high capital costs.

Surry Power Station is one of the strongest employers in Hampton Roads, and contributes to the extremely high median income that Surry enjoys, as well as significant public service corporation taxes to the county (along with Gravel Neck Power Station). Long term opportunities for nuclear employment revolve around leveraging the high degree of expertise granted to this region by the Navy, Jefferson Labs, and Newport News Shipbuilding. Given the current low prices of natural gas, there is unlikely to be major efforts to develop nuclear power in this nation until the long-term outlook for natural gas changes.

VII. BioMass and BioFuels

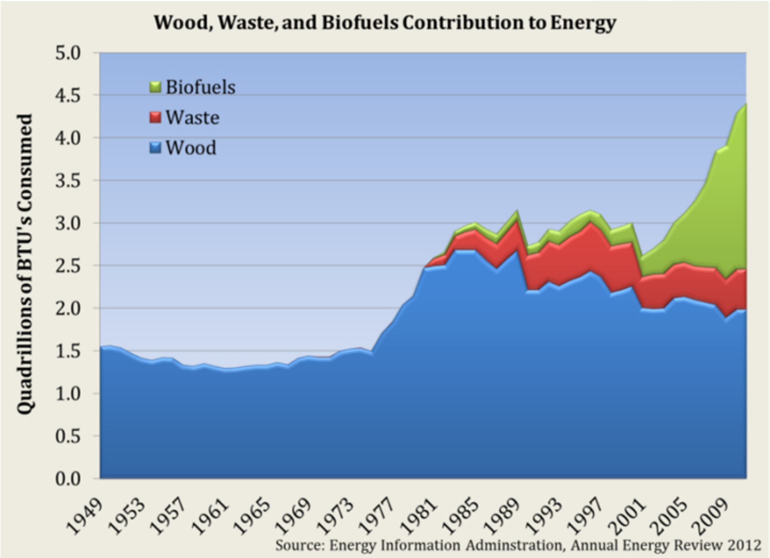
Biomass is currently the largest supplier of renewable energy in the United States, supplying 48.8% of all renewable power and 5.8% of total energy production in the U.S. While biomass had an equivalent share in 1949, total energy use in the United States has exploded since that time. The largest share of energy production comes from burning wood in biomass generators, but much of the recent growth has come from the expansion of biofuels (particularly ethanol), which have expanded from essentially 0 in 1981 to almost 1.9 quadrillion British Thermal Units (qBTUs) in 2011.



Quick Facts about Biomass and Biofuels

- While burning biomass produces CO_2, it is considered carbon neutral as all of the CO_2 produced had been recently removed from the atmosphere
- Biomass does emit particulate emissions as well as high levels of Nitrous Oxides
- Waste to Energy Projects are also considered Biomass
- The most common U.S. biofuel is corn based ethanol, no other biofuel has significant market share. Ethanol is 90% of the U.S. biofuel market
- Overall, Biomass represents 48.3% of all U.S. renewable energy, and 4.5% of total U.S. energy consumption

VII. BIOMASS AND BIOFUELS



BIOMASS FOR HEAT AND ENERGY

Currently, 2/3 of renewable energy in the world is in the form of biomass, a term used for any recently living plants and animals used as an energy source.[1] Energy from biomass now consists almost entirely from plant matter.[2] While most wood consumed in the world feeds simple cooking fires that harness a small portion of the wood energy and emit a relatively high portion of particulate emissions, there are now advanced wood combustion systems which address both of these issues. Modern home use of biomass heating has seen far greater deployment in Europe than the U.S. due to both higher European energy costs and natural gas disruptions that have occurred for both political and economic reasons.

Thermal efficiency is work and usable heat produced divided by the total energy inputs.

Biomass has also been used to produce electricity, and Dominion Resources has plans to convert three of its coal plants in the Commonwealth to biomass for electricity production. Unfortunately, the thermal efficiency of biomass electric production remains quite low, as wood-based electric only applications generally have thermal efficiencies below 30%. There are combined heat and power applications that have thermal efficiencies approaching 90%, but the U.S. has little infrastructure developed for these projects.[3] Biomass produces firm power and can be used for base load generation. It has become more popular in Europe as European countries try to meet their greenhouse gas standards and grow their energy security.

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[1] Fossil Fuels are technically renewable, but it took thousands of years of biomass to create a small amount of fuel after years of intense heat and pressure, so it is not renewable in terms of the current human conditions and consumption.

[2] As compared to previous use of whale oil for lighting or draft animals for work.

[3] They are more common in Europe, where the infrastructure for steam heat is tied into neighborhood generation centers, like a boiler for an entire building, but at a larger scale allowing it to be more efficient. President Obama has announced efforts to develop more combined heat and power operations, but because of a combination of factors, this seems unlikely to gain significant traction in the medium term. St. Paul, Minnesota currently has a combined heat and power plant which opened in 2003.

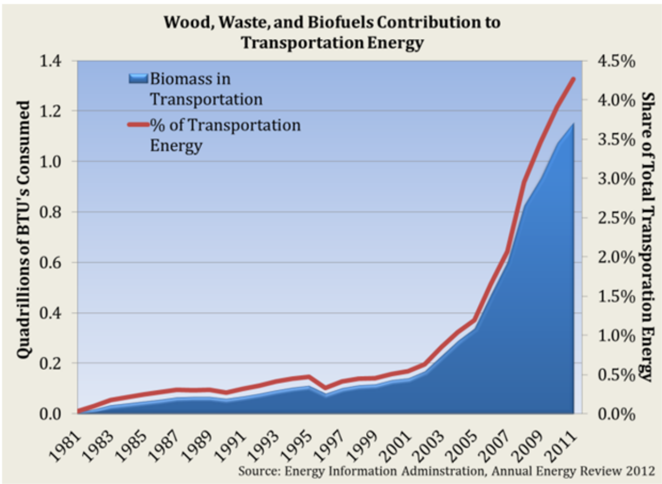
VII. BIOMASS AND BIOFUELS

WASTE TO ENERGY

Waste to energy has a tremendous amount of intellectual appeal, because it turns a nuisance (trash and debris) into a necessity, and thus could be considered energy recovery rather than energy creation. There are two major categories of waste to energy projects, those that directly burn the waste to produce electricity and steam, and those that capture or burn the gases that are released from landfills.

Burning waste to produce energy has been the most common method, and this broadly can be classified as thermal treatment. While the fuel for thermal treatment plants was very cheap (free, or sometimes subsidized since it involved the disposal of a nuisance), there were extensive capital and maintenance costs. These costs grew as pollution controls on thermal treatment plants become increasingly strict, and many of the newer methods attempt to mitigate the impact of the variety of pollutants that come from thermal treatment plants, which include particulates, heavy metals, and other emissions. The greater pollution controls require sorting the waste pre-burn, both through manual or mechanical sorting (this prevents harmful emissions and the need to clean pollution filters of those harmful emissions).

The other method involves gathering and treating the gas released by landfills to produce electricity or to be converted into fuel for homes or transportation. Typically these collect methane gas from landfills (the accumulation of which has been a major issue at landfills historically) by driving wells or trenches into a landfill, and then a blower to pull the gas to the collection wells. The plant then burns this gas to drive a boiler, or treated and used as a primary energy source. This method has the advantage of leaving many of the pollutants in place in the landfill, and additionally burning of the methane gas produced by the landfill (methane gas is an explosion risk, source of odor, and estimated to be the worst greenhouse gas).



BIOFUELS

"The Stone Age did not come to an end because we had a lack of stones, and the oil age will not come to an end because we have a lack of oil."- Sheiikh Yamaani, Saudi Arabian Oil Minister for 25 years (1962-1986) and Minister to OPEC.

VII. BIOMASS AND BIOFUELS

Oil serves as the feedstock for two separate transportation fuel classes, petroleum gasoline for cars, and then higher level distillates including diesel and jet fuel, and thus two different types of biofuels are needed to replace these two separate functions.

Substitute vs. Drop-in Replacement

-Substitute is a fuel that has similar properties, but is chemically different than the source fuel

-Drop in replacement has the same chemical and physical properties as the fuel being replaced.

Alternatives for Petroleum Gasoline

- Ethanol: Ethanol is the most common gasoline substitute in the world, and is currently used in a 10% blend with the vast majority of U.S. gasoline and in a similar mixture elsewhere in the world. There are also vehicles that are designed to burn ethanol and run on E85 (85% ethanol and 15% gasoline). Globally, over 23 billion gallons of ethanol were produced in 2010, almost 1% of global oil demand. Chemically, ethanol has significantly different properties than gasoline, with only 2/3 the energy density of gasoline. Also, ethanol absorbs water which presents significant issues for transporting it via pipelines or boats. Ethanol does have a higher octane rating, which allows an engine designed to run on ethanol to have a higher compression, which can mitigate the issue of lower energy density.

  Most ethanol today is made from carbohydrates, sugar in Brazil and India; while in the U.S. it is made from the starch contained in corn. Enzymes convert the corn starch into sugars, and these sugars are then fermented using yeast (note the extra step in U.S. ethanol production). The ethanol then needs to be purified/intensified by removing water, usually through the use of boilers. Another distinction between corn ethanol and that made from sugar cane, the fibrous waste from sugarcane (called bagasse) makes an excellent fuel for the boilers and minimizes fossil fuel inputs into the process.

- 1 Barrel of oil contains 5.8 million BTUs.
- 1 Barrel of ethanol contains 3.2 million BTUs.
- 87.3 M barrels of oil per day consumption would require (2010 World consumption) 158.2M barrels of ethanol to replace it.

- Cellulosic Ethanol: Cellulosic ethanol was commercially produced by the Germans in 1898, and the first U.S. plant opened in 1910, converting lumber mill waste into ethanol. The first plant in South Carolina and a second sister plant in Louisiana, had a daily capacity of 5,000 gallons of ethanol per day and operated for several years. Unfortunately, because of the extra steps of breaking cellulose into sugars (which add capital costs as well as time to the production costs) and the lower yield per ton of feed stock, cellulosic ethanol has never been commercially viable.[4] There are tax credits for companies that can

[4] Cellulose is chemically similar to starch, but the alignment of the molecules in cellulose forms a bond that proves more difficult to break down.

produce cellulosic ethanol and refiners currently pay a penalty if they do not mix the cellulosic ethanol with gasoline; even with those two policies in place, only 20,000 gallons of cellulosic ethanol have been produced in the U.S. in 2012.

- Methanol: Methanol is another fuel that could potentially replace gasoline. While most methanol made today is produced from natural gas, it also can be made from biomass. Since methanol is the simplest alcohol, it is the cheapest to produce relative to both petroleum and ethanol, trading at a 20% discount per equivalent unit of energy. It has a very low energy density (1/2 that of gasoline) and is even more corrosive.

Methanol, while considered toxic, is safe enough to use in windshield wiping fluid, and degrades quickly in open spills.

Before the ethanol policies were put in place, California explored methanol from 1979-2005, and had 21,000 M85 (85% methanol, 15% gasoline) vehicles in 1997

Alternatives for Distillates (consist of 30% of global consumption)

- Biodiesel results from reacting fats like vegetable oil with an alcohol (methanol), and this produces a combination of biodiesel and glycerin. Biodiesel has slightly different chemical properties than petroleum diesel. This shows up most frequently at cold temperatures where biodiesel starts to gel and freeze at higher temperature than conventional diesel. It is extremely easy to produce. It can be produced in a garage, and is a close substitute for diesel. Biodiesel is the most commonly used biofuel in Europe.
- Di-Methyl Ether (DME), used primarily as a propellant in consumer products is a gas that has been explored as a diesel substitute in both China and Sweden. Chemically, it is two methane molecules separated by an oxygen molecule, so only releases water and CO_2 when it is combusted.[5] Also DME is not corrosive, and while a gas, it liquefies under modest pressure. Currently China leads the world in DME capacity, producing it from coal and using it for both cooking and transportation. Sweden has been converting pulp mills into biorefineries, and Volvo has been conducting studies on the performance of DME in its trucks.

Diesel engines can run on straight vegetable oil, but eventually this leads to carbon deposits in the engine.

- Green Diesel: Distinct from Biodiesel, Green diesel is a drop in replacement for conventional diesel. Instead of using an alcohol to treat the feedstock, hydrogen is used to treat the fats and the reaction creates green diesel and propane. The long-hydrocarbon chains have the same properties as diesel, but it is much more difficult to get the hydrogen to react with the fats, and the capital costs for the process are much higher.

[5] Because of its use in consumer products, it has already been cleared as non-toxic and non-carcinogenic.

VII. BIOMASS AND BIOFUELS

CURRENT STATE OF BIOMASS

Biomass had experienced a renaissance recently because it offers a firm source of power that can be produced locally. There are 107 Biomass plants operating in the United States, but new biomass plants are expensive to build (nearly twice as expensive for the amount of energy output as natural gas plants according to current EIA projections, and slightly more expensive than nuclear plants). Additionally, many environmental groups have soured on biomass because of the relatively low thermal efficiency, specifically regarding the amount of CO_2 and Nitrous Oxides released per unit of energy produced, and worries that while renewable over 40 or 50 years, forests are not immediately renewable. The Massachusetts Department of Energy Resources recently limited ratepayer-funded subsidies of biomass plants more tightly.[6] The Code of Virginia currently includes this text-

> "A utility may use in meeting RPS (Renewable Portfolio Standard) goals, without limitation, the following sustainable biomass and biomass based waste to energy resources: mill residue, except wood chips, sawdust and bark; pre-commercial soft wood thinning; slash; logging and construction debris; brush; yard waste; shipping crates; dunnage; non-merchantable waste paper; landscape or right-of-way tree trimmings; agricultural and vineyard materials; grain; legumes; sugar; and gas produced from the anaerobic decomposition of animal waste." Code of Virginia § 56-585.2

While this allows wide latitude, the statute also restricts total renewable energy production to no more than 1.5 million tons of green wood per year, presumably to prevent competition with the construction, furniture, and paper industries. Dominion Resources noted in its renewable plan that the three plants it is converting to biomass energy will use waste wood to avoid this restriction.[7]

Ethanol production has grown throughout the country, and particularly in the Midwest, though almost no biofuels production occurs in Virginia. The growth in ethanol production was driven by Federal policies, particularly a tariff on imports and a blender's tax credit; while both of those policies have been removed, refiners are still required to blend ethanol into their gasoline which acts as a price/demand support for the ethanol industry. While previously there have been some conflicts

[6] Gies, Erica. "Massachusetts Addresses 'Biomass Loophole' and Limits Subsidies." Forbes. 2/33/2012. Accessed 09/01/2012: http://www.forbes.com/sites/ericagies/2012/05/22/massachusetts-addresses-biomass-loophole-and-limits-subsidies/

[7] Dominion Virginia Power Annual Report to the State Corpotation Commission on Renewable Energy. Nov 1, 2011. https://www.dom.com/about/stations/renewable/pdf/renewable_energy_report_110111.pdf

regarding the food vs. fuel debate, this year's drought covering most of the country brought the debate into focus. The corn crop projections were significantly lowered at one point, but the policy regarding the mandated blending was never removed, indicating the likelihood of its presence into the near future.

