DRAFT REPORT

Renewable Energy Policy

Outlook for West Virginia

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Prepared for:

West Virginia Division of Energy

8/27/2012

MARSHALL UNIVERSITY
CENTER FOR BUSINESS AND ECONOMIC RESEARCH

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Outlook for West Virginia

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Acknowledgements:

This report was funded by the West Virginia Division of Energy.

Disclaimer:

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Renewable Energy Policy Outlook for West Virginia

Purpose of the Report

The purpose of this report is to outline the future role of renewable energy in West Virginia. This is accomplished by a set of reports which discuss each of the renewable sources: Wind, Solar, Biomass, Hydropower and Geothermal. Each section includes a discussion of the characteristics of the fuel, the positive and negative aspects of its deployment and its current use in West Virginia. A thorough discussion of how energy efficiency can become an even more important part of the West Virginia energy mix is also included in a separate report. Each section provides conclusions and policy recommendations which can be included in the *Five Year West Virginia State Energy Plan 2013-2018.*

The West Virginia "*Alternative and Renewable Energy Portfolio Standard*" provides that utilities must obtain 25 percent of the energy they generate from alternative and renewable sources. This report evaluates all of the possible fuels which can be employed to meet the requirement of the *Standard*. When the *Standard* was adopted there were two objectives: to promote "energy independence and to meet environmental concerns. Since its adoption the energy environment has changed which requires a rethinking of what the most effective and least costly ways to the State's consumers and the State budget for the fulfillment of the *Standard.*

Thirty other states have standards with the same objective. These states have adopted a variety of public policies to promote alternate and renewable fuel usage. Included are tax exemptions or reductions for property taxes, reimbursements to consumers for purchase of energy efficient appliances, incentives for fleet vehicles to use alternative fuels, production incentives to electricity generators who use renewable or alternate fuels either to install the needed infrastructure for utilization or the direct use the desired fuel. In addition states provide grants, loans and loan guarantees related to capital investment related to the development of renewable and alternate energy.

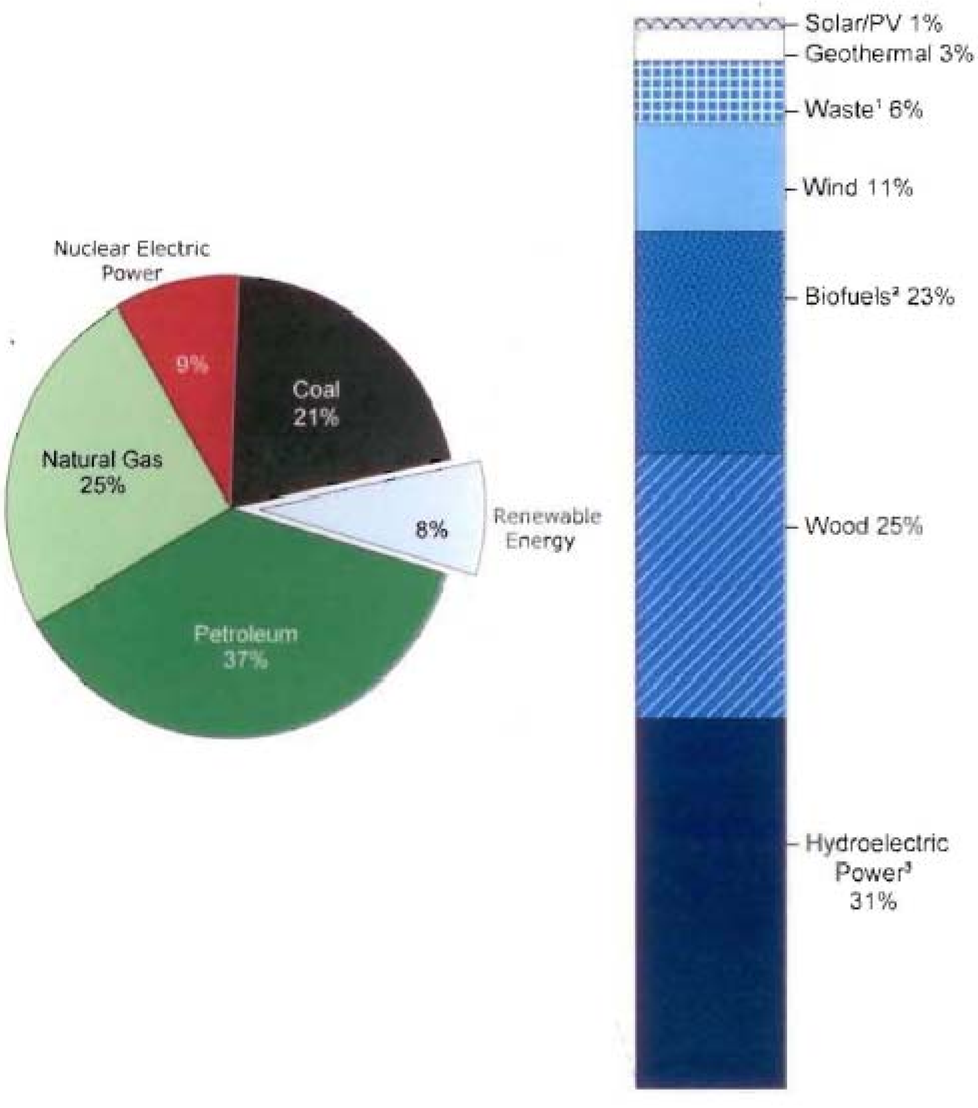
West Virginia has implemented some of these incentives as detailed in the report. These incentives have not been adopted with an overarching view as to how the objectives of the *Standard* are to be achieved. This report calls for careful consideration of the desirability and effectiveness of these incentives. West Virginia is unique in both its available energy resources and the demands placed on those resources. It is hoped that this report will provide the background for public policy decisions which recognize that uniqueness.

The report is the contribution of the Center for Business and Economic Research at Marshall University and is a companion to a report on fossil fuels, electricity and nuclear power prepared by the Bureau of Business and Economic Research at West Virginia University. Funding for the project has been provided by the West Virginia Division of Energy.

Overview of Renewable Energy

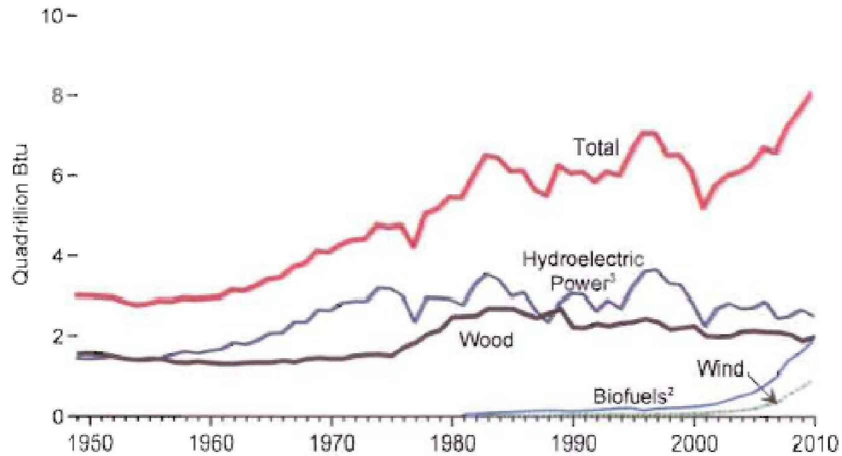
Renewable energy is the U.S. and world's fastest growing source of marketed energy. For 2010 (the last year for complete data) renewable energy accounted for 8 percent of total primary energy consumption as shown in Figure 1.

Figure 1: U.S. Renewable Energy as Share of Total Primary Energy Consumption, 2010



But this does not recognize the significant growth over the past few decades. As Figure 2 demonstrates the growth in renewable energy consumption has accelerated. In recent years this has been principally due to the growth in consumption of biofuels and wind.

Figure 2: Renewable Energy Total Consumption and Major Sources, 1949 to 2010



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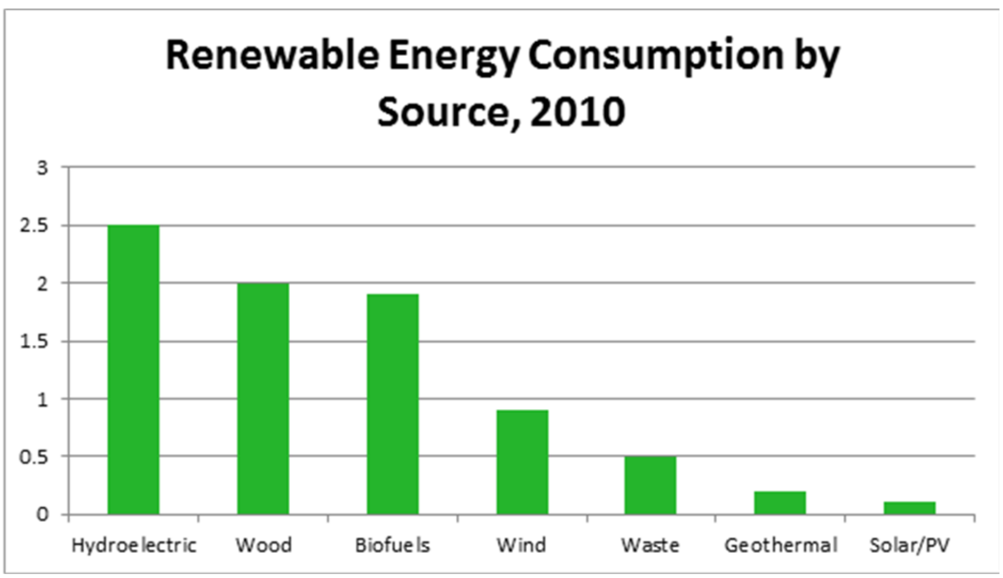
The actual amount of energy consumption from each renewable is is provided by Figure 3 which indicates the current dominance of hydroelectric power. If all sources of biomass are combined (wood, biofuels, waste) then biomass is the leading source of renewable energy consumption.

Figure 3: Renewable Energy Consumption by Source, 2010



Renewable Energy in West Virginia and the Region

In West Virginia consumption of renewable fuels totaled 41.3 TBtu in 2010. This was eight percent of total energy consumption in the state of 738.9 TBtu Of this amount 34.7 TBtu is coming from biofuels mostly ethanol use in transportation.

Overall Conclusions

Based on the research conducted in this report there are overall conclusions which apply to renewable energy as it is included in the *West Virginia State Energy Plan 2013-2018*

- None of alternative or renewable energy sources considered in this report is likely to provide fuel or electricity at a lower cost than currently is supplied by traditional sources. Environmental restrictions or fees at the federal level may alter this situation and increase the ability of alternate and renewable fuels to compete. Over the next five years the WV Department of Energy should remain conscious of any regulatory developments which would increase the competitiveness of these resources.
- The speed of transition away from current fuels can be increased only if the State is willing to subsidize these alternatives or to allow for rate increases to cover the increased costs. Neither option is recommended due to high costs and the uncertain level of fossil fuel displacement that variable resources such as wind and solar can provide.
- While not fully developed in this report there is a need for monitoring of potential transportation difficulties relating to all types of fuels and the electricity generated from them in the State. Particular emphasis should be placed on the ability of the transmission grid to accommodate any additional electricity which might be potentially come available in the next five years. While this does not currently appear to be an issue, monitoring by the Public Service Commission is appropriate.
- Environmental concerns regarding alternative and renewable fuels should be fully addressed over the next five years. Information from this investigation should be used to determine what legislative or regulatory action, if any, is desirable. This consideration should be completed prior to any policy changes.

Biomass

Conclusions

- There is little likelihood that ethanol production from corn will occur in the State due to the need for corn ethanol plants to be near significant sources of supply. Corn is not a major crop in terms of total production in West Virginia
- There is very limited potential for development of biodiesel as an industry in West Virginia. Biodiesel was manufactured only at the AC&S facility in Nitro West Virginal which could operate a three (3) million gallon a year batch plant. Production of soybeans in the State is insufficient to supply a major biodiesel facility. If the biodiesel industry were to develop most of the feedstock would have to be imported from out-of-state providing less economic impact than development using other fuels.
- Considering the extent of forestation in West Virginia, expanded study of the use of woody biomass as a fuel should be explored.
- There is a possibility that ethanol from switchgrass may have some limited potential in the State. But the need for a production facility in the state and the amount of alcohol fuel which can be produced locally will inhibit its development.
- *A donax* is another biofuel requiring advanced research before widespread use is likely. Considering the availability in West Virginia of reclaimed mine land and other marginal

soil in West Virginia, technological developments should be monitored. As is the case with all biofuels there will be a need to locate a refinery nearby if the potential is to be developed.

- While it does not appear that population densities in West Virginia are insufficient for WTE projects to be feasible, the success of facilities elsewhere is worthy of future investigation. The possibility of forming regional authorities around the State's population centers to construct these facilities is an option for consideration as this is the only way such facilities could become feasible.
- Energy from LFG merits only limited consideration. Currently there is one WTE landfill operating in the State and handful of others are considering such expansion. Contacts with operators of the other landfills indicate that most fills are not likely to pursue such development within the next five years.

Recommendations

- Efforts to promote corn ethanol or its increased blending into gasoline should be resisted as there are no economic benefits to the state. Considering the environmental objections to its use, the case for not encouraging expanded use of ethanol is further supported.
- The cost to the State of supporting biodiesel use in school districts should be studied before new incentives are provided or existing incentives continued. Currently no adequate data exists which would allow for this study to be completed. The Department of Education should collect the data in a useable format.
- The Department of Forestry should be tasked with undertaking a study of the economics of expanded use of wood and woody products as a fuel in electrical generation.
- Over the next five years the WVDOE should consider if the use of small scale electric generation facilities in the more remote locations of the state could be an incentive for the attraction of economic development into those areas. The State Department of Natural Resources should determine if the use of small scale power facilities would be beneficial to recreational and other areas which are not currently connected to the grid
- There is a need for further research on switchgrass and *A donax* potential considering the pilot projects on reclaimed mine sites already underway.
- Use of MSW for the production of electricity under WTE has shown some success elsewhere. It might be feasible in West Virginia if conducted on a regional basis in order to establish a sufficient and dependable volume of waste. An evaluation of this potential should be a joint project of the WV Department of Environmental Protection (WVDEP) and WVDOE.
- At this time there appears that LFG does not hold great potential for the state. But continued monitoring of developments in the area by the WVDOE is merited
- The WV Department of Agriculture (DOA) should stay up-to-date regarding decisions made by the EPA to restrict current uses of litter. In the event that restrictions put pressure on poultry farms, offering some sort of tax incentive to install energy systems that meet compliance may be considered. However, other less costly and purely agricultural litter systems that do not incorporate energy conversion may be better suited to the needs of the industry. The WV DOA should be the lead state organization to identify the future approach.

Solar

Conclusions

- Solar energy is a resource, but it is not as strong in WV as in other states. But WV's insolation is better than most states to the north. Due to grid integration issues, solar energy may not help conserve fossil resources, particularly coal resources, as much as hoped. Off-grid solar applications are likely the most efficient use of the resource.
- Distributed solar energy allows security of electricity supply, but to maintain round-the-clock security a facility must still be connected to the grid and able to consume power from grid whenever desired. If a consumer retains that ability some <u>firm</u> external supply must be immediately on-hand at night, and for cloudy days.
- Solar generation does not contribute as much economic value as other resources due to a lack of solar-related manufacturing in West Virginia and the very small level of resources needed for operation. If it is used on top of the existing generation mix it is a small adder, but the funds necessary to support it may be better spent elsewhere.
- Self-generation of electricity is a price hedge, although at an uncertain level, and is more effective with higher electricity rates. Thus, the near-term expansion of solar capacity in the State is not certain to yield savings on electricity expenditures. Funding solar systems through utility rate increases obscures the real price of avoided electricity purchases.
- Assigning the costs of solar energy to ratepayers reduces disposable income of all ratepayers, but especially those who do not invest in solar systems.
- The primary economic benefits of solar generation would come from the applicable state and local taxes: sales, property, and B&O. Ironically, because a primary way to make solar projects competitive is to exempt them from all or some of these common taxes, the main financial benefits are removed.
- Development of an SREC market in the state assigns the role of market maker to the State Legislature, a position that some would argue is inappropriate for a governing body.
- There are benefits to getting experience with an emerging technology such as PV systems. Individuals and households who install PV systems will come to understand the attributes of the technology and can participate in future adoption as technology improves. Local installers also develop valuable capacity regarding utilization of the resource.
- Solar panel efficiency is expected to increase but will improve more beyond the five-year timeframe evaluated for this report. In addition, beyond the five-year timeframe, grid integration solutions including demand response programs and smart-grid applications will be more widespread, allowing the potential benefits of solar to be more fully captured.

Recommendations

This evaluation concludes that there are few reasons to expand State-level incentives for grid-connected solar energy or to mandate production of solar-powered electricity given the current state of technology.

- **Maintain current policies.** The current State income tax credit, when combined with the Federal credit reduces the cost of investing in a residential solar system. This policy is likely to induce some interested WV residents to adopt solar PV technology. The tax credit is an ideal type of incentive to utilize because it is simple for tax payers to take advantage of and it is easy to administer. Adoption of incentive programs involving more complex administration, such as low-interest loan or grant programs, is not recommended.

  While there are unresolved grid efficiency issues related to integration of solar electricity the amount of new solar systems that this policy is likely to induce will be small relative to the total amount of electricity demanded in WV.

- **Monitor the results of research being conducted on the options to efficiently integrate wind and solar resources into the grid.** States with high levels of solar insolation, such as those in the southwest, will set examples for optimal integration. Once integration solutions have been identified and widely instituted, the State could consider adopting more aggressive incentives to deploy solar resource.

  Applicable State Organizations: Division of Energy, Public Service Commission

Wind

Conclusions

- Wind energy is a relatively small energy resource in West Virginia. The quantity of wind that is estimated to be available to be developed on private land is smaller than what has to date already been developed or is under consideration.
- Due to the relatively high cost of developing wind in the region, the installation of wind in West Virginia is driven by Federal incentives. The extension of the federal PTC for wind-powered electricity production will determine future development efforts.
- West Virginia's wind resources are good compared to other onshore resources in the Eastern United States but are not as strong as in the Midwest. This reduces the likelihood that State resources will be developed in the absence of the PTC.
- The primary economic benefits of developing wind energy are lease payments made to landowners and property taxes paid to county governments. The state has very few wind-related manufacturing component suppliers. A small, but growing employment base exists to supply turbine maintenance services.
- Siting of wind facilities is very difficult. The permit application process is lengthy and requires extensive documentation. The siting process is largely similar to that experienced by other power plant developers. However, wind facilities possess several unique attributes that make them quite different than conventional power plants. Nonetheless, any evaluation of the efficiency of the permitting process would have to take all types of power plants into consideration, not just wind facilities.
- There are unresolved efficiency issues related to grid integration of wind electricity that can be at least partly resolved by adopting a series of recommendations related to turbine control, real-time grid operations, reserve utilization protocols, demand response and

wind forecasting. However, such implementation will take time and may never be perfect solutions. In the meantime, the ability of wind energy to offset fossil emissions is less than its output due to the need to maintain oversupply of generation capability. More needs to be understood about this issue in terms of accomplishing policy objectives.

Recommendations

This evaluation concludes that current policies to encourage wind development in West Virginia are adequate, largely due to most development being caused by policies outside of the State.

- **Maintain current policies.** The two existing State tax incentives for wind have allowed this relatively new industry some cost savings for projects while also giving the State and local government income from the projects. They are a balanced acknowledgement of public and private interests.

- **Monitor the results of research being conducted on the options to efficiently integrate wind and solar resources into the grid.** During the next five years, the results of several research projects addressing this issue will be published that will provide more firm recommendations on how best to proceed. This issue also provides the State with an opportunity to become familiar with regional organizations that are shaping the future of the electrical grid.
  Applicable State Organizations: Division of Energy, Public Service Commission.

Hydropower

Conclusions

Small scale hydropower does not appear to have significant potential for the State. But there are instances in which small scale hydro may play a role. These would be primarily in direct use situations for providing power to a specific user such as a small factory, public building, recreational facility or isolated community.

Recommendations
- The State PSC should continue efforts with federal agencies and private companies to insure that the current preliminary licensed hydro projects are completed in a timely fashion.
- Work should be undertaken by the WVPSC to determine if there are other sites for development which have not been previously determined.
- Regarding small scale hydro power:
  - Determination should be made if there are public sites such as recreational areas which are not currently served by electrical connections for which development of mini and micro scale hydro is appropriate.
  - Current rules and regulations which effect small scale hydro should be reviewed to determine which, if any, were designed for large scale projects and could be eliminated or modified for application to small scale hydro.

- Similar incentives to those granted to direct use solar and wind facilities should be made available to mini and micro hydro installations.

Geothermal

Conclusions

- The generation potential of the geothermal resource in West Virginia is not as great as in other areas of the US, but that should not be construed to mean it would not have an impact. At nearly 31 GW of current estimated generation potential at 14 percent recovery, the State's geothermal resource could match a significant portion of electricity generation in West Virginia.

- Geothermal energy has been proven to provide consistent base load power through the constant loop of the input/output wells at generating facilities due to the fact that the temperature does not fluctuate. The reliability of geothermal systems in West Virginia would produce a secure supply of electricity from a renewable resource.

- Although a large amount of capital is required to establish a geothermal system, the local and state economy would likely benefit from the increase in job demand. Further study would be needed to analyze the potential benefit of developing this resource in this area.

