

---

## BODINGTON & COMPANY

---

*Investment Bankers to the Electric Power Industry*

*50 California Street, Suite 630 • San Francisco, CA 94111*

**Direct Evidence of Mr. Jeff Bodington**  
**2010 NSUARB–BRD–E–R–10**  
**Renewable Energy Community Based Feed-in Tariffs**

March 22, 2011

**Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.**

A. My name is Jeffrey Charles Bodington. My business address is 50 California Street, Suite 630, San Francisco, California.

**Q. WHAT IS YOUR OCCUPATION?**

A. I am an investment banker. My firm, Bodington & Company (“B&Co”) provides investment banking service to the electric power industry.

**Q. PLEASE SUMMARIZE YOUR EDUCATION AND EXPERIENCE.**

A. I hold degrees from UC Berkeley and Cornell University. I also have four securities registrations, and they are known as Series 7, 24, 63, and 79. My work experience includes four years with a management consulting firm, eight years working for Bechtel, and I founded B&Co in 1990. I provide investment banking services to the electric generation industry and I have substantial experience with biomass CHP. B&Co is a Broker/Dealer registered with the U.S. Securities and Exchange Commission and a member of the Financial Industry Regulatory Authority.

B&Co has advised owners and lenders on the financing, sale, and restructuring of over 400 power projects. More than 20 of those projects were biomass fired. I have published over 50 articles on the financing and valuation of power projects, spoken at many conferences. A copy of my resume follows this evidence.

**Q. ON WHOSE BEHALF ARE YOU SUBMITTING EVIDENCE?**

A. The Alliance of Nova Scotia Sawmillers (“ANSS”).

**Q. WHAT DID ANSS RETAIN YOU TO DO?**

- A. ANSS retained B&Co to review and assess the realism of the financing-related assumptions in the testimony prepared by Synapse Energy Economics, Inc. (“Synapse”), concerning biomass-fired combined heat and power (“biomass CHP”) projects, and filed in a rate proceeding before the Nova Scotia Utility and Review Board (“NSUARB”).

**Q. WHAT ARE YOUR FINDINGS AND RECOMMENDATIONS?**

- A. Synapse assumed 60% debt<sup>1</sup>, 9.5% cost of debt<sup>2</sup>, and 13% after-tax cost of equity<sup>3</sup>. In my opinion it is unrealistic to assume such a project will secure 60% of its financing through debt. The project is simply too small and too risky. In my opinion, 100% equity is a realistic capital structure for 2.0 MW biomass CHP projects. With respect to the return on equity, in my opinion, 17.5% is a realistic after-tax average cost of capital without an effective fuel cost hedge; the proposed 75/25 CPI/diesel index is not an effective fuel cost hedge. *If* an effective fuel cost hedge could be developed, such as a fuel pass-through, then 13.0% would be a realistic after-tax average cost of equity.

Therefore, I recommend that the NSUARB assume the following input assumptions in its biomass CHP tariff:

1. 100% equity financing
2. 17.5% return on equity if the currently proposed CPI/Diesel escalator is used;
3. Or, alternatively, 13% cost of capital with an “effective” fuel cost hedge, such as a cost flow-through.

## **DEBT-EQUITY RATIO**

**Q. WHAT IS THE BASIS FOR YOUR OPINION THAT 100% EQUITY IS REALISTIC FOR A 2.0 MW BIOMASS CHP PROJECT?**

- A. Synapse assumes a capital structure that is 40% equity and 60% debt for a 2.0 MW biomass-fired facility.<sup>4</sup> Due to the risks of biomass-fired power and the small size of the facility, it is unrealistic

---

<sup>1</sup> Synapse Testimony pages 11-12, Exhibit C, and page 1 of Exhibit K.

<sup>2</sup> Synapse Testimony pages 12-13, Exhibit C, and page 1 of Exhibit K.

<sup>3</sup> Synapse Testimony pages 14-16, Exhibit C, and page 1 of Exhibit K.

<sup>4</sup> See second page of Synapse Testimony, Exhibit K for net generator capacity of 2.05 MW in full condensing operation.

to assume that any amount of debt finance is realistic. The capital structure is most likely to be 100% equity.

Synapse states: *“In addition, the lenders we talked to who were familiar with biomass felt that CHP projects could be financed with 60% debt **if the question of fuel cost risk were addressed a satisfactory way.**”*<sup>5</sup>(my emphasis)

B&Co agrees with this assertion for projects that are large enough to justify the loan transaction and monitoring costs. Synapse proposes to index biomass fuel costs by an index that is 75% the Consumer Price Index (CPI) for Nova Scotia (all items excluding energy) and 25% a diesel fuel index.<sup>6</sup> Synapse does not show that such an index would meet its own standard of addressing fuel cost risk in a satisfactory way; the accuracy of Synapse’ index is an untested hypothesis.

B&Co’s experience is that such an index would track the actual fuel costs for a 2 MW biomass CHP project only by coincidence, and such an index would not materially mitigate fuel cost risk.

**Q. PLEASE ELABORATE WHY THE CPI/DIESEL INDEX WOULD NOT SATISFACTORILY ADDRESS FUEL COST RISK FOR A LENDER**

A. First, B&Co understands that the index proposed by Synapse is based on the New Page Port Hawkesbury (NPPH)-NSPI proceeding. Such an index may reasonably track biomass harvesting costs and thus in that case cover a self-supplier’s own costs. That is not the circumstance of a 2 MW CHP plant that must either buy or value its fuel on a market rather than harvesting-cost basis.

Market values are determined by the milieu of supply and demand. At a national and provincial level, biomass fuel costs are affected by things that affect the supply and demand for wood including housing starts, interest rates, industrial activity, and macroeconomic policy. At a local level, fuel costs are affected by specific changes in supply and demand including weather, logging activity, mill openings, mill closures, changes in mill operating levels, construction, demolition, forest fires, forest maintenance programs, waste disposal regulations, burning regulations, operational difficulties among suppliers and competitors, and changes in fuel transport costs.

---

<sup>5</sup> Synapse Testimony, page 11.

<sup>6</sup> Synapse Testimony, page 6.

It is rarely economic to transport biomass fuel by truck more than 100 miles; hence factors that change supply and demand within that radius can lead to large change in delivered fuel cost. This micro nature of the biomass fuel market is why the NPPH-NSPI circumstances do not apply and an index of 75% CPI/25% diesel would track 2 MW biomass CHP fuel costs only by unlikely coincidence.

**Q. IF SUCH AN INDEX HAD A PERIODIC REOPENER, WOULD THAT ADDRESS THE FUEL RISK?**

A. I understand that, in concept, a reopener could be a way to check to see if an index is tracking actual changes in fuel costs and then adjust the power price if the index is not tracking. In practice, fuel costs are so large and potentially volatile that a reopener would need to be frequent. In addition, the mechanism for adjustment would need to be clear, tested, and not discretionary at all. No one wants a dispute about the precise mechanics of a reopener in the future. Discretion over whether or not, or how, to adjust a price will neuter the effect of the reopener. Discretion eliminates the actual transfer of risk.

**Q. IN YOUR EXPERIENCE, WHAT WOULD BE AN EFFECTIVE FUEL COST HEDGE?**

A. The key is that there must be a mechanism that transfers the risk of substantial changes in fuel costs out of the project and thus away from potential lenders and equity investors. The State of Michigan has an example. Under legislation and subject to certain limitations, biomass-fired power projects submit fuel and operating cost records to the state each year. They also submit a record of what payments they actually received for energy sold under their PPAs. Then, utilities holding those PPAs pay the projects for the “overage” (the fuel and operating costs not already covered by payments under the PPA). The cost of the PPA and that overage is ultimately paid by utility ratepayers.

**Q. PLEASE CONTINUE TO EXPLAIN WHY 100% EQUITY FINANCING IS REALISTIC FOR A 2.0 MW BIOMASS CHP PROJECT?**

A. Financing a biomass-fired power project presents unique and difficult challenges. In particular, the magnitude and potential volatility of fuel costs can make earnings before interest, taxes, depreciation, and amortization (“EBITDA”) volatile. As EBITDA is volatile, the ability of a project to pay interest and principal on debt is endangered. Non-recourse debt financing for biomass projects is difficult, and sometimes impossible, to arrange. Fuel is the largest cost

associated with operating a biomass-fired power project. Fuel costs are usually larger than all other operating costs combined. For example, fuel costs in the Synapse CHP model account for 85% of annual total operating costs.<sup>7</sup> Although Synapse' non-fuel operating costs appear too low, its general finding that fuel costs account for over 50% of annual operating costs is consistent with B&Co's experience.

Potential volatility in fuel costs is not unusual; many natural-gas fired projects face similar volatility. However, the owners of such projects can hedge that volatility through long-term contracts with high-credit-quality counter parties such as Shell Energy. In many markets, the value of electric power is heavily determined by natural gas costs, so changes in such projects' revenues and fuel costs will be highly correlated and thus offsetting. Biomass-fired projects do not enjoy similar benefits. Long-term, fixed-price fuel contracts with high-credit-quality counter parties are rare.

B&Co's experience is that many fuel suppliers have few assets in addition to a truck and a chipper. Bankruptcies among fuel suppliers and the resulting failure of any contract in place are common. In addition, biomass costs do not set the market price of power in any market we know of; hence, there is no natural hedge between a biomass project's revenues and costs.

Biomass project EBITDA is also volatile due merely to the arithmetic of EBITDA. Revenues and costs are large, so EBITDA is the difference between two large numbers. This relationship magnifies the effect of fuel costs changes on EBITDA and debt service coverage. That large potential change in the net income available to pay interest and principal makes lenders cautious.

In addition, this is why a project's weighted average cost of capital is determined by primarily overall project risk and not the debt: equity ratio. As leverage goes up, the risks to equity also go up because lenders are paid before equity investors. As the risk to equity goes up so does the cost of equity. On balance, changing the debt:equity ratio does not therefore change the weighted average cost of capital. That average cost can only be lowered by shifting risk out of a project so that it is borne by neither debt nor equity. This important principal of finance and cost of capital was made well known by Modigliani and Miller in the late 1950s<sup>8</sup>.

---

<sup>7</sup> Synapse Testimony, Exhibit K, operating year 1.

<sup>8</sup> Modigliani, F., Miller, M., "The Cost of Capital, Corporation Finance and the Theory of Investment," American Economic Review 48(3), pp 261-297, 1958.

Finally, financing small projects with debt is difficult due to the large costs associated with evaluating, closing and monitoring a loan. Lenders typically retain fuel and engineering consultants to evaluate many aspects of a project. Legal costs are substantial due to the many agreements and permits that need to be evaluated and negotiated or obtained. The costs of this analysis often cripple the economics of a small project.

Synapse found that: *“Project size may serve as a barrier to market entry for some lenders since the project’s total capital requirements will likely be below their minimum lending threshold. A representative of at least one large lending institution, Manulife, reported that it is highly unlikely that they would lend to projects as small as the ones being considered for the COMFIT.”*<sup>9</sup>

Lenders active in biomass include Bank of Tokyo-Mitsubishi UFJ, CoBank, DZ Bank, United Bank of California, United Overseas Bank of Singapore, and others. These banks have large amounts of capital to invest and cannot afford to spend time on small deals. It is B&Co’s experience that these lenders usually pass on any project needing less than \$50,000,000.

**Q. WHAT DOES THE MARKET DATA DEMONSTRATE ABOUT DEBT FINANCING OF SUCH PROJECTS?**

**A.** Current market data support the lack of debt financing for small biomass projects. Of the 20 projects listed in the Power Finance & Risk’s March 7, 2011 Project Finance Deal Book, project sizes are listed for 17.<sup>10</sup> Of those 17, the smallest is a 20 MW solar project. None of the projects is biomass-fired.

Publicly-available data on several recent financings of biomass-fired power projects are summarized in the table below. Some key points to note include:

- The smallest project is 26.8 MW; there is no comparable project to the proposed community biomass CHP at issue in this proceeding.
- Iberdrola’s Lakeview project is financed at an upstream level with no project-specific debt.

---

<sup>9</sup> Synapse Testimony, page 11.

<sup>10</sup> See Power Finance & Risk, 7 March 2011, page 7.

- Of the three projects financed by debt, Cadillac and Piedmont are supported by PPAs and legislation that insulates lenders from fuel and maintenance costs risk. Lufkin's debt is Texas industrial revenue bonds, not commercial project debt.

#### EXAMPLES OF BIOMASS-FIRED PROJECT FINANCINGS

|                     | <b>Cadillac</b>                                           | <b>Lakeview</b>                  | <b>Lufkin</b>                     | <b>Piedmont</b>                                                     |
|---------------------|-----------------------------------------------------------|----------------------------------|-----------------------------------|---------------------------------------------------------------------|
| Capacity, MW        | 38.0                                                      | 26.8                             | 57.0                              | 53.5                                                                |
| Location            | Mich., US                                                 | Oregon, US                       | Texas, US                         | Georgia, US                                                         |
| Developer           | Began op. in 1993                                         | Iberdrola                        | Aspen                             | Rollcast                                                            |
| Status              | Acq. of oper. proj.                                       | Const.                           | Const. / Troubled                 | Const.                                                              |
| PPA                 |                                                           |                                  |                                   |                                                                     |
| Capacity            |                                                           | "... expect strong interest ..." | "... looking to secure a PPA ..." | "... majority of revenue ..."                                       |
| Energy              |                                                           | "... expect strong interest ..." | "... looking to secure a PPA ..." | "... adjustments mitigate potential biomass fuel price volatility." |
| Other               | State law allows pass thru of excess fuel and oper. cost. | "... expect strong interest ..." | "... looking to secure a PPA ..." |                                                                     |
| Total Cost, \$MM    | 77.0                                                      | 99.1                             | 99.1                              | 209.0                                                               |
| Debt                |                                                           |                                  |                                   |                                                                     |
| Amount, \$MM        | 42.0                                                      | 0.0                              | 55.0                              | 133.0                                                               |
| Amount, % of cost   | 55%                                                       | 0%                               | 55%                               | 64%                                                                 |
| Term, yrs           | NR                                                        | -                                | NR                                | 5                                                                   |
| Amortization, yrs   | NR                                                        | -                                | NR                                | 18                                                                  |
| Rate, %             | NR                                                        | -                                | NR                                | 5.2                                                                 |
| Additional Security | State pass thru                                           |                                  | Texas IRBs                        | Stimulus Grant                                                      |
| Example Reference   | PF&R, 11/1/10                                             | Iberdrola, 11/10/10              | SparkSpread, 8/3/10               | SparkSpread, 10/21/10                                               |

NR: Not reported in public media.

#### Q. ARE YOU AWARE OF SMALL BIOMASS PROJECTS WHICH HAVE SECURED DEBT FINANCING?

- A. I know of only one small biomass project that has been able to arrange project-level debt. NexBank made a loan to finance the 7.5 MW Big Valley biomass project and NexBank is now considering foreclosure.<sup>11</sup>

<sup>11</sup> Power Finance & Risk, 21 February 2001, page 2.

## COST OF EQUITY

### Q. HOW DID SYNAPSE ESTABLISH ITS RECOMMENDED COST OF EQUITY OF 13%?

- A. Synapse acknowledges difficulty in estimating the cost of equity capital. And although Synapse cites several NSUARB proceedings and decisions, including an allowed return of 13% to Heritage Gas Ltd., Synapse does not present a specific methodology for recommending a 13% cost of equity for biomass CHP.<sup>12</sup> Synapse states:

*“We received a range of comments from stakeholders regarding the return on equity (ROE) that COMFIT projects would need. Some people suggested that communities could tap investors motivated by social and environmental concerns and that these investors would require no return at all. Others felt that the risk associated with some COMFIT projects would require returns as high as 20% or more. It is not surprising that there is such a wide range of views on this issue. There is very little information available with which to benchmark the return on equity needed to attract capital to projects like the ones we are considering – very small projects, owned by small organizations with little experience in developing energy projects but backed by a COMFIT commitment with a very credit-worthy entity.”<sup>13</sup>*

*“Next, consider biomass CHP projects. We assume most of these projects will be developed by corporations or universities. These are “going concerns,” with significant existing assets and revenues. In some cases, the equity portion of these projects may be financed off of a corporate balance sheet. Where outside capital is sought, investors are likely to perceive less risk in these entities as project developers and owners than in a small, community-based organization. However, biomass CHP projects will face fuel cost risk. As discussed above, we propose to index biomass fuel costs to external factors and to assume a higher cost debt for biomass CHP than other COMFIT projects. However, our discussions with lenders, stakeholders and other experts leads us to believe that significant risk may still be perceived around biomass projects, even with this fuel indexing and allowance for more costly debt. Thus we have included a return on equity of 13% for biomass CHP projects, even though the developers of these projects are likely to be seen as less risky than the developers of other COMFIT projects.”<sup>14</sup>*

---

<sup>12</sup> Synapse Testimony, page 14.

<sup>13</sup> Synapse Testimony, page 14.

<sup>14</sup> Synapse Testimony, page 16.

Q. DO YOU AGREE WITH SYNAPSE'S JUSTIFICATION FOR RECOMMENDING 13% RETURN ON EQUITY?

A. No. There are flaws in the logic above.

Although the bases for Synapse' assertions are not clear, asserting that either size or "financing off a balance sheet" are relevant to cost of equity for a small CHP biomass project is a mistake in both financial and valuation theory. The correct cost of equity is determined by the risks associated with the subject investment. It is a mistake to infer that the cost of equity for that investment is affected by whether or not the investor is a going concern or has ample cash on its balance sheet. As was noted above, Modigliani and Miller are well known for their explanation in 1958 of why, and under what conditions, how an investment is financed has no effect on its value or the weighted average cost of capital.

Increasing the interest rate on debt from 8.0% for most COMFIT projects to 9.5% for CHP biomass does not adequately compensate lenders for fuel risk and is irrelevant to the cost of equity. Material fuel cost increases have a large impact on EBITDA, debt service coverage and lenders' chance to be repaid in full. As explained above, lenders do not make loans under such circumstances. An extra 1.5% per annum does not adequately protect a lender from a 25% to more than 75% loss of principal. B&Co has advised lenders who lost such amounts on loans to biomass-fired projects.

Further, assuming that the indexing is effective at all is unsubstantiated. For reasons I noted above, B&Co's experience is that such an index would usually be ignored as a material means of supporting a 20 year loan.

Biomass CHP and other power projects differ from each other in many respects. These differences alter the risks involved in a project and it is those risks that determine the cost of capital.

Q. ON WHAT DO YOU BASE YOUR RECOMMENDATION FOR THE COST OF CAPITAL?

A. My experience concerning the cost of capital for biomass CHP projects is presented below from two perspectives, (1) market data and (2) a widely-employed theoretical model.

Q. WHAT IS THE MARKET DATA EVIDENCE?

A. B&Co is active in the market for biomass-fired power projects. We represent both buyers and sellers, have many discussions with both about valuation, and we see the results of auctions. On that foundation, my experience is that investors in well-structured operating biomass projects, but projects that do **NOT** have substantial fuel cost protection expect a pre-tax unleveraged return of 14% to 15%. While tax benefits can be large and complex, after-tax returns on those projects are in the low teens. This experience and spread is consistent with Synapse' leveraged returns of 13.8% pre-tax and 13.0% after-tax.<sup>15</sup>

However, projects that involve development and construction risk demand higher returns. I understand that one of the intents of the tariff under consideration by the NSUARB is to justify development and construction of biomass CHP. Our experience is that the unleveraged pre-tax returns expected on such projects are in the high teens and over 20%. This is consistent with Synapse' finding quoted above "*Others felt that the risk associated with some COMFIT projects would require returns as high as 20% or more.*" After tax, B&Co's experience is that required returns on development-stage projects are in the mid to high teens.

