The Inextricable Bond:

Central Appalachia's Relationship to Land and Energy in the 21st Century

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Introduction

More so than many other regions in the world, Central Appalachians have always had a close and visceral relationship with the resources that the land provides. Native American tribes knew it as a bountiful land for hunting game and collecting medicinal herbs. Europeans learned to adapt homesteading techniques from the old world to their new environs and developed a unique culture that was intrinsically informed by their dependence on the land for sustenance. The commercial resource extraction age drastically changed those relationships, as maximum production and low operating costs were stressed over efficient and sustainable use of resources. Mining, drilling, and timber felling became the livelihoods of many Appalachians, and these occupations brought them into close contact with the resources desired by the nation in ways that were unimaginable a generation earlier. Over time, this region has lost much of that original connection and understanding of how to interact with the land as stewards rather than extractors, and nowhere is this concern more apparent and relevant than in the field of energy.

Central Appalachia has seen several periods of significant change since the time of the earliest European settlers in terms of the forms of energy used in the region. Harvesting of locally available trees for wood-fired heating, use of grasses and grains to feed draft animals who expended their energy in service to their human masters, and food grown to feed people who turned a majority of their calories into physical labor all typified the predominant forms of energy in use prior to the onset of coal mining. Coal, natural gas, and petroleum have drastically changed our relationship to energy, and we are largely dependent on them for most of the processes that we have come to accept as commonplace.

Given the finite nature of the aforementioned fossil-based resources as well as their contributions to global climate change and local environmental problems, it is necessary to assess the renewable energy options that are most applicable to Central Appalachia. Not only should this assessment be conducted with an eye toward economic feasibility and resource sustainability, but also within the framework of being well-adapted to the local culture. Holistic, multi-faceted systems should be stressed that can create economic and environmental benefits beyond direct energy production. A distinction should be made between “utility scale” and “family/community scale” systems, with approaches tailored to optimize all relevant scales. Finally, it will be assumed that that no single source can provide the energy needed to maintain a comfortable living for the current Central Appalachian population, and a multiplicity of approaches combined with an increase in energy efficiency and consequent reduction in per capita consumption will be required to ensure a smooth transition into a sustainable future.

Solar/Wind

Solar and wind are generally the first examples of renewable energy brought up in discussions of renewable energy. While these options will play a role in the overall mix, they are quite limited for many areas within the region in terms of utility scale power generation potential. Even where viable, wind power has met serious opposition from groups contending that turbine erection and use will be detrimental to viewsheds, property values, and endangered species of bats and birds. Nevertheless, utility scale wind projects should absolutely be pursued where the resource availability warrants and local concerns can be addressed or mitigated. Several wind generation sites are already in place on the outskirts of the region, and several more are planned. Small scale wind systems are quite expensive currently, but future innovations may enable them to be financially accessible and implementable for many families in the region.

Utility scale solar-electric installations are currently not cost-effective given the high initial cost of photovoltaic panels and the lack of existing incentives for generation combined with the low cost of coal-fired electricity in Central Appalachian states. Utility scale solar and wind are also intermittent sources, meaning that they are not well-suited to completely replacing fossil sources of energy until better energy storage media can be created in a cost-effective and large scale fashion. However, they should play a significant role in a broad energy mix and could find many uses in terms of family/community scale applications.

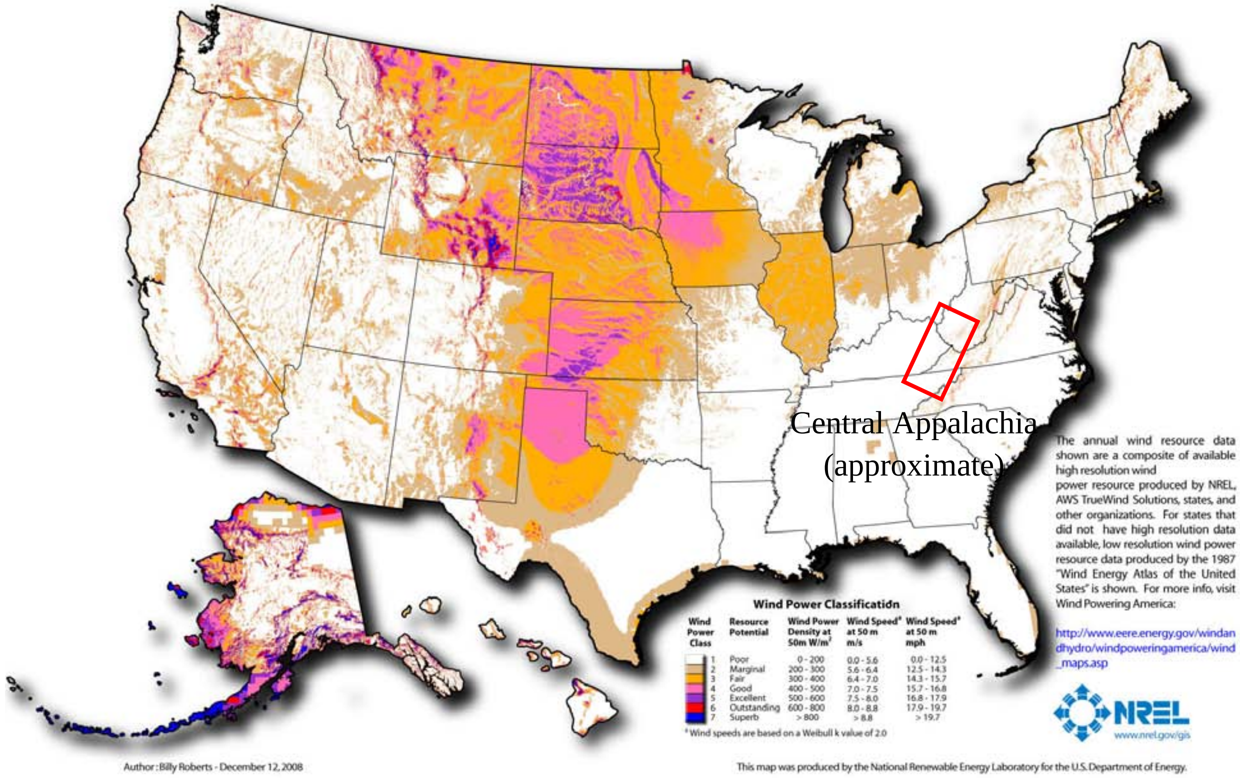

Figure 1: U.S. Wind Potential Map (National Renewable Energy Labs, 2006)

