Do-It-Yourself Supply Curve: Tools to Help You Get Involved in an Entrepreneurial Woody Biomass Project

6.0 Introduction

The feasibility of woody biomass utilization projects depends, in part, on the cost and availability of the wood resources. Identifying and communicating the availability and cost of biomass in an area is often the first step in gaining interest in and support for a biomass project. One way to illustrate the economic availability of biomass resources is with a supply curve. This chapter introduces several tools that you can use to construct supply curves for woody biomass resources in your area of interest (AOI). These tools may be useful to potential suppliers and users of biomass or to communities considering using biomass.

A supply curve is a basic economic tool used to determine the price of a resource at a given quantity of demand. For example, Figure 1 illustrates a hypothetical woody biomass resource supply curve. In this example, a small amount of biomass (Quantity 1) is available at low cost (Price 1) in the form of urban wood waste. When this supply runs out, more biomass (Quantity 2) can be acquired in the form of logging residues, though at a higher price (Price 2). If logging residues are also not sufficient to meet the demand, even more biomass (Quantity 3) can be purchased from commercial timber suppliers, though it would be the most expensive (Price 3). Thus, a supply curve shows the price of biomass at various levels of demand. If enough biomass (the x-axis) can be delivered continuously at a low enough price (the y-axis) then enough wood

Figure 1: Hypothetical supply curve illustrating price at various levels of demand.
Important questions to ask when considering an entrepreneurial woody biomass project:

• Is there a market?
• What are the product specifications?
• Are there time and volume supply commitments and if so, can they be met?
• Are there storage constraints at the facility planning to use biomass?
• Are there loading and unloading constraints? Transportation challenges?
• Are there environmental factors related to certification programs such as the Forest Stewardship Council (FSC) or Sustainable Forestry Initiative (SFI) that must be considered?
• Is the operation expected to be profitable?

may be available to supply a bioenergy project. A more complete supply curve might include other available resources and account for transportation costs in ranking the economic availability of these resources of different types at different travel times.

The following sections provide you with various tools, that when used together, can help you construct a “preliminary” biomass supply curve for a particular AOI. Using these tools and this approach, it is possible to develop a preliminary supply curve in just a few hours. This process is valuable because it allows you to get an initial assessment of the economic availability of various biomass resources in an AOI. It also allows you to make comparisons between different AOIs, which is an important step in site selection for bioenergy projects. Some of the individual tools or steps in the process may be useful in evaluating biomass resources.

After a preliminary supply curve has been constructed, the actual supplies and costs can be verified by contacting local suppliers. During this process of verifying the preliminary supply analysis, do not be surprised to find that the actual supply of biomass resources is shown to be higher or lower than that shown in the preliminary analysis. This will likely be because local supply and cost conditions vary and because you may identify additional resources not included in the preliminary assessment.

These instructions are provided using Microsoft® Excel 2007, though the basic approach could be applied by other means. The preliminary process includes the following:

1. Identify a potential bioenergy facility location.
2. Survey quantities of locally available biomass resources.
3. Estimate costs of locally available biomass resources.
4. Rank resources from cheapest to most expensive.
5. Create the supply curve.

6.1 Tool 1: Using Google Earth to Identify a Potential Biomass Utilization Facility Location

You may be interested in identifying or may be asked to help identify a tentative location for a biomass utilization facility. Google Earth is a good tool to help you get start-
ed with this task. (If you do not have Google Earth on your computer, go to http://earth.google.com to download the free program.) Some tools in Google Earth that may be useful in helping you identify a facility location are highlighted in Figure 2. If you are doing this analysis for a specific project, your location may already be proposed. If not, here are a few concepts to keep in mind: the location should be close to the community or industry that needs energy, have good access to transportation such as highway or rail, be close to biomass resources, and not be placed in high-traffic areas. The location may be an existing energy facility. If this is just a rough analysis of resources in the area, you might simply select a point near the center of your AOI until more information is available.