Waste energy has been very popular with both environmentalists and energy companies, but unfortunately there is a limit to how many viable waste energy sites are available for development.

BIOFUELS IN HAMPTON ROADS

As noted, there are no commercially produced biofuels in Virginia or Hampton Roads. While several scientists in this region (both at the Virginia Institute of Marine Science and at Old Dominion University) have produced research and patents regarding algae biofuel development, this process has yet to prove economically viable in the lab setting. Current research has focused on using algae to help clean up the Chesapeake Bay while making oil, which would be more expensive than algae grown only for fuel purposes[8]. The Department of Energy estimated baseline costs for algae fuel in 2011 to be $9.28 per gallon of algae fuel, and this is significantly above any near term projections for the price of gasoline.

Biomass and Waste Energy Plans in Hampton Roads

International Paper, Franklin Mill- This was the largest renewable energy plant in Hampton Roads in 2009, using black liquor as a primary energy source. Black liquor is a waste product from the production of paper which contains more than half the energy content of wood fed into a pulp mill. This plant had a nameplate capacity of 155 megawatts, and operated at 37.9% of capacity in 2009, though part of its efficiency is a result from cogenerating steam as well as electricity. While this is 2009 data, the plant has presumably resumed operation since the mill reopened this year.

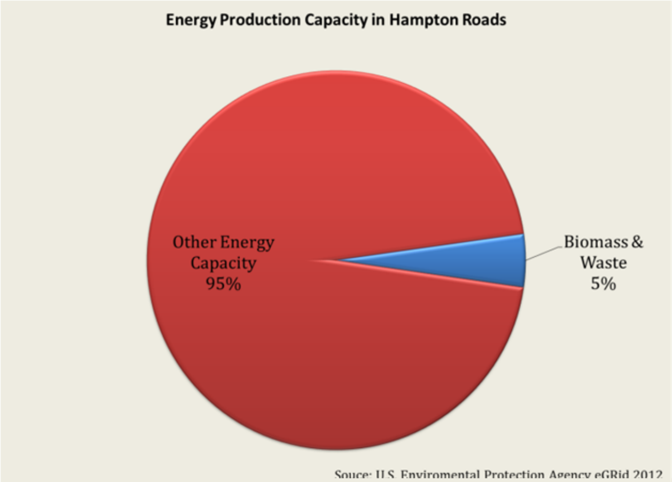
Wheelabrator Portsmouth Inc – Formerly SPSA Waste to Energy Power Plant, but was sold to Wheelabrator Technologies to raise funds ($150 million) in April of 2010. This plant uses municipal solid waste, which it shreds and dehydrates and burns for fuel. The plant has a generating capacity of 60 megawatts as well as steam for the Norfolk Naval Shipyard repair operations, but only operated at 28.7% of capacity in 2009 before the sale. Since that time Wheelabrator has invested $20M to

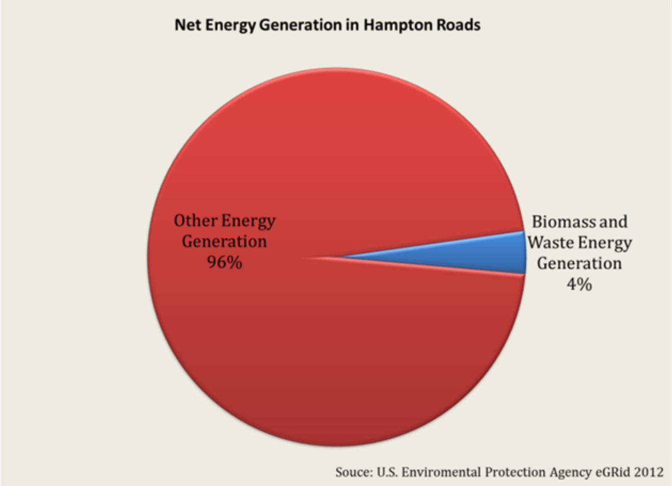
[8] Algae for fuel purposes needs to be specifically bred to produce oil to the point it phases out of water (or comes close to phasing out of water). Algae that focuses on cleaning up the Bay would be less efficient at producing oil.

upgrade the plant and currently meets the Environmental Protection Agency emission standards across all categories of pollution.

There are two Landfill Gas Plants in the region, one operated by Suffolk Energy Partners LP at the regional landfill and the other at the Middle Peninsula Landfill, which both use landfill gas to produce energy. This is a very clean technology that consumes waste gas produced onsite at these landfills, but only represents a small portion of electricity generated in this region (less than .1%). Hampton/NASA Langley also has a trash-to-steam plant that consumes 240 tons of trash each day and produces steam to power NASA Langley Research Center.

Southampton Power Station- This is a coal power station owned by Dominion Virginia Power which will be converted from a coal station with 63 megawatts of capacity to a biomass power generation facility with net capacity of 53 megawatts and will run on waste wood. This is one of three biomass conversions of existing power plants which Dominion Virginia has planned. It will be completed in 2013, and the plant will provide base power (or firm power) for the grid.



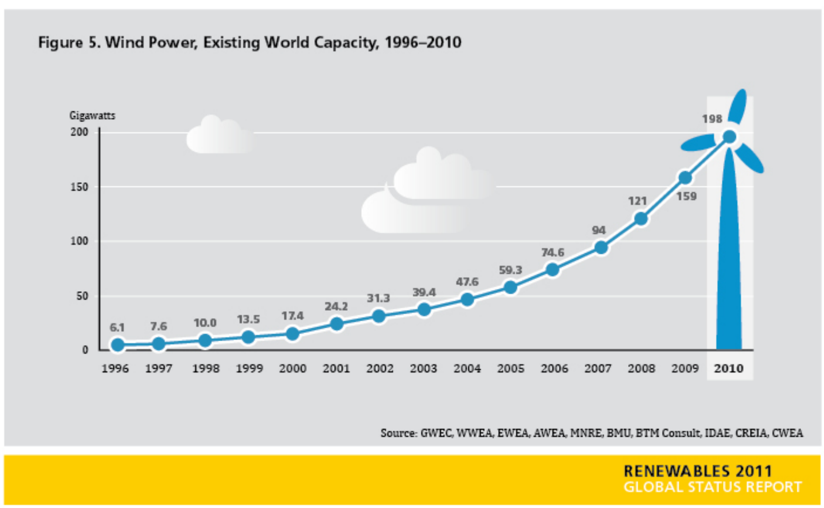


Conclusion

Sseveral facilities are currently operating in this region either capturing landfill gas or incinerating solid waste, and the economics of these activities are very good, especially with an existing facility. Unfortunately, there are few remaining sites where a waste to energy generation plant could be built in this region due to limits on available fuel. The biomass facility in Southampton will also provide renewable energy, but it is difficult to imagine this region producing sufficient waste wood to justify building another biomass plant. Production of wood pellets for sale to Europe should continue to be a strong business in this region, and it makes sense for local companies and the port to continue exploring a specialty in exporting wood pellets manufactured throughout the mid-Atlantic.

VIII. Wind

Man has harnessed the wind for transportation and for other labor saving activities for the last 2,000 years, including pumping water for irrigation and grinding grain. The first patent for producing electricity from wind power was granted in the United Kingdom in 1891, but the initial application and most subsequent applications were for an "off-grid" power source. While there were some utility scale wind farms before the 1970s, the idea of utility scale wind power started to gain force with a U.S. Department of Energy funded project to develop wind turbines. Concern about global warming in Europe led to a boom in European development and installation in the 1980s, though most of the growth in wind power has occurred over the last 20 years. In recent years, wind power has been one of the fastest growing sources of energy, with installed worldwide wind capacity increasing 32 fold since 1996, to 198 gigawatts of energy in 2010.



Quick Facts about Wind

- Produces no emissions during the power generation phase
- Three major concerns are noise, visual obstruction, and destruction of wildlife
- U.S. currently has no offshore wind capacity
- Plans to build the Cape Wind Project in Massachusetts are moving forward, at $2.5B for 454 MW capacity
- Wind energy supplied 1.2% of all energy consumed in the U.S. in 2011, up from 0.94% in 2010
- In 2011 wind supplied 2.9% of all electric generation in the U.S., up from 2.3% in 2010
- There is a stated goal by the U.S. Department of Energy for wind energy to producing 20% of U.S. electricity consumption by 2030.

VIII. WIND

POSITIVES AND NEGATIVES OF WIND DEVELOPMENT

Positives of Wind Power

Using wind power for fueling the electric grid is appealing for numerous reasons. Wind energy emits no air pollution during energy generation, removing concern about nitrous oxides, sulphur dioxide, particulates, and CO_2. Also, generation is not water intensive, which many of the primary energy extraction techniques are. When the wind blows it also directly "backs out" or replaces fossil fuel power generation that emit some or all of those pollutants.

Wind also appeals because it enhances energy security; once a wind turbine has been installed its fuel source is freely available and it is not subject to geopolitical considerations (as opposed to oil, particularly). Price certainty also appeals to many investors in wind power, which allows for the development of long term contracts.

Ten States Working with BOEM

- Maine
- Massachusetts
- Rhode Island
- New York
- New Jersey
- Delaware
- Maryland
- Virginia
- North Carolina
- South Carolina

Lastly, many individuals consider wind turbine manufacture an economic development opportunity, and wind energy was featured heavily in China's stimulus program and in other policies that China has in place. All but two Atlantic Coast governors have worked with the Bureau of Ocean Energy Management (BOEM) on the Smart from the Start program on offshore wind development.

Governor Christie of New Jersey said this upon signing an offshore energy bill in 2010, "The Offshore Wind Economic Development Act will provide New Jersey with an opportunity to leverage our vast resources and innovative technologies to allow businesses to engage in new and emerging sectors of the energy industry… developing New Jersey's renewable energy resources and industry is critical to our state's manufacturing and technology future."[1] This Act committed $100 million in tax credits to bring turbine manufacturing and assembly to Paulsboro, New Jersey.

Governor Deval Patrick of Massachusetts said this in June, "Every state along the East Coast is working to develop offshore wind, but they are all competing for second place, because Massachusetts will be first."[2] The same press release from that state

[1] http://www.earthtechling.com/2010/08/new-jersey-goes-offshore-for-wind-power/
[2] http://www.mass.gov/eea/pr-2012/120604-pr-offshore-wind.html

indicates that the first facility designed for the assembly, staging, and construction of offshore projects is in Massachusetts, and that Siemens Wind has located its North American headquarters in Boston.

Governor McDonnell of Virginia also announced that Virginia would be the first state to install an offshore wind energy turbine, although this project failed to be executed. It was believed that the Gamesa Energy and Huntingon Ingalls Newport News Shipbuilding partnership to build this turbine would keep Virginia on the cutting edge of renewable technology development, and promote supply chain and create experienced skilled labor in the Commonwealth.

Negatives of Wind Power

There exist two major negatives with wind power that impact community quality of life: noise and visual aesthetic considerations. This affects those areas in Virginia that have the greatest potential for onshore wind, particularly the scenic crests of the Appalachian Mountains. Issue over the visual and auditory 'pollution' have held up wind development in Virginia, but also in rural counties throughout the United States. The issue of sight obstruction particularly affected the Cape Wind project located in the Nantucket Sound, which originally applied for a permit in 2001, but has been delayed, by lawsuits and controversy that is ongoing. It is as a result of the issues from this project that the current development of offshore wind plans start outside of visual range of land. The current Wind Energy Area (WEA) for Virginia is located 23 nautical miles off of Virginia Beach.

From the developer and utility perspective, there are two significant drawbacks to wind power. One relates to the intermittency of wind. When the wind blows it can replace fossil fuel generation; however, it is impossible to control when the wind blows. This uncertainty requires utilities to have firm power to use for those times when the wind doesn't blow, which significantly increases the upfront costs of developing wind. The second issue relates to the location of wind energy throughout the country. Typically, the best sites for land based wind development are in the middle of the country far away from population and development centers. This forces utilities to develop long distance

On the Issue of Bird (and Bat) Kill

Thie issue of the impact on migratory birds has led to opposition from animal conservation and environmental groups to wind projects, particularly on land.

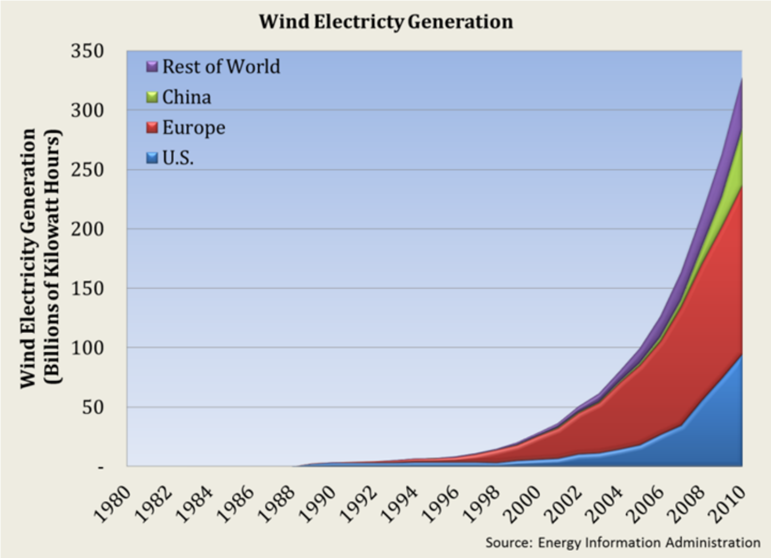
One wind farm in California is cited as killing 10,000 birds annually, and total birdkill from wind turbines has been estimated at 150,000 to 500,000 annually.

For context, the U.S. Forrest Service estimates 550 million (M) birds are killed annually by buildings, 130M by powerlines, 100M by cats, and 80M by automobiles.

transmission lines which are very expensive, and puts significant strain on the grid as that energy needs to be moved to the coast. Off-shore wind solves this issue because the population of the U.S. (and in most parts of the world) is concentrated near coastal areas.

WIND INDUSTRY IN THE U.S. AND WORLD

Wind energy has been a point of emphasis for most of the developed world over the past 15 years, with a large expansion of both capacity and net generation in both the United States and across the globe. This 32 fold increase in capacity only provides a small share of global electricity demands however, providing 2.0% of U.S. electricity demand and 4.0% of European electricity demand. China, which has rapidly expanded its wind capacity (44.7 gigawatts at the end of 2010), passed the U.S. (40.2 gigawatts) in installed wind power in 2010, though its operating capacity is less than its installed capacity (only 31 gigawatts of its wind resource are operative).[3]



Some countries have been more successful in transitioning to wind. One of the most successful countries has been Denmark, which has very strong wind resources and has made a hard push into wind energy. Roughly 19.7% of Danish electricity comes from wind production, very close to the U.S.'s 20% goal for 2030. Denmark has the goal of 50% of its electricity coming from wind in the future. It is worth noting that Denmark has a much lower level of electricity demand, with only 3.8 gigawatts of wind capacity installed, and also has access to the European power grid to compensate for the intermittency of the wind.