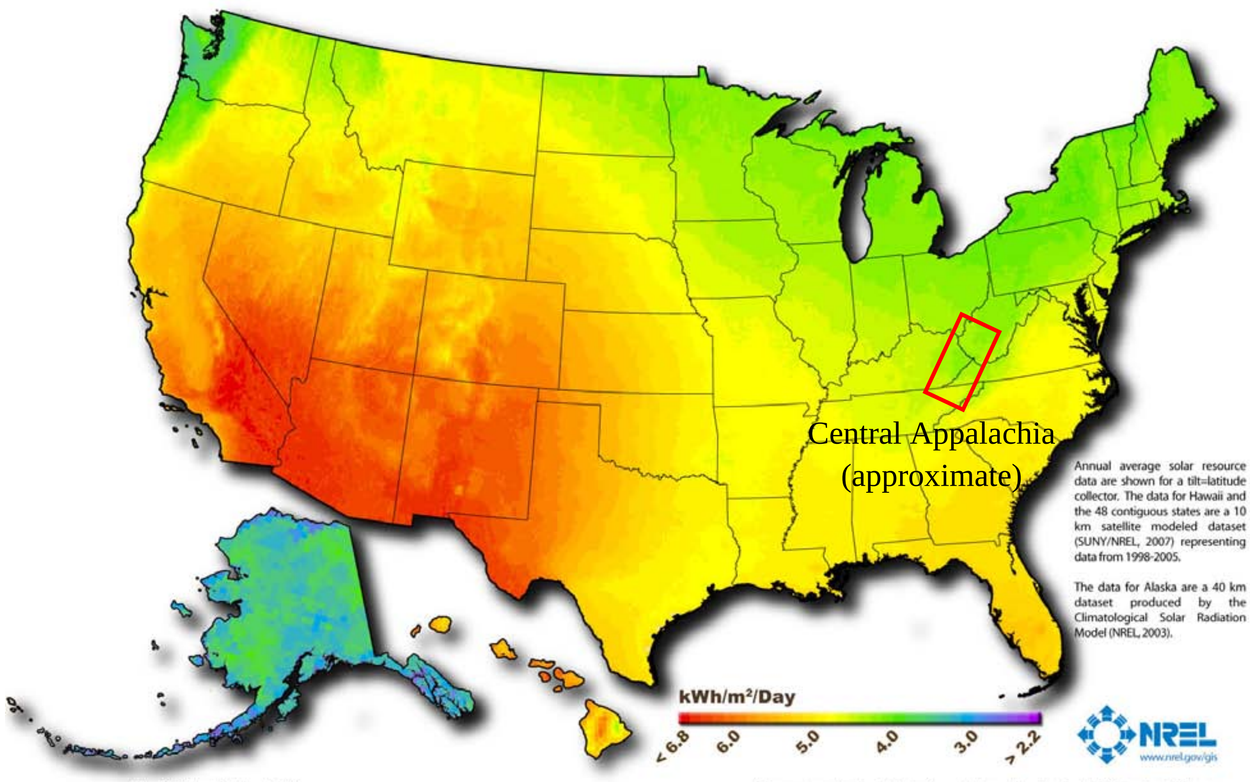

Figure 2: U.S. Solar Potential Map (National Renewable Energy Labs, 2006)

Solar applications can generally be broken down into "passive" and "active" systems. Passive solar simply refers to designing buildings and structures to make use of sunlight to efficiently and effectively provide both space heating and lighting, generally using high R-value windows to retain heat and eave overhangs that allow sunlight in during winter months when the sun is lower in the sky while blocking sunlight during summer months to reduce cooling costs. Active solar refers to technologies that convert solar radiation into usable energy by using mechanical and/or electrical components. The two most common active solar applications are photovoltaic cells (PV) for electrical generation, and solar thermal for heat generation. PV panels are currently less feasible for family/community scale installations because of their high initial cost and the lower than average per capita income within Central Appalachia. However, solar thermal systems could play a significant role in decreasing overall fossil energy consumption within the region due to their lower initial cost, high efficiency, and ease of construction and installation.

Solar thermal systems[1] are typically either of the flat plate or evacuated tube collector type. Regardless of design, they consist of a series of pipes through which a heat carrier liquid is circulated. The collector is designed to heat the liquid by using direct solar radiation. The heated liquid is generally used to heat another liquid via a heat exchanger, such as potable water for home use, or for space heating, such as within a radiant floor heating design. Evacuated tube collectors can function well even during cold and cloudy times of the year, though they are more expensive than flat plate designs.

[1] "Solar thermal" can sometimes refer to concentrated solar power systems, which use a mirrored parabolic trough to concentrate sunlight into a single point to heat liquid within a tube, which in turn is used to generate steam-based power. Due to limited solar resources in Central Appalachia, this approach is not considered in this paper.

