Clean and Diversified Energy Initiative

WESTERN GOVERNORS' ASSOCIATION

Biomass Task Force Report

January 2006

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The Western Governors' Association's Clean and Diversified Energy Advisory Committee (CDEAC) commissioned this task force report in February 2005. Members of the Task Force are listed below. This is one of several task force reports presented to the CDEAC on December 8, 2005 and accepted for further consideration as the CDEAC develops recommendations for the Governors. While this task force report represents the consensus views of the members, it does not represent the adopted policy of WGA or the CDEAC. At their Annual Meeting in June, 2006, Western Governors will consider and adopt a broad range of recommendations for increasing the development of clean and diverse energy, improving the efficient use of energy and ensuring adequate transmission. The CDEAC commends the Task Force for its thorough analysis and thoughtful recommendations.

Members of the Biomass Task Force

Ed Gray (Co-chair)	Antares Group Inc.
David Hallberg (Co-chair)	E3 Bio Fuels LLC (CDEAC member)
Gayle Gordon	National Biomass State & Regional Partnership
Butch Blazer/Kim Kostelnik	New Mexico Forestry Division
Drew Bolin/Olga Erlich	CO Governor's Office of Energy Management and Conservation
Bill Carlson	USA Biomass Power Producers Alliance
Craig Cox	Western Business Coalition for New Energy Technologies
Rob Davis	Future Forests LLC
Scott Haase	McNeil Technologies
Dick Hayslip/Jerald Hunter	Salt River Project
Ward Huffman	U.S. Department of Energy
Bryan Jenkins	UC Davis / CA Biomass Collaborative
Jay Jensen	Western Forestry Leadership Coalition
Jim Kerstetter	NM Governor Clean Energy Dev. Council - Biomass Task Force
Ken Krich	California Institute for Energy and Environment
Ravi Malhotra	International Center for Appropriate and Sustainable Technology
Tad Mason	TSS Consultants
Gregg Morris	Green Power Institute
Richard Nelson	Kansas State University
Ralph Overend	National Renewable Energy Lab
Marcia Patton-Mallory	United States Department of Agriculture Forest Service
Marc Rappaport	Oregon State Senator Vicki Walker
Phil Reese	California Biomass Energy Alliance / Colmac Energy
John Stewart	U.S. Department of the Interior
Scott Q. Turn	Hawaii Natural Energy Institute University of Hawaii

Chris Wentz	NM Energy Conservation & Mgmt Division
Ed Wheeless	Sanitation District of Los Angeles County

Facilitator

Will Singleton	The Keystone Center

Quantitative Working Group

The quantitative working group was created by the CDEAC to compare the analysis of data among task forces in order to ensure consistency in assumptions across the reports. The following members contributed to this report:

Doug Arent	National Renewable Energy Laboratory
John Tschirhart	Department of Economics, University of Wyoming
Dick Watson	Quantitative Working Group

Note: This Biomass Task Force report is focused on the use of biomass resources for the production of electricity as part of an overall effort of the Western Governor's Association to increase the contribution of clean and renewable energy in the region. Accordingly, in this report, the WGA Biomass Task Force does not address the significant contribution biomass can make in the supply of fuels to the transportation sector. The Task Force determined that the Governors' Ethanol Coalition would be a preferred venue for the development of policy recommendations related to biomass and transportation fuels. Because of this report's focus on electrical generation, it also does not address the potential of thermal energy.

Acronyms

Organizations:

CDEAC-	Clean and Diverse Energy Advisory Committee of the Western Governors' Association
NREL-	National Renewable Energy Laboratory
NASS-	National Agricultural Statistics Service
NRCS-	Natural Resource Conservation Service
EPRI-	Electric Power Research Institute
CEC-	California Energy Commission
ASAE-	American Society of Agricultural Engineers
FERC-	Federal Energy Regulatory Commission
USEPA-	United States Environmental Protection Agency
WGA-	Western Governors' Association
WREGIS-	Western Renewable Energy Generation Information System
WUI-	Wildland Urban Interface

Technical Terms:

MWe-	Megawatt-electric
MWth-	Megawatt-thermal
CHP-	Combined Heat and Power
BDT or bdt-	Bone dry ton
REC-	Renewable Energy Credit or Certificate
CT-	Conventional Tillage
RT-	Reduced Tillage
NT-	No Tillage
GT-	Gas Turbine
MSW-	Municipal Solid Waste
CI -	Crowning index
TI-	Torching index
SCF-	Standard Cubic Feet
O&M-	Operating and Maintenance
CAPEX-	Capital Expenditure
RPS-	Renewable Portfolio Standard
PPA-	Power Purchase Agreement
WREGIS-	Western Renewable Energy Generation Information System
PURPA-	Public Utility Regulatory Policy Act
PTC-	Production Tax Credit
WWTP-	Waste Water Treatment Plant

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An additional product of the Biomass Task Force is the Full Supply Report. It is intended to accompany this report in that it contains the basis of the supply summary in Section IV.

I. Executive Summary

Biomass as an energy resource has the potential to supply 15,000 MW of electricity to the Western states by the year 2015. At a production cost of 8 cents per kWh, 10,000 MW could be provided. Biomass can supply a constant, distributed, and economic energy supply that is renewable, and that provides important and unique ancillary environmental benefits while the resource is being utilized productively. Examples of these benefits include reduced risks of destructive wildfires, reduced consumption of landfill capacity, and air quality benefits due to reductions in open burning of agricultural and forest residues. In addition, the use of biomass as an energy resource actually reduces greenhouse gas emissions associated with the other dispositions of the material, and contributes to improved public health and stable rural economies. This report's analysis shows that governors can have a tremendous positive impact on the region's energy supply, transmission capacity, and economic health by implementing a few realistic policy recommendations.

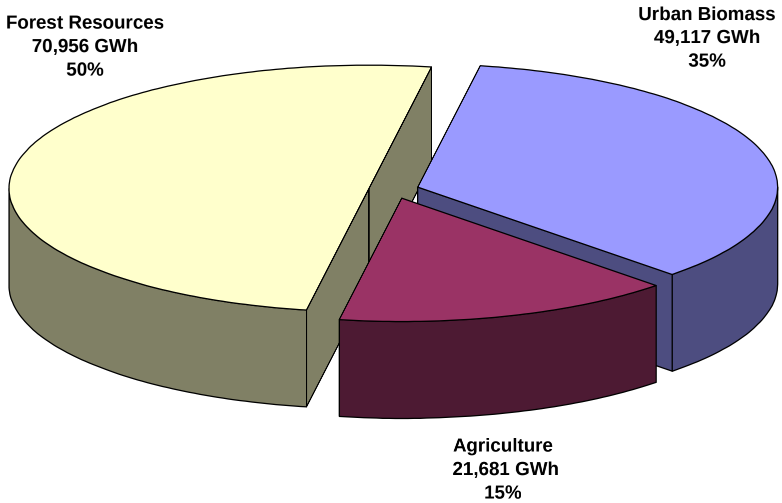
By providing a productive use for biomass residues that have no higher valued use, biomass energy production promotes environmental improvement, provides valuable rural employment and economic development opportunities, and contributes to creating healthier and more fire resilient forests. Biomass energy production makes substantial contributions to reducing greenhouse gas emissions by shifting the proportion of carbon emissions associated with biomass cycling away from more climate active forms, and by protecting forest biomass from destructive wildfires. The 10,000 MW biomass estimate by 2015 would provide for the diversion of roughly 72 million bdt per year of residues from landfill burial, open burning, and accumulation as forest overgrowth. These uncompensated benefits are worth more than $ 8 billion annually (base on 11 ¢ / kWh).

Supported analysis in this paper shows that substantial electrical power can be produced for the prescribed cost by the year 2015. Analysis also shows that if benefits are taken into account, the costs of using biomass energy (as opposed to fossil fuels) can be a *net positive.* While it is unlikely that all of those benefits can be fully compensated in abating the cost of biomass energy, this report's recommendations aim to turn those benefits into economic incentives enabling substantial amounts of increased biomass energy production to be introduced into the marketplace. These incentives will be very small when compared to the value of the ancillary societal benefits (> 11 ¢ / kWh).

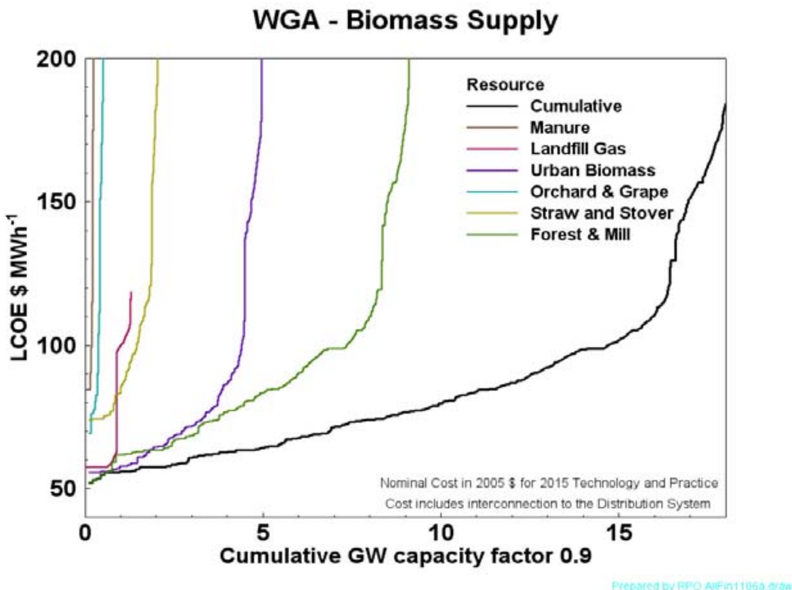
Biomass Supply

The analysis performed on behalf of the Task Force suggests that the potential supply of feedstocks can produce 15,000 MW of generating capacity, or half of the CDEAC target. Biomass feedstocks are extremely diverse. Technologies to utilize the different kinds of biomass fuels are also diverse. Feedstocks include forest resources, agricultural residues and products, and resources from the municipal waste stream including solid wastes, biosolids, sewage, and waste buried in landfills. Biomass is also an important energy source because it is distributed, easing transmission capacity stresses by promoting the production of power close to where it is used.

Figure 1: Biomass (GWh/y equivalent) in the WGA Region Available for Power Generation (Applying the conversion efficiencies suited to each component of the resource).



The Biomass Task Force has done extensive analysis of supply at the production cost of 8 cents / kWh. Our analysis, using the methodology put forward by the WGA Quantitative work group is that 10,000 MW of produced electricity would be available by 2015 at that price. The report highlights a number of different alternate case scenarios that can increase the understanding of the variables that contribute to overall production capacity predictions.



Due to the dispersed nature of biomass resources, there is no need to consider building major new transmission projects to open up resource-rich regions. Other renewable resources typically need major new transmission lines in order to open up areas of resource concentration that are remote from existing lines. Many rural biomass generators provide important voltage support services to the grid, while others may require transmission upgrades to accommodate their deliveries. But biomass facilities by their nature are dispersed, and can be located carefully with respect to the existing grid, rather requiring building out the grid to come to them.

Benefits

Biomass offers important benefits that stem directly from the use of biomass as fuel and thus productively utilizing materials that would otherwise be discarded. By providing a productive use benefit for biomass residues, biomass energy production promotes environmental improvement, provides rural employment and economic growth, and contributes to addressing the threat of forest fires in the Western forests. Biomass energy can also substantially reduce greenhouse gas emissions by shifting emissions from very climate active hydrocarbons such as methane to carbon dioxide, and by protecting forests from destructive wildfires and thus maintaining their ability to sequester carbon.

As the vast forests of the Western United States have become overgrown over the past century, dramatic wildfires have become more common, putting vital habitats, watersheds, and communities at risk. The biomass energy industry offers a low-environmental impact, productive use for dead wood that would otherwise require open burning or – more likely – serve as fuel for a future wildfire. Use of woody biomass for energy production provides an important economic incentive for fuel treatment.

This report features a methodology that a major national study used to demonstrate the net benefits of biomass power production from solid biomass fuels vs. conventional disposal of the same biomass and production of a like amount of energy from fossil fuels. The uncompensated societal benefit was estimated to be more than 11 cents / kWh—greater than the value of the income from electricity production alone. Approximately eighty percent of the total benefits are attributable to the productive use of biomass resources; the remainder is due to the displacement of fossil fuel use. The quantified impact included includes consideration of air pollutants, greenhouse gases, landfill consumption, and forest productivity improvements.

Uncompensated (Ancillary) Benefits of Biomass Energy Production
(from 1999 NREL Report)

US Biomass Fuel Mix

	thousand bdt/yr
Mill Residues	6,400
Forest Residues	1,800
Agricultural Residues	2,300
Urban Wood Residues	1,400
Total	11,900

Value of the Benefits

	¢ /kWh
Criteria Pollutants	4.3
Greenhouse Gases	5.9
Avoided Landfill	1.1
Timber Stand Improvement	0.1
Total Benefits, US Biomass fuel mix	11.4

An important benefit of biomass energy production is the reduction of greenhouse gas emissions relative to the non-productive use of biomass fuels. Agricultural and municipal biomass fuels shift the form of emissions from methane to carbon dioxide (methane is almost 25 times more detrimental as a greenhouse gas than CO2 on an instantaneous basis. Use of woody biomass for energy production lowers emissions relative to open burning because open burning emits unburned hydrocarbons that double or triple impacts on climate relative to controlled combustion in a biomass boiler.

There are significant policy barriers to realizing the integrated benefits of biomass energy and making the use of biomass resources more economic. The key problems are that the social and economic benefits are not compensated in the commercial market place. Air quality standards usually ignore the impacts of alternative disposal practices for the same resource. Permitting issues continue to pose challenges both in siting new production plants and in gaining access to the resources that could serve as fuel.

Recommendations

The Biomass Task Force developed the following ten recommendations to respond to challenges that biomass resource from meeting its true energy, environmental, and economic potential. The recommendations come from an analysis of the most important barriers to competitiveness of the resource relative to other fuel sources and barriers to realizing the benefits of the resource that come from avoiding the environmental costs of not using woody or wet biomass as an energy source.

The Task Force stresses in the report that each recommendation is an important step in realizing the full use of biomass. Selecting one or two of the recommendations will not have the same effect as if those same recommendations were implemented along with the others. The recommendations with brief descriptions follow:

1. Achieve Tax Parity Among Renewable Technologies.

Governors should work at the federal level with their congressional delegations to promote biomass as part of the Production Tax Credit contained in Section 45 of IRS Regulations. Parity should be achieved with wind and geothermal technologies in credit level and the credit should be permanent. Credit for existing facilities should be extended to ten years to match current provisions for new facilities. At the state level, Governors should advocate for parity in state tax incentives and they should be based on actual energy generation (both heat and power) as opposed to investment tax incentives. Again, programs should be at least for ten years. Parity continues to net metering for plants of less than 1 MW of production. Compensation should be provided for export of excess power. The western governors can play an important part in ensuring the widespread adoption of these policies across the region.

2. Strengthen Federal Land Management Policies to Allow Larger, Longer Restoration Projects.

Only long term, large-scale activities will attract infrastructure investment. Governors should work within their borders with federal land managers to ensure that they are using the most appropriate land management tool such as stewardship contracting or timber sale methods. Contracting tools are most helpful when they are long term (20 year minimum) and large scale (up to 150,000 acres or larger). Contracts should be based on the science-based needs of the resource to improve forest health. Project parameters should be collaboratively decided at the local level on a project-by-project basis. There should not be pre-determined artificial constraints on material use or tree diameter size. These should also be collaboratively determined based on the science-based needs of the resource. Arbitrary constraints hinder the commercial viability of the resource.

3. Environmental Benefits of Biomass Should Be Paid For by Beneficiaries.

Governors should advocate their legislatures and regulatory bodies on behalf of the ability of biomass projects to help solve problems such as waste disposal, air quality and forest land/ fire management. Solutions could include fuel subsidies and “biomass only” RFPs to address specific situations. Above-market costs should be borne by the primary beneficiaries of the environmental and waste management services. If utilities are the entities selected to provide supplemental support to biomass power, they should receive cost recovery for those activities.

4. Demonstrate Government Leadership by Purchasing Power/RECs from Biomass Projects and by Supporting Biomass R&D.

The state and federal governments should purchase biomass power directly, or an equivalent amount of RECs, to meet renewable purchase requirements. This would be a tangible demonstration that agencies realize the benefits biomass brings in addressing air quality, forest health, landfill space and rural economic growth. Programs should rely on incentives that are independent of annual budget and appropriations cycles.

The Governors should also take a leadership role in supporting cost shared R&D in partnership with the private sector to demonstrate the use of new biomass technologies and to conduct engineering development research that will lead to near-term commercialization of improved conversion and harvesting technology.

5. Recognize the Value of Firm Capacity in Renewable Purchase Programs.

The Governors should work with the state utility commissions to ensure that utility renewable purchase programs (RPS or otherwise) recognize the firming capacity of biomass by establishing the appropriate price structure. The ability of biomass to provide constant power is both a benefit in and of itself and it can also be used to address the intermittent nature of other resources.

6. Renewable Energy Credits Should Not Include Ancillary Environmental Benefits.

The many benefits of biomass may be accounted for in future credit schemes (such as air quality compliance) and can bring added value to the resource. Current RECs should be defined in a way that they only transfer the renewable nature of the power and only the environmental benefits that result directly from displacement of a like amount of fossil fueled generation.