Top 5 Countries for Wind Share (2009)

Denmark 19.7%
Portugal 15.1%
Spain 14.0%
Ireland 11.4%
Falkland Islands 11.3%
U.S. (23rd) 2.0%

Top 5 Countries for Wind Power (Billions of kilowatt-hours)

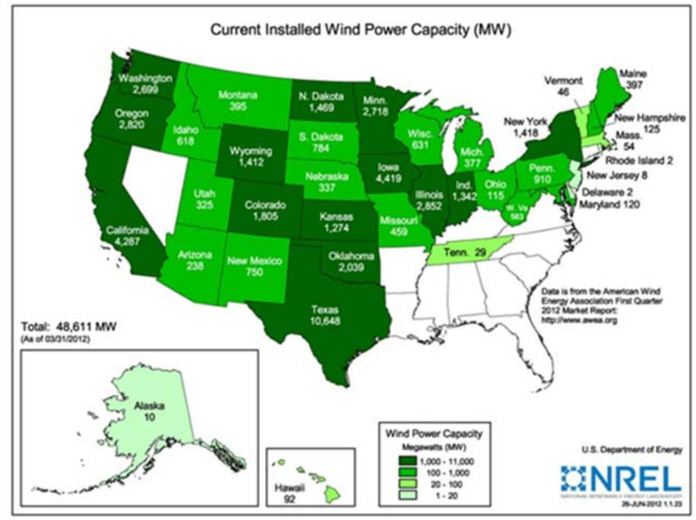
United States	73.8
Germany	36.7
Spain	35.9
China	25
India	17

[3] A large portion of newly installed wind in China is not currently hooked up to the grid, because of a variety of regulatory and incentive issues.

VIII. WIND

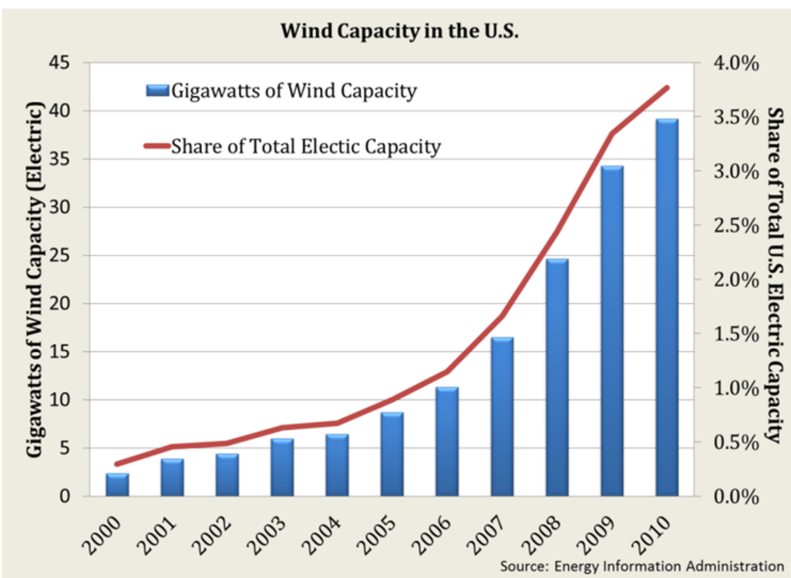
Almost 20% of the net worldwide generation growth (65.4 billion gigawatt hours) and 23.2% of the capacity growth (39 gigawatts) were added in 2010 alone, despite a weaker global economy. China added 14 gigawatts that were operative, while the U.S. added 5 gigawatts, followed by Spain (1.8), Germany (1.5), and India (1.4).

Wind Growth in the U.S.



U.S. wind development first occurred in California and other west coast states, driven by generous national and state level tax credits, but the new push for wind development in the U.S. has occurred mainly in the plains states. This is a result of having an abundance of wide open spaces and some of the best on land wind resources in the world.

There has been significant growth in U.S. wind power generating capacity, going from 2.4 gigawatts in 2000, to 8.7 in 2005, and 39.1 in 2010 (see the chart using Energy Information Administration data below). This capacity growth, as impressive as it is, still only represents 3.8% of total U.S. electric generating capacity, and because of the low capacity factor of wind technology, wind only represents 2.3% of net energy generation.



U.S. Wind Policies

The U.S. has encouraged wind development almost exclusively through the production tax credit, and this has been a major driver of wind installations, evidenced by the slowdown in wind development projects if the production tax credit is not renewed. These slowdowns have been the biggest concern about U.S. energy policy in general and for wind in particular.

VIII. WIND

The first tax credits expired in 1986, and left behind them a series of projects that had been built to garner the benefits of the tax credit rather than to be a productive energy resource. This led the second round of wind tax credits to be production tax credits based on the amount of electricity produced over the first ten years of a new project. The Energy Policy Act of 1992 started with a 1.5 cent credit-per-kilowatt-hour of electricity produced. It has been indexed with inflation and now provides a 2.2 cents per kilowatt-hour credit. It has also expired several times in its history, to be reenacted the next year. The American Reinvestment and Recovery Act also put in place several investment tax credits. Both the production tax credit and the investment tax credit expire on December 31, 2012 and have yet to be renewed. A wind farm completed before the end of this year would still be eligible for the full ten years of the tax credit.

In July 2012, the United States put a punitive tariff on steel turbines produced in China. This was based on the assertion that China has been selling these elements below cost. The U.S. has also considered placing tariffs on steel towers produced in Vietnam.

Gamesa, a Spanish wind turbine company, which had been working in concert with Newport News Shipbuilding, backed out of a test turbine project on the Eastern Shore because of the variability of the nation's energy policies.[4] That turbine was scheduled to be built in 2013, and would have been the first 'offshore' platform on the East Coast.

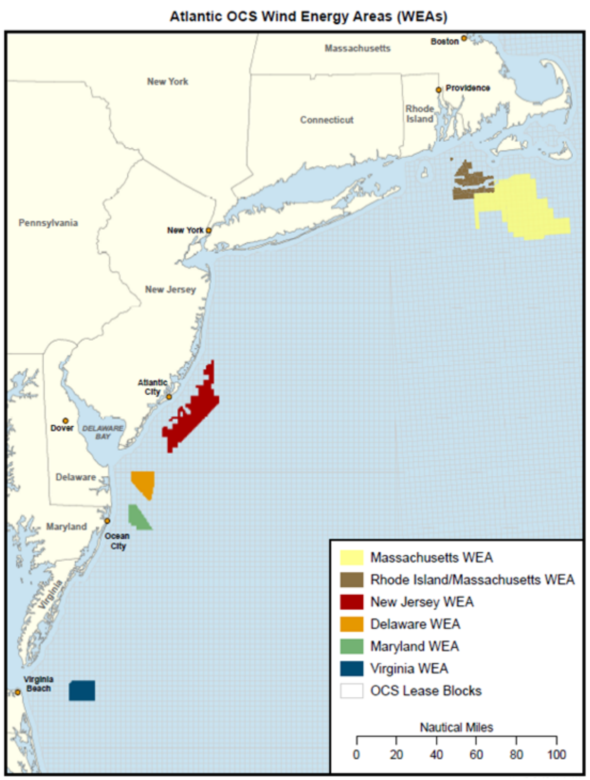
DISTRIBUTED WIND AND SMALL TURBINES

Small wind describes projects/turbines with a capacity of less than 100 kilowatts of capacity, typically deployed at residential, commercial, or industrial sites. Small wind and distributed wind are often used interchangeably, and small turbines are often considered distributed wind because they are placed at the point of usage. Distributed wind spread quickly in California between 1981 and 1985, as the two oil crises in the 1970s inspired both the U.S. and the state of California to offer tax credits for wind development. Unfortunately a significant number of these wind projects performed poorly, damaging the reputation of wind power, as developers both experimented with a variety of technologies and featured project leads who were more adept at managing the tax credits then developing the energy technology.

Distributed wind production is a supplement to, rather than a replacement for commercial generation. Small turbines avoid the issue of feeding into the grid and the distribution losses (though often less than 9% of electricity generated), but they have

[4] Gamesa also furloughed 92 workers at a turbine production plant in Pennsylvania, out of a total workforce of 115. Recently Siemens Wind laid off 600 out of 1800 U.S. employees.

a much higher capital cost per kilowatt of capacity (and per kilowatt-hour of power generated). Typically the upfront capital costs for small turbines are double what they are for utility scale wind, and thus while they may represent a fine option for individuals who want to lower their individual environmental impact, they do not represent a technology that should be supported by incentives.



Source: Bureau of Ocean Energy Management

Offshore Wind

Since the installation of the first offshore wind farm in Denmark in 1991, offshore wind has become a very popular technology. It has been seen as the solution to many of the issues presented by onshore wind.[5] Offshore wind farms are typically installed at least 5 miles offshore, mitigating the noise and aesthetic issues. The density of bird migrations also declines significantly the further from land, thus further lessening the concern of wildlife impacts. Offshore wind also allows turbines to be placed closer to population centers, which lowers the cost of developing infrastructure. Lastly, winds offshore are more powerful and more consistent, leading to a higher capacity factor for offshore projects. While onshore projects have historically produced approximately 28% of their theoretical capacity and newer turbines are projected to produce capacity factors of approximately 35%; modern offshore wind projects have demonstrated capacity factors between 44% and 47%.

In 2010, offshore wind installation only constituted 9.6%[6] of all wind installations in Europe, and produced 3.5% of all wind electricity on the continent. Current projections by Siemens Wind and other major manufactures indicate that offshore wind could equal 20% of all wind installations in the near future. Siemens Wind manufactured 80% of installed offshore wind power generation capacity in 2011.

[5] This includes the issues of transmission distance, impact on migratory species of bats and birds, noise, and impairing natural beauty.
[6] European Wind Energy Association (2011) "Wind in our Sails: The coming of Europe's offshore wind energy industry."

VIII. WIND

Offshore wind turbines are modern marvels, dwarfing even the tugboats that service them.

The Map on the previous page shows the current proposed wind energy areas as designated by Bureau of Ocean Energy Management by state. The development of the mid-Atlantic projects continues in lockstep, with Secretary of the Interior Salazar intending for all of the areas to have completed lease auctions by 2012. There appears to be no clear first mover for any of the projects within Smart from the Start. Only one offshore wind energy project currently is being developed in the United States federal waters that has currently met all of the regulatory steps required.

Cape Wind

In 2001, Jim Gordon's Energy Management Incorporated proposed a 130 turbine (420 megawatt) project in the Nantucket Sound. With shallow water and strong wind, this seemed like the ideal offshore wind project, especially with the high population density areas near this area. While many issues have been brought up that have delayed this project (final federal approval was just granted in 2010), the true underlying issue involves the visual aesthetic of the Hyannis Port community.

This led to a very difficult process, and a rigorous and comprehensive review. The Draft Environmental Impact Statement contained 5,000 comments and was 3,800 pages long. On October 6, 2010, after years of extensive environmental review and consultations, Cape Wind was issued the nation's first commercial lease to construct and operate an offshore wind power facility, with the goal of generating clean renewable energy for Massachusetts and the Cape Cod region. There have been several lawsuits since then, and at this point no loans have been made for this project. The developer has run into difficulty because it has only been able to sell half the electricity that the wind farm has been projected to produce, and will be unable to obtain full loans for the project until these contracts have been established.

In the meantime, a $250 million dollar 30-megawatt Block Island project has contracted to sell all of the electricity produced by its 5 Siemens 6-MW turbines to the National Grid PLC. This project is a very small offshore wind project, but it is expected to help the managing company, Deepwater Wind, develop expertise and real time information to help it with three 1,000 MW projects that it is currently developing in New England and New York waters.

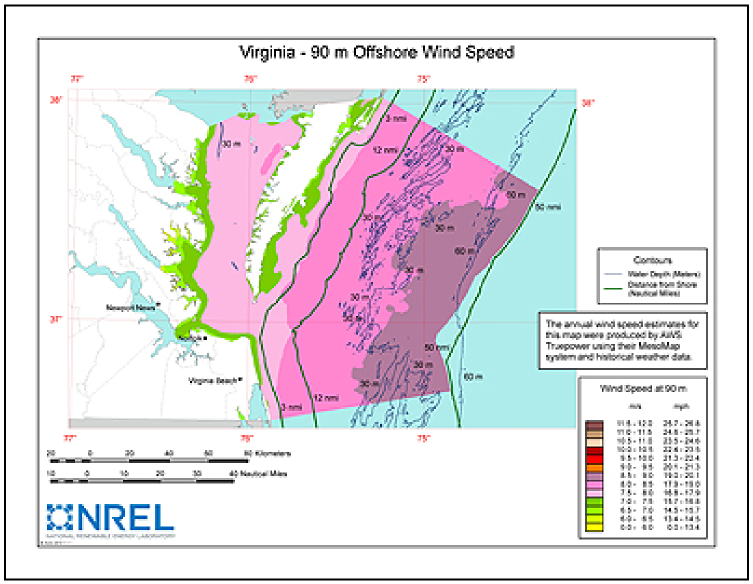
VIII. WIND

OFFSHORE WIND IN VIRGINIA AND HAMPTON ROADS

Advocates for offshore wind in Virginia point to the Commonwealth's and Hampton Roads' unique advantages to join the wind supply chain. Its mid-Atlantic position at the mouth of the Chesapeake Bay renders this region a central point for production, allowing for deliveries up and down the East Coast. There already exists a highly trained workforce with experience in a variety of marine projects. This region also has promise for the development of one of the first wind farms because of the well-developed electrical connections close to the shore line allowing for connection to the national grid with minimal transmission line upgrades.

8 Companies have bid to lease the Virginia WEA

1. Apex Virginia Offshore Wind
2. Acadia Offshore Virginia, LLC
3. Cirrus Wind Energy, Inc (only want to lease 3 whole blocks)
4. Dominion Virginia Power
5. enXco Development Corp.
6. Fisherman's Energy, LLC.
7. Iberdrola Renewable Inc.
8. Orisol Energy US, Inc.



The Virginia Economic Development Partnership (VEDP) analyzed the potential impacts of offshore wind on Virginia's economy. This analysis was based on a first mover advantage, that Virginia would be the first East Coast state to deploy offshore wind, and would build a farm of at least 1,000 megawatts. At this development size, European suppliers indicate they would start moving production. VEDP used the National Renewable Energy Laboratory's economic model[7] to project those impacts, and determined that if Virginia dominated the offshore wind supply chain in the U.S., the industry would produce 4,250 direct jobs in the Commonwealth, with a total employment impact of 9,670. Unfortunately the assumption of a first mover advantage seems to be optimistic as developments in Massachusetts and Rhode Island have completed the development process and lease sales.

The current proposed WEA for Virginia is composed of 112,799 acres that are 23 nautical miles off the coast of Virginia Beach. This consists of 19 three-mile by three-mile whole blocks and 13 partial blocks (16 partial blocks = 1 whole block) with water

[7] The NREL has developed the Offshore Jobs and Economic Development Impact (JEDI) model to estimate the employment impacts of energy projects.

depths between 20 and 30 meters, which is within the European experience for installing wind turbines. The potential capacity to be installed at this site is between 1,500 and 2,000 megawatts, and it is assumed the capacity factor will be at least 40%. Thus this lease has the potential to produce approximately 5.3 to 7.0 million megawatt-hours of electricity. This is equivalent to the consumption by 450,000 to 600,000 households, or the combined output of the three Dominion coal plants in Hampton Roads.[8] This power would have to be backed up by firm power elsewhere in the state, or by the Surry Nuclear plant which produced 13.5 million megawatt-hours in 2009.