Recommendations

- There is potential for EGS resources to contribute to the West Virginia alternative energy requirement and diversify the source of electricity generation in the State. However, successful development of geothermal resources in West Virginia will not produce immediate benefits. Due to continued improvement of geothermal development technology, establishing a new EGS power plant in this area would be costly at this time and is unlikely to be feasible in the short-term.

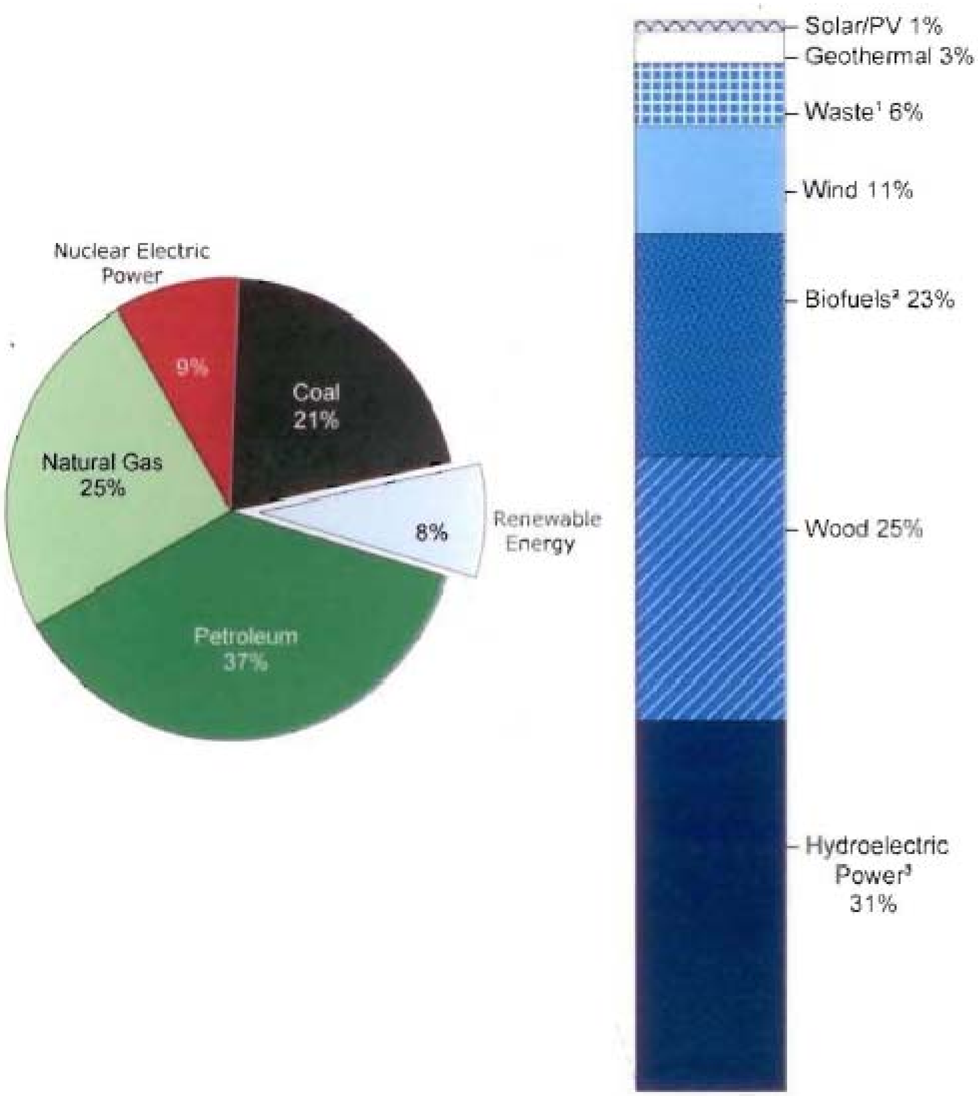
- It is recommended that assistance be provided through helping to identify potential development sites for building EGS test facilities**.** Although establishing a full-scale EGS power plant would currently be both time intensive and costly, setting up EGS test sites would be beneficial to discovering West Virginia's true geothermal potential as well as optimal resource locations. To promote test site development, the Division of Energy could provide assistance with identification of a location for a drilling demonstration if funding for such a project were made available.

- If the climate for EGS development and demonstration expands, the State of West Virginia could consider extending to geothermal facilities the property tax exemption granted to wind facilities. The expansion of EGS demonstration would depend on funding from the U.S. Department of Energy. If the US DOE were to develop a solicitation for a demonstration site in the eastern U.S., WV would be a candidate for such a project.

I. Overview of Renewable Energy

Renewable energy is the U.S. and world's fastest growing source of marketed energy.[1] For 2010 (the last year for complete data) renewable energy accounted for 8 percent of total primary U.S. energy consumption as shown in Figure 1.

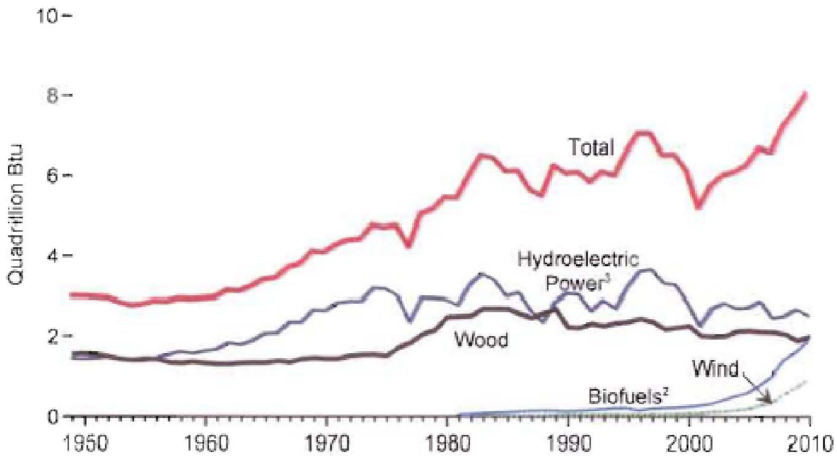
Figure 4: U.S. Renewable Energy as Share of Total Primary Energy Consumption, 2010



But this does not recognize the significant growth over the past few decades. As Figure 2 demonstrates the growth in renewable energy consumption has accelerated. In recent years this has been principally due to the growth in consumption of biofuels and wind[2].

[1] U.S. Energy Information Administration (June, 2012) *Annual Energy Outlook 2012*. P.75
[2] See Appendix A in Biofuels for complete data.

Figure 5: Renewable Energy Total Consumption and Major Sources, 1949 to 2010



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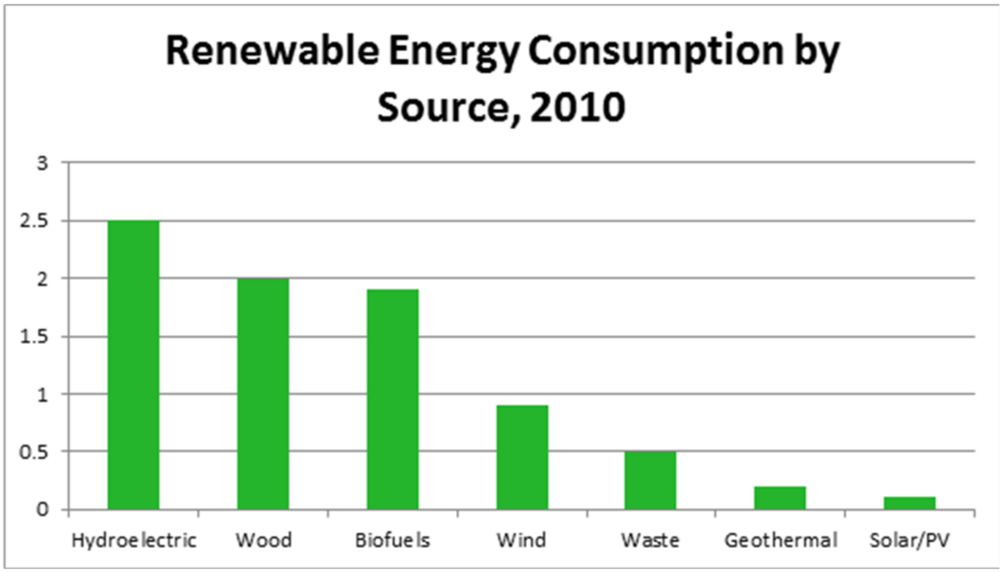
The actual amount of energy consumption from each renewable is is provided by Figure 3 which indicates the current dominance of hydroelectric power. If all sources of biomass are combined (wood, biofuels, waste) then biomass is the leading source of renewable energy consumption.

Figure 6: Renewable Energy Consumption by Source, 2010



EIA predicts that over the next 25 years the trend is to continue world wide with wind and biofuels being the primary contributors to overall renewable consumption.

Figure 7: World Renewable Electricity Generation by Source, forecasted to 2035

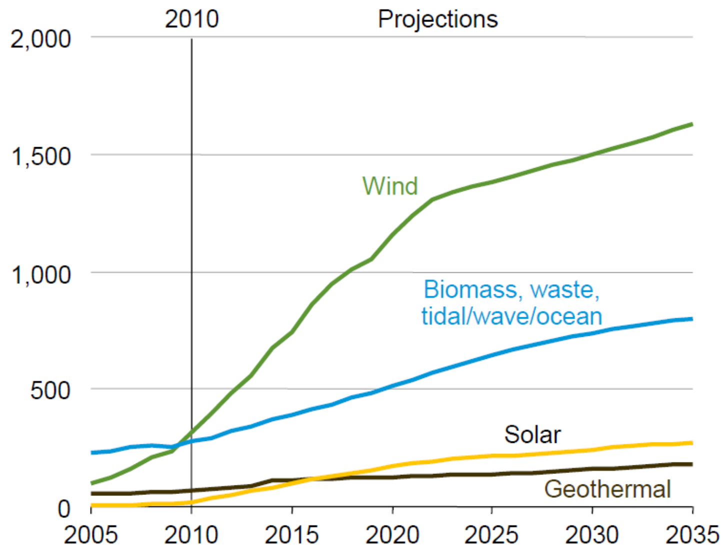
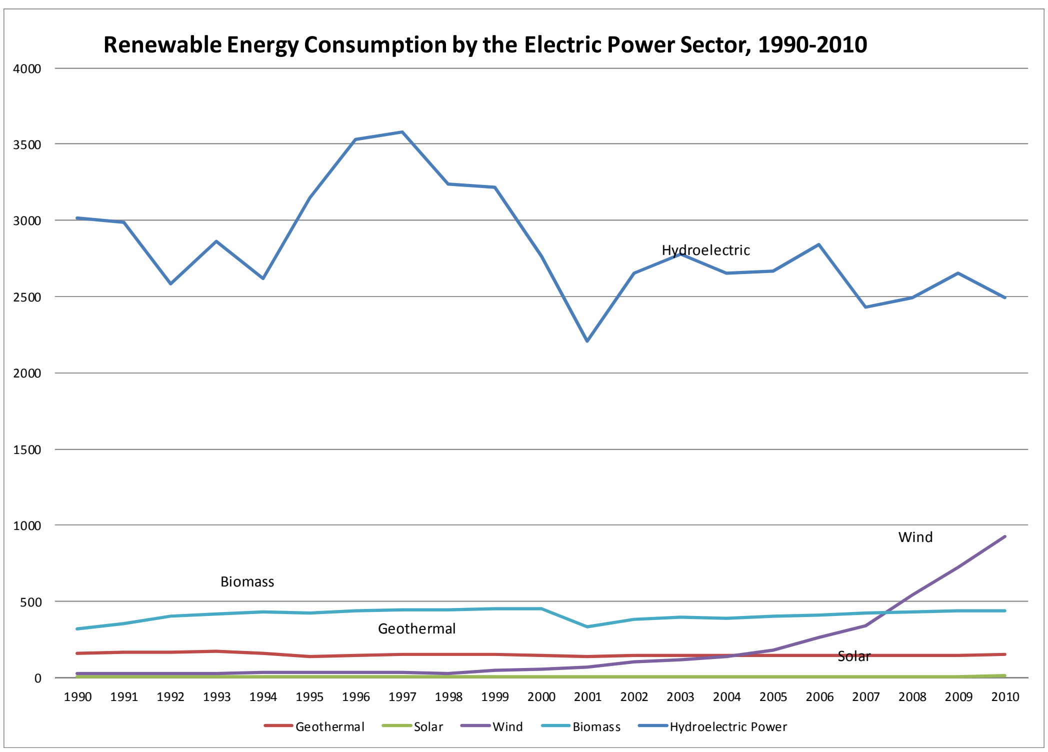


Figure 5 illustrates the composition of renewable energy consumed by the electric power sector for a period of 20 years. Hydroelectric power dominated during this time period, although the amount of wind generation increased sharply, particularly between 2004 and 2010.

Figure 8: Renewable Energy Consumption by the Electric Power Sector, 1990-2010



A. Renewable Energy in West Virginia and the Region

In West Virginia consumption of renewable fuels totaled 41.3 TBtu in 2010. This was eight percent of total energy consumption in the state of 738.9 TBtu.[3] Of this amount 34.7 TBtu is coming from biofuels mostly ethanol use in transportation.

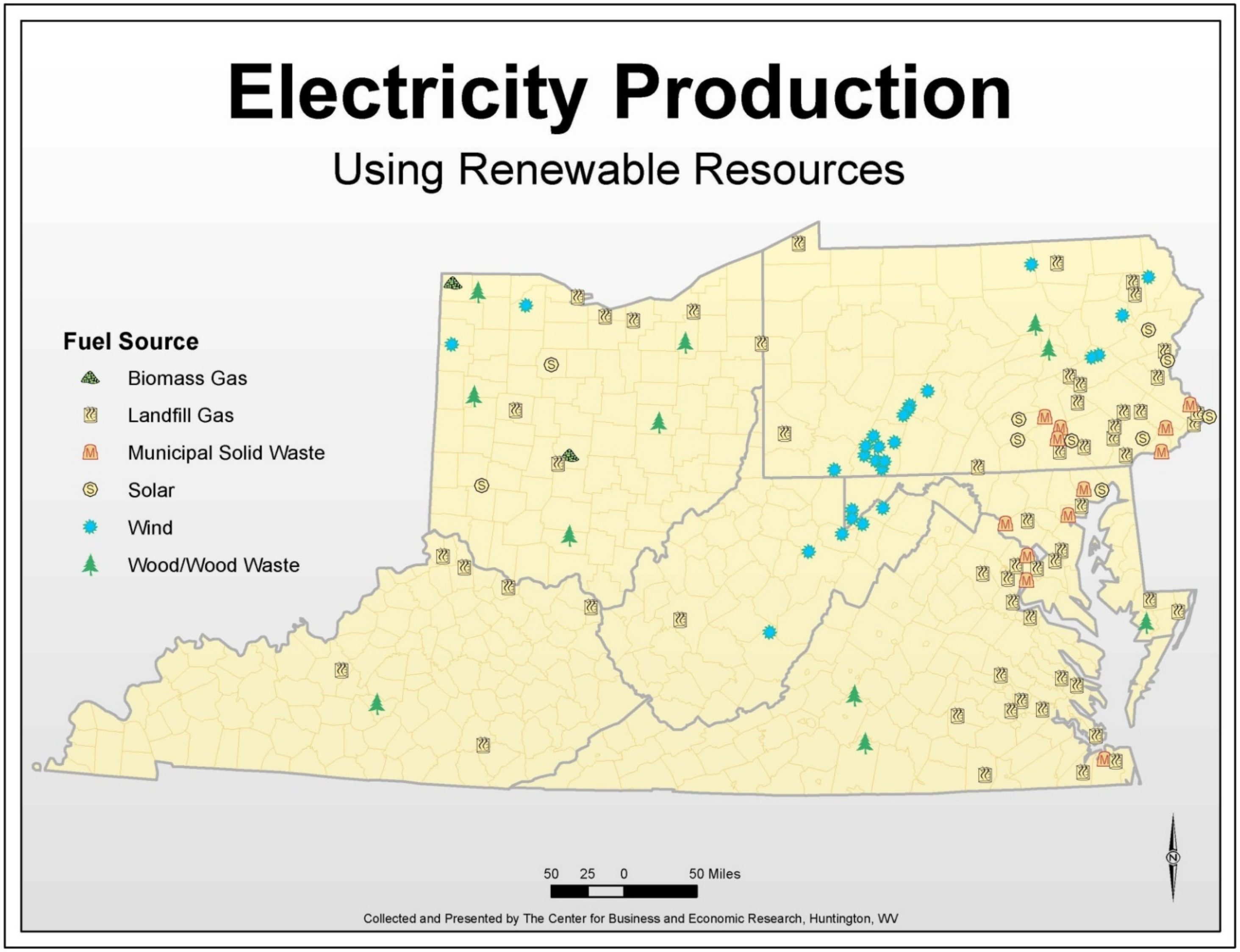
The purpose of this report is to outline the future role of renewable energy in West Virginia. This is accomplished by a set of reports which discuss each of the renewable sources: Wind, Solar, Biomass, Hydropower and Geothermal. Each section includes a discussion of the characteristics of the fuel, the positive and negative aspects of its deployment and its current use in West Virginia. A thorough discussion of how energy efficiency can become an even more important part of the West Virginia energy mix is also included in a separate report.

The purpose of each section is to provide conclusions and policy recommendations which can be in the *Five Year West Virginia State Energy Plan 2013-2017*. The report is the contribution of the Center for Business and Economic Research at Marshall University and is a companion to a report on fossil fuels, electricity and nuclear power prepared by the Bureau of Business and Economic Research at West Virginia University

To illustrate the extent of electricity generation already being produced from renewable resources, Figure 6 provides a map showing the location of power plants in the region that utilize renewable energy.

[3] U.S. Energy Information Administration (2010) “State Energy Data 2010: Consumption. P.3

Figure 9: Map of Renewable Energy Electricity Generation Facilities



II. Biomass Energy

Biomass produces energy from three sources: wood, waste and alcohol fuels[4]. Wood produces energy from wood harvested as fuel and wood waste streams which includes pulping liquor or "black liquor" from the paper industry which is the largest source of wood energy. Waste energy includes: municipal solid waste (MSW), manufacturing waste and landfill gas. Waste is the second largest source of biomass energy. The greatest source of biomass energy is alcohol fuels, primarily ethanol followed by biodiesel[5].

Biomass as a source of fuel has been discussed and researched since the oil embargo of the 1970's. The growing use of imported petroleum and environmental concerns of continued use of fossil fuels have continued and accentuated the inquiry. Turning to energy produced from biomass has been viewed as a means of meeting the nation's need for energy independence and environmental improvement[6]. This paper highlights the major sources of biomass energy and the public policy in West Virginia regarding their use. Conclusions regarding the prospects for each biofuel are also presented along with recommendations for inclusion in the West Virginia Five Year Energy Plan 2013-2018.

A. Growth in Biomass Energy Production and Consumption

There has been a significant increase in the production and consumption of biomass in the United States. Total biomass production in 1973 was 1,259 TBtu. This was 35 percent of total renewable energy produced. By 2011 production had increase to 4,483 TBtu which was 49 percent of all renewable energy production in the U.S. This growth was primarily in the production of biofuels which did not appear on the tabulations until 1985 at 93 TBtu and totaled 2,033 TBtu in 2011[7].

Appendix A provides a breakdown of consumption by type of biomass type: wood, waste and biofuels. Wood and bio-fuels are by far the main consumption components with nearly identical statistics in 2010 (1967 TBtu and 1933 TBtu respectively). These two constitute 90 percent of all biomass consumption. Wood and biofuels account for 43 percent of all renewable energy consumed in the U.S. Non-hydro renewables (primarily wind and biomass) and natural gas are anticipated to be the two fastest growing sources of energy production in the U.S. over the next quarter century[8].

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[4] U.S. Energy Information Administration (April 2009) "Renewable and alternative fuels" http://205.254.135.7/cneaf/solar.renewables/page/biomass/biomass.html. Accessed April 6, 2012

[5] U.S. Energy Information Administration (January 2012) *Renewable Energy Annual 2009,* U.S. Department of Energy: Washington DC

[6] National Renewable Energy Laboratory (April 13, 2012) "Learning about renewable energy: Biomass energy basics" Http://www.nrel.gov/learning/re_biomass.html Accessed May, 5, 2012.

[7] U.S. Energy Information Administration, (January 23,2012) *Annual Energy Outlook 2012: Early Release Edition* 2012 "Early release overview" .fig12.data

[8] EIA, *Annual Energy Outlook 2012: Early Release Edition*, op.cit.

B. Biofuels

1. Growth of Biofuels

Use of biofuels is expected to grow between 2011 and 2035 by 2.8 percent a year with most of the growth due to the new Federal Renewable Fuel Standard (RFS2) for transportation fuels and renewable portfolio standards (RPS) implemented in the states for electrical generation[9].
The production of biofuels envisioned in the Energy Independence and Security Act of 2007(EISA2007) has fallen well short of meeting the Renewable Fuel Standards for 2022. ERISA called for 36 billion gallons of biofuel to be produced by that date. Corn based ethanol was limited to 15 billion gallons with cellulosic ethanol and biodiesel were to contribute a minimum of 16 billion and 5 billion respectively[10].

These standards will not be met and the Environmental Protection Agency has substantially reduced the cellulosic biofuels mandate.[11] The cellulosic standard reductions over the past three years have been cut from 100, 250 and 500 million to only 8 million for 2012. Due to financial and technological reasons, cellulosic biofuel capacity has been very slow to develop. On the distribution side there are liability problems from misfueling and inadequate infrastructure that will mean even though the EPA has now allowed blending up to E15 dealers are being reluctant to offer the blend[12].

