Energize Missouri
Renewable Energy Study Subgrant

Feasibility Study for a Biomass Electrical Power Plant in the Viburnum Region

Subgrant Award Number DEFG2609EE0000131

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Acknowledgements and Disclaimers

The *Energize Missouri Renewable Energy Study Subgrant* program was created to increase the ability of businesses, governments and organizations to make informed decisions about complex renewable energy systems by understanding and solving information deficiency and technical uncertainties. Program funds are made possible through the American Recovery and Reinvestment Act and the Transform Missouri initiative and administered by the Missouri Department of Natural Resources.

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Executive Summary

The Viburnum Economic Development Area Corporation (VEDAC) was organized to promote the Viburnum area, be the central force in local economic development, and engage in activities to improve the economic vitality of the region. VEDAC was awarded an *Energize Missouri* Renewable Energy Subgrant by the Missouri Department of Natural Resources to study the feasibility for locating and operating a woody biomass electrical power plant in the VEDAC region. The region includes Washington, Iron, Dent, Reynolds and Crawford counties.

The feasibility study included an assessment of:

- Market considerations for the product and the biomass feedstock
- The available supply of biomass feedstock
- Organizational structure for development and operation of a biomass plant
- Plant size, location, and technology to be used
- Environmental and economic considerations
- Projected financial outcomes

The market analysis indicates a growing demand for electrical power, with concerns about the ability to meet demand due to retiring/obsolete power plants. Local demand includes mining-related activities which are power intensive. Power grid connections already exist in the region and may provide an advantage for this project. Existing power suppliers and industries are interested in purchasing power generated from renewable sources; however, regulations which have a significant impact on the requirements for doing so are still pending. These regulations would also likely have an impact on the selling price for the electricity.

Forest related industries are a significant economic force in the region. This includes logging operations, lumber, pallet and block mills, charcoal companies and other wood processing businesses. While mill residues are marketed and used to a large extent, the primary sources of feedstock for the biomass power plant – forest harvesting and timber management residues – are not currently being marketed or used on a large scale. Logging companies have expressed interest in participating in a woody biomass supply chain, assuming the price they can receive per ton is acceptable.

Several sources were referenced to develop an estimate of the available woody biomass feedstock supply. Based on the analysis, the available sustainable annual supply of feedstock from forest harvesting and management operations is between 412,000 and 582,000 green tons. This level of supply could support a woody biomass power plant up to 50 mW (best case). Considering biomass availability variables and local sources/amounts of demand for electrical power, the recommended plant size range is 8-20mW.

As the catalyst for this project, VEDAC is seeking a commercial entity to own, operate and maintain the plant. Pro-Energy Services, a successful Missouri-based multinational energy management company,

has expressed interest in the development of this project. A local Master Forester and mill owner, Shannon Jarvis (owner of Jarvis Timber), has indicated willingness to serve in a leadership role for coordinating and conducting the woody biomass supply chain.

An evaluation of the available technologies resulted in a choice to pursue the combustion steam boiler/turbine option due to lower capital costs and proven use of the technology. The estimated capital cost for an 8mW plant is $32.4 million, $52.5 million for 15 mW and $70 million for a 20 mW plant. Assuming a cost of $30 per delivered ton, the cost of biomass is estimated to be about $0.048 per kwh. Operating costs per kwh range from a high of $0.059 per kwh for an 8mW plant, down to $0.022 at the 20mW level. This assumes employing approximately 30 people to operate the plant on a 24/7 basis. It is estimated another 27 (at 8mW) to 98 people (at 20 mW) will be employed in the biomass supply chain.

The most favorable location is a site in the vicinity of Viburnum and Buick due to the following considerations:

- Unconstrained power plant sites (no local/county restrictions)
- Access to potential user of electrical power generated (Doe Run)
- Adequate renewable woody biomass resources within economical range
- Access to adequate water supply (for cooling and power plant use)
- Available workforce (area has high unemployment rates)
- Good State Highway access (possible rail)
- Potential Access to power grids for PPA or Transmission

The environmental requirements for operating a woody biomass electrical power plant are not unlike other electrical power plant operations. General guidelines from another proposed biomass plant in Missouri were used for a baseline consideration. The community has local knowledgeable resources available to offer technical assistance with permit applications and environmental compliance. The proposed developer is also knowledgeable in Missouri permitting and emissions factors.

The impact to the local communities is expected to be positive in terms of direct and indirect employment, additional businesses to support the plant, increased tax revenues and an overall improved economic environment. Local government, businesses and individuals have expressed support and commitment to the project. No current opposition has been voiced, but as plans for the plant become public, this is a possibility.

The financial outcomes are adverse or marginal for the 4 mW electrical power plant; however, local interest has been expressed for an electrical power plant in this range. An 8 mW electrical power plant demonstrates sustainability and the larger (15-20 mW) are the most economically feasible. An 8mW electrical power plant is the most likely size to be established based on potential customer input.

Financial Summary	4mW	8mW	15mW	20mW
	Yr 1	Yr 1	Yr 1	Yr 1
Capital Assets	16,500,000	32,424,000	52,525,276	70,033,701
Capitalized Interest	333,188	600,116	957,647	1,286,257
Year 0 Operating Expenses	290,000	290,000	290,000	290,000
Total Cash Needs for Start-up	17,123,188	33,314,116	53,772,923	71,609,958
Debt Financing	12,842,391	24,985,587	40,329,692	53,707,469
Equity Financing	4,280,797	8,328,529	13,443,231	17,902,490
Income				
Sales of Electricity	3,332,000	6,664,000	12,495,000	16,660,000
RETC	660,480	1,320,960	2,476,800	3,302,400
REC	300,000	600,000	1,125,000	1,500,000
Total Income	4,292,480	8,584,960	16,096,800	21,462,400
CGS and Operating Expenses				
Woody Biomass Feedstock	1,596,000	3,192,000	5,985,000	7,980,000
Labor	1,560,000	1,560,000	1,560,000	1,560,000
Variable O&M	20,000	40,000	75,000	100,000
Fixed O&M	402,000	804,000	1,507,500	2,010,000
Total Operating Expenses	3,578,000	5,596,000	9,127,500	11,650,000
EBITDA	714,480	2,988,960	6,969,300	9,812,400
Debt Servicing (P&I)*	1,241,489	2,415,386	3,898,719	5,191,965
Cash flow before taxes	(527,009)	573,574	3,070,581	4,620,435
Biomass cost per kwh	0.048	0.048	0.048	0.048
Operating cost per kwh	0.059	0.036	0.025	0.022
(Cash) Cost per kwh	0.107	0.084	0.073	0.070
Assumptions				
Number kwh:	33,320,000	66,640,000	124,950,000	166,600,000
Selling price per kwh:	$ 0.10	$ 0.10	$ 0.10	$ 0.10
# tons biomass per mWh	13,300	13,300	13,300	13,300
# tons biomass required	53,200	106,400	199,500	266,000
Biomass price/ton, delivered:	$ 30.00	$ 30.00	$ 30.00	$ 30.00
# plant employees:	30	30	30	30
# biomass jobs:	27	48	78	98
Debt Financing				
% of capital costs	75%	75%	75%	75%
Interest rate	7.5%	7.5%	7.5%	7.5%
# years	20	20	20	20
Annual payments (P&I)	$1,241,489	$2,415,386	$3,898,719	$5,191,965

* Interest during construction is capitalized and included in total cash needs for start-up

The conclusion of this study is that there is sufficient woody biomass in the region to support a power plant in the 8-20 mW range under consideration, and there is local interest among forest harvesting companies to participate in a woody biomass supply chain. There is more than one suitable site with existing transportation access and water supply for plant location. There are workers in the region with forestry, construction and production/manufacturing skills; and with high unemployment rates, an assumed ready supply of labor. The power plant and associated direct and indirect jobs would have a significant positive economic impact on the region. The most critical remaining uncertainty is how the power will be sold – who the customer or customers will be and how it will be transmitted – and for what price.

Recommended next steps are:

- Pursue further discussion with potential purchasers of the electricity to determine terms and logistics of supplying them with power.
- Continue building the relationship with Pro Energy, and facilitate exploration of local/state/federal incentives for development of the plant.
- Continue discussions with Doe Run to explore opportunities for their direct and indirect involvement in development, purchasing electricity from, and providing biomass to the plant.
- Engage in additional dialogue with potential members of the biomass supply chain to determine how best to organize the supply chain, and develop an inventory of what equipment is already in use and/or available for use.
- Closely follow the developments of regulations for Proposition C and evaluate how they impact the viability of this project.

In preparation of this evaluation, VEDAC and its subcontractor, has relied upon publically available information and information supplied by technology providers. While VEDAC and its subcontractor have no reason to believe that the information provided, and upon which VEDAC and its subcontractor has relied, is inaccurate or incomplete in any material respect, VEDAC and its subcontractor has not independently verified such information and cannot guarantee its accuracy or completeness.

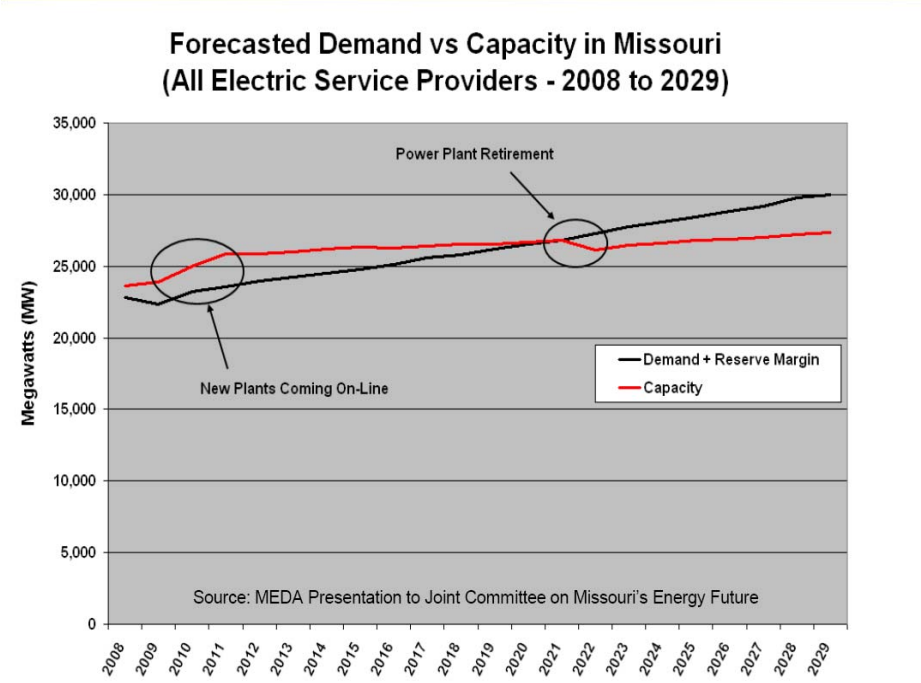
The information presented herein should enable a Missouri entity to determine the feasibility of a woody biomass electrical power plant for further evaluation, using referenced resources to provide additional supporting data.

Market Considerations

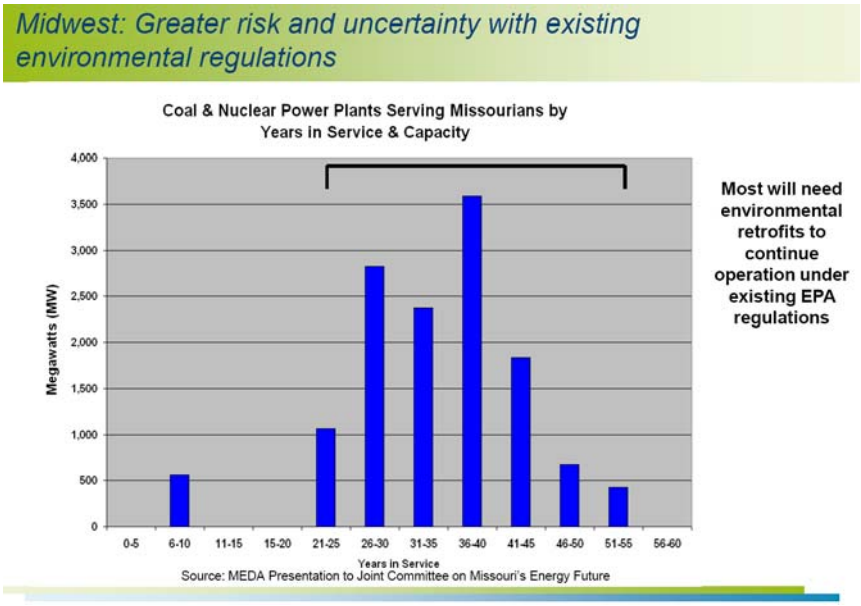
The primary product of the plant will be electrical power produced from renewable (biomass) sources. By-products are heat from the steam power plant, and fly ash.

A. Demand/Customers

The demand for electrical power in Missouri is growing at an estimated 2.75% per year. There is growing concern that the supply of electrical power will not meet this demand due to retiring electrical power plants and the inability to bring enough new plants online in time. Demand is expected to exceed capacity within the next 10 years. This concern was a key subject matter at the *Missouri's Energy Future* conference held at the University of Missouri in Columbia in March, 2010, and is illustrated in the following figures which were presented and discussed at the conference:



Forecasted Demand vs Capacity – Missouri (KCPL)[1]



Local demand for electricity in the Viburnum region is being met by existing electrical power providers and current usage in the area is well below the available supply. The primary purpose for proposing the development of a woody biomass electrical power plant in the area is not to increase the local power supply. Rather, the purpose of the project is for economic development of the region by utilizing its unique natural resources and forest-related industries to generate renewable energy – which will help meet growing demand for electricity outside of the region.

Power suppliers are motivated to seek out viable sources of electricity generated from renewable sources. In November 2008, Missouri adopted a renewable portfolio standard that requires investor-owned utilities to increase their use of renewable sources to 2 percent of total electricity generation by 2011, 5 percent by 2014, 10 percent by 2018, and 15 percent by 2021. As regulations related to this legislation evolve, they will likely have an impact on demand and pricing for locally-produced renewable source power. This implies that the plant's *competitors* described below may actually be key *customers*.