7. Establish a Single Definition for Biomass.

Governors should work with their state public utility commissioners and green power certification groups to require that the FERC definition of biomass (18CFR Part 292.202) is used to determine the eligibility of the resources as renewable. This definition, “any organic material not derived from fossil fuels,” affords biomass energy projects the greatest opportunity and flexibility to use technology innovation to create productive uses for all types of biomass materials. The ability of biomass facilities to choose from the wide array of biomass resources while conforming to all federal, state and community environmental standards will allow the technology to improve both on technical performance and on production economics.

8. Revise Utility Interconnection Policies.

Governors can work with their state public utility commissions to recognize the importance of recognizing that remote plants support local load and voltage support. This would help prevent artificial imposition of line losses and promote reliability in remote areas. An emphasis on centralized load centers falsely works from the assumption that all power is consumed from a centralized location.

9. Provide Long-Term Certainty for Biomass Programs.

Governors should require that long-term programs in support of biomass should be implemented. Long-term power purchase contracts, fuel supply incentives, tax credits and other measures will help provide the investment environment needed for infrastructure growth.

10. Consider Fuel-Based Emissions When Issuing Air Quality Permits.

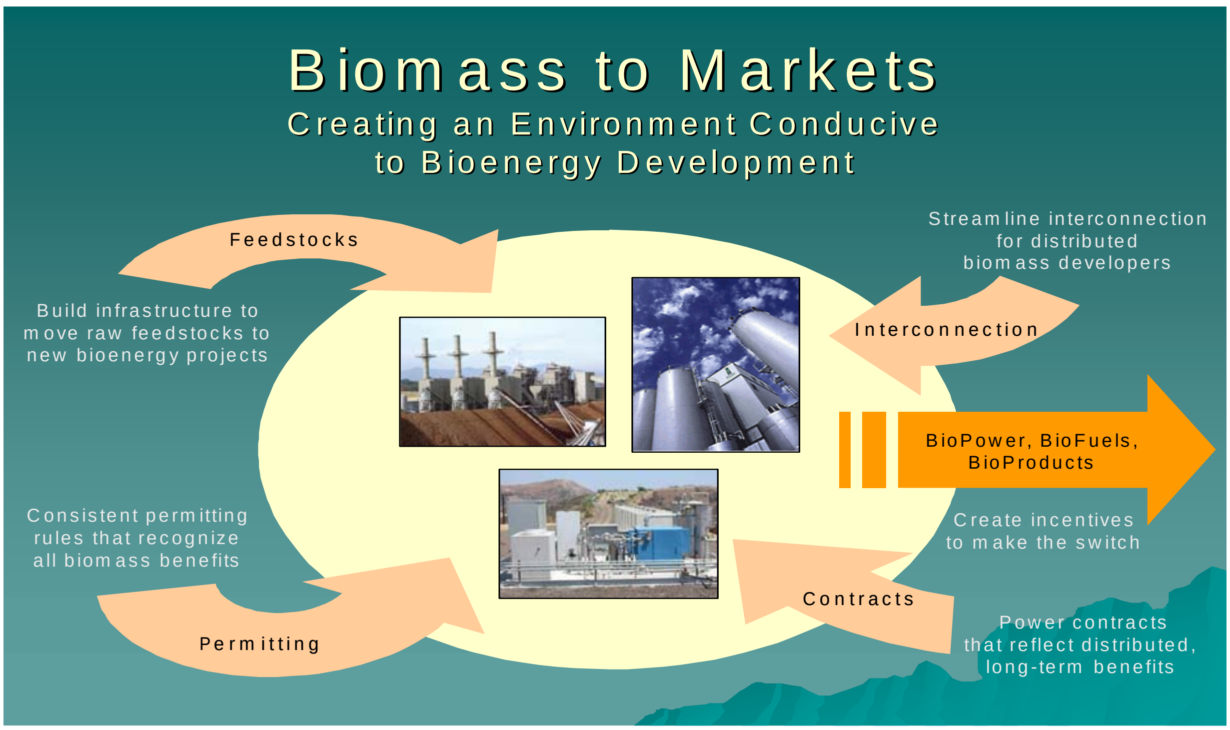
The avoided emissions of air pollutants from biomass plants' fuel, if that fuel is left to its alternate fate, should be recognized and credited to the biomass plants in the permitting process. True netting of the plant emissions should be done.

Further Task Force Work

Biomass Task Force Recommendation: In addition to the ten vital policy recommendations above, the Task Force believes that a follow-up effort building on the supply analysis performed for this report is needed to provide a clearer vision for the CDEAC and WGA of how the next era in the development of biomass resources would unfold. Teams comprised of task force members working on an integrated follow-on analysis can provide answers to key questions the task force could not address in the timeframe given and with readily available data used and generated. The crux of this analysis is to set forth the sequence for developing each of primary resources (with key improvements in resource estimates) in tandem with the conversion technologies and in response to the proposed policy measures. This analysis would directly consider the question of what is the likely mix of end uses by among heat, power, transportation fuels and Bio-based chemicals/products. Answering these key questions will provide the basis for crafting the implementation details of policy changes recommended by the Task Force.

II. Introduction

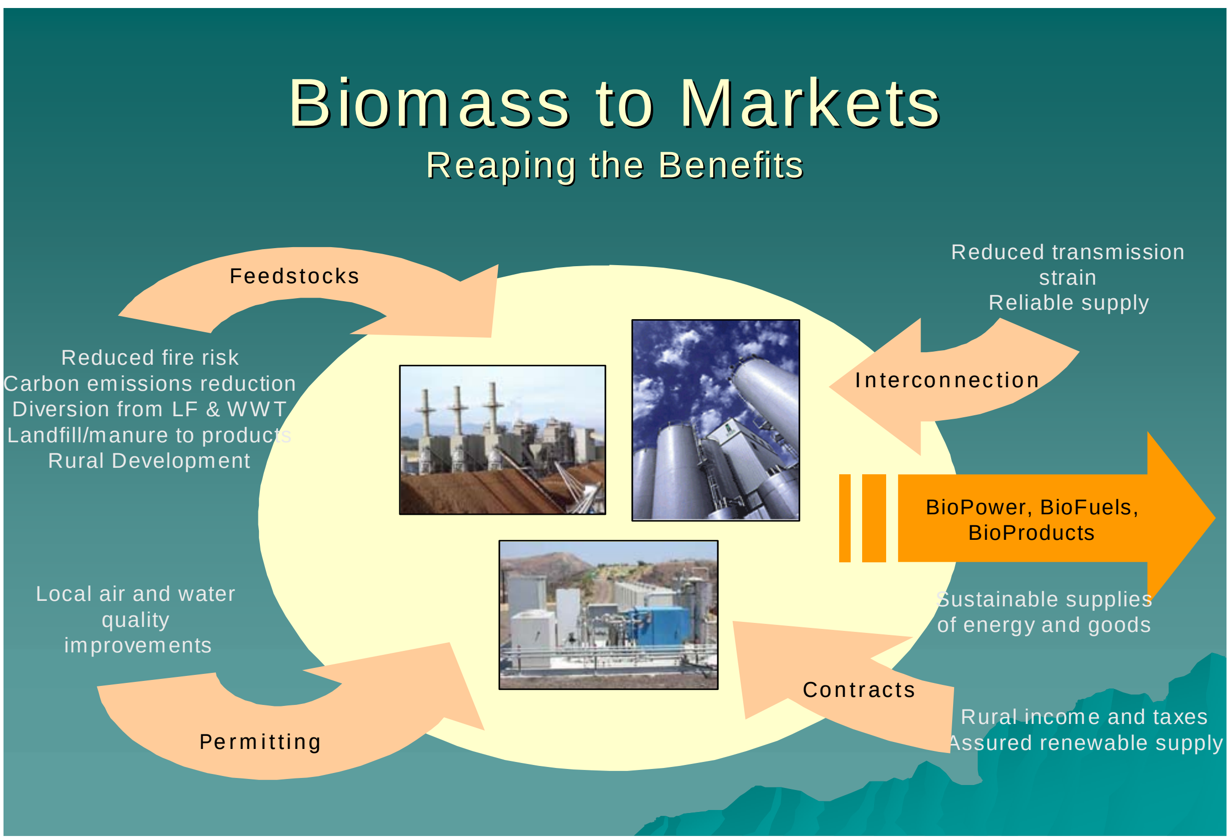
The two factors most likely to encourage bioenergy development and stimulate biomass energy production are, first, unleashing the tremendous desire on the part of many parties, including public and private land managers and an increasing portion of the environmental community, to perform fuels-reduction treatments on western forest lands; and second, the pressure to find productive uses for biomass materials that might otherwise end up contributing to waste stream management problems. As indicated in the diagram creating an environment conducive to bioenergy development in the West requires concerted action on five fronts:



- Increased economic availability of the feedstocks;
- Streamlined interconnection;
- Permitting process that account for biomass benefits;
- Long-term contracts for bioenergy; and
- Incentives to make the switch to a sustainable and renewable resource.

Note: While the mission of the Task Force was to examine the opportunities for development of resources for biomass power, at the very outset the members acknowledged that biomass conversion to heat, fuels and chemicals each have a major role to play in the full utilization of biomass in the West. The predominant use for Bioenergy today is combined heat and power for industry process needs. Biomass continues to be used as an alternative to natural gas, propane or fuel oil to produce thermal energy for homes, schools, and both commercial and public buildings. In the end the Western states will benefit most from a set of policies that encourage development of all end uses for Bioenergy making this resource as ubiquitous as natural gas is today.

One of the unique features of biomass resources is that they can be used to provide a variety of energy applications and products, including electricity, direct heat, transportation fuels, and specialty bioproducts. It is the contention of the Biomass Task Force that policies that encourage the full development of the biomass feedstock potential will in the long run create greater economic value and self-sustainability by serving the full slate of productive uses. The special benefits of biomass electricity production, which are discussed in detail in this report, are primarily related to its transformation from waste and fire management problem to a valued commercial and public service. However, the distributed nature of the resource as demonstrated in the chapter on biomass supply means that the resource can be tapped without straining the existing transmission system and in many cases reduces the need for transmission upgrades. Biomass energy production can utilize feedstock that will decrease the need for investment in transmission infrastructure. That distributed characteristic further contributes to widespread local economic growth in all of the states and not concentrated in a few locations. The benefits of pursuing an integrated policy for biomass development are illustrated in the diagram below.



The Format of this Report

This report of the Biomass Task Force is a cooperative effort of its members to demonstrate the important role biomass energy production can play in the WGA's goal of 30,000 MW additional clean and diverse energy production. Like the other task forces, the Biomass Task Force has pulled together the information on supply, barriers, and policy recommendations to contribute to the initiative.

Because we believe that the consideration of the full benefits of biomass is so important to its viability as an important energy source for the West, we have included a substantial section on benefits. The Benefits Section demonstrates the important benefits to society that biomass energy can bring and innovative solutions to problems that the Western Governors must face as they seek to address such as forest health needs, municipal and agricultural waste management, and the needs of rural communities.

The Supply Section meets our obligations to the initiative by describing the amount of the resource that would be available at the prescribed price per kWh in the year 2015. The section is a summary of the work of the Supply Working Group. The full Supply Report can be found as a companion to this document.

The Barriers Section describes some of the major hurdles that hamper the ability of biomass to reach its potential as an energy source both found and used in the West. These barriers are then addressed in the Policy Section that puts forward ten recommendations for the Governors to pursue under this initiative.

III. The Benefits of Biomass Energy Production

Biomass energy generation produces two distinct and important products: renewable energy, and environmentally productive use of wastes and residues. Biomass energy generation in the western U.S. today provides for a wide variety of benefits:

- productive use of more than 10 million tons per year of solid wastes and residues;
- clean-up of landfill emissions from almost 100 of the region's landfills;
- significant reduction in the need for new landfill capacity;
- significant reduction in the risk of massive wildfires and restore forests to sustainable, healthy conditions;
- significant reduction in greenhouse gas emissions associated with the disposal of biomass;
- significant reduction in smoke and particulate emissions from open burning of agricultural and forest residues;
- assists in environmental cleanup at a growing number of the region's dairies and feedlots; and
- promotion of watershed health and productivity- more and better seasonably adjusted water supplies.

The biomass residues used as fuel in the west come from a variety of sources, and would be subject to unproductive fates, such as open burning, burial in landfills and open pits, and accumulation in increasingly overgrown forests, if the biomass industry was not an available disposal option. Biomass energy production, which can productively use resources that have no higher-valued outlet,[1] can support and complement other recycling and reuse operations by providing an outlet for the otherwise unusable material.

By providing a productive use outlet for biomass residues that have no higher-valued use, biomass energy production promotes environmental improvement, provides valuable rural employment and economic development opportunities, and contributes to creating healthier and more fire-resilient forests. Biomass energy production also makes substantial contributions to reducing greenhouse gas emissions by shifting the proportion of carbon emissions associated with biomass cycling away from more climate-active forms (hydrocarbons, including methane), and toward the less climate-forcing form (carbon dioxide), and by protecting forests and forest biomass from the risks of destructive wildfires, thereby increasing the capacity of the forests to sequester carbon in the long term.

Vast stretches of forests in the western U.S. have deteriorated over the past century, altering the natural fire cycle, reducing habitat for native species, and altering ground water availability and quality. During the past decade the high visibility of out-of-control, massive wildfires in the West, as well as increasing human habitation in and near wildlands (the "wildland urban interface" or WUI), have served to focus public interest

[1] Energy production is the lowest-valued use for biomass. The most cost-effective way to underwrite some or all of the costs of residue removal is to ensure that any fraction of the biomass removed that has a higher-valued use is put to that higher-valued use, with the remainder used as power plant fuel.

on the problems on our unhealthy forests and rangelands. A number of laws and policies including the National Fire Plan, the WGA 10-Year Comprehensive Strategy, the President's Healthy Forest Initiative, the "Tribal Forest Protection Act" and the "Healthy Forests Restoration Act" have established a collaborative, locally driven effort to reduce the fuel load on these unhealthy lands, while at the same time restoring them to a condition that is resilient to the effects of future fires. Improving the health of these overgrown lands will require the removal of huge quantities of wood residues. The biomass energy industry offers a low-environmental impact, productive use for these residues, which otherwise would be open or pile burned, or not removed at all. The development of an infrastructure of biomass power plants and related wood products applications accessible to western forests that are candidates for fuel treatments will not only provide the region with renewable electricity, it will also facilitate protecting our lands and communities by contribution to the resources necessary to get the job done on the ground.

Biomass resources used for electricity production can be separated into two functionally distinct categories: biomass fuels (dry residues), and biogas resources (wet residues). In general, dry residues are amenable to thermochemical conversion technologies (combustion, gasification, liquefaction), while wet residues are amenable to biological conversion technologies (anaerobic digestion, fermentation). The major categories of biomass fuels and biogas resources used in the western U.S include:

Biomass Fuels (Dry Residues)

- Wood processing residues (sawdust, shavings, trimmings, bark)
- In-forest wood residues (harvesting residues, fuel treatments and thinnings)
- Woody Agricultural residues (orchard and vineyard prunings, straws)
- Urban wood wastes (land clearing, construction, tree trimming, other)

Biogas Resources (Wet Residues)

- Wet Agricultural residues (manures, food processing wastes, other)
- Biomass wastes buried in landfills and lagoons
- Sewage and biosolids

Some of the major benefits of biomass energy use include:

Energy production benefits

- Rural economic development – jobs and tax base
- Baseload and/or dispatchable energy source
- Avoided emissions from fossil fuel energy production
- Increased energy diversity and security

Dry residue use benefits

- Improved forest health
- Improved watershed production and quality
- Reduced emissions from open burning of forest and agricultural residues
- Reduced emission from catastrophic wildfires

- Reduced risk of wildfires to nearby communities and watersheds
- Avoided cost of fire suppression and damage
- Conserve landfill space and reduce environmental impacts
- Reduction in greenhouse gas emissions

Wet residue/biogas use benefits
- Reduced water pollution
- Conserved landfill space
- Reduction in greenhouse gas emissions
- Reduced emissions of noxious odors

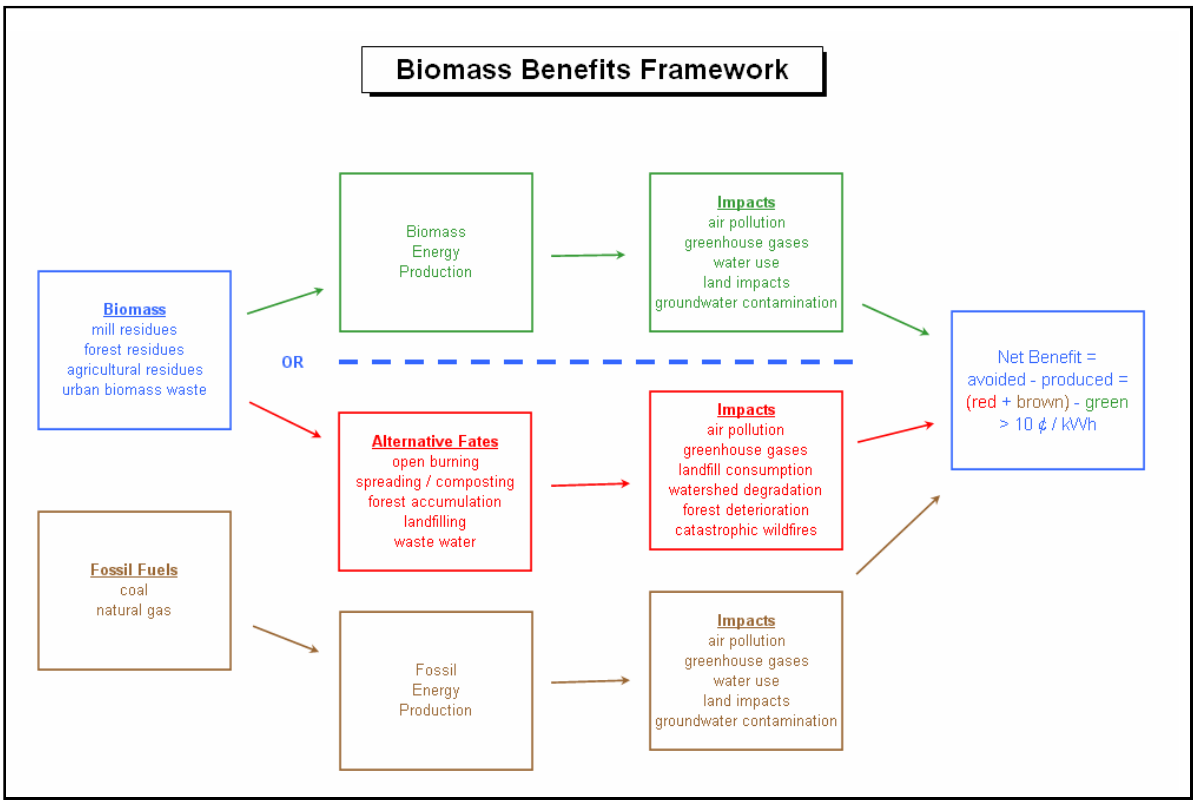
Framework for Biomass Benefits Assessment

Energy production from biomass offsets the production of a like amount of energy from conventional (fossil) sources. At the same time, the use of biomass fuels in energy facilities avoids the alternative disposal of these materials. While biomass energy production causes environmental impacts during fuels preparation and conversion to energy, these impacts have to be balanced against the avoidance of both the impacts associated with an equivalent amount of energy generation from fossil fuels, and the avoidance of the environmental impacts that would otherwise be caused by the alternative (conventional) disposal of the biomass residues used as fuel. The latter effect, avoidance of alternative disposal of biomass residues, quantitatively is the most important source of the environmental benefits associated with the production of energy from biomass resources.