Mr. Jon Founts, a Managing Director with Morgan Stanley, commented that development-stage projects "... can generate returns in the high teens to low 20% range."<sup>16</sup> Mr. Charles Costenbader, an Associate Director with Macquarie Energy, commented recently that a developer values a development-stage biomass project with "... generally north of 25% as an overall return, possibly even higher."<sup>17</sup> On the foundation of the results above, an after-tax return of 17.5% is a reasonable middle-of-the-range cost of capital.

Additional market data support an average cost of capital of approximately 17.5%. A common valuation metric is the enterprise ratio i.e. the enterprise value ("EV") divided by EBITDA (enterprise ratio is thus EV/EBITDA). Data on the sales of small businesses imply that most sell for 2.0 to 4.0 times annual earnings.<sup>18</sup> A 2 MW biomass CHP is a small to medium-small business. At year end 2010 the EV/ EBITDA for AES, a large company, was approximately 5.7. Two valuation identities are that (1) the cost of capital plus earnings growth rate equals a capitalization rate and (2) a capitalization rate is the reciprocal of EV/EBITDA. Therefore, assuming an

---

<sup>15</sup> Synapse Testimony, Exhibit K.

<sup>16</sup> Project Finance Newswire, February 2010, page 24.

<sup>17</sup> Project Finance Newswire, March 2011, pages 11 and 12.

<sup>18</sup> See for example quote of Ed Pendarvis, CEO of Sunbelt Business Advisors in FSB, March 2007, page 7.

EV/EBITDA of 5.0 and earnings growth of 2.5% for a 2 MW biomass CHP facility yields a  $(1/5.0) - 2.5 = 17.5\%$  average cost of capital.

**Q. WHAT IS CAPM AND YOUR CAPM-RELATED EVIDENCE?**

A. Although it is based on strong assumptions and the subject of much controversy, the capital asset pricing model (“CAPM”) is an often-employed theoretical method of estimating the cost of equity (“Ke”). It also used to estimate the weighted average cost of capital for an investment. The NSUARB would be familiar with the CAPM and has considered related evidence in relation to NSPI’s Application for Approval of Certain Revisions to its Rates, Charges and Regulations<sup>19</sup>.

I need to emphasize that I present CAPM evidence as a check and for completeness. I consider the market-based evidence that I presented above to be both more reliable and sufficient.

CAPM expresses Ke as a function of the risk-free rate (“Rf”), investment-specific beta (“β”), equity risk premium (“Rp”), and occasionally an additional unsystematic risk premium (“Ru”). One of several expressions of CAPM is:

$$Ke = Rf + (\beta * Rp) + Ru$$

Risk free rate, Rf:

- Rf for a risk-free investment with time horizon similar to the subject investment.
- The long-term average yield on 20-year government bonds is approximately 4.25%.
- As of March, 2005 the yield on 20-year government bonds was approximately 4.00%.

Beta, β:

- A statistical measure that evaluates the risk of a particular security relative to the systematic risk of a market portfolio of stocks. When CAPM is employed to estimate an unlevered cost of capital, β must reflect the underlying risk in unleveraged cash flows in the subject investment such as biomass CHP.
- Variance in biomass project EBITDA and net income is heavily influenced by fuel costs, and fuel costs are heavily influenced by activity in the lumber, wood products, and housing industries.

---

<sup>19</sup> 2005 NSUARB 27

- $\beta$  for Universal Forest Products (symbol UFPI) is 1.52.<sup>20</sup> B&Co did not find an independent analysis of an average beta, however, data on over 50 other companies in the forest, lumber, and wood products industries show most betas are over 1.50 and some are over 2.00.
- $\beta$  for housing-related stocks vary but tend to average over 1.50 (see symbols LEN, DHI, KBH, HOV, RYL).
- A  $\beta$  of 0.55 can be said to reflect the equity risks associated with a utility such as NSPI. This is not comparable to the asset risks associated with 2 MW biomass CHP.

Market risk premium,  $R_p$ :

- The risk premium is the return on the market in excess of the risk-free rate.
- Ibbotson Associates' Stocks, Bonds, Bills, and Inflation, 2010 Yearbook reported the risk premium at 6.7%.
- Average risk premium reported by investment practitioners in the U.S. and Canada during 2010 was 5.1%.<sup>21</sup>

Unsystematic risk premium,  $R_u$ :

- A controversial additional risk premium associated with investment-specific factors that cannot be diversified or hedged away.
- While power projects do involve many risks that are difficult to manage, B&Co is not aware of any independent estimate of this risk premium for power projects.

Subject to the qualifications and data above, an estimate of the cost of equity based on CAPM is:

$$4.00 \text{ to } 4.25 + (1.50 * 5.1 \text{ to } 6.7) + 0.0 = 11.65 \text{ to } 14.30 = \text{average of } 13.0\%$$

The result above is consistent with the market data presented above for operating projects. The market risk premium above is drawn from a large and diversified portfolio of investments, most of which are already earning income.  $\beta$  too is based on operating companies that are leveraged and diversified. Increasing  $\beta$  and/or adding an unsystematic risk premium is justified to account for development, construction, and other un-diversifiable risks. There is no proven method of making such adjustments. Adding another 4% to 5% to account for these extra risks yields 17.5% and this result is consistent with the market data presented above.

---

<sup>20</sup> Yahoo Finance, 5 March 2011, UFPI, Key Statistics.

<sup>21</sup> "The 2010 Equity Risk Premium from Practitioners," 3 June, 2010.

Q. WHAT IS THE BASIS FOR YOUR FINDING THAT 13.0% IS A REALISTIC AFTER TAX COST OF CAPITAL WITH A FUEL COST HEDGE?

A. In addition to the analysis above, ANSS asked B&Co to evaluate the cost of capital for a biomass CHP project whose rate structure that effectively hedges fuel cost risk. As noted above, we do not consider a 75% CPI/25% Diesel index to be an effective hedge. Such a hedge would address and insulate investors and lenders from changes in a power project's actual fuel costs.

If biomass fuel costs were hedged, then the risk profile of a biomass project would approach that of a natural-gas fired project with a long-term fuel contract or that operates in a market whose prices are determined primarily by natural costs. There is an active market for such projects, and the lower risk justifies a lower cost of capital.

My experience is that the after-tax cost of capital for such operating projects is in the range of 9% to 12%. Mr. Ted Brandt, Managing Direct of Marathon Capital, commented about wind projects at a high-certainty level of generation “... *most projects are bid around 9.5% to 10.0% unleveraged after-tax rates of return.*”<sup>22</sup>

Using 10% as a reasonable middle-of-the-range cost of capital for operating projects without material fuel cost risk, that is  $(15\% \text{ to } 14\%) - 10\% = (4\% \text{ to } 5\%)$  lower than the cost of capital for operating biomass projects presented in the section above. Accordingly, including development and construction risk, a reasonable middle-of-the-range cost of capital for operating biomass projects without material fuel cost risk is approximately  $17.5\% - 4.5\% = 13.0\%$ .

Subject again to the qualifications and controversy surrounding CAPM,  $\beta$  for a project with no fuel cost risk could be approximately 1.00 instead of 1.50. Using the assumptions above and  $\beta$  of 1.00 yields a cost of capital of 9.1% to 11.0%. Making the same adjustments of 4.0% to 5.0% for development and construction risk yields a cost of capital averaging approximately 14.5%. We place higher reliance on market data than CAPM, hence we view this result as supportive but not a strong reason to increase the cost of capital for a 2 MW biomass CHP project with fully hedged fuel risk over 13.0%.

Finally, I note again that Synapse' estimate of the cost of equity capital assuming a 75% CPI/25% diesel index to hedge fuel costs was 13.0%. B&Co's opinion is that Synapse' 13.0% is correct

---

<sup>22</sup> Project Finance Newswire, July 2010, page 17.

with the additions that, for reasons presented above, a 2 MW biomass CHP cannot justify any debt, 13% is the weighted average cost of capital for the project, and the fuel cost hedge must be clearly effective.

Q. WOULD YOU PLEASE SUMMARIZE YOUR FINDINGS?

A. Yes. I disagree with Synapse' assumed 60% debt, 9.5% cost of debt, and 13% after-tax cost of equity. In my opinion, 100% equity is a realistic capital structure for 2.0 MW biomass CHP projects. 17.5% is a reasonable after-tax average cost of capital without an effective fuel cost hedge, and a 75/25 CPI/diesel index is not an effective hedge. If an effective fuel cost hedge could be developed, 13.0% is a realistic after-tax average cost of capital.

Q. DOES THIS CONCLUDE YOUR EVIDENCE?

A. Yes. Thank you.

---

## BODINGTON & COMPANY

---

*Investment Bankers to the Electric Power Industry*

*50 California Street, Suite 630 • San Francisco, CA 94111*

### Jeff Bodington, Summary of Qualifications

**Bodington & Company** ([www.bodingtonandcompany.com](http://www.bodingtonandcompany.com))

1990-Present

Investment banking services to the electric power industry. Examples of services, clients and results drawn from over 400 engagements for over 150 clients include:

**Mergers & Acquisitions:** Lead and participate in purchases and sales of interests in power projects.

|                        |                                                                                       |
|------------------------|---------------------------------------------------------------------------------------|
| AES                    | Prepared, auctioned and sold 75 MW portfolio and fuels management company.            |
| Arctic Utilities, Inc. | Evaluated, auctioned and sold this utility serving Prudhoe Bay, AK.                   |
| Barclays               | Obtained multiple proposals and sold a troubled 175 MW gas-fired project.             |
| Bear River Power       | Represented landowners during site lease negotiations with Shell Wind Energy.         |
| BNP Paribas            | Obtained multiple offers and sold \$30 million letter of credit liability.            |
| BNP Paribas            | Evaluated, auctioned and sold gas-fired cogeneration project in Linden, NJ.           |
| Colmac                 | Obtained multiple proposals and closed sale of 50 MW biomass-fired power project.     |
| Conectiv & GE          | Obtained multiple offers and sold a 30 MW biomass-fired facility.                     |
| Diamond Generating     | Obtained multiple offers for interest in 1,220 MW combined cycle facility.            |
| Enerland / CPV         | Marketed site, obtained multiple offers and closed site lease for 600 MW project.     |
| General Electric       | Appraisal of lease residual supported re-rental of 75 MW project.                     |
| Malacha                | Obtained multiple proposals and closed sale of 30 MW hydro power project.             |
| MMC Energy             | Sold three operating projects and three LM6000s for total value over \$50 million.    |
| PG&E                   | Obtained multiple offers and sold a troubled \$55 million hydro project.              |
| Town of Scotia         | Obtained multiple offers and sold a troubled 30 MW biomass-fired facility.            |
| SMBC                   | Obtained multiple proposals and managed closing for sale of 5 hydroelectric projects. |

**Financing:** Arrange debt and equity financing for development, construction and operating-phase projects.

|                  |                                                                                 |
|------------------|---------------------------------------------------------------------------------|
| Cobisa-Person    | Arranged equity and debt financing for \$60 million, 140 MW peaking facility.   |
| Conectiv         | Arranged \$25 MM letter of credit to support tax exempt bonds.                  |
| Energy Investors | Obtained purchase proposal for development-stage gas-fired project.             |
| Endless Energy   | Managed offering and closing with funding partner to complete an 80 MW project. |
| Endless Energy   | Arranged funding and development partner to complete a 15 MW project.           |

**Restructuring:** Advise owners and lenders on various capitalization, value, repayment and management issues.

|                |                                                                                   |
|----------------|-----------------------------------------------------------------------------------|
| Deutsche Bank  | Advisor to bank group during restructuring a \$230 million financing.             |
| Merrill Lynch  | Advised Merrill during restructuring of its interests in a \$50 MM power project. |
| Mizuho Bank    | Advised bank concerning the restructuring of loan and prepayment of swap.         |
| Rolls Royce    | Appraisal of combustion turbines supported property tax reduction.                |
| Tenaska        | Expert testimony supported favorable resolution of \$200 MM litigation.           |
| Town of Scotia | Advised owner on restructuring and preparing to sell 30 MW biomass-fired project. |

**Other:** Author of over 50 articles. Invited speaker or chair at over 70 conferences. Own and manage interests in various natural gas, geothermal, wind and other power projects. Board of Directors 1996-2009, Power Association of Northern California. Member 2005-Present, Independent Energy Producers.

**Bechtel Group, Inc.**

1982-1989

Most time with Bechtel devoted to Energy Transportation Systems, Inc. (ETSI) and related electric power projects.

**Senior Finance Representative:** ETSI, 1986 – 1989. Reported to EVP and CFO, supervised staff and consultants.

**Manager of Business Analysis:** ETSI, 1982 – 1985. Supervised professional staff of five.

**Business Analyst:** ETSI, 1982.

**Resource Planning Associates, Inc.**

1978–1982

Evaluated competitive and financial aspects of energy-related business ventures for Fortune 500 clients.

Associate, 1979 – 1982.

Research Associate, 1978.

**SEC, FINRA, and SIPC**: Broker/Dealer; Registered General Securities Principal; Series 7, 24, 63, and 79

**Cornell University**, M.S., Applied Economics, 1978, New York Scholarship Tuition Award and Stipend

**University of California, Berkeley**, B.S., Field major in Economics and Statistics, 1976, Honors

## Client List, 1990-2010

---

|                              |                                 |                                |
|------------------------------|---------------------------------|--------------------------------|
| AES Corporation              | GE Energy Financial Services    | Owl Companies                  |
| Agua Fria                    | GE Power Funding                | PA Consulting                  |
| Amerling & Burns             | Genesis Energy Systems          | Pacific Gas & Electric         |
| Arctic Utilities, Inc.       | Greenwich NatWest               | Pacific Generation             |
| Arizona DOR                  | Gulf States Utilities           | Perkins Coie                   |
| Bank of America              | Hellman & Friedman              | Piper & Marbury                |
| BankCal                      | Husky Oil                       | Power ANSS                     |
| Bear River Power LLC         | Hydro Quebec                    | Project Finance International  |
| Beaver Michigan LP           | Ida-West Energy Company         | Prudential                     |
| Besicorp Shareholders        | IFG Network Securities          | Raser Technologies, Inc.       |
| Bethany Power Corp.          | Indeck Capital                  | Reliant Energy                 |
| Big Valley Lumber            | Indeck Energy                   | RMI / Navigant                 |
| Blackstone Group             | Industrial Risk Insurers        | Rolls Royce Power Ventures     |
| BNP Paribas                  | Internat'l Development Planners | Rosen & Weisman                |
| Bonneville Pacific Corp.     | Inyo County, California         | Sacramento MUD                 |
| Bottle Rock Power            | JCJ Ranches                     | San Gabriel Hydro Associates   |
| BZW – Barclays Bank PLC      | Kemper Insurance                | San Joaquin Valley Energy      |
| Caithness Resources          | Klickitat Energy Partners       | Sanders & Parks                |
| California Bank & Trust      | Latham & Watkins                | Sewell & Riggs                 |
| Calpine Corporation          | Legal Strategies Group          | Sierra Power Corporation       |
| CenterPoint Properties Trust | Levitant & Associates           | Smurfit Stone Container Corp.  |
| Charter Oak Energy           | Lillick & Charles               | Sonoma County, California      |
| City of Oxnard, CA           | Long Beach Gas Department       | Southern California Edison     |
| Clausen Miller et al         | Macquarie Infrastr. Partners    | Souza Realty & Development     |
| CBS Corporation              | Malacha Hydro L.P.              | Stoel Rives                    |
| CMS Generation               | Marshall & Stevens              | Sumitomo Bank / SMBC           |
| Cobisa Corporation           | Marubeni Sustainable Energy     | Swidler & Berlin               |
| Colmac Energy, Inc.          | McLarens Young International    | TDX Power, Inc.                |
| Conectiv                     | Medina Power Company            | Technology Funding, Inc.       |
| Constellation Energy         | Merrill Lynch                   | Tejon Ranch Company            |
| Credit Agricole CIB          | Mid-Atlantic Energy             | Tenaska, Inc.                  |
| CSW Energy                   | Mid-Continent Power Company     | Thompson River Cogen           |
| Davis Wright Tremaine        | Milbank Tweed                   | Tosco Oil Company              |
| Deutsche Bank                | Millard County, Utah            | Town of Scotia, LLC            |
| Diamond Generating Company   | Mirant Corporation              | United Bank of California      |
| DTE Energy Services          | Mitsubishi UFJ Trust and Bank   | United American Energy         |
| Duke Energy                  | Mizuho Bank                     | United Cogen, Inc.             |
| Dynegy                       | MMC Energy, Inc.                | Uintah County, Utah            |
| Edison Electric Institute    | Mono County, California         | U.S. Department of Interior    |
| Energy America               | Morrison & Foerster             | U.S. Department of Justice     |
| Endless Energy Corp.         | Nedwind                         | U.S. Renewables Group          |
| Energy Holdings LLC          | National Australia Bank         | USL Capital                    |
| Energy Investors Funds       | National Power Company          | Utah Dept. of Public Utilities |
| Enerland, LLC                | New Charleston Energy Partners  | Ventura County, California     |
| Enpower                      | New York ISO                    | Wellhead Electric Company      |
| Exergy                       | New York State Electric & Gas   | Western Farmers Elec. Coop.    |
| First American Tax Valuation | Niagara Mohawk Power            | Westmoreland Energy            |
| First Security Bank          | Nippon Credit Bank              |                                |
| First Solar, Inc.            | N. American Energy Services     |                                |
| Foster Wheeler Power         | Northwest Natural Gas           |                                |
| Fortistar LLC                | Nth Power Technologies          |                                |
| Friedman, Boyd, et al        | OmniBank                        |                                |
| Fuji Bank, Limited           | Orrick Herrington & Sutcliffe   |                                |

## Examples of Power Project Experience

---

### Biomass and waste fired

Big Valley  
Blue Lake  
Burney Forest Power  
Cadillac  
Central Wayne  
Colmac Energy  
Delano  
Fairhaven

Fort Bragg  
Imperial Valley RR  
Oroville  
Mendota  
Mesquite Lake RR  
Niagara Biomass  
ScotiaBiomass Power  
Sierra Power

SS Florence  
Sunshine  
Tracy  
Wadham  
Woodland  
Yellow Pine

### Geothermal

Baca Ranch  
Bottle Rock  
Calpine Geysers  
Clear Lake

Coso  
Dixie Valley  
Lightening Dock  
NCPA Geysers

Newberry  
Thermo #1

### Hydroelectric

Angels  
BP Hydro portfolio  
Chakachamna  
Crystal Springs  
El Dorado  
Friant  
Glacier Lodge

Hatchet Creek  
Indian Valley  
Inexcon portfolio  
Kern River  
Lime Saddle  
Malacha  
Potter Valley

San Gabriel  
San Gorgonio  
Highland portfolio  
Utica  
Wailuku

### Natural gas fired

Alamitos  
Arctic Utilities  
Big Spring  
Cardinal / Stanford  
Cardinal / Husky  
Chaminade  
Chehalis / Suez  
Chula Vista  
Cleburne  
Colusa / Enerland  
Corona  
Desert Generating  
Eco Electrica / PR  
Escondido  
Ferndale

FPB Cogen  
Forney  
Frederickson  
Freehold  
Fresno / Wellhead  
FW Martinez  
Indeck portfolio  
Kiowa  
Klickitat  
Linden  
Lordsburg  
Loring  
Mesquite  
Mid Continent  
Mid-Sun

New Harquahala  
Oildale / DAI  
Oildale / Enpower  
Panoche  
Pastoria  
Person  
Placeritas  
San Joaquin Cogen  
San Jose  
Santa Maria  
Sumas  
Texaco  
United Cogen  
Watsonville  
Wellhead portfolio