Potential Hampton Roads Economic Impact from Offshore Wind

During the initial stages of the lease for Virginia's offshore wind development rights, the federal government will receive $338,397 dollars per year, but once the site goes into operation, the annual rate will be a function of regional electricity prices and the actual capacity factor of the project (how much electricity it produces). Estimates using current dollars and a 40% capacity factor have the lease payment equal to $3.1 million during the first 8 years of operation, and $6.2 million for the remainder of the lease. There has been no public discussion at this point about sharing that money between the state and the federal government.

Estimating the potential impacts in Hampton Roads is much more difficult. Much depends on the assumptions about what percentage of the turbine manufacture and assembly work is completed in the region, and what percentage of the installation accrues to regional firms. Using estimates from a South Carolina study[9] as a baseline for the installation and maintenance impacts produces somewhat more conservative results for the economic impact of offshore wind, but probably better reflects a smaller potential offshore supply chain in Hampton Roads. The cost of an offshore wind project consists of both wind turbines, approximately 41% of the cost, and installation costs including foundation construction, ports, engineering/legal, and turbine installation. The average cost per megawatt of capacity installed was estimated to be $4.8 million dollars.

The South Carolina study estimated that each megawatt of capacity installed in a given year generated 1 job in the state for the given year, and had a multiplier of 1.6, meaning that each dollar of output generated 60 cents worth of additional output. This assumed that 25% of the gearbox and electrical manufacturing would occur within the state, while the English experience saw approximately 20% of such work done within the state. Buy American provisions could increase the percentage of

[8] Combined the Yorktown, Chesapeake, and Southampton Coal Plants produced 5.35 million megawatt-hours of electricity.
[9] Colbert-Busch, Carey, Saltaman (2012)

construction in the region, but would also likely drive up the cost of the project. The 1 job-year per megawatt installed provides a conservative estimate for the components manufacturing piece. It is worth noting that Siemens Wind, the largest provider of offshore wind, advertises the fact that assembly only occurs in the local port for an offshore wind project.

Virginia Employment Impact from a 2000 Megawatt Offshore Wind Farm		
Phase	Per MW	Total
Turbine Components	1	2,000
Wind Farm Instillation	11	22,000
Total from Construction		24,000
Yearly Operation and Maintenance	0.7	1,400

Offshore wind farm installation drives the majority of local employment impact, and has a higher multiplier, 2.1.[10] Most of the installation activities, even if they are not done by individuals previously living in the region, are required to locate in the region during the housing process and thus more money is in the region to be multiplied. The South Carolina study estimates impacts of 11.0 jobs per megawatt installed, thus a 2000 megawatt project would generate 22,000 jobs over the course of the project, or 2,200 jobs per year over a ten year installation.

The component manufacture and turbine installation would net the region an estimated 24,000 job, or more simply 2,400 employees during each year installation occurs assuming this process occurs over a 10 year period. Long term employment would be driven by the operation and maintenance of the wind turbines (which need significant maintenance to function optimally during their 20 year life span). Operation and maintenance is projected to create 0.7 jobs per megawatt installed, so from full build out at 2000 megawatts of capacity that would support 1,400 jobs annually in the region.

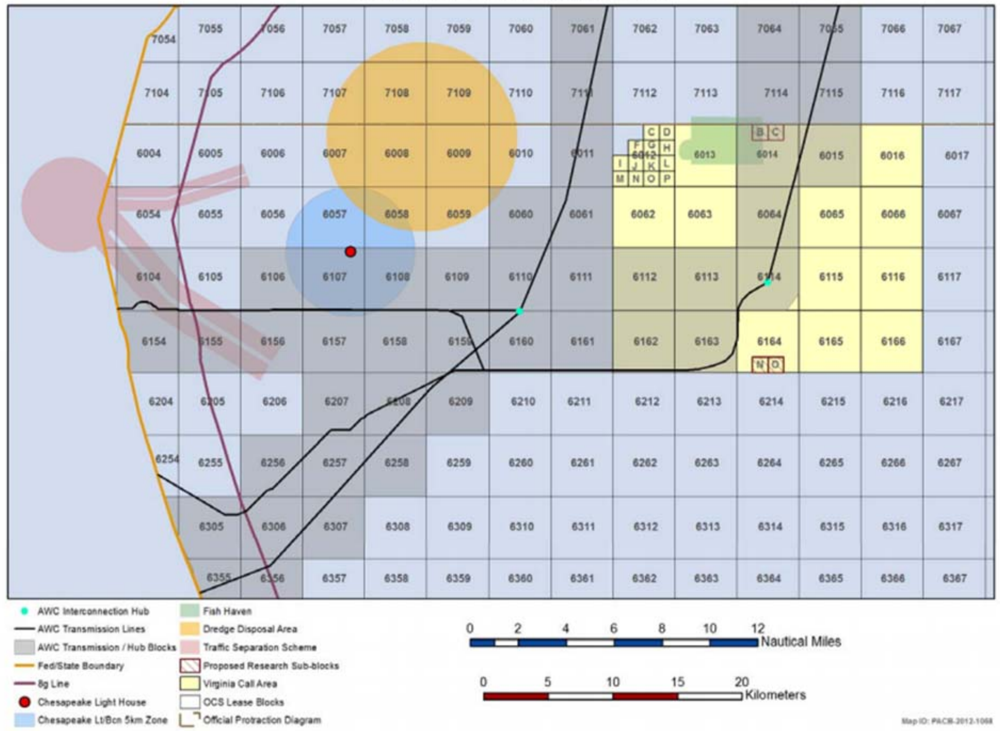
It is important to remember that these projects take a significant amount of time to come to fruition. Assuming that the lease sale proceeds without issue at the end of 2012, the company would have to develop a full survey of the site and then file a construction and operations plan before work could proceed. Currently, Virginia has put out an RFI to do a full survey of the ocean floor. Proposals were due on October 17, 2012. This will speed up the process and spare developers this upfront expense, but two environmental groups have placed comments asking for the survey to be altered.

[10] Installation is far more labor intensive than construction, and labor intensive activities have a higher multiplier, typically, than do capital intensive activites.

VIII. WIND

ATLANTIC WIND CONNECTION

BOEM Virginia Call Area with AWC Overlay



The Atlantic Wind Connection project seeks to create a high voltage transmission backbone along the east coast from New Jersey to Virginia, encouraging offshore wind development. Trans-Elect, the Maryland-based transmission-line company that proposed this venture said it hoped to begin construction in 2013. The company estimated that construction would cost $5 billion, plus financing and permit fees. The $1.8 billion first phase, a 150-mile stretch from northern New Jersey to Rehoboth Beach, Del., could go into service by early 2016. The rest would not be completed until 2021 at the earliest.

Even before any wind farms were built, the cable would channel existing supplies of electricity from southern Virginia, where Energy is cheap, to northern New Jersey, where energy is costly, bypassing one of the most congested parts of the North American electric grid while lowering energy costs for northern customers.

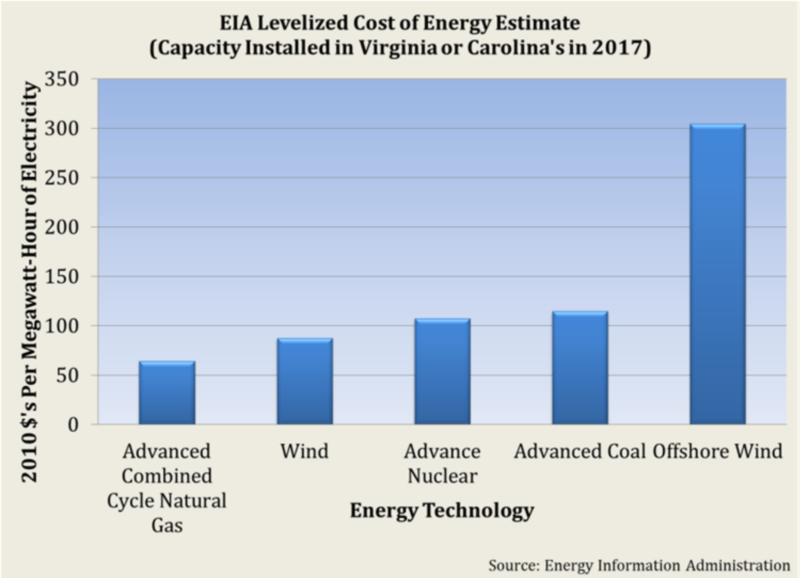
There has been mixed reception to the Atlantic Wind Connection project, with Dominion being the most strongly opposed group. Dominion Resources views it as improper to award the transmission lines before it is known who will win the lease bid, because the lack of transmission right of way would affect the value of the lease.

If the current construction project proceeds as planned with the Atlantic Wind Connection, it would appear to hold up wind development off the coast of Virginia until 2021.

VIII. WIND

CONCLUSION

While there was a significant amount of initial optimism regarding offshore wind in Hampton Roads, the development process has taken longer than proponents had hoped, and has incurred several setbacks. The continued variability in U.S. policy discouraged Gamesa's investment in a test turbine off the Eastern Shore, and this will inhibit their ability to develop a wind turbine that is specifically designed for Mid-Atlantic winds, sea, and weather conditions.



AREVA which is another company with a regional presence and experience building wind turbines has not made any investment in developing that industry in this region to date. Several projects in New England that will use Siemens Wind turbines (Siemens Wind's North American headquarters is in Boston) will probably be in the water before construction will begin on any of the four mid-Atlantic WEA's. This removes the likelihood of market dominance.

There is significant potential for regional employment growth as a result of investment in wind energy, but this has to be measured against possible drags created by higher energy costs. Denmark, which receives the largest percentage of its energy from wind of any country, also pays the highest utility rates in Europe. For the near future, either subsidies or renewable portfolio requirements will drive the viability of offshore wind. This region is not ideally suited for the more affordable onshore wind development, except in the areas already dedicated to resort functions.

The Energy Information Administration has estimated the levelized cost of building various types of power plants in the Virginia and North Carolina region. This levelized cost estimate attempts to combine the projected capital, operation and maintenance, fuel costs, and transmission costs of an energy project, and then divide that by the total amount of energy a plant will produce over a 30 year time span. Using the EIA 2017 estimate, offshore wind generating capacity installed in this region will cost $304.07 per megawatt-hour of electricity produced, compared to $87.22 for onshore wind, $107.20 for advanced nuclear, and $102.94 for advanced combined cycle natural gas plants. These are merely estimates, but they show that the significant capital costs for offshore wind will need to decline before it is competitive on its economic merits.

IX. Solar

In many ways, light from the sun provides for all other energy sources except for geothermal and tidal. Light from the sun heats the earth unevenly causing wind and waves. Light from the sun is converted into sugars by plants, allowing for biofuels and biomass. Those very same plants feed all animals and humans that do work with their muscles. And the accumulation of plants and animals over time, combined with pressure and heat creates coal, oil, and natural gas.

Solar, whether it is passive solar, solar thermal, or photovoltaics, serves as the most popular renewable energy with environmentalists because of its low impact with regard to emissions, and its long term sustainability.

Solar suffers from the same intermittency issues which plague wind, in that the sun does not shine 24 hours a day. Even worse, there are times that sky is overcast or cloudy. This makes the development of energy storage options other than pumped hydro[1] a key factor in the viability of solar. Currently, solar installations need firm power to back them up. Sunshine does more accurately match the peak consumption periods in the south, i.e. hot summer months where there is tremendous demand for powering air conditioning units in homes and businesses, particularly during the day.

Quick Facts about Solar

- Solar energy produced 0.16% of all energy consumed in the U.S. in 2011.
- Solar produced 1.73% of all U.S. renewable energy in 2011.
- Solar energy installations and total capacity have grown quickly in both the U.S. and internationally, and the U.S. added more capacity in 2011 then the country had total in 2008.
- Solar prices have been dropping rapidly both internationally and here in the U.S., because of overinvestment in solar manufacturing
- The U.S. has placed punitive tariffs on solar panels from China of between 34.29% and 265.20%

[1] Pumped hydro, or pumped-storage hydroelectricity, is a type of hydroelectric power generation utilized by some power plants for load balancing. The method stores energy in the form of potential energy of water, pumped from a lower elevation to a reservoir at a higher elevation. Low-cost off-peak electric power is used to run the pumps, or in the case of solar, excess power generated during the day. During periods of high electrical demand or when the sun fails to shine, the stored water is released through turbines to produce electric power. There are many issues with scaling the storage technology, from the evaporation of water resulting in 'lost' energy to the large amount of water and/or height differential to store large amounts of energy. While it is more efficient then an array of batteries, it still requires costly capital investment.

IX. SOLAR

THE THREE SOLAR PATHS

Passive Solar

Passive solar systems or design makes the most efficient use of the thermal heat from the sun, but do not involve the use of mechanical or electrical devices to circulate or collect that energy.

Passive solar construction has a long history, because human beings dealing with the limitations of energy has a long history. In fifth century Greece, houses were designed to take advantage of the sun's warmth in winter, with houses that faced the south.[2] The Romans also oriented their houses in the same way, but added glass to the southern facings, allowing sunlight in but preventing heated air from escaping. This led directly to the idea of greenhouses. 19th Century English estates featured greenhouses on the southern wall, and doors between the greenhouse and the rest of the manor house were opened during winter days to allow warmed air to circulate throughout the house.

Aerial view of the National Solar Thermal Test Facility at Sandia. The mirrors concentrate the sun's rays on the "power tower", which runs a steam generator. Source: National Renewable Energy Laboratory

Modern passive solar homes saw increasing interest around World War II but were derailed by the economies and convenience of electric and gas heating; however, interest in

[2] Greece experienced an energy shortage during this time, as the country was lightly wooded.

passive solar building design revived in the 1970s with the two oil shocks of that decade. Today's passive solar building techniques are influencing regional, commercial and public architecture, taking advantage of newer technologies in building insulation and window design.

Thermal Solar

This term applies to using the Sun's rays to collect heat energy, and applies equally to solar hot water heaters for homes and businesses as it does to utility grade solar thermal projects.

Solar hot water systems were popular in the Southwest before natural gas deposits (at this time a waste product of oil production) drove down energy prices for heating applications. Since that time, the quality of solar hot water heaters has improved significantly, but solar water heaters had a hard time finding traction until energy prices started to increase. In temperate climates where backup heat sources are required (typically electricity or natural gas), the payback period has declined significantly to as low as two years, and it is even lower in areas like the southwest.[3]

Solar thermal electric plants are the other major application of thermal solar technologies and until recent declines in photovoltaic prices, there was significant interest in developing utility scale solar thermal plants. Also called concentrating solar power (CSP), these systems use lenses or mirrors to concentrate the sun's rays, much like a magnifying glass. These concentrated rays heat a liquid directly to generate steam that drives a turbine, or can produce molten salts which are then used to generate steam through indirect heat transmission.