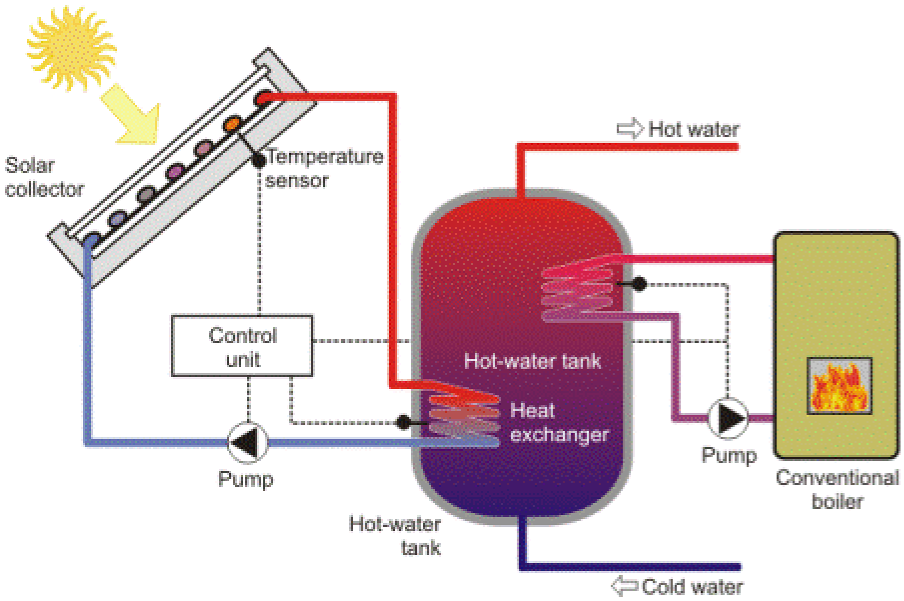

Figure 3: Solar thermal system diagram (Natl. Assoc. of Certified Home Inspectors)

Hydropower

Hydropower is often close behind solar and wind in terms of renewable energy options that the general populace is familiar with. There exists significant potential to retrofit existing dams within the region to produce power without causing additional environmental impacts. Further damming would most likely cause undesirable habitat and land use changes; as such, developments for utility scale hydropower projects within the region should be limited to those existing dams that do not currently have generators installed. Microhydro systems offer a very dynamic alternative to the larger installations and could represent a powerful component of a diversified family/community scale energy mix.

Microhydro systems can be installed in any location where a regular stream flow exists and where some amount of elevation drop occurs. They can be installed using relatively simple components and equipment, and do not adversely affect existing habitats and ecosystems. Depending on the flow rate and elevation change present, they can provide part of the electrical needs for a single home or all of the needs for an entire community. In addition, micro hydro can be easily integrated as an energy-producing addition to other processes, such as discharge from a wastewater treatment plant or effluent from an aquaculture/aquaponics operation.

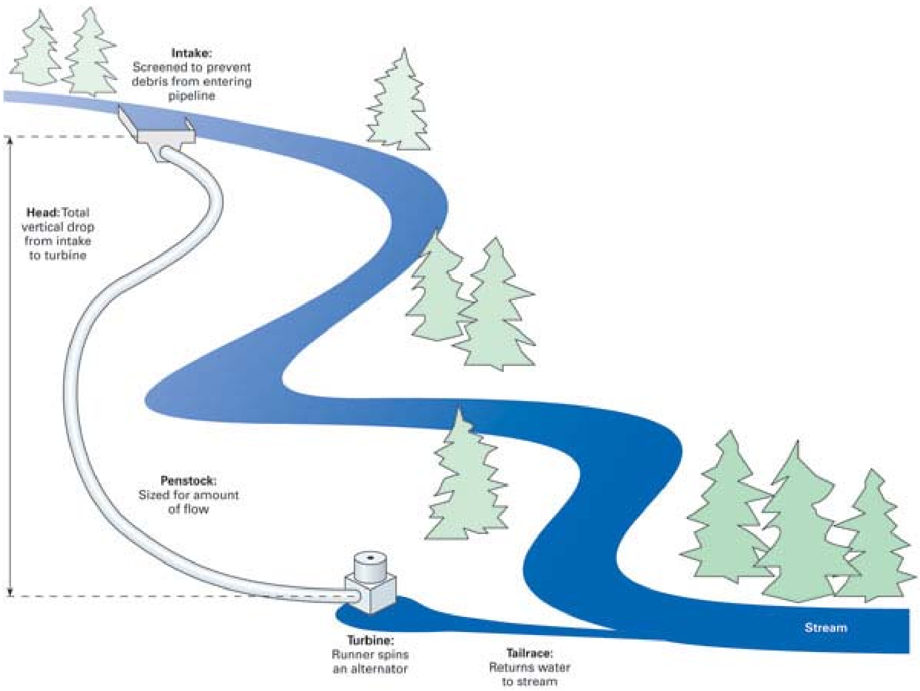

Figure 4: Micro hydro system diagram (Home Power Magazine, 2007)

Both solar thermal and microhydro are culturally compatible with the Central Appalachian region. They are relatively affordable compared to solar PV and small scale wind. The socio-economic conditions of the region require that very cost-effective approaches be emphasized when looking at installations that individuals or communities will be expected to fund largely on their own. These technologies are also easily adapted to the self-sufficient, independent, and do-it-yourself traits that have often typified the region. While commercially available systems and kits do exist, most of the parts needed to create one of these systems are available at local hardware stores and used equipment yards. Motivated mountaineers could feasibly build their own small scale set ups from scratch, and the potential for entrepreneurial startups specializing in the creation and installation of these systems also exists. In addition, existing HVAC and plumbing companies could easily be educated about and trained to install these systems. Thus, the job creation potential for installations of solar thermal and micro hydro systems could be significant, with 20 to 30 full-time specialists per Central Appalachian county. A region-wide grassroots education effort is now needed, wherein educational workshops and trainings are held to make the populace aware of these technologies, as well as the existing incentives and rebates available to those who implement them.

Biomass

Biomass, while generally the least well understood of the available renewable energy options, is most likely to be the single largest contributor to the region's renewable energy mix. Fully capable of serving roles both within the family/community scale as well as on a utility scale, biomass also has the most potential to be harmful and/or destructive, and must be carefully analyzed within each possible scenario.

The term "biomass" generally refers to anything that is or was recently living, and can refer to grasses, trees, animals, and wastes such as sawdust, chicken fat, manure, or paper. Dozens of pathways exist for turning any of these potential biomass sources into some form of energy, and each potential project must be evaluated on its own merits and based on the specific parameters of the particular situation. Key concerns include proximity to residential sites, physical/chemical makeup of feedstock material, potential emissions from specific energy production processes, and proposed methods of dealing with waste streams. The following paragraphs outline the most viable biomass feedstocks and processes for Central Appalachia based on the author's research, experience, and intuition.

