



Thermal Energy: The Key to Profitable Biopower

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SUMMARY:

In Virginia, the jobs that will be created by biomassⁱ power include construction, supplier, transportation and operating positions at any scale of output. Including thermal energy (combined heat and power, or CHP) as a marketable commodity greatly increases a project's return on investment and, thereby, prospects for long term success. This potential CHP revenue, however, is inversely related to scale: the markets for full deployment of thermal energy decrease as the scale of power production increases.

At 20 MW, a biomass power-only plant creates 138 construction jobs and 168 annual operating jobs. Adding CHP potential to a 20MW plant increases construction job impact marginally by five jobs, but operating jobs jump 16%, largely due to increased fuel purchases. Significantly, if the 20MW plant has a market for thermal energy that replaces fossil fuel, the revenues would increase by roughly 400%.

At a scale of 5MW each, four CHP (combining for 20MW output) plants using woody biomass would create 451 construction and 218 annual operating jobs in Virginia. At the 5MW scale, moreover, there is a much greater possibility for the sale of a significant percentage of thermal output as more relatively small scale customers exist. In addition, were these smaller scale projects to burn warm season grass instead of exclusively woody biomass, the greater efficiencies that result from feedstock with lower moisture content will produce even greater profit margins.

INTRODUCTION:

Biopower, or the generation of electricity from biomass, has great promise for producing jobs and revitalizing rural economies. In 2007, Alan W. Hodges and Mohammad Rahmaniⁱⁱ published an economic study showing the potential for significant economic impact related to 40MW and 20MW woody biomass burning facilities in the South. This study builds on their work, but focuses on the economics of biopower specifically in Virginia. Additionally, the study looks at the increase in positive economic effects that result from biomass facilities capable of combining heat and power (CHP) production. Finally, we consider, using warm season grasses as a primary biomass feedstock and compare the profitability of these projects to those burning woody biomass alone.

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ECONOMIC FRAMEWORK:

Hodges and Rhamani describe the economic impact of woody biomass burning facilities in a range of counties through the Southern United States. Though the final data we use measures only the impact in Virginia, their description merits repetition here.

The businesses in the wood energy sector (such as timber growers, loggers and electric power producers) sell their products and services to final consumers through wholesale and retail distributors and to other businesses, both within the local economy and to the rest of the national and world economy. Firms that purchase wood and other materials from local suppliers generate economic activity through recirculation of money in the local economy. Households of employees spend their earnings for personal consumption of items such as food, clothing, housing and transportation, which further increases local economic activity. Also, both businesses and households pay taxes to local governments. Eventually money leaves the local economy for purchase of goods and services not available locally, outside investments or federal taxes; this is known as “leakage.” The more raw materials (such as wood) that are obtained locally, the greater the increase in the local economy because less leakage occurs. If fossil fuels are imported from another state, comparatively little economic activity is created by a power plant that uses them.ⁱⁱⁱ

When a power plant also produces usable thermal energy that, in turn, replaces conventional fuel (most commonly oil or natural gas, and sometimes electricity) “leakage” is further reduced and more money is available for local spending, producing enhanced local economic impacts.

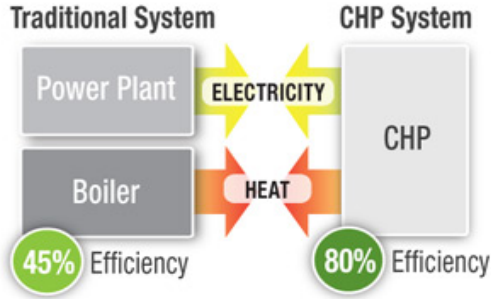
The model used to assess a biomass facility, IMPLAN,^{iv} estimates the economic impacts using the following terms:

1. Total output impacts – the effect on sales revenues of all businesses in a local economy resulting from the proposed industry activity.
2. Value added impacts – the effect on personal and business income in the local area.
3. Employment impacts – the effect on the total number of full-time, part-time and seasonal positions in the local area.^v

Hodges and Rhamani studied the “local” impact, using IMPLAN data, for twenty-seven counties in the South. They then averaged out the impacts described above to come up with the general impacts associated with a 40MW and 20MW woody biomass power plant in the South. These impacts vary most widely when considering the construction phase as many rural counties do not have an industrial base that will benefit from building a power plant.

