The College of Forest Resources
University of Washington

Report to the Washington State Legislature

Wood to Energy in Washington: Imperatives, Opportunities, and Obstacles to Progress

Executive Summary/Brief

June 2009

C. Larry Mason, Richard Gustafson, John Calhoun, Bruce R. Lippke, and Natalia Raffaeli

University of Washington
College of the Environment
School of Forest Resources
Box 352100
Seattle, WA. 98195-2100

Acknowledgements

This report represents a synthesis of information and analysis provided from many sources. The work of the research team included a review of scientific, government, non-governmental organization, and industry literature; the popular press; and interviews with government agency personnel, industry professionals, products venders, community representatives, tribal leaders, and others. Members of the collaborative research team included Larry Mason, Research Scientist and Project Coordinator of the Rural Technology Initiative (RTI); Richard Gustafson, Professor of Pulp and Paper Sciences and Director of the Bioenergy Workgroup at the University of Washington; John Calhoun, Director of the Olympic Natural Resources Center (ONRC); Bruce Lippke, Economics Professor and Director of the Consortium for Research in Renewable Industrial Materials (CORRIM) and Director of RTI; Natalia Raffaeli, Research Assistant and PhD. candidate. Administrative support was provided by Clara Burnett (RTI).

Additional assistance was provided by David Sjoding and Kim Lyons, Washington State University Energy Program; Peter Moulton, Tony Usibelli, Greg Nothstein, and Tim Stearns, Washington Department of Community, Trade and Economic Development; Mark Fuchs, Washington Department of Ecology; Craig Frear, Don Young, and Jonathan Yoder, Washington State University School of Economic Sciences, and many others.

This work was made possible by funding provided by and under the mandate of the Washington State Legislature through the Washington Department of Community, Trade and Economic Development.

Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the University of Washington, the Washington State Legislature or the many project cooperators.

The full document can be accessed and down loaded from the following address:
http://www.ruraltech.org/pubs/reports/2009/wood_to_energy/index.asp

“The fuel of the future is going to come from apples, weeds, sawdust—almost anything. There is fuel in every bit of vegetable matter that can be fermented.”

Henry Ford,

"Ford Predicts Fuel from Vegetation," New York Times, Sept. 20, 1925, p. 24.

"With all due deference for the dream chemists, armchair farmers and platform orators who have touted alcohol-gasoline as the greatest of all fuels, oil industry technologists know and automotive engineers know that it is not as satisfactory a fuel as straight gasoline of normal quality."

Conger Reynolds,

"The Alcohol Gasoline Proposal," American Petroleum Institute Proceedings, 20th Annual Meeting, Nov. 9, 1939.

Executive Summary

At the request of the Washington State Legislature, a thorough investigation of the potential for utilization of wood for renewable energy in Washington has been conducted by University of Washington scientists. Summary findings and recommendations are presented below.

Key Study Findings:

- ***Three fundamental imperatives compel changes in energy policy:* Climate Change Mitigation, Energy Independence, and Sustainability.**
  - ✓ *Washington is 100 percent reliant upon oil imported from other states or abroad. Petroleum consumption for transportation accounts for half of all Washington greenhouse gas (GHG) emissions. Washingtonians spent $9 billion on fuel imports in 2006.*
  - ✓ *Washington, with substantial hydro-electric and nuclear generation capacity, is a net power exporter, has low electricity rates, and generates the cleanest electricity in the Nation. Unlike the transportation sector, changes in electricity generation have comparatively limited potential to reduce greenhouse emissions.*
- ***Where possible, development of renewable in-state sources of transportation fuel should be the State's highest energy priority**.*
  - ✓ *Plant biomass is the only Washington renewable resource that can be converted to biofuels for transportation, such as ethanol.*
  - ✓ *Wood is the dominant biomass resource in Washington; accounting for two-thirds of all potentially available biomass.*
- ***Production of renewable biofuels in Washington will necessarily require wood as a primary feedstock and efforts to reduce State greenhouse gas emissions must fully consider forests and forest resources.***
  - ✓ *Forests play a unique role in climate change mitigation by absorbing CO_2 through photosynthesis, storing carbon in tree biomass and building products, offsetting use of polluting building product alternatives, and by providing biomass for energy.*
  - ✓ *Thinning forests to avoid CO_2 emissions from catastrophic wildfires while providing wood resources for green building materials and renewable biofuels will deliver double greenhouse gas emission reduction benefits while sustaining forest ecosystems. As example, in 2006, greenhouse gas emissions from wildfires in Washington were greater than total emissions from electricity generation.*
  - ✓ *The forest industry represents the State's largest biomass collection system, is the largest industrial provider of renewable energy, and has potential to significantly improve wood-to-energy recoveries and outputs.*
- ***Energy recovery of liquid fuels from wood biomass will require large integrated biorefinery installations that must be able to secure resources for operations and markets for bioenergy outputs.***
  - ✓ *Significant production of biofuels in Washington will be dependent upon regular collection of millions of tons of wood biomass augmented, where possible, with recovered biomass from cities and fields.*
  - ✓ *Federal policies, such as the Energy Independence and Security Act of 2007, restrict use of wood biomass from National Forests for energy conversions undermining both biofuels development and reduction of CO_2 emissions from forest fires.*
  - ✓ *Where possible, co-location of biorefineries with pulp and paper mills represents the greatest potential State opportunity to maximize energy recovery of liquid fuels, electricity, and process steam from woody biomass resources. Co-location will bring reduced capital costs, access to*