### Coal fired

Bailly  
Billings  
Bonanza  
Cedar Bay

Grant Town / AmBit  
Intermountain PA  
Mohave  
Roanoke Valley

Thompson River  
Westmoreland Coal

### Wind

Agua Fria  
Bear River Power  
Bethany  
Blue Canyon

Equinox  
Mile High Ranch  
Redington  
Seawest / AES

Sunbelt  
Windpower 1990  
Windpower 1991

## Selected Publications by Mr. Bodington

---

### Finance & Energy

- "Flying Through Turbulence", **Public Utilities Fortnightly**, April 2008, pp 26-27, 66.
- "Going to the Bank", **Public Utilities Fortnightly**, deal log for M. Burr, June 2005.
- "Ratepayers Back At Risk", **Public Utilities Fortnightly**, January 2005, pp. 23-25.
- "Current Merchant Plant Prices", **Project Finance NewsWire**, December 2004, pp. 15-18.
- "Merchant Power Deals ...", **Wiley's Natural Gas & Electricity**, June 2004, pp. 1-8.
- "Merchant Deals Start to Sell", **Project Finance NewsWire**, April 2004, pp. 6-8.
- "Back to the Rate Base", **Public Utilities Fortnightly**, deal log for M. Burr, March 2004.
- "Restructuring Merchant Power Project Financings", **Institutional Investor's JSPF**, Winter 2004, pp. 42-48.
- "Project Sales: Strategies That Work ...", **Project Finance NewsWire**, June 2003, pp 11-14.
- "Power Plant Valuation ...", **Public Utilities Fortnightly**, with R. Malko, May 2003, pp 18-21.
- "Deal of the 21<sup>st</sup>...", **Public Utilities Fortnightly**, deal log for M. Burr, March 2003, pp 22-29.
- "Asset Sales: Decade long sellers' market ...", **Electric Light & Power**, June 2002, pp. 1-4.
- "Project portfolios generate value ...", **Electric Light & Power**, March 2002, pp. 12-13.
- "Nine Reasons for the Mess in California", **Project Finance Monthly**, August 2001, pp. 3-5.
- "Generation sales in 2000 ...", **Electric Light & Power**, June 2001, pp 1-4.
- "Crafting a deal: Merchants ...", **Electric Light & Power**, October 2000, pp. 4-8.
- "Aggressive bidding sustains ...", **Electric Light & Power**, April 2000, pp. 1-13.
- "Seller's Market", **Independent Energy**, September 1999, pp. 9-14.
- "Utilities Divest 50,000 MW of Generation ...", **Electric Light & Power**, July 1999, pg 4.
- "Going Vertical", **Independent Energy**, October 1998, pp 32-36.
- "Divestiture Options ...", **Project Finance Monthly**, September 1998, pp 13-14.
- "Bidding Behavior", **Independent Energy**, October 1997, pp 32-35.
- "Managing Closing Risks ...", **Project Finance Monthly**, July 1997, pp 12-13.
- "Merchant Plant Worth", **Independent Energy**, March 1997, pp 26-27.
- "Valuing Merchant Plants", **Competitive Utility** and **Project Finance Monthly**, August 1996, 2 pgs.
- "U.S. Market is Active", **Independent Energy**, November 1996, 3 pgs.
- "Forced Leasing of ...", **Competitive Utility** and **Project Finance Monthly**, August 1996, 2 pgs.
- "PPA Buy Out Update", **Edison Electric Institute**, Washington D.C., March 1996, 22 pgs.
- "PPAs Under Pressure", **Independent Energy**, May 1996, pp 23-26.
- "Letter Stock Restructuring", **Competitive Utility**, with T. Flaim and R. Miller, February 1996, pp 17-18.
- "Max. the Value of Hydro Projects", **HydroReview**, with J. Christensen, December 1995, pp 12-66.
- "Utility Asset Sales", **Independent Energy**, October 1995, pp 20-22.
- "PPA Renegotiation", **Independent Energy**, with L. Barrett, May/June 1995, pp 48-49.
- "What Are Generating Assets Worth?", **Electrical World**, May 1995, pp 75-76.
- "Rescuing Projects", **Independent Energy**, January 1995, pp 46-49.
- "PPA Reneg. Experience", **Edison Electric Institute**, with EEI, Washington D.C., May 1994, 70 pages.
- "Changing Ownership", **Independent Energy**, April 1994, pp 42-4.
- "PPA Buy Out Exp.", **Edison Electric Institute**, with EEI, Washington D.C., November 1993, 45 pgs.
- "Securitizing Project Debt", **Independent Energy**, July/August 1993, pp 20-22.
- "Active Institutional Investors", **Independent Energy**, February 1993, pp 8-14.
- "Rating Project Debt", **Independent Energy**, November 1992, pp 14-18.
- "Secondary Market Update", **Project Finance Monthly**, October 1992, pp 20-22.
- "Rescuing Troubled Projects", **Independent Energy**, September 1992, pp 70-74.
- "Jumping In, Bailing Out", **Independent Energy**, with C. Hocker, February 1992, pp 9-14.
- "Appraising Operating Projects", **Independent Energy**, July/August 1991, pp 12-18.
- "Deal Structure Innovations: LP Finance", **Project Finance Monthly**, December 1991, pp 6-9.
- "Deal Structure Innovations: Adjustable Sinking Fund", **Project Finance Monthly**, July 1991, pp 12-15.
- "Effective Indexing Provisions", **Independent Energy**, January 1991, pp 20-24.

### Valuation Theory

- "Discount Rates for Consistent Valuation ...", **The Appraisal Journal**, July 2003, pp 228-236.
- "Discount Rates for Lost Profits", **Journal of Forensic Economics**, Fall 1992, pp 209-220.
- "Measuring Damage to a Firm's ...", **The Antitrust Bulletin**, with J. Taurman, Spring 1992, pp 57-106.
- "Income Taxes and Lost Profits", **Journal of Forensic Economics**, Winter 1991, pp 85-92.
- "Appraising Profits Lost by a Failed New Venture", **Journal of Forensic Economics**, Winter 1990, pp 7-14.

**Editorial Appointments**

Editorial Board, **Project Finance Monthly**, 1993 to 2004.

Contributing Editor, **Electric Light & Power**, 2000 to 2004.

Contributing Editor, **Independent Energy**, 1992 to 2000.

See also [http://www.cg972.fr/site/html/arch2/html/exposition\\_bodington/accueil.html](http://www.cg972.fr/site/html/arch2/html/exposition_bodington/accueil.html)

**NOVA SCOTIA UTILITY AND REVIEW BOARD**

In the Matter of:

**RENEWABLE ENERGY COMMUNITY FEED-IN TARIFFS**

-and-

In the Matter of:

**Electricity Act, R.S.N.S. 2004, c. 25, s. 1,  
(b) combined heat and power biomass facility**

Direct Testimony and Exhibits of:

**Patrick M. Hayes, P.E. - ESI**

On behalf of:

**Alliance of Nova Scotia Sawmillers**

**March 22, 2011**

## Table of Contents

|                                              |    |
|----------------------------------------------|----|
| Acronyms and Definitions .....               | 3  |
| I. Introduction.....                         | 4  |
| II. Overview and General Issues.....         | 7  |
| III. Review of Evidence – Design Basis ..... | 7  |
| IV. Review of Evidence – Capital Cost.....   | 10 |
| V. Review of Evidence – Operating Cost ..... | 14 |

## List of Exhibits:

|                                                                                          |    |
|------------------------------------------------------------------------------------------|----|
| Exhibit A – Resume for Patrick Mitchell Hayes .....                                      | 17 |
| Exhibit B – Qualifications Package for ESI.....                                          | 19 |
| Exhibit C – Resume for Thomas J. Baudhuin.....                                           | 51 |
| Exhibit D – Resume for James S. Pittman .....                                            | 53 |
| Exhibit E – Flow sheets (condensing / extracting facility) .....                         | 55 |
| Exhibit F – Design Basis document (condensing / extracting facility).....                | 59 |
| Exhibit G – Capital Cost Estimate Breakdown (condensing / extracting facility) .....     | 68 |
| Exhibit H – Scope of Work for Capital Cost Estimate (condensing / extracting facility) . | 70 |
| Exhibit I – General Arrangement Drawings (condensing / extracting facility) .....        | 77 |

## Acronyms and Defined Terms

|        |                                                                                                                               |
|--------|-------------------------------------------------------------------------------------------------------------------------------|
| ACS    | Architectural, Civil, and Structural                                                                                          |
| ANSS   | Alliance of Nova Scotia Sawmillers                                                                                            |
| CHP    | Combined Heat and Power                                                                                                       |
| COMFIT | Community-based Feed-in Tariff                                                                                                |
| CPI    | Consumer Price Index                                                                                                          |
| ESI    | ESI, Inc. of Tennessee                                                                                                        |
| EPC    | Engineer, Procure, Construct                                                                                                  |
| ICE    | Instrumentation, Controls, and Electrical                                                                                     |
| MC     | Moisture content                                                                                                              |
| MECH   | Mechanical                                                                                                                    |
| NSDOE  | Nova Scotia Department of Energy                                                                                              |
| NSUARB | Nova Scotia Utility and Review Board                                                                                          |
| O&M    | Operating & maintenance (typically attributed to fuel, non-fuel, and overhead such as taxes, insurance, administrative, etc.) |
| P&ID   | Process & Instrumentation Drawings                                                                                            |
| ROI    | Return on Investment                                                                                                          |
| TDF    | Tire Derived Fuel                                                                                                             |

**I. INTRODUCTION**

**Q. Please state the name, position, and business address of the person sponsoring this evidence.**

A. Patrick "Mitchell" Hayes. I am the Manager of Sales for ESI, Inc. of Tennessee located at 1250 Roberts Blvd, Kennesaw, Georgia 30144, USA.

**Q. What is your occupation?**

A. I work for a design / build engineering firm specializing in "environmentally friendly" steam and power facilities. My responsibilities include all conceptual engineering, estimating, and proposal efforts for the firm.

**Q. Summarize your professional education and experience.**

A. My corporate resume is attached as Exhibit A to this document.

In summary, I received an engineering degree from the United States Merchant Marine Academy where I studied Marine and Nuclear Engineering. I received a US Coast Guard 3<sup>rd</sup> Assistant Engineer's operating license from the Academy as well. I hold Professional Engineering and General Contracting licenses for my company. Recently I have completed my Masters in Business from Georgia State University.

Before joining ESI in 1993, I spent time operating maritime steam plants for InterOcean Management, SeaLand, and ARCO Petroleum. Since joining ESI I have had responsibilities in construction, engineering, commissioning & training, project management, business development, marketing, and sales.

I have been a construction manager and/or commissioning leader for power facilities ranging from small 30,000 pph gas-fired boilers and 5MW combustion turbine units up to 50MW (thermal) solid fuel CHP plants. I have worked on facilities utilizing natural gas, fuel oil, coal, TDF, sludge, and biomass plants.

As a project engineer I was responsible for the complete design of multiple steam and power facilities including equipment design and specification design calculations, mechanical arrangement, site plan, process & instrumentation drawings, erection drawings, piping design, and engineering coordination duties between departments (ACS, MECH, and ICE) for a complete integrated final design.

As a project manager I had responsibility for all ESI commercial aspects of the steam and power project including budget, schedule, engineering & construction

1 interface, client interface, engineering packages, construction subcontracts,  
2 contract compliance, commissioning & facility turnover.

3 As Manager of Sales I am responsible for conceptual engineering and budgeting  
4 for all projects including preliminary design, final concept design, mass and  
5 energy balance, emissions projections, preliminary equipment specification,  
6 preliminary drawings (site plan, general arrangements, P&IDs, electrical 1-line,  
7 process flow diagrams, etc.), consulting engineering, as well as engineering  
8 support for permitting and financing. My budgeting responsibilities include order  
9 of magnitude costs ( $\pm 50\%$ ) for preliminary project concepts to firm price ( $\pm 0\%$ )  
10 estimates for complete EPC projects ranging from \$5,000 USD consulting  
11 services to \$250,000,000 USD steam and power generation facilities.

12 Directly applicable to this matter, I have performed engineering and budgeting  
13 studies for more than 50 solid fuel (mostly woody biomass) fired steam and  
14 power facilities. ESI has successfully completed more than a dozen actual  
15 biomass facilities in the time that I have been here. We are currently engineering  
16 and constructing two biomass fired facilities in the United States. In the last few  
17 years we have completed multiple projects including: a 20 MW biomass fired  
18 facility for the US Department of Energy, a 30MW biomass fired CHP facility in  
19 Pennsylvania for an industrial client, conversion of two existing 25MW (nominal)  
20 pulverized coal fired boilers to complete biomass firing, and were selected as the  
21 engineer for the First Energy conversion of 270MW of existing coal fired assets  
22 to biomass firing (this project has been put on hold after completion of the  
23 material handling system engineering).

24 In the 1990's ESI designed and built two biomass CHP facilities in Eastern  
25 Canada including a 400,000 pph woody-biomass fired facility located in  
26 Cornerbrook, Newfoundland for which I was a Construction Manager and  
27 Commissioning Team Leader.

28 **Q. Describe ESI, Inc. of Tennessee.**

29 A. ESI Inc. of Tennessee is a design engineering and construction firm that  
30 specializes in the engineering, procurement, and construction (EPC) of steam  
31 and power facilities. ESI brings innovative, cost effective, and environmentally  
32 friendly solutions to its client's steam and power needs.

33 ESI has a long list of Fortune 500 industrial and utility clients for whom ESI has  
34 performed multiple projects. ESI services include the design, engineering,  
35 procurement, construction, start-up, and operator training for steam, power, and  
36 utility facilities. ESI has registered professional engineers in all disciplines;  
37 therefore, we perform 100% of design engineering "in-house".

Since ESI's primary business is the design and construction of steam, power, and other plant utility facilities, ESI differentiates itself from more traditional A/E firms that do not have the actual construction, commissioning, and operating experience and expertise to develop comprehensive and accurate EPC capital cost estimates. ESI's business model is the procurement of commercially available technology and equipment at point of manufacture. ESI then designs that equipment into a complete and totally integrated system followed by a construction model that provides the safest and most economical construction cost. This unique business execution model allows ESI to provide the maximum value to our clients while delivering the best overall project EPC cost possible.

Additional information on ESI is included as Exhibit B to this document.

**Q. Have you testified previously before the NSUARB?**

A. No this is the first testimony I have provided before this board.

**Q. Were there any other people involved in generating background information for this testimony?**

A. Not specifically for this testimony, but ESI did produce a CHP study to identify the design basis, operating costs, and capital costs of a "generic" biomass generation facility for ANSS. As part of that effort there were two other primary contributors from ESI – Thomas Baudhuin, P.E. and James Pittman, P.E. Tom Baudhuin is the Manager of Mechanical Process Engineering for ESI and Jim Pittman is a Senior Project Engineer with ESI, both of whom have been directly involved with the detailed design and construction of biomass fired power plants.

The corporate resumes for both individuals are attached as Exhibits C & D.

**Q. On whose behalf are you providing this testimony?**

A. I am providing testimony on behalf of the Alliance of Nova Scotia Sawmillers.

**Q. What is the purpose of this testimony?**

A. The purpose of this testimony is to address the recommendations made by the Synapse Energy Economics consulting firm (and team consisting of Bruce Biewald, Wilson Rickerson, Geoff Keith, and Susan Shaw, P.E.) on behalf of Synapse for the COMFIT program. This testimony is meant to address the evidence (rationale, assumptions, and calculations) and recommendations associated with ONLY the biomass CHP portion of the program.

Ultimately, the purpose of this testimony is to help the board set COMFIT rates which will allow for viable biomass CHP projects to be built in Nova Scotia.

**Q. Please summarize your recommendations and conclusions.**

**A.** The following are general statements summarizing the more detailed explanations provided herein and in the attachments.

- i. A condensing / extracting turbine model should be most viable for small steam users than a backpressure system.
- ii. Costs for generating the steam should be split between the steam and electricity user, not 100% allocated to the steam user.
- iii. Capital cost presented by Synapse appears significantly lower than what is required to construct a complete plant and should be adjusted according to the full EPC estimate provided herein.
- iv. Non-fuel operating and maintenance expenses do not appear to be adequately accounted for in the Synapse model and should be adjusted according to the non-fuel O&M estimate provided herein.
- v. Parasitic load (power) is not considered in the Synapse model and needs to be included in final model to develop the Tariff.
- vi. Boiler efficiency is over estimated at 80% in the Synapse model and should be adjusted to 69.9% to develop true fuel costs.

## **II. Overview and General Issues**

**Q. Are you proposing flat COMFIT rates or variable rates?**

**A.** We are commenting strictly on technical and budgetary considerations. Rates will be addressed under separate testimony by ANSS.

## **III. DESIGN BASIS**

**Q. Should the facility be designed as a back-pressure or condensing / extracting system?**

**A.** As discussed in the evidence submitted by Synapse, there is no clear definition of CHP provided by NSDOE. We agree with Synapse that sawmills represent a reasonable "small user" to base the Tariff on.

Further, we agree that the Tariff will need to be based on a condensing / extracting turbine due to the fact that the sawmill dry kilns will only require full heat load approximately 60% of the time. Dry kilns require time for loading and unloading as well as maintenance. This variability in steam load will more easily be solved by condensing / extracting systems. Also, the risk for investors is higher if the turbine is only operating when the sawmill is operating (backpressure system).

1 A condensing / extracting system sized for full condensing load is more capital  
2 intensive, but provides higher revenue by operating more hours per year and  
3 provides a facility that can operate independently from the steam host.

4 **Q. How should capital cost be allocated between the electricity generated and**  
5 **steam used for process heat?**

6 A. We do not agree with the rationale that the base cost of the boiler should be  
7 borne solely by the steam host. The evidence presented by Synapse argues that  
8 the host facility would have to build the boiler either way but the same could be  
9 said of the electrical generation facility. It is my interpretation that the purpose of  
10 the COMFIT program is to encourage the generation of "renewable power"  
11 through new CHP projects sharing the cost/benefit of both steam and power  
12 generation. The Synapse argument can be made two radically different ways.

13 1. The steam host would have to build a boiler plant in order to supply steam to  
14 itself and therefore the contribution of capital carried in the electrical sale should  
15 be the difference in capital cost between the steam only plant and the CHP plant.

16 2. The power facility would have to build a boiler plant in order to supply steam to  
17 the turbine to generate electricity and therefore the contribution of capital carried  
18 by the heat user should be the difference in capital cost between the power only  
19 plant and the CHP plant. (The CHP plant would have to be larger than the power-  
20 only plant in order to extract steam for sale and produce an equal amount of  
21 power).

22 Neither of these stances appears fair based on the intent of the program to  
23 promote renewable energy. In each scenario, one user is benefiting unfairly from  
24 the base cost of the plant built by the other user.

25 Therefore we would suggest that both the steam user and electrical user should  
26 share the cost of capital and the portion of fuel that goes to producing steam. If  
27 either facility (power only or steam only) were constructed, it would bear the  
28 entire cost of generating steam which in a CHP model should be shared  
29 equitably by both.

30 In addition to the intent of the program to promote power generation, based on  
31 numerous past and current discussions with developers and lenders, no investor  
32 is going to debt finance a CHP facility where the majority of revenue is generated  
33 from the steam sale because of the risk associated with the steam host revenue  
34 disappearing during the plant's useful life. It is assumed that with a PPA in place,  
35 the power can be sold throughout the life of the facility regardless of whether  
36 steam is sold from the plant. However, even with a steam sale contract, the

revenue is only realized as long as the steam host is a viable entity. Therefore the risk profile of having the majority of plant revenue tied to steam sales will hinder projects from being developed.

**Q. What should be assumed regarding the existing facilities remaining boiler life?**

A. The existing facility boiler life should not be considered as part of the Tariff rate. Although Synapse was not successful in soliciting actual data on existing boilers in operation, it would be unreasonable to assume that steam hosts have boilers currently designed for high pressure superheated steam which they are only operating at low pressure saturated steam conditions. Therefore the scenario considered in which an existing boiler could be used for the next ten years to generate electricity in a condensing turbine is not valid.