Waste biomass resources will be addressed first since they are relatively limited within the region but still worth exploring as pieces of the overall energy equation. Biodiesel produced from locally collected waste cooking oil can be used in municipal fleets such as school buses, garbage trucks, graders, and backhoes in a blend with conventional or synthetic/renewable diesel to increase fuel lubricity and significantly lower soot particulate and carbon monoxide emissions. The transesterification process converts cooking grease feedstock into fuel that can be used in practically any unmodified diesel engine and can occur within mobile, modular production units. These portable plants can double as educational facilities, and could play an important role in initiating the conversation about the potential for renewable energy in the region by partnering directly with public school systems and community/technical colleges.

Figure 5: Mobile biodiesel production/education system (Piedmont Biofuels, LLC)

Sewage treatment plants are currently expending large amounts of energy to dry and press the sludge effluent left after wastewater treatment, which is then hauled to a landfill where a tip fee is incurred. This material could be run through an anaerobic digester instead of drying/pressing to generate energy from the methane gases created by bacterial decomposition of the sludge. The leftover effluent is much more sanitary than the dried/pressed sludge due to the high temperatures and bacterial residence time within the digester, and can be safely used as a land-applied soil amendment provided that metal and pharmaceutical levels are minimal.

Landfills contain vast amounts of organic waste materials that produce a variety of gasses as they decompose. Methane is a significant component of this gas mix, and it is possible to install methane capture and utilizations systems to produce electricity or heat from this methane. Very few landfills in Central Appalachia currently have methane capture systems in place. Implementation of landfill methane systems can provide not only a means for electricity production from an otherwise wasted resource, but also a heat source for value-added enterprises such as greenhouses and glass-blowing studios.

Family/community scale biomass energy options from non-waste sources can be quite affordable, highly efficient, and well-tailored to a do-it-yourself attitude. Wood-fired boilers are possibly the most accessible and familiar option to many mountain families. While fireplaces and older wood burning stoves are still somewhat common in the region, wood-fired boilers are capable of higher efficiencies and potentially lower emissions than either of the former options in terms of space heating. They can also be used for hot water heating in much the same way as a solar hot water heating system. A wood-fired boiler can be tied directly in with a solar hot water system to provide year-round reliable space and water heating with no need for fossil fuel backup. Wood is a much more finite resource than solar radiation, and although renewable it should be utilized in a way that ensures a healthy forest habitat in the region and a continual supply for future generations. Some of these systems can be automatically fed by biomass pellets, and could feasibly require little to no effort on the part of the homeowner if a local pellet supply company regularly refills a pellet hopper. Sales and supply of locally produced pellets could stimulate additional job creation. It should be noted that older wood-fired boilers generated dense smoke that contained large amounts of harmful particulates. Newer EPA-certified Phase I and especially Phase II boilers are up to 90% cleaner than their older counterparts. It is recommended that only Phase II units be supplied and installed in the region to ensure that breathable air quality is maintained at the highest standards.

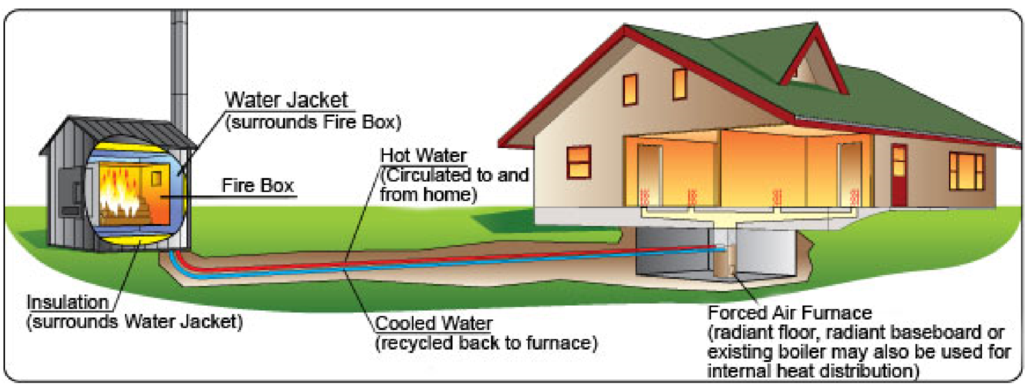

Figure 6: Wood-fired boiler for home heating (EPA, 2009)

Utility scale biomass energy requires a significantly different approach. In order to achieve generation capacities that can have some impact on replacing the amount of energy that is currently generated from fossil sources, systems must be created that are sizable enough to supply the existing energy infrastructure while carefully acknowledging the realities of feedstock materials that are readily and renewably available in the region. Furthermore, a biomass based energy network could potentially have the capacity to restore land that has been decimated by large scale surface mining while also integrating non-energy value-added enterprises. It will therefore be necessary to formulate a strategy that combines medium scale generating facilities with a sustainable feedstock supply network that can repair land rather than further degrade it.

The emphasis throughout should be on creating and retaining as much value as possible within the Central Appalachian region.

The most common technologies for biomass energy generation are cofiring, direct combustion, and pyrolysis/gasification. Cofiring refers simply to adding biomass materials to coal in an existing coal-fired power plant to offset the amount of fossil fuel combusted with some amount of renewable fuel. This will likely be the initial avenue by which biomass power is created in the region, since it utilizes existing facilities, extensive retrofitting is generally not required, and utilities are able to meet “green energy” requirements while also lowering their on-site pollution control costs. Since most coal-fired power plants are very large (greater than 100MW), inefficient, and outdated, it is unlikely that they will ever be fully converted over to biomass combustion since newer, smaller, and more efficient technologies will make much more effective use of limited biomass resources.