Solar thermal plants have greater capacity to deal with intermittency issues than do photovoltaic or wind. The steam generator that is used to produce energy, while typically heated with the solar radiation, could just as easily be heated with natural gas burners, allowing for backup energy production with a much lower capital cost. Additionally, heat energy stores

Solar Cells

- First energy solar cells where invented in 1883 by Charles Fritts, and were made of selenium (these only had an efficiency of 1%).
- Silicon solar cells were first deployed in 1954, and quickly reached efficiencies of 6%, and subsequent cells achieved efficiencies of 10%.
- Early solar cells cost $300/watt of capacity
- Most modern solar cells have efficiencies between 14% and 22% depending on cost.
- Some cutting edge designs have reached efficiencies of 40%, but they are not economical.

[3] Laborderic et al. (2011)

more readily then electrical energy, and thus molten salts can continue to drive the steam turbine after the sun sets or is obscured. It is this capacity that led solar thermal plants to become very popular in theory in the past decade, but the rapid drop in photovoltaic prices over the last few years has driven several concentrated solar projects and advocates to abandon the technology.

Photovoltaics (PV)

Photovoltaics is a method of generating electricity by converting solar radiation into direct current energy.

Solar panels consist of a connected assembly of individual photovoltaic cells, which take sunlight and use it to generate

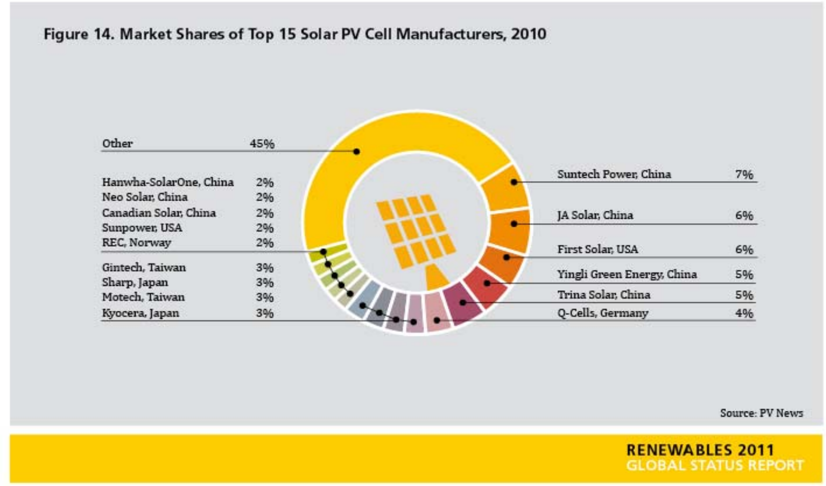


Figure 14. Market Shares of Top 15 Solar PV Cell Manufacturers, 2010

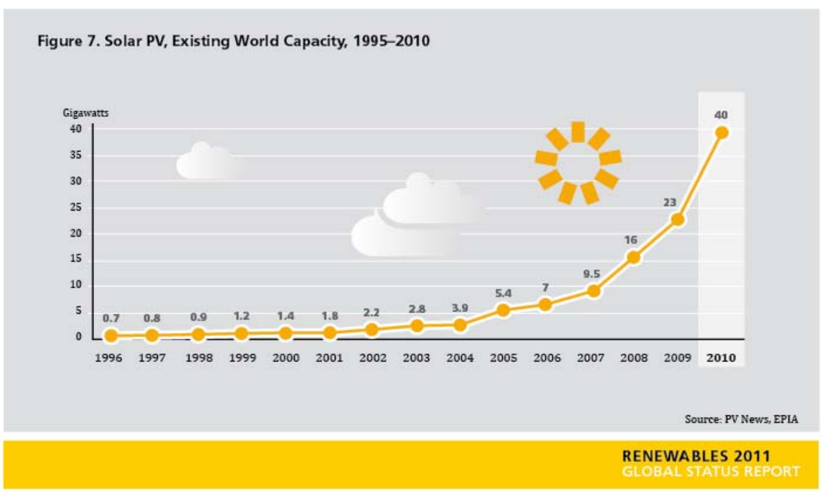


Figure 7. Solar PV, Existing World Capacity, 1995–2010

<u>*G.E.*</u>

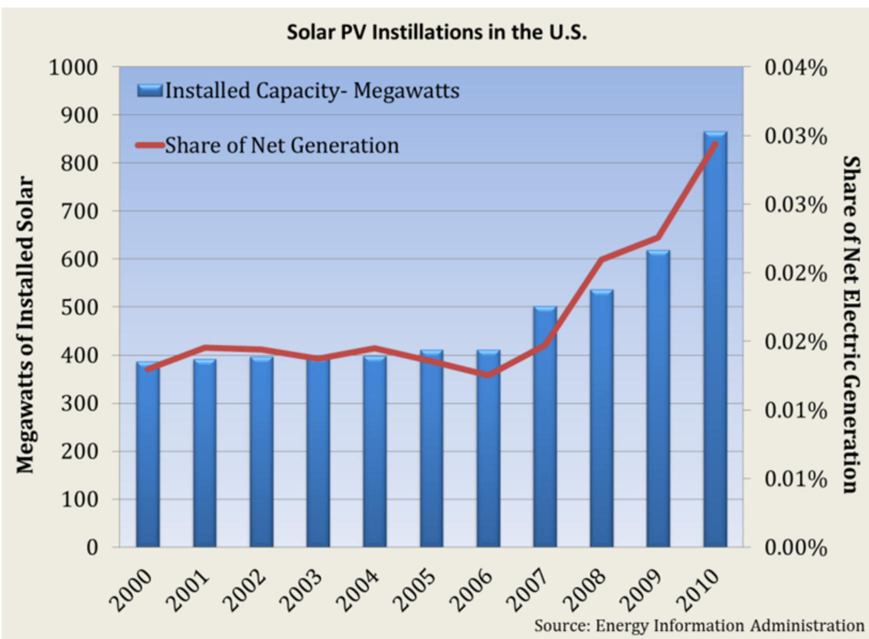
G.E. halted construction this summer on what would have been the largest solar plant in the U.S., producing 400 megawatts of solar panels annually and employing 400 workers.

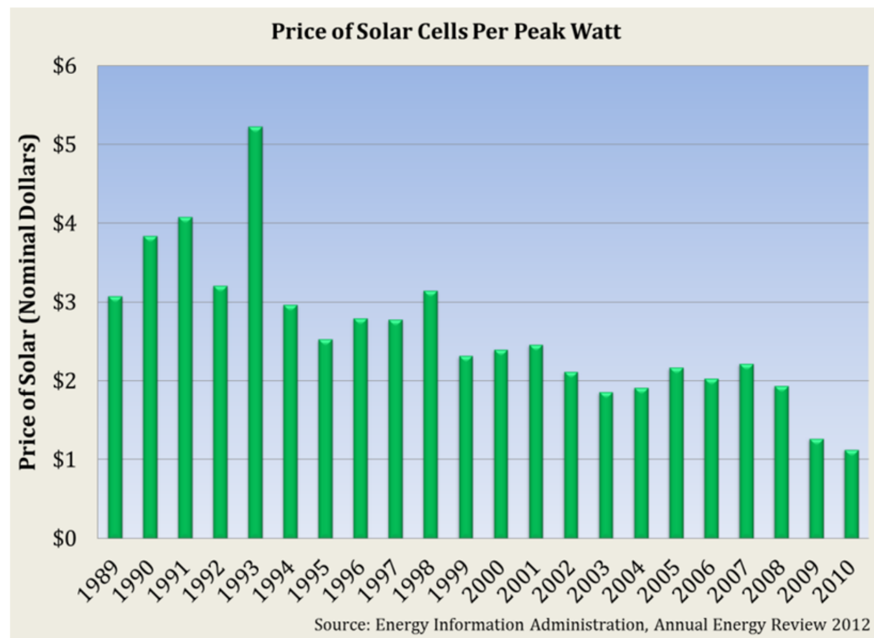
They have stopped work on the plant, because dropping polysilcon prices made their thing-film too inefficient, and will resume work on the plant after 18 months in the laboratory attempting to boost the efficiency of the solar panels.

electricity. Photovoltaics, or PV, are what people generally think of when they imagine solar energy. Particles of light, called photons, strike two thin sheets of material separated by a diode (these thin sheets are typically a silicon lattice). When the photon hits the panel, it knocks free an electron from one half which travels across the diode to the other half, and the flow of these electrons through the diode creates current and voltage.

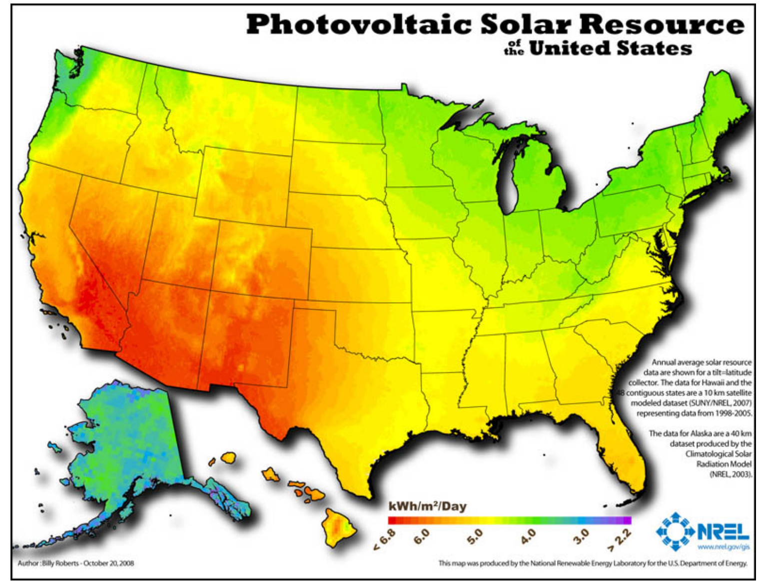
The price of PV has declined rapidly over the past 4 years, driven by overcapacity in both inputs to production (particularly the refined silicon), and with PV production itself. This has been a time of consolidation in the U.S. solar manufacturing industry, and for most of the developed world.

Some of these closings have been the result of poor timing or poor production choices. Many of the companies that have run into trouble, including Solyndra, were developing technologies to bypass expensive high poly-silicon prices. Unfortunately for these companies, global poly-silicon supplies caught up with rising demand, going from a high of $500 per kilogram in 2008 to a mere $35 on spot markets. Despite this consolidation, there is no one single market leader with regard to solar cell manufacture.



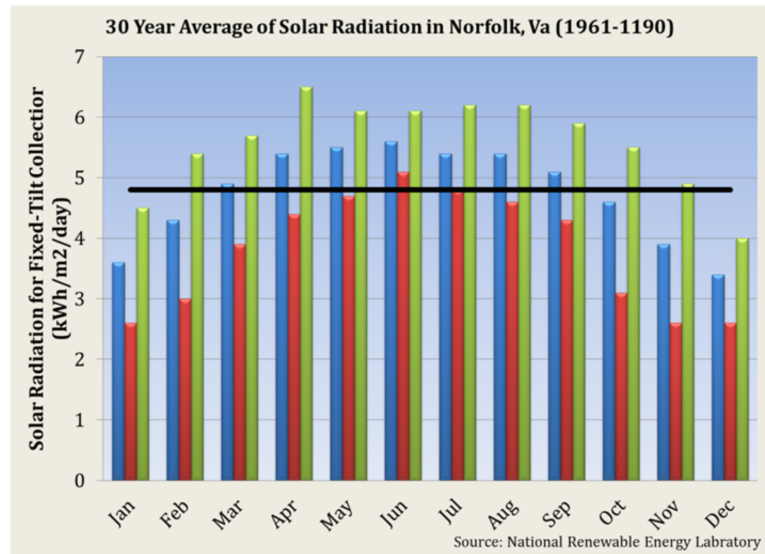


IX. SOLAR



Global solar PV has grown rapidly, especially over the last 4 years. As can be seen on the chart on the previous page, solar PV capacity increased by over 60% each of the past two years, and that trend has actually accelerated despite the economy. This is due to a combination of generous subsidies at the national level (and at the state level in the U.S.) and the rapidly declining price of Solar PV.

Today, the federal benefits for solar PV include: the investment tax credit, representing 30% of installed costs; and the accelerated depreciation benefits, representing approximately an additional 25% of installed costs. Current installed costs — on average — range from approximately $5/watt for residential systems (fixed mount) to roughly $3/watt for utility scale systems (with single axis tracking) with capacity factors of 17% for fixed mount (residential and commercial) systems and 23% for single-axis tracking (utility) systems.[4] The Federal Government's SunShot initiative (named after the moon shot) has the goal of lowering installed residential systems to $1.50/watt installed and utility grade to $1.00/watt installed.



One of the major challenges to PV in the U.S. relates to the expense of the installation of residential solar. Solar projects in the U.S. cost on average $20,000 versus a cost of $10,000 installed in Germany, but even if the panels themselves were free in the U.S., the cost would still be higher than the installed cost of solar in Germany. Evaluations of this cost difference point to soft costs in the United States, resulting from a higher net margin on solar installations, higher costs in attracting clients, and as a result of

[4] Mendelsohn 09.19.2012. "A better (more cost effective) mousetrap? How much do U.S. tax benefits cost per kWh of Solar production?" https://financere.nrel.gov/finance/content/better-more-cost-effective-mousetrap-how-much-do-us-tax-benefits-cost-kwh-solar-production- This estimate of capacity factor combines the average solar radiation in the U.S. with the inefficiencies of the system

less installation experience driving up the installation time (which drives up labor costs).

SOLAR IN VIRGINIA

While Virginia does not have the solar resources of Southern California or the other Southwestern states, this state does have very strong solar resources. PV solar radiation in this region is equivalent to 4.5 hours of noon quality sunlight on average and this provides approximately 4.5 to 5.0 kilowatt-hours per day of solar radiation per square meter (kWh/m2/day). In Norfolk, the long term observed average was 4.8 kWh/m2/day annually. Thus a 1 kilowatt capacity solar panel in Norfolk would produce 3.84 kilowatt-hours of electricity in an average day, or 1401.6 kilowatt-hours in a year.[5]

Virginia has several policies in place that are extremely helpful to distributed solar (or residential solar). The state has net metering, and this allows excess solar that a system generates to be sold back to the electric company (albeit at the retail rate, lower rate than the electric company sells energy to the customer)[6]. The Virginia also has a statute that allows localities to exempt solar panels and solar hot water heaters from local personal property tax.[7] Va. Code 55-352 also allows for easements for solar access (making sure a neighbors trees don't shade one's panels) and VA code 67-701 prevents community associations from prohibiting the installation and use of a solar collection device (though this does allow for reasonable restriction as to the size, place, and manner of placement).

[5] This combines the average solar radiation in a day over a given space, with the estimated inefficiencies that occur in any solar system.

[6] Established by HB 2155 this policy in April 1999, allows for up to 1% of the peak capacity of Virginia in one year, and a 20kWcapacity for a residential system.