The net environmental impacts of biomass energy production are defined as the impacts of the energy-production pathway, less the sum of the impacts of the alternative production of the same amount of energy from fossil fuels, **plus** the impacts of alternate disposal of the biomass residues that are converted to fuel. In order to analyze the net environmental implications of using biomass resources for energy production, it is necessary to determine what the alternative fate of the biomass would be if it were not used for energy production. Most of the solid-fuel biomass that is used for energy production in the western US would meet one of three alternative fates if it were not converted to energy: open burning, burial in a landfill or open pile, or accumulated as overgrowth in the region's forests. Most of the biogas resources used for energy production would otherwise be allowed to vent from landfills and lagoons, although an increasing fraction of the region's landfills are required to collect and flare if they do not collect for purposes of producing energy.

Open burning produces as much as 100 times more conventional pollutants than controlled combustion or gasification in a power boiler, and much greater quantities of greenhouse gases due to poor (incomplete) combustion conditions. Accumulation of forest overgrowth can have negative consequences for fish and wildlife habitat, reduces forest growth and resiliency to natural disturbance regimes (insects, disease, drought and weather events), increases the risk of devastating wildfires, and degrades the functioning of forested watersheds, both with respect to the amount and seasonality of water production, as well as water quality and sediment delivery to domestic water impoundments. Landfill burial of segregated woody biomass that can be diverted for productive uses such as recycled products or energy production consumes available landfill space, and produces greater quantities of greenhouse gas emissions than controlled combustion of the diverted material. For waste that is buried in a landfill, landfills outfitted with energy systems emit significantly less quantities of noxious odors and greenhouse gases than landfills that do not have energy-production systems. Dairies, feedlots, and other animal facilities produce manure that can, if not properly managed, contribute to air and water pollution. Using their manure to produce biogas energy can help them manage their effluents and reduce air emissions. In all cases, the energy production pathway provides an environmentally superior disposal alternative for the biomass that is being converted than any of the alternative disposal options that are available.

A framework for understanding the social and environmental benefits associated with energy production from biomass is illustrated in the figure below.



The Costs and Benefits of Biomass

A major national study showed that the uncompensated societal benefits of biomass power production from solid biomass fuels vs. conventional disposal of the same biomass and production of a like amount of electricity from fossil fuel, are worth more than 11 cents per kWh.[2] This is greater than the value of the electricity that is currently the sole source of revenue for a biomass power plant. Approximately eighty percent of the total net benefits are attributable to the productive use of the biomass resources, while the remainder is due to the displacement of fossil fuel powered electricity production. The impacts that were quantified in the study included conventional air pollutants, greenhouse gases, landfill consumption, and improvements in forest productivity. Many significant impacts were not quantified in the NREL study. Some of the significant impacts that were not quantified include: energy diversity and security, the costs and damages of wildfire suppression as compared to a fuels reduction approach; watershed damage and reduced water yields and lower water quality; and lost production and revenues due to wildfires and smoke affecting recreation, manufacturing, and education.

The table below shows a breakdown of the components of the value calculation from the 1999 NREL study. The value of avoiding greenhouse gases is the largest component of the calculation. It is based on an assumed value for CO_2 emissions of $33 /ton, which was the then (1999) projected value for CO_2 certificates based on an assumption of broad ratification and implementation of the Kyoto Protocols. The United States has so far declined to ratify Kyoto, thus delaying the creation of robust market for CO_2 certificates in the U.S. Criteria pollutants considered include SOx, NOx, CO, and particulates.

Uncompensated (Ancillary) Benefits of Biomass Energy Production

(from 1999 NREL Report)

US Biomass Fuel Mix

	thousand bdt/yr
Mill Residues	6,400
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Total	11,900

Value of the Benefits

	¢ /kWh
Criteria Pollutants	4.3
Greenhouse Gases	5.9
Avoided Landfill	1.1
Timber Stand Improvement	0.1
Total Benefits, US Biomass fuel mix	11.4

[2] Morris, G., *The Value of the Benefits of U.S. Biomass Power*, NREL Report No. NREL/SR-570-27541, November 1999.

The model that was developed for the 1999 NREL study can be used to calculate some of the component values that are implicit in the calculation of benefits for the total fuel-mix. In this exercise, the value calculation is performed individually for fuel diverted from the various conventional disposal options shown in the table (below). Based on the values for the various impact categories that were included in the 1999 study, the benefits associated with the use of biomass fuels that would otherwise be disposed of by open burning are worth more than the benefits of using biomass fuels diverted from landfill disposal, on a cents-per-kWh basis. Energy that is produced from fuels that would otherwise be left as overgrowth in forests provides a very valuable package of benefits, due to a combination of ameliorating acute air pollution episodes during wildfires, protecting the stock of sequestered carbon in the forest from wildfire destruction, as well as reducing losses of amenity and property values.

Benefits for Avoidance of Specific Disposal Options

(calculated using model and damage values from 1999 NREL Report)

	¢ /kWh
Avoided Open Burning	12.6
Diversion from Landfill Controlled with Flare	8.3
Diversion from Uncontrolled Landfill	11.7
Avoided Forest Overgrowth Accumulation	20.2

In order to illustrate how these values relate to actual projects in the field, we illustrate with an example of a 10 MW biomass facility that procures a mixture of one-third forest fuel, one-third urban fuel, and one-third agricultural fuel. We assume that half of the forest fuel would otherwise accumulate as forest overgrowth, and half would otherwise be pile burned. All of the urban fuel would otherwise be landfilled, and all of the agricultural fuel would otherwise be open burned for disposal. With these assumptions in place, and the damage values used in the 1999 study, the model calculates a value of 12.6 ¢/kWh for the ancillary benefits of the 10 MW facility. The facility consumes 84,000 bdt/yr of fuel, and produces 85 million kWh/yr of power. Thus, the facility produces 10.7 million dollars annually of ancillary benefits, while providing 20 jobs at the power plant, and supporting an additional 40 – 50 jobs in independent fuel-production operations. As a sensitivity test, in light of the fact that greenhouse gases are not yet regulated in the U.S., the benefits value is recalculated using a more conservative assumption for CO_2 emissions of $10 / ton. This yields a value for the ancillary benefits of the example 10 MW facility of $7.6 million. And, it should be noted, this is only the value of the benefits that are included in the model. The facility provides significant additional benefits that are not included in the calculated value, such as rural economic development opportunities, energy diversity and security, protection against the price volatility associated with fossil fuels, and increased agricultural and forestry health and productivity.

Open burning of agricultural residues and forest residues is standard practice throughout the
West. Air quality standards are in conflict with unrestrained open burning because open burning is a major contributor to local and regional air pollution. This problem will grow rapidly as the West addresses forest overgrowth and wildfire threats throughout the wildland-urban interface. Controlled combustion of biomass in a power plant also leads to emissions of air pollutants, but net emissions of conventional air pollutants associated with the disposal of the biomass are typically reduced by 90 – 99 percent compared with open burning. The air pollution impacts of open agricultural burning in California's San Joaquin Valley are so severe that the state is planning to ban the practice altogether, although doing so without harming the state's farmers will not be easy. Conversion to biomass fuel is an obvious solution, but it is not free, and allocating the costs fairly has so far proven elusive. Prescribed burning to address the forest health crisis in nearby forests exacerbates this conflict, limiting the number of available burn days (days on which agricultural burning is permitted), and extending the number of days during which air pollution meets or exceeds the maximum human-health risk levels.

One of the important areas in which biomass energy use provides significant benefits is in the area of greenhouse gas emissions reductions. Biomass energy production not only displaces the use of fossil fuels, it also reduces the greenhouse gas emissions associated with biomass disposal by shifting the form of the emissions of the waste and residue biomass carbon from methane to carbon dioxide (methane is almost 25 times more potent as a greenhouse gas than CO_2 on an instantaneous basis[3]). Furthermore, biomass energy use also makes forests more resistant to the devastating loss of sequestered biomass that occurs when wildfires fueled by biomass overgrowth destroy healthy, mature trees.

Biomass that is disposed of by burial emits carbon in an approximately 50:50 mixture of methane and CO_2. For biomass that is already buried in landfills, animal waste stored in lagoons, and material that cannot be diverted into clean biomass fuel, such as mixed municipal garbage, energy production from the landfill gas leads to greatly reduced overall greenhouse gas emissions. This is obviously true at landfills that would not otherwise be controlled. Less obviously, it is also true at landfills that are already required to collect and flare, because energy systems encourage and enable more extensive gas collection efforts at these landfills. Similarly, energy production from biogas produced from animal manures and sewage treatment operations shifts carbon emissions associated with the wastes from a mixture of methane and CO_2 to virtually all CO_2, greatly reducing the net greenhouse gas emissions. These significant greenhouse gas emissions reductions are in addition to the greenhouse gas emissions avoided by the displacement of fossil fuel use.

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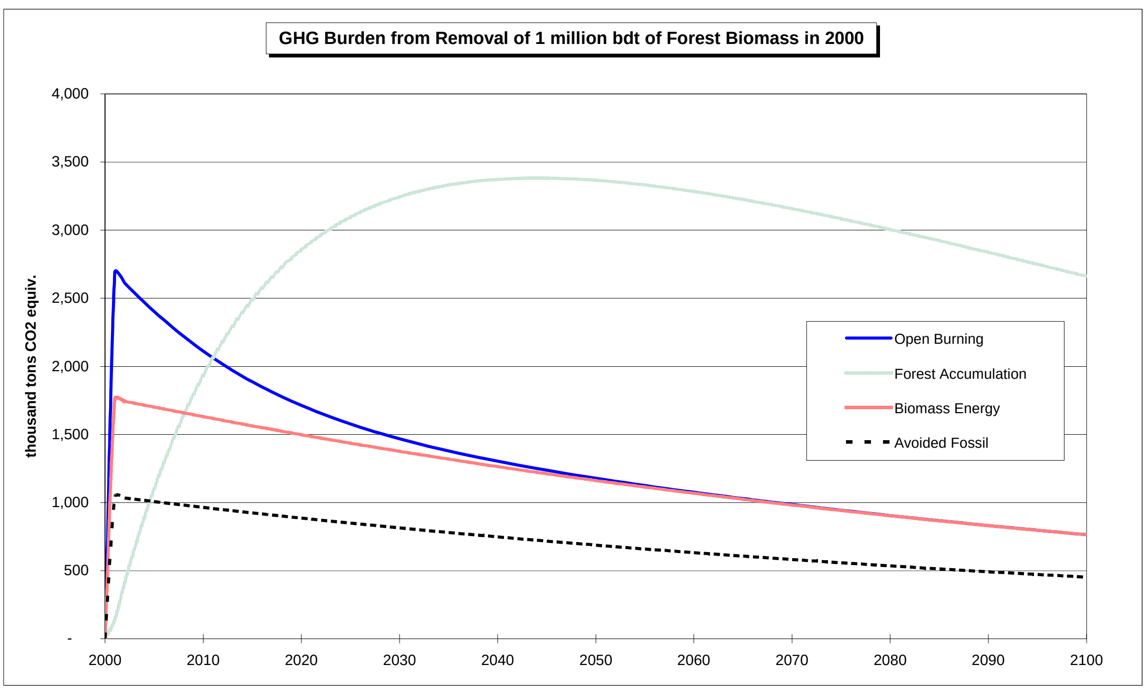
[3] J.T. Houghton et. al., editors, *Climate Change 1995: The Science of Climate Change*, Published for the Intergovernmental Panel on Climate Change by Cambridge University Press, 1966.

Greenhouse gas emissions are also reduced when biomass is diverted from open burning to energy applications. Open burning converts most of the disposed biomass carbon to CO_2, but unlike controlled burning, open burning emits a sufficient amount of the biomass carbon in the form of methane and hydrocarbons that the net greenhouse gas effect is doubled or tripled compared with controlled combustion in a biomass boiler. The figure below[4] shows the long-term atmospheric greenhouse gas burden associated with several alternatives for the disposal of one million bdt of forest residues in one year (2000 in the figure). The red curve is the atmospheric burden over time of greenhouse gases associated with the combustion of the fuel for biomass power combustion (CO_2 up the biomass power plant stack). The blue curve is the burden that would be associated with open burning of the fuel, which could be a combination of mechanical thinning with piling and burning, and prescription burning. The initial atmospheric burden associated with open burning is almost twice as great as with energy production, due to the emissions of greater amounts of hydrocarbons with poorly controlled combustion conditions. Over time, the burdens converge as the methane in the atmosphere oxidizes to CO_2. It is interesting to note that power production from biomass produces more CO_2 than production of the same amount of energy from fossil fuel (shown as the dashed line in the figure). This is due to the lower quality of biomass, from a purely energy perspective. Note that the total greenhouse gas benefit of energy production from forest residue removals, vs. open burning of the same residues, is the difference between the red and blue curves, plus the avoided fossil fuel curve.



The figure also shows, in green, the atmospheric burden of greenhouse gases that would result from not removing the one million tons of forest residues in 2000. From a

[4] Adapted from: Morris, G., *Biomass Energy Production in California: The Case for a Biomass Policy Initiative*, NREL Report No. NREL/SR-570-28805, November 2000.

greenhouse gas perspective, the immediate consequence of not thinning forests, as compared with thinning them, is that not thinning leaves the carbon in the forest, not in the atmosphere. However, over time the fire-prone forests that were not thinned, burn in uncharacteristically destructive wildfires, and the resulting loss of forest carbon is much greater than would occur if the forest had been thinned before fire moved through. By the end of ten to fifteen years, with the assumptions that were used in the analysis, failing to thin leads to a greater greenhouse gas burden than the thinning created in the first place, and that doesn't even account for the avoided fossil fuel greenhouse gas emissions due to the production of energy from the forest thinnings. In the long term, leaving forests overgrown and prone to unnaturally destructive wildfires means there will be significantly less biomass on the ground, and more greenhouse gases in the atmosphere.

Biomass energy production does not change the total amount of carbon that is in circulation in the combined atmospheric and biospheric stocks. Biomass energy production can reduce atmospheric greenhouse gas levels by shifting the proportion of the flow of biospheric-to-atmospheric carbon associated with biomass away from methane, and towards CO_2, and also by increasing the total amount of carbon that is stored in the terrestrial biosphere, which is commonly known as forest sequestration.

Fuel treatments demonstrably protect the tracts on which they are performed. The Figure (below) shows how treatment protected the previously thinned acres when the Northern California Goat Fire of 2000 swept through. In addition to protecting the treated acres themselves, it is believed that strategically located thinnings can stall the overall spread of wildfires, thus protecting acres beyond those treated. The cost of treating fuels on an acre of forested land is usually much less than the cost of active fire suppression on the same acre under wildfire conditions[5]. A preliminary report for a study currently in progress by Northern Arizona University concludes:

> Given these choices, it makes a great deal of economic sense to conduct forest restoration on a large scale today in order to retain future ecological and economic values. Our analysis demonstrates that the fire suppression costs that can be avoided in the future are sufficiently large by themselves to justify restoration expenditures today. [6]

[5] Also see Jefferson County, CO report that highlights the costs per acre of the Hayman Fire.

[6] Snider, G.B. et. al., *Analysis of Restoration-Based Hazardous Fuel Reduction Treatments vs. No Treatment*, Progress Report #1, Northern Arizona University.

Smoke and particulate matter from wildfires and prescribed fires may produce unhealthy air-quality conditions and safety concerns, particularly along highways and airports. Smoke production from prescribed burning can be significantly reduced by prior fuels reduction treatments and improving the opportunity to control wildfires.[7] Controlling the risks of wildfires also provides the obvious benefits of protecting lives and property.