Many environmental groups are wary of the cofiring approach, since it would require cooperation with the coal-based grid system, would involve shipping harvested materials long distances to be inefficiently combusted, and conceivably could create a harmful strain on forest and farm acreages to supply biomass if demand was to become great enough. In general, market conditions are such that it will not be economically justifiable to timber large forest tracts or convert food crop acreages for biomass production anytime in the near future, if ever. Coal is simply too cheap and plentiful, and other uses for trees and croplands provide greater returns than harvesting for cofiring. The likely short term scenario may be that some crop acreages that are within 50 miles of a coal power plant, especially those that are less suitable for high-value food crops, will be converted to fast-growing grasses for a period of time if incentives are great enough. Some lower value trees and forestry waste products may be incorporated into cofiring, but again only where incentives are particularly attractive and higher value uses are not feasible. Cofiring does not have the basis for being a threat at this time, and could be a beneficial first step in a transition toward more advanced, efficient, and localized energy systems.

Direct combustion generally refers to incinerating the biomass feedstock in a furnace to create heat that is used to turn a steam turbine for electricity generation. These systems may only be about 25% efficient in terms of the amount of energy that is actually converted to electricity, but this efficiency can be increased up to around 75% if the excess heat can be used for a productive purpose rather than simply vented. If the heat is used in such a way, it is referred to as a combined heat and power, or CHP system. Pyrolysis and gasification are two distinct but related processes that have the potential to make much more efficient, effective, and innovative use of the biomass feedstocks available in Central Appalachia [1].

Pyrolysis/Gasification

Pyrolysis generally refers to the thermal decomposition of carbon-rich feedstocks under low to no oxygen conditions and medium to high heat (400^{o} to 700^{o} C) at atmospheric pressure or under vacuum. This produces a mix of synthesis gas (syngas), bio-oil, and biochar (more commonly called “charcoal”). The syngas can be combusted in a gas engine for electricity generation or it can be reformulated into other fuels or value-added chemicals, such as synthetic natural gas, Fischer-Tropsch synthetic diesel or gasoline, methanol, and/or hydrogen gas. The bio-oil is a relatively unstable tar-like substance that can be immediately combusted to provide heat to fuel the pyrolysis process and/or to create electricity in a modified diesel engine, or it can be upgraded to a more stable state for transportation. The biochar, while it does have the potential to be combusted for energy purposes, has a potentially greater value as a nutrient-retaining and carbon-sequestering soil amendment. Gasification is similar to pyrolysis in that feedstock material is decomposed under controlled oxygen conditions, although higher amounts of oxygen in the process mean that a much greater amount of syngas is created relative to bio-oil and biochar [2]. Systems can often be optimized toward one extreme or another with some amount of flexibility as to the ratio of the outputs produced; a combined pyrolysis/gasification term will therefore be used in this paper. While the system is designed to be self-perpetuating in terms of the heat required to continue the process, the initial heat required to begin the process can be provided by a biodiesel-fired boiler in order to keep the energy inputs local and renewable.

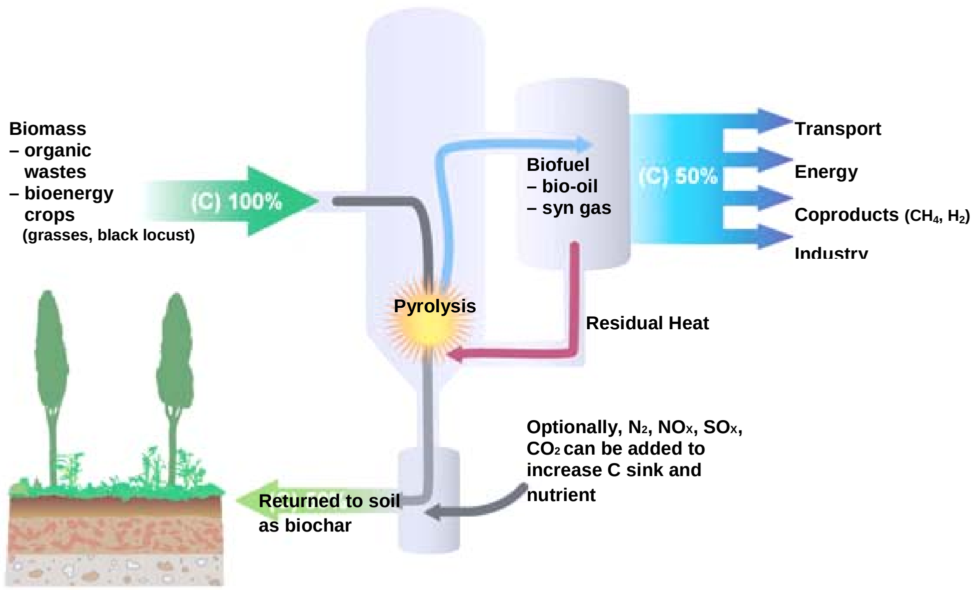

Figure 7: Pyrolysis/gasification system diagram (Lehmann, 2007)

Pyrolysis/gasification (hereafter referred to as P/G) represents an approach to technology that could enable a long term shift away from fossil-based energy production in Central Appalachia. While large scale (100-2,000 MW) generation facilities will likely not be achievable with P/G, a decentralized and distributed energy production network could prove very feasible. As coal production dwindles or is made less competitive because of environmental/market conditions, alternative sources must be relied upon more heavily and a more dynamic and flexible energy grid will become advantageous for several reasons.

Smaller generating sites spread throughout the region will allow for greater resiliency and adaptability to changing energy markets and feedstock availabilities. P/G technology can accept a variety of biomass feedstocks and can be tailored to produce various output streams; a mix of electricity, liquid fuels, chemicals, and soil amendments is feasible under an integrated biorefinery system. If each county in the region hosts 1 to 3 plants per county with electrical generating capacity of 5 to 15 MW each, then current residential electrical demand can likely be met with biomass power alone given that 1 MW can supply between 500 and 1,000 households, depending on the energy efficiency of the homes. Since there will ideally be at least 1 plant per 50 mile radius, transportation costs of feedstock materials can be minimized and power transmission/distribution costs can be mitigated. Further, liquid fuels produced at such sites could be distributed using existing infrastructure, and transportation costs will be lowered here as well. The potential also exists for on-site value-adding with chemicals that can be created as side streams (methanol, hydrogen, etc.) [3].