6.2 Tool 2: Surveying Quantities of Locally Available Biomass

The next tool is a biomass supply calculator. This will help you gather information about what woody biomass resources are available near the proposed facility location, and how much of each resource is available at what price. This information is needed to evaluate the viability of a bioenergy project. The price should be expressed as the total delivered cost to the facility, meaning it will include purchase, harvest, process, and transportation costs.

The following sections show how to calculate supply in your region for: urban waste wood, logging residues, construction and demolition debris, and wood from forest thinning for improved forest health and wildfire mitigation.

Quantifying urban waste wood using U.S. census data

Urban wood waste, waste generated when trees growing in urban areas are pruned, blown down, or removed, is typically hauled away by tree servicing companies, which charge homeowners or utility companies to remove trees. Tree-hauling companies then pay about $20/green ton\(^1\) to dispose of this wood.

\(^1\)“Green” ton indicates that the weight includes both the wood and moisture content in the wood. Freshly cut wood is about 50 percent water by weight. Air-dried wood is about 20 to 30 percent water by weight.
To quantify how much waste wood is being produced in these communities, use a per capita estimate of annual production of urban wood waste and multiply this by population in each area. Research shows that an average of 0.203 green tons of urban wood waste are produced per person per year in the United States (Wiltsee, 1998). This can serve as your per capita estimate. Now use Google Earth (http://earth.google.com/) or other maps to identify counties within about one hour, or fifty miles, from your proposed bioenergy facility location. Fifty miles is an appropriate distance because beyond this, transportation cost alone surpasses $15/ton, and because resources beyond this distance may be more competitive to other biomass users in surrounding locations. Make a table in Excel with a row for each community you are assessing. Go to http://www.census.gov and type each county name (one at a time) into the box shown in Figure 3 to find the most recent county census popula-

**Figure 3:** U.S. Census Bureau Web site at http://www.census.gov, where county population data can be retrieved.

**Figure 4:** Calculation of urban wood waste/county/year.
tion data. Enter these numbers in a second column (next to their corresponding county name) in your Excel spreadsheet. Multiply the population of each community by 0.203 green tons/person per year to find an estimate of the green tons/community/year as shown in Figure 4.

Quantify logging residues from FIA Data

When trees are harvested, logging residues (unmerchantable trees, tree tops, and branches) are produced in the harvesting operation and may be a low-cost biomass resource. These resources must be quantified if they are to be considered in a bioenergy project. Probably the best source of information on quantities of logging residues and other forest biomass is the Forest Inventory and Analysis (FIA) Program of the U.S. Forest Service. FIA collects, manages, and reports information on forests in the United States. The Timber Product Output (TPO) program of FIA generates county-level data on logging residues and forest products based on both FIA plot data and more frequent mill surveys (visit http://fia.fs.fed.us/program-features/tpo/ for more information). This information is available for the entire lower forty-eight states, covering both public and private lands. You may also contact your local forest service office for assistance.

This FIA and TPO data can be accessed in various ways. Raw data from the FIA database (FIADB) can be downloaded directly from the FIA DataMart (http://fiatools.fs.fed.us/fiadb-downloads/fiadb3.html) and can be imported to Microsoft Access or Microsoft Excel. Users’ Manuals for the FIADB are available at http://fia.fs.fed.us/library/database-documentation/. Alternatively, tools are available online to query the FIADB for data specific to a user’s needs and geographical area.

The U.S. Forest Service FIA TPO program reports the amount of logging residues by county. The following steps show how you can retrieve quantities of logging residues produced in counties that are within fifty miles of a proposed bioenergy facility. First, go to the U.S. Forest Service Timber Products Output Mapmaker2 at http://www.ncrs2.fs.fed.us/4801/fiadb/rpa_tpo/wc_rpa_tpo.ASP (Figure 5).

Figure 5: U.S. Forest Service Timber Products Output Mapmaker home page.

2 At this writing, FIA Mapmaker is likely to be superseded by FIA Forest Inventory Data Online (FIDO).
Next, go to your state, and select the radial button marked **Specific Counties**. Hold down the CTRL key as you select the counties within about fifty miles of your proposed location. Then click on **Continue** at the bottom of the page (Figure 6).