In considering government policy for biomass, the conclusions reached by the National Research Council (NRC) apply to all types of biofuels discussed in this paper. The NRC investigated the possibility and problems associated with meeting the Renewable Fuel Standard (RFS2). Their primary conclusions were:

- Without major technological advances the federal mandates for biofuels are unlikely to be fulfilled
- Biofuels are unlikely to become cost-competitive with petroleum based fuels unless there are sustained high oil prices (near or above $191), technological breakthroughs and/or mandated high costs of using carbon based fuels due to government policy.
- Using biofuels may not be an effective policy for reducing greenhouse gases emissions (GHG) depending on how they are produced and what land use changes occur in the their production.
- Without major increases in crop yields the additional cropland required for bio-fuel production will create competition for land use, raise cropland prices increasing the cost of food and feed production

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[9] U.S. Energy Information Administration (January 2012) *Annual Energy Outlook 2012 Early Release Overview.* U.S. Department of Energy Washington DC
[10] U.S. Energy Information Administration (June 2012) *Annual Energy Outlook 2012.* op.cit p.44
[11] U.S. Energy Information Administration (June 2012) *Annual Energy Outlook 2012.* op.cit. p. 97
[12] National Research Council,(2011) *Renewable fuel standard: Potential economic and environmental effects of U.S. biofuel policy*, The National Academies Press: Washington DC

- Achieving goals for bio-fuel production will require increased federal budget outlays for payments, grants, loans and loan guarantee plus forgoing tax revenue due to biofuel credits.
- The environmental effects of increased bio-fuel production depend on, feedstock type, management practices, and conversion yields
- The primary barrier to increased bio-fuel use is the high cost of producing cellulosic bio-fuels when compared to conventional fuels.[13]

Similar issues were raised by the U.S. General Accounting Office[14] in their report to Congress.

2. Ethanol as a fuel

Ethanol is produced with the expectation that it substitute for petroleum based gasoline. Ninety-nine (99) percent of all gasoline consumed in the U.S. in 2011 contained some ethanol[15]. Most of this consumption consists of a 10 percent mixture of ethanol with gasoline (E10). Due to EPA regulations, cars and light trucks built after 2007 must have engines capable of using an E15 mixture. E85 is consumed primarily in the Midwestern states where the majority of the corn feedstock is grown[16].

Although 98 percent of ethanol used in the U.S. is produced from corn[17], sorghum and barley have also found limited usage. Other potential sources for ethanol production which are being used, explored or tested are[18]:

- Potato skins
- Rice
- Sugar cane (used extensively in other nations such as Brazil)
- Sugar beets
- Yard waste
- Forest residue
- Switch grass and other woody crops.

While none of these are extensively used in the U.S. they do contain the sugars needed for ethanol production. Further research is moving forward to determine if the entire corn plant (Stover) can be converted to ethanol and not just the grain.

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[13] National Research Council (2011) *Renewable fuel standard: Potential economic and environmental effects of U.S. biofuel policy*, The National Academies Press: Washington DC
[14] U.S. Government Accountability Office (GAO) (August 2009) Biofuels: Potential effects and challenges of required increases in production and use. GAO-09-446
[15] U.S. Energy Information Administration (March 19,2012) "Biofuels: ethanol and biodiesel" http://www.eia.gov/energyexplained/index.cfm?page=biofuel_home Accessed April 18, 2012
[16] U.S. GAO, Biofuels op.cit.
[17] U.S. Government Accountability Office (August 2009) *Biofuels: Potential effects and challenges of required increase in production and use.* GAO-09-446, Washington DC p.17
[18] U.S. Energy Information Administration (March 19, 2012) "Biofuels: Ethanol and biodiesel" http://www.eia.gov/enegy/explained/indes.cfm?page=biofuel-home Accessed April 6, 2012.

There is continued controversy (including among major government agencies) regarding the impact of corn ethanol on crop production for human consumption and the impact on prices for foodstuffs. According to industry sources corn used in ethanol production required 40 percent of the U.S. corn crop in 2011[19]. Governors in two states have already requested the EPA to grant relief from the mandate for the use of ethanol citing rising feed prices.[20]

HR.1687 "Open Fuel Standard Act of 2011" would require by 2017, that 95 percent of all passenger and light truck vehicles are manufactured as to run on fuels which are not petroleum based. The bill specifically calls for these vehicles to use E85 or M85 fuels, fuel cells, or plug-in electric vehicles. Use of natural gas as a fuel is allowed as is biodiesel. The bill has not emerged from Subcommittee. Similar legislation was introduced in the Senate but remains in Committee.

3. Environmental effects of ethanol

The research on the environmental impacts of ethanol production and consumption is not conclusive[21]. Data from the U.S. Department of Energy contends:

- Ethanol produced from corn results in a 20 percent reduction in GHGs compared to gasoline and is fully biodegradable. This percentage increases to 85 percent for cellulosic ethanol
- Ethanol delivers one third more energy than is used to produce it[22]

Critics[23] claim the research supporting these findings is incorrect and does not consider the full "life cycle" effects of the chemicals and energy used in the production of ethanol. Other negative comments include:

- Land conversion from forest and/or pasture increases GHG and leads to deforestation
- Water supply is adversely impacted:
    - Pollution of water quality due to chemical runoff from crop production
    - Significant diversion of water from other uses to produce ethanol
- Higher food prices
- Reduced miles per gallon

All of these adverse impacts are reduced when corn is replaced with the "second generation" fuels such as switchgrass and other cellulosic feed stocks[24].

Switchgrass has received considerable attention as the most desirable of the "second generation" ethanol fuels. Using switchgrass is advanced as being carbon neutral, capable of growing on

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[19] Renewable Fuels Association (n.d.) Accelerating industry innovation: 2012 ethanol industry outlook. http://ethanolrfa#cdn.met/d4ad995fbfe_1vm62ypzd.pdf Accessed April 4, 2012

[20] Abbott, C. (August 10, 2012) "Update-Two states aks US to forgo use of corn ethanol in fuel." Reuters www.reuthers.com/article/2012/08/10/usa-ethanol-idUSL2EJAFAH20120810 Accessed August 13, 2012.

[21] US Governmental Accountability Office. op.cit pp. 133-146; National Research Council (2011) R*enewable fuel standards: Potential economic and environmental effects of U.S. biofuel policy*. op. cit

[22] U.S. Department of Energy (n.d.) "Ethanol myths and facts", Energy Efficiency& Renewable Energy Biomass Program. http://www1.eere.energy.gov/biomas/ethanol-myths-facts.html accessed March 10, 2012

[23] The World Bank (2008) "Biofuels: The promise and the risk" *World development report 2008*, pp. 70-71

[24] National Research Council op. cit.

marginal lands, producing high yields, needing little fertilizer and capable of being continually renewed:[25] The potential for switchgrass has been heightened with recent discovery of using genetic engineering to produce a higher grade of alcohol than ethanol from switchgrass without corn ethanol's negative features[26]. This has been accomplished by introducing e-coli bacteria which digests the cellulose fibers significantly reducing the cost of switchgrass as a fuel[27]. Introducing a corn gene into switchgrass doubles its yield and further improves conversion into fuel.[28]

4. Ethanol in West Virginia

Currently all gasoline sold in West Virginia is E10. There are no State incentives for the use or expansion of ethanol on the books. While there is national attention to increase the blending of ethanol so far there has not been any movement in that direction in the State to require increased blending.

C. Biodiesel as a Fuel

Most large trucks, buses and tractors use diesel fuel for a variety of reasons[29]. Any engine which can use petroleum based diesel can switch to a 5 percent blend (B5) of biodiesel without modification. Either used by itself or in blends with petroleum based diesel, biodiesel is growing in popularity not only in the U.S. but in other nations as well.

In the U.S. biodiesel production has expanded from 10 million gallons in 2001 to 229 million gallons in 2010. This was a drop from the 316 million the year before and was due to the expiration of the federal biodiesel tax credit. The credit returned in 2011. Along with demand for exports and the RFS, consumption soared to 772 million gallons last year[30].

The most popular blend of biodiesel is 80 percent petroleum and 20 percent biodiesel. (B20). Most petroleum based diesel fuels include at least 2 to 5 percent biodiesel as it has greater lubricating qualities and prolongs engine life. But pure biodiesel and blends are sensitive to cold weather and require a different type of anti-freeze. Pure biodiesel also has detergent qualities

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[25] Oak Ridge National Laboratory (2007) "Biofuels from switchgrass: Greener pastures", https://bioenergy.ornl.gov/papers/misc/switgrs.html. Accessed April 3, 2012 and Wright, Lynn (July 2007) "Historical perspective on how and why switchgrass was selected as a "model" high-potential energy crop" Oak Ridge National Laboratory, U.S. Department of Energy.

[26] Schwartz, Ariel (March 3, 2011) "Researchers produce gasoline-like fuel directly from switchgrass, corn stalks" Http:www. Fastcompany.com/1736131/researchers-produce-gasoline-likefuel-directly-from-from-switch-swithchgrass-corn-stalks.html Accessed April 20, 2012.

[27] Yarris, Lynn (November 29, 2011) "E.Coli bacteria engineered to eat switchgrass and make transportation fuels" Lawrence Berkley National Laboratory, U.S. Department of Energy.

[28] Chuck, George et.al. (October 10, 2011) "Overexpression of the maize corngrass1microRNA prevents flowering, improves digestibility, and increases starch content of switchgrass" *PNAS: Proceedings of the National Academy of Sciences 108/42*, pp.17550-17555.

[29] U.S. Energy Information Administration. (April 2, 2012) "Biodiesel performance, costs and use" http://www.eia.gov/oiaf/analysispaper/biodiesel/ Accessed April 2, 2012.

[30] U.S. Energy Information Administration (April 2, 2012) "Use of biodiesel" http://www.eia.gov/energyexplained/index.cfm?page+biofuel_biodiesel_use accessed April 2, 2012

which rule out its use in many vehicles, particularly older ones, as it leads to deterioration in hoses and couplings. Blends do not have this problem[31].

Biodiesel is primarily produced from soybean oil in the U.S[32] totaling 65 percent of all biodiesel production[33]. Other feed stocks used are:

- Rapeseed and sunflower oil (Europe)
- Palm oil (Asia)
- Vegetable oils
- Tallow and other animal fats
- Restaurant waste
- Trap grease

1. Biodiesel and the Environment

Biodiesel has definite advantages over petroleum based diesel fuel[34]. It is non-toxic and biodegradable plus producing fewer emissions such as carbon monoxide, sulfur dioxide, hydrocarbons (including CO_2) and particulates than petroleum based fuels. But there is a slight increase over petroleum based diesel in emissions of nitrogen oxides.

Since biodiesel is produced from plant matter (particularly soybean oil and palm oil in the US), it is considered carbon neutral as the vegetation absorbs the carbon produced when converted into fuel and the plant regrown. But in underdeveloped nations clear cutting of forests and other natural vegetation have been removed and not replanted to produce feedstock. In these cases the negative effects of biodiesel are believed to outweigh the positive.

2. Biodiesel in West Virginia

Biodiesel use in West Virginia has been encouraged by a requirement in the State's Public School Support Program (PSSP) which provides an additional allowance for districts that use alternative fuels.[35] For those districts, "An additional allowance of 10% of the actual expenditures for operations, maintenance and contracted services, exclusive of salaries, for that portion of the bus fleet that uses alternative fuels."[36] For fiscal year 2011-12, about 250,000 gallons was used by the 48 (out of 55) districts which availed themselves of the option[37]. The additional cost to the PSSP was around $1million.

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[31] Ibid.
[32] U.S. Energy Information Administration (October 7, 2007) "Biofuels in the U.S. Transportation Sector" http://www.eia/oiaf/analysispaper/biomass.html Accessed April 17, 20012
[33] US GAO op.cit. p 21
[34] U.S. Energy Information Administration (March 19, 2012) "Biodiesel and the environment" http://www.eia.gov/energyexplained/index.cfm?page=biofuel_biodiesel_environment. Accessed April 6, 2012.
[35]Office of School Finance (2012) *State of West Virginia Executive Summary of the Public School Support Program Based on the Final Computation for the 2011-12 Year*. West Virginia Department of Education, Charleston WV.
[36] Office of School Finance, op.cit. p.4
[37] Data from Shew, Ben, Office of Finance, West Virginia Department of Education, May 15, 2012.

There is currently no biodiesel being produced in the State due to economic considerations.[38] School districts use B5 but what they use is produced out of state and conveyed to the districts from local distributors. Prior to this B100 was purchased out of state and then "splash blended" at the terminal with conventional diesel to produce B5. Refineries are now producing B5 which has eliminated the blending process.

The cost of B100 is between $4-5 a gallon.[39] With the rack cost of diesel around $2 using biodiesel increases the cost of a gallon of B5 by 10 to 12.5 cents compared to petroleum based diesel. The benefits to users relate to the greater lubricating properties of B5 and the enhanced environmental effects. These have not been quantified, so the use of biodiesel must be supported on grounds other than reduced costs.

D. Woody Biomass

Woody biomass consists of wood and wood wastes primarily bark, sawdust, wood chips, wood scrap (slash) and paper mill residues.[40] Four percent of energy used in the U.S. comes from biomass and 45 percent of that from wood resulting in woody biomass producing slightly less that 2 percent of total U.S. energy production[41]. Woody biomass comes from several sources[42]

- Forest operation residues such as branches, tree tops, and stumps
- Wood products residue from sawdust and scraps from manufacturing facilities
- Urban waste wood and yard waste from landscaping, utility line maintenance and storm damage

While woody biomass can be converted to transportation fuels this is unlikely to expand significantly in the future. Because of the cost of building refineries and transporting the fuel, there are no commercial woody biomass refineries in U.S. production[43] although there are several small scale, mostly experimental, plants[44]. The costs of using woody biomass are in excess of the expense of using alternative renewables, so even in a carbon constrained world use of woody biomass is unlikely for transportation. Among the problems for using woody biomass as a fuel are[45]:

- Lack of reliable supply
- Poor and mixed quality
- Bulk, high moisture content and low energy value

[38] Cordle, Dean, Telephone interview, 15 June 2012
[39] Cordle, op.cit.
[40] U.S. Energy Information Administration (nd) "Renewable biomass" http://www.eia.gov/kids/energy.cfm?pages=biomass_home-basics-k.cfm accessed March 30, 2012
[41] U.S. Energy Information Administration. "Biomass" http://www.eia.gov/kids/energy.cfm?page=biomass_home-basics-k.cfm Accessed April 20, 2012.
[42] Ashton, Sarah (2009) "Woody biomass basics" in *Woody biomass desk guide and toolkit,* National Association of Conservation Districts: Washington DC.
[43] White Eric, (December, 2009) "Woody biomass for bioenergy and biofuels in the United States-A briefing paper. Department of Forest Engineering, Resources and Management, College of Forestry, Oregon State University, Corvallis OR
[44] Bevitt, Kent (November 16, 2011) "EIA issues 2012 cellulosic biofuel predictions." *Ethanol producer.* http://ethanoloproducer.com/articles/8355/eia-issues-celluosic-biofuel-. Accessed March 17, 2012.
[45] White, op.cit. GAO op.cit.

- High cost of collecting, harvesting, storing and transporting.

Currently the greatest use of woody biomass (70 percent of total use) is in the commercial sector of the economy primarily at pulp and paper mills plus lumbering facilities using combined heat and/or power (CHP) produced from residues[46]. Almost all of this consumption occurs on-site. If surplus electricity is generated it usually is provided off-grid for direct consumption.

There is potential for continued use of woody biomass in the production of electricity. In 2010 189 TBtu was generated from woody biofuels[47] which is less than 1 percent of total U.S. electric power generation. In electric generation for the grid, wood is usually co-fired with coal. This can be accomplished with only minor adjustments, if any, to existing plant technologies[48]. For wood to electricity to expand there must be a dependable source available which can be transported at low cost (usually less than 75 miles distance from the plant). The problems of using wood as a fuel in electric generation are the same as for using it in transportation. Plus there is concern that using forest waste will harm the natural forest ecology[49].

One study of the potential use of wood as a fuel for electric generation concluded:

- The high cost of moving wood from place of harvest to place of use meant that electric plants would be small and dispersed. (40-50 MW) Plants generally would have to be no more than 75 minutes one-way trip from power plant
- These small plants would not experience the economies of scale of larger plants which would mean they would be higher kWh producers.
- Plants of this size are only justified if they are subsidized or their use is required under a RNP.[50]

This research indicates that these smaller plants may be most feasible if used for both electrical generation and direct use as district heating. To insure a reliable source of wood chips it may be necessary for loggers to be supplied with special equipment to be used in collecting slash during their logging operations further increasing the cost of using these wood-to-wire plants.

1. Short Rotation Wood Crops (SRWC)

There has been interest in growing Short Rotation Wood Crops (SRWC) specifically for fuel. SRWC are fast growing tree species that can be planted at minimum cost and repeatedly

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[46] Stowe, Ned, (February 22, 2011) "A brief overview of the woody biomass power industry in the U.S." Future of Biopower Conference, Environmental and Energy Study Institute: St. Paul MN.
[47] U.S. Energy Information Administration, (October 2011), "Renewable Energy Consumption: Electric Power Sector, Selected Years 1949-2010" *Annual Energy Review 2010* p.297
[48] White, op.cit pp13-14
[49] GAO op.cit
[50] Timmons, David et. al. (December 2007) "Energy from forest biomass: Potential economic impacts in Massachusetts". Massachusetts Division of Energy Resources and Massachusetts Department of Conservation & Recreation. Boston: Massachusetts.

harvested[51]. Among the candidates currently being researched are loblolly pine, eucalyptus, poplar, willow, cottonwood, sweetgum and sycamore[52].

While there is still genetic engineering research ongoing directed to lowering the cost, SRWC has been successful as a fuel source in other countries and U.S. states are considering it as a means of rural development in heavily forested areas.[53] SRWC are usually grown on a plantation system near the electrical plant which will use them thereby reducing transportation costs.

2. Arundo Donax

A "cousin" to switchgrass and bamboo also has received increasing interest as a bio-fuel in electrical generation: Arundo donax (also known as *A donax*, giant reed, wild cane, Spanish cane and Carrizo)[54]. There is activity growing *A donax* in West Virginia on abandoned mine land[55]. There are advantages claimed for using *A donax* over coal, petroleum, corn, soy beans or other woody biomass:

- High yield compared to other woody crops
- Low maintenance (tillage, fertilization) except adequate rainfall
- Survives on low-fertility soils
- Cannot be used for food and is not consumed by animals
- Yields multiple harvests each year[56]

On the other hand *A donax* is viewed as an "invasive" or "noxious" weed in several states (CA[57], FL[58], GA,[59] plus TX, AZ, MD, VA[60]), Enthusiasts contend that the environmental problems can be managed and are the result of human error.[61]

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[51] Langholtz, M, Carter, D and Rockwood, D (July 2010) "Assessing the economic feasibility of short-rotation woody crops in Florida. School of Forest Resources and Conservation, University of Florida, Circular 1516.
[52] Hinchee, Maud et. al. (August 26, 2009) "Short-rotation woody crops for bioenergy and biofuels application" *Vitro Cell Development Bio Plant* published on-line. Http://www.nchbl.nlm.gov/pmc/articles/PMC2778772 Accessed April 4, 2012.
[53] http://www.window.state.tx.us/specialrpt/energy/renewable/wood.php
[54] ""Arundo donax" enotes, Http://www.enotes.com/topic/arundo_donax. Accessed May 2, 2012.
[55] Kuykendall, Taylor, (February 4, 2011) "Biomass industry developing in West Virginia", *The Register-Herald, Beckley WV.*
[56] Daquila, Phil, (2011) " The power in plants: biofuels and the giant cane debate" Http://unc.news21.com/index.php/stories/bioels.html
[57] Ambrose, Richard and Rundel, Philip, (November 2007) "Influence of nutrient loading on the invasion of an alien plant species, giant reed (*Arundo donax),* in Southern California riparian ecosystems" UC Water Resources Center Technical Completion Report Project No. W-960, UCLA.
[58] Odero, Dennis et.al. (2012) "Production of giant reed for biofuel" University of Florida IFAS #SS-AGR-318
[59] Anderson, T. et.al.(2004) "Final report on *Arundo donax* (Giant Reed Grass)" College of Agricultural and Environment Sciences, University of Georgia. Http//www.agmrc.org/media/cms/FinalReport1104.E20501B6CO14D.pdf . Accessed May 1, 2012.
[60] Daquila op.cit
[61] Biomass Gas & Electric "The truth about Arundo Donax" http://www.biggreenenergy.com/default.aspx?tabid=426 Accessed April 30, 2012

Despite the environmental problems created by *A donax*, plans are afoot in Oregon where PGE is committed to eliminating coal at its Boardman plant which supplies 15 percent of the OR's electric demand and using *A donax* as a fuel[62]. BGE in GA also plans to build an electric plant using *A donax*[63].