Many environmental and conservation groups are concerned that biomass energy initiatives will endanger existing forest reserves or divert valuable feedstocks away from other industries, such as sawdust for paper manufacturing or hay that would otherwise be used for livestock feed. Central Appalachia has a unique opportunity to mitigate these concerns by utilizing thousands of acres of land that are currently degraded, idle, and mostly unsuitable for higher value timber and crop production. Vast tracts of former mountaintops are now expanses of compacted scrublands that are currently supporting only a handful of mostly non-native grasses and shrubs, but they contain the potential to be transformed in a way that could sustainably provide the region with feedstocks for baseload power generation and diversified fuel and chemical production for the foreseeable future.

According to figures published by Oak Ridge National Labs, a biomass power plant operating at 80% capacity and 37.5% efficiency will require about 4,000 dry tons of biomass per MW. If 5 dry tons of biomass can be harvested per acre per year, then about 800 acres will be required to supply enough biomass for 1 MW of electrical generation. 5 dry tons per year per acre should be achievable on surface mined lands with the native feedstock crops described in the following sections. A 10 MW P/G plant would therefore require about 8,000 acres of surface mined land to maintain a consistent supply of feedstock. Most coal-producing counties within Central Appalachia have much more than 8,000 acres of abandoned or reclaimed surface mined land sitting idle with little to no productive use. While these lands could be used to produce most if not all of the required feedstocks for P/G plants, it may be desirable for economic and ecological reasons to also utilize existing waste wood resources (portions of timbered trees that are unsuitable for milling, sawmill residues, etc.) and also to engage in selective timbering of low-value trees in existing woodlots to provide higher value trees with a better growing environment. Advanced P/G plants should be able to achieve higher efficiencies than 37.5%, so the actual required feedstock crop acreage could be substantially less.

Bioenergy Feedstock/Ecological Remediation Plantations

Research has shown that some native tree and grass species are capable of surviving and even flourishing on Appalachian surface mined sites, although they may require more initial management than the typical non-native hydroseeded mix of tall fescue (*Festuca arundinacea*) and Chinese lespedeza (*Lespedeza cuneata*). Two native species that have received particular attention because of their abilities to tolerate extremely marginal site conditions, create a host of ecological benefits, and supply large amounts of biomass per acre are black locust (*Robinia pseudoacacia*) and switchgrass (*Panicum virgatum*).

Black locust is a fast-growing Appalachian hardwood that is a natural pioneer species, meaning that it is designed to colonize disturbed or degraded areas, establish quickly, provide a better growing environment for other successional species by stimulating soil rebuilding, and eventually be outcompeted by longer-lived hardwoods. As a member of the pea family Fabaceae, it is a legume which fixes atmospheric nitrogen into plant-available nitrogen through a relationship with rhizobium bacteria on nodules attached to its roots. Nitrogen is one of the most important nutrients for healthy plant growth, and is the most likely to be deficient on most soils. This nitrogen is made available to other nearby plants when its leaves drop and begin to decompose. The leaf litter also serves as one of the building blocks for new soil, as it contains a great deal of carbon (the most important element for plant growth) and stimulates a variety of microbial processes through its decomposition. Black locust also forms a symbiotic relationship with mycorrhizal fungi. Much is still being learned about the role that is played by the vast networks of this fungus within healthy forest and prairie ecosystems, but it is well known that it contributes greatly to overall ecological health by helping plants to access nutrients that they could not otherwise uptake while also stimulating a diversity of soil microbial activity. Surface mined sites are usually deficient in nitrogen, organic matter, and mycorrhizal networks, and as such black locust could play a key role in restoring these factors [4].

Figure 8: Black locust growing on surface mine, Floyd County, KY (Hall, 2009)

Switchgrass is a long-lived perennial grass that is native to the prairies of the Eastern and Central United States, and although Appalachia is not naturally prairie land the process of surface mining essentially creates an artificial prairie. It requires little to no inputs to grow and can achieve very high biomass yields per acre. Along with other tall prairie grass species, its deep, fibrous root system is responsible for much of the richness of the mollisols found throughout the Midwest, as the continuous growth and decomposition of roots and aboveground biomass over time creates vast stores of organically-enriched soils. Switchgrass also forms associations with mycorrhizal fungi, adding to its ability to restore ecological health to degraded lands [5]. It has recently been proven to grow very well even on highly compacted surface mine sites, outcompeting other energy crops in research trials in the Eastern Kentucky coalfields.

Figure 9: Switchgrass after one growth season on surface mine in Pike County, KY (Hall, 2009)

A combined black locust/switchgrass agroforestry/bioenergy plantation could promote ecosystem recovery on surface mined sites while also providing a continually renewable feedstock source for a regionally distributed network of P/G plants. By intercropping strips of switchgrass that are harvested once per year between rows of black locust trees that are coppiced once every 4-5 years, a perpetual supply of wood chips and straw pellets can be maintained [6]. These sites could provide several other benefits as well. Locals often use the brambly border areas between surface mine sites and the intact forest to hunt for quail and grouse. Switchgrass has been shown to be an excellent habitat for quail, and the rows of black locust will effectively create a series of repeating border areas that could be conducive to grouse. Deer and reintroduced elk would also make use of young black locust leaves and early switchgrass growth. The potential exists to integrate a game farm set up into the bioenergy plantation, which could vastly increase local support for such a bioenergy initiative. Black locust is grown commercially in Europe as a feed source for honeybees; many Appalachians are already familiar with beekeeping, and could work within a honey-producing aspect of the operation. An additional honey crop, such as sweet clover, could be mixed in with the switchgrass to provide multi-season forage for the bees. Finally, while existing surface mines are not suitable for higher value oilseed crops for biodiesel, hardy plants such as hemp, hazelnut, and castor could potentially do well on these sites if they have been improved by switchgrass and black locust growth for a period of years.