B. Supply/Competitors

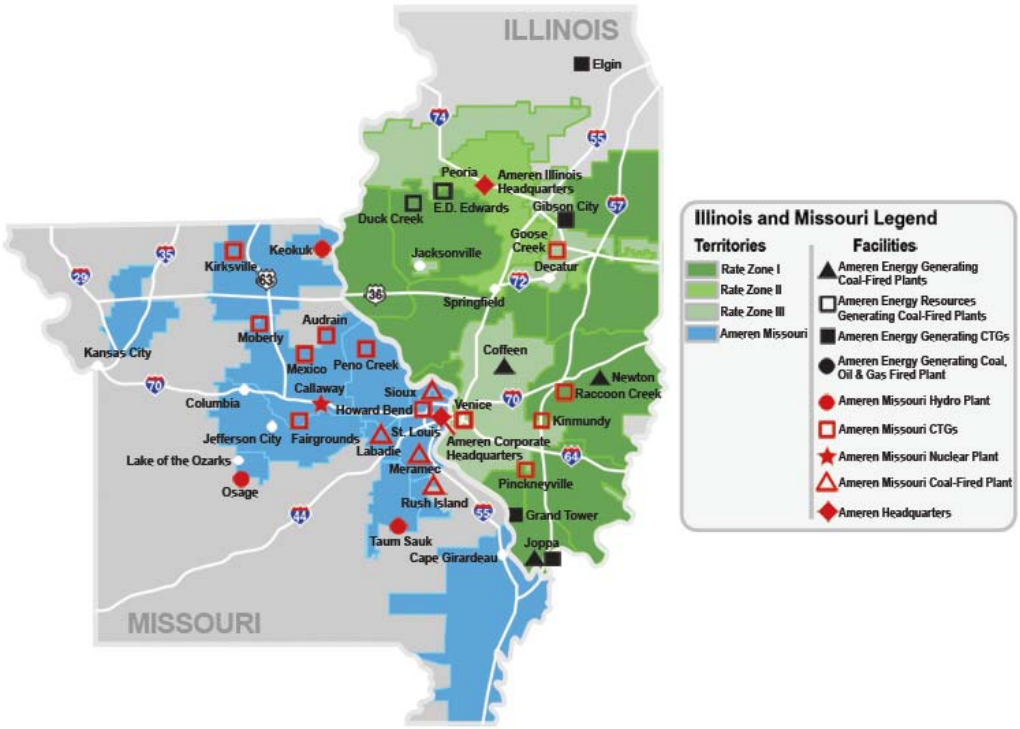
Two major electrical power providers (and their affiliate members) have a presence in the Viburnum region:

1. **Ameren Missouri** (formerly Union Electric) is the state's largest electric utility, providing services to approximately 1.2 million customers across central and eastern Missouri, including the greater St. Louis area.

   Regarding purchase of renewable source energy: the company website describes current activities and initiatives for wind, solar, landfill/biomass and hydro source power, and states that

it continues to pursue renewable generating opportunities, such as wind, solar, landfill gas, agricultural methane, hydro and other alternative energy sources to generate electricity.

The following map shows Ameren's service area and facilities:

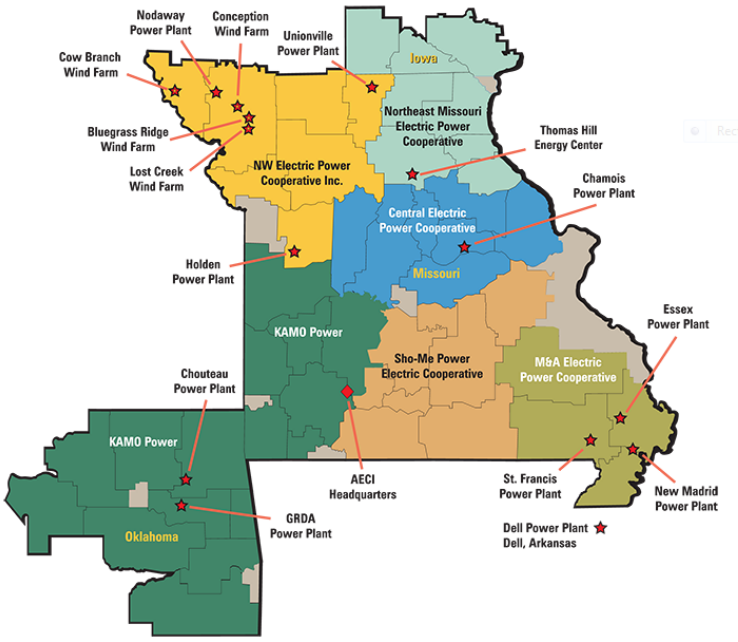


Source: Ameren Website

2. **Associated Electric Cooperative, Inc. (AECI)** – Associated and its member systems are tied together in a three-tiered system of generation, transmission and distribution cooperatives. Each tier is committed to the others through all-requirements contracts which ensure that Associated will provide a wholesale power supply to meet members' needs, and that member systems will buy all their power supply from Associated. The AECI *transmission* cooperative members (responsible for the transmission lines/connections) in the VEDAC region are M&A Electric and Show-Me Power. The *distribution* cooperative members include Black River, Crawford, Intercounty and Ozark Border.

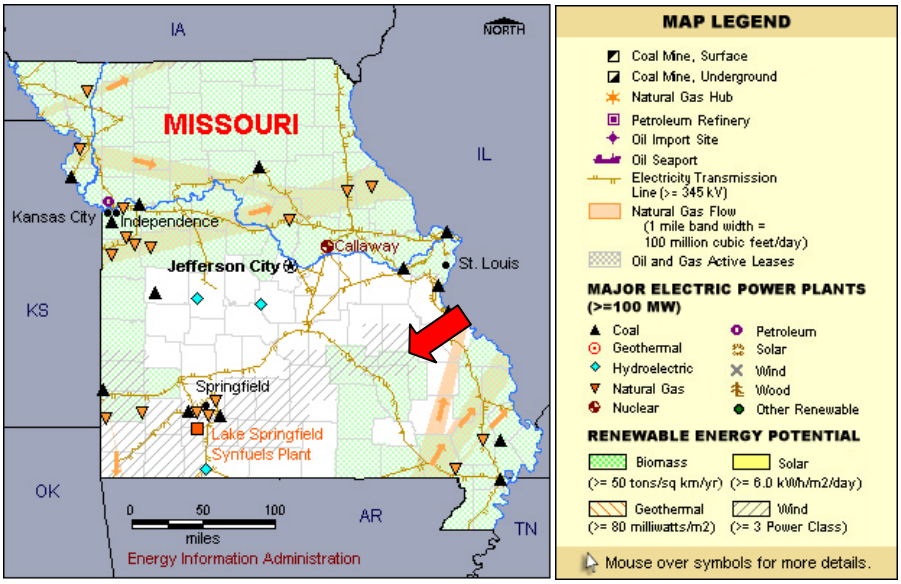
   Regarding purchase of renewable source energy: according to its website, AECI has offered both wind and biomass energy through its green power program. The biomass energy is generated at Central Electric Power Cooperative's Chamois Power Plant. AECI also is purchasing all the wind power from Missouri's first utility-scale wind farms. AECI's commitment to buy all the power from these farms in northwest Missouri for 20 years and the co-ops' vast transmission system made the wind farms possible.

AECI serves six G&T cooperatives that serve 51 electric distribution cooperatives in three states



Source: AECI Website

As shown in the following map from the Energy Information Administration, there are no utility grade power generation plants in the immediate region of VEDAC (the Taum Sauk site shown on the Ameren map above on is a secondary power generation facility – energy storage for peak time usage.) The map also highlights the biomass renewable energy potential in the region.



The region has 345 kva, 161kva and 34.5 kva electrical power grid connections, facilitating delivery of electrical power through the extended region from Lake of the Ozarks to New Madrid and St. Louis to Springfield, Missouri. Utilization of this existing infrastructure could reduce the costs and timeframe of developing connectivity to the electrical grid. Resolution of regulations for Missouri's Proposition C will impact how this is accomplished.

C. Market Considerations for Biomass Feedstock

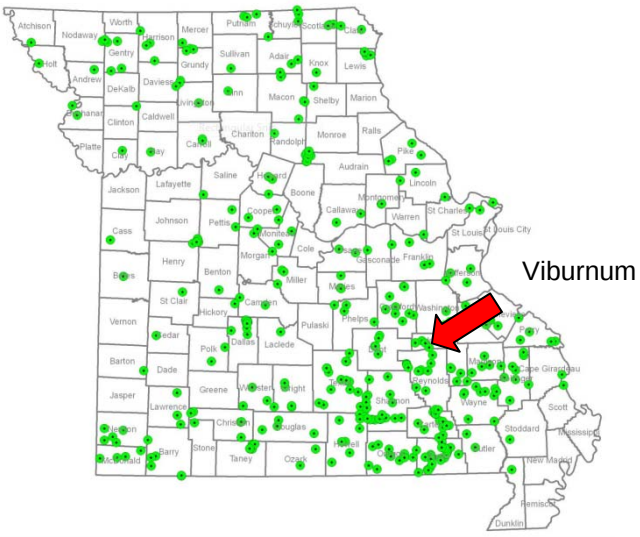
The primary source of feedstock under consideration is harvested woody biomass from timber harvesting and timberland improvement operations.

The Missouri Forest Products' *Woody Biomass Technology Demonstration Project* report (January 2010)[2] provides relevant analysis and insight for several aspects of the VEDAC region project, including mail surveys and interviews of logging firms in the Salem, Missouri (Dent County) area. The report indicates there is an interest in expanding logging operations to include production of woody biomass, with an estimated delivered price of $30-$35 per green ton within a 30-mile transportation distance.

Documentation for the University of Missouri *Woody Biomass Assessment Tool (*http://projects.cares.missouri.edu/MoBAT/BioMass_V1.html)[3] succinctly describes the competitive harvest pressure of this feedstock:

> *"Biomass found in small-diameter trees (5"-9" diameter at breast height) is prime material for scrag block mills. These mills produce lumber used to make pallets and blocking, and they may either be stand-alone operations or integrated in larger sawmills. Beyond direct competition for small diameter trees, mills utilizing larger trees might feel threatened if they sense that the better-form, small-diameter trees destined one day to be processed by their mill is being chipped for biomass. These established wood product companies could make it difficult for an energy facility to procure their needed wood fiber.*
>
> *On the other side of the coin lies opportunity. Depending upon the raw material specifications of the energy plant, they may be able to purchase mill residues. Of course, supply-and-demand and existing customer-supplier relationships will be key factors in determining what that final market will look like. Another possibility, could lie in partnering with existing logging crews to simultaneously extract biomass material from the harvest residues currently left in the forest."*

The Woody Biomass Assessment Tool described above returns a result of 44 mills within the analysis area, and 137 overlapping harvest areas. The Missouri Forest Industries *2010 Directory of Primary Wood Processor*[4] lists 43 mills in the 5-county VEDAC area (see map below).



Location of Primary Wood Processors

The Missouri Department of Conservation online searchable database of mill products (http://mdc.mo.gov/mdc/find-wood-processing-mill*)* lists over 100 mills sourcing from the subject area, with more than 70 companies engaged in manufacturing pallets and blocks

Secondary sources of biomass feedstock include mill by-products. The key competitors for these raw materials are:

1. Charcoal manufacturers (2 within the 5-county region)
2. Fuel pellet manufacturers (the nearest pellet manufacturer is about 125 miles from Viburnum)
3. Mulch processors/distributors (no significant/standout competitors in this category)
4. Other biomass power operations – as of the date of this study, no active competitors in this category. (The proposed Perryville woody biomass plant has been put on hold without any definite actions to pursue)

During the conduct of this study, site visits were made to several potential competitors and sources for feedstock to evaluate usage/volumes. The feedstock products, sources and analysis of competitive situation are summarized in the following table:

Feedstock	**Sources**	**Competitive situation**
Tops, limbs, bark, bows, etc.	Timbering operations	Small percentage is currently being utilized
Tops, limbs, bark, bows, culled trees	Timberland improvement operations	Growing supply as timberland improvement operations are gradually being accepted and implemented
Sawmill dust, chips, bark, slabs	Sawmills/re-saws	More available than currently being consumed
End scraps, broken boards, sawdust	Pallet mills	More available than currently being consumed
Sawdust, ends, milling chips, splits, etc.	Finished wood product operations	More available than currently being consumed

The analysis of available woody biomass for the proposed power plant has only considered the feedstock coming only from timbering and timberland improvement operations, for a conservative assessment of the available biomass. These other woody biomass sources (sawmills/re-saws, pallet mills, finished wood product operations) in excess of what is being consumed, would be more appropriate for woody fuel pellet operations.

Plans for a proposed woody biomass plant (LG Biomass)[5] plant in Perryville, Missouri has recently been abandoned. If resolution of Proposition C regulations, emission issues, and/or other factors initiate resumption of development of that power plant, biomass resource studies indicate the biomass requirements of that plant would not interfere with a woody biomass power plant located in the Viburnum region.

D. Market Considerations for By-Products

Excess Heat

Potential uses of the excess heat from the steam power plant are:

- Drying the biomass prior to use
- Using a heat recovery system to generate additional electricity (such as Combined Heat and Power systems by Turbosteam (www.turbosteam.com))
- Use by adjacent companies for heating and drying purposes (building heat, timber, chips, other materials)

During the conduct of this study, no definite needs for the excess heat were determined. The plant would initially be planned utilizing cooling water towers or similar methods. This area will be explored when the final site is selected and the project initiated. This report does not consider the benefits accruing from the excess heat utilization since the technology and use will be site specific and driven by customer needs.

Fly Ash

The fly ash from the power plant may be used in the production of fertilizer (mixed with limestone). No associated cost or cost benefit to the power plant operations is being considered in this study. At least one user for the wood ash has been identified, although no remuneration for the ash was offered (this would save the disposition costs for the ash). The fly ash can also be used in mine/land mitigation and in improving forest land fertility.

E. Input from Marketing Experts

The following marketing/subject matter experts were consulted and contributed to the content of the feasibility study:

- **Al Marcus (Missouri Enterprise)** - Al Marcus has more than 35 years experience in marketing, sales management, strategic / marketing planning and market research. He has worked for small privately owned firms as well as Fortune 500 manufacturing companies. Al has created

marketing and market research departments in the aerospace and food equipment industries. His accomplishments include tripling sales to $33 million in one product; capturing $4 million of new niche markets sales in the first year for another; developing a compensation program that increased operating income by $2 million; and developing a total promotional campaign which sold out the year's production in four months. Al has a B.A. in Mathematics from St. Louis University, M.S. in Statistics from St. Louis University and M.B.A. in Marketing and Finance from Southern Illinois University at Edwardsville. He received additional training in marketing at the Wharton Business School and University of Chicago Graduate School. Al is an adjunct professor, teaching marketing at Webster University's Graduate School. He is a past president of the St. Louis Chapter of Sales and Marketing Executives

- **Rob Osborn (ex-Missouri Enterprise)** – Currently employed as a Marketing and Sales Consultant, Rob has over 18 years of manufacturing experience, in the food industry, and is experienced at Value-Added Products with emphasis on USDA FSIS. Rob has owned four businesses with two of them being turn-around operations. With a strong background in product development and marketing, he has consulted as free lance marketer for Missouri Enterprise and Broadcasting companies. Market Share growth and niche product branding are areas that he has excelled at in growing product line and recognition along with new concept develop of products. Combined with this, Rob has formal training in building layout and design; developing businesses from conception to operation. Graduate and Alumni - Wizard of Ads Academy, Buda, Texas – Sandler Sales Systems.
- **Jimmy Story (Missouri Enterprise)** - Jimmy oversees feasibility studies and business analysis for agriculture related projects and provides assistance to agriculture producers and cooperatives in obtaining state and federal grants. He works closely with MASBDA, USDA, EIERA and other state and federal officials. Jimmy has a Bachelor of Science Degree in Business Administration/Marketing from Columbia College. .