3. Bio-Oil

For over a decade **Bio-oil** has been discussed as a means of using woody biomass as a substitute for fuel oil in residential, commercial, industrial and electrical applications[64]. Bio-oil, also called pyrolysis oil, results from rapid condensation of vapors produced by "cooking" wood by-products in an oxygen starved environment[65]. The quantity and quality of bio-oil produced varies considerably based upon the methods used, so it is difficult to reach definite conclusions about bio-oil potential without being specific regarding these methods.[66]

The major producer of bio-oil in the U.S. and Canada lists the following virtues of using bio-oil:

- Considered to be carbon neutral with emissions of other pollutants (SOX, NOX) equal or less than fossil fuels which allows its use to earn carbon credits
- Produced from wood-wastes and agricultural wastes
- Is a renewable feedstock material
- Can be used as a single source fuel or in combination with other fuels
- Does not require a new distribution system
- Appropriate to be used in the production of hydrogen gas or syngas[67]

. The problems in using bio-oil have been identified as:

- Lower energy content than conventional liquid fuels
- Higher acidity than fossil fuels which leads to corrosion in storage and distribution facilities
- High moisture content.
- High oxygen content
- Does not blend well with conventional fuels[68]

Bio-oil is currently in limited commercial use but research is continuing[69] with government support in the U.S. and Canada[70]

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62 "Broadman's next life may depend on giant cane" http:www.sustainablebusinessoregon.com/articles/2012/01/broadmans-next-life-may-depend-on-giant-cane..html Accessed May 2, 2012

63 Daquila op. cit.

64 Easterly, James L, (November 1, 2002) "Assessment of bio-oil as a replacement for heating oil" Northeast Regional Biomass Program, CONEG Policy Research Center.

65 "Bio-oil" (January 13, 2009) Sustainable Energy Research Center (SERC), Mississippi State University. http;//ww.serc.msstate.edu/bio-oil.html Accessed May 4, 2012.

66 Mohan, D. Pittman, C. and Steele, P. (March 10, 2006) ""Pyrolysis of wood/biomass for bio-oil" *Energy fuels*, 20(3), pp. 848-889

67 Dynamotive (2009) "Dynamotive BioOil information booklet 2012" Dynamotive Energy Systems Corporation, Richmond BC, Canada

68 Easterly op.cit

E. Municipal Solid Waste (MSW)

Energy recovered from waste results from conversion of non-recyclable waste into heat or electricity. Methods used for conversion include direct combustion, gasification, pyrolization, anaerobic digestion and landfill gas (LFG) recovery. The common name for all these processes is "Waste to-Energy" (WTE).[71]

Recycling of waste accounts for 34 percent of the total waste generated in the U.S. in 2010. Per capita this amounts to 1.51 pounds per day. WTE has grown steadily in the past half century increasing from less than 10 percent of MSM in 1980 to the current figure.[72].

1. Waste to Electricity (WTE) by Incineration

Burning of MSW for energy has existed since the 1880's. In 2010 there were 86 WTE facilities in 25 states primarily in the Northeast. These facilities can produce 2,720 megawatts of power by processing 28 million tons of waste each year.[73] The EPA claims WTE produces electricity at 4 cents per kWh. The GAO places the cost at 7.5 cents

There are several reasons as to why WTE has not expanded more quickly[74].

- <u>Capital costs</u>. The cost of building a WTE facility ranges from $100 to $300 million. This makes WTE non-competitive with landfills in areas which are not densely populated.
- <u>Need for dense populations</u> to generate sufficient waste. Countries with dense populations in Europe, Japan and India have made extensive use of WTE, but those population densities do not exist in West Virginia
- <u>Problems with long term contracts</u> (30 years+). WTE facilities require long payback periods and a constant and consistent supply of waste. In places where waste is collected by private carters, it is difficult to get long term commitments.

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[69] Evans, J. (February 1, 2012) "Two become one for bio-oil upgrade" *Chemistry world*, http:www.rsc.org/chemistryworld/News/2012/February.html Accessed May 4, 2012, Brown, R et. al. (nd) "Options for producing bio-oil for subsequent upgrading to fuels and chemicals" Center for Sustainable environmental technologies, Iowa State University, Garcia-Perez, Manuel et. al (May 18, 2007). "Production and fuel properties of pine chip bio-oil/biodiesel blends", *Energy Fuels ASAP Article* 10.1021/efo60633e So887-624(06)00533-0.

[70] Center for Research and Innovation in the Bio-Economy (CRIBE) April 12, 2012 "Wood waste to transport fuel project secures funding in Ontario" http://www.waste-management-world.com. Accessed April 30, 2012; Lane, Jim (April 13, 2012) "DOE to award up to $15M for bio-oil R&D, catalysis, separation, analytics in focus" http://www.bopfie;sdogest.com/bdigest/2012/14/13 html Accessed April 30, 2012.

[71] U.S. Environmental Protection Agency (April 17, 2012) "Energy recovery from waste" http://www.epa.gov/osw/nonhaz/municipal/wte/indes.html Accessed April 22, 2012

[72] U.S. Environmental Protection Agency (n.d.) "Municipal solid waste generation, recycling, and disposal in the United States: Facts and figures for 2010". Http://epa.gov/osw/nonhaz/municipal/wte/index.html Accessed April 22, 2012

[73] U.S. Environmental Protection Agency, "Energy Recovery From Waste" op.cit

[74] U.S. Environment Protection Agency, "Energy Recovery from waste" op.cit and U.S. Government Accountability Office, (May 2005) "Natural resources: Federal agencies are engaged in various efforts to promote the utilization of woody biomass, but significant obstacles to its use remain" GAO-5-373 Washington DC.

- Public opposition to incineration. Until the Clean Air Act of 1970 MTE facilities were significant polluters. Since then federal and state regulations have significantly reduced the problem but opposition under NIMBY remains. CO_2 from WTE is not counted as GHG emissions (except landfill gas) as it is considered as part of the "natural carbon cycle". This has created opposition from some environmental groups.
- Problems from disposal of fly ash. 15-25 percent of the waste used in electrical generation remains as fly ash which has to be disposed in specially created landfills which are difficult to site and expensive to build.

a. WTE in Central Pennsylvania

The situation in Central Pennsylvania illustrates both the potential and problems with using WTE. Both York[75] and Lancaster[76] Counties operate WTE successfully converting burnable waste into electricity which is used to power the recovery facilities with remaining power being sold to the grid on long term contracts. Neither facility is tax supported. Both receive revenue from tipping fees, sale of ash and primarily sale of electricity. Both receive waste from outside their immediate jurisdictions including entities in New Jersey and Maryland.

The success in York and Lancaster is due to:

- Sufficient population to support an adequate and consistent supply of waste.
- Long term contracts with governments outside their jurisdictions for the supply of waste
- Long term contracts with electric distribution companies for the sale of electricity
- Management by public authorities isolated from political pressures
- Quality operation by private contractors
- "Green Credits" for waste conversion.[77]

The WTE facility in Harrisburg has not been financially successful and has been cited as one of the causes of that city's recent bankruptcy[78]. Recent investigations indicate the failure to be the result of mismanagement, corruption and political favoritism[79]. The Lancaster authority is currently in the process of purchasing the Harrisburg facility out of bankruptcy.[80] It is doing so to utilize the excess capacity in the Harrisburg facility as an alternative to building an additional plant in Lancaster. While the purchase cannot be consummated until after the bankruptcy proceeding is finalized, the current purchase price is $124 million.

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[75] York County Solid Waste Authority (n.d.) http://www.ycswa.com/about_main.asp Accessed August 10, 2012
[76] Lancaster County Solid Waste Management Authority (n.d.) http://www.lcsmwa.org/lcswma_energy_overview.html Asscessed August 10, 2012
[77] Interview with James Warner CEO Lancaster County Solid Waste Management Authority July 10, 2012.
[78] Varghese, R. Bathon, M and Sandler, L (October 12, 2011) "Harrisburg files for bankruptcy on overdue incinerator debt" Bloomberg News.
[79] Malawskey, N. (August 2, 2012) "Tale of two incinerators: Harrisburg known for financial mismanagement, Lancaster is a model for waste disposal" *The Patriot-News.* Http://blog.pennlive.com/midstate_impact/print.html
[80] Gletter, D (August 2, 2012) "Lancaster County Solid Waste Management Authority CEO James Warner outlines why the authority wants to buy the Harrisburg incinerator" http://videos.pennlive.com/patriot-news/2012/08/lancaster_county_solid_waste_m.html Accessed August 10, 2012

2. Landfill Gas (LFG)

Landfill gas (LFG) is the major source of MSW used either directly as a boiler fuel or indirectly in electrical generation[81]. According to the U.S. EPA, 54 percent of all MSW is deposited in landfills. These landfills are the second largest human-caused source of methane emission in the nation. As a contributor to global warming methane is 20 times as potent as is CO_2. Using this gas rather than flaring it or allowing it to leak into the atmosphere, is viewed as one of the best ways to reduce the impact of humans on global climate change.[82]

a. Use of Landfill Gas to Generate Electricity

Across the U.S. 2/3rds of the LFG projects are used to generate electricity while the rest are in direct use. Electric generation employs gas turbines or internal combustion engines which can range in size from1 MG to 250kW. LFG is also used in cogeneration projects for electrical generation.[83]

Direct use is most likely successful when the user is within 5 miles of the landfill (some have been as far as 10 miles).[84] There are several cases where large industrial facilities have made direct use of LFG, but smaller projects include firing brick kilns, supplying pipeline quality gas, fueling garbage trucks, and heating for farm applications.[85]

The first step in estimating if a LFG project is viable is to establish if the site will produce sufficient methane to support the project. The following criteria are used by EPA. Does the landfill:

- Contain at least 1 million tons of MSW.
- Has a depth of 50 feet or more
- Open or recently closed
- Receives at least 25 inches of rainfall annually[86]

A further consideration is the quality of the gas. LFG is a varying quality and must be cleaned of impurities and subject to dehumidification, particulate filtration and compression prior to usage. Improved technology has reduced this problem and LFG is now used in some instances with little or no further processing.[87]

b. Landfill Gas in West Virginia

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[81] U.S. Environmental Protection Agency (April 6, 2011) “Landfill Methane Outreach Program: Project Development Handbook” Http://www.epa.gov/lmop/publications-tools/handbook.html Accessed April 30, 2012.
[82] U.S. EPA “ Project development handbook, op.cit pp.1-2 through 1-9
[83] U.S. Environmental Protection Agency, “LFG energy project development handbook” op.cit. p. 1-5
[84] U*.S. Environmental Protection Agency, “LFG energy project development handbook” op cit. p1-6
[85] U.S. Environmental protection agency (March 28, 2012) LFG energy project profiles” http://www.epa.gov/imop/projects-candidates/profiles.html accessed April 30, 2012
[86] U.S. Environmental Protection agency “LFG energy project development handbook. Op.cit. p.1-12
[87] U.S.. Environmental Protection Agency, “LFG energy project development handbook”. Op.cit. p.1-1

There are currently 576 LFG plants operating in the US[88] with two in West Virginia: City of Charleston and J. P. Mascaro & Sons in Wetzel County. A third site, Berkeley County Solid Waste Authority, closed in 2003. Two other landfills have plans to possibly start electrical production within 2-3 years. The EPA lists nine other West Virginia sites as "candidates" for LFG usage and an additional 11 as having "potential"[89].

An unpublished survey by the Marshall University Center for Business and Economic Research in 2012 of all private and public landfill operators in the State found that most are not yet ready to install flaring structures due to cost and an insufficient supply of methane. If flaring is cost prohibitive than the additional capital costs of using landfill gas for electrical generation makes this expansion unrealistic. The cost of installing WTE facilities would lead to increases in tipping fees which are likely to be passed on to consumers.

All landfills are required to place monies into several escrow accounts to cover mandatory expenditures such as maintenance and closure. While the use of some of these funds might be available for covering the costs of the infrastructure for electrical generation this is not the purpose of these funds but an operator could petition the WV Public Service Commission to release funds for that purpose. None have done so to date.[90]

F. Poultry Litter

The use of poultry litter as a fuel is being research in the State. The poultry industry in West Virginia is concerned with energy as a production cost. Most of the industry relies on propane to heat its houses, a fuel that has increased in price in recent years. Although meat is the industry's primary product, poultry litter and bedding is a secondary product or co-product of many farms due to its nutrient content. Use of litter as an energy resource is uncommon, but limited potential exists.

There are several methods of extracting energy from broiler litter. The primary techniques are: anaerobic digestion (AD) and pyrolysis which includes gasification, and direct combustion[91]. There are research projects underway in the State on alternative uses of litter including generation of energy.

1. Anaerobic Digestion

The Bioplex project at West Virginia State University (WVSU) is an early thermophilic anaerobic digester (TAD) demonstration unit operating on broiler litter. This pilot plant has been continuously operating on chicken litter since 2003; the results derived from its research suggest this technology being feasible as a waste control and potentially as energy source on the farm. In

[88] U.S. Environmental Protection Agency (April 26, 2012) "Landfill methane outreach program" http://www.epa.gov/imop/basic-info/index.html Accessed May 1, 2012
[89] U.S. Environmental Protection Agency (October 11, 2011) "Landfill and LFG Energy Project Database-West Virginia". http://www.epa.gov/imop/publication-tools/state-resources.html Accessed April 30, 2012
[90] Information supplied by Steve Kaz of the Utilities Division of the WV Public Service Commission
[91] Martin J. (n.d.). "Options for Using Poultry Litter."

2007 Brinson Farm in Mississippi became the first on-farm TAD unit installed to operate solely on broiler litter[92]. The facility also generates electricity.

The main research focus of the Bioplex digester program at WVSU has been: (1) to study the effect of temperature control strategy, frequency of feeding and organic overloads on digester performance[93]. The university has developed its own computer control software for the pilot plant based on real-time feedback of pH, temperature, and biogas composition and production. Reduction in pathogens during digestion is an important feature of the system. Various experiments evaluate pathogen kill over time and demonstrate that the material remaining after known incubation times is not viable.

WVSU has also proposed recommended practices for the use of digested poultry-litter solids and liquids as replacements for commercial fertilizers using test crops to demonstrate nutrient management practices when land-applying combinations of digested, poultry-litter liquids and solids. Due to the high cost of producing energy from the digester, the focus of the research has historically been pathogens and fertilizer products. A 2005 report from WVSU states[94]: "Methane gas production from anaerobic digestion of animal manures is still not sufficient to justify construction of capital intensive regional digesters, even when natural gas prices were at $12 per 1000 cubic feet."

WVSU also operates a "plug flow" digester, which is more suited for odor control but is less often used to generate electricity or other byproducts. Plug flow digesters are smaller and less expensive than anaerobic digesters, and the output of the digester is a more flowable material. This type of system may be more suited to small and medium-sized farms when faced with the requirement to utilize all their litter on-farm[95].

2. Gasification

The Frye Farm gasification plant in Hardy County, WV utilizes up to 5,300 tons of broiler litter per year, with full capacity of 1,200 pounds per hour. Replacing propane costs was only one component of the project. As compared to propane heaters, this system reduced moisture in farm poultry houses, thereby reducing the concentration of ammonia in the air which improved bird health.[96]

3. Pyrolysis

A mobile Virginia Cooperative Extension and Virginia Tech University sponsored demonstration pyrolysis unit in Rockingham County, Virginia can process up to 5,500 tons of litter per year. The system is designed to produce slow release fertilizer (bio-char), bio-oil for use as heating oil,

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[92] Arora, S. (2011)"Poultry Manure: The New Frontier for Anaerobic Digestion."
[93] West Virginia State University. "Bioplex Research Description" 2005.
[94] Ibid.
[95] Correspondence with John Bombadier of West Virginia State University, July 15, 2010.
[96] Correspondence with Mike McGolden of Coaltec, Inc February 15, 2008.

and biogas that can be used to heat poultry houses. The process is considered “fast pyrolysis” and operates at a temperature of 400 to 450 degrees Celsius. Because the unit is mobile it can be transported from farm to farm as needed[97].

4. Incineration

Incineration is the most commercially available and lowest-cost method of producing energy from poultry litter. It allows removal of large quantities of poultry litter in a centralized location and can utilize a combination of various types of biomass. A long-proposed incineration plant in Salisbury, MD is being revived in part due to new a State law that specifically allows such electricity to comply with its renewable portfolio standard. The proposed combined-heat-and-power (CHP) biomass boiler operation will create 70,000 pounds per hour of steam for an adjacent Perdue Agribusiness complex using a combination of poultry litter, layer hen manure, wood chips and other local biomass[98].

Each of the four methods of converting broiler litter has its own benefits. However, because of its current value as a fertilizer, broiler litter is unlikely to become a suitable resource for energy production unless environmental regulations restrict its use as a fertilizer. Even then, litter is likely to require a large subsidy in order to be developed.

Demand for litter as a fuel may have to compete with the market for treated litter, which may possess superior economics compared to development for energy[99]. Treated litter products retain some nutrient value and could eventually become more marketable as a fertilizer. If EPA regulations remove litter as an income stream for growers, many farms may be faced with a dual problem of excess litter and reduced revenue. In this event, providing an incentive to utilize litter in the growing operation may be more logical.

State financial incentives specifically for poultry litter are rare. Most incentives are directed toward the energy conversion technology or animal waste in general. Anaerobic digestion is included as a qualifying portfolio standard technology in several regional states including West Virginia, Delaware, Maryland and Pennsylvania although the type of waste that is digested is not specified. In May 2012 the Maryland legislature enacted a bill allowing thermal energy associated with biomass systems that primarily use animal waste to qualify as Tier I resources under the State RPS. AD is also available for corporate tax credits taken against electricity produced in Maryland. In Pennsylvania, AD is eligible for grants and loans through the State Alternative Energy Investment Fund. AD was included as a local option under Ohio’s Special

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[97] BioEnergy Planet, Inc.(2010) “Carbon-Negative Network” http://www.carbonnegative.us/docs/BEP_Pyrolyzer.pdf Accessed August 2, 2012)

[98] Biomass Magazine (December 30, 2011) “Poultry-litter-to-energy partners propose 10 MW facility for MD.” *Biomass Magazine*

[99] Risch C. (2008) “Evaluation of opportunities to commercialize thermophilic anaerobic digestion (TAD) of boiler litter in the Mid-Atlantic Region.” Center for Business and Economic Research, Marshall University, Huntington WV.

Energy Improvement Districts legislation, a low-interest loan program, although the program was suspended[100].

Due to the markets that already exist for broiler litter, the use of chicken litter as energy feedstock is not a viable option in the next five years. If environmental regulations become more stringent alternative uses of litter including energy may become more viable. Even in the presence of greater environmental restrictions on the use of litter, developing poultry litter to produce energy may not be the best use. The markets for other litter products, primarily the fertilizer market, may prove more feasible.

G. Biomass and Biofuels Policy in West Virginia

The West Virginia "Alternative and Renewable Energy Portfolio Standard"[101] (W.Va. Code 24-2F-1 et. seg. and SB 350 6/11/2010) stipulates that utilities must obtain 25 percent of their energy resources by 2025 from alternative and renewable resources. Appropriate biomass sources include: landfill gas, biomass, municipal solid waste, biodiesel and anaerobic digestion[102]. As of 2009, renewable energy produced in West Virginia amount to 35.6 TBtu with a statistically insignificant amount coming from biomass and biofuels[103].

Other than using biomass as a means of meeting the State's Renewable Portfolio Standard and the incentive for schools to use biodiesel, there are no specific laws, regulations, tax credits, subsidies or other incentives for use of biomass in the State[104]. There are provisions for use of alternate fuels in vehicles and transportation, but these apply only to fuels such as natural gas, propane, electricity, hydrogen, and coal-derived liquid fuels but not biomass.

Programs to encourage use of biomass in surrounding states are provided in the following graphic.

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[100] Database of State Incentives for Renewables & Efficiency (2011) *DESIRE solar policy guide: A resource for state policymakers.* North Carolina Solar Center, North Carolina State University, Raleigh NC

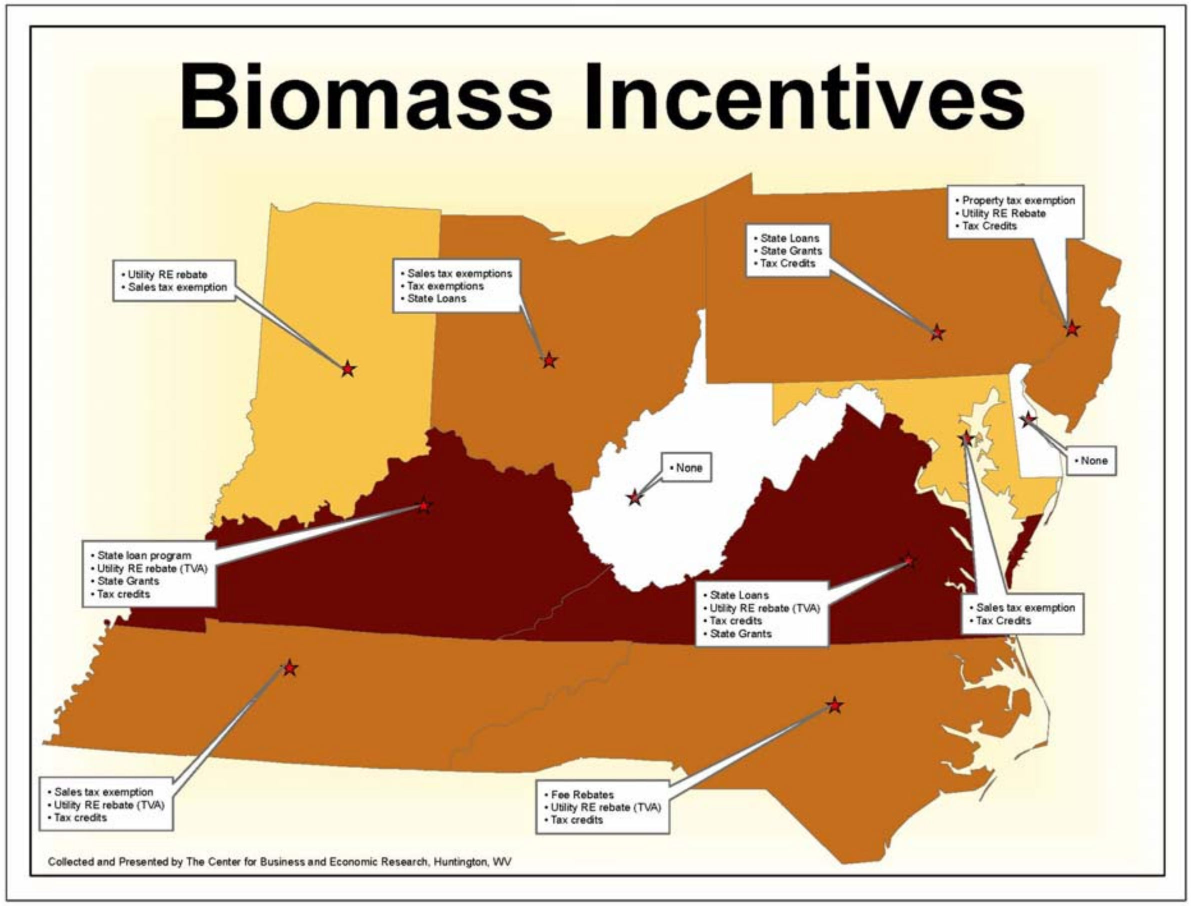
[101] W.Va. Code 24-2F-1 *et.seg.* and SB 350 June 11, 2010

[102] W.VA Code 24-2F-3(13)

[103] U.S. Energy Information Administration (December 12, 2011)" State Energy Data System" http://205.254.135.7/state/seds/hf.jsp?incfile=sep_use/total/use_tot_WVahtml. Accessed April 4, 2012.