Treatments should always be designed based on collaboratively and locally determined treatment-outcome goals for the forest, not the needs of a biomass power plant. Those goals can often be achieved, if not promoted, by the removal of a limited number of larger trees. Fuels treatments with no higher value products can cost from $600-$1000/acre, while allowing an appropriate removal of larger trees (maintaining forest densities to meet ecological restoration goals) can help defray costs of fuels treatments and net $400-$600/acre.[8]

Biomass energy production also provides highly desirable rural employment and economic development opportunities, and biomass power plants are among the most

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[7] Hardy, Colin C.; Ottmar, Roger D.; Peterson, Janice L. [and others], comps., eds. 2001. Smoke management guide for prescribed and wildland fire: 2001 edition. PMS 420-2. Boise, ID: National Wildfire Coordinating Group.

[8] USDA Forest Service, *A Strategic Assessment of Forest Biomass and Fuel Reduction Treatments in Western states*, Rocky Mountain Research Station General Technical Report 149, March 2005.

dependable generators on the grid. The dispatchability characteristics and dependable nature of biomass power technologies are important considerations for acceptance within the electric utility sector. Biomass power production provides jobs not only in the construction and operation of the generating facilities; it also supports jobs in fuels production (forestry, agriculture) and transportation. An operating power plant typically requires two to three times as many workers to provide the fuel for the operation as work at the power plant itself, this is an estimated 4-5 jobs per MW of capacity.

Biomass power plants are often the largest property tax payers in their rural communities, and offer long-term economic stability that is increasingly elusive in these regions. These facilities provide sustainable, living wage jobs that are sorely lacking in many rural communities.[9] Investments in biomass provide 1.4 ¢ /kWh more than other renewables in the form of wages, and 1.5 ¢ /kWh more than fossil fuel generators. Biomass power plants also provide valuable distributed power generation benefits to rural communities, and often provide voltage stabilization and load reduction benefits to overstrained transmission systems.

Policy Implications

The future of biomass energy production faces a difficult dilemma. On the one hand, it delivers unique and valuable social and environmental benefits that not even other renewables can match. On the other hand, biomass energy production is expensive, and in most cases the energy market cannot carry the entire enterprise by itself. The case for public policy intervention on behalf of beneficial applications for biomass wastes and residues is clear and overwhelming. In addition to the financial challenges, there are a number of barriers that will restrain the future development of biomass energy production in the WGA region. Some of the principal barriers to increased biomass energy development in the region include:

- The social and environmental benefits of biomass are not compensated in the commercial marketplace. As an inevitable result, they are under-produced in comparison to their value to society.

- Permitting issues plague biomass energy development across the West. Permitting barriers challenge both the siting of the conversion facilities, and the ability of the facilities to gain access to the biomass resources they need in order to obtain financing and sustain operations. Air quality regulations usually ignore the alternative disposal fates of potential biomass fuels, which are usually much worse for the same and adjacent air basins.

- RECs (renewable energy credits) are poised to become the common currency of renewable “attributes” across the West. Indeed, the WGA is a part of the development of a regional tracking system for RECs called WREGIS (Western

[9] Morris, G., *Biomass Energy Production in California: The Case for a Biomass Policy Initiative,* NREL Report No. NREL/SR-570-28805, November 2000.

Renewable Energy Generation Information System).[10] The exact definition of the REC in each participating jurisdiction must carefully differentiate between those characteristics that are common to all renewables, and thus the essence of the REC, and those environmental services that are produced as ancillary products, or co-products, of energy production, and thus should be the rightful property of the generator. Failure to do so jeopardizes the biomass generator's efforts to obtain compensation for these benefits, and thus limits the potential development of this valuable generating resource.

[10] See http://www.westgov.org/wga_wregis.htm. The WGA and the California Energy Commission are working collaboratively to develop a Western-wide renewable tracking system. WREGIS will be an accounting system that tracks renewable energy generation, creates RECs , and accounts for transactions involving RECs in the geographic region covered by the Western Electricity Coordinating Council.

Biomass Supply for the Western United States

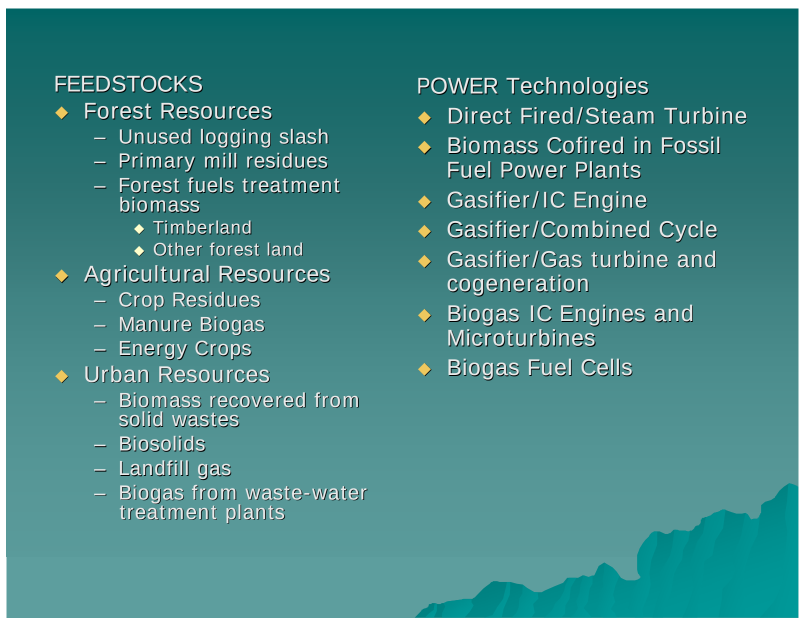
Biomass Supply in the Western states

An assessment of biomass resources was undertaken as part of the WGA's evaluation of the potential for generating additional electrical energy from clean and diversified energy resources in the WGA member states and territories. The full assessment of biomass resources is a companion report to the Biomass Task Force entitled "**Biomass Electric Supply Resources for the Western states, Report of the Biomass Supply Working Group**." This section of the Biomass Task Force Report summarizes the analysis and conclusions of the longer companion document.

Biomass Supply Overview

Biomass feedstocks are as diverse as the biosphere that produces them. There is an equally diverse set of conversion technologies that are available to convert raw feedstocks to power, transportation fuels and chemical products. Categories of feedstocks and a list of technologies for power production are listed in Exhibit 1-1 with brief definitions provided in the following report sections on feedstocks and conversion technologies. Biomass facilities can provide power in the kilowatt range to farms and light industry or in the multi-megawatt range to communities, campuses and industrial complexes. These qualities alone make biomass the most diverse, complex and strategic renewable resource in the region. The Biomass Task Force concludes that biomass is most likely to be developed on a widely distributed basis providing baseload power close to customer needs. In estimating the potential of biomass resources, requirements for sustainable harvests of forest and agricultural biomass have been taken fully into account. The restrictions and limits placed on harvests are detailed in the full supply report companion document.

Exhibit 0-1 Western Biomass Resources



The analysis of the potential supply of biomass feedstocks in the region suggests that nearly 15 GW_e of generating capacity could be produced from biomass. By analyzing the locations and quantities of biomass resources in relation to electric load centers and entry points to the electric grid, the Task Force has determined that nearly all of this power could be produced and distributed to customers without increasing transmission capacity. Careful consideration has been given to potential opportunities to productively use biomass generated by fuel treatments to timberland near communities at risk of forest fire. A summary of that analysis is provided in the feedstocks section below.

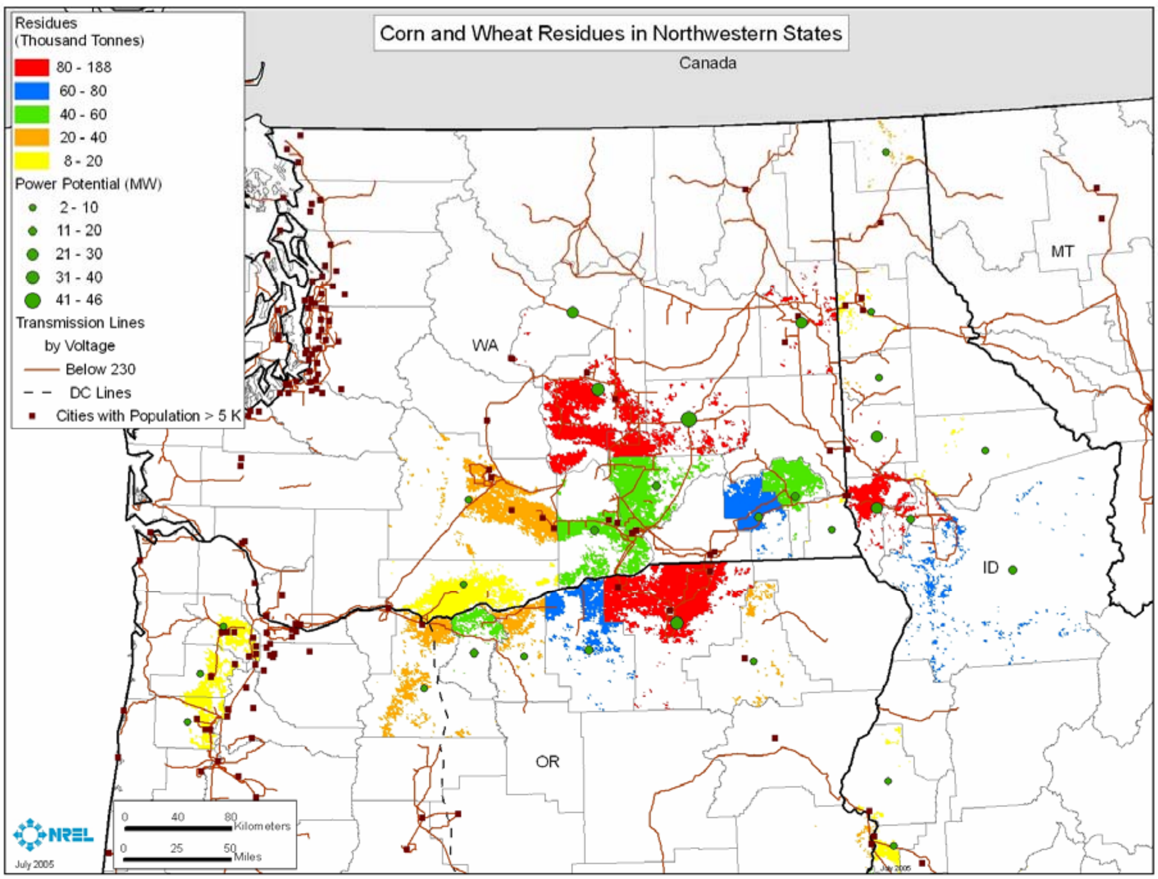
Development of biomass resources could achieve approximately half of the CDEAC goal of 30 GWe in new generation capacity. The Biomass Task Force believes that policies encouraging the development of biomass resources will not only increase the supplies of power but will simultaneously create opportunities for the development of liquid fuels and bio-based chemicals.

Biomass is a Distributed Generation Resource

Biomass is a widely distributed resource. Fuel competition and transportation costs typically preclude the construction of power plants of greater than 50 MW capacities. Most future power plants fueled by dry biomass resources are likely to be in the range of 15 to 30 MW. Larger systems are possible with gasification combined cycles technologies in the 100 MW range but even these by utility standards are small generating capacities. Systems built for biogas generated from landfills and manure will typically be under 10 MW. The Biomass Task Force believes that by serving loads at the end of the transmission line biomass plants will almost always provide grid support and relieve the strain on grid capacity. The Task Force agreed that a simplified GIS analysis to verify this characteristic was appropriate. In the analysis, the transmission grid and the location of towns and urban centers have been overlaid with biomass resource estimates to evaluate the potential to serve load centers. One of the key results of the analysis is that new transmission lines or transmission line upgrades will be the exception and not the rule for wide-spread biomass utilization. Biomass facilities should generally be treated as distributed generation projects and should not be charged with energy losses to remote load centers, but instead credited with improvements to system voltage and reliability.

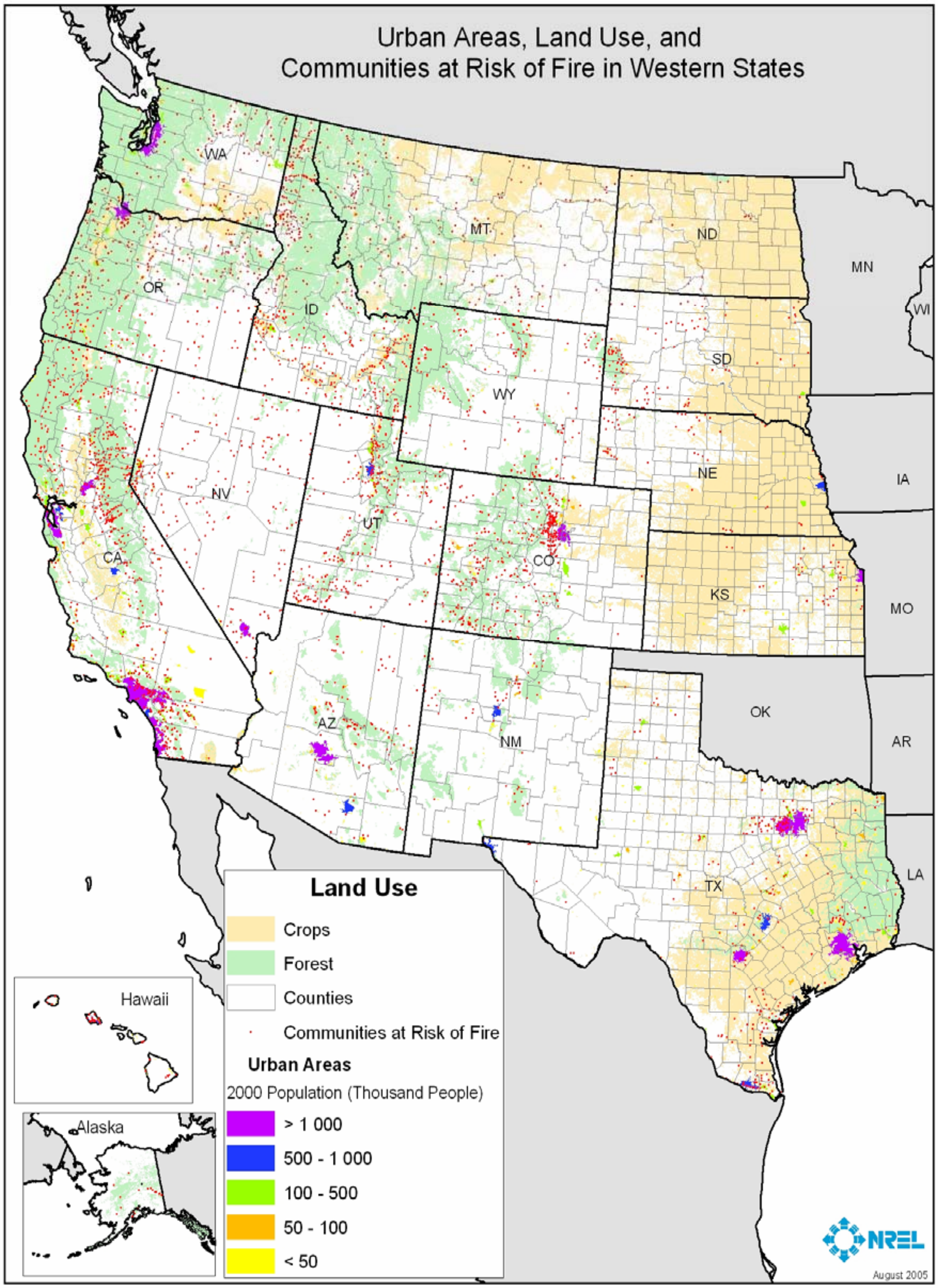
Exhibit 1.2 illustrates the principles above for one important segment of the resource: potential crop residues in the Northwest. The green pins on the chart are the loci of supply sheds for crop residue supplies and not the proposed location of the plants. In nearly every instance the plants can be sited near the towns (representing load centers) and electric utility lines with carrying capacity less than 230 kV. In some cases the fuel supply will support cogeneration facilities for industries near those towns.

Exhibit 0-2 Crop Residue Supplies in Relation to Communities and Subtransmission lines



The case for the use of biomass is enhanced by the proximity of potential forest resources to population centers and, more importantly, to communities at risk for forest fires as illustrated in Exhibit 1.3, Forest Resources in Proximity to Communities. If efforts to reduce forest fuels gain community and government support, such resources will be important additional component of fuel supply to power plants and Biorefineries developed in these regions.

Exhibit 0-3 Forest and Crop Resources in Proximity to Communities in WGA Region



Methodology for Developing the Biomass Generation Supply Curves

For each representative plant site NREL calculated the cost of electricity using the fuel costs specific to the surrounding supply shed coupled with the conversion technology characteristic curves provided in this report. Individual production costs for all sites are sorted from lowest production cost to highest and plotted to build an electricity supply curve. The supply curves below *include interconnection costs*. However, the analysis team believes that in many cases the costs of interconnection will be partially offset by capacity credits. These credits would accrue given the likely geographic distribution of the potential sites which supports the Biomass Task Force's contention that biomass plants will reduce the strain on the transmission system.