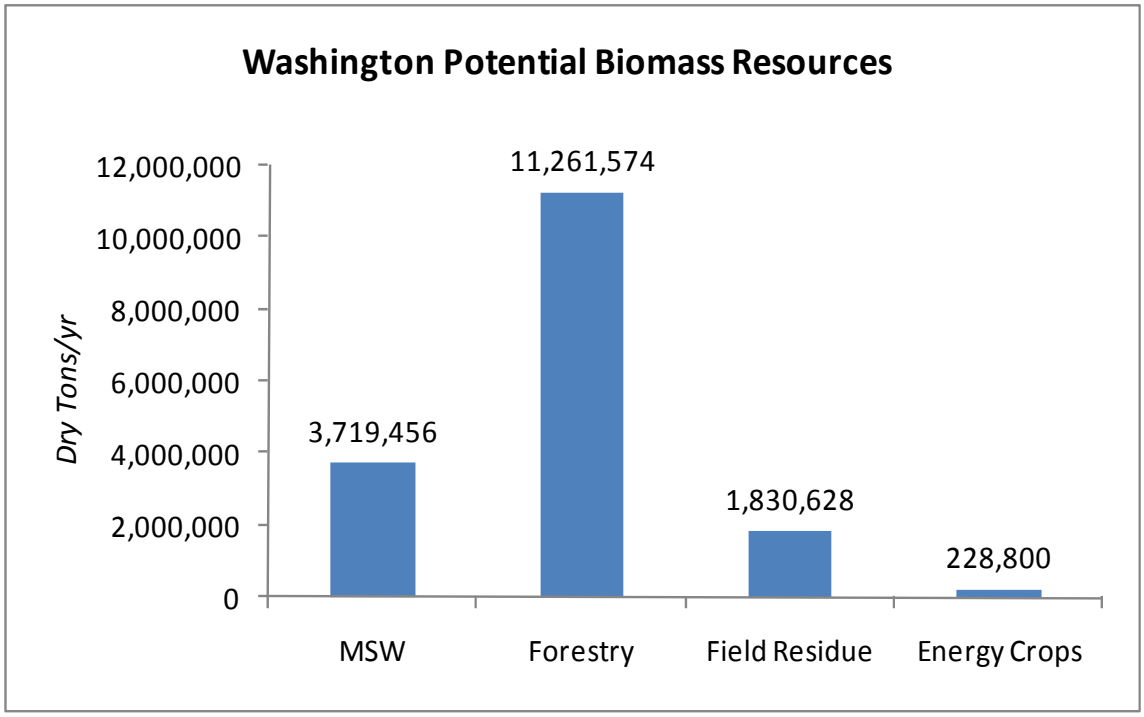
needed infrastructure, synergies for integrated raw materials and product streams, and an engaged corps of highly-skilled chemical engineers and union workers.