[104] Alternate Fuels and Advanced Vehicles Data Center (nd) "West Virginia incentives and laws" U.S. Department of Energy-Energy Efficiency and Renewable Energy http://www.afdc.energy.gov/afdc/laws/laws/WV Accessed April 17, 2012

Figure 10:Map of Regional Biomass Incentives



East Coast states have a variety of incentives for the production and distribution of bio-fuels[105].

- (Uncapped) Producer Production Incentives are provided to producers primarily in the form of tax credits and reimbursements for the percentages of capital costs of the project with no monetary limit. (IN, MA, OH) Ohio provides payments to ethanol producers up 50 percent of invested capital in ethanol plants. This program expires tax year 2013.
- (Capped) Producer Production Incentives are the same as above, but the amount of the credit or reimbursement is capped at a dollar amount. (IL, IN, KY, MD, MS, PA, TN, VA) which varies based on the fuel stock and type of facility. Kentucky provides an income tax credit to biodiesel producers of $1 per gallon with a statewide cap of $1.5. Million. Maryland provides a 20 cent per gallon subsidy for ethanol or biodiesel made from soybean oil and a 5 cent per gallon subsidy if made from other small grains. Virginia provides a grant of 10 cents per gallon for biofuels sold in the state.

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[105] Koplow, Doug (October 2006) *Biofuels-at what cost? Government support for ethanol and biodiesel in the United States.* Global Studies Initiative (GSI) of the International Institute for Sustainable Development (IISD), Geneva, Switzerland

- Government Renewable-Fuel Vehicle Purchase Mandates provide for the state to discount or reimburse for the cost of obtaining renewable fueled vehicles. (IN)
- Grants, Subsidized Credit and Tax Concessions related to capital investment includes loans, loan guarantees and tax credits to increase renewable fuel plant development projects for new or existing facilities (DL, IL, IN, KY, NJ, NY, NC, PA) Both Kentucky and Pennsylvania have made small grants for ethanol and biodiesel facilities.
- Government-Funded Research, Development, Demonstration Projects and Market Promotion encompass grants and rebates for biofuel research and demonstration projects. (DL, IL, NY) Illinois and New York have programs to fund research related to ethanol and biodiesel production with an emphasis on cellulosic ethanol.
- Consumption Subsidies provides rebates for state and local governments and private consumers who purchase alternative fuels. (MD, NJ, NY, NC) Maryland has a 50 percent rebate of the incremental cost of purchasing blended biodiesel.
- Subsidies for Infra-structure Related to Biofuel Distribution provide grants, tax credits and cost reimbursements for the installation costs of biofuel infrastructure. (IL, IN, KY, MA, NJ, NC, OH, TN) Ohio's program provides a $5,000 grant for facilities to handle E85 and $15,000 grant for B20 infrastructure.
- Subsidies to Biofuel Consuming Capital including tax credits for the purchase of alternative fueled vehicles and/or mandates requiring the purchase of these. (GA, IL, WV) West Virginia has a $3,750 tax credit to be taken over three (3) years for E85 infrastructure.
- Support for the Production of Feedstocks/Renewable Fuel Mandates refer to expedited permits for biofuel plants and mandates or goals for state and local government use of renewable fuels (IL, NJ, NY, NC, OH, VA, MD, WV) the Ohio program mandates the purchase of vehicles in the state fleet to be able to drive on E85 while Virginia's program only encourages state fleets to use biodiesel when available.

H. Conclusions

Based on the above analysis there are possible conclusions to be drawn regarding renewable biomass energy policy under the State's Energy Plan for the upcoming five years.

- There is little likelihood that ethanol production from corn will occur in the State due to the need for corn ethanol plants to be near significant sources of supply. Corn is not a major crop in terms of total production in West Virginia.[106]
- There is very limited potential for development of biodiesel as an industry in West Virginia. Biodiesel was manufactured only at the AC&S facility in Nitro West Virginal which could operate a three (3) million gallon a year batch plant[107]. Production of soybeans in the State is insufficient to supply a major bio-diesel facility.[108] If the biodiesel industry were to develop most of the feedstock would have to be imported from out-of-state providing less economic impact than development using other fuels.

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[106] Hanshaw, Robert. (September 5, 2007) "Biomass and ethanol production: A new role for West Virginia agriculture? WV Department of Agriculture.

[107] US Energy Information Administration, "Biodiesel Monthly Report" http://www.eia.gov/cnef/solar.renewables/page/biodiesel/table_4.html , Accessed April 26, 2012

[108] Hanshaw, op.cit.

Currently there is only one biodiesel distribution center in West Virginia at Inwood on IH 81 south of Martinsburg. Encouraging use of biodiesel has environmental benefits but these have not been quantified.

- Considering the extent of forestation in West Virginia, study of the use of woody biomass as a fuel should be explored. The U.S. Forest Service in 2010 claimed West Virginia is one of only a few states which have heavy forestation which has not prepared an evaluation of biomass availability and utilization as an energy source.[109] A 2007 report does discuss the use of wood as a fuel and indicates the processes which could be used to reduce the cost of using wood as a co-generator with coal at West Virginia generating plants.[110] But the report indicated that using coal was not cost effective when compared to conventional fuels given current technology.
- There is a possibility that ethanol from switchgrass may have some limited potential in the State. But the need for a production facility in the state and the amount of alcohol fuel which can be produced locally will inhibit its development.
- *A donax* is another bio-fuel which requires advanced research before its widespread use is likely. Considering the availability in West Virginia of reclaimed mine land and other marginal soil in West Virginia, technological developments should be monitored. As is the case with all biofuels there will be a need to locate a bio-refinery nearby if the potential is to be developed.
- While it does not appear that population densities in West Virginia are insufficient for WTE projects to be feasible, the success of facilities elsewhere is worthy of future investigation. The possibility of forming regional authorities around the State's population centers to construct these facilities is an option for consideration as is the only way such facilities could become feasible. This would require special legislation.
- Energy from LFG, merits only limited consideration. Currently there are only two WTE landfills operating in the State. Contacts with operators of the other landfills indicate little possibility that development is likely to occur within the next five years.

I. Overall Recommendations

- None of biomass alternative or renewable energy sources considered in this report is likely to provide fuel or electricity at a lower cost than currently is supplied by traditional sources. Environmental restrictions or fees at the federal level may alter than situation and increase the ability of alternate and renewable fuels to compete. Over the next five years the WV Department of Energy should remain conscious of any regulatory developments which would increase the competitiveness of biomass.
- The speed of transition from current fuels to biomass can be increased only if the State is willing to subsidize these alternatives or to allow for rate increases to cover the increased costs. Neither option is recommended.

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[109] U.S. Forest Service (nd) "State woody biomass utilization assessments and strategies" http://fs.fed.us/woodybiomass/state.shtml Accessed April 14, 2012.

[110] Wang, J, Grushecky, S, McNeel, J. (September 10, 2007) *Biomass resources, uses and opportunities in West Virginia, West Virginia University,* Biomaterials and Wood Utilization Center, Division of Forestry and Natural Resources, Morgantown WV pp.65-68.

- While not fully developed in this report there is a need for monitoring of potential transportation difficulties relating to all energy fuels and the electricity generated from them in the State. Particular emphasis should be placed on the ability of the transmission grid to accommodate any additional electricity which might be potentially come available in the next five years. While this does not currently appear to be an issue, monitoring by the Public Service Commission is appropriate.
- Environmental concerns regarding alternative and renewable fuels should be fully addressed over the next five years. Information from this investigation should be used to determine what legislative or regulatory action, if any, is desirable. This consideration should be completed prior to any policy changes.

J. Specific Recommendations

- Efforts to promote corn ethanol or its increased blending into gasoline should be resisted as there are no economic benefits to the state. Considering the environmental objections to its use, the case for not encouraging expanded use of ethanol is further supported.
- The cost to the State of supporting biodiesel use in school districts should be studied before new incentives are provided or existing incentives continued. Currently no adequate data exists which would allow for this study to be completed. The Department of Education should collect the data in a useable format.
- Since West Virginia has not prepared an evaluation of wood biomass availability and utilization as a fuel.[111] The Department of Forestry should be tasked with that undertaking. Preparation of the analysis should be a high priority.
- Several projects are underway across the nation in creating rural woody biomass industries as a form of rural community development. Over the next five years the WVDO should consider if the use of small scale electric generation facilities in the more remote locations of the state could be an incentive for the attraction of economic development into those areas. The State Department of Natural Resources should determine if the use of small scale power facilities would be beneficial to recreational and other areas which are not currently connected to the grid or if these would provide power at lower costs.
- There is a need for further research on switchgrass and *A donax* potential considering the pilot projects on reclaimed mine sites already underway.
- Use of MSW for the production of electricity under WTE has shown some success elsewhere. It might be feasible in West Virginia if conducted on a regional basis in order to establish a sufficient and dependable volume of waste. An evaluation of this potential should be a joint project of the WV Department of Environmental Protection (WVDEP) and WVDOE.
- At this time there appears that LFG does not hold great potential for the state. But continued monitoring of developments in the area by the WV Department of Energy is merited In light of the nine landfills which are "candidates" for LFG projects and the 10 others which are "potential" sites, work with the U.S. Environmental Protection Agency's Landfill Methane Outreach Program (LMOP) the WVDEP should continue to determine if any of these sites can be readied for use within the five year timeframe of this plan.

[111] U.S. Forest Service (nd) "State woody biomass utilization assessments and strategies" http://fs.fed.us/woodybiomass/state.shtml Accessed April 14, 2012.

- The WV Department of Agriculture (DOA) should stay up-to-date regarding decisions made by the EPA to restrict current uses of litter. In the event that restrictions put pressure on poultry farms, offering some sort of tax incentive to install energy systems that meet compliance may be considered. However, other less costly and purely agricultural litter systems that do not incorporate energy conversion may be better suited to the needs of the industry. The WV DOA should be the lead state organization to identify the future approach.

III. Overview of Solar Energy in the US and WV Energy Picture

Solar-powered electricity production is still small relative to total production and consumption in the U.S. However, solar generating capacity has grown sharply in recent years. As of 2011, there were approximately 2,500 MW of photovoltaic (PV) capacity installed in the United States.[112] In 2010, annual global PV module shipments exceeded 17,000 MW, a 120% increase over 2009 although going forward research suggests that the growth rate could subside to a forecasted 14% growth in 2011 and 20% in 2012.[113] Much of this recent growth was driven by stable federal incentives, largely tax credits and cash grants provided through stimulus funding which were concentrated in the year 2010.[114]

As expected, states with higher insolation produce larger quantities of electricity from this resource than does West Virginia. Table 1 below provides a comparison of average annual solar insolation for select cities, demonstrating the variation in intensity by geography.[115]

Table 1: Average Annual Solar Insolation

Area	**kWh/m^2/day**		**Area**	**kWh/m^2/day**
Daggett, CA	6.51		Philadelphia, PA	4.75
Las Vegas, NV	6.31		Charleston, WV	4.55
Flagstaff, AZ	5.91		Cleveland, OH	4.31
Austin, TX	5.24		Boston, MA	4.23
Atlanta, GA	5.03		Seattle, WA	3.67

SOURCE: PV Watts (2012).

An index called the Solar Optimum Deployment Index (OSDI) ranks each of the 50 states by several factors that make installation of solar capacity desirable. These factors are the level of insolation, the amount of economic activity that would be created by the facility, the cost per watt to install the facility, the price of electricity in the state and the carbon dioxide that the solar-generated electricity might offset based on the generation mix in that state. The OSDI ranks West Virginia 24th out of 50, presumed to be due largely to the current carbon-heavy generation mix, even though the state's solar insolation is only ranked 8 out of 50, with 50 being the best. If only costs and insolation are considered West Virginia is ranked 29th. If only price and CO^2 savings are considered West Virginia is ranked 35th. Based on these rankings it is concluded that the optimal location for solar deployment is in the western U.S., which should be most heavily developed for its solar resources.[116]

112 (NREL 2011)
113 (Electric Power Research Institute 2011)
114 (Interstate Renewable Energy Council 2011)
115 (NREL 2012)
116 (Croucher 2010)

A. Utilization Trends

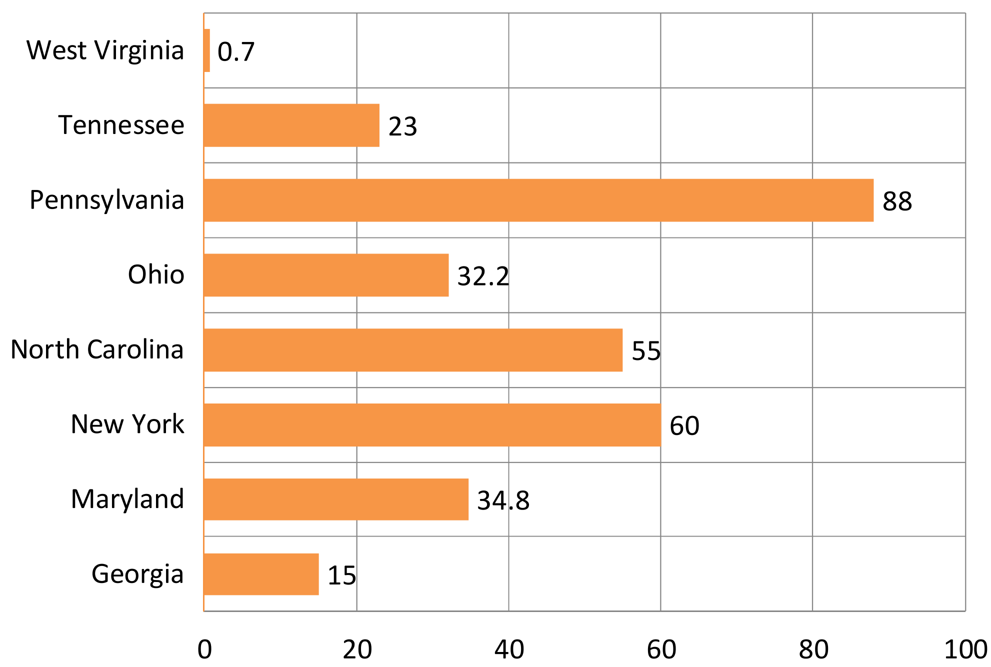
Demand for solar energy systems in the United States is concentrated in the West, with California being the largest market with 28 percent of installed capacity in 2010.[117] In the eastern U.S., states with solar mandates have seen considerable growth in installations. Regionally these include the states of Pennsylvania, Ohio, North Carolina, New Jersey, New York, Maryland and Delaware as well as the District of Columbia.

A study of State-level solar installation for the time period of 2000 to 2008 concluded that states with higher levels of installations have not just better solar resources in common.[118] States with higher levels of solar deployment tend to have the following characteristics:

- larger populations
- higher average incomes
- higher electricity or natural gas prices
- a need to import more energy
- better solar resources
- a more liberal citizenry.

The following figure compares installed solar capacity for select regional states as of the end of 2011. West Virginia has about 660 KW of installed solar capacity at public and commercial sites as of early 2012. If residential installations were included the number would be larger.

Figure 11: Cumulative Installed Solar Capacity for Select Appalachian States[119] [120]



117 (Interstate Renewable Energy Council 2011)
118 (Sarzynski 2009)
119 (Solar Energy Industries Association 2012), (Clean Technica 2012), (Saporta Report 2012) and WVPSC 2012.
120 Capacity for NY, PA and NC from Clean Technica; capacity for OH and MD from SEIA; capacity for TN from Wikipedia. Capacity for GA from the Saporta Report; capacity for WV from the WVPSC.

1. Solar renewable energy credits

Solar renewable energy credits (SRECs) have come to play a very important role in the demand for and utilization of solar energy. SRECs are state-specific markets for electricity generated by solar energy and are tied to state mandates that solar energy comprise a portion of renewable portfolio standards. Typically, one SREC is issued for each MWh of electricity generated from a solar electric system. The price of an SREC is tied to the rate required to be paid for non-compliance, a solar alternative compliance payment (SACP), and the existence of a SACP. Another important factor is whether the state SREC market is open or closed to systems installed outside of the state.

Regional states with SREC markets are New Jersey, Pennsylvania, Delaware, the District of Columbia[121], Maryland and Ohio. The State of North Carolina has a solar mandate but has no alternative compliance payment requirement and thus has no real market for SRECs.[122] Most of these states are closed to participation by outside systems. Ohio allows participation by bordering states only at an amount equal to 50 percent of the solar set-aside. Pennsylvania is the only state whose SREC market is currently open to all states within the PJM region.[123]

Table xx shows the range of SREC prices for various states over the last two to three years. As SACP levels are set to decline over time, the prices for SRECs decline as well.

Table 2: Range of Prices for Regional SREC Markets ($/MWh)

STATE	2012/2013 Compliant?	2012	2011	2010	Market Open To
Delaware	Yes/No	$40-$60	$60 to $260	$200 to $300	DE only
The District	No/No	$240-300	$20 to $325	$250 to $405	DC only
Maryland	No/No	$170 to $218	$175 to $320	$320 to $390	MD only
New Jersey	Yes/Yes	$155 to $245	$550 to $670	$640 to $660	NJ only
Ohio	Yes/Yes	$30 to $285	$30 to $400	$290 to $400	IN, MI OH, PA, WV
Pennsylvania	Yes/Yes	$16 to $20	$10 to $250	$200 to $310	DC, DE IL, MD, NC, NJ, OH, PA, VA, WV

Sources: (SRECTrade Inc., 2012) and Flett Exchange.

It has been stated that, in the case of Pennsylvania, market inclusiveness combined with lack of a firm SACP level has caused an oversupply of SRECs and suppressed prices. The Pennsylvania SACP is 200% of the average market value of SRECs sold in that energy year and is not disclosed until six months after the close of the energy year.[124] New Jersey, on the other hand,

121 Only out-of-state systems registered prior to 1/31/2011 can continue to sell SRECs in the DC market.
122 (SRECTrade 2011)
123 (Flett 2012)
124 Ibid.

has pre-set prices for SACPs. State legislatures are responsible for setting SACPs and some states adjust portfolio goals in an effort to keep prices high and avoid volatility.

2. Trends in prices

The price of solar PV modules has declined steadily over the last 30 years, falling to nearly $2 per watt in 2010 from $23 per watt in 1980 (NREL 2011). The cost of installed systems has fallen from about $11 per watt in 2001 to around $7 per watt in 2010 for "behind-the-meter" or utility customer-connected systems.[125] Larger installations tend to be less expensive per watt than smaller installations due to economies of scale and volume discounts.