To calculate fuel costs for this analysis, NREL has combined the spatial distribution of resources, harvesting/collection costs, and a transportation cost function to determine the delivered biomass fuel cost to representative plant sites. For analytical simplicity and given that most of the resources fell within counties with nearby load centers, representative plant sites were located at the geographic center of counties central to each biomass supply shed. Actual plant sites will be close to load centers or subtransmission lines to minimize grid connection costs. The results of the analysis are an aggregate supply curve for biomass generated electricity in the Western states in the 2015 time frame. The components of the biomass supply are:

- Forest Resources: This component adds together mill residues, fuel harvests, timber harvest residues and forest fire treatment materials for a given county. The current model takes the quantity and cost of each assortment and sums them up to an individual county level.
- Agricultural Residues: Only wheat straw and corn stover that could be sustainably removed from farm land were included in the crop residues assessment. Data on orchard and vineyard pruning were available for California and included in a separate component supply curve.
- Landfill gas: This important segment of supply contributes to the lowest cost portion of the supply curve and could add several GWe of additional power supply all in urban locations. By 2015 there will be increasing competition for the use of the biomass that would be headed for the landfill in today's circumstances. That effect could constrain the growth of landfill gas supplies.
- Animal manure resources. Conversion of decomposing animal manures into useful energy is already making good strides and by 2015 will likely be included in best management practices for dairy, swine and cattle operation.
- Urban Biomass is biomass recovered from municipal solid waste streams. Recovery rates of 40% were projected for 2015 making this resource a key low cost component of the biomass supply curve.

The Task force resource assessment did not include a number of additional resources. They are potentially important sources of additional biomass in the total resource estimate in the 2015 timeframe.

- Potential feedstocks on Federal lands where an active, integrated ecosystem management approach is employed to enhance or maintain wildlife habitat, reduce hazardous fuels, remove disease infested stands, improve scenic vistas or highway corridors, and improve or protect water quality.
- Forest treatments and hazardous fuel reductions for counties in wet climate regions
- Energy Crops – both herbaceous and short-rotation woody crops They are not expected to provide a significant contribution in the timeframe of this analysis but could be a very large component of biomass supply in the long term.
- Orchard and vineyard pruning residues outside of CA
- Materials from forest management practices such as timber stand improvement thinnings – especially on private and industrial forest lands
- Pulp and paper industry byproducts (bark, pulping liquors, and paper sludges) have not been included. The readily available data for this segment of the resource was too old to include in the supply data. This industry sector is already a major source of biomass power generation. To be included in the supply analysis data on potential plant expansion, boiler upgrades and new facilities would have to be developed.
- Wastewater treatment plant sludge and biosolids have not been included. Technologies for recovering energy from these wet biomass supplies may be economic by 2015.

Recommendations for Follow-up Analysis and Developing a Vision for the next Era in Biomass Development in the West

To provide a clearer vision for the CDEAC and Western Governors of how the next era in the development of biomass resources would unfold, the work of the task force should be refined and assimilated. Teams comprised of task force members working on an integrated follow-on analysis will provide answers to key questions the task force could not address in the timeframe given and with readily available data used and generated. Answering these key questions will provide the basis for crafting the implementation details of policy changes recommended by the task force.

- Forest Resources – Add potential resources where warranted and develop the pathways to utilization of the resource that the recommended policy measures are designed to encourage. Conduct an analysis of potential feedstocks on Federal lands (using examples from selected field units) where an active, integrated ecosystem management approach is employed. Examples should include field units using biomass thinning to enhance or maintain wildlife habitat, reduce hazardous fuels, improve scenic vistas or highway corridors, and/or address forest health concerns.
- Urban Resources - Review the assessment of urban biomass; resolve the comparative analysis of landfill energy recovery versus biomass extraction from the MSW stream for urban Bioenergy facilities.
- Agricultural Resources – Add other potential resources (e.g., barley, oats, rye, and rice straw) where warranted and reconsider the potential for herbaceous and short-

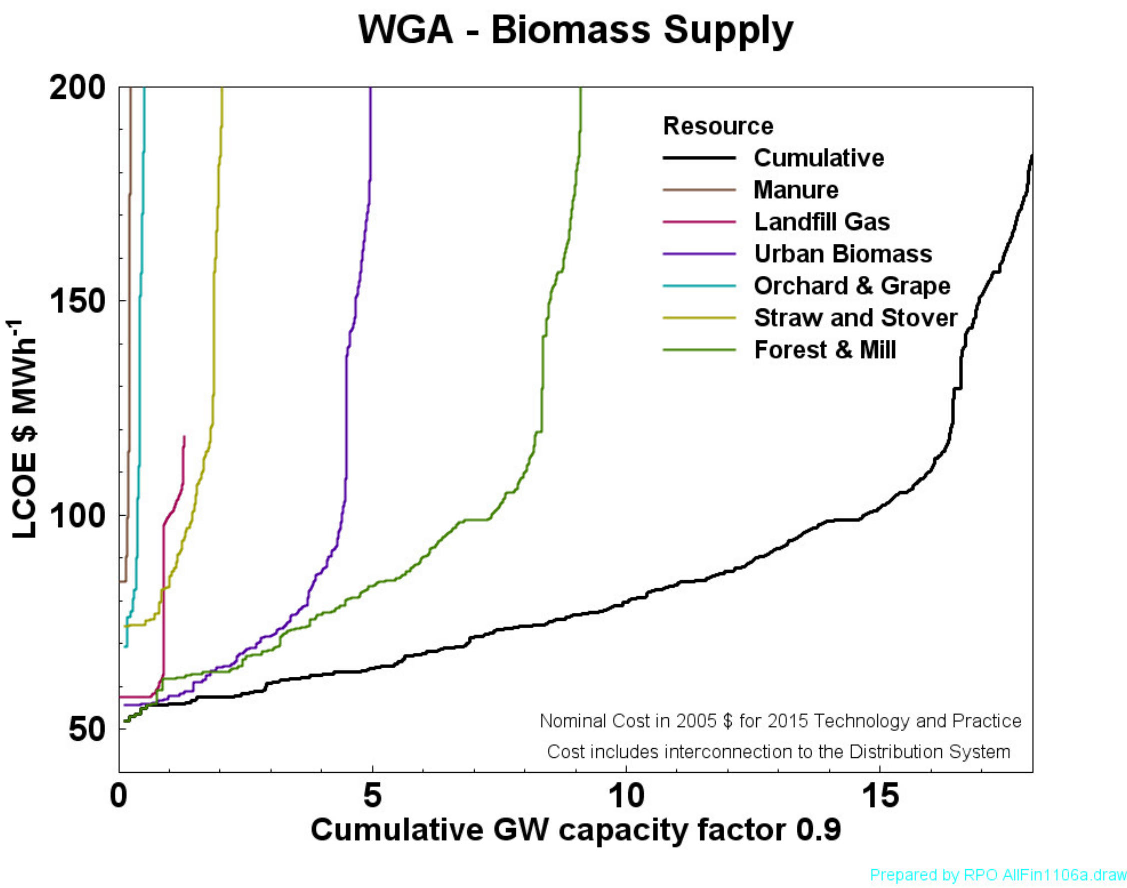
rotation woody energy crops to contribute a reasonable and sustainable supply. Characterize the potential for Bioenergy crop production in a sustainable manner marginal lands and land coming out of production due to shifts in agricultural markets.

- For each resource category determine the approximate timing and split in end uses – power and liquid fuels production – this will help build a framework for an integrated biomass policy rather than a competitive set of policies.
- For each resource determine the relative impacts of the top ten policy recommendations to provide a clear understanding of which resources and end uses will benefit and what the return on political investment is likely to be.

Supply Curve Analysis Results

Aggregate and component supply curves are provided in Exhibit 4-3. The curves indicate that the bulk of the biomass power generation will be produced in the gradually upward sloping portion of the regional supply curve up to a cumulative production cost of $100/MWh (including the costs for interconnection to the grid). This portion of the curve represents the conversion of available fuels in areas of sufficient feedstock density for power production and could provide about 15 GWe of baseload power at a 90% capacity factor. At a cumulative production cost of $80/MWh, biomass would support 10 GWe of baseload power. The portion of the curve that swings sharply upwards is consistent with the costs of converting “stranded biomass” (biomass that is too widely distributed or too costly to harvest to be easily converted to power). However, some portion of this stranded biomass may be an artifact of the modeling scheme which does not attempt to treat generation facilities under one megawatt. Further, the model does not currently aggregate different types of resources in the same area, for example combining agricultural and forest supplies to fuel a plant.

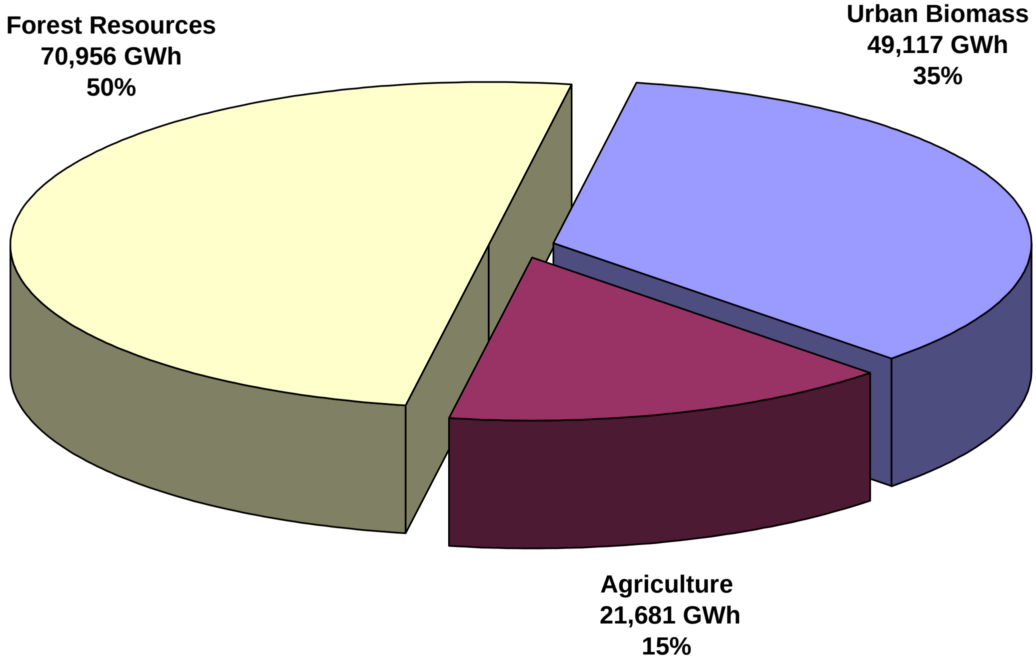
Exhibit 4-3 Aggregate and Component Biomass Power Production Curves



Feedstocks Summary

Data were developed for each of the resource categories for each of the Western states. Where possible, data were compiled at the county level for each of the WGA states in the contiguous US along with Alaska and Hawaii. Data limitations resulted in Guam, American Samoa, and the Northern Mariana Islands being excluded from the current assessment. The biomass available annually for power generation projects within the WGA region is tallied in three major resource categories: agriculture accounts for 15%, forestry 50%, and municipal or urban sources 35% (Exhibit 2-1).

Exhibit 2-1 Biomass (GWh/y equivalent) in the WGA Region Available for Power Generation (Applying the conversion efficiencies suited to each component of the resource)


Forest Resources
70,956 GWh
50%
Urban Biomass
49,117 GWh
35%
Agriculture
21,681 GWh
15%

Biomass Classes

Agricultural Biomass: Lignocellulosic biomass that remains in the field after harvest of agricultural crops and animal manures. Crops grown specifically for bioenergy production are being developed but are not included in the Biomass Task Force resource estimates.

Urban Biomass Resources: Urban Biomass includes four components

- **Biomass Extracted from Municipal Wastes:** Includes only the biomass component of municipal solid waste (MSW) and not the entire MSW stream. This includes paper and cardboard, green waste, food waste, construction wood waste, and specifically excludes plastics, tires, and other non-biomass materials.

- **Biosolids:** Organic materials derived from wastewater solids (sewage sludge and residential septage) that have been stabilized, meet specific processing and quality criteria and are suitable for land application.

- **Landfill Waste in Place:** Waste currently in place in U.S. landfills as an indirect measure of the potential to generate biogas from landfill biomass decomposition.

- **Wastewater *(Biogas from waste-water treatment plants)*:** Used water that goes down the drain in homes and businesses and ends up in wastewater treatment facilities.

Forest Biomass: Forest Biomass has three key components

- **Unused Logging Slash:** Wood debris left after a timber harvest and includes branches, chunks, bark, and stumps. Traditionally, logging slash has been left in the forest or piled and burned because there has been no market for these wood materials.

- **Primary Mill Residues:** Unmerchantable biomass (large bulk waste, wood chips, shavings, and sander dust) generated by sawmill facilities.

- **Forest Fuels Treatment Biomass:** Biomass that is removed from forestland in order to mitigate fire hazard. For the WGA report two sources are analyzed separately (1) timberland or reserved forestland and (2) Forest land biomass found other than in timberland or reserved forestland. It includes forestland that is incapable of producing merchantable wood.

Forest biomass resources are potentially the largest component of Bioenergy supply. Forest fuel treatment and thinning biomass is a particularly strategic source of biomass materials in the Western states. This is only one component of forest biomass that could be available for Bioenergy production with appropriate policy support but it is the one that is most driven by forest health and community risk standards rather than the demands of Bioenergy facilities. Bioenergy facilities provide a productive use for the materials derived from treatment and thereby reduce the economic liability for disposing of those materials. Estimates of forest thinning biomass to be removed in order to mitigate fire hazard *on timberland*[11] were obtained using the Fuel Treatment Evaluator Version 3.0.[12] The Forest Service applied several screens to identify the areas of timberland that would most benefit the public and forest health if treatments were performed to reduce fire hazards. The results of the screens being applied are shown in Exhibit 1-1.

Exhibit 1-1 Screening Timberland for Fuel Treatments

The Fuel Treatment Evaluator excludes roadless areas and counties with very wet climates. The screening identified 23 million acres of timberland in 12 Western states[13] at high risk for stand replacement fire (crowning index (CI) or torching index (TI) less than 25 mi/h).[14]

This scenario would treat all 23 million acres identified and provide 318 million dry tons of wood from the 12 Western states. If 1.0 million acres were treated per year, then 14.5 million dry tons of total biomass would be provided per year over 22 years. One million acres is chosen as a tentative annual treatment area to represent a plausible moderate increase in thinning area on public and private timberland. If 50% of the biomass would be used for higher value products, then the remaining 50%, or 7.2 million dry tons per year, may be available for fuel (included in biomass estimates for the Forest portion of Exhibit 1-1 of the WGA full report). After 22 years, more area will have moved into the higher fire hazard class, and continued thinnings would likely be required.

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[11] Timberland is forest land that has not been withdrawn from timber utilization by statute or regulation and is capable of producing 20 ft^3/acre/year of merchantable wood in natural stands.

[12] Miles, Patrick D. Aug-04-2005. Fuel Treatment Evaluator web-application version 3.0. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. [Available only on internet: http://www.ncrs2.fs.fed.us/4801/fiadb/fte_test/fte_testwc.asp]

[13] Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, Washington, and Wyoming.

[14] Eligible timberland acres excluded forest types where high severity fire regimes are the norm—lodgepole pine type and spruce–fir type—with the qualification that these types received limited treatment in wildland urban interface areas. Eligible timberland acres also excluded inventoried roadless areas.

Estimates of forest thinning biomass to be removed in order to mitigate fire hazard *on "other forest land"* were obtained from the report *Biomass as feedstock for a bioenergy and bioproducts industry: The technical feasibility of a billion-ton annual supply*.[15] Other forest land is forest land other than timberland or reserved forest land. It includes forest land that is incapable of producing 20 ft^3/year of merchantable wood. 16 Western states[16] contain 141 million acres of timberland and 80 million acres of other forest land. The "billion-ton" report estimates 10 million odd tons of wood biomass could be supplied annually for fuel or bioproducts from other forest land (included in biomass estimates for the Forest portion of Exhibit 1-1 of the WGA full report). State-level estimates of biomass removals were apportioned to the county level in proportion to the amount of "other forest land" in each county in each state.

[15] Perlack, R.D. et al. 2005 Biomass as feedstock for a bioenergy and bioproducts industry: the technical feasibility of a billion ton supply. Oak Ridge National Laboratory, Oak Ridge, TN 60 p. http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf

[16] Adding Kansas, Texas, Nebraska and North Dakota to the twelve above.

Bioconversion Technology and Applications

Current Biomass Energy Conversion Technology

There is a wide array of technologies for converting biomass into power, heat and fuels. Primary conversions can be classified into thermochemical and biochemical conversions. Thermochemical conversions include direct combustion, pyrolysis, and gasification. The major differences are the amount of oxygen used by the process and the intermediate products produced.

Direct combustion is the oldest conversion technology. The technologies used for direct conversion include pile burners, stoker boilers, and fluidized bed boilers. These all produce heat that can be used directly, or more often, converted into steam as an intermediate product. Gasifiers convert biomass into a combustible gas by using less than stoichiometric amounts of air (air-starved environment). Biomass can be gasified using heat generated from combustion of a portion of the biomass or from externally generated heat. The gas can be burned to produce heat or steam or it can be converted into liquid fuels such as methanol or diesel. Pyrolysis involves heating the biomass in the absence of any oxygen and producing a mixture of gases, liquids, and solids. The pyrolysis gases can be burned and the liquids are generally of the heavy oil type that can be further processed or burned. The solids (usually a process char) are often recycled into the pyrolysis conversion system. Biochemical conversions include anaerobic digestion and fermentation. Anaerobic digestion is the preferred conversion method for high moisture content, biomass resources, such as animal manures. Fermentation involves the selective conversion of biomass materials into desired products through the selection of specific biological organisms. Most fermentation-based technologies are focused on converting biomass into ethanol. Exhibit 3-1 shows the technologies that are most representative of those widely used today (Sample characteristic curves for technology cost and performance to be added in final version).