Additionally, the board heard testimony from multiple experts in February of this year regarding the depreciation of utility assets in which those experts argued that boiler life for solid fuel boilers should be assumed to be in excess of 40 years and in some cases could be reasonably assumed to approach 80 years (summarized from separate Testimonies submitted by Jacob Pous, James T. Selecky, and Paul Chernick among others in February, 2011 regarding the Application by NSPI for Depreciation Rates). I have simplified and co-opted these arguments, but they are useful to consider here. We can reasonably assume that most, if not all, steam users in the Province have assets which they will continue to operate for the foreseeable future.

Therefore, we can reasonably assume that no existing steam host has assets matching the need for cogeneration that they are simply not using and no one is going to retire assets currently operating to build a CHP plant unless the electrical Tariff incentive covers a portion of the capital and operating costs for such an investment.

**Q. How did you size the facility?**

A. We solicited data from ANSS, which was in large part similar to what Synapse used for a design basis. We compared a backpressure facility and a condensing / extracting facility sized to export steam at 18,000 pph and 35 psia. Both boilers were designed to operate at the same pressure and temperature at the main stop valve. Obviously a higher pressure and temperature unit would produce more electricity but would also drive up the metal costs for the boiler, piping, and steam turbine. Based on our 30 years of experience in designing these facilities we settled on 615 psia / 750°F as a reasonable trade-off between capital cost and power production in the turbine.

The condensing / extracting plant was sized to provide extraction for the steam host (18,000 pph) plus extraction for the deaerator (2,300 pph) based on 95% condensate return at 170°F while maintaining enough flow through the final stages of the turbine to maintain blade cooling (4,700 pph). This represents about 25% of throttle flow, requiring roughly 5,000 pph steam flow through the final stages of the turbine. Therefore the boiler capacity was sized for 25,000 pph.

Given these steam loads for a condensing / extracting facility, we solicited actual turbine generator quotes for this facility. Based on our mass and energy balance and conservative equipment selection we believe that the facility will perform as follows (this table is simplified):

**Table I: Nominal Plant Design**

|                           |     | Normal Operation | Full Condensing |
|---------------------------|-----|------------------|-----------------|
| Throttle flow (turbine)   | pph | 25,000           | 25,000          |
| Extraction (steam host)   | pph | 18,000           | 0               |
| DA flow                   | pph | 2,300            | 3,330           |
| Condensing                | pph | 4,700            | 21,770          |
| Electrical generation (g) | kW  | 1,602            | 2,414           |

As can be seen, the electrical power produced from this facility is slightly higher than that of the approximated Synapse facility.

**Table II: Comparison of Electrical Output**

|                       |    | Normal Operation | Full Condensing |
|-----------------------|----|------------------|-----------------|
| Synapse approximation | MW | 1.55             | 2.05            |
| ESI actual equipment  | MW | 1.602            | 2.414           |

Flow sheets for the condensing / extracting case are attached as Exhibit E (condensing / extracting).

A complete design basis for the facility is included as Exhibit F.

#### **IV. CAPITAL COSTS**

**Q. How did you develop the capital costs for a generic CHP facility?**

A. ESI ran detailed mass and energy balance models for the facility. Using this information we developed specifications and solicited quotes for the major pieces of equipment from two or more manufacturers. The balance of plant equipment was cost estimated using quotes for similar equipment in ESI's extensive database (adjusted for sizing and inflation). Using a combination of vendor

1 information from new quotes and information from previous ESI projects, general  
2 arrangement drawings were generated to allow material take-offs for  
3 construction. Therefore, the EPC budget estimate was generated using  
4 information from actual vendor quotes (new and adjusted old) and take-offs for  
5 commodity and construction pricing utilizing ESI's database of biomass projects.

6 The capital cost estimate for equipment is in the  $\pm 10\%$  accuracy range for a  
7 brown-field facility with conditions similar to the assumptions we made in our  
8 study. ESI has performed biomass construction projects in Newfoundland,  
9 Quebec and Ontario along with engineering for biomass projects in Maine and  
10 New Brunswick but not in Nova Scotia – therefore we expect that the accuracy of  
11 our construction estimate is in the  $\pm 20\%$  range (allowing for variables in  
12 productivity and the possible need to bring in specialty subcontractors for small  
13 portions of the project such as boilermakers for code work).

14 However, since this is a “generic” facility with unidentified geotechnical,  
15 infrastructure, and design conditions – this overall budget should probably be  
16 considered  $\pm 20\%$  for the purposes of risk analysis. Varying conditions such as  
17 soil conditions, proximity to steam host, existing steam host auxiliary systems  
18 (such as fire protection, water supply, sewer systems, interconnect, etc.), and  
19 other factors will be unknown for this facility until a specific site is picked.

20 The total capital cost is based on an EPC model in which one entity acts as the  
21 “turnkey” provider of the facility – therefore engineering, procurement,  
22 construction, commissioning, operator training, project management,  
23 construction management, overhead, contingency (5% on equipment and  
24 construction only), and profit (8% for the EPC contractor) are all accounted for in  
25 the capital estimate.

26 This detailed estimate resulted in budget for the condensing / extracting CHP of  
27 **FIFTEEN MILLION, EIGHT HUNDRED FORTY-SIX THOUSAND, ONE**  
28 **HUNDRED FIFTY DOLLARS (\$15,846,150 CAD).**

29 The detailed estimate for both the backpressure as well as the condensing /  
30 extracting facility may be seen as Exhibit G to this document.

31 **Q. What are the apparent differences in the ESI capital estimate and the one**  
32 **provided by Synapse?**

33 **A.** The estimate given in the Testimony by Synapse was too general to draw many  
34 direct conclusions, but based on the four categories included some inferences  
35 may be drawn. We tried to group our detailed estimate into categories to

compare the two and determine where the primary differences are. There are a number of apparent differences between the two estimates as charted below:

**Table III: Capital Cost Comparison of Condensing / Extracting Facility**

| Category                         | Synapse      | ESI         | Delta     |
|----------------------------------|--------------|-------------|-----------|
| <b>Boiler Installed Cost</b>     | 3,057,600    |             |           |
| Foundations                      | assumed incl | 472,921     |           |
| Steel                            | assumed incl | 660,210     |           |
| Boiler                           | assumed incl | 1,718,000   |           |
| Fans                             | assumed incl | 130,041     |           |
| Startup Burner                   | assumed incl | 85,000      |           |
| Flues & Ducts (incl Stack)       | assumed incl | 268,735     |           |
| <b>SUBTOTAL</b>                  | 3,057,600    | 3,334,907   | 277,307   |
| <b>Emissions Controls</b>        | 305,760      | 758,000     |           |
| <b>SUBTOTAL</b>                  | 305,760      | 758,000     | 452,240   |
| <b>Turbine Installed Cost</b>    | 2,894,528    | 3,712,100   |           |
| Condenser / Cooling Tower        | 1,630,720    | Incl w. STG |           |
| Electrical Equipment             | assumed incl | 490,466     |           |
| <b>SUBTOTAL</b>                  | 4,525,248    | 4,202,566   | -322,682  |
| <b>Material Handling Systems</b> | 0            |             |           |
| Receiving & Storage              | 0            | 399,420     |           |
| Conveying                        | 0            | 574,600     |           |
| Misc                             | 0            | 141,705     |           |
| Ash Handling                     | 0            | 30,000      |           |
| <b>SUBTOTAL</b>                  | 0            | 1,145,725   | 1,145,725 |
| <b>Balance of Plant</b>          | 0            |             |           |
| Sewer                            | 0            | 19,500      |           |
| HVAC                             | 0            | 47,000      |           |
| Pre-eng building                 | 0            | 396,356     |           |
| Painting                         | 0            | 70,821      |           |
| Fire Protection                  | 0            | 90,690      |           |
| Water Treatment                  | 0            | 189,650     |           |
| Storage Tanks                    | 0            | 78,385      |           |
| Air Compressors                  | 0            | 77,700      |           |
| Pumps                            | 0            | 188,464     |           |
| <b>SUBTOTAL</b>                  | 0            | 1,158,566   | 1,158,566 |
| <b>Commodity Construction</b>    | 0            |             |           |
| Piping & Valves                  | 0            | 502,037     |           |
| Insulation & Lagging             | 0            | 47,322      |           |
| Control System                   | 0            | 693,010     |           |
| Instrumentation                  | 0            | 315,790     |           |

|                                    |          |                  |                  |
|------------------------------------|----------|------------------|------------------|
| Construction Expenses              | 0        | 594,138          |                  |
| Commercial                         | 0        | 57,450           |                  |
| Construction Contingency           | 0        | 776,622          |                  |
| <b>SUBTOTAL</b>                    | <b>0</b> | <b>2,986,369</b> | <b>2,986,369</b> |
| <b>Engineering &amp; Proj Mgmt</b> | <b>0</b> | <b>715,060</b>   |                  |
| <b>Construction Mgmt</b>           | <b>0</b> | <b>277,268</b>   |                  |
| <b>EPC Profit</b>                  | <b>0</b> | <b>1,267,692</b> |                  |
| <b>SUBTOTAL</b>                    | <b>0</b> | <b>2,260,020</b> | <b>2,260,020</b> |

|                              |                  |                   |                  |
|------------------------------|------------------|-------------------|------------------|
| <b>TOTAL PROJECT CAPITAL</b> | <b>7,888,608</b> | <b>15,846,150</b> | <b>7,957,545</b> |
|------------------------------|------------------|-------------------|------------------|

I do not mean to imply that Synapse disregarded every item by which there is a zero - I think the implication is that there are probably some categories which were not considered and others which were undervalued. In particular, based on the estimate in their testimony, I would guess that they did not consider the material handling systems, water treatment systems, building, plant controls system & instrumentation, and construction expenses (which include the crane, trailers, equipment, welding machines, etc.).

In addition it appears that the contingency, engineering, project management, construction management, and EPC profit were not considered. These services are required for every project of this type and must be considered in the capital cost as they will be incorporated into the construction loan.

A detailed scope of work provided in the ESI capital estimate is included as Exhibit H (condensing / extracting).

A site plan for a generic CHP plant used to generate take-offs for construction is included as Exhibit I (condensing / extracting).

**Q. Using the ESI capital estimate and the Synapse costs for financing, what would be the CHP cost for consideration on a \$/MW basis?**

**A.** The new "total cost" including the financing costs as estimated by Synapse would be \$19,050,135 CAD. Utilizing the plant size of 2.414 MW (at full condensing) - this results in a relative cost for the facility of 7,892 \$/kW.

**V. OPERATING COSTS**

**Q. What is the assumed availability of the facility?**

A. Synapse considered an availability of 85% (60% at full extraction and 25% at full condensing). Based on dozens of facilities we have constructed over the last 30 years, we would expect to construct a biomass CHP with an availability of 90% of which 60% of the time would be full extraction and 30% would be considered full condensing.

We recommend using a 90% availability rate for consideration of this TARIFF. This puts impetus on the operator to maintain the facility which will provide higher availability and longer facility life.

**Q. What is the calculated steam usage of the facility?**

The steam usage of the condensing / extracting facility will include the steam to the process host, the steam used in the deaerator, and the steam used in turbine blade cooling in the last turbine stages (approximately 25% of throttle flow). This equates to a 25,000 pph boiler design. The extraction steam flow to the host facility (18,000 pph) is assumed to be returned as condensate at a rate of 95% and 170°F.

We chose to utilize only one feedwater heater in the system (the deaerator is a low pressure contact heater) based on quick calculations to determine increased efficiency of the heater cycle versus increased capital cost in the turbine (additional extraction), piping, feedwater heater, and decreased electrical generation (for the same throttle flow). The ROI for installing an additional feedwater heater is not high enough to consider for this type facility.

**Q. What is the calculated electrical usage of the facility?**

A. The CHP facility will utilize a portion of the power it generates which is known as "parasitic loss". This power is used for the fans, pumps, motors, lights, etcetera in the CHP facility. Based on an analysis of the motors and miscellaneous electrical loads this loss is calculated to be 348 kw for the condensing / extracting facility. This number represents 14.4% of the generation when fully condensing and 21.7% of the power generated when in full extraction operation.

As best we can tell, this is not considered in the Synapse calculations.

**Q. What are the apparent differences between the expected non-fuel O&M costs of the Synapse estimate and ESI estimate?**

A. The Synapse model considers most of the non-fuel operating expenses between a steam only plant and the CHP to be zero, however, simply by operating the condensing / extracting plant for 7,884 hpy versus 5,256 hpy for the steam only plant (90% versus 60%) – we know that there will be some difference in O&M costs.

Here is a comparison of what ESI projects to be the non-fuel operating and maintenance costs associated with the facility (net of a steam-only facility):

**Table IV: Non-fuel O&M Cost Comparison of Facility**

|                                   | Synapse<br>Model | ESI<br>model | \$/unit         |           |
|-----------------------------------|------------------|--------------|-----------------|-----------|
| Power Cost (\$000/yr) - parasitic | 0.0              | 102.9        | 0.08822         | \$/kw     |
| Water Cost (\$000/yr)             | 0.0              | 30.5         | 1.00            | \$/000gal |
| Chemical Cost (\$000/yr)          | 0.0              | 13.7         | 0.45            | \$/000gal |
| Sewer Cost (\$000/yr)             | 0.0              | 0.1          | 0.30            | \$/000gal |
| Landfill Cost (\$000/yr)          | 0.0              | 13.4         | 15.00           | \$/ton    |
| Maintenance Cost (\$000/yr)       | 93.7             | 98.2         | 10.5            | \$/eqMWh  |
| <b>SUBTOTAL</b>                   | <b>93.7</b>      | <b>259.0</b> | <b>\$000/yr</b> |           |

The parasitic power losses for a generating plant are higher due to the larger plant size and the extra motors (hotwell pumps, cooling tower fans, cooling water pumps, etc.).

The water costs for the generating plant are higher because of the make-up required for the cooling tower evaporation and blowdown.

The water treatment chemical costs will be higher because of the addition of anti-scalant in the condenser loop and the biocide for the cooling tower basin.

The Sewer costs are essentially the same.

The landfill costs will be higher because of the additional fuel burned (ash in fuel plus unburned carbon).

The maintenance cost will be higher due to the additional equipment including the amortized price of the turbine generator overhaul.

Operating labor obviously constitutes another area for review in the non-fuel O&M costs. The operating labor will be addressed in separately submitted testimony based on the certifications required for operators of this type facility and actual salary plus benefits analysis being conducted by ANSS.

**Q. What is the calculated boiler combustion efficiency?**

A. The number utilized by Synapse is 80% which is more indicative of natural gas or coal fired facilities than woody biomass fired facilities. Because there is so much more water in the fuel (of typical green wood) that must be evaporated in combustion, the efficiency of wood boilers can only approach that of other fuels if this moisture is removed prior to use in the boiler (requiring energy from somewhere else). Using a more accurate efficiency for woody biomass boilers will dramatically impact the calculation for fuel usage.

There are two primary methods used to calculate the design boiler efficiency and both use completely different approaches to the calculation. One method is an additive method where all of the sources which can add energy to the system are calculated and “added” up. The second and more familiar method is known as the Loss Method where the calculation starts with a theoretical boiler efficiency of 100% and subtracts all major calculated losses. ESI uses both when designing boilers and used both to analyze this application utilizing the design fuel analysis. The two methods converged to yield a result within 0.1% of each other giving us high confidence that when burning the design wood fuel with 50% moisture content the following summary is correctly predicting design boiler efficiency:

**Table V: Loss Method Boiler Efficiency Calculation**

|                                                |       |
|------------------------------------------------|-------|
| Dry Gas Loss (%) - assume 325°F stack exit     | 6.29  |
| Hydrogen and Moisture in Fuel (%) – 50%MC fuel | 20.33 |
| Moisture in Air (%) – 55% relative humidity    | 0.15  |
| Unburned Combustibles (%)                      | 1.01  |
| Sorbent Losses (%)                             | 0.00  |
| Radiation Losses (%)                           | 1.39  |
| Manufacturer's Margin (%)                      | 1.00  |
| Total Heat Loss (%)                            | 30.17 |
| Boiler Efficiency (%)                          | 69.83 |

Therefore we would recommend using a boiler combustion efficiency of 69.9% to calculate the fuel contribution to O&M costs.

**Q. Does this conclude your testimony?**

A. Yes.



*Design/Build Engineers & Contractors  
Specialists in Steam and Cogeneration Systems*

**ESI Inc. of Tennessee**  
1250 Roberts Blvd  
Kennesaw, GA 30144  
Phone: 770-427-6200  
Fax: 770-425-3660  
[www.esitenn.com](http://www.esitenn.com)

# Exhibit A – Resume for Patrick Mitchell Hayes

**PATRICK MITCHELL HAYES, P.E.**

**POSITION:** **MANAGER OF SALES**

**EDUCATION:** Bachelor of Science in Marine Engineering Systems  
United States Merchant Marine Academy

Masters of Business Administration  
Georgia State University

**RESPONSIBILITIES:** Manager of Sales Engineering and Proposals

**EXPERIENCE:**

- In 2005, Mr. Hayes was promoted to Manager of Sales. In this position, Mr. Hayes is responsible for the conceptual engineering, estimating and consulting services produced by ESI. His group is responsible for the generation of sales proposals, engineering studies, and EPC project development.
- From 2002-2005, Mr. Hayes Served as a Project Manager for the design and construction of steam and power generating facilities. In this capacity he was responsible for overall project success including: all project costs; scheduling and coordination of engineering and construction activities; primary interface with customer, manufacturers, and subcontractors; supervision of construction management and field engineering; and facility commissioning and operator training.
- Mr. Hayes moved to the Sales Department in 2000 as a Project Development Engineer. In this position, Mr. Hayes was responsible for the generation of budget and firm price proposals and/or performing engineering studies. These activities required initial engineering, equipment sizing, layout design, cost estimation, and proposal writing.
- In 1998 Mr. Hayes moved into a position in the Mechanical Engineering department where he was responsible for performing design calculations for equipment, piping, ductwork and mass & energy balances; specifying and selecting equipment; as well as generating P&ID's, GA's, and other design documents.
- Mr. Hayes was the Field Superintendent for several projects for ESI, where he was responsible for all aspects of the erection portion of the project. Completed projects include: a 120,000 pph turbine test facility for Demag-Delaval in Trenton, New Jersey and a 240,000 pph steam system for Occidental Chemical in Pottstown, Pennsylvania.
- Mr. Hayes joined ESI as a Field/Start-Up Engineer in 1993 and worked on a wide variety of projects including wood, gas/oil, and coal-fired boiler plants, various water treatment systems, and solid fuel handling systems. Responsibilities included: construction supervision, field design work, commissioning, tuning of system, and operator training.
- Mr. Hayes holds a U.S. Coast Guard 3rd Assistant Engineer operating license and is a Lieutenant Commander in the United States Naval Reserve.



*Design/Build Engineers & Contractors  
Specialists in Steam and Cogeneration Systems*

**ESI Inc. of Tennessee**  
1250 Roberts Blvd  
Kennesaw, GA 30144  
Phone: 770-427-6200  
Fax: 770-425-3660  
[www.esitenn.com](http://www.esitenn.com)

# Exhibit B – Standard Qualifications Package for ESI



# Qualifications Package

**Prepared by**  
**ESI, INC. OF TENNESSEE**  
**December 2010**

**ESI Inc. of Tennessee**  
*1250 Roberts Boulevard*  
*Kennesaw, GA 30144*  
*Phone: 770-427-6200 Fax: 770-425-3660*  
*Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)*

## Table of Contents

|                                        | <b>PAGE</b> |
|----------------------------------------|-------------|
| <b>Company Overview</b>                | <b>2</b>    |
| <b>Company History</b>                 | <b>3</b>    |
| <b>Corporate Mission</b>               | <b>6</b>    |
| <b>ESI <i>SPECIAL FORCES</i>®</b>      | <b>7</b>    |
| <b>Representative Client List</b>      | <b>8</b>    |
| <b>Design and Engineering Approach</b> | <b>9</b>    |
| <b>Purchasing Approach</b>             | <b>11</b>   |
| <b>Construction Approach</b>           | <b>12</b>   |
| <b>Certifications</b>                  | <b>14</b>   |
| <b>References</b>                      | <b>15</b>   |
| <b>Personnel Resumes</b>               | <b>20</b>   |
| <b>Project Experience</b>              | <b>33</b>   |

## Company Overview

ESI Inc. of Tennessee is a design engineering and construction firm that specializes in the engineering, procurement, and construction (EPC) of steam and power facilities. As the Special Forces™ of the steam and power business, ESI brings innovative, cost effective, and environmentally friendly solutions to its clients steam and power needs.