The supply of solar panels manufactured in Asia has been one driver of reduced systems costs for consumers in the U.S. In 2010, 59 percent of all PV cells were produced in China and Taiwan.[126] In 2011, low-priced panels induced a "dumping war" of solar manufacturing products between the US and China when the U.S. Department of Commerce stated that is was considering countervailing import duties against Chinese PV module producers, a move that benefited manufacturers in Taiwan.[127] According the Solar Energy Industries Association U.S. solar PV manufacturers produced 1,100 MW of panels in 2010, nearly double that of 2009.[128]

Most solar PV installations are residential. As of 2010, more than 139,000 of 154,000 PV installations connected to the grid were residential.[129] Utility-scale solar systems have also been installed in greater numbers in recent years and dwarf residential and average non-residential systems in size. Most of the 74 utility-scale systems - as listed in a PV Insider report - are located in the southwest and Florida but 17 are located in the Eastern U.S. Additional projects are in the development stage.[130]

Table 3: Regional States With Operational or Under Construction Utility-scale Solar Systems

State	# of projects, Capacity	Electricity Purchaser(s)
Delaware	1 project, 10 MW	Delmarva Power
Illinois	1 project, 20 MW	Commonwealth Edison
Indiana	1 project, 10 MW	Indianapolis Power & Light
Maryland	2 projects, 26 MW	Constellation Energy, NA
New Jersey	6 projects, 87 MW	Atlantic City Electric, Vineland Municipal, NA
New York	2 projects, 37 MW	Long Island Power Authority
North Carolina	1 project, 17 MW	Duke Energy
Ohio	2 projects, 22 MW	American Electric Power, Campbell Soup Co.
Pennsylvania	1 project, 20 MW	NA

Source: (PV Insider 2012)

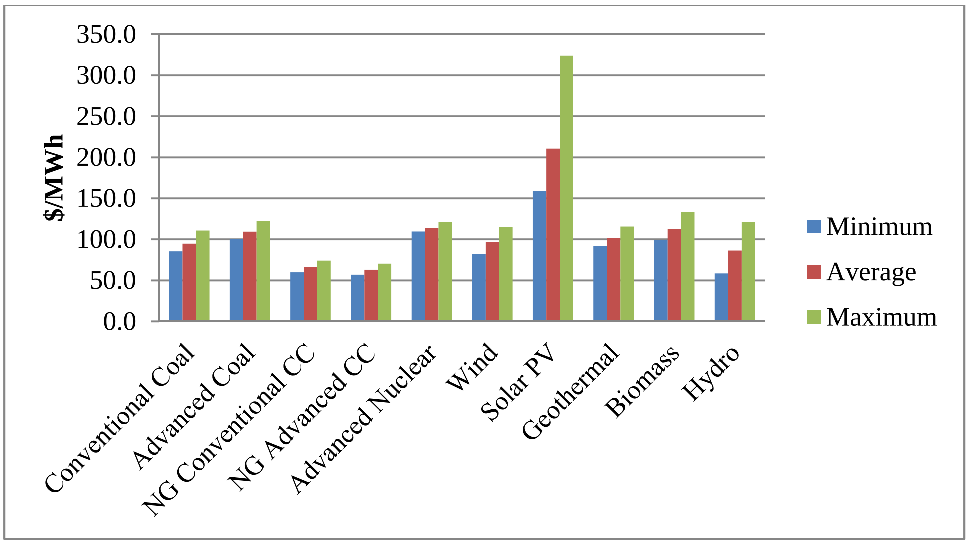
[125] (NREL 2011)
[126] Ibid.
[127] (PVTech 2012)
[128] (NREL 2011)
[129] (Interstate Renewable Energy Council 2011).
[130] (PV Insider 2012)

Other industry trends include the increasing size of a solar system both for residential and non-residential installations. For residential installations the average system size increased from around 3 kW in 2001 to nearly 6 kW in 2010. The average non-residential system increased from around 30 kW in 2001 to 80 kW in 2010.[131]

3. Cost of Production

In terms of an annualized cost per MWh of electricity produced, the levelized cost of electricity (LCOE) produced from solar systems has declined but remains high compared to other resources. Figure xx shows Energy Information Administration (EIA) estimates of LCOE for new power plants to be brought on line in 2016, including solar and other types of facilities.[132]

Figure 12: Estimated Levelized Cost of New Generation Power Plants[133]



SOURCE: Energy Information Administration (EIA), 2010.

State and federal tax incentives are not included in the above figures. Federal incentives have had a significant impact on the level of solar installations over the last few years. Such incentives lower these costs by subsidizing a portion of capital or by allowing a portion of capital costs to be deducted from taxes owed. The Emergency Economic Stabilization Act of 2008 removed the investment tax credit cap for both residential and commercial systems, extended it to 2016 and also made utilities eligible for the credit.[134] This incentive allows individuals and corporations, including utilities, to receive an uncapped tax credit equal to 30 percent of the cost of the PV system.

[131] (Interstate Renewable Energy Council 2011)
[132] LCOE figures include overnight capital costs, fuel costs, fixed and variable O&M costs, financing costs and assumed utilization rate for each plant type.
[133] "NG" refers to "natural gas-fired plants" and "CC" refers to "combined cycle."
[134] (NREL 2011)

4. Competitive Position

The current state of solar electricity production is well-summarized by the following quote from the Managing Editor of Renewable Energy Focus. “The key factor for now in determining the potential returns and thus cost-competitiveness of solar PV from an investor's view is the level and life-span of public subsidy available to it in any give location.”[135]

The cost of electricity based on the cost to generate a unit of electricity is not the only important aspect of the resource. The issue of grid integration is also very important, and one that makes achieving the avoided emission goals of deploying solar energy less possible. Because insolation is variable, a solar-powered system does not offset conventional generation all the time or even at a constant rate when it is generating. Conventional generation must still be made available to serve electricity load whenever solar resources are not available, e.g. at night and when it is too cloudy to generate. While peak solar energy output corresponds somewhat closely with increasing load during much of the year, approximately 10am to 3pm, the ultimate peak load occurs earlier or later in the day when insolation is much less. In a 2008 study, Carnegie Mellon University concluded that solar PV systems have a larger magnitude of power output fluctuation than wind energy and that the costs of large scale solar PV integration are thus likely to be larger than those of wind.[136]

The National Renewable Energy Laboratory hosted a workshop on utility-scale PV integration in 2009. The primary lesson learned was that more data was needed in order to fully understand the impact of solar variability on system operations, particularly with attention paid to the impact on real-time power quality.[137]

Thus, a grid-connected solar facility’s ability to offset conventional generation and reduce emission from fossil fuels is not one to one because system resources must still be committed. This is evidenced by the presentation of utility requests to recover the costs of providing stand-by power to customers with net-metered systems. The Commonwealth of Virginia allows utilities to impose “stand-by charges” on net-metered systems larger than 10 kW, including expedited processing by the Virginia State Corporation Commission for such requests.[138] While the fossil emissions avoided by solar facilities is unlikely to be zero on an annual basis it is also unlikely that every MWh of solar-generated electricity can offset the emissions generated by the system in producing one MWh.

5. Future Prospects

The trend of declining capital costs is not expected to continue. Current module prices are said to be nearly too low to sustain manufacturing and there is excess supply in the market.[139] As many federal and State financial incentives are disappearing or diminishing, the affordability of solar systems is not likely to improve in the near-term.

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135 (Rajgor 2012)
136 (Apt and Curtright 2008)
137 (NREL 2009)
138 (Pierobon 2011)
139 (Botha 2012)

Considerable resources are being devoted to understanding and improving the grid integration issue. Among these are the National Renewable Energy Laboratory's Energy Systems Integration effort (NREL 2012) and stakeholder groups such as the Utility Variable-Generation Integration Group (UVIG) - formerly the Utility Wind Integration Group - a consortium of utilities, grid operators and regulators devoted to accelerating the integration of variable resources into utility power systems (UWIG 2012). The results of the next few years of research will more clearly reveal the opportunities to efficiently deploy technology to capture solar energy. In terms of the PV systems that would be deployed in West Virginia, newer generation modules with higher efficiencies are being developed. However, due to lower insolation it is more expensive to capture solar energy in places like West Virginia and these systems are also less able to induce significant emissions reductions.

B. **West Virginia Law Relating to Solar Energy**

1. Legislation/Regulation

Solar energy is specifically listed as a resource eligible to participate in net metering arrangements per the WV Public Service Commission.[140] There are no special provisions applicable to solar energy required of the WV PSC outside of interconnections standards that apply to all net metering projects.

Solar energy is also listed as an eligible resource to comply with the State Alternative and Renewable Portfolio Act.[141] The Act includes no mandated share of generation that must be supplied with solar.

West Virginia passed legislation protecting solar access rights. H.B. 2740 restricts housing associations from prohibiting solar energy systems on homes, although housing association members may vote to establish or remove such restrictions.[142]

2. Tax Policy

Under WV Code §11-13Z-1 the State provides a $2000 personal income tax credit for households that install solar energy systems. The credit applies to residential systems that: 1) generate electricity; 2) heat or cool a structure; or, 3) provide hot water for use in the structure or to provide solar process heat. Swimming pools, hot tubs or any other energy storage medium that has a function other than storage are not covered unless the system used to provide hot water derives at least fifty percent of its energy to heat or cool from the sun. As currently worded, the credit does not apply to systems installed after July 1, 2013.[143]

[140] (WV PSC 2010)
[141] (WV Legislature 2009)
[142] (DSIRE 2012)
[143] (WV Lesiglature 2011)

C. **Policy Options**

1. Portfolio standards/Solar Mandates

The primary state-level incentives used to induce solar installations are solar set-asides, also known as solar carve-outs. Regional states with solar set-asides mandate that solar energy comprise a set portion, often two percent, of the state's renewable portfolio standard. This amount is made mandatory through setting of alternative compliance payments that a utility must pay if they do not meet the state target. Solar renewable energy credits (SRECs) represent the value of the compliance payment, which is set by state legislatures.

2. Rules and regulations

State-level regulation of solar energy is largely limited to the utility portfolio standard requirements discussed above. Some states have siting rules that affect solar facilities, but such rules primarily ensure that siting can occur and are in the form of access rights, easements or siting standards. Siting regulations are more common in states with solar mandates. For example, New Jersey has a law allowing solar-powered electricity production as a permitted use in qualified industrial zones. The State of Maryland provides a solar access easement to preserve the exposure of solar energy devices to the sun.[144]

3. Taxation

Several states have developed ways to encourage solar installations through exemption from various taxes including: sales tax, income tax (like that currently allowed in WV), property tax, etc. Presently, solar panel purchases in West Virginia are subject to the State sales tax. Solar panels themselves are not officially exempt from local property taxes, although since most installations are relatively new it is unlikely that property appraisers have included the panels in valuation.[145]

As there are no utility-scale solar facilities in West Virginia the question of what rate to tax such generation has not been raised and it is assumed that solar-powered electricity would be taxed at the same rate as non-wind generation. The property tax exemption that currently applies to utility-scale wind generating equipment in WV also does not apply to solar equipment.

Other states have put in place incentives designed to recruit solar equipment manufacturers. The State of Virginia offers a direct payment of $.075 per watt of panels sold.[146]

4. Other incentives

144 (Database of State Incentives for Renewables & Efficiency 2011)
145 (Sherald 2012)
146 (DSIRE 2012)

States have also instituted low cost loan and grant programs to promote adoption of solar energy systems. Such programs are heavy on paperwork, inefficient and arguably inappropriate for state governments to undertake. Some state grant funds may now be greatly reduced as many were largely ARRA-funded. In West Virginia, most consumers will not be willing to enter into a loan agreement for a solar electricity system with the payback they would receive as borrowing money simply increases the cost of a system.

Most states in the region have chosen to fund solar by passing costs along to all electricity customers via their utility. Given the recent utility rate increases imposed on West Virginia ratepayers it is unlikely that the PSC CAD and other rate case interveners would support such surcharges.

The following graphic shows the types of incentives that are available to develop solar resources in regional states. Local or non-profit incentives are not included. West Virginia has fewer incentives for solar energy than most of the nearby states. However, West Virginia is one of only three states in the region that have a personal income tax exemption option for installing solar systems.

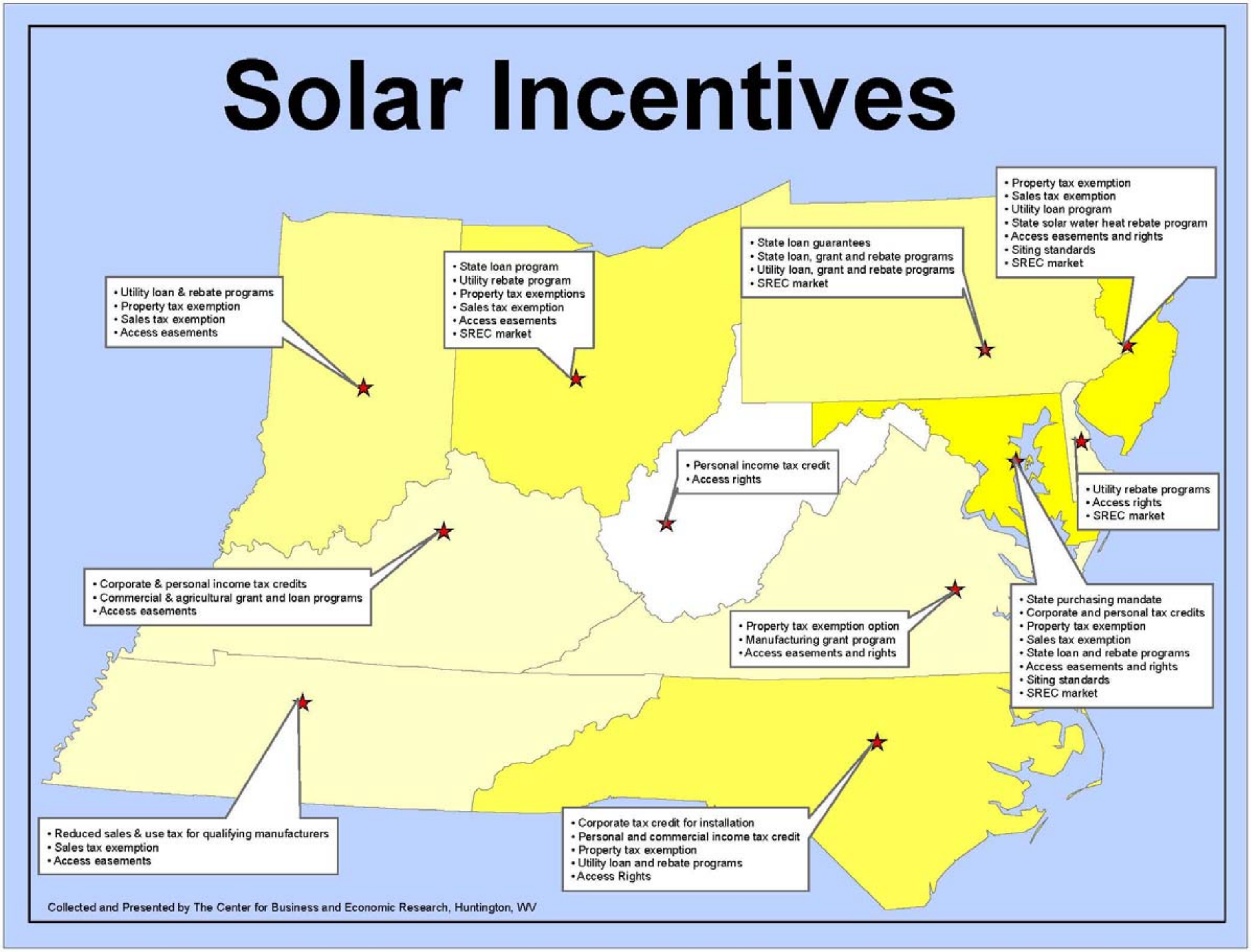

Figure 13:Map of Solar Incentives by State and Type

D. Conclusions

The research has made the following conclusions in terms of the objectives of the Energy Opportunities Document.

- Solar energy is a resource, but it is not as strong in WV as in other areas. On the other hand, WV's insolation is better than most states to the north. Due to grid integration issues, solar energy may not help conserve fossil resources, particularly coal resources, as much as predicted. Off-grid solar applications are likely the most efficient use of the resource.
- Distributed solar energy allows security of electricity supply, to an extent, but to maintain round-the-clock security a facility must still be connected to the grid and able to consume power from grid whenever desired. If a consumer retains that ability some firm external supply must be immediately on-hand at night, and for cloudy days.
- Solar generation does not contribute as much economic value as other resources due to a lack of solar-related manufacturing in West Virginia and the very small level of resources needed for operation. If it is used on top of the existing generation mix it is a small adder, but the funds necessary to support it may be better spent elsewhere.
- Self-generation of electricity is a price hedge, although at an uncertain level, and is more effective with higher electricity rates. Thus, the near-term expansion of solar capacity in the State is not certain to yield savings on electricity expenditures. Funding solar systems through utility rate increases obscures the real price of avoided electricity purchases.
- Assigning the costs of solar energy to ratepayers reduces disposable income of all ratepayers, but especially those who do not invest in solar systems.
- The primary economic benefits of solar generation would come from the applicable state and local taxes: sales, property, and B&O. Ironically, because a primary way to make solar projects competitive is to exempt them from all or some of these common taxes, the main financial benefits are removed.
- Development of an SREC market in the state assigns the role of market maker to the State Legislature, a position that some would argue is inappropriate for a governing body.
- There are benefits to getting experience with an emerging technology such as PV systems. Individuals and households who install PV systems will come to understand the attributes of the technology and can participate in future adoption as technology improves. Local installers also develop valuable capacity regarding utilization of the resource and interconnection in general.
- Solar panel efficiency is expected to increase but will improve more beyond the five-year timeframe evaluated for this report. In addition, beyond the five-year timeframe, grid integration solutions including demand response programs and smart-grid applications will be more widespread, allowing the potential benefits of solar to be more fully captured.

E. Recommendations

This evaluation concludes that there are few reasons to expand State-level incentives for grid-connected solar energy or to mandate production of solar-powered electricity given the current state of technology.

- **Maintain current policies.** The current State income tax credit, when combined with the Federal credit reduces the cost of investing in a residential solar system. This policy is likely to induce some interested WV residents to adopt solar PV technology. The tax credit is an ideal type of incentive to utilize because it is simple for tax payers to take advantage of and it is easy to administer. Adoption of incentive programs involving more complex administration, such as low-interest loan or grant programs, is not recommended.

  While there are unresolved grid efficiency issues related to integration of solar electricity the amount of new solar systems that this policy is likely to induce will be small relative to the total amount of electricity demanded in WV.

- **Monitor the results of research being conducted on the options to efficiently integrate wind and solar resources into the grid.** States with high levels of solar insolation, such as those in the southwest, will set examples for optimal integration. Once integration solutions have been identified and widely instituted, the State could consider adopting more aggressive incentives to deploy solar resources.

  Applicable State Organizations: Division of Energy, Public Service Commission

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IV. Overview of Wind Energy in the US and WV Energy Picture

As of the end of 2010, total installed wind capacity in the U.S. stood at around 40 GW. The year of maximum wind capacity installation was 2009, when 10 GW was added[147]. Recent forecasts of global wind power development project a doubling of installed capacity between 2010 and 2014[148] although the actual level of installation will depend heavily on federal incentives.

In 2010 new wind power projects contributed about 25 percent of new nameplate capacity added to the U.S. electrical grid[149]. Wind installations tend to be higher in the mid-west wind corridor, where output per turbine is higher. Among the U.S. states, Texas leads in installed wind capacity with 10.7 GW. Iowa with 4.4 GW and California with 4.2 GW have the second and third largest capacity.

Wind energy provided 2.9 percent of electricity generated in the U.S. in 2011, up from 2.3 percent in 2010[150]. In states with high wind resources wind provides a larger share of electricity. In South Dakota for example, wind generated more than 22 percent of all electricity produced in the state in 2011, while in West Virginia wind generated just over one percent of electricity produced in the state (EIA 2012). Table x provides a list of regional states with installed wind capacity, national ranking in terms of capacity and percent of in-state electricity generation for each state comparing 2011 and 2010 output.

Table 4: Installed Wind Capacity and Generation in Regional States as of End of 2011

State	Installed Capacity	State Rank in 2011	% of In-State MWh in 2010	% of In-State MWh in 2011
Delaware	2 MW	37th	0.05%	0.04%[151]
Illinois	2.7 GW	4th	2.21%	3.15%
Indiana	1.3 GW	13th	2.34%	2.72%
Maryland	120 MW	28th	0.00%	0.76%
New Jersey	7.5 MW	36th	0.02%	0.02%
New York	1.4 GW	12th	1.90%	2.06%
Ohio	112 MW	29th	0.01%	0.13%
Pennsylvania	789 MW	15th	0.81%	0.86%
West Virginia	584 MW	20th	1.16%	1.39%

Sources: (Wind Powering America 2012), (AWEA 2012) and (EIA 2012).

[147] (AWEA 2012)
[148] (Electric Power Research Institute 2011)
[149] (NREL 2011)
[150] (EIA 2012)
[151] Data not published. Percentage is based on the same output as in 2010.

A. National Utilization Trends

Over the last few years a continuing industry trend has been toward larger average nameplate capacity, hub height, and rotor diameter of installed wind turbines[152]. Some of the reason for this is to serve lower-wind-speed sites, which require larger rotor diameters to be feasible. Larger sized turbines have contributed to higher capacity utilization of wind facilities as higher wind speeds can be accessed with taller towers. Average capacity factors have declined somewhat in recent years due to the need to curtail wind output in some electricity markets and development of lower-quality wind in some areas[153].

The use of recommended processes to more efficiently integrate wind energy into the electricity transmission system is expanding. Ubiquitous recommendations such as consolidated balancing areas, expansion of forecasting, and intra-hour scheduling are being implemented more broadly. The FERC recently mandated that transmission providers offer 15-minute transmission scheduling[154].

Contrary to solar panel supply, wind component supply has trended toward U.S. production rather than away. It is reported that nine of the eleven largest wind turbine manufacturers in the U.S. market had one or more manufacturing facilities in the United States in 2010 (NREL 2011).

B. Utilization in West Virginia

West Virginia currently has five operating wind facilities with a combined nameplate capacity of 610.5 MW. These facilities are

- Florida Power and Light's 66 MW Mountaineer facility in Tucker County
- Shell Wind Energy/Dominion/Nedpower's 264 MW Mount Storm facility in Grant County
- Invenergy's 100.5 MW Beech Ridge facility in Greenbrier County
- AES Corp.'s 125 MW Laurel Mountain facility in Barbour/Randolph County
- US Wind Force's 55 MW Pinnacle facility in Mineral County

Two additional projects have been permitted but are not yet operational, while others are still in early stages of development. Siting a wind facility is a long process. It has been stated that it is just as hard to site a wind plant as it is to site a conventional power plant[155].