**Figure 6:** Selecting counties from the U.S. Forest Service Timber Products Output Mapmaker.

From the next page, select **Volume of Logging Residue (CuFt)** and click **Continue** (Figure 7).

**Figure 7:** Select attribute of interest from U.S. Forest Service Timber Products Output Mapmaker.
Accept with default Page, Row, and Column variables, and click **Continue** (Figure 8).

**Figure 8**: Default Page, Row, and Column variables of U.S. Forest Service Timber Products Output Mapmaker.

Select **Continue** from the next page to retrieve your data (Figure 9).

**Figure 9**: Last page before retrieving data from the U.S. Forest Service Timber Products Output Mapmaker.

Finally, logging residues are reported as hardwoods and softwood for your selected counties (Figure 10).

**Figure 10**: Data reported from U.S. Forest Service Timber Products Output Mapmaker.
Copy the data retrieved from the U.S. Forest Service Timber Products Output Mapmaker and paste it into your Excel worksheet. The Web site reports logging residue data in cubic feet, which is a measure of volume. Because wood used in biomass facilities is measured by weight, you need to convert the volume of residue to weight to continue calculations for the supply curve. Hardwoods are trees with broad leaves, such as oak, maple, and sweetgum. Softwoods are conifers such as pine and cypress. Because hardwood is denser than softwood, an equal volume of branches should have slightly different weights.

The data are reported in cubic feet/year, which should be converted to tons/year to make the units comparable with the urban wood waste quantities. Multiply the reported softwood cubic feet by 30 lbs/cubic foot and divide by 2,000 lbs/ton to calculate dry tons of softwood logging residues produced per year. Multiply the reported hardwood cubic feet by 32 lbs/cubic foot and divide by 2,000 lbs/ton to calculate dry tons of hardwood logging residues produced per year (Figure 11).

Figure 11: Importing data from U.S. Forest Service Timber Products Output Mapmaker and converting to dry tons.

![Figure 11: Importing data from U.S. Forest Service Timber Products Output Mapmaker and converting to dry tons.](image)

Sum the columns of hardwood and softwood logging residues to get total logging residues produced per county per year (Figure 12).

Figure 12: Calculating total logging residues per county per year.

![Figure 12: Calculating total logging residues per county per year.](image)
Other biomass resources may also be available in your area. For example, if industrial demand for pulpwood or small-diameter timber in your AOI is projected to decline, some of this resource may be available for energy. Similarly, small-diameter timber close to a proposed bioenergy facility may be available at a competitive price. Pulpwood harvests by county are reported at http://srsfia2.fs.fed.us/php/tpo2/tpo2.php and can be included in a supply analysis. Other types of resources such as agricultural residues may also be available in your AOI. A good starting point for learning about these resources is “A Geographic Perspective on the Current Biomass Resource Availability in the United States” available at http://www.nrel.gov/docs/fy06osti/39181.pdf.

Construction and demolition debris is available from populated areas at a rate of about 0.09 tons per person per year (Wiltsee, 1998), though it may be expensive to sort clean wood out of this resource. Wood from thinning to improve forest health, such as for beetle control or to reduce wildfire fuel loads, may be available, though these data are not available nationally. Talk to a local Resource Conservation and Development (RC&D) Council person or forest extension agent to learn about quantifying this resource in your area. For every available form of biomass, obtain the quantity available on a sustainable basis per year, and enter dry tons into your spreadsheet. Information should be reported in dry tons to keep the units consistent.

Set up your data as shown in cells B10–D18 in Figure 13 to make the next steps easier. Convert the urban wood waste to dry ton equivalent. Assuming urban wood waste is 40 percent moisture, then the wood content is 60 percent. Multiply the green ton amount by 0.6 to calculate the dry ton equivalent. If you’d like to assume that not all the urban wood waste is available for energy, you can reduce this quantity again. Multiply again by 0.6 to indicate that only 60 percent of the urban wood waste might be captured for energy. These calculations are shown in Figure 13, cell D11:

Figure 13: Converting green tons to available dry tons of urban wood waste.
As with urban waste wood, assume that only 60 percent of the logging residue will be collected and available. Multiple your dry tons of residue by 0.6 and add these data to your chart with the urban waste data as shown here (Figure 14).