ESI has a long list of repeat Fortune 500 industrial and utility clients for whom ESI has performed projects. ESI continues to service many of these clients by performing all their steam and power projects using a negotiated open book approach. ESI services include the design, engineering, procurement, construction, start-up, operator training, and providing rental equipment for steam, power, and utility facilities. ESI has registered professional engineers in all disciplines; therefore, we perform 100% of design engineering “in-house”.

Since ESI’s primary business is the design and construction of steam, power, and other plant utility facilities, ESI differentiates itself from more traditional engineering firms that do not have the actual construction experience and expertise to develop comprehensive and accurate EPC capital cost estimates. ESI’s business model is the procurement of commercially available technology and equipment at point of manufacture. ESI then designs that equipment into a complete and totally integrated system followed by a construction model that provides the lowest possible construction cost. This unique business execution model allows ESI to provide the maximum value to our clients while delivering the best overall project EPC cost possible.

ESI is committed to meet and exceed the expectations of our customers regardless of the size or project location. Our business focus is not to sell engineering services, but to help clients move projects from development to reality by providing whatever value added services they require.

ESI is privately owned by the Senior Management Team and we own and occupy our own 30,000 square foot office building located in Kennesaw, Georgia, an Atlanta suburb. ESI also owns and operates its own private aircraft which expedites our ability to service our customers.

Following is ESI contact information:

ESI Inc. of Tennessee  
1250 Roberts Blvd.  
Kennesaw, Georgia

Phone – (770) 427-6200  
Fax – (770) 425 3660  
Website – [www.esitenn.com](http://www.esitenn.com)

## Company History

With over 30 years of company growth and developing successful business relationships, we are often asked about the background and history of ESI.

The ESI of today has evolved to be known as the Steam & Power *SPECIAL FORCES®* providing clients with innovative, cost-effective, and environmentally-friendly solutions.

### 1978

ESI began in 1978 in Chattanooga, Tennessee, addressing the need to reduce client utility cost by performing the conversion of industrial clients from firing natural gas and oil to coal.

### 1980-1989

In the early 80's, the dramatic difference in energy fuel costs between gas/oil and coal provided a substantial economic driving force for these conversion projects. In the mid 80's, the drop in gas/oil prices and more stringent environmental regulations essentially ended the coal conversion business.

In 1984, ESI relocated its offices to Atlanta for strategic growth reasons.

Through the 80's, ESI transitioned our business to performing gas/oil, wood waste, plant waste, and other alternative fuel projects. Our primary business evolved into performing major modifications to existing wood-fired boilers. During that time, most operating wood-fired boilers had been installed over the previous three decades by companies in the forest product industry. These boilers were actually coal-fired designs installed to incinerate wood waste generated in production. Subsequently, these boiler designs were very inefficient in burning wood waste. In the 80's, clients began focusing on taking advantage of the energy value of this waste wood, as well as responding to increasing environmental pressures to operate with reduced emissions.

ESI performed several wood-fired boiler enhancement projects which consisted of adding water-cooled surface, installing complete new front walls, designing and installing state-of-the-technology fuel feed and overfire air systems, installing lower maintenance water-cooled stokers, etc. These modifications improved combustion efficiency, increased steam capacity, and eliminated emission problems that allowed these customers to delay installing new boiler capacity and other environmental equipment projects. We were successful in making wood-fired wood fired power boilers track plant process load swings without the need to combination fire more expensive gas and oil with wood waste.

In the late 80's, ESI purchased the license to the Bahco bark drying technology, which complemented other technologies to improve wood-fired boiler operations. We actively began performing projects in the pulp and paper industry, which included handling and disposal of paper mill sludge. ESI's broad handling experience with difficult materials, such as waste wood, paper mill sludge, and other plant waste materials, has been a fundamental capability that has brought clients to ESI to apply that expertise in specialized applications.

**1990-1999**

In the 90's, ESI was involved in several projects that represented both first-of-a-kind applications and emerging commercial technologies. These projects included:

- A paper mill sludge conversion facility that receives, handles, dries, and converts 1300 tons per day of 60% moisture content paper mill sludge into steam, power, and a glass aggregate product for commercial sale.
- A carbon burn-out facility that reduces the high carbon content of utility fly ash caused by low NOx burner conversion while simultaneously recovering the energy into the utility boiler heater cycle.
- The recommissioning and retrofit of a chemical recovery boiler with an open bottom bubbling fluid bed technology to increase steam capacity while simultaneously burning paper mill sludge, wood waste, and tire-derived fuel.
- A power boiler retrofit to process and burn 3% solids paper mill sludge in suspension along with conventional fossil fuels.

**2000-Present**

With the beginning of a new millennium, ESI has taken great strides in the proliferation of its business into the utility and power generation industry. Recent ESI projects include:

- Complete equipment specification and design engineering responsibilities for a 37 MW wood waste-fired central heating plant facility and utility station. This facility complements an existing coal-fired downtown central heating plant for a major Midwest city.
- Design and construction of a new combined cycle facility for a pulp and paper customer located in the northeast. This new facility includes a new 7 MW combustion turbine, fresh air-fired HRSG, plant peak load shedding system, and the retrofit of a 6 MW double controlled extraction condensing steam turbine generator with state-of-the-technology controls.
- Design and construction of a second carbon burn-out facility for a major southeast utility. This facility processes 210,000 tons per year of high carbon fly ash producing a high quality fly ash with superior qualities in the manufacture of pozzolan cement. The successful commercial application of this carbon burn-out technology at two facilities has resulted in the consideration of several new facilities to be designed and constructed throughout the eastern US.
- Design and construction of a new 1,100,000 pph coal/pet coke/natural gas-fired facility. The facility includes a field-erected circulating fluid bed boiler and all necessary auxiliaries to provide 650 psig/750°F superheated steam to the plant process.

- Design and construction of a new 20 MW biomass and TDF fired bubbling fluidized bed boiler system in the Southeast. This facility is comprised of two BFB boilers, steam turbine generator, fuel storage, processing and handling systems, and all auxiliaries to act as a power and steam producing co-gen facility for the neighboring host.
- Design and construction for the conversion of two pulverized coal fired boilers to biomass firing for the production of 400,000 pph of steam and approximately 50 MW of power using existing turbine assets. This conversion includes a complete new fuel handling system, modifications of the furnace for biomass firing on a grate, modifications of the gas path including new economizer and air heaters, and upgrades to the ash handling system.
- Design and construction management for a new 30MW cogen biomass fired boiler system in the Eastern US. This facility included a 325,000 pph circulating fluidized bed boiler system and all auxiliaries to generate 30MW of electricity and supply the host facility with process steam.
- Design of a new 200,000 ton per year wood pelletizing facility in the Southeastern United States. This facility receives virgin wood to dry and pelletize for sale to the European pellet market.

### **2010 and Beyond**

As we enter this next decade, ESI will continue to focus on renewable energy projects and the cutting edge of environmental compliance technologies to remain a world leader in environmentally friendly industrial and utility power projects. This includes the recent entry into solving client plant waste and waste water problems through state-of-the-art waste water treatment plant and renewable energy integrated solutions.

In addition to executing exciting new projects, ESI will continue to refine our engineering, procurement, construction, start-up, and operator training practices and quality assurance to remain a leader in our market.

We have many fond memories of our company history, but probably none better than the opportunity to develop many close business and personal relationships with our customer representatives. We truly owe our success to your faith in our abilities, the opportunity you have given us to serve you, and your unending support. Thanks to all of you from all of us at ESI. We look forward to writing more chapters in our company's history.

## Corporate Mission

Our corporate mission is:

**TO CREATE THE HIGHEST LEVEL OF CLIENT AND EMPLOYEE SATISFACTION WHILE PROVIDING INNOVATIVE, COST-EFFECTIVE, AND ENVIRONMENTALLY-PROVEN SOLUTIONS TO CLIENT NEEDS.**

We believe our success is founded in our CORE VALUES & OPERATING CODE OF ETHICS AND STANDARDS. Every business has a definite culture that defines the character not only of the corporation, but of the individuals that make up the whole. ESI's company culture is defined by the core values that govern our behavior. The core values by which we measure all our efforts are:

|                   |                   |                        |                       |
|-------------------|-------------------|------------------------|-----------------------|
| <b>Integrity</b>  | <b>Teamwork</b>   | <b>Performance</b>     | <b>Customer Focus</b> |
| <b>Innovation</b> | <b>Excellence</b> | <b>Personal Growth</b> |                       |

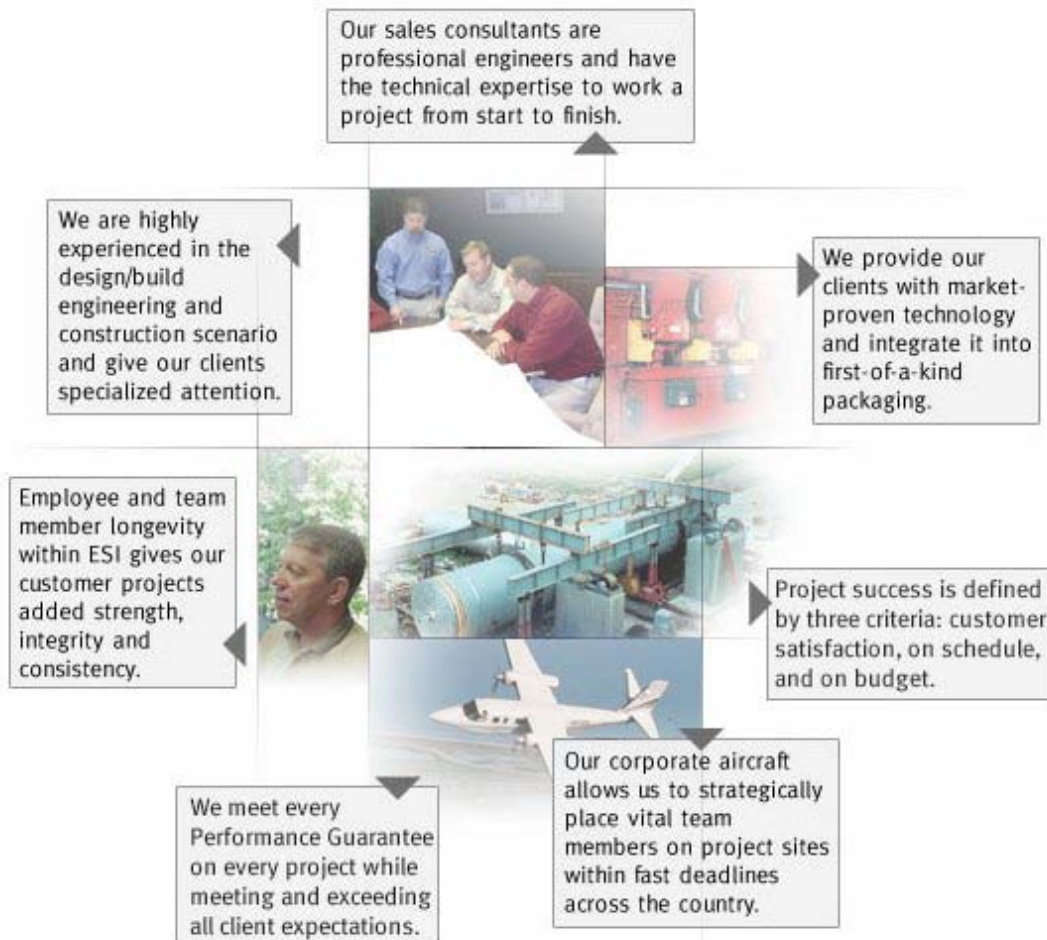
ESI can only be successful through the empowerment of its managers and associates to execute their job responsibilities to the best of their individual and collective abilities. Following is the operating code of ethics and standards which ESI follows:

- We will build personal relationships with our clients founded upon honesty and mutual respect and trust.
- We will preserve human dignity by conducting ourselves in a manner to afford respect and care for other associates, clients and vendors.
- We will only make commitments to an associate, client, or vendor which we intend to keep and/or fulfill to the best of our ability.
- We will ensure that all our work product and efforts conform with company standards and procedures.
- We will immediately seek confirmation, help, and/or understanding when we are lacking proper experience, are unsure, or confused.
- We will confirm rather than assume.
- We will never attempt to cover up. Instead, we will announce problems or mistakes immediately upon discovery so that we can mitigate damage by collectively attacking the problem with all the necessary resources and experience.
- We will utilize company and client resources in a manner consistent with the utilization of our own personal resources.
- We will never request or expect someone to do anything that we are unwilling to do ourselves. Conversely, we are committed to do those things we request or expect of others.
- We only succeed or fail collectively as a team. Therefore, we will work as a team and pledge to do our part while encouraging and helping our fellow teammates who are struggling to get their part done.
- We will strive to make our work place a fun place to work.

## ESI SPECIAL FORCES®

What makes ESI the *SPECIAL FORCES*® of the steam and power industry and how does it benefit our clients?

The United States military "special forces" have long been known for their quick and precise execution of the most difficult missions using elite, carefully selected, and highly trained professionals. ESI has applied these same principles regarding careful selection and extensive training of elite professionals, precise execution, and efficient use of time as extraordinary benchmarks for quality and customer satisfaction. We are the Steam & Power *SPECIAL FORCES*®.



## Representative Client List

The development of long-lasting client relationships is of strategic importance to ESI and can only be accomplished through mutual trust, respect, and exceeding client expectations.

Following is a representative partial client list:

- Alabama River Pulp Company
- Anheuser-Busch, Inc.
- Appleton Papers, Inc.
- Babcock & Wilcox Company
- Bayer Corporation
- Bear Island Paper Company, LLC
- Bowater Newsprint
- Celanese Acetate
- Chrysler Capital
- Cognis Corporation
- Consolidated Edison
- Corn Products International
- Corner Brook Pulp & Paper, Ltd.
- Demag Delaval
- Dominion Energy
- Dow Chemical
- Dow Corning
- DTE Energy Services
- Duke Energy
- DuPont – Teijin Films
- Dynegy Northeast Generation, Inc.
- Emory University
- Exxon/Tampella Power Corporation
- Finch, Pruyn, & Company, Inc.
- First Energy
- Fraser Papers
- Frito-Lay
- GlassPack, LLC
- Green Bay Packaging
- H.J. Heinz Company
- International Paper
- Jack Daniel Distillery
- Kemira, Inc.
- Kimberly Clark Corporation
- LTV Steel Company
- MeadWestvaco Corporation
- Merck & Company, Inc.
- Miller Brewing Company
- Minergy Neenah, LLC
- Occidental Chemical
- Owensboro Municipal Utilities
- Packaging Corporation of America
- Procter & Gamble
- Progress Energy
- Rohm & Haas
- Roquette America
- Russell Corporation
- Santee Cooper
- Sonoco Chemicals
- South Carolina Electric & Gas
- St. Paul Cogeneration, LLC
- Trigen-Cinergy Solutions
- U.S. Alliance
- Union Carbide Corporation
- United Development Group
- Wausau Papers
- WestPoint Stevens
- Weyerhaeuser Company

## Design and Engineering Approach

When ESI performs the design and engineering for a project, we carefully research and select the appropriate equipment and meticulously design our projects as if we were designing and constructing our own facility using our own funds. This translates into a high level of project quality, integrity, and consistency as well as only incorporating features in the design which we would be willing to purchase ourselves.

Our project execution strategy is to assign a team of highly trained engineers from each engineering discipline to the project under the leadership of a project manager. ESI is committed to the project management concept, where an individual with comprehensive and broad experience in steam and power plant technology is assigned to be responsible for providing overall direction of the project. Our project managers have many years of experience in the design, engineering, construction, and start-up of all types of steam and power plant equipment; including boilers, solid fuel and waste-handling systems, ash-handling systems, turbine-generators, and related equipment.

The ESI project manager is the prime focus and liaison between ESI and the client. All project managers report directly to the Chief Operating Officer (COO). This assures clients that top management attention will always be focused on their project. ESI's top management firmly believes that a successful project requires a constant check and balance by all personnel of the organization, thereby producing a successful project with a minimum of design, construction, and/or operational problems.

Within our ESI specialized teams, we have registered professional engineers in Architectural, Civil/Structural, Chemical, Electrical, Instrumentation & Controls, and Mechanical engineering. This is a major benefit for our client projects because all of our design engineering is done "in-house" under close supervision, including every aspect of the project, from site work to final emissions compliance measuring equipment. We also use the same engineers that design the systems to perform their initial start-up and operation. This ensures design sensitivity to the needs of operating and maintenance personnel including items such as maintenance access or the location of control valves, transmitters, or other access-critical components.

ESI will provide the client with every opportunity to review both preliminary and final design information prior to completion and issuance of the construction drawings and specifications. This will assure the client's representatives that specific requirements are being met and included in the design.

During detailed design, regular communication will be maintained with the client's representatives. This will assure the client of continued involvement in the design process and also assure the client that specific plant and corporate requirements are included.

Detailed design activities typically include:

- Final equipment sizing.
- Final equipment specifications.
- Finalization of client design criteria and requirements.
- Preparation of P&IDs.
- Preparation of electrical one-line diagrams.
- Preparation of control logic diagrams.
- Preparation of piping drawings.
- Preparation of construction drawings for mechanical, electrical, and civil/structural aspects of the work.
- Finalization of vendors for all equipment and materials.
- Issuing contracts and purchase orders for equipment and materials.
- Expediting of vendor information including drawings.
- Vendor expediting and equipment surveillance.
- Preparation of operating instructions and plant data manual.
- Preparation of construction specifications.
- Design constructability review.
- Preparation of test procedures.

From our successful 30 plus years of experience in the design and construction of steam and power generation facilities, we have been able to identify crucial project specifications that ultimately have a major impact on performance, reliability, and maintainability.

## Purchasing Approach

As steam and power system integrators, ESI purchases all specialty materials and equipment directly from the source of manufacture. Unlike our competitors who typically purchase complete systems, ESI is able to add value by avoiding double mark-up on equipment purchases and pass those savings on to our customers.

For example, instead of purchasing a solid fuel-fired boiler system from inlet chute to stack from a boiler manufacturer, ESI typically only purchases drums, tubes, and casing from the boiler manufacturer. We then purchase our own economizer, air heater, fans, firing equipment, ducts and breeching, trim, and support steel directly from the source of manufacture.

ESI obtains performance guarantees from each individual equipment manufacturer. We then wrap all these guarantees together to offer our client a single source performance guarantee. Because steam and power is all we do, ESI is able to get favorable OEM pricing from many of the industry leaders in the manufacturer of steam and power equipment. Again, these savings are passed to the customer. ESI purchases equipment from virtually every major manufacturer. We have no alliance to a particular vendor for a particular application. Since we have no contractual ties to equipment suppliers, we are able to select the best equipment and technology for the application. This provides the customer with the highest quality facility for the best price.

## Construction Approach

On each of our EPC projects, ESI serves as the general contractor, subcontracting as much as possible with local contractors in the project area. ESI's design group prepares multiple, specific bid packages for each phase of construction. Since each design and engineering project is never the same, the specific bid package is totally customized per the exact specifications of the project. In this management scenario we can truly act as the customer's representative on the construction site, demanding high quality from our subcontractors. This construction execution methodology truly eliminates conflicts of interest generally associated with design/build.