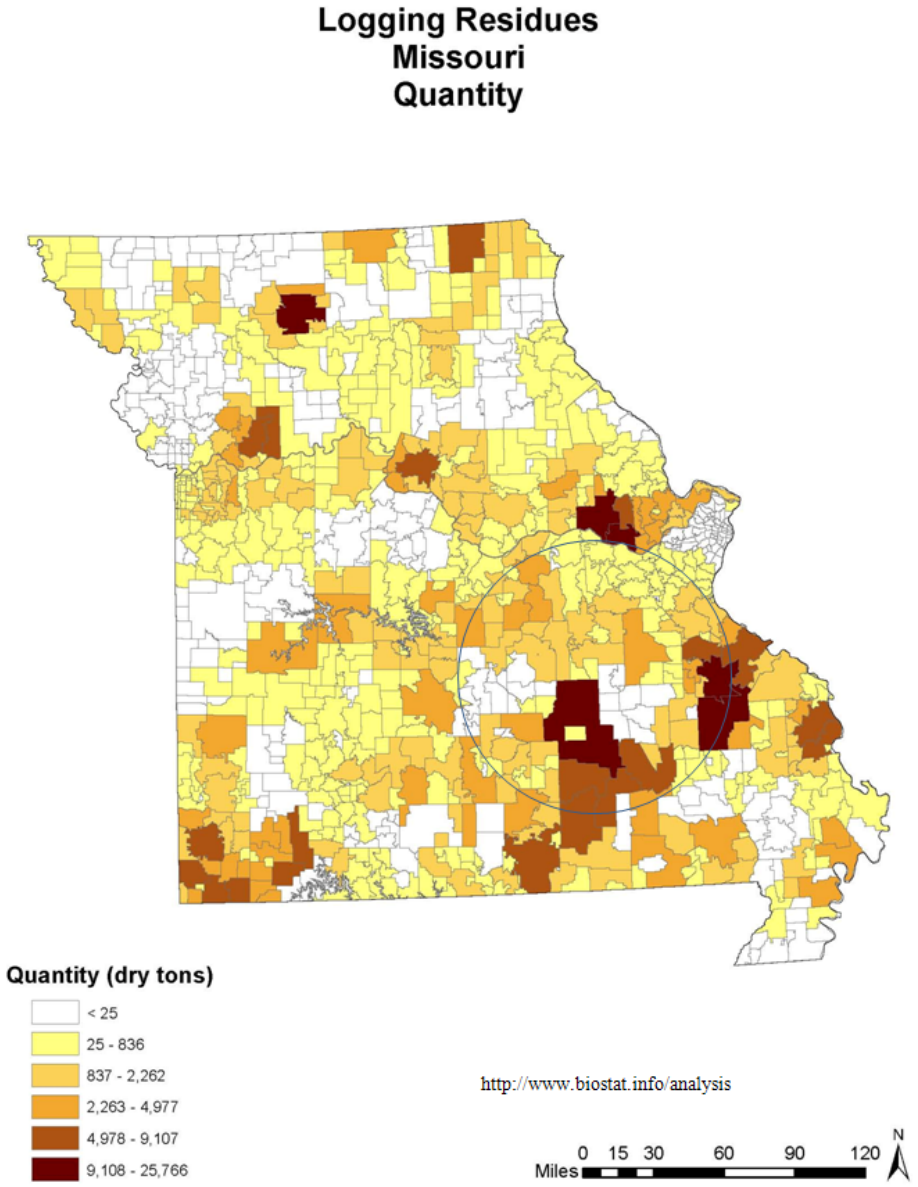
Others consulted/utilized:

- Richard Newell, EIA Administration, U.S. Department of Energy (left on July 1, 2011, now at Duke University as a professor of energy and environmental economics. Personally consulted on May 3, 2011 (Biomass in the United States Energy Economy)
- Michael J. Schewel, McGuire Woods, Energy & Climate Change Team. Personally consulted on May 4, 2011 (Biomass Power Outlook).
- Eric Kingsley, Vice-President of Innovative Natural Resource Solutions LLC. Personally consulted on May 16, 2011 (Biomass Energy – Mixed Signals Abound)

Raw Material Availability

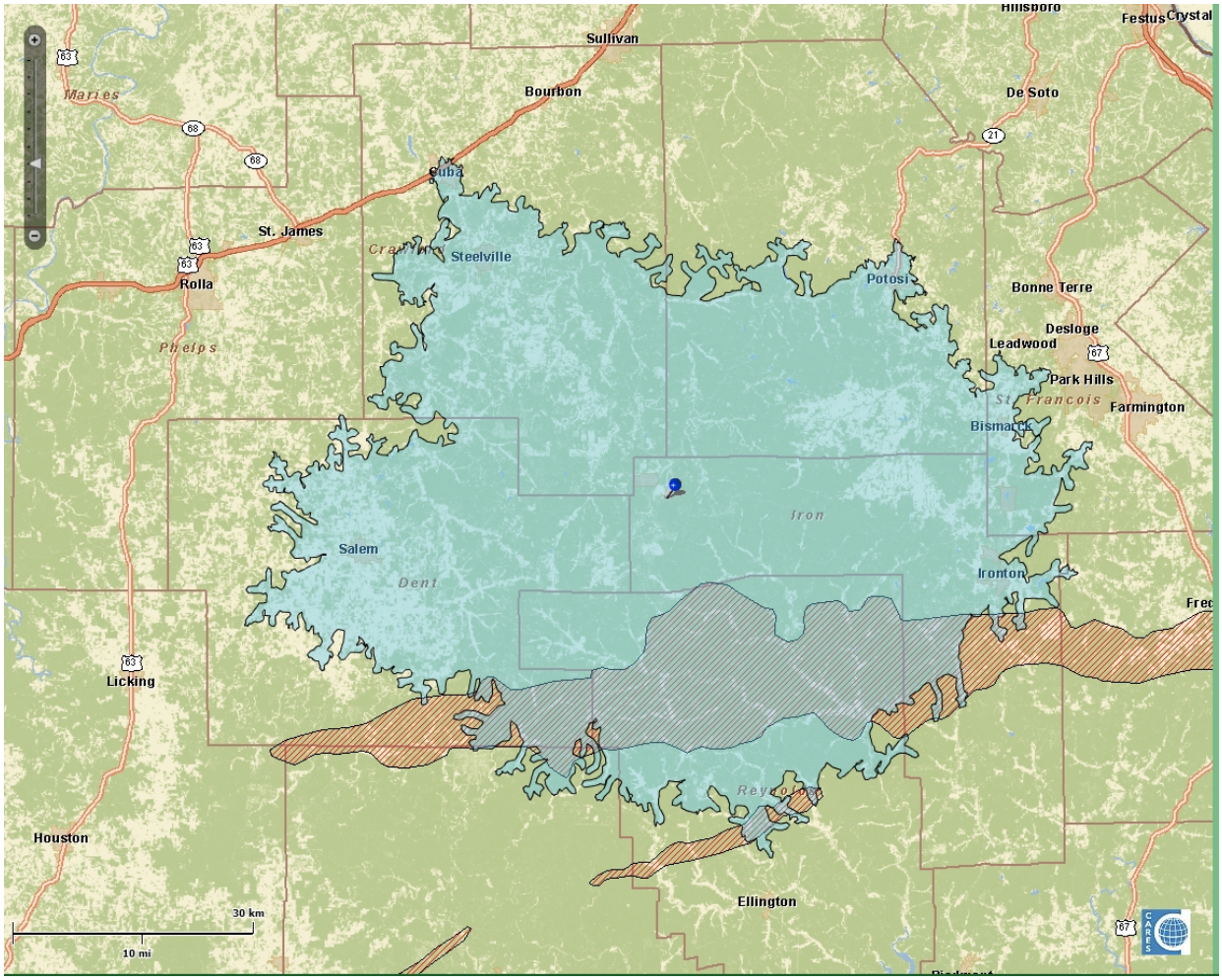
The VEDAC region includes significant logging residues that provide a location advantage over other regions in the State of Missouri. Existing and planned sustainable timberland improvement projects in the region will generate additional woody biomass.

The below map indicates the logging residues with a 50 mile radius of Viburnum, based on information from BioStat (http://www.biostat.info/analysis).



The University of Missouri Center for Applied Research and Environmental Systems' *Missouri Woody Biomass Assessment Tool* [3] was used to calculate the estimated annual available green tons to "sustainable" biomass within a 75 minute route centered on a Viburnum location for the power plant, has the following attributes:

1,258,997 total acres
658,667 harvestable acres
8,244,822 estimated green tons
412,214 total sustainable annual available green tons (at 100% landowner participation)
There are 44 mills in the analysis area, with 137 overlapping harvest areas.



75 Minute Driving Radius Biomass Map (centered on Viburnum)[2]

A description of the methodology and other key information about this tool can be found at http://projects.cares.missouri.edu/MoBAT).

The Forest Inventory & Analysis (FIA) EVALIDATOR (http://www.fia.fs.fed.us/tools-data/default.asp) provides the following woody biomass availability information for the subject area:

Table 1
Missouri (29) -- Net growth of all live on timberland by Species group and Ownership (in cuft/year)
50 mile radius from Viburnum

Tree species group	Ownership							Total	
	National Forest (11)	National Park Service (21)	Department of Defense or Energy (24)	Other Federal (25)	State (31)	Local (county, municipal, etc.) (32)	Undifferentiated private (46)	CuFt	Green Tons
Loblolly and shortleaf pines (2)	6,958,583	-	--	46,489	1,022,052	--	6,991,294	15,075,467	395,733
Other eastern softwoods (9)	163,290	-	--	14,696	98,007	--	4,409,756	4,700,554	123,390
Select white oaks (25)	7,769,682	-	131,608	27,428	4,266,257	5,150	23,877,841	35,293,252	926,454
Select red oaks (26)	141,479	-	44,130	70,358	847,018	--	1,420,529	2,017,367	52,956
Other white oaks (27)	776,789	-	-	--	353,918	50,389	6,549,545	7,751,394	203,475
Other red oaks (28)	6,309,561	-	62,012	43,717	3,490,869	(215,107)	15,881,182	25,724,756	675,279
Hickory (29)	1,124,713	-	49,931	208,825	960,278	49,051	8,027,221	10,307,733	270,580
Hard maple (31)	205,954	-	63,992	25,885	420,656	--	2,804,997	3,521,483	92,440
Soft maple (32)	30,052	--	103,134	-	29,282	--	232,515	394,983	10,368
Sweetgum (34)	37,449	--	--	--	549,326	--	61,812	648,587	17,026
Tupelo and blackgum (35)	491,281	-	6,247	--	625,647	-	615,025	1,738,758	45,643
Ash (36)	223,578	-	42,337	62,936	153,836	--	490,871	1,156,893	30,369
Basswood (38)	50,222	-	--	--	--	--	1,005	51,227	1,345
Black walnut (40)	(186,226)	-	75,286	--	321,269	--	1,609,910	1,822,776	47,848
Other eastern soft hardwoods (41)	751,962	-	612,370	39,895	305,849	11,109	3,379,218	5,116,751	134,316
Other eastern hard hardwoods (42)	67,816	-	20,226	5,335	64,930	-	188,253	346,561	9,097
Eastern noncommercial hardwoods	11,841	-	11,177	13,515	(10,159)	--	46,887	73,261	1,923
Totals:	24,928,029	-	1,222,449	559,079	13,499,037	(99,408)	76,587,860	115,741,803	3,038,241

Source: Forest Inventory & Analysis (FIA); EVALIDATOR Custom Retrievals-Missouri

The Net Growth table does not include the removals from the subject harvest area. Table 2 provides the average annual removals for the subject area:

Table 2
Missouri (39.1) - Average annual removals of live trees (at least 5 inches d.b.h./d.r.c.), in cubic feet, by species group and owner class
50 mile radius from Viburnum

Missouri (29) -- Removals of all live on forest land by Species group and Ownership (in cuft/year)									
Tree species group	Ownership							Total	Green Tons
	Annual Net Growth	National Park Service (21)	Department of Defense or Energy (24)	Other Federal (25)	State (31)	Local (county, municipal, etc.) (32)	Undifferentiated private (46)		
Loblolly and shortleaf pines (2)	421,960	-	--	-	124,247	--	3,457,066	5,518,834	144,870
Other eastern softwoods (9)	-	-	--	-	-	--	314,695	503,950	13,229
Select white oaks (25)	252,144	-	-	-	173,337	-	6,401,293	9,412,591	247,082
Select red oaks (26)	151,418	-	-	-	-	--	946,398	1,097,816	28,818
Other white oaks (27)	84,481	-	-	--	-	-	1,792,995	2,316,427	60,807
Other red oaks (28)	3,369,015	-	-	-	1,016,140	-	9,551,769	18,478,455	485,062
Hickory (29)	74,683	-	-	-	-	-	2,832,212	3,010,782	79,034
Hard maple (31)	62,685	-	-	-	-	--	37,146	99,832	2,621
Soft maple (32)	9,515	--	-	-	-	--	-	9,515	250
Sweetgum (34)	-	--	--	--	-	--	-	-	-
Tupelo and blackgum (35)	31,894	-	-	--	-	-	19,697	68,513	1,798
Ash (36)	-	-	-	-	-	--	-	426,351	11,192
Basswood (38)	-	-	--	--	--	--	-	-	-
Black walnut (40)	-	-	--	-	-	--	26,465	322,678	8,470
Other eastern soft hardwoods (41)	6,200	-	-	-	-	-	61,830	334,899	8,791
Other eastern hard hardwoods (42)	-	-	-	-	-	-	13,253	41,903	1,100
Eastern noncommercial hardwoods	-	-	--	-	-	--	-	68,290	1,793
Totals:	4,463,995	-	-	-	1,313,724	-	25,454,820	41,710,837	1,094,916

The difference between the two tables above provides the available net growth of the region. Following suit for the methodology used in the *Woody Biomass Technology Demonstration Project* [2], a conservative estimate of removing only 30% of the net tonnage (growth less removals) yields about 583,000 green tons available in the subject area.