Exhibit 3-1 Representative Technologies

Fuel Type	Technology	Sizes, MW
Solid Fuels	Direct fired/steam turbine	5,10,25,50, 100
	Direct co-fire with coal*	7.5, 15, 30
Biogas/Manure	IC-engine	65kW, 130kW, 650 kW
Biogas/Landfill	IC-engine	1, 5

* Biomass Capacity at 10% of boiler heat input

Stoker and fluidized bed boilers combined with steam turbines represent the most widely used biomass power technology in the United States. They are both mature technologies. Exhibit 3-2 shows heat rates and costs representative of existing power plants.

Exhibit 3-2 Direct Combustion-Steam Turbine Operating and Economic Characteristics

Plant Size	MW	3.4	10	15	50	60
Capacity factor	Percent	90	90	90	80	80
Net heat rate	Btu/kWh	20,800	26,686	26,508	14,486	12,325
Total Capital	2004$/kW	4,235	2,875	3,116	2,191	1,946
Fixed Operating	2004$/kW-yr	274	270	254	81	67
Variable operating	2004 ¢/kW-hr	0.00	0.00	0.00	0.95	0.78
Boiler Technology		Pile	Stoker	Fluidized bed	Stoker	Stoker
Data Source		TSS	Antares	Antares	EPRI	EPRI

3.2 Biomass Conversion Technologies in 2015-2025

New and improved commercially accepted technologies are expected in the coming years. Gasification will permit the use of more efficient and lower cost electric conversion technologies including internal combustion engines and combined cycle systems. Exhibit 3-3 shows the technologies selected as being commercially accepted in the 2015-2025 time frame. Costs are expected to decrease due to research and development, economies of scale, and project experience. Cost improvements achieved through project development and operational experience (i.e. learning) have been documented for other technologies. In the supply analysis the model was programmed to pick the optimal technology and plant capacity for the supply characteristics in each county. The Task force recognizes that technology choices represent the best estimate for the performance of improved technologies in the 1015 timeframe for modeling purposes. The actual set of technologies delivering those performance characteristics may differ from the choices made in the modeling effort.

Exhibit 3-3 Technologies Expected to be in Use in 2010-2025

Fuel Type	Technology	Sizes, MW
Solid	Direct Fired/Steam Turbine	25 to 80
Solid	Gasifier/IC Engine	3, 8, 15
Solid	Gasifier/Combined Cycle	13 to 110
Solid	Gasifier/Gas turbine cogeneration	6 to 25
Spent Liquor	Gasifier/Combined Cycle	150
Biogas/Landfill	IC Engines	0.5 to 10
Biogas/Manure	IC Engines and Microturbines	0.1 to 1

Overlaying Alternative Cases and Other Considerations

Some simplifying assumptions about technology choices and the relationships between the grid, plant and resource are made to build the base deployment case show above. In reality, developers will expend considerable resources choosing plant sites and markets that will afford the best economics. The Biomass Task Force has considered the following alternative cases to capture some of these variables

- Alternate agricultural field management case - increased use of reduced and/or no-till practices that can potentially increase availability of crop residues
- Technology improvements case – lower heat rates and lower production costs are projected for biomass power generation technologies
- Retail side generation (CHP) case – improved economics result when both heat and power can be put to use in an industrial application and power is used locally
- High and low fuel transport cases - 10 cents a ton mile representing the lower end of the commercial spectrum and 30 cents per ton mile reflecting the potential effects higher transportation fuels costs (as received tons range from 15% to 50% moisture content by weight depending on the type of type of resource)
- Monetized societal benefits case – based on calculated value of environmental and fire prevention benefits assigned to specific biomass generation resources
- Monetized electric grid benefits – benefits that produce value to the grid including reduced congestion, voltage support
- Cooperative development of the biomass resource for both transportation and power generation fuels will increase fuel availability and improve economics for all uses

A discussion of the approach to consider the impacts of these variables follows and projected impacts are evaluated for each of the major components of the supply curve.

Alternate agricultural field management

The Biomass Task Force examined the effects of a realistic, but yet unrealized level of conservation tillage on the price of crop residues. The primary impact is expected to come through changes in biomass yields with conservation tillage practices. The alternative field management case markedly increases the supply of this resource category and this case was incorporated into the aggregate supply curve.

Overlaying technology advances

Since the focus of the WGA assessment is on what could be possible by 2015, the Task Force accounted for the projected technological changes over time in each component of production costs. Technologies that make it possible for biomass to take advantage of higher efficiency prime movers including advanced cogeneration cycles will increase the energy produced from the base of resources. The conversion section of this report details the expected future technology characteristics used in this analysis. The base case for supply curves presented in this chapter is the 2015 case for technology cost and performance characteristics. Thus technology improvements have already been taken into account.

Retail Side Generation Case

Retail generation with biomass is possible anywhere that biomass resources and industrial heat and power demands coincide. Opportunities for success increase greatly when either the facility generates its own biomass resources or the facility is located in an area of constrained grid capacity or congestion. From a system perspective biomass generation in areas of constrained transmission capacity can generate important benefits for the electricity system as a whole and the customers served by the system. When the industrial facility generates biomass byproducts the owner can reap the dual benefits of reduced electricity consumption and productive use of processing/manufacturing wastes. This benefit will be enhanced in situations where combined heat and power applications are practical. The Biomass Task Force is projecting the potential for retail side biomass generation as an alternative case to indicate the positive effects on the regional supply curve.

This alternative case may be evaluated two ways:

- Identifying the industries within the supply sheds developed in the base case and applying the CHP model to those resources
- Assuming a reasonable overall level of CHP development within the mix of conversion technologies

The effort to acquire data on the location and loads of the industrial facilities and the work to perform the site by site analysis would take more resources than the Task Force has available. Therefore the CHP case will be run assuming a fixed proportion of the sites that are potentially amenable to CHP. Since this one of the principal means by which biomass has been developed in the past[17], this case assumes a 30% CHP deployment in the development mix. In those cases approximately half of the resources used will be byproducts of the business. A simple analysis comparing power production costs for electricity in a cogeneration case and a stand alone power plant suggests that a savings of 20 to 30% in production costs is possible. Combined with the 30% penetration in the biomass development mix, cogeneration can reduce production costs by 6% to 9 % for the overall supply curve.

In addition the results of the recent CEC study examining the benefits of distributed biomass generation development in capacity constrained urban areas of the state indicated significant system benefits. These benefits can be derived from independent generators and CHP projects in the areas of congestion.

Monetizing the Benefits of Biomass to Communities in the West

The benefits section of the Biomass Task Force report delineates the environmental and fire protection benefits that are generated by biomass energy projects. In this section, the

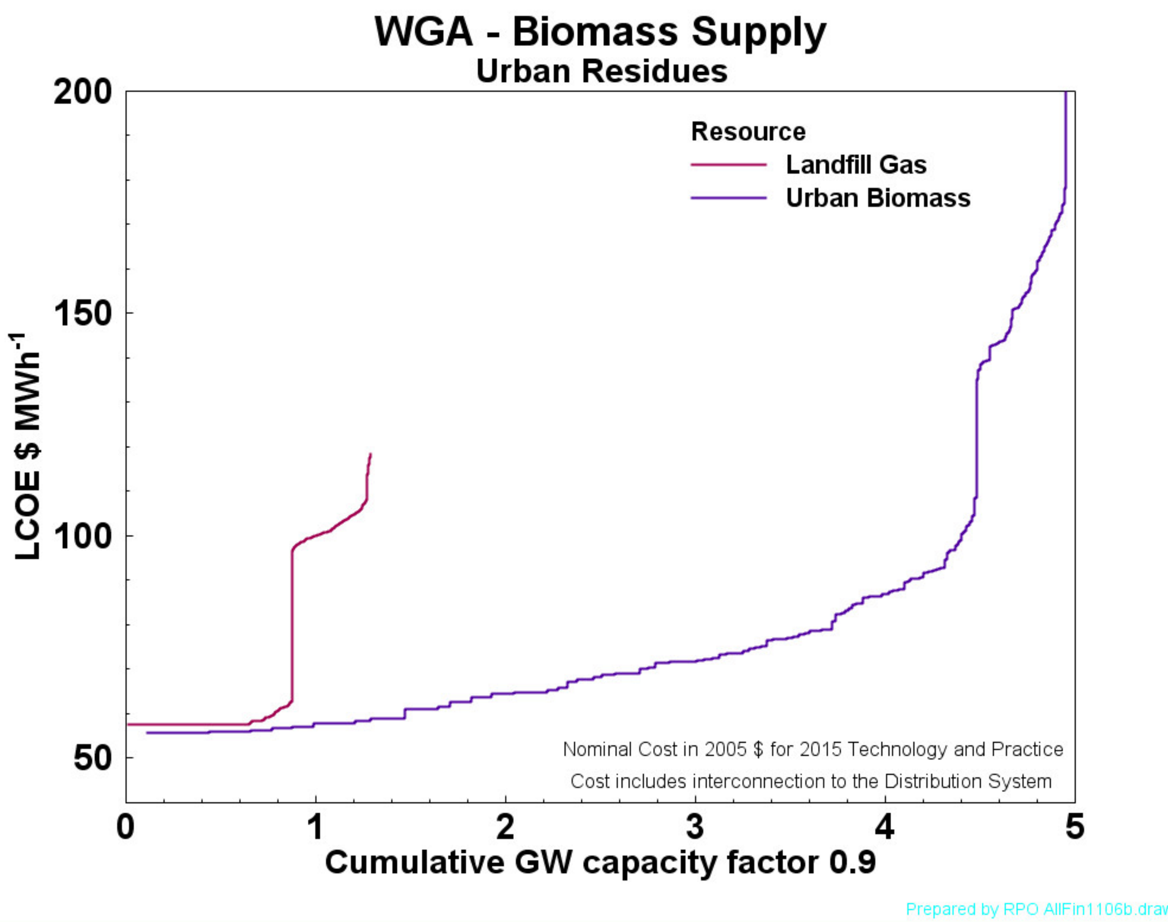
[17] XX% of biomass power generated today is done through onsite generation. EIA Annual Energy Outlook, 2004

monetary values assigned to those benefits are used to calculate a net benefits supply curve.

Application of Alternate Cases to the Components of the Supply Curve

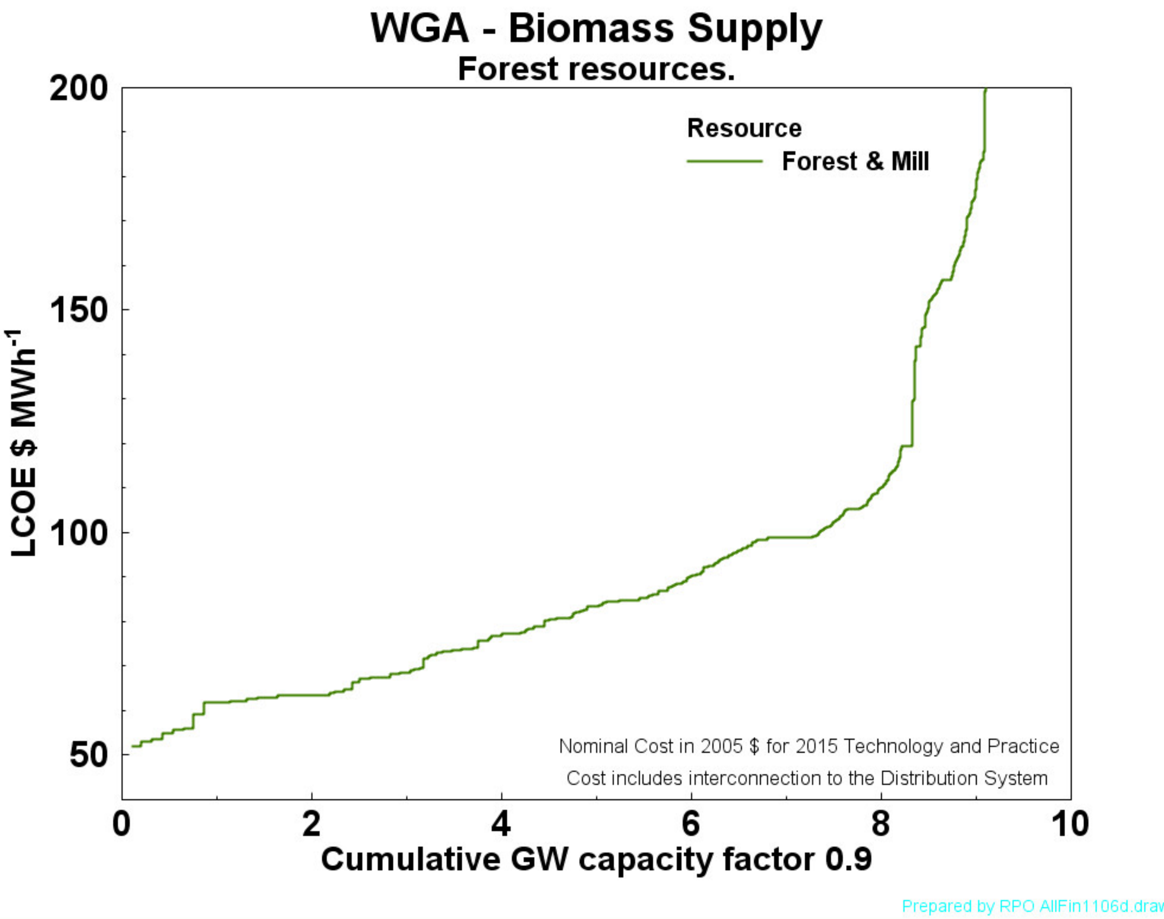
The following exhibits (4-4 to 4-6) display the resource model results by feedstock category. These individual curves all share the same characteristic shape of the total biomass supply curve. The effects of the alternative cases on the each component curve are evaluated.

Exhibit 4-4 Landfill Gas and Urban Solid Biomass Resources Supply Curves



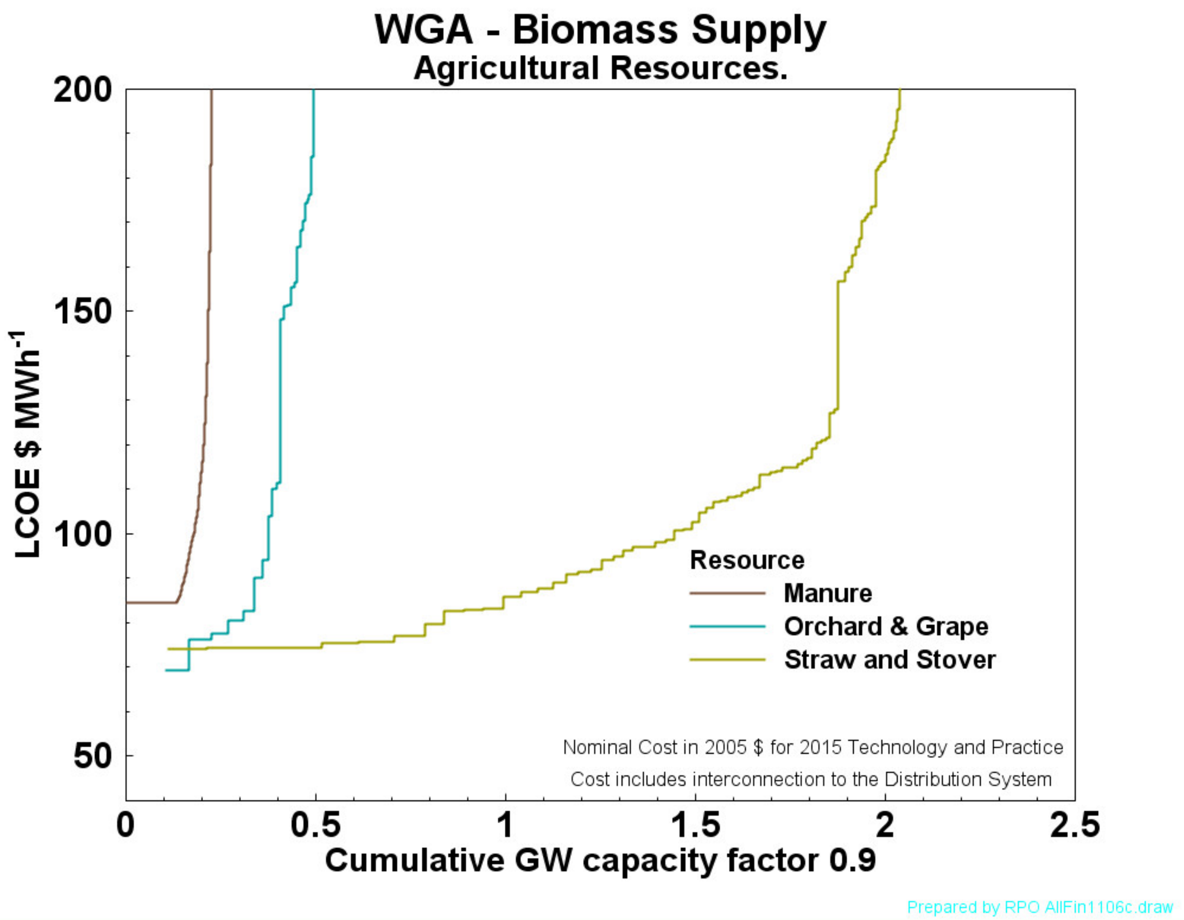
Biomass recovered from the urban waste stream and biogas recovered from decomposing biomass in landfills are typically two of the lowest cost biomass resources and they are resources with significant benefits for mitigating carbon emissions. Depending on the value of carbon credits ($2.00 per ton in current trades to $10 per ton or more in future trades in a carbon constrained environment) the cost of electricity production can be reduced by 16$/MWh to 83$/MWh if the biomass is diverted from a controlled landfill. Using the difference in values between the controlled and uncontrolled landfill benefits reported in Section 2, the conversion of landfill biogas to electricity earns a 34$/MWh credit for methane control. If these benefits are fully valued the supply curves for these two components would shift downward dramatically. Since these benefits are widely recognized for landfill gas this component of the supply has made impressive gains already.