[7] § 58.1-3661 A. Certified solar energy equipment facilities or devices and certified recycling equipment, facilities, or devices, as defined herein, are hereby declared to be a separate class of property and shall constitute a classification for local taxation separate from other classifications of real or personal property. The governing body of any county, city or town may, by ordinance, exempt or partially exempt such property from local taxation in the manner provided by subsection D.

The largest impediment to residential and distributed solar in Virginia is the current low price of energy. Electricity costs in the Commonwealth average 11.46 cents per kilowatt-hour, just over the national average of 11.43 cents per kilowatt-hour. At current prices for both solar installations and residential energy, the payback period for solar projects remains longer than 19 years in Virginia, even with the federal tax credit.

CONCLUSION

While Dominion has begun examining a community solar program with between 10 to 30 Megawatts of panels distributed through sites around the Commonwealth that they would rent from localities and business, there has been little movement to a full utility grade solar farm as has been seen in other states. While distributed solar forms a relatively attractive technology in states with high energy costs, it is unlikely to gain momentum in Virginia until solar prices fall precipitously or energy prices increase significantly.

Hampton Roads could encourage solar by working as a region and through individual localities to streamline the permitting process; the entire country of Germany uses the same two page online form for all residential permitting. Driving down the cost of installation will increase uptake of solar energy which has many long term benefits to the region, but the decline in installation costs will also limit the job impact that it will have in the region.

Dominion and Solar

Currently Dominion purchases power from residential customers through the net metering program, but Dominion has moved to change this arrangement.

1. The first change was adding a fee for large residential solar installations (between 10 and 20 kilowatts). This is a $2.79/kilowatt charge for distribution and a $1.40/kilowatt charge for transmission. Dominion indicates this change is needed to cover the capital costs of transmission lines. Only 1 user in Virginia right now has sufficient capacity to pay this new rate.
2. Dominion wants customers to sign up to sell all of their solar electricity (up to 3 megawatts total) to Dominion for 15 cents/kilowatt, and Dominion will provide them electricity back at 12 cents per kilowatt hour. This also includes the transfer of Renewable Energy Certificates to Dominion which allows it to meet its Renewable levels, but at a much lower rate than they sell for in the market.

X. Policy Recommendations and Conclusion

From an economic perspective, it is extremely difficult to make recommendations on energy policy because decisions on energy are closely intertwined with concerns about the environment, health, safety, and security. There are however, several clear implications for the current energy market in Virginia, and several best practices that merit consideration for local and regional policies.

LONG TERM GOALS FOR LOCAL ENERGY POLICY

It is important to know what a region is trying to achieve with its energy policy, particularly as it relates to its economy. In general a region/locality has three specific goals with regard to energy (in order)-

1. High Energy Surety
2. Low Energy Costs
3. Increasing Energy Jobs

While there are elements that balance or can change this order, in general this tends to be how society (collectively) and governments rank these elements. It is important for individuals and businesses that they be able to access power from the grid at any point it might be needed, to the point many businesses and residences have backup generators. Following that, the diffuse costs of higher energy prices are a larger drag on the overall economy than the benefit of a marginally larger number of individuals employed in energy related fields.

Tangentially to the economics of energy policy, there have also been attempts to use regional or local energy policy as a method of marketing the region to the rest of the U.S. and world. While this option is valid as a policy choice, it is an expensive policy choice. One example of this is Masdar in the United Arab Emirates, billed as the world's first sustainable city, it is currently being built at an expected cost of $18.7B and will house 40,000 residents.

Exceptions that Prove the Rule

While the long term policy goals usually retain this ordering, there are a couple of obvious exceptions to the ordering presented to the left. Instances where costs trumps surety, or where jobs trumps costs.

1. While there would be less power outages during storms and hurricanes if electric transmission lines were all buried, the additional expense this would add to energy bills prevents this from becoming policy.

2. In a small economy, increasing the number of energy jobs theoretically could grow the economy larger than the diffuse impacts of higher energy costs for consumers and businesses.

X. POLICY RECOMMENDATIONS AND CONCLUSION

ROLE OF LOCALITIES IN ENERGY POLICY (see Appendix 2 for three examples of regional policies)

The multiple roles of the local governments (as decision-makers, planning authorities, managers of municipal infrastructure, and role models for citizens and businesses) are crucial to the global transition towards renewable energy that is now underway. It is their political mandate that makes local governments ideal drivers of change–- to govern and guide their communities, provide services, and manage municipal assets. Potential roles for local government are as follows:

1**. Target setting**. The local government establishes a target (goal) for some future level of renewable energy. The target can be for government-only consumption, or apply to all or some classes of energy consumers within the local government's jurisdiction. This is a voluntary activity that is often the starting point for adopting policies and actions. There are many different types of targets that cities can adopt. Many targets are for future emissions reductions of CO_2, to be met by a combination of energy conservation, energy efficiency, changes in energy demand patterns (such as transport modal shifts), and investment in or purchase of renewable energy.[1]

2**. Regulation based on legal responsibilities and jurisdiction**. These policies and activities are regulatory in nature, based upon the legal responsibilities and jurisdiction of the local government that are provided by charters or similar articles of incorporation, and by national and state laws. Primary examples are urban planning, building codes, and local taxes.[2]

3. **Operation of municipal infrastructure**. These policies and activities modify the ongoing operation of municipal infrastructure to incorporate renewable energy, for example, government energy purchases or infrastructure investment, or policies or activities by public utility companies (particularly electric utilities) that can be controlled or regulated by the local government.[3] This category also includes renewable energy policies by private local utilities that may be enacted independently of government control.

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[1] Most commonly, the proportion of the CO_2 reduction to be met by renewables is unspecified, so CO_2 reduction targets are considered "partial" targets for renewable energy. In most cases, CO_2 reduction targets alone, without a corresponding explicit renewable energy target, imply a larger proportion of reductions from energy savings and efficiency than from renewable energy.

[2] Virginia Code 58.1-3221.2 Allows building to be established as its own class of real estate, and thus be assessed at a different level of taxation. The cities of Charlottesville, Spotsyvania, and Virginia Beach are the only cities to utilize this option. Another option for localities is to ignore solar panels for the purposes of personal property taxes.

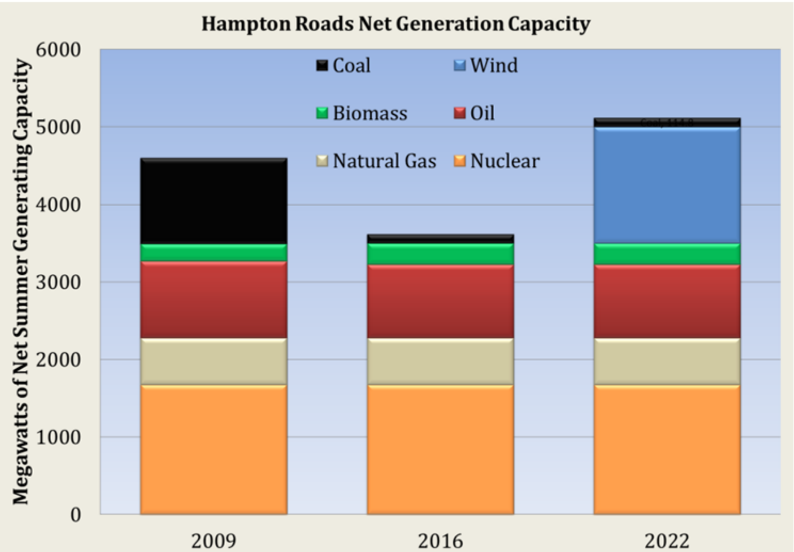
[3] Public utility policies depend upon to what degree utility infrastructure is under local control or jurisdiction

4. **Voluntary actions and government serving as role model.** These policies and activities go beyond legal responsibilities and jurisdiction to take advantage of the various possible roles of a local government as market facilitator, promoter, and role model. Many of these policies and activities may also contribute to raising general awareness. Additionally, a working paper from Harvard Business School indicates that municipal governments' green building procurement policies accelerate the use of green practices within both the city itself and in surrounding jurisdictions.[4]

5. **Information, promotion and raising awareness**. These policies and activities target the general public, specific stakeholders or groups, and/or private businesses, with the aim of facilitating or enabling support for renewable energy. Activities may also include informational and media campaigns, support for education and training programs, analysis of renewable energy potentials, building-specific audits, and geographic information system (GIS) databases.

ENERGY SURETY

Probably the most important aspect of an energy system is that it is reliable, and that individuals within the region have access to energy when they require it. This particularly relates to heating for the winter cold and electricity for summer heat (which is why net summer capacity from May 1 through October 31 is how an electrical system is measured). Another aspect of energy surety relates to the speed in returning capacity after a natural disaster, particularly hurricanes in this region. Almost all policy documents from California (which has experienced extensive brownouts in its history) and Europe (which routinely sees its natural gas supplies threatened by politics) focus on the reliability of the energy system.

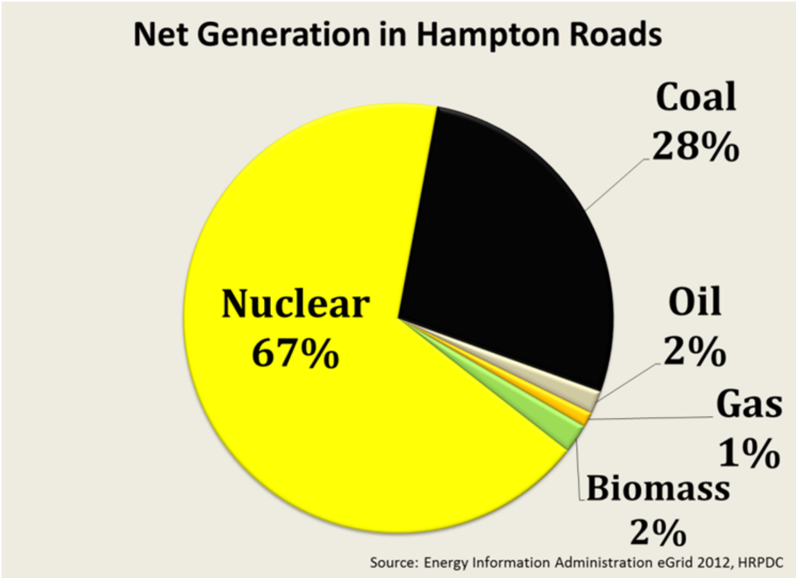


Source: Energy Information Administration eGrid 2012, Dominion Resources, HRPDC

There are two aspects to energy surety that need to be discussed, and one is adequate generation for the region's energy demands, both in absolute demand levels and for the timing of supply. The second

[4] Simcoe, Timothy, and Toffel, Michael W. (2012) "Public Procurment and the Pricate Sup[ply of Green Buildings." Accessed September 22, 2012 <http://hbswk.hbs.edu/item/7099.html>

revolves around adequate transmission and connectivity to prevent disruptions due to weather and meet the changing nature of supply.



Hampton Roads Generation Capacity

Hampton Roads currently has significant generating capacity, the most significant element being the Surry Nuclear Power Station. The Surry Power Station has 1,676 Megawatts net capacity, which is higher than all four of the coal plants in the region combined (1,103 megawatts). When net generation is examined rather than capacity, nuclear provided twice the electricity of coal, oil, gas, and biomass generation in the region combined. Over the next three years, all of the coal plants owned by Dominion Resources are planned to cease operating in the region (the Southampton Plant will switch from coal to biomass generation). This decision was made because of the high cost of retrofitting the plants to comply with new environmental regulations, and the decreased competitiveness of coal plants due to natural gas prices.

While nuclear represents only 36.5% of the generation capacity in the region, it generated 67% of the power and operates at a capacity factor of 87.6%. Natural gas and oil while combining for 1,593 megawatts of generation capacity are only used to meet peak demand, generating only 3% of the total power produced in Hampton Roads.

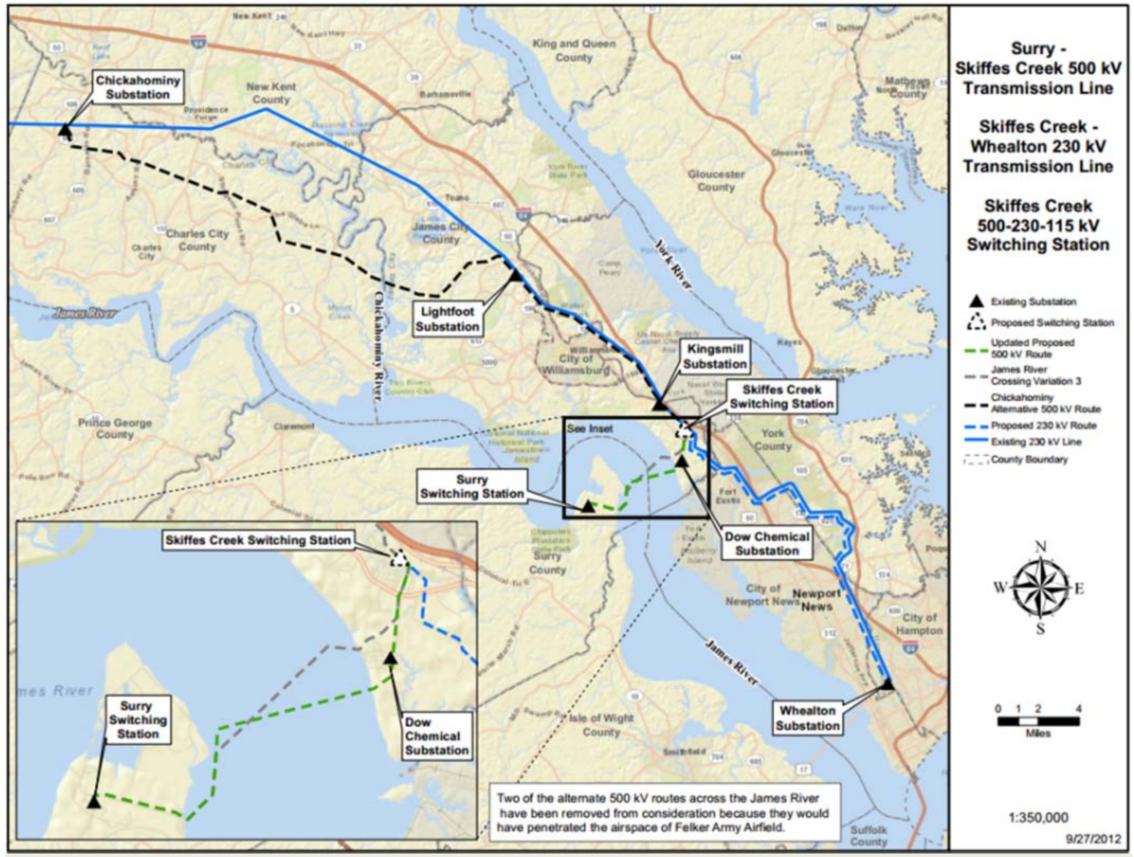
Hampton Roads Electricity Consumption

This region consumes approximately 23.1 million megawatt-hours annually (2011), while it produced 19.3 million megawatt-hours in 2009, and no new capacity has been added over the past three years.