- ***Sustainable development of renewable energy alternatives to fossil fuels will require careful planning, resource conservation, and committed policy supports.***
  - ✓ *Where biorefinery development is feasible, State policies must be designed to accommodate considerable biomass deliveries.*
  - ✓ *Where biorefinery development is not feasible, secondary wood-to-energy priorities could include co-fired generation, wood pellet manufacture, or institutional heating.*
- ***Washington State must have a cohesive strategy for renewable energy development to meet its renewable energy and green house emission goals.***
  - ✓ *Washington does not have a Department of Energy or other organizational framework for effective scientific participation in policy consideration of the interrelated topics of energy, climate, and forest resources.*
  - ✓ *Criteria for comparisons of potential alternative energy and resource applications have not been developed to inform energy policy priorities. As example, the implications of wood biomass combustion for electricity verses chemical conversion to transportation fuels appear, as of yet, to have not been considered in State energy policy.*
  - ✓ *The many public benefits of energy alternatives to fossil fuels are not readily captured by consumer markets and, in lieu of integrated planning, are not adequately characterized in State energy policy.*
  - ✓ *Current State energy policies, such as I-937, inadvertently favor small-scale and inefficient conversions of biomass to electricity which fail to address energy independence, have poor raw material-to-energy yields, and compromise biofuels development.*
- ***In absence of integrated planning and enduring commitment to change, opportunities for wood to energy are compromised while combustion of imported fossil fuels and associated green house gas emissions continue to increase.***

Recommendations:

- ***A lead State agency is needed to coordinate policy development for the interrelated topic areas of climate change mitigation, energy independence, and sustainable management of State natural resources.***
  - ✓ *An inter-disciplinary team of scientists from Washington's universities should be assembled to develop recommendations for realistic, effective, and implementable strategies for renewable energy development and climate change mitigation.*
  - ✓ *Robust methodologies such as Life Cycle Assessments (LCA) and Net Energy Balance (NEB) must be employed for energy alternative evaluations if comparative benefits are to be understood.*
- ***Energy priorities need to be identified to inform development of a cohesive State energy plan.***
  - ✓ *Policy mechanisms should be designed to capture the non-market values and avoided costs of reduced reliance upon fossil energy.*
  - ✓ *An effectiveness comparison for Washington of a cap and trade program verses a carbon tax or other climate policy option should be conducted once energy priorities are identified.*
  - ✓ *Policy supports must be developed to encourage investment in renewable energy and assure viable markets for energy products.*

- ***Washington should pursue policies that support large-scale biofuels projects rather than inefficient small-scale power projects.***
  - ✓ *A pilot project for an integrated biorefinery, located at a pulp and paper mill, should be developed and implemented in Washington.*
  - ✓ *Washington policy makers should pursue regulatory changes that broaden rather than constrain access to forest biomass resources.*
  - ✓ *Investments in thinning for forest health offer unique opportunities to combine ecosystem protections with bioenergy development.*



Washington's Potential Biomass Resources (Frear 2008).

Summary Narrative:

This analysis began as an investigation of barriers to woody biomass utilization for energy in Washington but expanded quickly to become more comprehensive as our analysis revealed that perhaps a significant barrier is a lack of integrated understanding of complex issues that need serious consideration if progress is to be achieved. Issues include technical, economic, environmental, social, and moral questions that require continued scholarly research but ultimately can only be resolved by an informed political process. The choices ahead are difficult, expensive and long-lasting with implications for future generations and forest ecosystems in Washington and around the world. While obstacles appear formidable and numerous, none are insurmountable if Washington citizens *choose* to focus sufficient resolve.

The conversion of solar radiation into chemical energy via photosynthesis results in the growth of vegetative biomass made up of organic compounds which have intrinsic energy content. Biomass is effectively stored solar energy. Most of the world's biomass is found in forests. Forests play a specific and important role in global carbon cycling by absorbing carbon dioxide during photosynthesis, storing carbon above and below ground, and producing oxygen as a by-product of photosynthesis. In the presence of increased greenhouse gases in the atmosphere, healthy forests help to mitigate the effects of climate change on the environment by removing carbon dioxide (CO_2) from the atmosphere. Forests in the United States absorb and store about 171 million metric tons of carbon each year, an amount

equivalent to 11 percent of the country's CO_2 emissions. The highest sustained carbon accumulation rates for American forests are reported to occur with new forest growth on high productivity sites in the western Pacific Northwest. Sustainably-managed forests that are periodically harvested, planted, and re-grown to produce a continuing series of short- and long-lived products and energy feedstocks, sequester and offset more cumulative carbon than forests that are left unharvested. When forest health declines or when forest fires occur, releases of stored forest carbon transform forests so that they become a carbon source rather than a sink.