Exhibit 4-5 Forest Biomass Resource Supply Curve



Forest-based Biomass Resources are the largest supply component when all the sources from lumber mill residues to fire prevention treatments are considered. Like agricultural biomass it is produced in rural areas and will be used to create a highly distributed generation network with facilities load centers including cogeneration application in the wood products industries that use the primary resource. Cogeneration applications are already very energy efficient and increasingly economic and these applications can help reduce the power production costs shown in the supply curve above by 20 to 30 percent. Policies recommended by the Task Force can effectively encourage industry and large institutions to employ this application. The most dramatic benefit associated with this resource is the reduction in forest fires near communities at risk. If those benefits were fully monetized as described in the benefits section of this report, the total value attributed to reduced unhealthy accumulations of forest overgrowth could add up to 200$/MWH of Bioenergy produced. Policies that allow good forest stewardship to recover even a quarter of that social benefit would make a large portion of the high end of the supply curve (8 to 10 $/MWH) economic to use BioEnergy applications.

Exhibit 4-6 Animal Manure and Agricultural Crop Resources Supply Curves



Agriculture is the third major resource component of the biomass supply curve. It enables the productive use of the biomass residuals from wheat, corn, and livestock production plus pruning from orchards and vineyards. The benefits that potentially offset a portion of the production costs for this resource include improved manure management and reduced open field burning. In the benefits section, an upper value of $126 per MWh of BioEnergy produced was attributed to avoidance of open burning. Although a value for the benefits of manure management has not been calculated, the issue has gained wide attention and increased regulation has begun to create the economic opportunity for Bioenergy production.

V. Policy Barriers

Biomass Renewable Generation

Fuel costs place biomass power generators at a disadvantage relative to wind and geothermal resources that do not use or pay for fuel. Production costs of biofuels are also higher than production costs for fossil fuels. Biopower is at some disadvantage relative to combined cycle natural gas power plants operating at substantially higher efficiency. Although the United States is placing heavy emphasis on natural gas for new power generation, it has not yet adopted a policy addressing the sequestration of the resultant CO_2, as needed to meet environmental goals for sustainable development, although greenhouse gas emissions are beginning to be addressed through transportation[18] policy, a climate change registry, and participation in developing REC trading markets (e.g. WREGIS). Based on the projected value of tradable carbon credits, adoption of such policies could result in incentives for power of $0.03/kWh or more.[19] Biomass, through photosynthesis, is the only renewable resource, however, that can be used directly to sink additional carbon from the atmosphere, if not permanently at least for long periods of time until renewable alternatives to fossil energy can fully implemented. No policies currently exist to encourage sequestering of this sort. Biomass conversion can also avoid uncontrolled emissions of methane from decomposition, reducing the global warming potential of the carbon emitted.[20] The lack of policy to credit the distinct sustainability benefits of biomass or to require sustainable use of natural gas and other fossil resources makes the cost of biomass appear high.

The ability of landfills to adjust tipping fees in competition with other industries may still lead to difficulties in introducing new technologies without more specific policies to limit waste disposal. Some, perhaps many, jurisdictions operate landfills as revenue generators, and adjust tipping fees according to competitive demands for components of the waste stream. Policies concerning landfill will need to be developed with careful attention to technology improvements that are now being investigated including bioreactor landfills, management of landfills to allow for landfill gas storage, and the operation of landfill gas-fueled peaking power plants. These developments may essentially move landfills into the category of conversion technologies. Permitting landfill gas to energy and other biogas facilities remains an issue due to air emissions from generating equipment even though other emissions are reduced. Continued research, development, and demonstration coupled with public education will be critical to moving forward with improvements in waste management.

The lack of more comprehensive policies leads in some cases to unintended consequences. Legislation in California (SB 705, 2003) eliminating agricultural burning in the San Joaquin Valley of California, for example, was enacted in complement with legislation providing subsidies for the use of agricultural biomass in power plants (SB

[18] *e.g. Governor's Environmental Goals and Policy Report, Office of Planning and Research, Sacramento, CA, 2003.*
[19] *The value of RECs in some regions of the US exceeds $0.05/kWh.*
[20]*Morris, 2000,. Biomass energy production in California: the case for a biomass policy initiative. NREL/SR-570-28805, National Renewable Energy Laboratory, Golden, CO.*

704, 2003). The subsidies were of only very short duration and have since expired. The legislation had unintended consequences for permitting new facilities that might be deployed to use the biomass. By eliminating open burning, agricultural burning emissions were no longer surplus and could not be counted as emission offsets required to obtain air permits for new sources. The lack of emission offsets constitutes a significant barrier to technology development and deployment. Further policy development or legislation will be needed to overcome this barrier if the original legislative intent was to encourage such technologies. Without the recognition that biomass plants lower overall emissions, permitting of new facilities is not likely to occur.

Permitting Difficulties

Permitting and siting processes are generally considered by technology developers to be complex, arduous, and sometimes unclear. Virtually every new biomass project will be an industrial development, and as such will require a land use permit, conditional use permit, a zoning or master plan amendment, or some combination of these. These permits are discretionary, usually approved or not approved by elected bodies such as County Supervisors or City Councils, and cannot be assured at the onset of a development process. The permit process can take months or years, is generally very expensive, and is subject to public review, comment, and, usually, opposition. Regulators and proponents have discussed streamlining these processes but few if any specific actions have yet been taken. How or whether these processes can be streamlined while continuing to protect health and environmental quality is subject to debate. Regulations attempting to define technologies and resources often create narrow or technically inaccurate definitions that inhibit application. Performance based standards in general may prove more effective in achieving environmental objectives without inhibiting technical innovation.

Grid Interconnection

When access to the electric grid is desired, utility interconnection can be difficult or expensive, and uniform national standards still have not yet been implemented. Interconnection costs can be high owing to required grid-impact studies, standby charges, and exit fees. Biomass plants are often at the fringes of the electric transmission grids. As such, biomass plants usually provide voltage support and reliability to the grid in areas where it is needed. However, in evaluating interconnections, utilities assume that the power generated by the biomass plants is used at some (usually distant) load center, and wheeling and line losses are presumed. In fact, biomass power is almost always consumed locally, and such line losses do not occur and should not be assessed against the plant.

Net metering is an important means of valuing the benefits of biomass and other renewables but is available only to certain types of biomass facilities. Current caps on the capacity allowed for net metering significantly limit expansion.

Inadequacy of Short-Term Policies

A number of programs designed to support the biomass generation industry have been put in place in recent years. Almost without exception, these programs have been short in duration - - 5 years or less in length. In California, in 2002, a program to provide a cash subsidy to biomass plants for each ton of agricultural residues collected by the biomass plants for use as fuel. The intent was to improve air quality by eliminating the open-field burning of these agricultural wastes. Based on the subsidy, a number of plants set up infrastructure to collect these wastes. The program's funding was cancelled after six months, resulting in net costs to many plants, and the open-burning problem remains.

At the federal level, the Production Tax Credit available to *existing* biomass generators is only 5 years in length, as contrasted to the 10-year term available to wind generators. Numerous other examples are available.

The problem with short-term programs is that long-term planning of maintenance and capital expenditures cannot be done efficiently. Financing of repairs, upgrades, infrastructure upgrades, etc. cannot be done with only a short economic horizon. Investments in new biomass generation facilities cannot be done based on 5-year or shorter programs.

Programs involving contracts and support of any type must be at least 15, and preferably 20, years in length. The establishment of the "Standard-Offer" contracts in California following the enactment of PURPA in 1978 is proof of this. These contracts were offered in a 30-year term, and were solely responsible for the creation of the biomass generation industry in California, home to almost 40% of the entire U.S. biomass fleet.

Varying Definitions of Biomass

In the states and at the Federal level there are various definitions of "biomass." These definitions vary from relatively narrow to quite all-inclusive. Some definitions unnecessarily disqualify certain types of biomass fuel from eligibility for certain support programs, while others are too broad, resulting in dilution of available benefits or funds. The definition of biomass should be uniform across all Western states.

Personnel Training

Obtaining appropriately skilled personnel to work in an expanding bio-based industry should be a relatively minor problem in the short term, but could be major if substantial growth happens. Few programs exist for training the necessary skilled personnel, although some important aspects of biomass power plant operation are similar to more conventional fossil-fueled power plant operation. Other skills required would generally be transferable from other industries, such as mechanic, welder, instrument and controls technician, water chemist, heavy equipment operator, etc. With potential rural jobs numbering in the tens of thousands for a fully expanded industry, education and training will become increasingly important.

Public Perception Barriers

Public Awareness

The general public is not aware of the true nature of biomass power generation, nor of its environmental, waste-management, and social benefits. The view of the public and some environmental groups is that biomass direct combustion processes increase air pollution, without recognition of the overall net air quality benefits.

Information on the broad-based benefits of biopower, biofuels, biochemicals, and other bio-based products is not widely disseminated in the general public, and as a result biomass industries have not so-far been assigned a central role in the West's environmental and economic future.

Negative Perceptions

Much of this may stem simply from the fact that biomass power plants have a smokestack, while other renewables do not. This manifests itself in a constantly tightening circle that biomass works in. In many states, biomass can only gain green credits for burning certain fuels, even though all biomass fuels are "renewable." Biomass has been characterized as a front for the forest products industry when it is described as "logging by another name". Artificial constraints, such as maximum tree diameter or use of the product, are frequently placed on forest thinning operations or stewardship contracts as a result of these perceptions. Biomass green credits are typically not worth nearly as much as those of wind or solar projects. In some states, biomass is placed in a lower Tier when it comes to the amount of renewables the utilities need to acquire to comply with an RPS.

Animal health and welfare concerns sometimes create opposition towards public incentives for technologies benefiting large animal operations where biomass utilization is integral to environmental management.[21]

If the Governors could spearhead a drive to really inform people (i.e. Legislatures) of the benefits that the biomass industry brings to society on many levels, maybe the industry would finally start getting paid for some of those benefits. (this sentence should be in the policy section if it is necessary there)

Resolving policy and regulatory issues will require good coordination among the various agencies involved, as well as increasing public awareness. This is especially true of conversion technologies to utilize solid wastes. Although modern solid-waste power plants are designed to and do meet air quality standards and are deployed elsewhere in the US and around the world, public concerns over "incineration" have effectively eliminated the technology from consideration in the West. These concerns extend in part to other waste conversion processes. Other concerns are associated with the potential for conversion technologies to draw resources away from recycling operations, although energy conversion also serves to recycle biomass resources through new biomass production.

Value to National Energy Security, and to Rural Areas

Biomass generation is renewable energy, and as such insulates the United States from requirements for imported oil or natural gas since renewable electricity always displaces

[21] *http://motherlode.sierraclub.org/MethaneDigestersSIERRACLUBGUIDANCE.htm*

fossil fuel fired generation. Biomass is always “home-grown” energy fuel, improving the Nation’s energy security.

Biomass plants are almost always located in rural areas. In rural areas, job creation and stability are always needed and important. Biomass electricity generation facilities are very labor intensive, and provide a broad spectrum of jobs, across skilled and unskilled labor and technical areas, and include engineering, administrative, and management jobs. In the biomass fuel supply infrastructure necessarily associated with every biomass generation plant, jobs are generated in fuel collection, processing, and transportation.

Rural job creation is a clear benefit beyond that of producing renewable electric energy. Biomass power generation requires approximately 20 times the personnel per MW of generating capacity than does natural gas fired generation, when the personnel in the fuel supply infrastructure are rightfully included.

VI. WGA Policy Recommendations

The following ten policy recommendations are designed to create a setting in the Western states in which biomass energy can be successfully employed; not just to produce sustainable and renewable energy; but to help solve the region's forest and range health, agricultural and livestock waste and solid waste management problems. This effort would benefit from the formation of an organization similar to the Governor's Ethanol Coalition, which has been so successful in advocating on behalf of the production and use of renewable transportation fuels. Like ethanol, the use of biomass for electric generation can benefit substantially from the mix of policy changes at the state and federal level spelled out below.

Number 1: Achieve Tax Parity Among Renewable Technologies

At the federal level, the Governors shall work with elected Senators and Representatives to ensure tax parity across renewable technologies, particularly with respect to the Production Tax Credit (PTC) for open loop biomass contained in Section 45 of IRS Regulations, which was recently extended and modified. Open loop biomass should be raised to parity with wind and geothermal technologies in terms of credit level, and the credit should be made permanent. The credit for *existing* biomass facilities should be extended to 10 years to match that for new facilities.

At the state level, Governors should advocate for parity of state tax incentives across all renewable technologies. Tax credits or incentives should be awarded only on the basis of actual generation, as opposed to investment tax incentives, and should be long-term programs (10-year minimum).

Net metering should be made available to biomass plants of less than 1 MW, again as parity with other renewables, and reasonable compensation should be provided for exports of excess power. WGA should spearhead a west wide process that results in the adoption by states of the above net metering rules, as well as uniform rules for the use of tradable renewable energy credits.

Rationale

With numerous Western states adding renewable capacity through renewable auctions in accordance with state Renewable Portfolio Standards (RPS), there should be a level playing field among renewables in terms of appropriate federal and state tax incentives. Without parity, the auctions will be dominated by one technology (wind), as has been the case to date, as wind has historically enjoyed a substantially greater Section 45 credit (level and duration). Existing biomass facilities need a larger credit in order to assure continued full load operation; particularly as many reach the end of current contracts, and will be bidding into the same auctions. With tax parity, the cost of biomass energy will be reduced to utilities and consumers, and the supply curve for biomass will drop, creating more opportunity.

Net metering allows small self-generators to meet their own electrical needs cost effectively when their generation or load varies diurnally or seasonally. Most states provide this benefit for solar power and often for other renewable technologies. The same benefit should be available for biomass, and on the same basis as other renewable technologies. This will accelerate the growth of electricity generation using animal waste such as on dairies, feedlots, and poultry farms, or in small-scale woody biomass applications.

Number 2: Strengthen Federal Land Management Policies To Allow Larger, Longer Restoration Projects

The Governors shall work with key federal land managers within their borders to ensure that science based sustainable forest and range forest health activities undertaken be done using the most appropriate land management tools such as stewardship contracting, service contracts or timber sale methods, and be under the longest term (20 year or more), and landscape scale (up to 150,000 acres or larger) contracts, in order to attract new private investment in processing infrastructure where little now exists. These projects should be fully funded at the outset, without the need for annual Congressional appropriations.

Contracts should be based on the science-based needs of the resource to improve forest health. Project parameters should be collaboratively decided at the local level on a project-by-project basis. Such contracts should not contain artificial constraints such as limitations on material use or allowable tree diameters. These should also be collaboratively determined based on the science-based needs of the resource. All forest health activities should be determined solely by the needs of the land and resource, not by a need to provide products or fuel, but should be cognizant of the fact that only long term, landscape-scale activities with assured funding will attract new private infrastructure investment. All forest health activities involving removal of excess materials shall have as a goal that all materials go to their “highest and best use,” with only the residual amount becoming fuel for biomass energy.

Rationale

Many tens of millions of acres in the West are in need of forest and range restoration as they are deteriorating due to insect and disease attack, or are being lost to catastrophic wildfire. New stewardship and service contracting authority allows the agencies to achieve the restoration necessary via large long-term contracts, with appropriate oversight. Much of the processing infrastructure that would support these activities and make them more cost effective has been lost over the last two decades resulting in severe harm to rural economies. By offering landscape- scale, long-term stewardship, service or timber sale contracts, new private investment will flow to these rural areas and a more cost effective restoration will result. This will only be the case, however, if artificial constraints are not placed on the activities. Rather, management should be guided by the sustainable restoration needs of the land and resource in conjunction with the collaborative decision of the local stakeholders. After all higher valued products are utilized; much of the removed material will still be available as fuel for a vibrant biomass power and fuels industry. Long-term resource supply certainty is a basic requisite for being able to finance development and construction of new biomass generation or small log processing facilities.

Number 3: Environmental Benefits Of Biomass Should Be Paid For By Beneficiaries

The Governors should advocate with various legislatures, regulatory bodies, and air quality agencies on behalf of the ability of biomass projects to solve, or contribute to the solution of, various local and regional waste disposal, air quality, and range and forest land management problems. To facilitate such solutions, the Governors should advocate for policies that advance biomass energy generation in ways that reflect each state's resource potential, regulatory environment and renewable energy generation requirements. Solutions could include targeted fuel subsidies and "biomass only" utility request for proposals (RFP) to address specific situations. Above-market costs of biomass generation could and should be borne by the primary beneficiaries of the environmental and waste management services provided by biomass generators. If utilities are the entities selected to provide supplemental support to biomass power, they should receive full cost recovery for such activities.

Rationale

Biomass is unique among renewables in its ability to address and solve a host of local and regional environmental issues through the choice of its fuel supply. The issue may be dwindling landfill space, landfill emissions, agricultural residue burning, animal waste disposal, or buildup of material choking our forests, but part or all of the solution involves the installation and operation of biomass plants either as stand-alone facilities, or in a combined heat and power (CHP) application. NREL has valued these environmental benefits at over 11 cents/Kwh equivalent. These solutions will not happen, however, without targeted subsidies or set asides that create economic situations for the plants. The Governors should recognize these facts and become advocates for such unique solutions. For example, a small surcharge on citizens' trash bills could be distributed to biomass plants in the state in proportion to their biomass fuel consumption. This would partially pay for the waste disposal services provided. Likewise, a small water bill surcharge could fund watershed improvement through biomass removal that could provide fire protection and increase water yield.