Virginia's per capita electricity consumption in 2011 equaled 13.78 megawatt-hours, so the Hampton Roads region consumed approximately 23.1 million megawatt-hours. The region produced 19.3 million megawatt-hours, and thus had to import 3.8 million megawatt-hours of electricity. With the retirement of coal plants producing 5.1 megawatt-hours of electricity, the region will be importing 62% of its electricity and all of its primary energy supplies by 2016. This will decline if a projected 1,500 megawatts of wind power are installed (shown in blue on the previous page), but the capacity factor of that wind installation has been estimated at 40%, meaning that the installation would produce approximately 7.9 million megawatt hours. Nuclear would constitute the majority of electricity production in this region until the plants are retired (currently Surry Unit #1 has a license to operate through 2032 & Unit 2 through 2033).

Hampton Roads Electric Transmission (and energy transmission)

As both the Commonwealth and Hampton Roads are regional importers of electricity, the construction and maintenance of the transmission network is of utmost importance, both for current power supplies as well as any potential build out of power generation in the future. The North American Electric Reliability Corporation (NERC) enforces mandatory standards for reliability of the transmission network, and can fine offending organizations up to $1 million per day if they are out of compliance. The Energy Information Administration (EIA) also reviews emergency incidents and supply disruptions through the collection of mandatory supply disruption reports.[5] It is due to the standards of both NERC and the EIA that Dominion currently has planned an expansion of its transmission lines in Hampton Roads, through the Surry-Skiffes Creek project and other planned transmission upgrades. The Surry-Skiffes project, which has



Source: Dominion Resources

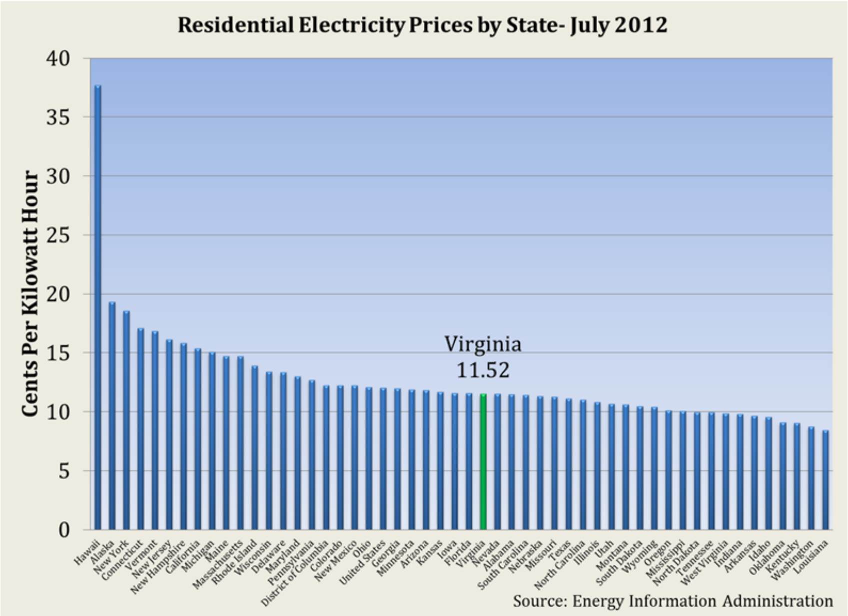
[5] Form OE-415

created controversy partly because it will cross the James River, is necessary to connect the power plants in Surry to the Peninsula to provide power after the Yorktown Coal units close. There are alternatives to the current plans, including burying the lines underground under the James River or routing them over the Chickahominy, but both of these alternatives will add substantially to the costs of the transmissions project. Dominion resources indicates that Virginia state law would require that all localities affected by the burying of the line would have to agree to an additional tax in the jurisdiction to fund the undergrounding of a transmission line, which will occur as a separate line item on their electric bill.[6]

Since the Yorktown Refinery shut down, there are no refined products produced in this region, but as long as the major oil and natural gas pipelines continue to operate, there remains little risk of either a spike in price or a lack of access due to distribution constraints.

ENERGY PRICES

Competitive energy costs are a major factor that can impact the economic growth of a region. Virginia energy prices are at the national average, with the 27th highest energy costs for residential electricity and 29th highest for average retail price. State energy prices are competitive with other South Atlantic states, with higher electricity prices as you move further north.



Electricity prices have grown in the region over the past decade, in a manner consistent with the rest of the United States. One factor that drives Virginia and Hampton Roads to have energy prices close to the national average is that the state imports roughly 20% of its electrical energy, and thus pays regional wholesale prices for the electricity (it should be noted that a significant amount of that electricity is power Dominion sells to itself from generation facilities outside of this state).[7] Energy usage in Virginia is slightly above average (13.8

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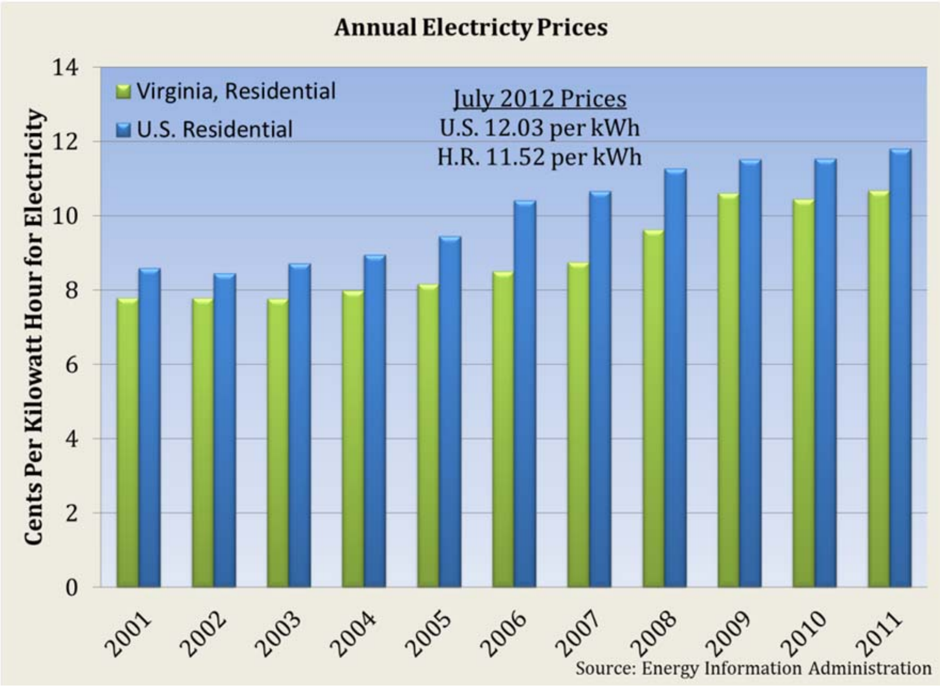
[6] Code of Virginia 15.2-2404 Section F

[7] The wholesale prices are determined by the weighted average of electricity sales between companies at selected energy hubs at peak times, but electricity sales between two entities of a parent company (common for Dominion) are considered non-qualifying for the purposes of calculating this price.

megawatt-hours per person using the EIA's sales revenue database), and thus the average cost of electricity per person in this state is $1,223 per year, 27th out of the states and above the U.S. average.

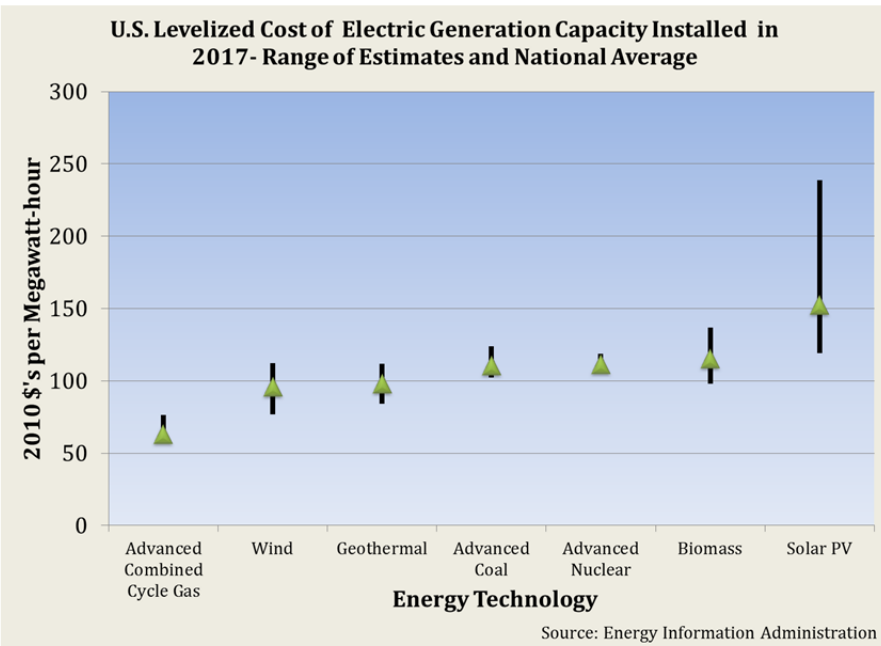


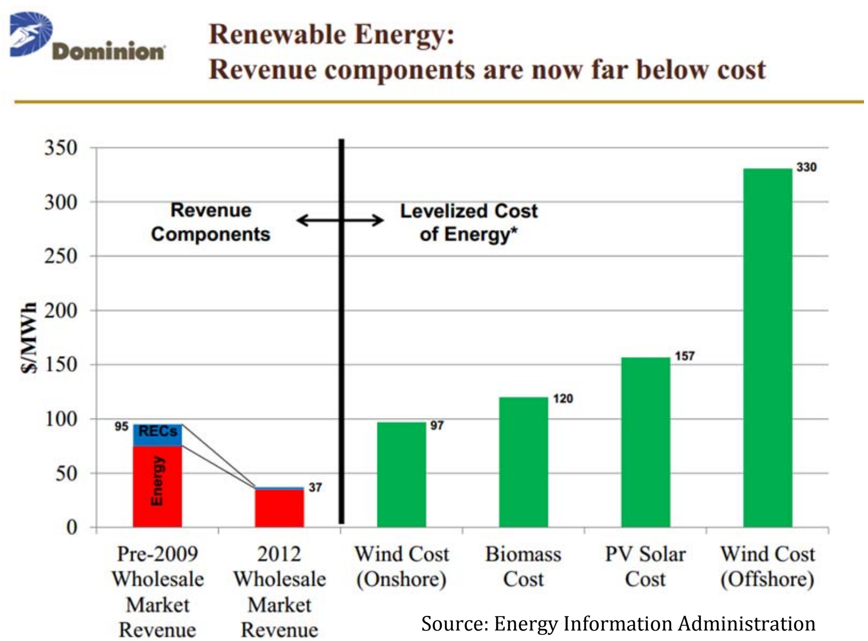
Electricity prices do not include heating oil or natural gas costs, which form a far larger portion of the energy expenditures in states that have severe winters.

An important consideration in the energy policy is the cost of developing new energy resources for Hampton Roads and for the Commonwealth. Older plants that have long ago had their capital amortized typically are far cheaper to operate than building new generating capacity; however, new energy resources will be necessary as complying with environmental regulation, safety requirements, and increasing maintenance costs encourages the retirement of older power plants. Most energy companies and the EIA expect that energy consumption will increase over the next 10 to 20 years in the U.S. (though some environmental groups believe that conservation efforts would mitigate that increasing demand). As part of its integrated resource plan Dominion Resources has estimated the growth in electricity consumption in its service area through 2027. Dominion expects a 30% increase in total energy sales, and a 28% increase in peak summer capacity demand.

The power plants that will be built to replace the retired capacity and to meet new generation demand will have a significant impact on future prices in the region, and thus the cost of the various electricity production plants is very important when considering the region's energy mix. The levelized cost of energy is defined as the constant price per unit of energy that causes the investment to just break-even or earn a present discounted value equal to zero. It is an economic assessment of the cost of the energy-generating system including all the costs over its lifetime (initial investment, operations and maintenance, cost of fuel, cost of capital) and is useful in calculating the costs of generation from different sources. The EIA produces levelized cost estimates at the national and sub-regional level for each of the energy technologies that are technically feasible. As can be seen on the figures below, almost all current technologies are more expensive then the most recent wholesale price of energy. This has been especially true for renewable technologies except for onshore wind. Additionally, current cost estimates by the EIA predict that offshore wind will cost twice as much as utility grade solar PV, and almost 3 times as much as technologies ranging from wind to advanced nuclear.

These forecasts are extremely variable, as technology and policy changes can have a large impact on these estimates. These estimates are very sensitive to assumptions about the overnight cost of capital and future fuel expenses.[8] EIA estimates that the cost of Solar PV plants has declined significantly, declining from $210.70 per megawatt-hour (Annual Energy Outlook 2011) to $152.70 per megawatt-hour (Annual Energy Outlook 2012), a drop of 27.5%. While many experts are predicting a continued decline in the cost of PV panels, it is impossible to estimate what will happen as solar manufactures consolidate.





[8] Renewable technologies have no fuel costs, and thus relatively modest increases in the cost of fuel make them more cost competitive. These estimates also include a $15/ton tax on carbon, which drives up the cost of coal relative to the current expense in building a plant.

X. POLICY RECOMMENDATIONS AND CONCLUSION

ENERGY JOBS

While creating jobs may be considered the least important of the three goals of energy policy (as it relates to economics), it generates a great deal of discussion. Asked about the current high cost of offshore wind development, the President of the Offshore Wind Development Coalition justified the high cost by touting the estimated 77,000 job years of direct employment from full implementation of offshore wind (7,000 megawatts).[9] Navigant Consulting currently estimates that the total capital cost for offshore wind is $3 billion for a 500 megawatt plant, which would average out to an approximately $545,000 investment per job year.[10] This does not preclude the viability of the project, but it is a very expensive way to fund jobs if the energy costs do not make the project viable.

The 2011 annual data from the Quarterly Census of Employment and Wages indicates that there are 8,998 payroll jobs in electric power generation and supply in this state, a further 1,359 employed in natural gas distribution in Virginia (coal and natural gas extraction and pipeline transmission are not included in this total). Unfortunately, because of the large roles that a relatively few companies play in the provision of these services in Hampton Roads, the local employment data is undisclosed.