For this study, however, we used IMPLAN to assess the economic impacts of biomass power plant construction and operation on the entire state of Virginia, understanding that the operation of smaller scale (5MW compared to 20MW) will have its largest impact in a very local region, while construction benefits would extend much further.

CHP Process Flow Diagram



Finally, the original study looked at Chesterfield and Fluvanna Counties, adding their predicted impacts into the average results of construction and operating a 40MW and 20MW woody biomass fuelled plant. For this report, we are focused only on the 20MW data, as new larger scale plants do not look likely at this time. In addition, except for a very specific industrial customer, fully using thermal energy at the 20MW scale is a major challenge.

THE IMPACT OF COMBINED HEAT AND POWER:

Most coal fired power plants operate at 30% efficiency. The very newest ones might operate at 35%, but carbon sequestration (with technology not yet determined) could drop those percentages dramatically. Natural gas combined cycle power plants operate at up to 60 percent efficiency, but still waste considerable thermal energy.

Because power most often is produced by steam running through a mechanical turbine, the thermal content of the used steam must be drawn out by cooling before the water can be reused. Also, because most fossil plants are located away from built up areas – where convenient customers for thermal energy might be found – there is often no opportunity to sell this valuable energy.

Maximizing the full value of combusted fuel benefits the environment and the economy in that more is gained for what is burned. CHP can yield efficiencies up to 90% and is worth doing no matter what the fuel may be. When using biomass as a fuel, moreover, the higher efficiencies related to CHP mean that the biomass fiber basket (or area from which fuel must be gathered) can produce more useable energy, with enhanced sustainability, more efficient transportation, and less impact on other biomass using industries.^{vi}

Issues related to the sustainability and carbon footprint of large scale woody biomass power plants^{vii} become much less controversial when biopower is produced at a scale that makes CHP feasible.

Since the biggest impact of a biomass facility is in the supply and delivery of the feedstock, as the table below explains, the more feedstock we can efficiently use per unit of construction cost, the greater will be the economic impact.

The absence of either Virginia or federal policies that *require* utilities to deliver a certain percentage of electricity from renewable sources effectively limits regulated utilities to sources of power that are cost competitive with conventional sources. At this time, biomass power is very close^{viii} but still more expensive than conventional power. If, however, customers for the thermal energy that is produced in appropriately scaled CHP biomass facilities are developed, revenue from such sales could be almost four times power sales.

The table below compares total revenues from a 5 MW biomass CHP facility, using either woody biomass or warm season grasses exclusively. To put this amount of thermal energy into perspective, a typical Virginia community college has about 200,000 square feet of institutional space. With heating oil at roughly \$2.75/gallon, that facility would use about \$110,000 for heating – still a long way from the CHP potential of a 5 MW installation.

The use of native warm season grasses in a biomass facility increases efficiency because it is typically made available at about 12% moisture after dormant harvesting. The efficiency premium results from not having to boil off the volume of water found in wood (between 40 and 50%) before the wood can be burned. This premium can be returned to the feedstock suppliers in higher fuel prices (increasing the economic impact) or be used to increase the rate of return for investors.