Wood residues from forests can be referred to as woody biomass or as lignocellulosic or cellulosic energy feedstocks. All wood fiber that does not have higher value product potential for non-energy applications can be considered as woody biomass. Woody biomass can include forest residues such as tops, limbs, foliage, bark, rotten logs, and stumps (otherwise commonly known as logging slash) that historically have been left on site or burned following timber harvest. Woody biomass may also include such materials as may be salvaged from pre-commercial thinning activities, designed to reduce stocking densities in young forests such that remaining tree growth is optimized. Forest fuels reductions (generally in fire-prone dry forests) can produce woody biomass as small diameter understory stems and ladder fuels are removed to create conditions such that, when an ignition occurs, a comparatively benign ground fire is the result rather than a destructive crown fire. Woody biomass also refers to primary and secondary wood product manufacturing residuals including bark, saw dust, planer shavings, and ground wood pieces known as hog fuel. Wood chips that are manufactured from round logs not suitable for lumber manufacture or sawmill slabs and pieces may also be used for energy feedstocks but are generally considered to have higher value for paper manufacture. A by-product of pulp and paper manufacture is black liquor; which is another wood process residual that is used for energy. Dedicated tree plantation crops such as fast-growing poplar and willow may also be used for energy generation. The yield from such crops is considered woody biomass although the cultivation practices more closely resemble those of agriculture.

There are many contemporary wood-to-energy conversion alternatives that can be and are employed to produce heat and electricity as well as solid, liquid, or gaseous fuels. Energy conversions can be as simple as combustion for heat or as sophisticated as biochemical and thermochemical processes to produce transportation fuels such as ethanol. We find that, while conversion technologies are improving through continued research, many wood-to-energy applications have been used for decades, are technically feasible, and could be immediately implemented; albeit at costs that are not readily competitive with fossil fuel alternatives given current energy market dynamics.

Examination of energy markets reveals that significant environmental and economic costs resulting from fossil fuel combustion and reliance upon imported oil have not been incorporated into consumer prices. For example, societal costs of climate change and health impacts from gasoline combustion have been estimated at more than $1.00 per gallon while reliance upon imported oil from politically volatile areas of the world has been shown to reduce US gross domestic product by upwards of one percent. These real public costs add up to hundreds of billions of dollars annually but are not included in the consumer price of fossil energy.

There are also substantial public costs associated with failure to manage forests to reduce overstocked densities. Especially compelling are the considerable potentially avoided environmental and economic costs of catastrophic wildfires. US wildfire suppression costs alone are in the billions of dollars annually and the Climate Impacts Group at the University of Washington forecasts that, without action, global warming will increase incidence and intensities of forest fires in the inland west. Wood biomass is the dominant State non-hydro source of renewable energy; representing fully two-thirds of Washington's potentially available biomass inventory. Unlike agriculture, forests don't require large amounts of polluting fertilizers, volumes of water for irrigation, or transformations of ecosystems to non-native vegetation. The Washington forest industry represents the largest biomass collection infrastructure in the state. Given Washington commitments to renewable energy development and greenhouse gas emissions reductions, utilization of wood wastes for energy should be a high priority.

However, if progress is to occur then the economics and other benefits of wood biomass for energy must be better understood. Given that fossil fuels are energy-rich and inexpensive, policy supports for

renewable energy alternatives, based upon explicit cost/benefit analyses, will be needed. It should be recognized that the existing forest industry infrastructure is a significant contributor of renewable energy and that, with policy support for investment, could increase energy outputs from the existing captured resources such as hog fuel and black liquor. Manufacturing wastes are a byproduct of higher value solid wood and paper manufacture and are the lowest cost source of biomass. The pulp and paper industry has potential for biorefinery development to efficiently produce a mixture of products outputs that could be expanded to include heat, electricity, and liquid fuels, such as ethanol, at lower cost than new stand-alone energy plants. Low cost hog fuel, when mixed with higher cost forest residues, can result in a raw material cost index to support broad utilization of wood biomass resources.