There are many jobs related to energy in this region that do not fall under employment within the utility industry. These include scientist developing cutting edge energy technologies and refining current

Job growth in some renewable fuel industries

RENEWABLE ENERGY SEGMENT	JOBS 2010	ABSOLUTE CHANGE IN JOBS FROM 2003-2010	ANNUAL AVERAGE % CHANGE IN JOBS
HYDROPOWER	55,467	– 16,158	– 3.6 %
WIND	24,294	+ 15,110	+ 14.9
SOLAR PHOTOVOLTAIC	24,152	+ 12,286	+ 10.7
FUELS/BIOMASS	20,680	+ 9,296	+ 8.9
SOLAR THERMAL	5,379	+ 3,732	+ 18.4
WASTE-TO-ENERGY	3,320	+ 754	+ 3.7
GEOTHERMAL	2,720	+ 998	+ 6.7

Source: The Brookings Institution

The Brookings Institution: http://www.brookings.edu/research/reports/2011/07/13-clean-economy

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9 Offshore Wind and Atlantic Connection- HIS Global Insight Study Findings. http://www.atlanticwindconnection.com/ferc/Oct2012/Handout_IHS_Study_Mid_Atlantic_Findings.pdf

10 Using the 4.8 Billion per 1000 megawatt-hour estimate that South Carolina used, it would be $436,363 per job year

energy technologies, at universities in Hampton Roads as well as at Jefferson Lab and NASA Langley Research Center. Perhaps one of the strongest areas of opportunities for job growth in Hampton Roads related to energy comes from a combination of green energy installations and green energy efficiency. The Solar Energy Foundation estimated that 57.2% of all U.S. solar employment was directly related to installation, while only 13.8% was related to solar manufacture. Energy efficiency projects have received increasing attention in recent years as a result of the Energy Efficiency and Conservation Block Grant Program (which was funded with 3.2 billion dollars through the American Recovery and Reinvestment Act).

Jefferson Lab

As a world-leading nuclear physics research facility, Jefferson Lab is engaged in many exciting science programs and has developed areas of expertise that support its primary mission to explore the nucleus of the atom. These programs and areas of expertise include experimental nuclear physics, computational and theoretical nuclear physics.

Energy efficiency improvements and distributed power installations are labor intensive activities, and thus investments in these areas have a greater energy jobs impact than manufacturing or utility scale development (this also explains why distributed generation has higher installation costs then utility scale generation).

POLICY RECOMENDATIONS

National energy policy continues to change at a remarkable rate, both because of technology changes and because of the difficulty in establishing policy at the national level. Without firm guidance on the future of wind tax credits, energy efficiency grants, and EPA regulations, making large-fixed investments in energy policy at the local and regional level would be extremely premature. The role of policy at this level is to improve education, clarity, and stability of both the economics and regulation of energy in the region, in a way that promotes high energy surety, low energy prices, and the potential for energy job growth.

Avoid the temptation to pick winners- Energy outcomes are highly uncertain because of technology advances, national policies, and international politics. There are many exciting energy opportunities in which to invest a region's time and money, but the direction of energy production is unclear, and most predicitions even at the national level have been highly inaccurate (natural gas prices, solar panel prices, and raw coal prices are three that deviated from EIA forecasts to a great extent in the past two years).

X. POLICY RECOMMENDATIONS AND CONCLUSION

Energy Efficiency is the most cost effective way to meet energy needs- While many of the fossil fuel technologies available are more cost effective than renewable energy production when estimating levelized cost, both cost more than current wholesale market revenue from electriityc production. This ensures that as new production comes online wholesale costs will continue to increase.

Energy efficiency spending has a far greater job creation profile than new generating capacity, simply because energy efficiency projects are far more labor intensive than building power plants. Also, because many of the tools and materials used for energy efficiency projects are purchased through local supply chains, efficiency projects have a far greater indirect impact on the local supply chain. The financing for these projects can also be sourced locally which allows the money saved on electricity costs to either fund local investment (through banks) or local consumption spending.

While it places a burden on new home purchases and office construction, the long-term benefits of increased energy efficiency suggests updating the regional construction standards and local building codes to put renewed emphasis on energy efficiency. This also indicates that any local energy incentive program or grants should target energy efficiency rather than distributed generation, until energy costs increase sufficiently to make distributed energy generation cost effective.

Maintain simple permitting processes for distributed energy technologies- Most localities require only an electrical permit (typically ~$60) before installing solar or wind generation. Some localities in Virginia require architectural plans that are approved by the city engineer, which increases paperwork costs in excess of $600. Hampton Roads should continue to keep permitting for these projects as simple as possible, and resist efforts that might prevent homeowners from making this investment. Germany has one two page form for the entire country that is filled out online for solar installation projects.

Recognize that some questions are policy questions and not economic or energy questions- Questions about transmission lines, new coal plants (pending litigation against the EPA), and offshore wind/oil development deal with energy and economics, but they are also policy questions. Energy choices embody tradeoffs between the environment, community aesthetics, economic prosperity, and quality of life that do not fit easily into a simple economic analysis. While the economics staff can review the economics of projects that have concrete specifications, an economic analysis alone cannot justify a project or disqualify a project.

X. POLICY RECOMMENDATIONS AND CONCLUSION

Support the Hampton Roads Energy Corridor- This is a regional effort of federal facilities that are working together to meet a 28% carbon reduction goal by 2020 and enhance energy surety and security. This is a very ambitious project, and they are working to consider all technologies, as well as greater energy efficiency efforts for their building. They continue to learn more about what is feasible in this region with regards to energy technologies. There are two important lessons that have already resulted from these efforts-

- ***That energy efforts that combine to meet the needs of multiple installations (or localities) are far more cost effective and garner greater interest than those that only serve one installation***
- ***That there is no silver bullet regarding the energy question, rather there are many of smaller silver pellets.***

One key way that the region can support the Energy Corridor comes from being an advocate with the State for a multi-tier electric rate structure, similar to one that is offered on a limited basis to consumers. This rate structure would allow for an higher rates for businesses and installations that want to ensure either low-carbon electricity or increased energy surety/security without passing on higher costs to all consumers. This would allow federal facilities to meet their required goals, while potentially acting as a feed-in-tariff for greater energy surety and sustainability.

A1. APPENDIX

A1. History of Energy

In the beginning, all energy was chemical and renewable; the only way that man was able to use that energy was through digestion powering their own muscles. All pre-history human activity revolved around obtaining sufficient food to maintain life (calories measure the energy content of food). Eventually, the hunting and gathering cultures developed into farming cultures with domesticated animals (a more efficient power plant for turning food energy and muscle energy). They also discovered fire, which was a way to turn non-food plants into heat, for both control over the environment and for cooking. This marks the first time that there are different sources of energy for different tasks.

WIND AND WATER POWER

While wind power was used for trade and transportation even before recorded history, wind and water power first began to be used for mechanical power in the 1st century A.D. The technology did not achieve widespread adoption at this time, probably because of the prevalence of slaves during the Roman Empire which provided labor for many of those industrial tasks. Medieval Europe around the end of the first millennium saw the first widespread adoption of wind and water energy.

Wind power captures the modern imagination, especially in Hampton Roads, but water wheels were far more popular in Medieval Europe as a result of their simpler technology and their greater reliability. While certain seasonal and weather related events could stop water's flow at the site of a mill (drought, freezing, and floods), these changes were both less common and far more predicable than shifts in the winds intensity. Craftsman of the time had several methods of controlling the power of a water wheel, using canals, dams, and sluice gates for that purpose. During this time, sites of water wheels became the sites of medieval towns; however, many regions, such as the Netherlands, lacked the swift moving water (the natural resource which enables water wheels) for water power, and it was these areas that exploited wind power. Wind technology advanced incredible through the middle ages.

Water power continued to dominate from 1000 AD to the age of steam and coal. Industrial activity began to cluster around areas with water, and this culminated with large water industrial complexes, including the Arkwright's Cotton Mill (also called Mason's Mill) in Derbyshire, England. Despite attempts by England to prevent the technology from spreading, the technology crossed the Atlantic within a decade of the opening of the mill in Derbyshire, and lead within two decades to the rise of the

New England industrial towns such as Lowell, Massachusetts. The demand for energy would not leave water mills kind for much longer however.

COAL POWER

Coal was mentioned by Greek writers in the 4th and 3rd centuries A.D., and was extensively exploited by the Romans in Britain by the 2nd Century A.D., for use both by artisans (smelters and metal workers) and for heating barracks. While presumably exploited by Britain throughout the first millennium as a result of its large and easily accessible resources, it received major attention in 1306; a royal proclamation was made that year banning London Artisans from using coal (and encouraging the use of wood/charcoal) because of the noxious smoke it produced. [1]

Despite this issue, coal continued to be used for 'manufactured' goods in England and on the content where it was increasingly exported. It also began to be used more intensively for household heating as furnace and chimney technology improved. First, it was used solely around the mines, but eventually it was used further afield for heating.

As demand for coal increased[2], more intensive coal mining techniques were deployed. As miners moved away from drift and open pit mining techniques, water seepage into the tunnels through soft rock became a significant issue. Several mines began to attach chain pumps to water wheels to remove the water, but where water resources were far from the mine, the pumps had to be powered by human or animal muscles which were expensive. Thus the development of the steam engine was driven by the desire to obtain energy.

It took a century to develop the steam engine, and while the first practical steam engine was built by Thomas Savery in 1698, it was not commercial successful. The steam engine continued to be developed by Thomas Newcomen in the first half of the 18th century, and James Watt in the middle of the century, but it was not until 1800 that steam engines began powering textile mills beside water wheels. Before that time, steam engines were used only for pumping out mines where the source of to power them was plentiful and relatively cheap.

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[1] This was the first of several ordinances, and the penalties have to be increased significantly because artisans were unwilling to stop using coal.

[2] There has been several authors that have suggested the demand for coal in England increased because of the increase in energy demand due to a growing population and the gradual decline in forests in Great Brittain (Freese 2003)

A1. APPENDIX

During the course of the 19th century, entrepreneurs and businessmen began to value the geographic mobility which steam power had, and flexibility encouraged its adoption even as it was still technologically inferior to water power in many ways. Though in America steam engines in the early 1800 were first powered by wood, they quickly gave way to coal as resources east of the Appalachia mountains were discovered (primarily in Western Pennsylvania).

Coal and the steam engine led to the dawning of the industrial age, which greatly increased the wealth of Western societies that adopted it. Many of the same technological innovation that allowed water power to be used for industrial tasks were applied to steam engines, powering textile mills and foundries. Throughout this time the quality of steam engines steadily improved, and was only in 1840 that the production of steam driven mills was competitive to that of water mills, wut the portability of steam power drove its economic efficiency.

Another major step in this process was the development of steam powered transport, including steam driven boats in 1804 and the first successful steam locomotives in 1812. These drove the demand for coal, and allowed for the greater spread of coal through faster transport. It is also hard to underestimate the impact of high speed transportation on the geographic growth of America and the expansion of trade.

ELECTRICITY

In 1881 both Thomas Edison and Werner von Siemens connected steam power to dynamos which ushered in the age of electricity. While coal continued to be the dominate source of both electricity and energy in the United States through the 1950's, this was a fundamental change in the way that energy was used. Instead of using primary energy in the form of natural gas, electric lights were used. The first electric street railway was constructed in Richmond, Virginia in 1887. This also allowed for other power sources to begin to be used, including Niagara Falls hydropower, not to directly power a mill, but to power electricity throughout the state. California has its own experience, with long distance transmission lines connecting coastal cities to power sites in the Sierra Nevada Mountains.

As electricity became the preferred method of consuming energy, other methods of producing power became popular. As noted, hydroelectric was initially extremely popular, but suitable sites for water power generation were soon all being used. As engineers improved steam turbines efficiency allowing a greater amount of energy to be produced using a smaller amount of fuel, making the economics of coal and eventually oil power generation facilities practical. Oil was especially important for power generation on the west coast because of their distance from Eastern Coal resources.[3]

As efficiencies in electricity production plateaued in 1960s, and the most readily available coal and oil resources were already being exploited, the price of electricity began to climb. There was also a desire to develop energy which would not have the pollution impacts of oil and coal, and thus there was a move to turn the science of the Manhattan project into energy. In 1958 the first commercial nuclear power plant opened in Shippingport, but nuclear continued to grow quickly through the 60's and early 70's. Unfortunately, growing concern over the waste from nuclear plants as well as the safety of nuclear plants. While the initial hope was for energy that would be too cheap to meter, at the end of that construction period only 132 nuclear plants were built out of the 253 initially ordered. The United States currently producers more nuclear power than any other country on the planet, while France, and until recently Japan, received a larger share of their total power generation from nuclear.

There has been a long term push to move into renewable sources of energy for future electricity and heating needs. This include hydroelectricity which the U.S. has already developed to a significant extant. Other technologies for energy production include geothermal, wind power, and solar power (both photo voltaic and concentrated solar). While each technology has its supporters, currently renewable energy only constitutes 10.1% of total domestically produced energy, with just over 60% of that derived from hydroelectric power. Investment and the total power capacity of renewables in the United States has grown rapidly over the past decade.

[3] While the Powder River Basin in Wyoming in Montana provides approximately 40% of the U.S. coal needs, the first mine did not open in that region unitl the 1920s, and large-scale open cut mining did not begin until the 1970s.

A2. Examples of Energy Policy

Examples of Local Level Policies from
Renewable 21 Global Status Report on Local Renewable Energy Policies

Boston MA, USA (population 610,000). In 2007, Boston committed to reduce greenhouse gas emissions 7% by 2012 and 80% by 2050 (base 1990). Also in 2007, an executive order required the city to purchase 11% of its own-use electricity from renewables by 2007 and 15% by 2012, also required all new municipal motor vehicle purchases to be alternative fuel vehicles, and committed to reduce the city s own-use transportation fuel use by 5% by 2012. The city also targets 25 MW of solar PV by 2015, and has adopted a number of regulatory measures, including zoning regulations for utility-scale and small-scale wind power projects, and requirements that new housing under its Green Affordable Housing Program be "solar ready." The city also maintains an online GIS tracking system that features every renewable energy installation in the city, and allows building owners to calculate the available solar irradiance on their rooftop, taking shading into account. From 2007 to mid-2009, renewable energy capacity in Boston grew from 500kW to almost 2MW.

Madison WI, USA (population 220,000). Madison launched the Mpowering Madison Campaign in 2008 to reduce city-wide CO2 emissions by 100,000 tons by 2011. The city has undertaken a number of activities toward that goal, such as renewable energy installations on municipal infrastructure, including solar hot water systems on all fire stations and solar PV systems on community facilities. The MadiSUN Solar Energy Program, supported by the U.S. Solar American Cities Program, offers free consultations for installations of solar PV and solar hot water by residences and businesses, and intends to double the number of such systems city-wide by 2011. The electric utility serving Madison, Madison Gas and Electric, has a number of cooperative initiatives with the city, including joint operation of a wind farm, green power purchasing, and solar PV production credits. Madison aims to purchase about 20% of its municipal own-use power from renewables by 2010, including green power purchases of wind, biomass, and hydro from the utility.

Portland OR, USA (population 580,000). Portland has an extensive history of land-use and transportation planning dating back 30 years. Portland first adopted a local energy policy in 1979, the first in the United States. Portland's first greenhouse gas reduction plan was adopted in 1993 (also a U.S. first), and then updated in 2001 with a goal of reducing greenhouse gas emissions to 10% below 1990 levels by 2010. In 2006, the city adopted the first local renewable fuels standard in the United States, which mandates 5% biodiesel and 10% ethanol blending with all diesel and gasoline sold within the city limits. The city purchases biofuels for municipal fleet vehicles and also established a $450,000 Biofuels

Investment Fund that supports various biofuels production and distribution projects, including projects to install or convert fueling equipment. The city also launched a five-year $2.5 million Green Investment Fund with private partners that is investing in renewable energy projects, and the city facilitates business partnerships for renewable energy investment and green power sales. The Bureau of Planning and Sustainability oversees these efforts

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