We see construction management as a vital part of a total EPC solution. We purchase all of the specialty equipment, perform the design engineering, and place on-site experienced professionals who can manage the construction of a steam and power facility. We then recruit and utilize the very best skilled and productive crafts people in a given project area who are already working for the local subcontractors. ESI's project execution approach is focused toward tapping an existing productive, strong local talent resource.

While on-site, the field staff is responsible for all construction trade subcontractors and the implementation of ESI's construction quality control and safety procedures, assuring construction compliance with ESI and vendor design drawings and specifications.

After award of contracts for trade subcontractors, the field construction staff is responsible for the day-to-day management, supervision, and administration of all trade subcontractors. Specifically, ESI's field construction staff is responsible for the following during the construction phase:

- Review and award of trade subcontracts.
- Receipt and verification of all materials and equipment.
- Orderly storage of materials and equipment on-site.
- Implementation and monitoring of ESI's Jobsite Safety Program.
- Communication and interfacing with client's staff as required.
- Liaison and communication with ESI's home office staff regarding overall project status.
- Monitoring and review of subcontractor performance to assure compliance with drawings and specifications.
- Implementation and monitoring of ESI's Jobsite Quality Control Program to assure that the work being performed is to the highest level of quality consistent with design requirements.

- Field accounting, including approval of subcontractor invoices for payment (by the home office).
- Issuing of field purchase orders for miscellaneous materials and supplies.
- Preparation of weekly work schedule reports, including schedule updates and analysis of subcontractor performance.
- Coordination and interfacing between all trade subcontractors.
- Providing direct construction supervision to all trade subcontractor superintendents.
- Implementation and monitoring of the site security program consistent with ESI and the client's requirements.
- Supervision and coordination of system checkout, testing, and start-up activities.
- Coordination of vendor service and start-up personnel regarding the initial checkout and start-up of vendor- supplied equipment.
- Supervision of the overall plant start-up and operator training program.
- Demonstration of performance of the system.
- Implementation of ESI's Drug Testing Program applied to all ESI and subcontractor personnel.

Our on site field staff is augmented as required to maintain high quality installations by frequent visits from our project manager and engineering department members. These visits close the loop on the project by ensuring that the installation is being performed based on the intent of the design as well as providing valuable feedback on design features so improvements can be made on future projects.

## Certifications

The ESI management team encourages professional and industry certification efforts by our associates. It is through these vital associations and organizations that companies can maintain higher performance and quality standards from company team members. We are strongly committed to supporting these important industry safety and performance certifications.

National and State certifications allow us to complete our "EPC" style approach by keeping all of our engineering "in-house" and guaranteeing our customers the expertise needed for today's multifaceted engineering projects.

We currently hold Certificates of Authorization for the ASME "S" and "PP" stamps and the National Board "R" stamp. These stamps enable us to perform all types of boiler assembly, modifications, repairs and balance-of-plant piping.

ESI also has licensed Professional Engineers in all disciplines including Civil/Structural, Chemical, Electrical, Controls, and Mechanical engineers who are currently registered in most states and provinces in Canada. We continue to register in more states and provinces as we grow and are increasing our number of registered Professional Engineers each year.

## **Project Experience**

The following Project Sheets demonstrate some of the unique projects performed by ESI as well as provide a broad overview of ESI's experience and expertise with many different technologies and project applications.

# St. Paul Biomass Cogeneration Power Plant



## 37 MW Wood-Fired Power Generation Facility

### ■ Owner:

Trigen-Cinergy Solutions

### ■ Project Location:

St. Paul, Minnesota

### ■ Project Completion:

December 2002

### ■ Project Description:

ESI was the engineer for this 37 MW wood-fired power generation facility. The facility included a field-erected wood-fired boiler designed to provide 1200 psig/950°F superheated steam to a nominal 37 MW steam turbine generator. A portion of the 325,000 pph of steam is utilized to provide hot water to the St. Paul Central Heating Plant. Also included was a complete material storage and handling system, ash storage and handling system, reverse osmosis water treatment system, deaerator, boiler feedwater pumps, SNCR system, precipitator, continuous emission monitoring system, Westinghouse distributed control system, and a new 50,000-gallon capacity #2 fuel oil tank. This system was housed in a new engineered structural steel building.



### ESI Inc. of Tennessee

1250 Roberts Boulevard

Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# Cognis Water Treatment Facility



## 1300 GPM Countercurrent Fluidized Bed Demineralization System

■ **Owner:**

Cognis Corporation

■ **Project Location:**

Cincinnati, Ohio

■ **Project Completion:**

January 2001

■ **Project Description:**

ESI was the engineer and construction manager for the installation of a new 1300 gpm countercurrent fluidized bed demineralization system. This facility utilizes state-of-the-art technology to minimize the operating cost while providing the purest water available. Raw water is supplied to the demin plant from a storage tank via forwarding pumps. Water flows from the cation to the decarbonator and into the anion units before finishing in the demin water storage tank. From here demin water pumps supply treated water to the process. This system replaced the existing hot lime water treatment system which treated water for the entire facility.



**ESI Inc. of Tennessee**

1250 Roberts Boulevard

Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# Wausau Papers Cogeneration Facility



## 7.5 MW Cogeneration Facility

- **Owner:**

Wausau Papers

- **Project Location:**

Groveton, New Hampshire

- **Project Completion:**

May 2002

- **Project Description:**

ESI was the EPC Contractor for this 7.5 MW natural gas-fired cogeneration facility. This facility included the installation of a new 7.5 MW Solar combustion turbine coupled to a new fully fired 170,000 pph heat recovery steam generator designed to produce 450 psig/600°F superheated steam. The project also included the controls upgrade of an existing 6 MW steam turbine that is now driven by the new HRSG. The entire powerhouse including the new equipment, the existing steam turbine, and a 200,000 pph natural gas and #6 fuel oil back-up boiler were upgraded to a new ABB/Bailey distributed control system. All new equipment was housed in a new engineered metal building.



### ESI Inc. of Tennessee

1250 Roberts Boulevard

Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# Corn Products Steam Facility



## 1,100,000 PPH Coal-Fired Steam Facility

- **Owner:**

Corn Products International

- **Project Location:**

Bedford Park, Illinois

- **Project Completion:**

December 2006

- **Project Description:**

ESI is performing the engineering, procurement, and construction management (EPCM) for this 1,100,000 pph coal/pet coke/natural gas-fired facility. The facility will include a field-erected circulating fluid bed boiler designed to provide 650 psig/750°F superheated steam to the plant process. The facility will also include complete coal and pet coke material receiving, storage and handling systems, ash storage and handling systems, limestone receiving, storage and handling systems, boiler feedwater pumps, SNCR system, air pollutant emission control systems, continuous emission monitoring system, Foxboro distributed control system, and a new 250-foot dual-wall stack. This system will be housed in a new engineered structural steel building.



### ESI Inc. of Tennessee

1250 Roberts Boulevard

Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# Fox Valley Glass Aggregate Facility



## 230,000 PPH Sludge/Natural Gas Combustion and Glass Aggregate Facility



### ■ Owner:

Minergy Neenah, LLC  
(A non-regulated utility subsidiary of Wisconsin Energy)

### ■ Project Location:

Neenah, Wisconsin

### ■ Project Completion:

March 1998

### ■ Project Description:

ESI was the EPC Contractor for the Fox Valley Glass Aggregate Facility. This first-of-a-kind facility receives 1300 tons/day of paper mill sludge from Wisconsin Tissue Mills, Kimberly-Clark, P. H. Glatfelter, and other local mills. The sludge is received, handled, dried, and combusted along with natural gas to produce process steam and glass aggregate as sellable byproducts. The markets for the glass aggregate include sandblasting grit, abrasives, roofing shingle granules, asphalt aggregate, chip seal aggregate, and decorative landscaping. This facility includes: one B&W 230,000 pph boiler with two special cyclone furnaces, extensive material handling equipment, complete sludge drying system, and state-of-the-art emission controls including SNCR, baghouse, etc. This facility received *POWER Magazine's* 1999 Power Plant of the Year Award.



### ESI Inc. of Tennessee

1250 Roberts Boulevard

Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# Fraser Papers Steam Facility



## 60,000 PPH Bubbling Fluidized Bed Boiler System

- **Owner:**

Fraser Papers

- **Project Location:**

West Carrollton, Ohio

- **Project Completion:**

November 1998

- **Project Description:**

ESI was the EPC Contractor for this new boiler system. This system included: one 60,000 pph bubbling fluidized bed boiler designed to produce 600 psig/700°F superheated steam firing sludge and coal; along with a NO<sub>x</sub> reduction system; fuel handling systems for ash, sludge, and coal; sand feed and reclaim system; ash handling system; and a distributed control system. This system was erected in the power house. Demolition of an existing steam generating system and all associated equipment was required. The controls on the existing boilers were upgraded to a new distributed control system.



### ESI Inc. of Tennessee

1250 Roberts Boulevard

Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# Evergreen Community Power



## 30 MW Wood-fired Cogeneration Facility

- **Owner:**

Evergreen Community Power

- **Project Location:**

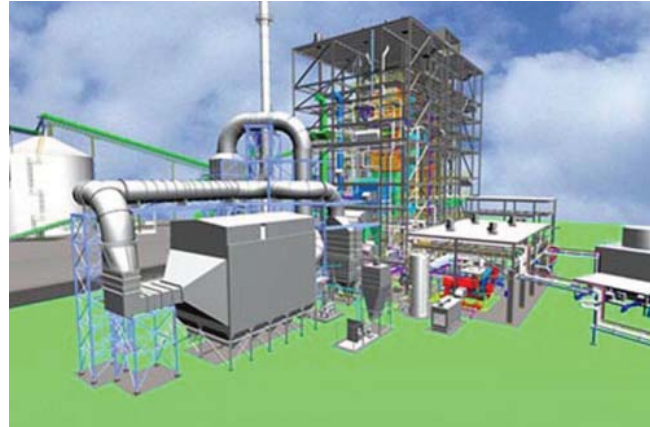
Reading, Pennsylvania

- **Project Completion:**

August 2009

- **Project Description:**

ESI performed the balance of the plant engineering for the complete new installation of a circulating fluidized bed boiler system to fire biomass to make both power and process steam for sale across the fence to United Correstack Paper Mill. The project included the installation of a 325,000 pph AAEVR circulating fluidized bed boiler and a nominal 30MW steam turbine generator. The facility design included complete scope of supply for the material handling, ash handling, waterside auxiliaries, water treatment, air emissions control systems, and electrical and piping tie-ins. ESI developed the purchase orders for all auxiliary equipment and bid packages to scope their installation. In addition to the engineering, ESI was the construction manager and scheduler for the project.



### ESI Inc. of Tennessee

1250 Roberts Boulevard

Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# Bowater Newsprint Steam Facility



## Conversion of Recovery Boiler to Bubbling Fluidized Bed Boiler

### ■ Owner:

Bowater Newsprint

### ■ Project Location:

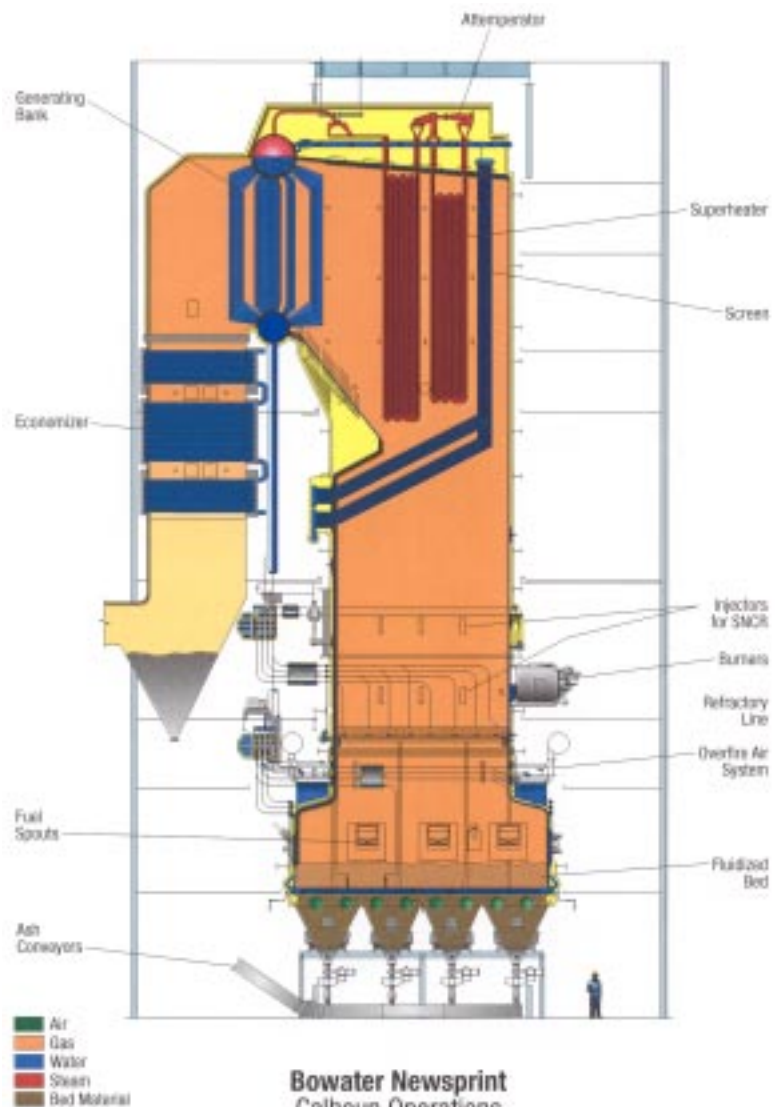
Calhoun, Tennessee

### ■ Project Completion:

March 1999

### ■ Project Description:

In a joint venture with Babcock & Wilcox, ESI converted an existing recovery boiler to a bubbling fluidized bed boiler. This system included: one bubbling fluidized bed boiler designed to produce 450,000 pph, 850 psig/825°F superheated steam firing sludge, wood waste, and tire chips (TDF); along with a SNCR NO<sub>x</sub> reduction system; fuel handling systems for the sludge, wood waste, and TDF; sand feed and reclaim system; ash handling system; and a new distributed control system.



**Bowater Newsprint**  
Calhoun Operations

Babcock & Wilcox  
a McDermott Company

### ESI Inc. of Tennessee

1250 Roberts Boulevard

Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# DTEES Stoneman Plant



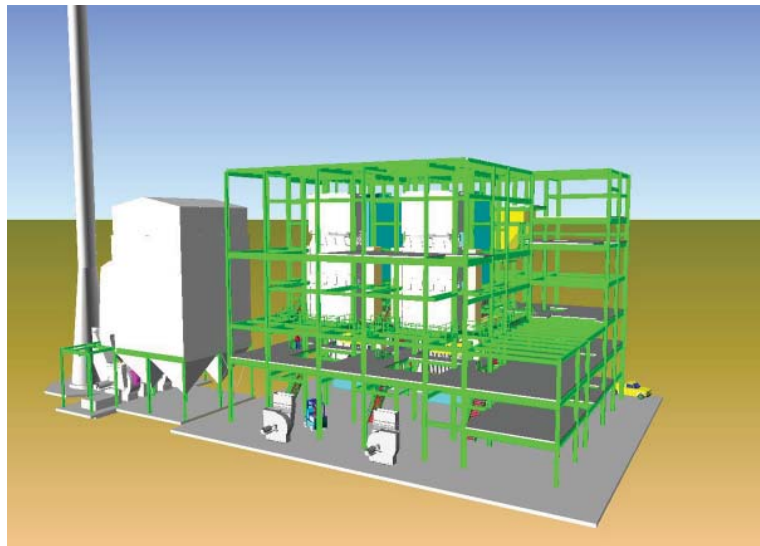
## Coal Boiler Conversion to Biomass Firing Boiler System

■ Owner:  
Detroit Edison Energy Systems  
(DTEES)

■ Project Location:  
Cassville, Wisconsin

■ Project Completion:  
June 2010

■ Project Description:  
ESI was selected to provide complete engineering for conversion of the two existing 27 MW pulverized coal fired utility boilers at the DTEES owned Cassville facility to a biomass fired boiler system. The goal of this project is to convert two (2) identical 1950 vintage Riley wall-fired coal boilers to stoker fired biomass units with a total capacity of 47 MW. Modifications to the system include replacing the lower furnace and ash hoppers with a larger furnace, overfire air system, and installation of a new water-cooled vibrating grate stoker system. The upgrade also required replacement of all the existing fans and air heaters and economizers, a complete new fuel receiving handling system, air quality control systems, and upgrades for the electrical and controls systems.



### ESI Inc. of Tennessee

1250 Roberts Boulevard  
Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# Corner Brook Steam Facility



## 300,000 PPH Wood-Fired Steam Facility

- **Owner:**

Corner Brook Pulp & Paper, Ltd.

- **Project Location:**

Corner Brook, Newfoundland

- **Project Completion:**

June 1995

- **Project Description:**

ESI was the EPC Contractor for this 300,000 pph steam facility. This facility included one 300,000 pph field-erected boiler designed to produce 800 psig, 850°F superheated steam firing wood and #6 fuel oil, along with a new wood yard and material handling system, waterside auxiliaries, wet scrubber with ash system dewatering, and a distributed control system. Two of the existing power boilers were reinstrumented and converted to this new distributed control system, as well as retrofitted with new low NO<sub>x</sub> oil burners to bring the mill in compliance with local regulations.



### ESI Inc. of Tennessee

1250 Roberts Boulevard

Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# Department of Energy Savannah River Facility



## Engineering for 20MW Biomass Plant

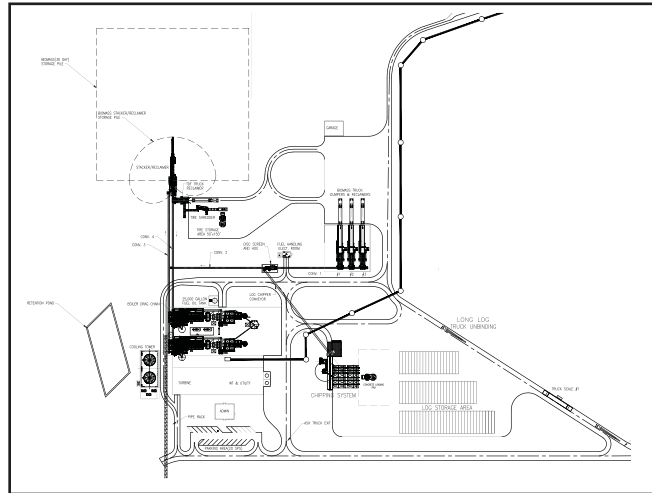
■ Owner:  
Ameresco Federal Solutions

■ Project Location:  
Aiken, South Carolina

■ Project Completion:  
December 2011

■ Project Description:

ESI has been selected to perform the engineering for the complete new installation of a bubbling fluidized bed boiler system firing biomass and tire-derived fuel, to make both power and process steam available to the Department of Energy Savannah River facility. The project includes installation of two bubbling fluidized bed boilers and a nominal 20MW steam turbine generator. The facility design includes complete scope of supply for a greenfield operating cogeneration facility consisting of site work; concrete; foundations; buildings; structural steel; waterside auxiliaries; water treatment; material handling and storage bins for biomass, ash, and limestone; stack; distribution and plant piping; electrical, instrumentation and distributed control system; electrical including power distribution and utility interconnects; and other miscellaneous requirements. The facility design also includes two 15,000 pph wood fired boilers to provide low pressure steam to remote steam users on the site.



### ESI Inc. of Tennessee

1250 Roberts Boulevard  
Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# Chesapeake CBO Facility



## Fly Ash Carbon Burn-Out Facility

■ **Owner:**

Progress Materials, Inc.