We identify three imperatives for guiding progress that have been well-documented in the literature, but have not been adequately integrated into policy. ***Energy policies should seek to maximize integrated achievement of three important goals: climate change mitigation, energy independence, and sustainability.*** When viewed from this perspective, it is readily apparent that the state energy priority should be liquid transportation fuels and that, for Washington, wood is the primary raw material available for biofuels conversions. Combustion of fossil fuels for transportation accounts for fully one-half of the annual greenhouse emissions in Washington; more than twice that released from any other source. Other than minor in-state production of biodiesel, all transportation fuels consumed in Washington are imported from other states or abroad whereas Washington, with abundant hydro-power, generates the cleanest electricity in the nation and is a net electricity exporter. Wind power installations are adding new clean electricity capacity but cannot provide for liquid fuel needs. The decline in Alaska oil production, on which Washington is dependent, should further focus State attention towards securing new liquid fuel resources.

Washington's potentially available wood biomass resource has been estimated to be more than 11 million bone dry tons per year. For relative perspective on the magnitude of this resource, we offer the following theoretical conversions. Total potential ethanol produced from all Washington wood biomass resources could be 900 million gallons per year; enough to replace one-third of 2008 gasoline consumption. WSU colleagues have estimated that the potential electricity from Washington's wood biomass would be equal to 11.5 million MWh or about 13 percent of total Washington electricity use.

We find, however, that a lack of strategic energy priorities in Washington, compounded by political disagreements, has resulted in a peculiar assortment of counterproductive policies (discussed below) that inadvertently reward underutilization of energy resources by focusing on small-scale, capital-intensive, and inefficient conversion projects to produce low-priority electricity. Further, although State policy makers have clearly identified greenhouse gas emissions reductions and renewable energy development as very important public objectives, policies appear to have overlooked the need to integrate resource stewardship and energy generation towards best fit with existing industrial infrastructure.

While obstacles appear formidable and numerous, we hypothesize that none are insurmountable if Washington citizens *choose* to focus enlightened resolve. We refer the reader to the history of ethanol development in Brazil as example. On the other hand, the challenges to substantive reductions in fossil fuel consumption must not be discounted. Fossil fuels are energy-rich, are supported by a vast infrastructure, and, without consideration of factors such as greenhouse gas emissions and energy independence, appear as least-cost energy options for consumers.

Important to any discussion of renewable energy substitution for fossil fuels is a recognition that progress will occur at the margin. Review of domestic and international analyses indicates that total energy independence from fossil fuels is not potentially achievable within any foreseeable planning window. This does not imply, however, that incremental improvements cannot be important or should not be pursued. Development of all potential domestic renewable resources, with careful planning towards an integrated energy portfolio, will ensure optimized levels of success.

Evolving public perceptions regarding forests, biomass exploitation, and non-market amenities will play a major role in how much of the wood resource base may be used for energy. The public must be credibly assured that woody biomass produced from Washington State forests is an environmentally sound and

safe source of renewable energy. However, given the mounting problems of global warming and forest health declines, concerned stakeholders must be challenged to revisit out-dated notions that forests unmanaged are protected. It will be important that the consequences of failing to act be fully appreciated. As demonstrated in many of the discussions presented throughout this report, failure to mitigate climate change, reduce fossil fuel pollution, increase energy independence, and implement practices to ensure forest sustainability is already resulting in significant environmental, social, and economic costs. Numerous international, national, and state political leaders have characterized the need for effective response to current climate and energy challenges as the paramount concerns of the twenty-first century.

The Intergovernmental Panel on Climate Change (IPCC) is a globally-convened body of hundreds of scientists that are generally recognized as the pre-eminent international authority on climate change. IPCC investigation into potential climate change mitigation options resulted in the following conclusion.

"In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fiber, or energy from the forest, will generate the largest sustained mitigation benefit." *(IPCC. 2007. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the IPCC.).*

The four most important findings that emerge from this study:

1) Energy policy must be examined in the context of three over-arching imperatives that compel immediate attention: Climate Change Mitigation, Energy Independence, and Sustainability.
2) Wood is second only to water as a source of renewable energy for Washington, and, conversions to liquid transportation fuels emerge as the highest priority for maximizing integrated achievement of the imperative objectives.
3) Liquid fuels conversions from wood biomass will require large biorefinery capacity designed to utilize dispersed biomass resources for maximized bioenergy outputs. Co-location with State pulp and paper mills represents the greatest opportunity for success.
4) While a paradigm shift from fossil fuels to renewable energy will be difficult and expensive, the environmental and economic costs of inaction outweigh needed investment for change.

Sandia National Laboratories and General Motors have found that ethanol from plant and forestry biomass could sustainably replace a third of gasoline use by the year 2030 (Wong).