Table 3

Missouri Annual Growth vs. Removals

50 mile radius from Viburnum

Missouri (29) -- Removals of all live on forest land by Species Group (in cuft/year)					30%
Tree species group	Cubic Feet Per Year			Total	Available
	Growth	Removals	Net	Green Tons	Green Tons
Loblolly and shortleaf pines (2)	15,075,467	5,518,834	9,556,633	250,863	75,259
Other eastern softwoods (9)	4,700,554	503,950	4,196,604	110,162	33,048
Select white oaks (25)	35,293,252	9,412,591	25,880,661	679,372	203,811
Select red oaks (26)	2,017,367	1,097,816	919,551	24,138	7,242
Other white oaks (27)	7,751,394	2,316,427	5,434,967	142,669	42,801
Other red oaks (28)	25,724,756	18,478,455	7,246,301	190,217	57,065
Hickory (29)	10,307,733	3,010,782	7,296,951	191,546	57,464
Hard Maple (31)	3,521,483	99,832	3,421,651	89,819	26,946
Soft Maple (32)	394,983	9,515	385,468	10,119	3,036
Sweetgum (34)	648,587	-	648,587	17,026	5,108
Tupleo and blackgum (35)	1,738,758	68,513	1,670,245	43,844	13,153
Ash (36)	1,156,893	426,351	730,542	19,177	5,753
Basswood (38)	51,227	-	51,227	1,345	403
Black Walnut (40)	1,822,776	322,678	1,500,098	39,378	11,813
Other eastern soft hardwoods (41)	5,116,751	334,899	4,781,852	125,524	37,657
Other eastern hard hardwoods (42)	346,561	41,903	304,658	7,997	2,399
Eastern noncommercial hardwoods (43)	73,261	68,290	4,971	130	39
Totals	115,741,803	41,710,836	74,030,967	1,943,325	582,998

Source: Tabel 1 and 2

Although there are several plants in operation, the use of woody biomass to generate electricity on a large scale is still an emerging model. A number of federal and state government agencies and forestry associations have commissioned studies and demonstration projects relating to this practice, and several of these were used for reference in this study. One key variable for determining efficiency and economic feasibility for woody biomass power is how many green tons of biomass are required per megawatt of power. According to published studies and reports, this variable does not appear to be widely agreed upon, as outlined in the samples below:

Source	GT per mW
USDA – Value & Power Calculations[6]	17,472
NASF Biomass[7]	13,300
Woody Biomass Utilization Guide[8]	8,000

The conversion factors (USDA[6], NASF[7], and WBUG[8]) consider the efficiencies from green tons to mW potential in the calculation.

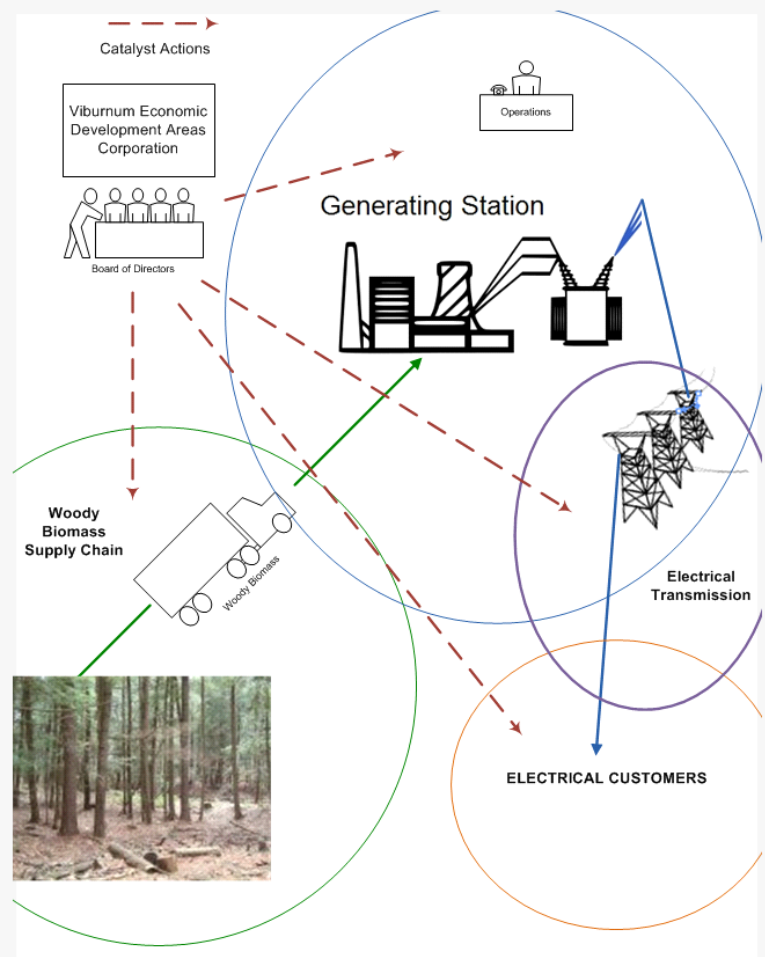
An analysis of the potential mW capacity based on the estimated range of biomass available and using the varying measures for GT/mW described above suggests a sustainable supply for a power plant in the 4-20mW range being considered.

			# GT per mW			
			USDA	NASF	WBUG	Average
			17,472	13,300	8,000	12,924
Source	Participation	GT Available	mW potential			
CARES 75-minute drive	30%	123,664	7	9	15	11
	50%	206,107	12	15	26	18
	75%	309,161	18	23	39	27
	100%	412,214	24	31	52	35
FIA 50 mile radius	30%	582,998	33	44	73	50

Organizational Structure

Two possible organizational structures were considered during this study:

1. Viburnum Economic Development Area Corporation (VEDAC) will serve as a *catalyst* to the establishment of a woody biomass power plant in the region, with the plant being constructed, owned and managed by a commercial entity (e.g. Pro-Energy). The commercial entity would be responsible for dealing directly with electrical customer(s) (electric utility or a major energy consumer such as a manufacturing facility), and for dealing with the woody biomass supply chain.
2. VEDAC will enter into a formal partnership with a commercial entity which will construct and manage the plant. The partnership will share ownership and will deal directly with customer(s) and the biomass supply chain.



VEDAC prefers to pursue the first option – to be a catalyst for the project – identifying and bringing economic incentives and support from various sources (regional, state, federal, private). It is not the mission of VEDAC, nor does it have the organizational or financial capacity, to own and manage a power plant. The only potential change in the existing VEDAC organization may be to hire a full-time Executive Director to facilitate additional economic development initiatives related to, and/or resulting from, the power plant project.

A. Commercial Management

VEDAC intends currently to build on its existing relationship with Pro-Energy Services, a Sedalia-Missouri based company which constructs and manages electrical power plants, for the commercial component of the project. This relationship was developed through a previous, similar evaluation of locating a biomass power plant in the region (related to a potential expansion of the Doe Run Company). Pro-Energy currently manages two plants in Missouri (Vandalia 600mW, and Columbia 140mW.) More information about Pro-Energy is provided in the Technical section.

B. Biomass Supply Chain

Shannon Jarvis, Missouri Master Forster, owner of Jarvis Timber Company, LLC, in Potosi has indicated willingness to establish and coordinate the woody biomass supply chain. Mr. Jarvis has participated in Missouri Timberland Improvement Programs, and will work cooperatively with the Missouri Forest Products Association in the development and training for the woody biomass harvesting operations. The supply chain will be grounded in the principles of sustainable timberland improvement.

C. Transmission

The electrical transmission entity will be determined by the final plant site and electrical customer(s). Localized demand may allow direct connection to customer(s), not utilizing the power grid. Regulations and standards regarding interconnectivity and transmission of electrical power, and geographic sourcing of renewable power, are currently under consideration by the Missouri legislature. The outcome of actions on new regulations could have a significant impact on this project.

D. Plant and Biomass Supply Chain Personnel

Personnel Needs	4 mW	8 mW	15 mW	20 mW
Woody Biomass Supply Chain	27	48	78	98
Electrical Power Plant	30	30	30	30
Total Personnel	57	78	108	128
Woody Biomass Skill Trades (estimated)				
Feller (4 man crew per 2mW)[1]	8	16	30	40
Skid Operators	3	6	10	12
Chipper Operators	3	6	10	12
Loader Operators	3	6	10	12
Truck Drivers	3	6	10	12
Supervisor/Forester	2	2	2	4
Management	3	4	4	4
Accounting/Finance	2	2	2	2
	27	48	78	98
Electrical Power Plant Trades				
Boiler Operators	8	8	8	8
Electricians	4	4	4	4
Laborers	4	4	4	4
Equipment Operators	6	6	6	6
Supervisors	4	4	4	4
Management	2	2	2	2
Accounting/Finance	2	2	2	2
	30	30	30	30

A power plant operating 24 hours per day, 7 days per week will require certain positions on each shift regardless of the mW size of the plant. This is one of the constraints that render smaller mW plants less economically feasible. The estimated number of employees needed for a plant up to 20 mW is 30, as described above.

The mW size of the plant does have a direct impact, however, on the number of workers needed in the woody biomass supply chain. The estimate starts at 27 for a 4mW plant and increases incrementally up to 98 for a 20mW plant.

As described in the discussion regarding plant location later in this report, the local labor force is well suited to meet the needs of both the plant and biomass supply chain.

Technical Considerations

A. Plant Technology Options – Direct Combustion vs. Gasification

The July, 2009 NREL report "*Market Assessment of Biomass Gasification and Combustion Technology for Small and Medium-Scale Applications*"[9], provides a useful evaluation of the two basic options for converting solid biomass to power.

In direct combustion, the biomass is burned to produce a hot flue gas which is used directly for heat, or used in a boiler system to generate steam. The steam can be used for heat or to power industrial processes, and to generate electricity with a steam turbine. In gasification, biomass is converted to a combustible gas which is burned directly for heating/drying applications, or in a boiler to produce steam.

Direct combustion technology is simpler, lower cost, more flexible in fuel moisture and size, and more mature (proven) than gasification. However, direct combustion has higher emissions and a less efficient conversion process than gasification; and requires water for steam turbine power generation.

VEDAC leadership gathered and evaluated available information on the relative advantages and disadvantages of the two technology options, including a November, 2010, site visit to a direct combustion/steam boiler biomass plant in Wisconsin (DTE Stoneman Station Biomass Plant – 40 mW) with woody biomass as the principal fuel. Based on the information available, including the history of 22 California woody biomass power plants, and the prevalence of active use of steam boiler power plants utilizing woody biomass, VEDAC is exploring development of the plant using the direct combustion technology with traditional fluidized bed steam boilers, as its preferred course.

Gasification Evaluation

During the course of this study, VEDAC and its contractor conducted research regarding current gasification systems and the state of readiness for use for a woody biomass power plant in the region. Based on this research, VEDAC has determined the direct combustion technology is better suited for this project for the following reasons:

- Status of the technology – Gasification technology for woody biomass power generation is, to a large extent, still in the demonstration phase. Published research, presentations and discussions with those knowledgeable in this technology indicate problems with more primary, secondary, and tertiary tars, and with additional maintenance requirements. Conversely, direct combustion systems have a proven track record, and nearly all of the U.S. facilities using biomass to produce power use direct combustion technology[9]. The risk tolerance for use of a less proven/mature technology for this project is low.
- Financial viability – The Financial Analysis section later in this report provides a resource describing the sensitivity of various factors on the cost of generating electricity. A factor with one of the highest levels of sensitivity is the cost of capital. Gasification technology has a higher capital cost than direct combustion, and reportedly higher operating costs. Considering the higher capital costs, more stringent requirements for fuel size and moisture levels, and increased

maintenance requirements, the financial viability of gasification plants is inferior to that of direct combustion plants.

Review of current gasification systems and the state of readiness for use for a woody biomass power plant in the VEDAC region was conducted. Reviewing the state of the process, and considering the location and use of the power plant, VEDAC chose to utilize the more traditional (and proven) steam boiler plant technology.

The information and rationale utilized in this decision concerning the gasification system:

The Vermont Biomass Gasification Project in Burlington, Vermont, was reviewed as it was America's largest scale up of biomass gasification utilizing a circulating bed reactor. It only has a capacity of 200 dry tons per day. After the projected was successfully completed, the project was shut down and not continued.[10]

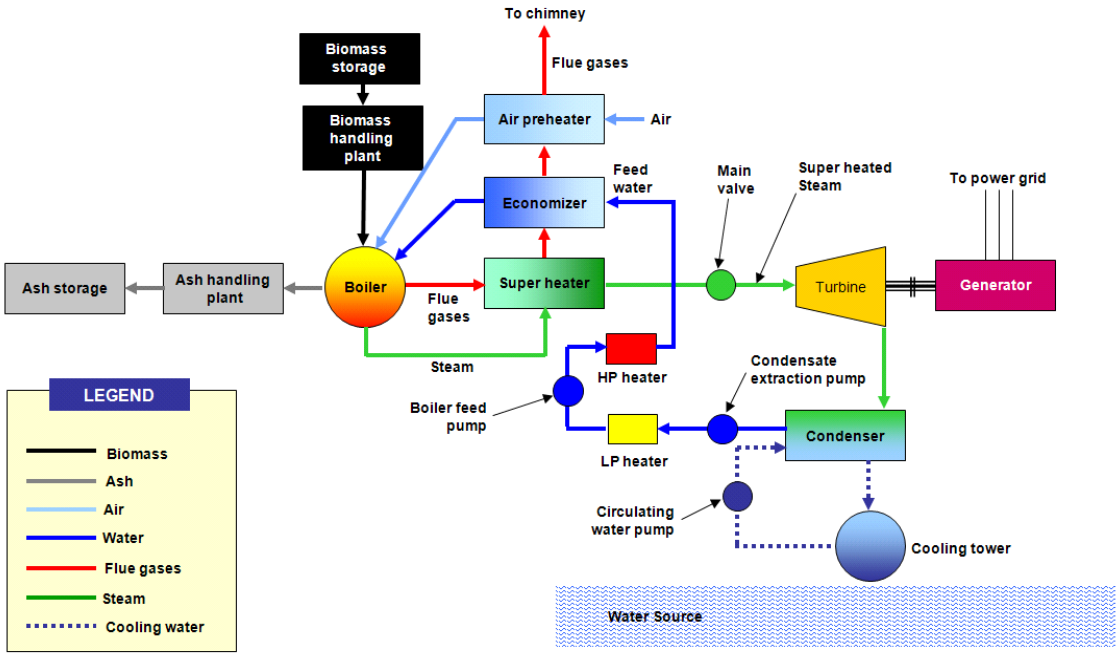
According to Morrisville State College (Dr. Jeffrey Elwood), large scale gasification plants have not proven financial viability. (March 2011):

"The main point here is that these large-scale systems are technically possible, but they require a lot of biomass to run them, and they are expensive to build (large capital investment)." Excerpt from: http://www.woodgas.com/small_gasifiers.htm

"Systems that employ direct combustion to convert biomass into energy for heat, power, and CHP are widely utilized and commercially available for small- and medium-scale applications. Direct combustion boiler systems are used for a variety of facility heating purposes and have a solid track record in the field. Additionally, nearly all of the U.S. facilities using biomass to produce power utilize direct combustion technology."[9]

Philip McKenzie, Business Development Manager at Babcock & Wilcox Company, made a presentation[11] at the 2011 International Biomass Conference & Expo concerning Gasification plants, and expressed the concerns and issues it takes to make the systems work. The B&W Vølund Fixed Bed Updraft gasifier, while operational, had issues with primary, secondary, and tertiary tars, and with additional maintenance requirements than designed. Onsite technical/engineering assistance was continuously needed.