**Figure 14: Converting to available dry tons of logging residues.**

After you have estimated the quantities of locally available biomass resources, you will need to estimate the price of these resources as shown in the next section.

### 6.3 Tool 4: Estimate Costs of Locally Available Biomass Resources

To evaluate the economic availability of biomass resources, it is necessary to assign prices to the resources that were quantified in the previous section. Future prices cannot be known with certainty, as economic conditions are constantly changing. However, if a project is to be considered, some sort of cost estimates need to be made.

The total delivered cost of forest products is the sum of (1) the price to purchase the wood from the landowner, (2) the price paid to the logger to gather the material, and (3) the price needed to haul the material from the forest to the processing facility. As gasoline costs rise, the price of hauling wood will also change.

Table 1 shows typical costs of urban wood waste and logging residues in Florida in December 2007. You can use these costs in your cost analysis, or update them with costs you find for your AOI. Local contacts, RC&D Council representatives, consultants, and extension agents may be able to provide local cost estimates. Note that the procurement cost of urban wood waste is negative in Table 1, because tree service companies pay to get rid of, rather than sell, their waste wood.

<table>
<thead>
<tr>
<th></th>
<th>Urban Wood Waste</th>
<th>Logging Residues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase cost</td>
<td>25.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Harvest and process</td>
<td>30.00</td>
<td>33.00</td>
</tr>
<tr>
<td>Load and unload</td>
<td>1.98</td>
<td>1.80</td>
</tr>
<tr>
<td>Two-way haul (per hour)</td>
<td>11.86</td>
<td>10.78</td>
</tr>
<tr>
<td>Example total delivered cost of a 1 hour haul</td>
<td>18.84</td>
<td>48.58</td>
</tr>
</tbody>
</table>

* The cost of purchasing wood on site. Negative costs for urban wood waste reflect disposal costs, known as “tipping fees.”
* Includes the costs of bundling, collecting, and chipping
* The cost per ton to transport wood for one hour and return with an empty truck (for a total of two hours of driving time). A truck can carry 23 tons and typically gets 6 mpg.
* Equals the sum of the four cost categories.
Copy the cost values from Table 1 into your Excel spreadsheet as shown in Figure 15. If you include additional biomass resources, you’ll need to include some cost assumptions for these resources as well, either from local contacts, an extension agent, or a consultant.

Figure 15: Adding cost assumptions by resource type.

Transportation costs increase with both the distance of the haul and with time on the road. Transportation costs can be calculated based on the time truckers spend driving. You can use Google Maps, Mapquest, or Yahoo Maps to estimate drive time from the forest to the proposed facility or site. Add the haul times to your Excel spreadsheet for each source county center to the proposed facility (Figure 16).

Figure 16: Adding haul time.
Divide haul times by 60 to convert minutes to hours, and multiply by the two-way transportation cost to calculate a haul cost for each county (Figure 17).

**Figure 17: Convert haul time to two-way transportation cost.**

Add a new column titled **TOTAL DELIVERED COST ($/DRY TON)**. Sum procurement cost, harvest and process cost, load and unload cost, and two-way transportation cost in this column (Figure 18).

**Figure 18: Sum costs to calculate total delivered costs by resource.**
Rank resources from cheapest to most expensive

The next step in assessing the economic availability of these resources is to rank the resources from cheapest to most expensive. This step can be done manually. Alternatively, the data can be ranked automatically. To do this, start by making sure that the quantities are values rather than references. To do this, you can select the data in the column **Dry Tons**, copy the cells, and paste them as values by using the **Paste Special** function (Figure 19).

Figure 19: Paste special to convert formulas to values.

Select all the data in the table, and click **Sort** under the **Data** ribbon (Figure 20).

Figure 20: Select the sort tool.
Next, sort the data by **Total Delivered** cost from smallest to largest (Figure 21).

**Figure 21: Sort the data from cheapest to most expensive.**

To construct a supply curve, add a column called **Cumulative Tons**. This column will list a cumulative quantity of wood, so that each entry is added to the total above it. Make the first cell in the column equal to the original tons (Figure 22).