**5 MW Biomass CHP Generator
Revenue Streams (\$ millions)**

Thermal Utilization %	0%	10%	30%	50%	70%	100%
Electric Revenue @ .0874/kWh	3.71	3.71	3.71	3.71	3.71	3.71
Thermal Revenue@ \$2.783/gal (#2 Oil)	0	1.42	4.26	7.10	9.94	14.20
Total Revenue (wood)	3.71	5.13	7.97	10.81	13.65	17.91
WSG efficiency premium	1.24	1.24	1.24	1.24	1.24	1.24
Total Revenue (WSG)	4.95	6.37	9.21	10.63	14.89	19.15

COMPARING ECONOMIC IMPACTS:

The near term potential for biomass power in Virginia is indirectly related to scale of production. There are greater job impacts, as shown below, when facilities are built at a scale of about 5MW. Additionally, at this scale there are other benefits:

- The potential for finding customers for significant proportions of the thermal energy is enhanced.
- The supply of biomass to such a facility—roughly 33,000 Bone Dry Tons (BDT) per year – is more likely to be sustainable. Warm season grasses to supply such a plant could be grown on 4,000 acres.^{ix}
- The competition with other existing users of biomass will be much less intense, yet full utilization of locally available biomass is more likely.
- Distributed small scale power production reduces congestion on the existing grid, and provides energy security and cost stability to local communities.
- The construction of multiple small scale power facilities, as opposed to fewer large generators, allows for more rapid introduction of state of the art technology and access to expanded sources of investment capital.

The table below shows the difference in economic impact of a 20MW wood fired power-only facility and one operating as a CHP generator. Also shown is the impact of that same 20MW being delivered from four separate 5MW CHP facilities.^x

<u>Facility Type</u>	<u>Output (Million\$)</u>	<u>Value added</u>	<u>Employment (jobs)</u>	
			<i>Indirect</i>	<i>On-site</i>
<i>Power Only -20MW</i>				
Construction	36.41	17.73	138	
Operating	11.85	6.73	168	15
<i>CHP-20 MW</i>				
Construction	37.01	17.95	143	
Operating	13.71	7.84	200	15
<i>CHP-5MW</i>				
Construction	22.79	11.40	113	
Operating	5.11	2.56	55	6
<i>4 X CHP 5 MW</i>				
Construction	91.15	45.61	451	
Operating	20.43	10.25	218	24

CONCLUSIONS:

Virginia has a significant biomass energy potential which can be put to economic use with existing technology. How this resource is developed will influence the number of jobs created, and the overall economic impact of developing a completely new industrial sector in the Commonwealth. Additionally, attention to scale will maximize return on investment, minimize the environmental impact, and distribute broadly the benefits of renewable energy. Biomass CHP should be an important tool in Virginia's campaign to revitalize our rural economy and stabilize rural communities.

CREDITS:

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ENDNOTES

ⁱ This report considers only woody biomass and native warm season grasses. Biomass includes any organic material or derivative – such as methane gas produce in anaerobic digesters from manure or landfills – with a number of specific definitions competing for primacy. Technology for CHP production from woody biomass is proven and widely available.

ⁱⁱ Hodges, Alan W. and Rahmani, Mohammad, *Economic Impacts of Generating Electricity, Wood to Energy Fact Sheet*, University of Florida, September, 2007. The authors are grateful to Mssrs. Hodges and Rhamani for providing the base data we have used in this analysis.

ⁱⁱⁱ Ibid., page 2.

^{iv} Version 2.0, The Minnesota Implan Group, Inc. Stillwater, MN. This is not the most current version of this modeling software, but was used to keep CHP calculations consistent with the data used by Hodges and Rhamani.

^v Hodges, *op cit*, page 5.

^{vi} The graphic is used with permission from *The HVAC Reporter*.

^{vii} *Biomass Sustainability and Carbon Policy Study*, Manomet Center for Conservation Sciences, 2010.

^{viii} Electric Power Research Institute (EPRI) report #1018329, 2009.

^{ix} Biomass profitability gets more challenging as the distance these feedstocks must be transported increases. Generally, a 25 mile haul distance is considered the optimum limit. Inside a circle, then, with a 50 mile radius, there are 1,256,000 acres. A 5 MW CHP plant would use less than 0.4% of this land.

^x It is important to note that the model used does not measure the increased value of the plant's output when it produces marketable thermal energy, but only measures the economic impact of purchasing more fuel when operating in the CHP mode. In practice, this additional revenue could be spent in the community, could revert to investors, or be used to pay more for locally grown feedstock.



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