West Virginia's potentially developable resources are small by some estimates. Early estimates of the total potential for wind energy resources in WV, including federal or State lands, was 10,780 MW. Excluding most resources on federal or State lands, and counting only resources with an estimated gross capacity factor of at least 30 percent at 80 meters, the most recent statewide estimate is 1,883 MW, a reduction from earlier estimates of 3,800 MW (AWS

[152] (NREL 2010)
[153] (NREL 2011)
[154] (FERC 2012)
[155] (TeleNomic Research, LLC 2011)

Truewind 2010). As the State currently has 584 MW of operating wind capacity there is an additional 1,300 MW that could be developed on private lands. Of this remainder, at least 600 MW worth of projects is known to have been under assessment or permitted. Thus, it is possible that only 700 MW remains as developable without seeking access to public lands. Wind projects have been sited on federal lands in other states but not in the region surrounding West Virginia.

1. Trends in prices

Wind turbine prices doubled between 2002 and 2008, and then fell through most of 2011. Since mid-2011 prices have been rising, largely in response to a demand increase tied to expiration of the federal grant program[156]. Total installed costs are a function of turbine capital costs as well as development costs, interconnection costs and construction costs and are expected to decline somewhat in the near-term as turbine prices are expected to decline (NREL 2011).

2. Cost of Production

In terms of an annualized cost per MWh of electricity produced, the levelized cost of electricity (LCOE) produced from a wind facility ranges from around $60/MWh for onshore systems with high-quality wind to about $152/MWh for offshore systems[157] [158]. High quality wind resources, such as those found throughout much of the Midwest, are able to produce electricity at a cost that is competitive with conventional coal-fired electricity. Regionally, West Virginia is an Eastern state and prices for wind energy produced in the region - based on a sample of purchase power agreements - are higher than average but not as high as in California[159].

3. Competitive Position

As with solar energy, the cost of electricity based on the cost to generate a unit of electricity is not the only important aspect of the resource. The federal PTC is a primary driver for installing wind generation. In the absence of this subsidy only the highest quality wind sites are likely to be competitive with conventional generation. Wind resources in the Midwest are superior to the resources available in West Virginia and other onshore sites in the Eastern U.S. On average, West Virginia's best wind resources are in the range of 7.5 to 8.0 meters per second at an altitude of 80 meters while the best wind resources in the Midwest are in the range of 9.0 to 9.5 meters per second[160]. Wind resources in the Midwest are also more ubiquitous.

The issue of grid integration is also very important for the competitive position of wind energy. The question of the cost of integrating wind is one of economics and efficiency. A review of various estimates of the cost of wind integration concluded that the cost could be as high as 18 percent of the nameplate capacity of wind in terms of the systems reserves needed to cover the

[156] (LBNL 2011)
[157] (NREL 2012)
[158] (Electric Power Research Institute 2011)
[159] (NREL 2012)
[160] (AWS Truepower2011)

variability of wind (NREL 2011). This needed reserve is not constant however, as wind is an element of weather and changes with seasons and throughout the day. This complicates the ability to calculate the avoided burning of fossil fuels and emissions allowed by substituting wind for other types of generation.

The costs of grid integration are more and more frequently being assigned directly to wind facilities. To date, such assignment is regional, e.g. Bonneville Power Authority, but could eventually become national in scope if some of FERC's recent proposals become law. Such policies increase the costs of wind generation and make it less competitive.

4. Future Prospects

At the national level, considerable resources are being devoted to understanding and improving the grid integration issue. Among these are the National Renewable Energy Laboratory's Energy Systems Integration effort (NREL 2012) and stakeholder groups such as the Utility Variable-Generation Integration Group (UVIG) - formerly the Utility Wind Integration Group - a consortium of utilities, grid operators and regulators devoted to accelerating the integration of variable resources into utility power systems[161]. The results of the next few years of research will more clearly reveal the opportunities to deploy technology to capture wind energy in a way that ensures efficient use of resources.

Several of the best areas for wind in West Virginia have already been developed. Development in other prime areas has been stalled due to complications related to permitting and financing. As it is very difficult to site a wind facility on public land, the availability of windy locations that are candidates to host a wind facility is few in the State.

The combination of the PTC, the region's close proximity to large electricity demand centers and existing transmission access has to date made West Virginia's wind resources attractive to development. However, the State's wind resources are unlikely to be further developed without the Federal PTC due to the relatively high cost of development in the region.

B. **West Virginia Law Relating to Wind Energy**

1. Legislation/Regulation

Wind energy is specifically listed as a resource eligible to participate in net metering arrangements per the WV Public Service Commission[162]. There are no special provisions applicable to wind energy required of the WV PSC outside of interconnections standards that

[161] (UWIG 2012)
[162] (WV PSC 2010)

apply to all net metering projects. Wind energy is also listed as an eligible resource to comply with the State Alternative and Renewable Portfolio Act[163].

2. Tax Policy

Wind energy systems have two special taxation policies in the State found under WV Code §11-6A-5a and WV Code §11-13-2o. Both of these policies provide tax rates for wind that are lower than for conventional generating equipment.

Wind turbines and towers are classified as emissions control technology and are eligible to be taxed at salvage value. The equipment that counts as part of the "wind turbine and tower" is explicitly listed in the State Code. The rest of the plant is not accorded salvage value. This policy allows up to 79 percent of the total value of the facility to receive this designation[164].

Wind systems also have a special Business & Occupation (B&O) tax rate levied against generating capacity. WV Code §11-13-2o specifies that wind facilities are to be taxed based on 12 percent of the "official capability" of the unit, while other types of generators are taxed at 40 percent[165].

3. Siting Policy

Elements of a permit application to site a wind facility include: economic impact, environmental impact, wildlife impacts, viewshed impacts, cultural impact, noise impact, shadow flicker, historical preservation, construction impacts, and public health impacts e.g. setbacks from roads, homes or property lines, as well as general construction permits. State law requires wind developers seeking a siting permit to file copies of the results of spring and fall avian migration studies including lighting studies and risk assessments. This requirement is unique to wind facilities[166]. Other siting requirements are the same as what is required of any type of power plant.

Because commercial-scale wind facilities are relatively new in the State, and because each facility that has been sited is unique in terms of size and location, developers have had varied experiences with the permitting process.

C. Policy Options

The development of wind energy is encouraged via various policy mechanisms in surrounding states. Most states in the region have more types of incentives available relative to what West Virginia offers.

[163] (WV Legislature 2009)
[164] (WV Legislature 2007)
[165] (WV Legislature 2008)
[166] (West Virginia Public Service Commission n.d.)

1. Portfolio standards

No states in the region dictate that wind energy be used to meet a certain percentage of their RPS. However, wind is eligible to meet requirements in all states with an RPS.

2. Renewable Energy Credits

Renewable energy credits (RECs) are based on state compliance markets and reflect the avoided alternative compliance payment that a utility would be required to pay if they did not procure qualifying renewable generation to meet the State RPS. Generic RECs are priced much lower than solar RECs. Although RECs can be acquired using several types of renewable resources, wind energy is the most common new resource deployed to meet an RPS due to its relatively low cost and widespread availability.

3. Rules and regulations

State-level regulation of wind energy is largely related to siting policy. However, in the Eastern U.S. most siting is determined by local governments although a few states set guidelines for how localities can restrict development. West Virginia is one exception, with siting decisions for all power plants made centrally by the Public Service Commission (WVPSC). The State of Virginia has enacted broad guidelines for how localities can create ordinances that impact the siting of wind turbines. These guidelines state that such ordinances must: 1) be consistent with the Commonwealth Energy Policy; 2) provide reasonable criteria for siting, while protecting the locality and promoting wind and solar development; and, 3) establish reasonable requirements for noise limitations, buffer areas, setbacks, and facility decommissioning[167]. The State of Delaware has a law prohibiting unreasonable restriction on the installation of residential wind energy systems and defines how restrictive local regulations may be[168].

4. Taxation

Several states in the region, including Maryland, Pennsylvania, and Indiana exempt wind turbines entirely from property tax. Others states, including West Virginia and Tennessee, allow partial exemption. Income tax credits taken against purchase of a wind energy system is allowed in several states and can apply to all types of taxpayers, e.g. Maryland, or may be exclusive to households, e.g. North Carolina, or corporate entities, e.g. Kentucky. Other common tax-related incentives include exclusion of equipment purchases from sales and use tax.

5. Other incentives

[167] (DSIRE 2012)
[168] *Ibid.*

Several states in the region offer some type of loan, rebate and/or grant programs that apply to wind energy systems. In some states utility programs may also include grant, loan and rebate programs that cover purchase of wind energy systems and may exist instead of state programs, e.g. Tennessee and Ohio, or in addition to state programs, e.g. New Jersey and Virginia. Some programs are available only to certain sectors, i.e. residential or commercial, while others are available to all entities.

Additional incentives that are available to subsidize the cost of wind energy are production-based incentives (PBI), where the owner of a wind turbine or facility can receive payments based on electricity generation. Utilities are authorized to make PBI payments to system owners and in turn receive the associated RECs which are then used for RPS compliance. PBI payments can be received by any entity that owns a grid-connected wind turbine.

The following graphic shows the types of incentives that are available to develop wind resources in regional states. Local or non-profit incentives are not included.

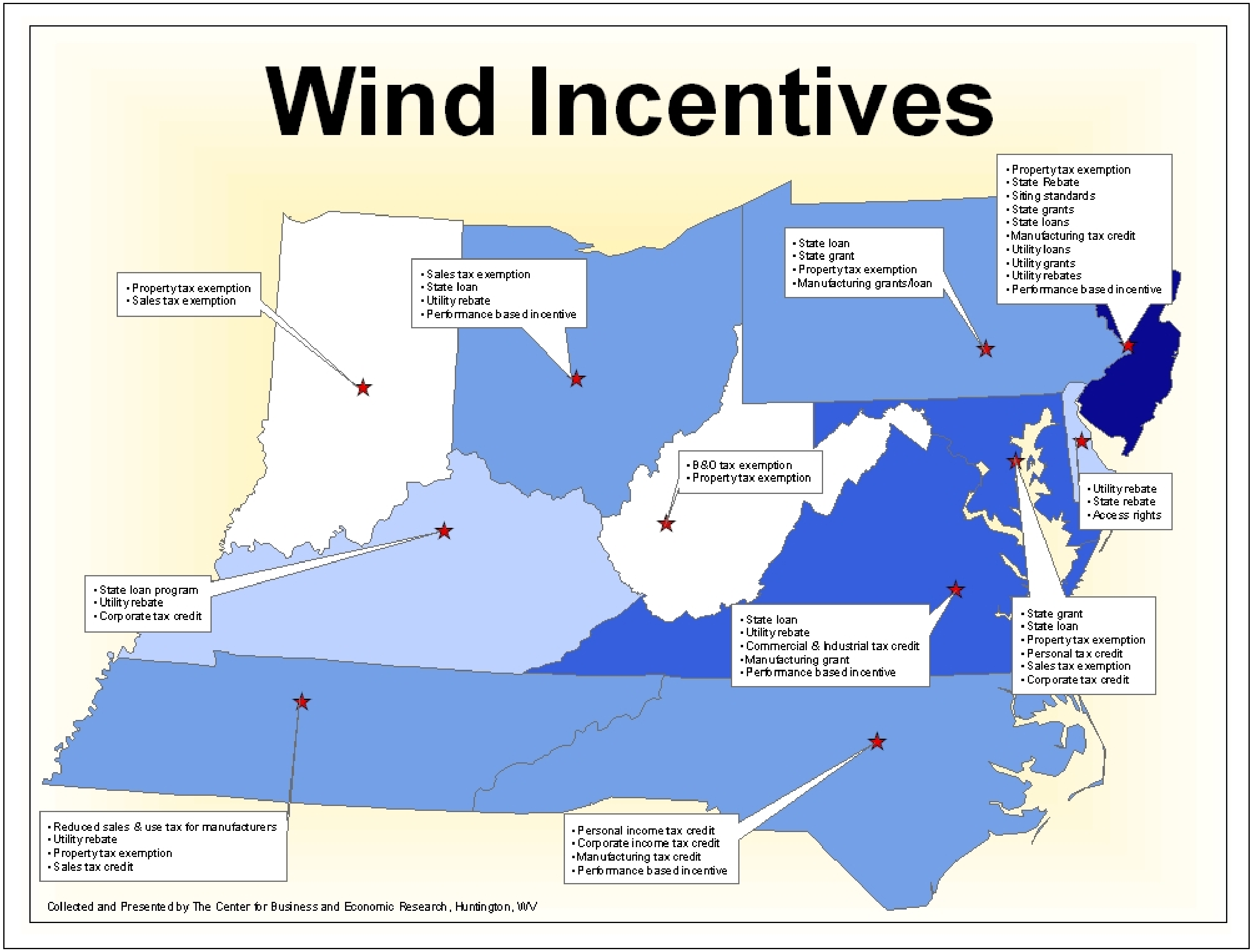

Figure 14: Map of Wind Incentives by State and Type

D. Conclusions

The research has made the following conclusions in terms of the objectives of the Energy Opportunities Document.

- At one percent of total electricity generation, wind energy is a relatively small energy resource in West Virginia. The quantity of wind that is estimated to be available to be developed on private land is smaller than what has to date already been developed or is under consideration.
- Due to the relatively high cost of developing wind in the region, the installation of wind in West Virginia is driven by Federal incentives. The extension of the federal PTC for wind-powered electricity production will determine future development efforts.
- West Virginia’s wind resources are good compared to many other onshore resources in the Eastern United States but are not as strong as in the Midwest. This reduces the likelihood that State resources will be developed in the absence of the PTC.
- The primary economic benefits of developing wind energy are lease payments made to landowners and property taxes paid to county governments. A small, but growing employment base exists to supply turbine maintenance services. The state has very few wind-related manufacturing component suppliers.
- Siting of wind facilities is very difficult. The permit application process is lengthy and requires extensive documentation. The siting process is largely similar to that experienced by other power plant developers, although wind facilities possess several unique attributes that make them quite different than conventional power plants. Nonetheless, any evaluation of the efficiency of the permitting process would have to take all types of power plants into consideration, not just wind facilities.
- There are unresolved efficiency issues related to grid integration of wind electricity that can be at least partly resolved by adopting a series of recommendations related to turbine control, real-time grid operations, reserve utilization protocols, demand response and wind forecasting. However, such implementation will take time and may never be perfect solutions. In the meantime, the ability of wind energy to offset fossil emissions is less than its output due to the need to maintain oversupply of generation capability. More needs to be understood about this issue in terms of accomplishing policy objectives.

E. Recommendations

This evaluation concludes that current policies to encourage wind development in West Virginia are adequate, largely due to most development being caused by policies outside of the State.

- **Maintain current policies.** The two existing State tax incentives for wind have allowed this relatively new industry some cost savings for projects while also giving the State and local government income from the projects. They are a balanced acknowledgement of public and private interests.

- **Monitor the results of research being conducted on the options to efficiently integrate wind and solar resources into the grid.** During the next five years, the results of several research projects addressing this issue will be published that will provide more firm recommendations on how best to proceed. This issue also provides the State with an opportunity to become familiar with regional organizations that are shaping the future of the electrical grid.
  Applicable State Organizations: Division of Energy, Public Service Commission.

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V. Overview of Hydropower

Hydropower is the nation's oldest source of electric energy used in manufacturing with the first hydroelectric plant installed in Wisconsin in 1882[169]. Although its share has been declining in recent years, hydropower is the largest source of renewable energy in the US accounting for 31 percent of all renewable energy in 2009[170] predominantly in the Western US. Considerable attention has been given to off-shore hydro generation which is not applicable to WV.

Advocates of expanded use of hydropower cite that it produces no GHG emissions, is reliable and its ability to "load follow" which permits the immediate adjustment in generation responding to consumer demand.[171] But the hydropower is not entirely benign. The operation of large hydropower installations at times leads to periodic flooding with the undesirable impacts of harming fish, invertebrates, amphibians and other aquatic life during periods of extremely low flow.[172]

A. Hydropower in WV

In West Virginia hydropower accounted for 1,645,927 thousand kilowatt hours of renewable net generating. This represents 68 percent of all renewable generation in the state for 2009.[173] The existing hydro power facilities in West Virginia are presented in Table I[174]

Table 5: Hydropower Facilities in West Virginia

Name	Location	Capacity
Summersville Dam	Gauley River	80 MW
Winfield Dam	Kanawha River	28.8 MW
London/Marmet Dam	Kanawha River	14.76 MW
Lake-Lynn Dam	Monongahela River	51.2 MW
Hawks Nest Dam	New River	69 MW
Belleville Dam	Ohio River	42 MW
New Martinsville Dam	Ohio River	35.72 MW
Dam No. 4	Potomac River	1.9 MW
Dam No. 5	Potomac River	1.21 MW
Millville Dam	Shenandoah River	2.84 MW

[169] Practical Action (n.d.) Small-scale hydro power. Http://practicalaction.org/small-scale-hydro-power-2 accessed August 2, 2012)
[170] EIA. Renewable Energy Annual 2009, Energy Information Administration, US Department of Energy Washington DC.
[171] US Fish and Wildlife Service (n.d.) "Hydropower" http://www.fws.gov/westvirginiafieldoffice/hydropower. (accessed July 23, 2012)
[172] Ibid.
[173] EIA. Renewable Energy Annual, op.cit. p.46
[174] Public Service Commission of West Virginia (2012) *Alternative and renewable energy resource planning assessment: Report to the Governor, Senate President and Speaker of the House of Delegates.* Charleston WV.

There have been three major hydro projects either completed or underway in the State:[175]

- An upgrade by Brookfield Renewable Power at Glenn Farris which will generate 38,000 mWh which would provide power to 4,500 users
- The Hawks Nest 102 megawatt plant is undergoing extensive upgrades during a 20 year capital investment program
- The New Martinsville 36 megawatt plant produces enough power for 49,000 households supplying both the City and the grid.

Over a decade ago it was estimated that there were 37 sites in West Virginia with the potential for hydropower generation. Estimates ranged from 1,149 to 1,924 megawatts of additional generation. While most of these sites already had dams located on them they were not equipped with generation capabilities. These sites were located on the Kanawha, Monongahela, Ohio and Potomac Rivers.[176]

Hydropower is well developed at existing sites in West Virginia and construction at additional dams has received federal preliminary permits from FERC as noted in Table II[177]

Table 6: Approved Preliminary Hydropower Projects in West Virginia

Name	Location	Capacity
Glen Ferris Dam	New River	38 MW
Willow Island Dam	Ohio River	35 MW
Sutton Dam	Elk River	12 MW
R.D. Bailey Dam	Guyandotte River	7.8 MW
Hildebrand Dam	Monongahela River	20 MW
Morgantown Dam	Monongahela River	15 MW
Opekiska Dam	Monongahela River	10 MW
Pike Island Dam	Ohio River	49.5 MW
New Cumberland Dam	Ohio River	36 MW
Tygart Dam	Tygart River	29 MW
Stonewall Jackson Dam	West Fork River	0.3 MW
Mount Storm pumped storage	Maysville, WV	450 MW

Source: West Virginia Public Service Commission

B. Small Scale Hydropower

[175] WV Department of Commerce, (2012) "Hydropower" http://www.wvcommerce.org/energy/renewable/hydro (Accessed July 23, 2012)
[176] Conner, A and Francfort, J. (February 1998) "Hydropower Resource Assessment for West Virginia" Idaho National Engineering and Environmental Laboratory, Idaho Falls ID
[177] Public Service Commission op. cit. pp. 8-9

Recent years have seen worldwide interest in small scale hydro power.[178] In the US small hydro is defined as a system having up to 10 MW of capacity. Small hydro is further broken down into mini hydro with less than 1,000 kW and micro hydro with less than 100kW generating capacity. The latter is feasible for smaller communities, families or small enterprises[179]. Small hydro does not make use of reservoirs but takes moving water a uses it to rotate a power a generator. Usually this is a "run of the river" installation which is most efficient in hilly sites.

The available power from a small hydro system depends of the "flow" or volume of water and the "head" or vertical drop. A head of at least two feet is required, but the higher the head the greater the amount of electricity generated and the lower the cost of the project. Adequate flow is related to the height of the head, but generally at least 2 gallons per minute will be required.[180] For these reasons small scale hydro is not practical in most locations.[181]

While "off-the-shelf" generators are available the cost of small scale hydro is not competitive with other sources of electric power.[182] But small scale hydropower is competitive with other renewable options such as solar and wind. When it is possible to sell power to the grid the cost is further reduced. Advocates of small scale hydro indicate that the higher initial costs are offset by the lower costs of maintenance and the long life of the installation (up to 50 years) if well maintained.[183]

As is the case with all alternative and renewable energy sources there are pros and cons to small scale hydro deployment.[184]

- Advantages
    - Efficient. With the low head and low flow requirements there are numerous locations where small scale hydro can be efficiently installed
    - Reliable. Generation potential must be calculated at the lowest level of stream flow to determine its reliability. Since the flow is dependable at that level the problem of peaking is eliminated.
    - No reservoir. Since small scale hydro operates without a reservoir on a run-of-the-river there are lower costs and almost no environmental problems than with other forms of renewable energy
    - Cost effective. Technological advances have produced low cost "water-to-wire" systems. Installation costs and maintenance is low meaning the cost of electricity is competitive with conventional sources in less developed nations. (This is not applicable for West Virginia)

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[178] Irish Hydro Power Association (n.d.) "Small Scale Hydroelectricity" Agricultural Food Development Authority, Cork Ireland

[179] National Renewable Energy Laboratory (July 2001) "Small Hydropower Systems" US Department of Energy DOE/Go-102001-1173

[180] Ibid. The formula for determining the electrical output from a small hydro facility is Watts=head[(feet) x flow (gpm)]/10

[181] NoOutage.com (nd) "Hydroelectric information" http://nooutage.comhydroelec.htm

[182] Practical action op.cit.