Schematic diagram of woody biomass based steam power plant



B. Biomass Supply Chain Technical Approach

The U.S. Forest Service has and is currently pursuing timberland improvement programs in the National Forests in Missouri – including the Mark Twain National Forest – which has extensive landholdings in the subject region. The establishment of a supply chain to feed the biomass power plant will provide the local landowners and the Forest Service a market for the woody biomass from these improvement efforts, in addition to recovery of the biomass from normal forest harvesting activities. The amount of sustainable woody biomass in the region appears more than sufficient to supply the amount required for the plant size under consideration.

The region (and this project) is fortunate to have the participation of Master Forester Shannon Jarvis – a recognized leader in sustainable forestry management. Mr. Jarvis, in cooperation with the Missouri Forest Products Association, will work to facilitate participation of existing forest product companies in the supply chain. In addition, new ventures may be formed specifically to serve the woody biomass supply chain. He holds a Master Logger Certification (http://www.moforest.org/MLC/MLCProgram.html) enabling him to utilize ecologically sound harvest practices, in concord with the Best Practices of sustainable timberland harvesting.

Mr. Jarvis has committed to ensure that the woody biomass feedstock supply will be accomplished in a sustainable manner to improve and maintain forest health and vitality while providing the level of supply appropriate for the planned plant size. Mr. Jarvis will also work with Pro-Energy to facilitate acquisition of biomass harvesting equipment, much of which is already in the region. Additional chippers may be required.

Sustainable forestry management provides adequate spacing between trees to allow optimum growth and health, producing high quality lumber. The trees that do not provide adequate spacing or are unhealthy, or growing in a manner not able to yield quality lumber, are selectively harvested. Adequate woody residues are left to prevent erosion and provide wildlife habitat. Studies have shown that forests in sustainable forestry management increase timber and woody biomass yields while increasing the quality of the timber.

Supply Chain Equipment [12]

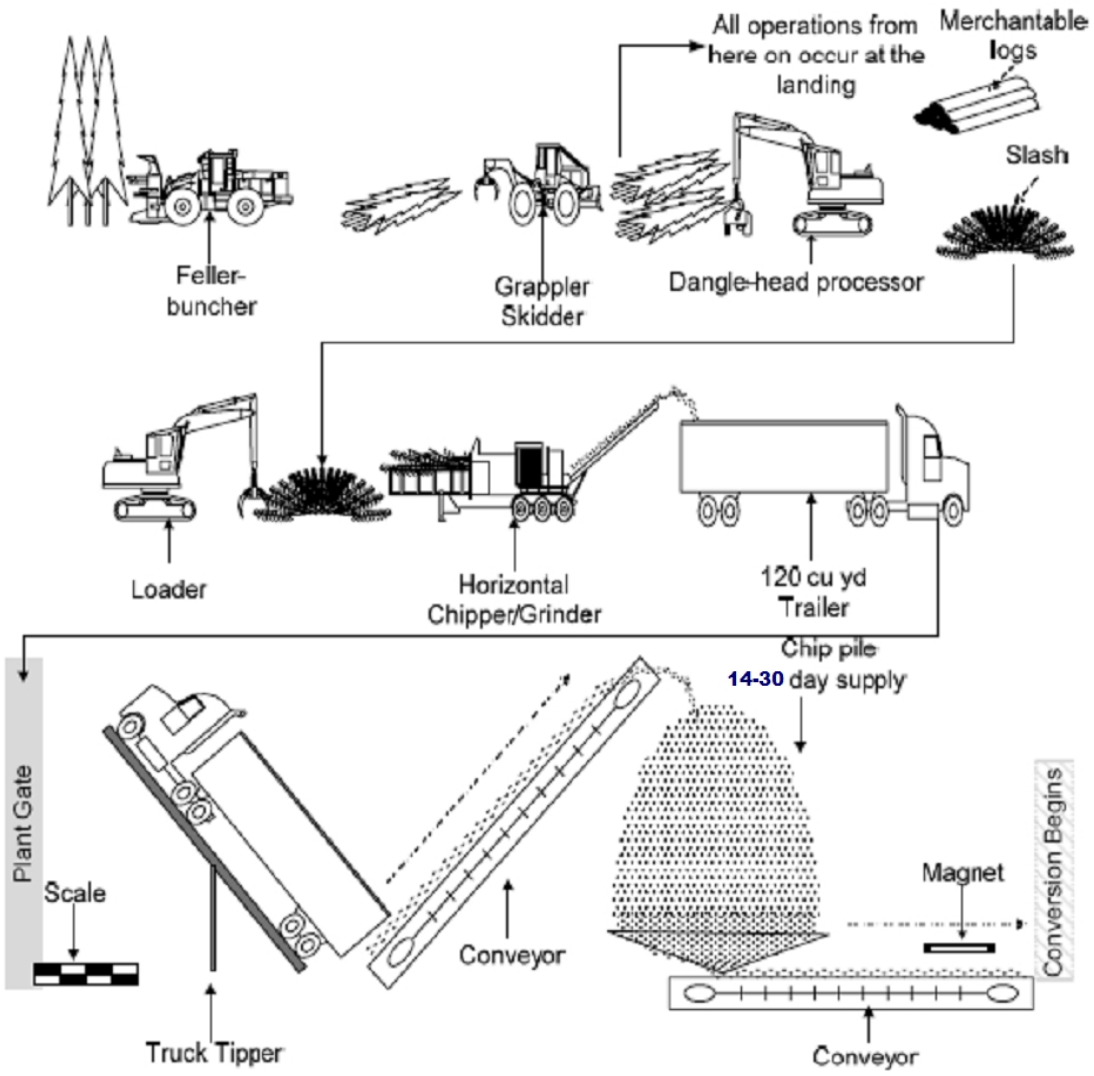
It is assumed the biomass supply chain will be organized as a separate entity or entities (not owned by the power plant owner). In addition to chip trailers and trucks, the following equipment will be needed for biomass harvest and transportation:

Description	Example	Price Range (New Condition)
Wood chippers/grinders	Morbark Model 30	$295,000 - $350,000
Feller Bunchers	HydroAx 411	$125,000 - $195,000
Skids/Loaders	Timberjack 450B	$125,000 - $175,000

Some equipment is already owned/leased and in use by existing logging operations. Additional equipment needed can be purchased or leased from commercial sellers. The estimated cost for equipping a biomass supply chain to feed a power plant in the size range under consideration is about $6 million.

Biomass Supply at Powerplant

The normal recommendation for the woody biomass supply for the powerplant is 14 days[12]; however, due to recent bad weather events in the region (derechos, ice storms, etc.), and the impact it had on transportation , the surge supply to 30 days may be prudent during potential bad weather periods.



Supply System – Woody Biomass [12]

C. Plant Size and Equipment Needs

Size

Based on growing demand for power and an assumed market for any (reasonable) quantity of available power, the key factors in determining plant size are 1) quantity of available biomass, and 2) economic feasibility based on revenue, capital requirements, and operating costs.

As described in Section C, Raw Material Availability, it is estimated the available woody biomass within the region can sustainably support a 4-20 mW plant, depending on the level of participation of landowners. The Financial Analysis section demonstrates that plants at the upper end of the range are more economically viable.

Equipment

VEDAC has engaged Pro-Energy Services to assist in evaluating costs and other factors for the plant. Sedalia, Missouri based Pro-Energy Services (http://www.proenergyservices.com/missouri/html) was founded in 2002 in response to a growing need within the energy industry for cost-effective, safe, reliable power plant construction, operation and maintenance. The company has grown to more than 1,000 employees, and along with its Sedalia headquarters, has U.S. offices in Houston, TX, Tulsa, OK, Fort Collins, CO; and international offices in Mexico, Venezuela, Argentina, Ghana, Pakistan, Panama and Brazil. Besides construction, management/operation and maintenance of energy generation facilities and equipment, the company serves a variety of manufacturers, with a niche in the ethanol industry.

Pro-Energy was involved in an earlier evaluation of a potential biomass plant in the region related to a planned expansion by the Doe Run Company. They have indicated intent to be fully involved in the VEDAC project, including obtaining funding, arranging for construction, operation and maintenance of the biomass plant.

Figure 7 - Woody Biomass Power Plant (Pro Energy)

Power Plant Equipment

The basic equipment/facility requirements for the proposed plant using combustion/steam boiler technology are:

- Woody biomass boiler
- Steam turbine electrical generator
- Feedstock material handling system
- Electrical transformer, substation and controls
- Cooling water system
- Woody biomass feedstock yard
- Woody biomass unloading/transfer system

The Power Plant equipment will be selected by Pro-Energy (or other commercial developer/manager) based on their expertise in electrical power plants, the mW rating, local conditions, and other technical considerations. Pro-Energy is proposing to build and operate the plant, and has provided limited data to maintain its competitive position. Their proposal is based on return of their investment through the sale of the electrical power generated.

Environmental and Community Considerations

A. Location and infrastructure

Factors considered in selecting a site were: location of potential customer(s), central proximity to available biomass feedstock, transportation accessibility, access to electric transmission lines/facilities, water supply and labor force. Four potential sites were considered for the plant:

1. In Iron County near the city of Viburnum – provides the best options for electrical power grid connections (Ameren UE, Associated Electric, Black River).
2. Proposed "Taum Sauk 2" site on Church Mountain – recently under consideration by Ameren, but has been removed from current plans.
3. The Doe Run Glover site – previously evaluated by Doe Run and Pro-Energy as a potential site for a woody biomass power plant during evaluation of a planned expansion by the company. The company chose a different site for expansion.
4. The Doe Run Resource Recycling Division (RRD) site – this site could provide potential direct supply to an industrial customer.

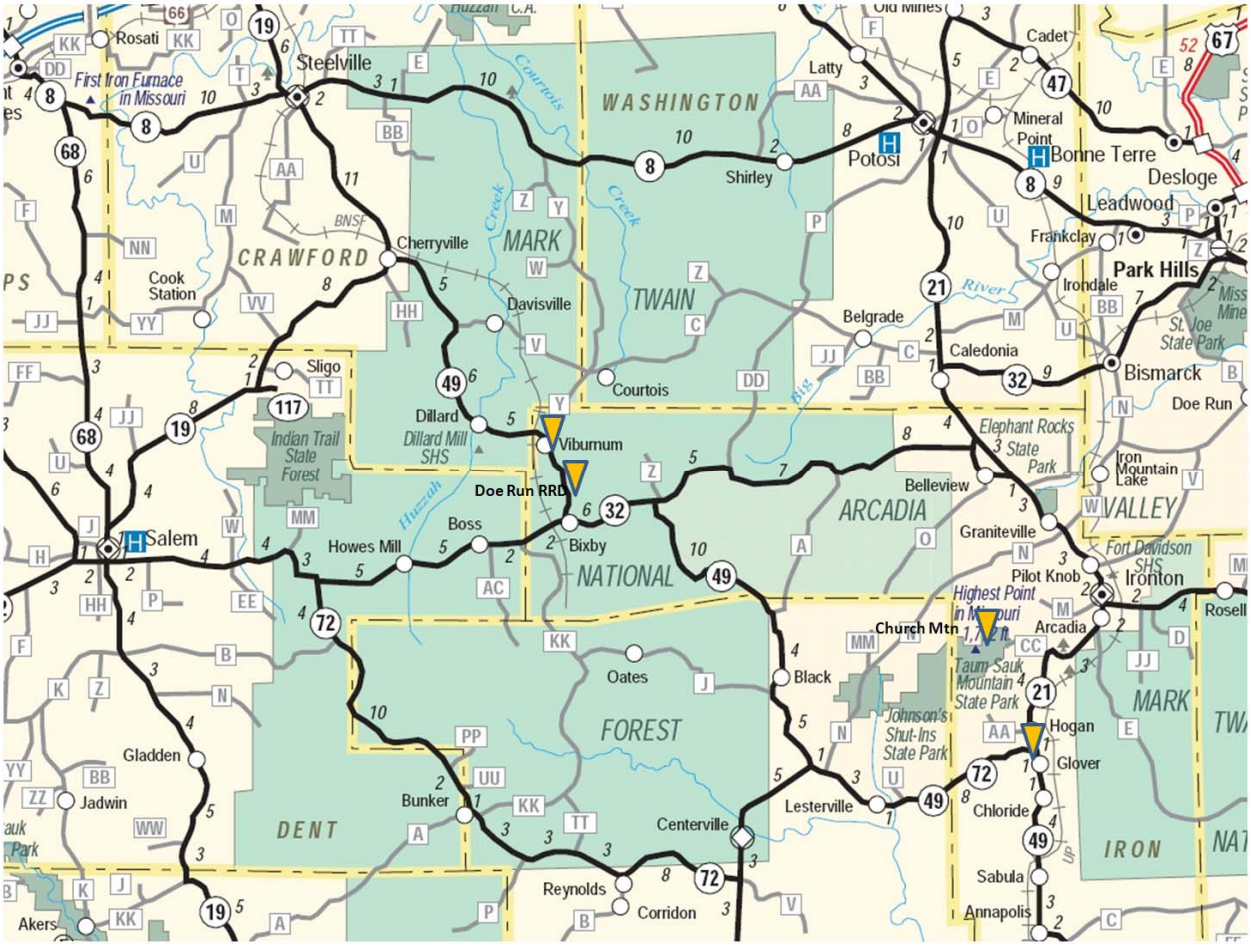


Figure 1- Location of Considered Sites

Location of potential customers and electric transmission lines/facilities

Locating a plant next to the Doe Run Glover or RRD site may present an opportunity to sell power directly to the area's most power-intensive industrial customer (The Doe Run Company). With the consideration of other electric power providers as potential customers, the Viburnum site offers an advantage due to proximity of available power grid connections and a local consumer population, also giving advantage to the City of Viburnum and VEDAC in negotiating local electrical rates and fees.

Proximity to biomass feedstock

All four sites have adequate proximity to available biomass feedstock, as described in the Raw Material Availability section of this report. All sites have adequate space for woody biomass storage (up to 30 days).

Transportation infrastructure and accessibility

All sites under consideration have adequate transportation infrastructure and accessibility. The region is home to existing heavy industries, so area highways are currently being used by commercial trucks on a daily basis. Because of existing forest harvesting and improvement operations, roads for accessing woody biomass are already established in the area. Railroad infrastructure is accessible, but the railroad assets have been abandoned for use. Local efforts are underway to revitalize the railroad assets, but are not being considered in this study.