Examples of programs that work to increase biomass generation are found in California. A small charge on electric bills in partially distributed to biomass plants during low energy price periods in order to keep the plants at full load consuming biomass that would otherwise be open burned or deposited in a landfill. A short term subsidy for agricultural fuels from the San Joaquin Valley resulted in a substantial amount of agricultural waste being diverted from open burning to controlled combustion in biomass plants.

Number 4: Demonstrate State Government Leadership By Purchasing Power/RECs from Biomass Projects and by Supporting Biomass RD&D

State government agencies should purchase biomass power directly, or an equivalent amount of RECs, to meet mandated or self-imposed renewable purchase requirements. This is a tangible demonstration that agencies understand and support the contributions biomass projects can make to address forest health, air quality, landfill space and rural economic needs.

The Governors should also take a leadership role in supporting cost shared R&D in partnership with the private sector to demonstrate the use of new biomass technologies and to conduct engineering development research that will lead to near-term commercialization of improved conversion and harvesting technology.

Rationale. Governments, at local, state and federal levels, are major purchasers of electric power for such things as irrigation pumping, street lighting, water and wastewater treatment, etc. As a consequence, government purchase of biomass power/REC's can be a major boost to the prospects for biomass energy in the region.

Government can make a very public commitment to the benefits of biomass power by purchasing directly biomass power or by purchasing RECs from biomass generation. Government is also a major beneficiary of the improvements in forest health, forest fire risk reduction, watershed function, air quality, landfill life and rural economic health that results from using biomass fuel for power generation. Consequently, it is simply demonstrating this symbiotic relationship when government entities step forward to purchase biomass power and/or RECs.

With respect to support of biomass Research, Development and Demonstration (RD&D), by partnering with industry the state helps to validate technologies for wider use. By evaluating and publicizing the performance and benefits of new technologies in an objective assessment the state greatly reduces the risk for the next user. Each state should adopt the technology and resources that is potentially most beneficial to its energy, economic and environmental goals. Collectively all of the critical new technologies would then have sponsors and the likelihood of success in meeting CDEAC goals would be increased substantially.

Number 5: Recognize Value of Firm Capacity in Renewable Purchase Programs

The Governors should communicate to the various State public utility commissions that when implementing utility renewable purchase programs, through an RPS or otherwise, that biomass be given value for reliable baseload Firm Capacity when establishing a price structure or in preparing a ranking of renewable bids.

Rationale

A typical State RPS requires utilities to purchase renewable kilowatt-hours up to some percentage of their annual sales. Some renewable technologies produce intermittent power, whose capacity cannot be predicted with certainty. Others, such as biomass, produce reliable firm capacity that does not need to be backed by additional utility generation beyond typical reserve requirements. The purchase prices and bid ranking should reflect the greater value of reliable firm power.

Number 6: Renewable Energy Credits Should Not Include Ancillary Environmental Benefits

Renewable energy credits (REC's) that are transferred from generators to utilities and accounted for through WREGIS, should be defined to include only the environmental benefits that derive from displacing a like amount of non-renewable energy. The transferred REC should not contain any emission reduction value or other social or environmental benefits that may result from offsetting emissions from biomass fuel sources or provision of any type of waste management, forest fire risk reduction, forest health, watershed improvement, or other service. States should allow RECs to be included in RPS goals.

Rationale

All renewable technologies displace the combustion of non-renewable fuels. Biomass is unique among renewables in that it further displaces emissions that would have resulted if its fuel had been disposed of differently. These offsets may, in the future, have value in air quality compliance schemes (emission reduction credits), as part of a greenhouse gas reduction strategy or in a carbon sequestration strategy. These and other environmental values, unique to biomass, should not be transferred to the purchasing utility along with the generic RECs.

The Governors should also address the issue of whether REC's should be tradable across the west in support of RPS compliance or as demonstration of green power purchase compliance. While a complex issue for several reasons, it is best addressed and resolved by a regional body such as the WGA.

Number 7: Establish a Single Definition of Biomass

Governors should work with their state public utility commissioners and green power certification groups to require that the FERC definition of biomass (18CFR Part 292.202) is used to determine the eligibility of the resources as renewable. This definition, "any organic material not derived from fossil fuels," affords biomass energy projects the greatest opportunity and flexibility to use technology innovation to create productive uses for all types of biomass materials. The ability of biomass facilities to choose from the wide array of biomass resources while conforming to all federal, state and community environmental standards will allow the technology to improve both on technical performance and on production economics.

Rationale

Many states a have taken a highly prescriptive approach in defining biomass attempting to pass judgment on various combinations of resource and conversion technologies with the goal of deciding which combinations are worthy to earn renewable incentives offered by the state. This often leads to a highly inflexible set of biomass options that project developers are forced to choose from. This approach almost always has unintended negative consequences for the economics and for technology innovation in new biomass projects. Resources that might have been used productively with new conversion and environmental control technologies coming on line instead, end up in the waste stream.

The Biomass Task Force believes that the more effective approach is to use the simplest and broadest definition of biomass. The FERC definition of biomass meets those criteria: “Biomass means any organic material not derived from fossil fuels.” It is up to the ingenuity of the biomass projects design team to use the conversion and emission control technology best able to meet all state and federal environmental standards and to win community approval to be permitted. This performance-based approach allows for innovation and the widest choices in biomass feedstocks while ensuring that the environmental benefits associated with renewable generation are realized. It is also in keeping with the way in which states provide environmental protections for all renewable power generation projects.

The Governors should provide leadership on this issue by issuing guidelines to state agencies that require the FERC definition, and by including in WREGIS guidelines the appropriate biomass definition to be included in REC tracking.

Number 8: Revise Utility Interconnection Policies

The Governors should communicate to State public utility commissions that certain utility interconnection policies unfairly discriminate against biomass projects, and should be changed. Specifically, in utility interconnection and power flow studies the assumption is typically made that all power is consumed at a central load center, which is not factual. Instead of being charged losses to a central load center, utility policies should reward appropriately sized biomass plants for local load and voltage support, saving line losses and providing reliability in remote areas.

Rationale

Biomass projects are typically small by utility standards, and located in rural areas. When initially being modeled for interconnection to the utility, the utility models assume that all power flows to a central location, and losses and infrastructure requirements are assigned accordingly. In actuality, the power generated is typically consumed locally, saving losses and providing valuable voltage support and system reliability, usually to remote areas of the grid. For example, on the isolated north coast of California, two biomass plants are charged nearly a 10% energy delivery penalty despite the fact that this electrically remote area has power flowing <u>into</u> it at all times from remote fossil generation. Modeling must recognize this reality and appropriate credit given.

Number 9: Provide Long-Term Certainty for Biomass Programs

The Governors should require that, wherever feasible, long-term policies and programs in support of the biomass generation industry be emplaced. This would include the issuance of long-term (20-year minimum) power purchase contracts, fuel supply-related incentives, tax credits, and other measures. The Governors should work with elected Senators and Representatives to see that incentives for biomass utilization included in the Healthy Forest Restoration Act and Energy Bill be fully funded.

Rationale
In the past, support and incentive programs have been put in place to support and encourage biomass generation. These typically have been no longer than five years in duration and in many cases have been shorter. Long-range capital investment, maintenance and operation plans cannot be properly formulated and carried out with short economic horizons. New facility development cannot be financed without programs, contracts, incentives, etc. long enough to pay off debt. Further, programs that turn out to be shorter than anticipated because of the lack of long-term assurance often lead to false starts, wasted effort and money, and are in general counterproductive. Often, incentives at both the state and federal level have been put in place after much effort and with great fanfare, but are then only funded at a small fraction of the authorized amount.

As one of the higher capital cost renewable technologies, biomass depends on a long-term debt structure in order to lower debt as a fraction of total energy cost. This cannot be accomplished with a short term power contract, short term fuel supply assurance or a short term incentive structure. It is in the best interest of all parties to extend the time horizon for biomass projects, thus lowering overall cost and moving the supply curve down to include more biomass resources.

Number 10: Consider Avoided Fuel Based Emissions When Issuing Air Quality Permits

The Governors should communicate with the US EPA and State and local air regulatory bodies that permitting and standard setting for biomass plants should recognize the role that biomass plants play in reducing emissions from its fuel supply base. The avoided non-point-source emissions of air pollutants from the biomass plants' fuel, if that fuel is left to its alternate fate, should be recognized and credited to the biomass plants in the permitting processes leading to a netting of overall emissions. Any emission reductions below requirements should be available for sale by plant owners as emission reduction credits (ERC's)

The Governors should communicate with the USEPA that the initiation of co-firing of biomass with coal in an existing plant should not trigger an air quality re-permitting of the plant.

Rationale
Typically, biomass plants are treated like other fixed sources of emissions with respect to permitting and standard setting. The result is a constant tightening of regulations and the installation of ever more sophisticated and expensive pollution control devices. One recent biomass plant proposed envisioned a hot ESP, ammonia injection, followed by two stages of catalysts followed by a spray dryer and baghouse. All of this for a plant that burns standard wood waste. Because of the increased capital and operating cost and

lowered efficiency, the plant is not economical. The result will be lowered air and water quality in the region as the proposed fuel supply continues to be piled at mill sites or burned in the open with no controls. Air quality agencies must be made to understand the relationship, set future standards and permits accordingly, and provide a netting of emissions from the current fuel supply base.

Combustion of biomass in conjunction with coal in existing plants can often be the most economical use of biomass resources located nearby. The biomass will lower plant emissions due to lower sulfur content, lower combustion temperatures and carbon neutrality. Despite these air quality advantages, the USEPA insists that the change in fuel supply trigger a re-permitting of plant air quality that will lead to the addition of more pollution control equipment. This linkage is stifling proposals to add biomass co-firing and is counterproductive both from an energy and an air quality perspective. Co-firing is an excellent opportunity to increase the supply curve for biomass resources that might otherwise be uneconomic if used in a dedicated facility.

VII. Conversion Factors and Glossary

FOREST FUEL TREATMENT/BIOMASS UTILIZATION

BIOMASS CONVERSION FACTORS

Summarized below are some woody biomass conversion factors that are commonly used by natural resource managers in the West:

1 green ton (GT) of chips	= 2000 lbs.(not adjusted for moisture)
1 bone dry ton (BDT) of chips,	= 2000 dry lbs.(assumes no moisture content)
1 bone dry unit (BDU) of chips,	= 2400 dry lbs. (assumes no moisture content)
1 unit of chips	= 200 cubic feet
1 BDT chips	= 2.0 GT (assuming 50% moisture content)
1 unit of chips	= 1.0 to 1.5 BDT chips (varies by compaction)
1 ccf (hundred cubic feet) roundwood	= 1.0 BDU chips
1 ccf roundwood (logs)	= 1.2 BDT chips
1 ccf roundwood (logs)	= 1.2 units of chips
1 ccf roundwood (logs)	= 1.2 cords roundwood (@ 85cu.ft. wood/cord)
1 BF	= board foot lumber measure equivalent to wood volume of 12” x 12” x 1” thick
1 MBF	= 1,000 BF
1 GT of logs	= 160 BF of lumber
6 GT of logs	= 1 MBF

1 standard chip van carries 25 green tons, or approximately 12.5 BDT assuming 50% moisture content.

When woody biomass is utilized in a commercial (10+ MW electrical output) scale power generation facility the following energy output rule of thumb applies:

1 BDT fuel will produce approximately 10,000 lbs. of steam 10,000 lbs. of steam will generate about 1 megawatt hour (MWH) of electricity.

And 1 MW equivalents:
1 MW = 1,000 horsepower
1 MW = power for approximately 750 to 1,000 homes
1 GW = 1,000 MW (or enough power for 750,000 to 1,000,000 homes)

GLOSSARY OF COMMON TERMS

Listed below are some of the more common terms/abbreviations frequently used by resource managers. These definitions are from a variety of sources including the USDA Forest Products Lab, and the Society of American Foresters – Forestry Dictionary.

Anaerobic digestion – Anaerobic digestion is a biological process that produces a gas principally composed of methane (CH_4) and carbon dioxide (CO_2) otherwise known as biogas.
Baseload power– Minimum amount of electric power delivered or required over a given period of time.

Bioenergy – Useful, renewable energy produced from organic matter – the conversion of the complex carbohydrates in organic matter to energy. Organic matter may either be used directly as a fuel, processed into liquids and gasses, or be a residual of processing and conversion.
Biofuels **–** Fuels made from cellulosic biomass resources. Biofuels include ethanol, biodiesel, and methanol.

Biogas – The combustible gas produced from the anaerobic decomposition of organic material. Principally composed of CH_4 and CO_2.

Biomass – Organic matter in trees, agricultural crops and other living plant material. Carbohydrates are the organic compounds that make up biomass. These compounds are formed in growing plant life through photosynthesis, a natural process by which energy from the sun converts carbon dioxide and water into carbohydrates, including sugars, starches and cellulose.

Bioproducts – A commercial or industrial product (other than food or feed), that is composed in whole or in significant part, of biological products or renewable domestic agricultural materials (including plant, animal, and marine materials) or forestry materials.

Board Foot – The amount of wood contained in an unfinished board 1 inch thick, 12 inches long, and 12 inches wide. Abbreviated "BF". Common units as related to saw log volume measurement include - 1,000 BF or MBF and 1,000,000 BF or MMBF.

Bone Dry Ton – Traditional unit of measure used by industries (pulp/paper, biomass power) that utilize biomass as a primary raw material. One bone dry ton (BDT) is 2,000 pounds of biomass (usually in chip form) at zero percent moisture. Typically biomass collected and processed in the forest is delivered "green" to the end use facility at 50%

moisture. One BDT (assuming 50% moisture content) is two green tons (4,000 pounds at 50% moisture content).

British Thermal Unit **–** The quantity of heat required to raise the temperature of one pound of water, 1 degree F (Fahrenheit).

Busbar costs – The cost to deliver electricity to an electrical conductor in the form of rigid bars that serves as a common connection for two or more electric circuits.

Chip – A small piece of wood typically used in the manufacture of pulp/paper, composite panels, fuel for power/heat generation, and landscape cover/soil amendment.

Cogeneration – The combined generation of both heat and power at one facility using the same fuel source. Typically the heat is used to generate steam that is utilized on site (process steam). Power generated is in the form of electricity that is utilized on site or sold to a local utility. (Synonym: Combined Heat and Power (CHP))

Conventional Tillage – The traditional method of farming in which soil is prepared for planting by completely inverting it with a moldboard plow. Subsequent working of the soil with other implements is usually performed to smooth the soil surface. Bare soil is exposed to the weather for some varying length of time depending on soil and climatic conditions.

Criteria pollutants – EPA uses six "criteria pollutants" as indicators of air quality, and has established for each of them a maximum concentration above which adverse effects on human health may occur. Criteria Pollutants include lead, particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide, and ozone.

Crowning Index – Fire risk is classified based on crowning index, which is the potential wind speed at 20-feet above the ground needed to initialize and carry a crown fire in a stand. High risk stands have a crowning index value of 25 miles per hour (mph) or less. Moderate stands have a crowning index of 25 – 50 mph. Low risk stands have a crowning index value of 50 mph or more.

Cull log – Logs that do not meet certain minimum specifications for usability or grade. A cull log typically has very little value in the production of lumber products.

Gasification - the thermochemical conversion of organic solids and liquids into a producer or synthetic gas (syngas) under very controlled conditions of heat and strict control of air or oxygen.

Gasifier – A combustion device that produces biogas from solid biomass.

Generation – The process of creating electricity. Typically generation is accomplished to supply electricity to an on site facility and/or for sale to an electric utility.

Greenhouse Gases – Those gases, such as water vapor, carbon dioxide, tropospheric ozone, nitrous oxide, and methane, that are transparent to solar radiation but opaque to longwave radiation. Their action is similar to that of glass in a greenhouse.

Kilowatt – A standard unit for expressing the rate of electrical output.

Lignocellulosic biomass – Organic material whose composition is dominated by lignified cell walls from vegetative plants.

Liquefaction – The process of converting biomass from a solid to a liquid. The conversion process is a chemical change that takes place at elevated temperatures and pressures.

Megawatt – One thousand kilowatts. Enough electricity to support approximately 750 to 1,000 households.

Moisture content – The amount of moisture contained in biomass material. Typically expressed as a percentage of total weight.

Net metering – A method of crediting customers for electricity that they generate on site in excess of their own electricity consumption.

Open loop biomass – any agricultural livestock waste nutrients or any solid, nonhazardous, cellulosic waste material or nonhazardous lignin waste material which is segregated from other waste materials and derived from forest-related resources including mill and harvesting, residues, precommercial thinnings, slash, and brush, or solid wood waste materials including waste pellets, crates, dunnage, manufacturing and construction wood wastes, and landscape or right-of-way tree trimmings, or agricultural sources including orchard tree crops, vineyard, grain, legumes, sugar, and other crop byproducts or residues. (Does not include municipal solid waste, gas derived from the biodegradation of solid waste, or paper which is commonly recycled. Does not include biomass burned in conjunction with fossil fuel (co-firing) beyond such fossil fuel required for startup and flame stabilization.)

Renewable energy – Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy sources include biomass, geothermal, wind, solar, ocean, and hydropower.

Renewable Energy Credits – Also known as RECs, green tags, green energy certificates, or tradable renewable certificates, certificates that represent the technology and environmental attributes of electricity generated from renewable sources.

Saw log – A log that meets minimum regional standards of diameter, length, and defect, intended for sawing into lumber products.

Volume – Gross - Measurement of log content in log-scale board foot (see board foot definition – above) without deduction for defect.

Volume – Net – Measurement of the actual amount of merchantable wood in log-scale board foot – after deductions for defect.

Wildland Urban Interface – Zone where structures and other human developments meet, or intermingle with, undeveloped wildlands.