[183] Energy Savings Trust (n.d.) "hydroelectricity" http://www.energysavingtrust.org.uk/layout/set/print/Generate-your-own-energy/Hydroelectricity

[184] Alternative Energy News (October 26, 2006) "Micro-hydro power-pros and cons" http:www.alternative-energy-news.info/micro-hydro-power-pros-and-cons/ (Accessed July 24, 2012)

- Serves isolated areas. Small scale hydro is used extensively in areas where access to the grid is not available. Due to its low cost many rural areas in other nations have used it as a substitute for power from the grid. (This is not applicable for West Virginia)
- Grid integration. Where allowed excess power can be sold to the grid which reduces the cost of the installation.
- No GHG emissions. Small hydro using running water produces no air pollution.

- Disadvantages
  - Site suitability. Not all stream sites are usable. Dependable flow rate and drop are required. Also the distance from the stream to the user or the grid can be a negative.
  - Expansion. Since capacity is determined at low flow it will be difficult to expand capacity if demand increases.
  - Seasonable power. During high stream flow periods more power is available but cannot be relied upon during the entire year which reduces small hydro usability unless back-up power from the grid is available.
  - Environment impacts. While the environment impacts are less than other sources of power, most states require an impact plan prior to licensure. But a portion of the stream flow is diverted and there may be an impact on aquatic life particularly in low flow periods.

C. **Regulatory Considerations**

There are also regulator considerations. Small scale hydro will require state and often federal permits. The Federal Energy Regulatory Commission (FERC) will have jurisdiction over any hydro facility which meets the following qualifications:

- Is on a navigable waterway
- Will effect interstate commerce (if the system is connected to a regional electric transmission grid)
- The project is on federal land
- If water used is from a federal dam[185]

The second of these may apply to small scale hydro if its surplus power is sold back to the grid.

In most states permission is required from the state department of natural resources, fish and wildlife agency, environmental protection agency or similar regulatory body. There may be further legal issues regarding water rights held by downstream users.[186] These legal complications increase both the cost as well as the time of installing small scale hydro.

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[185] Federal Energy Regulatory Commission (July 16, 2012) "Licensing" http;//www.ferc.gov/industries/hydropower.asp Accessed August 2, 2012.

[186] NoOutage.com op. cit.

D. Current Incentives for Hydro Power Installations

In terms of financial incentives for hydroelectric facilities are not as commonly allowed technologies compared to wind and solar. Advocates of small scale hydro request that the federal and state governments should provide the same incentives given to other forms of alternative and renewable energy.[187] In particular they seek identical access to the grid for surplus power production, tax credits, exemptions from or reductions in property and/or sales taxes in addition to installation subsidies or rebates. Some of these are available in other locations.

Hydropower is a resource eligible to comply with State portfolio standards in most states in the region. It is eligible to receive performance-based credits or RECs in parts of Ohio (FirstEnergy) and is eligible for the feed-in tariff in parts of Indiana.

Hydroelectric facilities are sometimes listed as eligible for exemption from property tax, as in Indiana, Ohio and New Jersey, or exemption from sales tax, as in Indiana. Some states, including Maryland and North Carolina, allow purchases of hydroelectric generating equipment to quality for income tax credits. Tennessee and Virginia include hydroelectric equipment in the list of eligible technologies to receive manufacturing-related incentives. In the region, only Pennsylvania explicitly lists hydropower as being eligible for utility and state grant and loan programs.

There are no specific incentives for hydropower in West Virginia. The figure below shows incentives for which hydro is eligible in regional states.

[187] National Hydropower Association (2012) "US Hydropower Supply Chain Snapshot" http://hydro.org/why-hydro/available/hydropower-supply-chain-snapshot

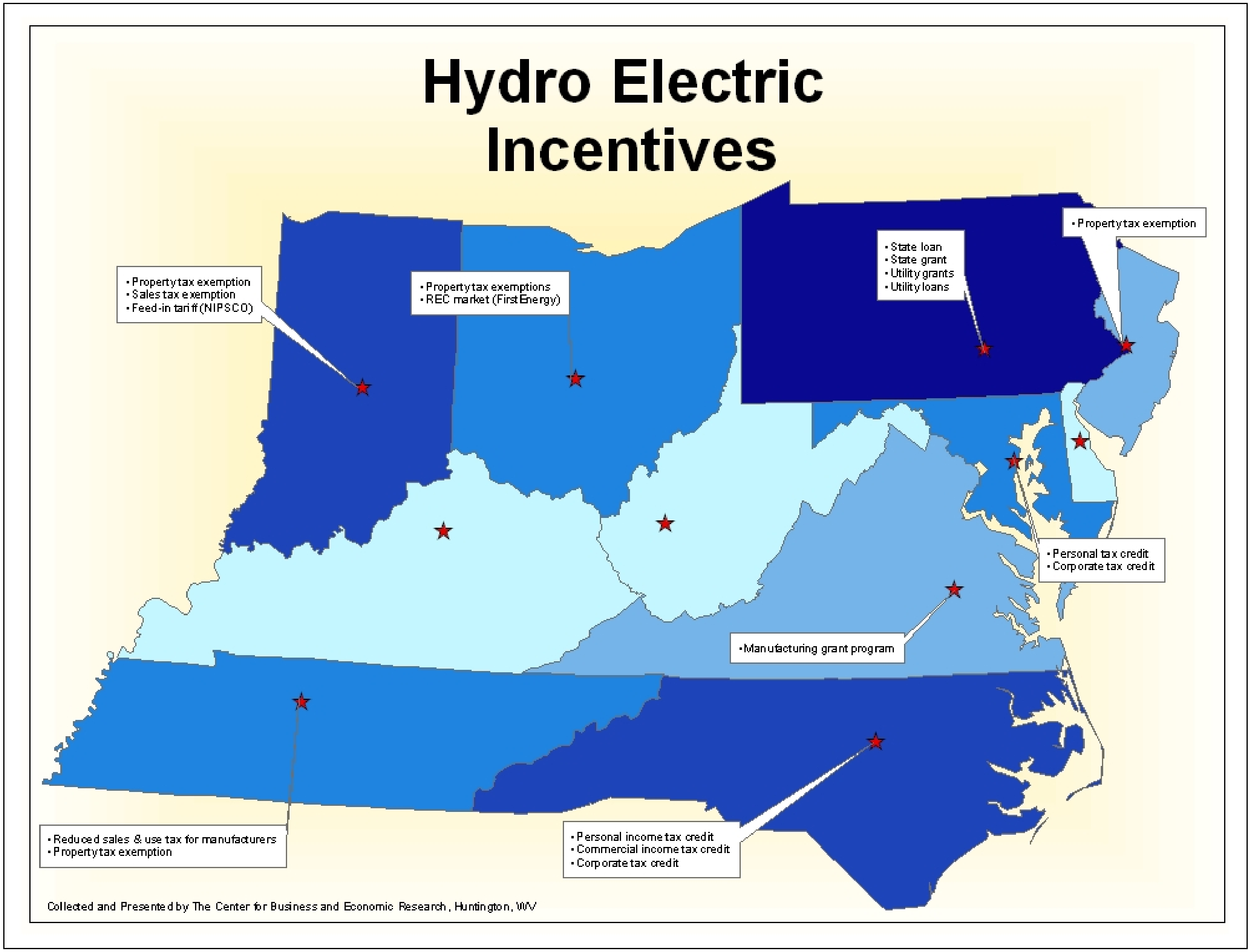


Figure 15: Map of Incentives for Hydro Power by State and Type

E. Conclusions

Small scale hydropower does not appear to have significant potential for the State. But there are instances in which small scale hydro may play a role. These would be primarily in direct use situations for providing power to a specific user such as a small factory, public building, recreational facility or isolated community.

In other nations small scale hydro has been a very successful strategy for the attraction of manufacturing business to an area. But with the State already well connected to the grid the advantage would only be if the cost of direct use was lower than power off the grid. This assumes that sufficient dependable power would be available.

F. Recommendations

- The State PSC should continue efforts with federal agencies and private companies to insure that the current preliminary licensed hydro projects are completed in a timely fashion.
- Work should be undertaken by the WVPSC to determine if there are other sites for development which have not been previously determined.
- Regarding small scale hydro power:
    - Determination should be made if there are public sites such as recreational areas which are not currently served by electrical connections for which development of mini and micro scale hydro is appropriate.
    - Current rules and regulations which effect small scale hydro should be reviewed to determine which, if any, were designed for large scale projects and could be eliminated or modified for application to small scale hydro.
    - Similar incentives to those granted to direct use solar and wind facilities should be made available to mini and micro hydro installations.

VI. Overview of Geothermal Energy and the Current State of the Resource in West Virginia

Geothermal energy is harvested through two main methods: conventional and enhanced geothermal systems. Because conventional geothermal systems require attributes[188] not available in West Virginia, an enhanced geothermal system (EGS) would be required for renewable energy production via this source. The use of geothermal energy could benefit West Virginia and advance the State's energy resources on both an economic and environmental level. Development of such resources in West Virginia would promote economic development through job creation for site research, drilling of EGS wells and establishing power plants in the most ideal locations in the State.

The generation of electricity through geothermal resources, compared to fossil fuel-based power plants, emits fewer toxic emissions (including nitrous oxide, hydrogen sulfide and sulfur dioxide). Further, geothermal energy has been shown to provide consistent base load power, making this resource useful in providing stable supply of electricity, particularly at peak hours (MIT 2006).

Although harnessing the geothermal resource for electricity production is not a new concept, the functional implementation of such a system has largely gained momentum in recent years. The Southern Methodist University (SMU) Geothermal Laboratory estimated that nearly 3,000 GW of electricity could be generated nationwide through geothermal production at 14 percent recovery (Google 2011). Of that total, the geothermal energy production potential in West Virginia was estimated to be approximately 30.8 GW at 14 percent recovery.

United States-based geothermal systems are most prevalent in the western states. SMU estimated that Texas had the largest (293.5 GW) and Nevada had the second largest (288.3 GW) production potential at 14 percent recovery (Google 2011). In West Virginia, the greatest geothermal potential lies in the northeastern portion of the State.

In terms of net generation, electricity produced from geothermal resources has varied by state in the last year. Hawaii's net generation of electricity from geothermal increased by 21 percent from May 2011 to May 2012 (EIA 2012). Utah experienced the largest drop (4 percent) from 25,000 MWh to 24,000 MWh over all sectors. Net electricity generation from geothermal in the five states with measurable geothermal energy production is provided in the following table. Note that both electric utilities and independent power producers represent the electric power sector.

[188] Conventional geothermal systems require natural geothermal reservoirs (pockets of water heated by the Earth) which are common in the western US but are not found in West Virginia.

Table 7: Net Generation from Geothermal Resource

	All Sectors			Electric Utilities			Independent Power Producers		
	May 2012	**May 2011**	**Percent Change**	**May 2012**	**May 2011**	**Percent Change**	**May 2012**	**May 2011**	**Percent Change**
Hawaii	23	19	21.05%	--	--	0.00%	23	19	21.05%
Nevada	239	230	3.91%	--	--	0.00%	239	230	3.91%
Idaho	8	8	0.00%	--	--	0.00%	8	8	0.00%
California	1,144	1,156	-1.04%	73	71	2.82%	1,071	1,084	-1.20%
Utah	24	25	-4.00%	23	25	-8.00%	NM	NM	0.00%

Energy Information Administration (EIA), 2012.
Note: Net generation data in thousand MWh. "NM" represents "not meaningful."

By extension, consumption of geothermal energy in the United States has increased in recent years from 181 trillion BTU in 2005 to 200 trillion BTU in 2009 (EIA 2009).

A. Competitive Position

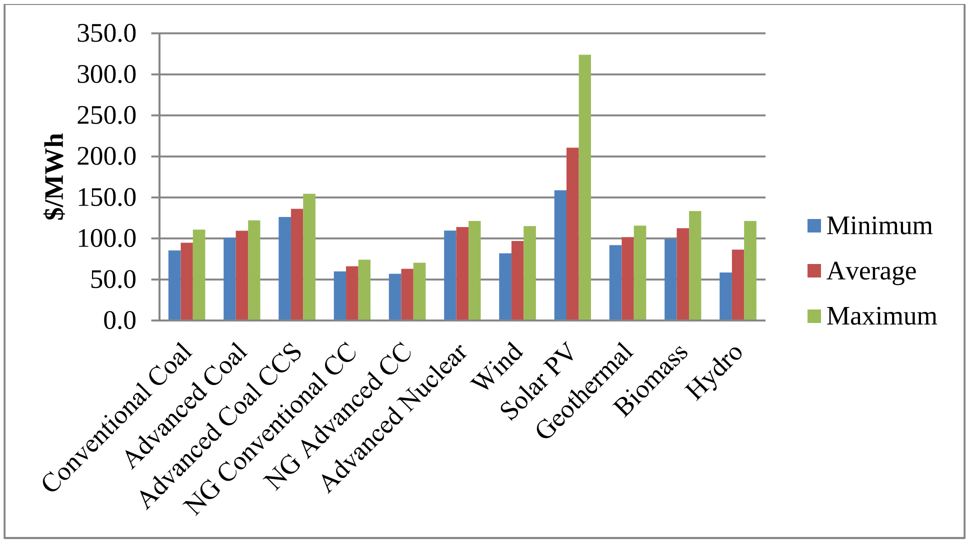
It is difficult, considering that the advancement of geothermal power plants in the United States and worldwide is still in early development stages, to determine a solid cost estimate for the geothermal potential in West Virginia. The State's geothermal resource exists in much deeper depths than in the western states (in some cases by as much as 3 to 4 km) which would likely result in higher costs. Holding this caveat in consideration, guidance can be drawn from other states with higher geothermal temperatures at more shallow depths to compare the cost of developing geothermal energy.

The levelized energy cost (LEC) of EGS operations can vary based on a number of factors, including site specifics (such as well depth, flow rates and temperature of the resource) and capital costs. One study estimated the LEC for six mature EGS operations with an 80 kg/s production rate. The lowest and highest LECs were estimated at 3.9 and 8.8 ¢/kWh, respectively (MIT 2006). By comparison, costs at The Geysers geothermal power plant in California are estimated between 3 and 3.5 ¢/kWh (EERE 2011).

Compared to other fuel resources, conventional geothermal[189] energy is fairly cost competitive, as illustrated in the following figure. It is important to note that federal and state tax incentives are excluded from the calculations; inclusion of these incentives could change the final cost. Further, the estimated costs may vary regionally (EIA 2010).

[189] Please note: the following cost comparisons between geothermal and other fuel resources consider conventional geothermal only. Cost comparison of EGS with other fuel resources may vary.

Figure 16: Estimated Levelized Cost of New Generation Power Plants



Energy Information Administration (EIA), 2010.

On average, the levelized cost of geothermal energy was estimated to be $101.70 per MWh for new generation resources coming online in the year 2016 (EIA 2010). When compared to new generation of other fuel resources coming online at the same time, such as conventional coal ($94.80 per MWh) and natural gas conventional combined cycle ($66.10 per MWh), geothermal energy costs are higher. However, when compared to biomass ($112.50 per MWh), advanced nuclear ($113.90 per MWh) and solar photovoltaic ($210.70 per MWh) suggest geothermal energy is much more cost competitive (EIA 2010). It is expected that the cost of producing geothermal energy will decrease as research and development, exploration, drilling and other technologies improve.

B. West Virginia Law Relating to the Resource

1. Legislation/Regulation

Geothermal energy is listed as one of the eligible renewable energy resources[190] under the Alternative and Renewable Energy Portfolio Act. There are no additional legislative conditions placed on the development or regulation of electricity generated by geothermal sources in West Virginia at this time.

Geothermal electric is listed among the eligible renewable technologies acceptable to reach the 25 percent renewable portfolio standard (RPS) goal in West Virginia (DSIRE 2012).

At this time, West Virginia does not offer financial incentives for the development of geothermal electric (DSIRE 2012). However, AEP Appalachian Power in West Virginia does provide a

[190] West Virginia Code §24-2F-3(13)(E).

Utility Rebate Program up to $150,000 per account per year for geothermal heat pumps used in the commercial and industrial sectors (DSIRE 2012).

2. Tax Policy

No tax policies currently exist specifically for geothermal energy production in West Virginia.

C. **Policy Options**

Along with more conventional renewable energy sources—such as wind, solar and biomass—geothermal energy is considered an eligible renewable technology in many state renewable portfolio standards (RPS). Of the 34[191] states (including the District of Columbia) with RPS goals as of April 2009, 28 include geothermal energy as an eligible technology (EPA 2009). States with more prevalent geothermal presence, such as California, Idaho and Nevada, have integrated more incentives and regulations for this technology. However, as geothermal systems are presently uncommon in this area of the eastern US, the incidence of such regulations and incentives become more generalized. For the best comparison, policy options for states surrounding West Virginia are examined.

1. Portfolio Standards

Four[192] of the five states surrounding West Virginia have implemented RPS or voluntary renewable energy portfolio goals (REPG) policy. Compared to West Virginia's alternative portfolio standard of 25 percent by 2025, Maryland has the highest goal of 20 percent by 2022 and Ohio has the lowest (12.5 percent by 2024) (DSIRE 2012). Virginia is the sole voluntary REPG of this selection. In all cases, geothermal electric is an eligible renewable technology.

2. Rules and Regulations

Because of the lack of EGS prevalence in this area of the eastern US, very few legislative regulations related to geothermal drilling currently exist. In most cases, states are more likely to have established policy regulating direct-use geothermal and geothermal heat pumps than commercial-scale EGS development.

Maryland, Ohio and Virginia all impose interconnection standard policies on several renewable technologies, including geothermal electric. The capacity limit is set at 20 MW in Ohio and Virginia and 10 MW in Maryland per state statutes (DSIRE 2012).

[191] RPS goals in five of these states—North Dakota, South Dakota, Utah, Virginia and Vermont—are not mandatory as of 2009 (EPA 2009).
[192] Kentucky is the only of the five states without an RPS/REPG in place.

Maryland,[193] Ohio[194] and Virginia[195] each require a permit to drill a geothermal well. The State of Maryland requires a subsequent bond under the Maryland Geothermal Resources Act. Further, Virginia imposes legislative regulations under the Virginia Geothermal Resource Conservation Act to both aid in the development of and protect the State's geothermal resources.[196]

3. Taxation

Few tax laws regarding geothermal development have been imposed in this area. Maryland requires that geothermal systems used for heating and cooling in a building (such as a geothermal heat pump) be assessed at the same value as a conventional heating and cooling system.[197] The sale of geothermal equipment—defined as the in-ground technology used to heat and cool in a geothermal system—is exempted in Maryland.[198]

4. Other Incentives

Along with other renewable technologies—such as solar thermal electric, PV, wind and hydroelectric—geothermal electric is eligible for a net metering incentive in Virginia (DSIRE 2012). The capacity limit is 500 kW for non-residential and 20 kW for residential. In addition, Ohio Revised Code allows a provision for municipalities to establish a low-cost alternative energy revolving loan program for assistance in installing geothermal energy projects.[199]

Pennsylvania provides the Geothermal Loan Program as part of the Keystone HELP Residential Energy Efficiency incentive program for geothermal heat pump installation. Pennsylvania residents making improvements on owner-occupied dwellings are eligible for up to $15,000 at 4.99 percent interest on a 3, 5 or 10-year term (Keystone HELP 2012).

D. **Conclusions**

The following conclusions have resulted from the research on geothermal energy in West Virginia in terms of the potential short-term impact of State policy related to geothermal energy.

The generation potential of the geothermal resource in West Virginia is not as great as in other areas of the US, but that should not be construed to mean it would not have an impact. At nearly 31 GW of current estimated generation potential at 14 percent recovery, the State's geothermal resource could match a significant portion of electricity generation in West Virginia.

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[193] Annotated Code of Maryland: Environment §5-601 et. seq.
[194] Ohio Revised Code §1509.221.
[195] Code of Virginia §32.1-176.4.
[196] Code of Virginia §45.1-179.1 et. seq.
[197] Annotated Code of Maryland: Tax-Property §8-240.
[198] Annotated Code of Maryland: Tax-General §11-230.
[199] Ohio Revised Code §717.25(B)(1).

Geothermal energy has been proven to provide consistent base load power through the constant loop of the input/output wells at generating facilities due to the fact that the temperature does not fluctuate. The reliability of geothermal systems in West Virginia would produce a secure supply of electricity from a renewable resource.

Although a large amount of capital is required to establish a geothermal system, the local and state economy would likely benefit from the increase in job demand. Further study would be needed to analyze the potential benefit of developing this resource in this area.

E. Recommendations

There is potential for EGS resources to contribute to the West Virginia alternative energy requirement and diversify the source of electricity generation in the State. However, successful development of geothermal resources in West Virginia will not produce immediate benefits. Due to continued improvement of geothermal development technology, establishing a new EGS power plant in this area would be costly at this time and is unlikely to be feasible in the short-term.

It is recommended that assistance be provided through helping to identify potential development sites for building EGS test facilities. Although establishing a full-scale EGS power plant would currently be both time intensive and costly, setting up EGS test sites would be beneficial to discovering West Virginia's true geothermal potential as well as optimal resource locations. To promote test site development, the Division of Energy could provide assistance with identification of a location for a drilling demonstration if funding for such a project were made available.

If the climate for EGS development and demonstration expands, the State of West Virginia could consider extending to geothermal facilities the property tax exemption granted to wind facilities. The expansion of EGS demonstration would depend on funding from the U.S. Department of Energy. If the US DOE were to develop a solicitation for a demonstration site in the eastern U.S., WV would be a candidate for such a project.

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