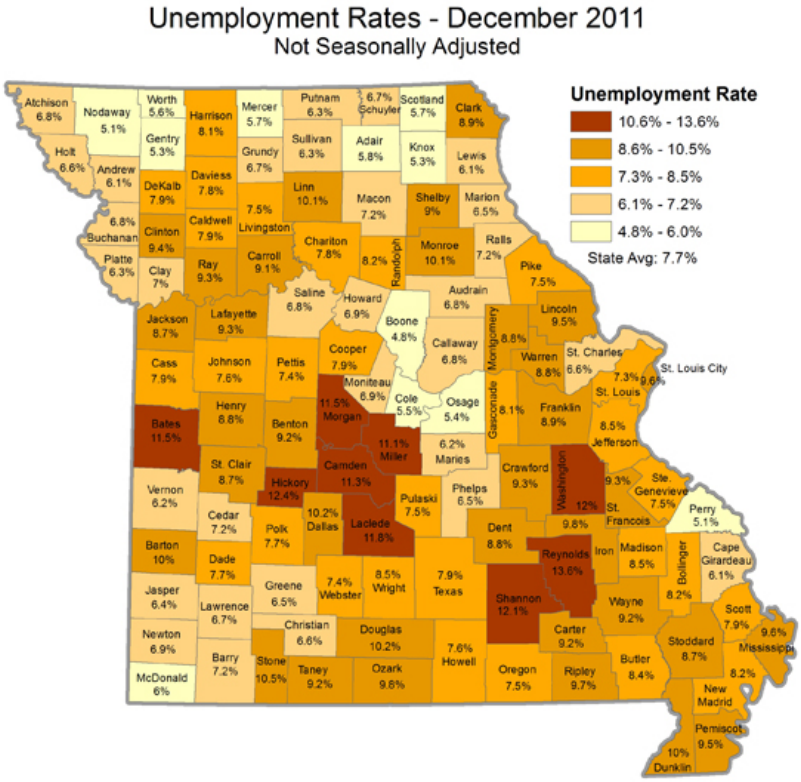
Water supply

Water is readily available in the region. Besides the above ground sources (lakes, ponds, streams, and rivers) enormous amount are available in the rock formations under the soil, and readily accessible by pump. Several mine shafts and mines from the past and current lead mining operations have considerable water resources. Active mines require continual pumping of water. Closed mines become quickly flooded when the pumps are turned off. Closed loop systems incorporating closed mines are feasible, along with using mine ponds. Diverting pumped water from active mines is also possible if a power plant is placed in economically feasible proximity.

Available labor force

The area has a high unemployment rate. As of December, 2011, Reynolds County had the highest unemployment rate in the state (see map from MERIC[13] on next page).

The table below provides employment data from the U.S. Census Bureau for the VEDAC region compared to that for the state of Missouri, with differences of more than 3% highlighted. In the VEDAC region about 7% more than the state average work in natural resources, construction and maintenance occupations; and almost 10% more than the state average work in production, transportation and material moving occupations. This corresponds to the higher percentages employed in the agriculture, forestry, fishing and hunting, and mining industries; and in construction and manufacturing industries.



VEDAC Employment Compared to State	VEDAC	Percent	Missouri %	Difference
OCCUPATION				
Civilian employed population 16 years and over	31,129			
Management, business, science, and arts occupations	6,415	20.6%	34.4%	-13.8%
Service occupations	5,946	19.1%	18.0%	1.1%
Sales and office occupations	6,748	21.7%	25.6%	-3.9%
Natural resources, construction, and maintenance	4,861	15.6%	8.8%	6.8%
Production, transportation, and material moving	7,159	23.0%	13.2%	9.8%
INDUSTRY				
Civilian employed population 16 years and over	31,129			
Agriculture, forestry, fishing and hunting, and mining	2,085	6.7%	1.7%	5.0%
Construction	2,802	9.0%	5.9%	3.1%
Manufacturing	5,930	19.0%	11.3%	7.7%
Wholesale trade	794	2.6%	2.9%	-0.3%
Retail trade	4,085	13.1%	12.1%	1.0%
Transportation and warehousing, and utilities	1,442	4.6%	5.1%	-0.5%
Information	251	0.8%	2.3%	-1.5%
Finance and insurance, and real estate and rental and	918	2.9%	7.0%	-4.0%
Professional, scientific, and management, and	1,289	4.1%	8.8%	-4.7%
Educational services, and health care and social	6,951	22.3%	24.2%	-1.8%
Arts, entertainment, and recreation, and accommodation	1,768	5.7%	9.1%	-3.4%
Other services, except public administration	1,251	4.0%	4.7%	-0.7%
Public administration	1,563	5.0%	4.9%	0.2%
CLASS OF WORKER				
Civilian employed population 16 years and over	31,129			
Private wage and salary workers	24,049	77.3%	80.2%	-3.0%
Government workers	4,533	14.6%	13.6%	1.0%
Self-employed in own not incorporated business workers	2,500	8.0%	6.1%	2.0%
Unpaid family workers	47	0.2%	0.1%	0.0%

Source: U.S. 2010 Census Data

The following Census data table compares income the VEDAC region population to the state of Missouri. The differences highlight significantly lower median household income and median earnings for full-time workers in the region, and a higher percentage of income from Social Security and retirement.

VEDAC Income Compared to State	VEDAC	Percent	Missouri %	Difference
Total households	31,826			
Less than $10,000	3,381	10.6%	8.5%	2.2%
$10,000 to $14,999	2,871	9.0%	6.5%	2.5%
$15,000 to $24,999	4,974	15.6%	12.8%	2.8%
$25,000 to $34,999	4,928	15.5%	11.8%	3.7%
$35,000 to $49,999	5,419	17.0%	15.5%	1.6%
$50,000 to $74,999	5,727	18.0%	18.6%	-0.6%
$75,000 to $99,999	2,662	8.4%	11.1%	-2.7%
$100,000 to $149,999	1,424	4.5%	10.0%	-5.5%
$150,000 to $199,999	282	0.9%	2.7%	-1.8%
$200,000 or more	158	0.5%	2.5%	-2.0%
Median household income (dollars)	33,677			-24.0%
With earnings	22,040	69.3%	77.2%	-7.9%
With Social Security	12,139	38.1%	30.5%	7.6%
With retirement income	7,769	24.4%	18.1%	6.3%
With Supplemental Security Income	2,440	7.7%	5.1%	2.5%
With cash public assistance income	887	2.8%	2.4%	0.4%
With Food Stamp/SNAP benefits in the past 12 months	5,634	17.7%	13.3%	4.4%
Median earnings for male full-time, year-round workers		35,617	42,282	-15.8%
Median earnings for female full-time, year-round workers		25,121	32,481	-22.7%

Source: U.S. 2010 Census Data

Personnel Training:
Training will be required for several of the positions. Biomass Harvesting Training will be provided by the Missouri Forest Products Association and/or Missouri. Three Rivers Community College (Popular Bluff) and Mineral Area Community College (Park Hills) can provide locations and/or workforce training for employees. Due to the new jobs in an economically depressed region, job training subsidiaries should be available.

B. Permits and Environmental Protection Measures

The permit application process must be initiated in the early stages of project start-up. The following permits/requirements will be needed for construction and operation:

- Permit to Construct
- Permit for Emissions (Operating and Emission)
- Haul Roads specifications and limitations
- Cooling Tower – Specifications, Operating Limits, and Emission Limits
    - Total Dissolved Solids (TDS)
    - Cooling water circulation rate limits
- Emergency Generator and Firewater Pump (Specifications, Operating Limits, Emission Limits)

At a minimum, the following environmental protection systems will be necessary:

- Continuous Emission Monitoring System (CEMS)/Continuous Opacity Monitoring System (COMS)
- Fabric filtration system (baghouse) for control of filterable particulate matter less than 10 microns in diameter
- Selective Non-Catalytic Reduction (SNCR) for control of nitrogen oxide (NOx) emissions
- Alkaline sorbent injection system for control of HCl emissions

The Pro-Energy proposal to Doe Run included all necessary systems to comply with emission and environmental permits.

Actual requirements for environmental protection measures at the power plant will be established by regulatory agencies based on final location, plant size and other factors. The threshold requirements previously established for the proposed LG Biomass plant to be located in Perryville, Missouri[14] are provided below as a general guide. (Plans for the Perryville plant are on hold at this time).

Water Quality	Not provided
Hydrogen Chloride (HCl)	10 tons/12 mo
Organic Compounds	Not provided
Fluorides	Not provided
Carbon monoxide (CO)	51.4 lbs/hr
Particulate $Matter_{10}$	14.4 lb/hr
Particulate Matter condensable	8.16 lb/hr
Nitrogen Oxides (NOx)	54.7 lb/hr
Sulfur Dioxide (SO_2)	39.8 lb/hr
Mercury	Not provided
TCDD (2,3,4,8-tectrachlorodibenzo-p-dioxins)	0.232 lb/12 mo
Lead	Not provided
Sulfuric Acid Mist	Not provided
TDS – circulated cooling water	2551 ppm

The environmental aspects are typical for power plants. However, DNR will take in consideration local issues and concerns in their development of the specific requirements and limits.

The Doe Run Company, which has extensive knowledge in environmental requirements, constraints and considerations for the region, has indicated willingness to provide technical assistance to VEDAC and the power plant developer/manager for purposes of this project.

C. Community impact

Employment

The power plant and related biomass supply chain are expected to employ a total of 57-128 people. This will have a significant impact in a region that includes two counties with unemployment rates of more than 12%.

Local economic growth

Besides the creation of approximately 57-128 direct jobs, the project has the potential for economic growth as follows:

- 2nd and 3rd tier jobs in the associated service and supply industries
- Local tax revenue will likely increase due to increased property values, retail sales, and other tax revenue sources
- Development and operation of a woody biomass power plant may provide markets for other businesses to be started or expanded in the region, especially in the following sectors:
    - Equipment – dealers, parts, maintenance
    - Services – food, soft goods, hard goods
    - Education – Personnel training (power plant, biomass supply chain, secondary occupations)
    - Timber Industry – the sustainable woody biomass supply chain will produce higher quality timber stock in increased volumes
    - Other Industries – locally generated power and increased economic development resources may help attract other industries to the region

Community Concerns

Local governments, businesses and industries (especially The Doe Run Company) are supportive of the project. Discussions with community members and residents in the VEDAC region did not reveal any adverse concerns regarding the plant. All logging and sawmill operators contacted expressed a positive position for the project once the benefits had been explained.

As the project progresses and becomes more public, it may become the target of groups in active opposition to woody biomass power plants. As of the date of this study, no such group has contacted any personnel involved with the project.

Financial Analysis

This section provides Financial Analysis of a proposed Woody Biomass Electrical Power Plant. There are four parts to each analysis (as applicable) based on 4mW, 8 mW, 15mW, and 20 mW power plant. The best case is the 20 mW plant, the worst case is the 4 mW plant, and the most likely is the 8 mW plant.

Financial Summary	**4mW**	**8mW**	**15mW**	**20mW**
	Yr 1	Yr 1	Yr 1	Yr 1
Capital Assets	16,500,000	32,424,000	52,525,276	70,033,701
Capitalized Interest	333,188	600,116	957,647	1,286,257
Year 0 Operating Expenses	290,000	290,000	290,000	290,000
Total Cash Needs for Start-up	17,123,188	33,314,116	53,772,923	71,609,958
Debt Financing	12,842,391	24,985,587	40,329,692	53,707,469
Equity Financing	4,280,797	8,328,529	13,443,231	17,902,490
Income				
Sales of Electricity	3,332,000	6,664,000	12,495,000	16,660,000
RETC	660,480	1,320,960	2,476,800	3,302,400
REC	300,000	600,000	1,125,000	1,500,000
Total Income	4,292,480	8,584,960	16,096,800	21,462,400
CGS and Operating Expenses				
Woody Biomass Feedstock	1,596,000	3,192,000	5,985,000	7,980,000
Labor	1,560,000	1,560,000	1,560,000	1,560,000
Variable O&M	20,000	40,000	75,000	100,000
Fixed O&M	402,000	804,000	1,507,500	2,010,000
Total Operating Expenses	3,578,000	5,596,000	9,127,500	11,650,000
EBITDA	714,480	2,988,960	6,969,300	9,812,400
Debt Servicing (P&I)*	1,241,489	2,415,386	3,898,719	5,191,965
Cash flow before taxes	(527,009)	573,574	3,070,581	4,620,435
Biomass cost per kwh	0.048	0.048	0.048	0.048
Operating cost per kwh	0.059	0.036	0.025	0.022
(Cash) Cost per kwh	0.107	0.084	0.073	0.070
Assumptions				
Number kwh:	33,320,000	66,640,000	124,950,000	166,600,000
Selling price per kwh:	$ 0.10	$ 0.10	$ 0.10	$ 0.10
# tons biomass per mWh	13,300	13,300	13,300	13,300
# tons biomass required	53,200	106,400	199,500	266,000
Biomass price/ton, delivered:	$ 30.00	$ 30.00	$ 30.00	$ 30.00
# plant employees:	30	30	30	30
# biomass jobs:	27	48	78	98
Debt Financing				
% of capital costs	75%	75%	75%	75%
Interest rate	7.5%	7.5%	7.5%	7.5%
# years	20	20	20	20
Annual payments (P&I)	$1,241,489	$2,415,386	$3,898,719	$5,191,965

* Interest during construction is capitalized and included in total cash needs for start-up

A. Key Assumptions

The key assumptions to these financial analyses are as follows:

Capital investment – the cost of the plant (land, building, equipment) was estimated based on the costs of other biomass plants, including the proposed Perryville plant. The estimates range from $16.5 million for a 4mW plant, up to $70 million at the 20mW level.

Financing – the commercial entity will be responsible for financing the plant. For analysis purposes, it is assumed 75% of the costs will be financed at 7.5% over 20 years.

Total generation (kwh for sale) – assumed 83.3% uptime based on planned/unplanned maintenance and 300 operating days.

Sales price per kwh – assumed $0.10 based on a recent proposal from Pro Energy to Doe Run and the assumption used in the Missouri Forest Products study. Consumer prices in the area currently range from $0.072 to $0.0966. A sales price per kwh below $0.08 (holding all other variables constant) would not be economically feasible.

Renewable Energy Credits and Tax Credits (REC and RETC) – Renewable Energy Certificates (RECs), are tradable, non-tangible energy commodities in the United States that represent proof that 1 megawatt-hour (MWh) of electricity was generated from an eligible renewable energy resource. Current markets for REC are mixed, but SRECs (Solar REC) trade at $35-284 per SREC (2012).

Federal Renewable Energy Production Tax Credits (RETC) are based on Section 1101 of the American Recovery and Reinvestment Act (ARRA). Current expectations are that the provisions will be extended.

GT biomass per mW – assumed the 13,300 figure from the National Association of State Foresters (NASF)[7] source (see previous discussion in the Raw Material Availability section.)

Cost per delivered ton of biomass – assumed $30 based on estimate in the Missouri Forest Products study[2], and based on a range of $25-$40 for locations outside of Missouri.

Plant labor costs – assumed 30 employees at an average cost of $25/hr (including benefits)

Fixed and variable operating and maintenance (O&M) costs – used 15% and 0.8% of electricity sales based on steam plant operating experience.