The problem of compaction on mine sites should be mentioned. Heavy equipment is used to intentionally compact the spoil (blasted bedrock) material during the reclamation process, and the resulting compacted zone that begins at depths of 6-8” is the single most inhibiting factor to plant growth and reestablishment of native hardwoods [7]. Both black locust and switchgrass have been able to do well on compacted sites because of their ability to have a laterally branching root system even if they are unable to establish a strong taproot. However, black locust can achieve much better annual growth rates if the compaction is broken up with a deep soil ripper or if the spoil is only loosely graded in the first place. Also, if the intention is to eventually transition back to a native forest ecosystem after a period of use as a bioenergy plantation, then this will be greatly facilitated by deep soil ripping or loose grading. The ripping is fairly energy intensive as it requires a large diesel bulldozer to pull a 4-6’ shank through compacted rocky material, and initial loose grading of spoil will likely make non-tree (i.e. switchgrass) establishment and management more difficult since a smooth, lightly packed seedbed is desirable for planting. It could prove feasible to rip only in the rows where black locusts will be planted, and a mechanical tree planter could be added to the deep ripper attachment to enable one-pass ripping/planting [8].

Figure 10: Deep soil ripper on large dozer and loose-graded spoil (Sweigard et al, 2007)

Biochar, a co-product of the P/G process, could have far-reaching climate-preserving implications. Up to 50% of the carbon that was fixed into the feedstock crop's biomass during conversion of atmospheric CO_2 into O_2 can be retained in this biochar, meaning that the CO_2 released upon combustion of the syngas and bio-oil (or upgraded products) is actually less than the amount of CO_2 that was removed from the atmosphere during the plant's growth cycle. If the biochar is added to soils rather than combusted, P/G can achieve carbon-negative energy production since the biochar can retain the carbon for thousands of years before eventually decomposing and releasing it back to the atmosphere. It will therefore have very high value as carbon credit and cap-and-trade markets develop in the future. Surface micropores and a high cation exchange capacity enable biochar-enriched soils to retain important plant-available macro and micro nutrients up to 40 times longer than typical soils [9]. Biochar combined with the aforementioned benefits of switchgrass and black locust could ecologically regenerate Appalachian surface mined lands, whereas now they are simply "reclaimed" to a minimum standard in order for coal companies to achieve bond release.

Bioenergy Job Creation

The employment potential of this decentralized bioenergy network could be substantial. Each P/G plant would require 20 to 30 full time workers, with several of these utilizing professional degrees in mechanical, electrical, and chemical engineering. Youth of the region would have an incentive to return for these advanced and well-paying jobs. Research and development projects could also be integrated into the value-adding and post-processing side of the operation. The bioenergy plantations would require at least 20-30 workers per 500-1,000 acre site to operate and repair machinery and equipment, as well as positions for plant and soil management, accounting, and other administrative needs. Several such plantations could be in operation per county. This methodology is based on the author's experience with similar types of industrial processes, as no examples currently exist to enable accurate predictions of the potential overall job creation under a regional P/G regime.

Workers who have previously been employed by mining companies would be well-suited for much of this work, since they either have previous experience operating heavy machinery (used to plant, harvest, and maintain bioenergy plantations) or have experience working around industrial installations such as coal tipples and processing plants (somewhat similar working environment to P/G plant, although the latter would expose them to much less in the way of health hazards). Furthermore, many of these workers are currently unemployed since the coal industry has required fewer and fewer workers over time as the scale of surface mining has increased and coal from the Western regions (Wyoming, Montana, etc.) has made Appalachian coal less competitive. This system could provide a steady, long-term source of employment that does not disappear once the seam of coal has been mined out. Existing skillsets can be utilized while providing innovative opportunities for the region's educated youth.

The implementation and management of both the feedstock plantations and P/G plants could occur within the framework of a local, independent, and cooperatively owned business. The energy products would be sold at wholesale rates to existing public utilities and fuel distributors, while the value-added aspects would benefit from the entrepreneurial innovation and flexibility inherent in this business structure. If local people are employees, shareholders, and stakeholders, then they will have greater interest in and involvement with ensuring that such an operation is viable for the long-term and creates maximum benefit for the region.

Opportunities and Challenges

There are several challenges that must be overcome in order for the aforementioned P/G and bioenergy plantation/ecological remediation project to be viable. The principal issue that must be addressed is economic feasibility. The technology for biomass P/G is proven and operating in many locations in Europe, Asia, and South America, but there are usually either excellent subsidies available for “green energy” production in those areas, or there are strong incentives based on lack of locally available fossil resources and high costs of importation. Central Appalachia is at a disadvantage for implementation of sustainable energy projects because of a lack of strong subsidies and also due to artificially cheap energy prices based on current abundance of fossil-based resources (mainly coal) that do not take into account externalized costs such as damage to ecosystems, contribution to global climate change, and taxpayer-backed health care costs for industry workers who are injured or contract diseases such as pneumoconiosis (black lung).

Some national programs do exist that could be applied to projects within the region, but these programs do not have a guaranteed future and there is not a particular focus on Central Appalachia at this time. The USDA Biomass Crop Assistance Program, or BCAP, provides a dollar-per-dollar match to entities that sell certified biomass to BCAP-certified “conversion” facilities (i.e. if a company harvests and sells $100 worth of switchgrass to a biomass power plant, USDA will pay the company an additional $100). However, this program is not guaranteed past 2012. Federal programs such as the corporate renewable energy production tax credit at $0.021/kWh for closed-loop biomass can provide some incentive, but they need to be paired with strong state incentives which are generally lacking in the region. The USDA biorefinery assistance program provides loan guarantees so that developers can get more favorable loan rates on biorefinery projects, although it is limited since there is no grant component. The DOE has a competitive biorefinery grant program for pilot and demonstration scale plants (generally $2-25 million per grant), but to date no projects within Central Appalachia have been funded. The USDA Rural Energy for America Program (REAP) grant can fund up to 25% of total eligible project costs and another 50% can be covered under their guaranteed loan program. Again, most funding for this program has fallen outside of the Central Appalachian region. The Appalachian Regional Commission (ARC) has made various kinds of funding available for energy projects, but it has mostly been very small amounts for educational and non-profit organizations. They do have economic development funding sources; however, these are generally only available to local government bodies and not to private entrepreneurs. Further, much of these ARC funding streams has gone to the non-distressed counties outside of the coalfields, instead of the sections of their service area where it is needed most.