**Figure 22: Add a “Cumulative tons” column.**
Make the second cell in the column equal to the second quantity plus the original quantity ($17,545 + 1,096 = 18,641$) (Figure 23).

**Figure 23:** Calculate cumulative tons.

Drag this cell down (or copy and paste it down the remainder of the table) to create a cumulative sum of quantities from cheapest to most expensive (Figure 24).

**Figure 24:** Finish calculating cumulative tons.

You now have compiled important information about resource supply and cost. If desired, this information can be presented as a table, showing each resource, its cost per ton, the amount available per year, and the cumulative supply available up to a given cost per ton. A project planner looking for 100,000 dry tons equivalent of woody biomass per year, for example, would look down column L and find that this quantity is probably available at a price of up to $44.63 per dry ton (cell K17). For comparison, examples of quantities used by actual projects are shown in Table 2.

To show this information graphically, it can be converted into a supply curve, where the cumulative tons are shown as the x-axis, and the total cost per ton is shown as the y-axis. This is explained on page 73.
Another curve that may be useful is the “blended price” supply curve. This curve shows the weighted average price at the level of supply. For example: a buyer purchases 80 tons of biomass at $10.00 per ton, and then buys 20 additional tons at $20.00 per ton. The average price at the total of 100 tons is $15.00 per ton. But the blended price at the total of 100 tons is only $12.00/ton, because 80 percent of the supply was purchased at the lower rate. Showing the blended price is important because it explains the overall cost of biomass to a bioenergy producer. The following steps show how to add the data needed for a blended price supply curve, and then how to show both curves in an Excel graph.

Add a column titled \( P \times Q \) which stands for Price times Quantity. In this column, multiply dry tons by total delivered cost for each row (Figure 25).

### Table 2: Example bioenergy projects and quantities used.

<table>
<thead>
<tr>
<th>Example Use</th>
<th>Resource</th>
<th>Quantity used (dry tons/year)</th>
<th>Energy produced</th>
<th>Net energy produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dakota Adventist Academy, Bismarck, ND</td>
<td>Wood chips</td>
<td>517</td>
<td>Heat</td>
<td>12,100 MMBtu/year</td>
</tr>
<tr>
<td>Rowan High school, Moorhead, KY</td>
<td>Waste sawdust</td>
<td>756</td>
<td>Heat</td>
<td>0.15 Thermal MW</td>
</tr>
<tr>
<td>McNeil Facility in Burlington, VT</td>
<td>Wood chips</td>
<td>231,000</td>
<td>Electricity</td>
<td>50MW</td>
</tr>
<tr>
<td>Range Fuels Ethanol, Soperton, GA(^a)</td>
<td>Waste wood</td>
<td>216,000</td>
<td>Ethanol</td>
<td>40 million gallons/yr</td>
</tr>
<tr>
<td>Pyrolysis/Gasification(^b)</td>
<td>Waste wood</td>
<td>1,000,000</td>
<td>Electricity</td>
<td>100 MW</td>
</tr>
</tbody>
</table>

\(^a\) Under construction, July 2008.
\(^b\) Alex Green, personal communication, October 26th, 2008.

Figure 25: Multiply price by quantity for each resource.
Add a column titled **Cumulative P\*Q**. In this column, calculate the cumulative price from the column \(P\*Q\) in the same way you generated the column **Cumulative Sum** (Figure 26).

**Figure 26:** Calculate cumulative cost.

<table>
<thead>
<tr>
<th>Delivered cost ($/dry ton)</th>
<th>Cumulative P*Q</th>
<th>Cumulative P*Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>17,545</td>
<td>160,614.54</td>
</tr>
<tr>
<td>1</td>
<td>18,641</td>
<td>16,653.32</td>
</tr>
<tr>
<td>1</td>
<td>20,743</td>
<td>30,467.14</td>
</tr>
<tr>
<td>1</td>
<td>21,987</td>
<td>21,217.10</td>
</tr>
<tr>
<td>3</td>
<td>65,342</td>
<td>1,692,284.10</td>
</tr>
<tr>
<td>3</td>
<td>86,521</td>
<td>1,977,395.74</td>
</tr>
<tr>
<td>3</td>
<td>101,292</td>
<td>659,190.34</td>
</tr>
<tr>
<td>3</td>
<td>110,944</td>
<td>453,286.88</td>
</tr>
</tbody>
</table>

Add a column titled **Blended Delivered Cost**. In this column, divide **Cumulative P\*Q** by **Cumulative Cost** to get the running average cost of the total supply (Figure 27).