Plant/equipment depreciation method – used straight line over 20 years.

Incentives – Potential state or local financial incentives or programs were not included in the financial assumptions.

Financial and Data

The following pages provide start-up cash, profit and loss, cash flow, balance sheet, breakeven and ratio analysis for each of four potential sizes (4, 8, 15 and 20mW).

Sales Forecast (not-escalated)

	Year 1	Year 2	Year 3 & following
4 mW	-0-	$3,302,400	$3,302,400
8 mW	-0-	$6,604,800	$6,604,800
15 mW	-0-	$12,384,000	$12,384,000
20 mW	-0-	$16,512,000	$16,512,000

Personnel

Personnel Needs	4 mW	8 mW	15 mW	20 mW
Woody Biomass Supply Chain	27	48	78	98
Electrical Power Plant	30	30	30	30
Total Personnel	57	78	108	128
Woody Biomass Skill Trades (estimated)				
Feller (4 man crew per 2mW)[1]	8	16	30	40
Skid Operators	3	6	10	12
Chipper Operators	3	6	10	12
Loader Operators	3	6	10	12
Truck Drivers	3	6	10	12
Supervisor/Forester	2	2	2	4
Management	3	4	4	4
Accounting/Finance	2	2	2	2
	27	48	78	98
Electrical Power Plant Trades				
Boiler Operators	8	8	8	8
Electricians	4	4	4	4
Laborers	4	4	4	4
Equipment Operators	6	6	6	6
Supervisors	4	4	4	4
Management	2	2	2	2
Accounting/Finance	2	2	2	2
	30	30	30	30

Start-Up Cash Flow:

4mW Start-up Cash

Month	Description	Inflows	Acquisitions & Labor	Interest to Capitalize	Balance
Equity investment		4,280,797			4,280,797
1	Land acquisition		274,167		4,006,630
2	Site prep		524,167		3,482,464
3	Building		924,167		2,558,297
4	Building		924,167		1,634,130
5	Building		924,167		709,964
6	Building	215,550	924,167	1,347	(0)
7	Building	931,335	924,167	7,168	0
8	Equipment	3,805,117	3,774,167	30,950	0
9	Equipment	3,829,048	3,774,167	54,882	0
10	Equipment	3,853,130	3,774,167	78,964	(0)
11	Testing and training	103,779	24,167	79,612	0
12	Testing and training	104,432	24,167	80,265	0
		17,123,188	16,790,000	333,188	
			Total outflows	17,123,188	
			Equity required	4,280,797	

8mW Start-up Cash

Month	Description	Inflows	Acquisitions & Labor	Interest to Capitalize	Balance
Equity investment		8,328,529			8,328,529
1	Land acquisition		274,167		8,054,362
2	Site prep		524,167		7,530,196
3	Building		924,167		6,606,029
4	Building		924,167		5,681,862
5	Building		924,167		4,757,696
6	Building		924,167		3,833,529
7	Building		924,167		2,909,362
8	Equipment	6,211,627	9,082,167	38,823	(0)
9	Equipment	9,178,354	9,082,167	96,187	(0)
10	Equipment	9,236,080	9,082,167	153,913	0
11	Testing and training	179,199	24,167	155,033	(0)
12	Testing and training	180,327	24,167	156,160	0
		33,314,116	32,714,000	600,116	
			Total outflows	33,314,116	
			Equity required	8,328,529	

15mW Start-up Cash

Month	Description	Inflows	Acquisitions & Labor	Interest to Capitalize	Balance
Equity investment		13,443,231			13,443,231
1	Land acquisition		274,167		13,169,064
2	Site prep		524,167		12,644,898
3	Building		1,224,167		11,420,731
4	Building		1,224,167		10,196,564
5	Building		1,224,167		8,972,398
6	Building		1,224,167		7,748,231
7	Building		1,224,167		6,524,064
8	Equipment	8,813,613	15,282,592	55,085	0
9	Equipment	15,434,140	15,282,592	151,548	(0)
10	Equipment	15,531,211	15,282,592	248,619	0
11	Testing and training	274,501	24,167	250,334	0
12	Testing and training	276,227	24,167	252,061	0
		53,772,923	52,815,276	957,647	
			Total outflows	53,772,923	
			Equity required	13,443,231	

20mW Start-up Cash

Month	Description	Inflows	Acquisitions & Labor	Interest to Capitalize	Balance
Equity investment		17,902,490			17,902,490
1	Land acquisition		274,167		17,628,323
2	Site prep		524,167		17,104,157
3	Building		2,024,167		15,079,990
4	Building		2,024,167		13,055,823
5	Building		2,024,167		11,031,657
6	Building		2,024,167		9,007,490
7	Building		2,024,167		6,983,323
8	Equipment	12,882,593	19,785,400	80,516	(0)
9	Equipment	19,990,860	19,785,400	205,459	0
10	Equipment	20,116,588	19,785,400	331,188	0
11	Testing and training	357,589	24,167	333,423	(0)
12	Testing and training	359,838	24,167	335,672	(0)
		71,609,958	70,323,701	1,286,257	
			Total outflows	71,609,958	
			Equity required	17,902,490	

Financial Analysis – Profit/Loss, Balance Sheet, Ratios

4mW	Year 1	Year 2	Year 3	Year 4	Year 5
Profit/Loss					
Income					
Electricity Sales	3,332,000	3,332,000	3,332,000	3,332,000	3,332,000
RETC	660,480	660,480	660,480	660,480	660,480
REC	300,000	300,000	300,000	300,000	300,000
Total Income	4,292,480	4,292,480	4,292,480	4,292,480	4,292,480
Cost of Goods Sold					
Biomass	1,596,000	1,596,000	1,596,000	1,596,000	1,596,000
Labor	1,560,000	1,560,000	1,560,000	1,560,000	1,560,000
Total Cost of Goods Sold	3,156,000	3,156,000	3,156,000	3,156,000	3,156,000
Gross Margin	1,136,480	1,136,480	1,136,480	1,136,480	1,136,480
Operating Expenses					
Fixed O&M	402,000	402,000	402,000	402,000	402,000
Variable O&M	20,000	20,000	20,000	20,000	20,000
Interest	953,410	931,046	906,945	880,974	852,986
Depreciation	679,159	679,159	679,159	679,159	679,159
Total Operating Expenses	2,054,570	2,032,205	2,008,105	1,982,133	1,954,146
Income Before Taxes	(918,090)	(895,725)	(871,625)	(845,653)	(817,666)
Net Cash Flow	(527,009)	(527,009)	(527,009)	(527,009)	(527,009)
Net cost per kwh	0.156	0.156	0.155	0.154	0.153
Breakeven price per kwh*	0.128	0.127	0.126	0.125	0.125
Breakeven cost of biomass*	12.74	13.16	13.62	14.10	14.63
*Holding all other variables constant					
Balance Sheet					
Cash	0	(0)	0	0	0
Property, Plant & Equipment	16,833,188	16,833,188	16,833,188	16,833,188	16,833,188
Less Accum. Depreciation	(679,159)	(1,358,319)	(2,037,478)	(2,716,638)	(3,395,797)
PPE Net	16,154,028	15,474,869	14,795,709	14,116,550	13,437,391
Total Assets	16,154,029	15,474,869	14,795,709	14,116,550	13,437,391
Line of Credit	527,009	1,054,018	1,581,027	2,108,036	2,635,045
Notes Payable, Current Portion	310,443	334,544	360,515	388,503	418,663
Long-term Notes Payable	12,243,869	11,909,325	11,548,810	11,160,307	10,741,645
Total Liabilities	13,081,321	13,297,887	13,490,352	13,656,846	13,795,353
Owner Investment	4,280,797	4,280,797	4,280,797	4,280,797	4,280,797
Retained Earnings	(1,208,090)	(2,103,815)	(2,975,440)	(3,821,093)	(4,638,759)
Total Equity	3,072,707	2,176,982	1,305,357	459,704	(357,962)
Total Liabilities and Equity	16,154,028	15,474,869	14,795,709	14,116,550	13,437,391
Ratio analysis					
Current Ratio	-	-	-	-	-
Debt-Equity	4.26	6.11	10.33	29.71	(38.54)
Return on Assets	-5.68%	-5.79%	-5.89%	-5.99%	-6.09%
Net Profit Margin	-21.39%	-20.87%	-20.31%	-19.70%	-19.05%
Net present value of cash flow from first 5 years in operation (10% discount rate):				($1,997,779)	

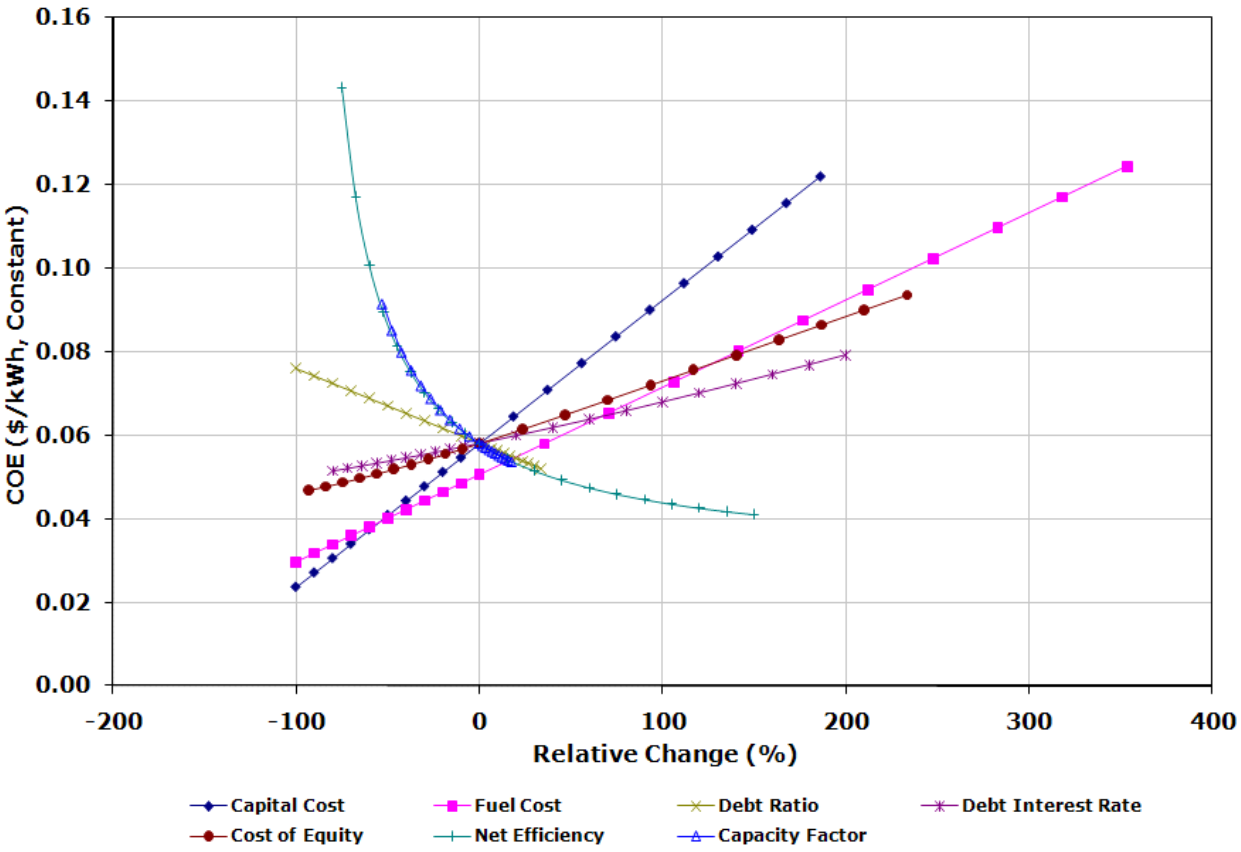
8mW	Year 1	Year 2	Year 3	Year 4	Year 5
Profit/Loss					
Income					
Electricity Sales	6,664,000	6,664,000	6,664,000	6,664,000	6,664,000
RETC	1,320,960	1,320,960	1,320,960	1,320,960	1,320,960
REC	600,000	600,000	600,000	600,000	600,000
Total Income	8,584,960	8,584,960	8,584,960	8,584,960	8,584,960
Cost of Goods Sold					
Biomass	3,192,000	3,192,000	3,192,000	3,192,000	3,192,000
Labor	1,560,000	1,560,000	1,560,000	1,560,000	1,560,000
Total Cost of Goods Sold	4,752,000	4,752,000	4,752,000	4,752,000	4,752,000
Gross Margin	3,832,960	3,832,960	3,832,960	3,832,960	3,832,960
Operating Expenses					
Fixed O&M	804,000	804,000	804,000	804,000	804,000
Variable O&M	40,000	40,000	40,000	40,000	40,000
Interest	1,854,913	1,811,402	1,764,513	1,713,984	1,659,532
Depreciation	1,458,700	1,458,700	1,458,700	1,458,700	1,458,700
Total Operating Expenses	4,157,613	4,114,102	4,067,213	4,016,684	3,962,232
Income Before Taxes	(324,653)	(281,142)	(234,253)	(183,724)	(129,272)
Net Cash Flow	573,574	573,574	573,574	573,574	573,574
Net cost per kwh	0.134	0.133	0.132	0.132	0.131
Breakeven price per kwh	0.105	0.104	0.104	0.103	0.102
Breakeven cost of biomas	26.95	27.36	27.80	28.27	28.79
Balance Sheet					
Cash	573,574	1,147,148	1,720,722	2,294,295	2,867,869
Property, Plant & Equipment	33,024,116	33,024,116	33,024,116	33,024,116	33,024,116
Less Accum. Depreciation	(1,458,700)	(2,917,400)	(4,376,100)	(5,834,800)	(7,293,500)
PPE Net	31,565,416	30,106,716	28,648,016	27,189,316	25,730,616
Total Assets	32,138,990	31,253,864	30,368,737	29,483,611	28,598,485
Line of Credit	-	-	-	-	-
Notes Payable, Current Portion	603,984	650,873	701,402	755,854	814,533
Long-term Notes Payable	23,821,129	23,170,256	22,468,853	21,712,999	20,898,466
Total Liabilities	24,425,113	23,821,129	23,170,256	22,468,853	21,712,999
Owner Investment	8,328,529	8,328,529	8,328,529	8,328,529	8,328,529
Retained Earnings	(614,653)	(895,795)	(1,130,047)	(1,313,771)	(1,443,044)
Total Equity	7,713,876	7,432,734	7,198,481	7,014,758	6,885,485
Total Liabilities and Equity	32,138,989	31,253,863	30,368,737	29,483,611	28,598,485
Ratio analysis					
Current Ratio	0.95	1.76	2.45	3.04	3.52
Debt-Equity	3.17	3.20	3.22	3.20	3.15
Return on Assets	-1.01%	-0.90%	-0.77%	-0.62%	-0.45%
Net Profit Margin	-3.78%	-3.27%	-2.73%	-2.14%	-1.51%
Net present value of cash flow from first 5 years in operation (10% discount rate):				$2,174,296	