■ **Project Location:**

Chesapeake, Virginia

■ **Project Completion:**

November 2006

■ **Project Description:**

ESI was the EPC Contractor for this carbon burn-out facility. This facility utilizes patented fluid bed technology designed by ESI and developed by Progress Materials to reduce the high carbon content of fly ash resulting from low NOx burner conversion of pulverized coal-fired utility boilers. The heat recovered from this process results is captured in the utility heater cycle which in an improvement to the utility boiler heat rate. The carbon burn-out plant processes the fly ash in an efficient manner to reduce the carbon content and provide a superior additive product for concrete. This facility was constructed at the Dominion-owned Chesapeake Electric Generating Station and was designed to process 200,000 tons per year of high LOI flyash and reduce it to 2% LOI. The marketable ash is pneumatically conveyed to a 40,000-ton loadout silo for storage and later reclaim to the loadout silo.



**ESI Inc. of Tennessee**

1250 Roberts Boulevard  
Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# Santee Cooper Winyah Station Carbon Burn-Out Facility



## Fly Ash Carbon Burn-Out Facility

- **Owner:**

The SEFA Group

- **Project Location:**

Georgetown, South Carolina

- **Project Completion:**

September 2002

- **Project Description:**

ESI was the EPC contractor for this carbon burn-out facility. This facility utilizes patented technology developed by Progress Materials to reduce the high carbon content of fly ash resulting from low NO<sub>x</sub> burner conversion of pulverized coal-fired utility boilers. The heat recovered from this process results in an improvement to the utility boiler heat rate.

The carbon burn-out plant processes the fly ash in an efficient manner to reduce the carbon content and provide a superior additive product for concrete. This facility was constructed at Santee Cooper's Winyah Electric Generating Station and was designed to accept all of the ash produced by Santee Cooper's Grainger Electric Generating Station in Conway, SC as well as the majority of the ash produced at the Winyah Station. The facility will allow for the truck shipment of ash from Grainger Station with pneumatic unloading into receiving silos. This ash will be combusted as well as the ash from Winyah Station with the captured heat being returned to the Winyah heat cycle and the marketable ash being sent to a 1,000-ton loadout silo or to a 125-foot diameter concrete dome for storage and later reclaim to the loadout silo.



### ESI Inc. of Tennessee

1250 Roberts Boulevard

Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# FRAM Renewable Fuels



## Pellett Mill Facility Engineering

- **Owner:**

FRAM Renewable Fuels

- **Project Location:**

Appling, Georgia

- **Project Completion:**

February 2007

- **Project Description:**

ESI developed the preliminary engineering for a new 200,000 ton per year facility to receive, dry, and pelletize virgin wood that will be used in the European heating and power generation markets. The engineering included specification and recommendation of all major system components, assisting in the application of the environmental permits, and development of the facility site layout.



### ESI Inc. of Tennessee

1250 Roberts Boulevard

Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)

# Appleton Papers Steam Facility



## 150,000 PPH Natural Gas and #6 Fuel Oil Steam Facility

- **Owner:**

Appleton Papers

- **Project Location:**

Roaring Spring, Pennsylvania

- **Project Completion:**

October 1996

- **Project Description:**

ESI was the EPC Contractor for this 150,000 pph steam facility. This facility included one field-erected boiler designed to produce 650 psig/750°F superheated steam firing natural gas or #6 fuel oil, along with a deaerator with boiler feed water pumps, forced flue gas recirculation system, continuous emission monitoring system, Bailey INFI-90 distributed control system, and a new 50,000-gallon capacity #6 fuel oil tank. This system was housed in a new engineered structural steel building.



### ESI Inc. of Tennessee

1250 Roberts Boulevard

Kennesaw, GA 30144

Phone: 770-427-6200 Fax: 770-425-3660

Web Site: [www.esitenn.com](http://www.esitenn.com) E-mail: [info@esitenn.com](mailto:info@esitenn.com)



*Design/Build Engineers & Contractors  
Specialists in Steam and Cogeneration Systems*

**ESI Inc. of Tennessee**  
1250 Roberts Blvd  
Kennesaw, GA 30144  
Phone: 770-427-6200  
Fax: 770-425-3660  
[www.esitenn.com](http://www.esitenn.com)

# Exhibit C – Resume for Thomas J. Baudhuin

**TOM BAUDHUIN, P.E.**

**POSITION:** **MANAGER OF PROCESS ENGINEERING**

**EDUCATION:** Bachelor of Science in Mechanical Engineering  
Milwaukee School of Engineering

**RESPONSIBILITIES:** Manage Process Engineering Activities

**EXPERIENCE:**

- Mr. Baudhuin took over the role as Manager of Process Engineering in 2010. In this role he is responsible for all mechanical engineering functions at ESI including design calculations, project design basis, equipment specifications, engineering for drawings, management of Project Engineers, and training of engineering staff.
- Mr. Baudhuin joined ESI in 2008, assigned to the Sales Department. He was responsible for the generation of budget and firm price proposals, including project cost estimation, preliminary engineering, equipment and technology selection, design basis development and proposal writing. In 2010, Mr. Baudhuin was promoted to manage all process engineering activities for ESI projects.
- Prior to joining ESI, Mr. Baudhuin was the Manager of Engineering for Minergy Corporation, located in Neenah, Wisconsin. At Minergy, Mr. Baudhuin was responsible for project development, implementation, plant operations, providing technical oversight and managing capital projects. Mr. Baudhuin has experience in commissioning, operation and maintenance of many types of combustion systems and air emissions control technologies. At Minergy, Mr. Baudhuin served as the Project Manager for the Minergy R&D Center, which developed oxy-fuel burner technology for high ash fuels and demonstrated ultra low air emissions factors. Mr. Baudhuin was also the Project Manager for the development, permitting, and construction of the Fox Valley Glass Aggregate Plant, in Neenah, Wisconsin.
- Mr. Baudhuin began his career with the Wisconsin Electric Power Company in 1981. He spent 10 years at the Pleasant Prairie Power Plant in Kenosha, Wisconsin, where he was responsible for power boiler inspections and repairs, maintenance outage project management, equipment failure investigations, and equipment performance testing. He then transferred to the Business Development Group, working with large electric customers on energy management and cogeneration feasibility studies.



*Design/Build Engineers & Contractors  
Specialists in Steam and Cogeneration Systems*

**ESI Inc. of Tennessee**  
1250 Roberts Blvd  
Kennesaw, GA 30144  
Phone: 770-427-6200  
Fax: 770-425-3660  
[www.esitenn.com](http://www.esitenn.com)

# Exhibit D – Resume for James S. Pittman

**JAMES S. PITTMAN, P.E.**

**POSITION:** **LEAD MECHANICAL ENGINEER**

**EDUCATION:** Bachelor of Science in Mechanical Engineering  
Auburn University

**RESPONSIBILITIES:** Project Lead Mechanical Engineering and Design

**EXPERIENCE:**

- Mr. Pittman joined ESI in 1998 as a Mechanical Engineer. His responsibilities include: process engineering, equipment sizing and selection, layout, duct design of new and existing steam and power generation facilities, and start-up of the equipment. Mr. Pittman also works daily with the Project Manager to ensure design and engineering schedules are maintained. Mr. Pittman recently served as the Lead Engineer for a CFB fired biomass power plant for Evergreen Community Power in Reading, Pennsylvania.
- Other projects Mr. Pittman has led as an engineer include: a new coal fired steam facility for Kimberly Clark in Thailand; a 5 MW Steam Turbine Facility for Bear Island Paper in Ashland, Virginia; a new 1,100,000 pph coal-fired steam facility for Corn Products International in Bedford Park, Illinois; a new 50,000 pph steam facility for Procter & Gamble in Brown Summit, North Carolina; and the complete engineering for a 37 MW wood-fired power boiler system located in St. Paul, Minnesota for Cinergy Solutions.
- Prior to joining ESI, Mr. Pittman served as a Plant Engineer with National Textiles in Eden, North Carolina. His responsibilities included the supervision and management of the maintenance department, in addition to the execution of plant engineering projects.

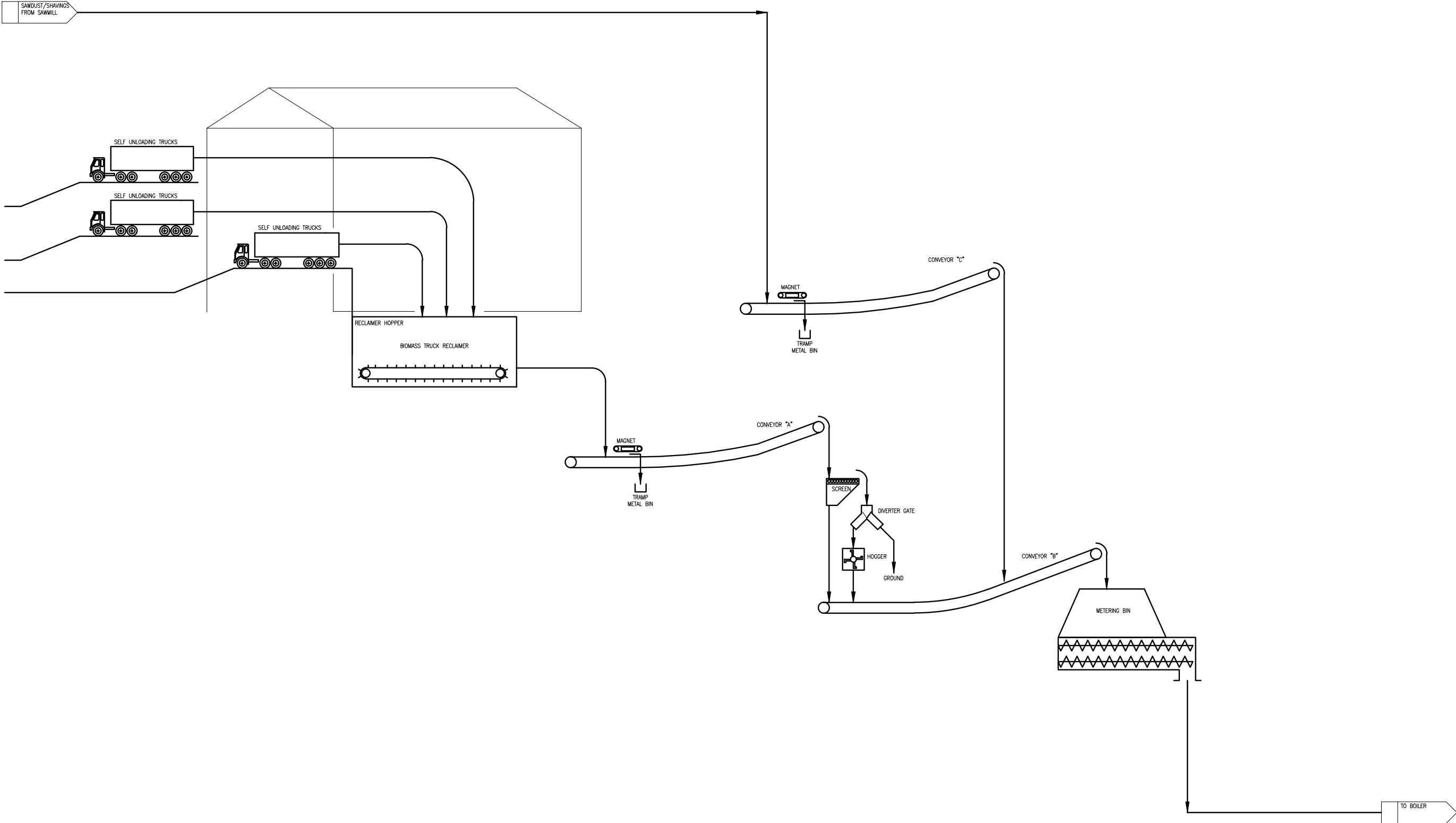


*Design/Build Engineers & Contractors  
Specialists in Steam and Cogeneration Systems*

**ESI Inc. of Tennessee**  
1250 Roberts Blvd  
Kennesaw, GA 30144  
Phone: 770-427-6200  
Fax: 770-425-3660  
[www.esitenn.com](http://www.esitenn.com)

# Exhibit E – Flow Sheets (condensing / extracting facility)

Plotted by Stowers, Jonathan on Monday, March 07, 2011 1:20:24 PM



| REV | DRAWN | DATE    | CHK'D | DATE     | DESCRIPTION                | REFERENCE DRAWINGS | NOT FOR CONSTRUCTION | THE DESIGN DATA AND INFORMATION CONTAINED HEREIN IS PROPRIETARY TO ESI INC. OF TENNESSEE. NO PORTION OF THIS INFORMATION SHALL BE RELEASED EXCEPT AS AUTHORIZED THROUGH PRIOR WRITTEN APPROVAL BY ESI INC. OF TENNESSEE. | FUEL HANDLING FLOW SHEET                              |              |      |
|-----|-------|---------|-------|----------|----------------------------|--------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|--------------|------|
| A   | JSP   | 2/14/11 | TJB   | 03/07/11 | ISSUED FOR CUSTOMER REVIEW |                    |                      |                                                                                                                                                                                                                          | MARWOOD                                               |              |      |
|     |       |         |       |          |                            |                    |                      |                                                                                                                                                                                                                          | NOVA SCOTIA                                           |              |      |
|     |       |         |       |          |                            |                    |                      |                                                                                                                                                                                                                          | SCALE:                                                | DRAWING NO.: | REV: |
|     |       |         |       |          |                            |                    |                      |                                                                                                                                                                                                                          | None                                                  | 688002 F01   | A    |
|     |       |         |       |          |                            |                    |                      |                                                                                                                                                                                                                          | DRAWING SCALE BASED ON A REPRODUCTION SIZE OF 24"x36" |              |      |
|     |       |         |       |          |                            |                    |                      |                                                                                                                                                                                                                          |                                                       |              |      |
|     |       |         |       |          |                            |                    |                      |                                                                                                                                                                                                                          |                                                       |              |      |
|     |       |         |       |          |                            |                    |                      |                                                                                                                                                                                                                          |                                                       |              |      |
|     |       |         |       |          |                            |                    |                      |                                                                                                                                                                                                                          |                                                       |              |      |



ESI Inc. of Tennessee  
1250 Roberts Blvd.  
Kennesaw, GA 30144  
(770)427-6200  
esitenn.com

| DESIGN            | 1    | 2    | 3    | 4 | 5     | 6 | 7 | 8 | 9     | 10 | 11 | 12 | 13     | 14     | 15     | 16     | 17     | 18   | 19 | 20     | 21   | 22   | 23 | 24 | 25 | 26 | 27     | 28 | 29 | 30 | 31 | 40     | 41     |   |   |   |   |   |  | GENERATOR |
|-------------------|------|------|------|---|-------|---|---|---|-------|----|----|----|--------|--------|--------|--------|--------|------|----|--------|------|------|----|----|----|----|--------|----|----|----|----|--------|--------|---|---|---|---|---|--|-----------|
| FLOW kpph         | 1.93 | 1.93 | 1.93 |   | 26.0  |   |   |   | 1.0   | -  | -  |    | 25.0   | 25.0   | 18.0   | 2.34   | 4.70   | 4.70 |    | 18.0   | 17.1 | 17.1 |    |    |    |    | 2.30   |    |    |    |    | 1327.4 | 1327.4 | - | - | - | - | - |  | OUTPUT    |
| PRESSURE psia     | 75   | 60   | 75   |   | 679   |   |   |   | 623.0 | -  | -  |    | 615    | 605    | 35     | 35     | 1.0    | 1.0  |    | 30     | 30   | 90   |    |    |    |    | 25     |    |    |    |    | 22     | 14     | - | - | - | - | - |  | KILOWATT  |
| TEMPERATURE deg F | 70   | 70   | 70   |   | 240   |   |   |   | 493   | -  | -  |    | 750    | 750    | 260    | 260    | 102    | 102  |    | 260    | 170  | 170  |    |    |    |    | 260    |    |    |    |    | 73     | 76.5   | - | - | - | - | - |  |           |
| Enthalpy Btu/lb   | 38   | 38   | 38   |   | 209.0 |   |   |   | 480.0 | -  | -  |    | 1380.0 | 1381.0 | 1167.0 | 1167.0 | 1062.0 | 70.0 |    | 1169.0 | 138  | 138  |    |    |    |    | 1170.0 |    |    |    |    | 41.0   | 44.5   | - | - | - | - | - |  | 1,602     |

[illegible]

| DESIGN            | 1    | 2    | 3    | 4 | 5     | 6 | 7 | 8 | 9     | 10 | 11 | 12 | 13     | 14     | 15     | 16     | 17     | 18    | 19 | 20     | 21  | 22  | 23 | 24 | 25 | 26 | 27     | 28 | 29 | 30 | 31 | 40     | 41     |   |   |   |   |   |  | GENERATOR |
|-------------------|------|------|------|---|-------|---|---|---|-------|----|----|----|--------|--------|--------|--------|--------|-------|----|--------|-----|-----|----|----|----|----|--------|----|----|----|----|--------|--------|---|---|---|---|---|--|-----------|
| FLOW kpph         | 1.03 | 1.03 | 1.03 |   | 26.0  |   |   |   | 1.0   | -  | -  |    | 25.0   | 25.0   | 0.0    | 3.33   | 21.67  | 21.67 |    | 0.0    | 0.0 | 0.0 |    |    |    |    | 3.33   |    |    |    |    | 1327.4 | 1327.4 | - | - | - | - | - |  | OUTPUT    |
| PRESSURE psia     | 75   | 60   | 75   |   | 679   |   |   |   | 623.0 | -  | -  |    | 615    | 605    | 35     | 35     | 1.0    | 1.0   |    | 35     | 30  | 90  |    |    |    |    | 25     |    |    |    |    | 22     | 14     | - | - | - | - | - |  | KILOWATT  |
| TEMPERATURE deg F | 70   | 70   | 70   |   | 240   |   |   |   | 493   | -  | -  |    | 750    | 750    | 260    | 260    | 102    | 102   |    | 260    | 170 | 170 |    |    |    |    | 260    |    |    |    |    | 80     | 95.3   | - | - | - | - | - |  |           |
| Enthalpy Btu/lb   | 38   | 38   | 38   |   | 209.0 |   |   |   | 480.0 | -  | -  |    | 1380.0 | 1381.0 | 1167.0 | 1167.0 | 1009.0 | 70.0  |    | 1169.0 | 138 | 138 |    |    |    |    | 1170.5 |    |    |    |    | 48.0   | 63.3   | - | - | - | - | - |  | 2,414     |

| REV | DRAWN | DATE    | CHK'D | DATE    | DESCRIPTION                                                                        | REFERENCE DRAWINGS                 |
|-----|-------|---------|-------|---------|------------------------------------------------------------------------------------|------------------------------------|
| A   | JSP   | 1/24/11 | TJB   | 1/26/11 | ISSUED FOR REVIEW                                                                  |                                    |
| B   | JSP   | 1/27/11 | TJB   | 1/27/11 | REVISED WITH 18 MMBTU/HR HEAT LOAD TO PLANT, LOWER PRESSURE AND LOWER EXHAUST FLOW |                                    |
| C   | JSP   | 2/2/11  | TJB   | 2/28/11 | ISSUED FOR CUSTOMER REVIEW                                                         |                                    |
|     |       |         |       |         |                                                                                    |                                    |
|     |       |         |       |         |                                                                                    |                                    |
|     |       |         |       |         |                                                                                    |                                    |
|     |       |         |       |         |                                                                                    |                                    |
|     |       |         |       |         |                                                                                    |                                    |
|     |       |         |       |         |                                                                                    |                                    |
|     |       |         |       |         |                                                                                    |                                    |
|     |       |         |       |         |                                                                                    |                                    |
|     |       |         |       |         |                                                                                    |                                    |
|     |       |         |       |         |                                                                                    |                                    |
|     |       |         |       |         |                                                                                    |                                    |
|     |       |         |       |         |                                                                                    | Drawing File Name<br>688002F06.dwg |

NOT FOR CONSTRUCTION

THE DESIGN DATA AND INFORMATION CONTAINED HEREIN IS PROPRIETARY TO ESI INC. OF TENNESSEE. NO PORTION OF THIS INFORMATION SHALL BE RELEASED EXCEPT AS AUTHORIZED THROUGH PRIOR WRITTEN APPROVAL BY ESI INC. OF TENNESSEE.