**Figure 27:** Calculate blended delivered cost.
Now create two supply curves on a graph. To do this, select **Scatter Plot** from the **Insert** ribbon (Figure 28).

**Figure 28: Insert scatter plot.**

Select the chart, and click **Select Data** from the Design ribbon (Figure 29).

**Figure 29: Select data for the supply curves.**
Click **Edit** to select the data for the graphs (Figure 30).

**Figure 30:** Using the **Select Data Source** dialog box.

Set **Cumulative Tons** as the x-axis, and **Total Delivered Cost** to create the first supply curve (Figure 31).

**Figure 31:** Selecting the supply curve data.

Set **Cumulative Tons** as the x-axis, and **Blended Delivered Cost** on the y-axis to create the blended supply curve (Figure 32).

**Figure 32:** Selecting the blended supply curve data.
Now you should have a graph that shows the cost of a ton of biomass as well as the blended cost of a ton of biomass at any supply level along the x-axis. You can right-click on the data series and click on **Format Data Series** to add lines to the data points. Edit the graph as appropriate. Here’s an example product (Figure 33).

Figure 33: Supply curve and blended cost supply curve.

Finally, you can convert these values into electricity generating capacity and energy units. One Megawatt (MW) of electricity is produced when about 6,600 dry tons of wood is burned. Add a column titled **MW** and calculate this column by dividing **Cumulative Tons** by 6,600. Add a column titled **Total Delivered Cost ($/MBtu)** and divide the original **Total Delivered Cost** by 16 (about a ton of dry wood produces about 16 million Btu) to get total delivered cost per million Btu. Add a column titled **Blended Delivered Cost ($/MBtu)** and divide the original blended by 16 to get blended delivered cost per million Btu (Figure 34).

Figure 34: Calculating price/MMBtu.

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3 “Btu” stands for British thermal unit, a unit of energy. In the electric industry, “MMBtu” stands for “Thousand thousand Btu,” which is one million Btu.
Copy the original graph and drag the data points to show MW capacity on the x-axis and price in $/million Btu on the y-axis as shown here (Figure 35).

Figure 35: Generating graph in cost per MMBtu and MW capacity.

Now a new graph is generated showing MW capacity and price in units of energy (Figure 36).

Figure 36: Graph showing cost/MMBtu and MW capacity.

Coal currently costs an equivalent of about $3.00/MMBtu in many states. You can use this new graph to indicate how many MW of capacity might be produced from woody biomass on a sustainable basis at a price competitive with conventional coal energy.
6.5 Summary and Conclusion

Producing forest biomass for energy and other bioproducts generates not only additional revenue from biomass sales but also a variety of other benefits to landowners and communities. Financing a bioenergy project requires demonstrating that feedstocks are available in sufficient quantity at a low enough price. This information may also be helpful for landowners considering biomass production, community leaders examining wood as a potential way to meet growing energy needs, or a venture capitalist searching for a good investment. In this section, several tools for developing supply curves to evaluate the economic availability of biomass resources were presented. This general approach can be modified to reflect resources and costs in your AOI. For information about funding opportunities for biomass projects, see Handout 6: Financing a Bioenergy Project.

For examples showing economic analyses of other woodsheds, see the Supply and Cost Profiles in Appendices D through F. The Supply and Cost Profiles represent analyses from three regions of the U.S.: Alaska, Florida, and Massachusetts. Profiles were adapted from existing projects and vary in terms of the types of wood resources considered, the breadth of the data, and the characteristics unique to each area and provide opportunities for comparison of methods and findings.

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References