In addition to economic concerns, land ownership could be an issue. Surface mined lands are generally either still controlled by individual landowners who leased the land to the mining company for the duration of mining and reclamation, or they are wholly owned by a mining and/or landholding company. Individuals may not be interested in using their land for a strange and new purpose unless there is a clear up-front financial or other incentive involved, even though the vast majority of this "hay and pasture" or "fish and wildlife habitat" reclaimed land is not being used for any productive purpose and is often trespassed upon for recreational ATV riding and occasionally for criminal activity. Coal/landholding companies may potentially be more interested than individuals since such a project could be used to create further revenue from land that is currently only generating tax costs. The potential also exists for such a project to be used in a "greenwashing" campaign; that is, to create positive PR material for the coal companies because of investing in "green" energy while also showing that land that has been surface mined can still be used for energy production and other useful purposes, thereby justifying further surface mining. Balancing the need for utility scale renewable energy and long-term ecosystem repair with the potential to inadvertently promote additional mountaintop removal is a concern that should not be taken lightly.

Recommendations

In order to effectively begin moving toward a new reality, concrete steps must be taken and projects initiated. Very few people in the region are aware of the various options available in terms of family/community scale renewable energy. A comprehensive series of free workshops and educational seminars should be held to demonstrate the aforementioned types of systems that are immediately feasible and implementable from a cost and resource availability perspective. These events should be intentionally conducted in the least progressive regions of the interior coalfields, since it is these areas that could benefit most greatly from clean, affordable, and renewable sources of energy. New or existing non-profit community groups could partner with local governmental and educational institutions to fund and conduct these events, with experienced installers and experts brought in from other areas when feasible. Both potential customers and local installers should be targeted, and the available incentives and subsidies for implementing these systems should be covered thoroughly. Ideally, this will spawn both consumer demand for installations as well as generate an installer and technician base. Public demonstration sites with early adopters should be promoted wherever possible to begin showing that such systems are very feasible. Funding could be pursued through ARC's energy and education programs, private foundations, as well as local pools of coal severance tax funds.

Stimulating a regional ecological remediation and advanced bioenergy network will require a large scale effort that addresses several of the shortcomings of current funding opportunities. First, federal agencies should recognize that nowhere in the nation is sustainable economic diversification needed more than in coalfield Central Appalachia, and that advanced biorefineries coupled with ecological repair of surface mined lands constitutes a significant opportunity. The ARC has publicly stated that the region needs to diversify its energy base, and certainly those "distressed" status counties (which happen to be the highest coal producing counties) are in the greatest need of that diversification. The DOE and USDA have both identified biorefineries as the most efficient and viable means by which the country should move into a green energy future. It is now necessary to bring these agencies together to make significant funding available for a pilot project that can demonstrate the viability of this multi-faceted, holistically beneficial approach to development in our country's most maligned region.

By combining the previously mentioned existing grant and incentive programs with direct line item funding from the relevant agencies (DOE, USDA, and ARC) as well as direct contributions from state agencies, it should be possible to procure around $20 million for a 5 to 10 MW P/G plant that will also have some capacity for liquid fuel and/or chemical production. Ideally this funding will also encompass a 4,000 to 8,000 acre bioenergy feedstock/land remediation project and all of the necessary equipment to prepare, plant, and harvest switchgrass and black locust. Coal severance tax funding would be an ideal supplemental funding source for a project of this type, especially since this pool was specifically created to help create diverse economic development in coal-producing regions, which has rarely been the purpose for which it has been used. A more diverse set of funding sources should greatly increase the overall likelihood of being funded, since agencies generally prefer to see multi-faceted support for projects that are new and innovative. Local/community ownership of the project will be essential to ensure that this will serve as a precedent for empowering the people of Appalachia to direct their own energy future, rather than perpetuating the paradigm of outsider control and profit.

Finally, a more stable long-term set of incentive programs would be greatly beneficial for stimulating the initial round of funding for a project of this type. The BCAP funding is not guaranteed beyond the next two years; if that program were to not be renewed, it would be difficult to economically justify moving forward with a project of this type, even if significant investments had already been made. Since it will take 2-4 years both for the crops to establish to the point of being harvestable as well as for the entire permitting and construction process of the P/G plant to be completed, programs like BCAP must be established for longer time periods to ensure that these essential safety nets will not disappear. A dedicated lobbying and advocacy effort to state and federal representatives is needed to show that there is grassroots support for programs of this type.

Conclusion

It is not realistic to think that Appalachia as a whole could ever return to the hunter-gatherer or homestead agrarian lifestyles that once were the norm, barring any unforeseen global disasters. This region has been indelibly shaped by the forces that have controlled it for the past 130 years. Nevertheless, there still remains that spirit of resourcefulness, resilience, and hard work that will enable this area to find new solutions and adapt to the requirements of a new age.

Those ties to place and connections to the land are still present. There are now innovative opportunities to reinvigorate those connections, and the region's relationship to resources is overdue for revision. The projects promoted herein have involved advanced technologies and scientifically-informed approaches to land use, but they also fall within that which is native and suited to the region. Once again there can be an emphasis on the most efficient use of a broad set of resources in a way that allows them to be continually available for generations to come. By emphasizing procurement, production, and use networks that are localized in nature, Central Appalachia can move beyond the undiversified extraction paradigm to a multi-faceted system that is dedicated to long-term regional improvement.

Many of the region's problems and issues are related to the fact that the people have lost hope; they do not see options and opportunities for the future. As new, innovative, and locallycentered projects become reality, there exists the possibility for something of a revival. Inspired by their direct involvement with creating a new future for themselves, coalfield Appalachians will be empowered to transition into an age of stability and prosperity. This should truly be the theme that defines Appalachia in the 21st century.

Resources

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