15mW

	Year 1	Year 2	Year 3	Year 4	Year 5
Profit/Loss					
Income					
Electricity Sales	12,495,000	12,495,000	12,495,000	12,495,000	12,495,000
RETC	2,476,800	2,476,800	2,476,800	2,476,800	2,476,800
REC	1,125,000	1,125,000	1,125,000	1,125,000	1,125,000
Total Income	16,096,800	16,096,800	16,096,800	16,096,800	16,096,800
Cost of Goods Sold					
Biomass	5,985,000	5,985,000	5,985,000	5,985,000	5,985,000
Labor	1,560,000	1,560,000	1,560,000	1,560,000	1,560,000
Total Cost of Goods Sold	7,545,000	7,545,000	7,545,000	7,545,000	7,545,000
Gross Margin	8,551,800	8,551,800	8,551,800	8,551,800	8,551,800
Operating Expenses					
Fixed O&M	1,507,500	1,507,500	1,507,500	1,507,500	1,507,500
Variable O&M	75,000	75,000	75,000	75,000	75,000
Interest	2,994,049	2,923,817	2,848,133	2,766,573	2,678,681
Depreciation	2,463,764	2,463,764	2,463,764	2,463,764	2,463,764
Total Operating Expenses	7,040,312	6,970,081	6,894,396	6,812,837	6,724,945
Income Before Taxes	1,511,488	1,581,719	1,657,404	1,738,963	1,826,855
Net Cash Flow	3,070,581	3,070,581	3,070,581	3,070,581	3,070,581
Net cost per kwh	0.117	0.116	0.116	0.115	0.114
Breakeven price per kwh	0.088	0.087	0.087	0.086	0.085
Breakeven cost of biomass	37.58	37.93	38.31	38.72	39.16
Balance Sheet					
Cash	3,070,581	6,141,162	9,211,743	12,282,324	15,352,905
Property, Plant & Equipment	53,482,923	53,482,923	53,482,923	53,482,923	53,482,923
Less Accum. Depreciation	(2,463,764)	(4,927,528)	(7,391,291)	(9,855,055)	(12,318,819)
PPE Net	51,019,159	48,555,395	46,091,631	43,627,868	41,164,104
Total Assets	54,089,740	54,696,557	55,303,374	55,910,192	56,517,009
Line of Credit	-	-	-	-	-
Notes Payable, Current Portion	3,893,677	3,792,888	3,684,274	3,567,228	3,441,095
Long-term Notes Payable	35,531,345	34,657,232	33,715,259	32,700,159	31,606,254
Total Liabilities	39,425,022	38,450,119	37,399,533	36,267,386	35,047,349
Owner Investment	13,443,231	13,443,231	13,443,231	13,443,231	13,443,231
Retained Earnings	1,221,488	2,803,207	4,460,611	6,199,574	8,026,429
Total Equity	14,664,718	16,246,438	17,903,841	19,642,805	21,469,660
Total Liabilities and Equity	54,089,740	54,696,557	55,303,374	55,910,191	56,517,009
Ratio analysis					
Current Ratio	0.79	1.62	2.50	3.44	4.46
Debt-Equity	2.69	2.37	2.09	1.85	1.63
Return on Assets	2.79%	2.89%	3.00%	3.11%	3.23%
Net Profit Margin	9.39%	9.83%	10.30%	10.80%	11.35%
Net present value of cash flow from first 5 years in operation (10% discount rate)				$11,639,918	

20mW	Year 1	Year 2	Year 3	Year 4	Year 5
Profit/Loss					
Income					
Electricity Sales	16,660,000	16,660,000	16,660,000	16,660,000	16,660,000
RETC	3,302,400	3,302,400	3,302,400	3,302,400	3,302,400
REC	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000
Total Income	21,462,400	21,462,400	21,462,400	21,462,400	21,462,400
Cost of Goods Sold					
Biomass	7,980,000	7,980,000	7,980,000	7,980,000	7,980,000
Labor	1,560,000	1,560,000	1,560,000	1,560,000	1,560,000
Total Cost of Goods Sold	9,540,000	9,540,000	9,540,000	9,540,000	9,540,000
Gross Margin	11,922,400	11,922,400	11,922,400	11,922,400	11,922,400
Operating Expenses					
Fixed O&M	2,010,000	2,010,000	2,010,000	2,010,000	2,010,000
Variable O&M	100,000	100,000	100,000	100,000	100,000
Interest	3,987,206	3,893,677	3,792,888	3,684,274	3,567,228
Depreciation	3,339,185	3,339,185	3,339,185	3,339,185	3,339,185
Total Operating Expenses	9,436,391	9,342,862	9,242,073	9,133,459	9,016,413
Income Before Taxes	2,486,009	2,579,538	2,680,327	2,788,941	2,905,987
Net Cash Flow	4,620,435	4,620,435	4,620,435	4,620,435	4,620,435
Net cost per kwh	0.114	0.113	0.113	0.112	0.111
Breakeven price per kwh	0.085	0.085	0.084	0.083	0.083
Breakeven cost of biomass	39.35	39.70	40.08	40.48	40.92
Balance Sheet					
Cash	4,620,435	9,240,871	13,861,306	18,481,742	23,102,177
Property, Plant & Equipment	71,319,958	71,319,958	71,319,958	71,319,958	71,319,958
Less Accum. Depreciation	(3,339,185)	(6,678,370)	(10,017,555)	(13,356,740)	(16,695,925)
PPE Net	67,980,773	64,641,588	61,302,403	57,963,218	54,624,033
Total Assets	72,601,209	73,882,459	75,163,710	76,444,960	77,726,210
Line of Credit	-	-	-	-	-
Notes Payable, Current Portion	1,298,288	1,399,077	1,507,691	1,624,737	1,750,869
Long-term Notes Payable	51,204,422	49,805,345	48,297,654	46,672,917	44,922,048
Total Liabilities	52,502,710	51,204,422	49,805,345	48,297,654	46,672,917
Owner Investment	17,902,490	17,902,490	17,902,490	17,902,490	17,902,490
Retained Earnings	2,196,009	4,775,547	7,455,875	10,244,816	13,150,803
Total Equity	20,098,499	22,678,037	25,358,364	28,147,306	31,053,293
Total Liabilities and Equity	72,601,209	73,882,459	75,163,710	76,444,960	77,726,210
Ratio analysis					
Current Ratio	3.56	6.60	9.19	11.38	13.19
Debt-Equity	2.61	2.26	1.96	1.72	1.50
Return on Assets	3.42%	3.49%	3.57%	3.65%	3.74%
Net Profit Margin	11.58%	12.02%	12.49%	12.99%	13.54%
Net present value of cash flow from first 5 years in operation (10% discount rate)				$17,515,086	

SENSITIVITY OF FACTORS AFFECTING COST OF ENERGY IN ELECTRICAL POWER PLANTS[15]
There are several factors in determining the cost model for an electrical power generation plant. Each of these factors have different impacts on the Cost of Electricity (COE), which is measured in $/kwh. The following diagram indicates the impact on the COE due to changes in each of the factors. The baseline for this diagram is a COE of $0.06/kWh.



SENSITIVITY DIAGRAM – 20 mW Power Plant – from Generic Biomass Power Plant Model[14]
The factors used in the financial analysis are current as of the published date. If these factors vary from those utilized in this report at the time of commencing the proposed project (or a different project), the use of the Sensitivity Diagram will allow determination of the impact of the variation on the COE.
This discussion is being incorporated into this report to allow the user to generalize the effect of these factors from the values used in this report for financial analysis of this or other electrical power plant installations.

Woody Biomass Harvesting Financial Analysis

This Financial Analysis is for the establishment of a Woody Biomass Harvesting/Timberland Improvement Program operation. One operation would have the capability of 144,760 green tons/year[3].

This analysis represents one Woody Biomass Harvesting operation. Depending on the size of the power plant, one or more operations may be needed, and the full capacity of the operations may not be reached. Other operations, such a Timberland Improvement and other timber harvesting operations may also be included.

This analysis provides the capital investment and operations of one operation.

Capital Investment	**Woody Biomass Harvesting**		
	Qty	Cost	Total
Chippers	6	$750,000	$4,500,000
Feller/Buncher (supplied by logger)	0		
Skidders	6	$150,000	$900,000
Project Management	1	$72,800	$72,800
Project Engineering	1	$75,000	$75,000
Misc. Freight for Equipment	1	$26,000	$26,000
Contingency	1	$500,000	$500,000
Office Equipment	1	$20,000	$20,000
Legal Start-up Cost	1	$20,000	$20,000
Total Capital Cost			$6,113,800

	Woody Biomass Harvesting				
Projected Income Statement	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Sales	$500,000	$4,200,000	$5,000,000	$5,400,000	$5,700,000
Govt Incentives	$80,000	$1,000,000	$750,000	$725,000	$725,000
Total Income	$580,000	$5,200,000	$5,750,000	$6,125,000	$6,425,000
Cost of Goods Sold					
Payment for Feedstock	$117,000	$1,000,000	$1,025,000	$1,050,000	$1,080,000
Fuel, Lube, Tires	$37,500	$315,000	$325,000	$335,000	$345,000
Shipping	$165,000	$1,200,000	$1,350,000	$1,350,000	$1,350,000
Equipment R&M	$0	$165,000	$175,000	$185,000	$190,000
Labor Benefits	$11,250	$98,997	$105,747	$107,997	$112,496
Processing Labor	$25,000	$220,000	$235,000	$240,000	$250,000
Total COG	$355,750	$2,998,997	$3,215,747	$3,267,997	$3,327,496
Gross Margin	$224,250	$2,201,003	$2,534,253	$2,857,003	$3,097,504
General and Administrative					
Administration/Management	$65,000	$255,000	$265,000	$275,000	$280,000
Process Engr Consultants	$65,000	$22,500	$22,500	$22,500	$22,500
Office - Storage - Utilities	$12,500	$75,000	$75,000	$75,000	$75,000
Insurance & Bonds	$25,000	$225,000	$150,000	$115,000	$100,000
Accounting/Legal	$6,000	$35,500	$36,000	$36,500	$37,000
Taxes - Licenses	$0	$60,000	$60,000	$60,000	$60,000
Logistics Consultant	$15,000	$80,000	$80,000	$80,000	$80,000
Supplies & Office Expenses	$15,000	$30,000	$30,000	$30,000	$30,000
Interest	$235,000	$500,000	$400,000	$300,000	$200,000
Depreciation	$0	$825,000	$810,000	$810,000	$810,000
Total G&A	$438,500	$2,108,000	$1,928,500	$1,804,000	$1,694,500
Net Profit (Loss) Pre-Tax	-$214,250	$93,003	$605,753	$1,053,003	$1,403,004

Conclusions and Recommendations

A. Conclusions

The market analysis indicates a growing statewide demand for electrical power, with concerns about the ability to meet demand due to retiring/obsolete power plants. Local demand includes mining-related activities which are power-intensive. Existing power suppliers and industries are interested in purchasing power generated from renewable sources, especially if renewable energy incentives become reality for Missouri. Power grid connections already exist in the region and may provide an advantage for this project.

This report demonstrates that the forest resources in the region can feasibly support a woody biomass electrical power plant up to 50 mW based on the USFS FIA data. Suitable locations, adequate labor resources, transportation infrastructure and water supplies are available.

The community and commercial partners for establishing a woody biomass electrical power plant have been involved in this study: VEDAC as the economic development facilitator, Pro Energy for development and operation of the power plant, and Jarvis Timber for development and coordination of the woody biomass supply chain.

The current key obstacle in this project is the identification and commitment of a customer or customers for the output of the power plant. While interest has been expressed by local industry, and the existing electric utilities have need for sources of renewable energy, no firm commitments have been secured. The favorable resolution of the Proposition C Renewable Energy regulations could spur heightened interest and a sense of urgency on the part of the existing utility providers.

B. Recommendations

Recommended next steps are:

- Pursue further discussion with potential purchasers of the electricity to determine terms and logistics of supplying them with power.
- Continue building the relationship with Pro Energy, and facilitate exploration of local/state/federal incentives for development of the plant.
- Continue discussions with Doe Run to explore opportunities for their direct and indirect involvement in development, purchasing electricity from, and providing biomass to the plant.
- Engage in additional dialogue with potential members of the biomass supply chain to determine how best to organize the supply chain, and develop an inventory of what equipment is already in use and/or available for use.
- Closely follow the developments of regulations for Proposition C and evaluate how they impact the viability of this project.

In preparation of this evaluation, VEDAC and its subcontractor, has relied upon publically available information and information supplied by technology providers. While VEDAC and its subcontractor have no reason to believe that the information provided, and upon which VEDAC and its subcontractor has relied, is inaccurate or incomplete in any material respect, VEDAC and its subcontractor has not independently verified such information and cannot guarantee its accuracy or completeness.

The information presented herein should serve as a foundation to enable a Missouri entity to determine the feasibility of a woody biomass electrical power plant for further evaluation, using referenced resources to provide additional supporting data.

References

REFERENCES

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2	Woody Biomass Technology Demonstration Project	Missouri Forest Products Association	1/1/2010	http://www.moforest.org	Missouri Forest Products Association
3	Woody Biomass Assessment Tool	University of Missouri	2012	http://projects.cares.missouri.edu/MoBAT/BioMass_V1.html	
4	2010 Directory of Primary Wood Processors	Missouri Forest Institute	2010		
5	Perryville Renewable Energy Center	LG Biomass Missouri LLC	11/18/2010		
6	FUEL VALUE & POWER CALCULATORS	State & Private Forestry Technology Marketing Unit	7/27/2009	http://www.fpl.fs.fed.us/documnts/techline/fuel-**value-calculator**.xls	USDA Forest Service
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8	Woody Biomass Utilization Desk Guide	National Forest Service	August 2007		National Forest Service
9	Market Assessment of Biomass Gasification and Combustion Technology for Small and Medium-Scale Applications	NREL	7/1/1905	http://www.nrel.gov/docs/fy09osti/46190.pdf	NREL
10	Major Projects – The McNeil Project	Brian Callnan		http://www.vppsa.com/includes/subpage.html?SKU=59	Vermont Public Power Supply Authority
11	Updraft Gasification: A Status on B&W Technology	Philip McKenzie, Business Development Manager,	5/3/2011	http://www.biomassconference.com/ema/DisplayPage.aspx?pageId=2011_Agenda	Babcock & Wilcox Company

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14	Permit to Construct - LG Biomass Missouri LLC	Missouri Department of Natural Resources	5/14/2010	Permit Number 052010-012	Missouri Department of Natural Resources
15	Generic Biomass Power Plant Model	UC-Davis Biomass	3/1/2008	http://biomass.ucdavis.edu/materials/calculator/EconCalculator_GenericPowerOnly.xls	UC- Davis