ESI Inc. of Tennessee  
1250 Roberts Blvd.  
Kennesaw, GA 30144  
  
(770)427-6200  
estenn.com

MASS & ENERGY BALANCE  
OPTION 2- FULL CONDENSING

MARWOOD

NOVA SCOTIA

SCALE: None

DRAWING NO.: 688002 F06

REV: C



*Design/Build Engineers & Contractors  
Specialists in Steam and Cogeneration Systems*

**ESI Inc. of Tennessee**  
1250 Roberts Blvd  
Kennesaw, GA 30144  
Phone: 770-427-6200  
Fax: 770-425-3660  
[www.esitenn.com](http://www.esitenn.com)

# Exhibit F –

## Design Basis Document

(condensing / extracting facility)

| PRELIMINARY DESIGN BASIS   |                                  |                   |         |               |                 |                 |     |
|----------------------------|----------------------------------|-------------------|---------|---------------|-----------------|-----------------|-----|
| ESI PROJECT NUMBER -688002 |                                  |                   |         |               |                 |                 |     |
|                            | Revision                         |                   | C       |               |                 |                 |     |
|                            | Description                      |                   | Marwood |               |                 |                 |     |
|                            | Revised By                       |                   | JSP     |               |                 |                 |     |
|                            | Checked by                       |                   | TJB     |               |                 |                 |     |
|                            | Revision Date                    |                   | 3/7/11  |               |                 |                 |     |
| LOCATION                   |                                  |                   |         |               | Nova Scotia     |                 |     |
| ELEVATION                  | Plant                            |                   |         |               | 200             |                 |     |
| ENVIRONMENTAL              |                                  |                   |         |               |                 |                 |     |
|                            | Governing Code                   |                   |         |               | NSBCR           |                 |     |
|                            | Seismic Zone                     |                   |         |               |                 |                 |     |
|                            | Sa (.2)                          |                   |         |               | 0.24            |                 |     |
|                            | Sa (1.0)                         |                   |         |               | 0.062           |                 |     |
|                            | Hourly Wind Pressure- 1/10       |                   |         |               | 8.6             |                 | psf |
|                            | Hourly Wind Pressure- 1/50       |                   |         |               | 12.10           |                 | psf |
|                            | Ambient Temperature              |                   |         |               |                 |                 |     |
|                            | Winter DB                        |                   |         |               | -11             |                 | °F  |
|                            | Percentile                       |                   |         |               | 99.0            |                 | %   |
|                            | Summer DB                        |                   |         |               | 84              |                 | °F  |
|                            | Percentile                       |                   |         |               | 1.0             |                 | %   |
|                            | Summer WB                        |                   |         |               | 70              |                 | °F  |
|                            | Ground Snow Load, S <sub>s</sub> |                   |         |               | 50              |                 | psf |
| AVAILIBLTY                 |                                  |                   |         | Back Pressure | Full Condensing | Max. Extraction |     |
|                            | Hours/year (90%)                 |                   |         | 60% = 5256    | 30% = 2628      | 60% = 5256      | hr  |
| FUEL DATA                  |                                  |                   |         |               |                 |                 |     |
| Generic Biomass            |                                  | Ultimate Analysis | Wood    | % Weight      |                 |                 |     |
|                            |                                  | As Received       | Units   |               |                 |                 |     |
|                            |                                  | Moisture          | %       | 50.00         |                 |                 |     |
|                            |                                  | Ash               | %       | 2.50          |                 |                 |     |
|                            |                                  | Carbon            | %       | 25.00         |                 |                 |     |
|                            |                                  | Hydrogen          | %       | 5.00          |                 |                 |     |
|                            |                                  | Nitrogen          | %       | 0.25          |                 |                 |     |
|                            |                                  | Sulfur            | %       | 0.02          |                 |                 |     |
|                            |                                  | Oxygen            | %       | 17.22         |                 |                 |     |
|                            |                                  | Chlorine          | %       | 0.01          |                 |                 |     |
|                            |                                  |                   |         | 100           |                 |                 |     |
|                            |                                  | Heating Value     | Btu/lb  | 4,300         |                 |                 |     |
|                            |                                  | Dry               | Units   | 0.0%          |                 |                 |     |
|                            |                                  | Moisture          | %       | 0.00          |                 |                 |     |
|                            |                                  | Ash               | %       | 5.00          |                 |                 |     |
|                            |                                  | Carbon            | %       | 50.00         |                 |                 |     |
|                            |                                  | Hydrogen          | %       | 10.00         |                 |                 |     |
|                            |                                  | Nitrogen          | %       | 0.50          |                 |                 |     |
|                            |                                  | Sulfur            | %       | 0.04          |                 |                 |     |
|                            |                                  | Oxygen            | %       | 34.44         |                 |                 |     |
|                            |                                  | Chlorine          | %       | 0.02          |                 |                 |     |
|                            |                                  |                   |         | 100           |                 |                 |     |
|                            |                                  | Heating Value     | Btu/lb  | 8600.0        |                 |                 |     |

| BARK - COMPOSITE ANALYSIS |                                   |          |          |        |                            |
|---------------------------|-----------------------------------|----------|----------|--------|----------------------------|
|                           | moisture content (design)         |          | 50.0     |        | %                          |
|                           | Density (conveying)               |          | 15.0     |        | lb/ft <sup>3</sup> - wet   |
|                           | Density (storage)                 |          | 20.0     |        | lb/ft <sup>3</sup> - wet   |
|                           | Density (horsepower)              |          | 25.0     |        | lb/ft <sup>3</sup> - wet   |
|                           | Density (structural)              |          | 35.0     |        | lb/ft <sup>3</sup> - wet   |
|                           | Angle of repose                   |          | Negative |        | degrees                    |
|                           | Size                              |          | 3" minus |        |                            |
| ASH SYSTEM                |                                   |          |          |        |                            |
| ASH                       |                                   | Option 1 | Option 2 | Design |                            |
|                           | Total Ash Production              | 76       | 95       | 157    | lb/hr                      |
|                           | Unburned Carbon in Fly Ash        | 8.0%     | 8.0%     | 8.0%   | %                          |
|                           | (lb/hr)                           | 7        | 8        | 14     | lb/hr                      |
|                           | Total                             | 83       | 104      | 171    | lb/hr                      |
|                           |                                   |          |          |        |                            |
|                           | % Fly Ash                         | 50%      | 50%      | 50%    |                            |
|                           | Fly Ash Production                | 41       | 52       | 86     | lb/hr                      |
|                           | Density                           | 15       | 15       | 16     | lb/ft <sup>3</sup>         |
|                           | Hourly volume                     | 3        | 3        | 5      | ft <sup>3</sup> /hr        |
|                           | Daily production                  | 66       | 83       | 128    | ft <sup>3</sup> /24 hrs    |
|                           |                                   |          |          |        |                            |
|                           | % Removal by Mech. Collector      | 50%      | 50%      | 50%    |                            |
|                           | lb/hr removed by Mech. Collector  | 21       | 26       | 43     |                            |
|                           | lb/hr to the ESP                  | 21       | 26       | 43     |                            |
|                           |                                   |          |          |        |                            |
|                           | Bottom ash production (dry basis) | 41       | 52       | 86     | lb/hr                      |
|                           | % dry solids content              | 45%      | 45%      | 45%    |                            |
|                           | Wet basis                         | 92       | 115      | 190    | lb/hr                      |
|                           | Density                           | 55       | 55       | 55     | lb/ft <sup>3</sup>         |
|                           | Hourly volume                     | 2        | 2        | 3      | ft <sup>3</sup> /hr        |
|                           | Daily production                  | 40       | 50       | 83     | ft <sup>3</sup> /24-hr day |
|                           | Daily production                  | 1.5      | 1.9      | 3.1    | yd <sup>3</sup> /24-hr day |
|                           |                                   |          |          |        |                            |
|                           | Ash factor                        | 3.98     | 3.98     | 6.57   | lb/mmBtu                   |
|                           |                                   |          |          |        |                            |
|                           | Method of Disposal                | Dumpster |          |        |                            |

| BOILER DESIGN                          |                                     |  |                 |                 |                                     |          |
|----------------------------------------|-------------------------------------|--|-----------------|-----------------|-------------------------------------|----------|
|                                        |                                     |  |                 |                 |                                     |          |
| <b>BARK &amp; SAW DUST FUEL BOILER</b> |                                     |  | <b>Option 1</b> | <b>Option 2</b> |                                     |          |
|                                        | Boiler heat input                   |  | 33.6            | 42.0            | mmbtu/hr                            |          |
|                                        | Total Heat Input                    |  | 33.6            | 42.0            | mmbtu/hr                            |          |
|                                        | Fuel Rate PPH                       |  | 7,814           | 9,767           | pph                                 |          |
|                                        | Fuel Rate TPY                       |  | 20,535          | 38,502          | ton/yr at Design Availability hours |          |
|                                        | Boiler steam output                 |  | 20,000          | 25,000          | pph                                 |          |
|                                        | Steam pressure (Outlet of MSSNRV)   |  | 600             | 600             | psig                                |          |
|                                        | Steam temperature                   |  | 750             | 750             | °F                                  |          |
|                                        | Efficiency                          |  | 69.9            | 69.9            | %                                   |          |
|                                        | Continuous Blowdown %               |  | 4               | 4               | %                                   |          |
|                                        | Continuous Blowdown Flow            |  | 800             | 1,000           | pph                                 |          |
|                                        | Combustion air flow                 |  | 30,954          | 38,690          | pph                                 |          |
|                                        | Flue gas flow                       |  | 38,474          | 48,089          | pph                                 |          |
|                                        | Flue gas temperature                |  | 350             | 350             | °F                                  |          |
|                                        | Flue gas volume                     |  | 13,862          | 17,324          | acfm                                |          |
| <b>Start-up Burners</b>                |                                     |  | <b>Option 1</b> | <b>Option 2</b> |                                     |          |
|                                        | Burner input MCR - per burner       |  | 3.4             | 4.2             | mmbtu/hr                            |          |
|                                        | Quantity                            |  | 1               | 1               |                                     |          |
|                                        | Fuel                                |  | Propane         | Propane         |                                     |          |
|                                        | Turndown Limit                      |  | 8:1             | 8:1             | Ratio                               |          |
|                                        | Gas supply pressure(@ Vendor Limit) |  | 40              | 40              | psig                                |          |
|                                        | Static pressue loss (delta P)       |  | 0.5             | 0.5             | 0.5                                 | in. w.c. |
|                                        |                                     |  |                 |                 |                                     |          |

| AIR QUALITY CONTROL               |                                  |                                                 |                                   |                                   |               |            |
|-----------------------------------|----------------------------------|-------------------------------------------------|-----------------------------------|-----------------------------------|---------------|------------|
| <b>MECHANICAL COLLECTOR</b>       |                                  |                                                 |                                   |                                   |               |            |
|                                   |                                  |                                                 | <b>Option 1</b>                   | <b>Option 2</b>                   | <b>Design</b> |            |
|                                   |                                  | Ash mass flow                                   | 41                                | 52                                | 86            | pph        |
|                                   |                                  | Trona mass flow                                 | 0                                 | 0                                 | 0             | pph        |
|                                   |                                  | Total particulate matter                        | 41                                | 52                                | 86            | pph        |
|                                   |                                  | Minimum removal efficiency (for ESP inlet load) | 50%                               | 50%                               | 50%           | percent    |
|                                   |                                  | Dust loading to ESP                             | 21                                | 26                                | 43            | pph        |
|                                   |                                  | Flow gas flow                                   | 38,474                            | 48,089                            | 48,089        | pph        |
|                                   |                                  | Flow                                            | 13,862                            | 17,324                            | 17,324        | acfm       |
|                                   |                                  | Gas temperature                                 | 350                               | 350                               | 350           | F          |
|                                   |                                  | Static pressue loss (delta P)                   | 2.5                               | 2.5                               | 2.5           | in. w.c.   |
| <b>ELECTROSTATIC PRECIPITATOR</b> |                                  |                                                 |                                   |                                   |               |            |
|                                   |                                  |                                                 |                                   |                                   |               |            |
|                                   |                                  | Model                                           |                                   |                                   |               |            |
|                                   |                                  | Case                                            | <b>Option 1</b>                   | <b>Option 2</b>                   | <b>Design</b> |            |
|                                   |                                  | Operating temperature                           | 350                               | 350                               | 350           | °F         |
|                                   |                                  | Gas mass flow                                   | 38,474                            | 48,089                            | 48,089        | pph        |
|                                   |                                  | Gas volume                                      | 13,862                            | 17,324                            | 17,324        | acfm       |
|                                   |                                  | Total PM Inlet Loading                          | 21                                | 26                                | 43            | pph        |
|                                   |                                  | Total PM Inlet Loading                          | 0.62                              | 0.62                              | 1.02          | lb/MMBTU   |
|                                   |                                  | Total PM Outlet Loading                         | 1.01                              | 1.26                              | 1.26          | pph        |
|                                   |                                  | Total PM Outlet Loading                         | 0.030                             | 0.030                             | 0.030         | lb/MMBTU   |
|                                   |                                  | Removal Efficiency                              | 95.1%                             | 95.1%                             | 97.1%         | %          |
|                                   |                                  | Static pressue loss (delta P)                   | 0.5                               | 0.5                               | 0.5           | in. w.c.   |
| <b>MATERIAL HANDLING</b>          |                                  |                                                 |                                   |                                   |               |            |
| <b>BIOMASS SCALES</b>             |                                  |                                                 |                                   |                                   |               |            |
|                                   | Quantity                         |                                                 |                                   | 0                                 |               |            |
| <b>BIOMASS RECEIVING SYSTEM</b>   |                                  |                                                 | <b>Option 1</b>                   | <b>Option 2</b>                   |               |            |
|                                   | Delivery Source                  |                                                 | Trucks                            | Trucks                            |               |            |
|                                   | Receiving Equipment Type         |                                                 | Fuel Feed Hopper with Live Bottom | Fuel Feed Hopper with Live Bottom |               |            |
|                                   | Quantity                         |                                                 | 1                                 | 1                                 |               |            |
|                                   | Reclaimer Hopper Capacity        |                                                 | 9,000                             | 9,000                             |               | cf         |
|                                   | Reclaimer Hopper Capacity        |                                                 | 68                                | 68                                |               | tons (wet) |
|                                   | Time to Unload Truck             |                                                 | 15                                | 15                                |               | minutes    |
|                                   | Reclaimer Conveying Capacity     |                                                 | 4.2                               | 5.2                               |               | tph (wet)  |
|                                   | Number of Days for Delivery/Week |                                                 | 7                                 | 7                                 |               |            |
|                                   | Delivery Hours per Day           |                                                 | 12                                | 12                                |               |            |
|                                   | No. Trucks to Discharge Per Day  |                                                 | 4.2                               | 5.2                               |               |            |
|                                   | Capacity per Truck               |                                                 | 22                                | 22                                |               | tons       |

| MATERIAL HANDLING                        |                             |  |                          |                          |                    |
|------------------------------------------|-----------------------------|--|--------------------------|--------------------------|--------------------|
| <b>BIOMASS CLASSIFICATION SYSTEM</b>     |                             |  |                          |                          |                    |
|                                          | Material Sizing             |  | 3" Minus                 | 3" Minus                 | inches             |
|                                          | Screen Capacity (unloading) |  | 4.2                      | 5.2                      | tph (wet)          |
|                                          | Rejects Hog Sizing          |  | 2.1                      | 2.6                      | tph (wet)          |
| <b>BIOMASS LONG TERM STORAGE SYSTEM</b>  |                             |  |                          |                          |                    |
|                                          | Fuel                        |  | Logs                     | Logs                     |                    |
| <b>BIOMASS SHORT TERM STORAGE SYSTEM</b> |                             |  |                          |                          |                    |
|                                          | Fuel                        |  | Bark / Biomass           | Bark / Biomass           |                    |
|                                          | Type                        |  | Fuel Feed Hopper         | Fuel Feed Hopper         |                    |
|                                          | Storage Density             |  | 20                       | 20                       | pcf                |
|                                          | Storage Time                |  | 24                       | 18                       | hours              |
|                                          | Storage Capacity Required   |  | 92                       | 86                       | tons               |
|                                          | Storage Capacity Required   |  | 9,162                    | 8,589                    | ft3                |
|                                          | Walking Floor Width         |  | 16.8                     | 16.8                     | ft                 |
|                                          | Walking Floor Length        |  | 46.7                     | 46.7                     | ft                 |
|                                          | Walking Floor Height        |  | 17                       | 17                       | ft                 |
|                                          | Fuel                        |  | Sawdust                  | Sawdust                  |                    |
|                                          | Type                        |  | None                     | None                     |                    |
| <b>BIOMASS RECLAIM SYSTEM</b>            |                             |  |                          |                          |                    |
|                                          | Fuel                        |  | Bark / Market Biomass    | Bark / Market Biomass    |                    |
|                                          | Type                        |  | Walking Floor            | Walking Floor            |                    |
|                                          | Capacity                    |  | 4.2                      | 5.2                      | tph                |
|                                          | Capacity                    |  | 560                      | 700                      | cfh                |
|                                          | Number of Reclaimers        |  | 1                        | 1                        |                    |
|                                          | Fuel                        |  | Sawdust                  | Sawdust                  |                    |
|                                          | Type                        |  | Belt Conveyor            | Belt Conveyor            |                    |
| <b>BIOMASS BOILER FEED SYSTEM</b>        |                             |  |                          |                          |                    |
|                                          | Type                        |  | Live Bottom Metering Bin | Live Bottom Metering Bin |                    |
|                                          | Capacity                    |  | 3.8                      | 4.8                      | tph                |
|                                          | Capacity (Volumetric)       |  | 509                      | 636                      | cfh                |
|                                          | Number of Feeders           |  | 1                        | 1                        |                    |
| <b>BOTTOM ASH COLLECTION SYSTEM</b>      |                             |  |                          |                          |                    |
|                                          | Type                        |  | Submerged Ash Drag Chain | Submerged Ash Drag Chain |                    |
|                                          | Capacity (each boiler)      |  | 115                      | 190                      | pph                |
|                                          | Total Capacity              |  | 115                      | 190                      | pph                |
|                                          | Density                     |  | 45                       | 45                       | lb/ft <sup>3</sup> |
|                                          | Design temperature          |  | 500                      | 500                      | °F                 |
| <b>BOTTOM ASH STORAGE</b>                |                             |  |                          |                          |                    |
|                                          | Type                        |  | 20 cy Dumpster           | 20 cy Dumpster           |                    |
|                                          | Capacity                    |  | 12.2                     | 12.2                     | tons               |
|                                          | Number of Days              |  | 11.0                     | 8.8                      |                    |
|                                          | Density                     |  | 45                       | 45                       | lb/ft <sup>3</sup> |
|                                          | Design temperature          |  | 200                      | 200                      | °F                 |
| <b>FLY ASH COLLECTION SYSTEM</b>         |                             |  |                          |                          |                    |
|                                          | Type                        |  | Mechanical               | Mechanical               |                    |
|                                          | Total Capacity              |  | 41                       | 52                       | pph                |
|                                          | Density                     |  | 20                       | 20                       | lb/ft <sup>3</sup> |
|                                          | Design temperature          |  | 600                      | 600                      | °F                 |
| <b>FLY ASH STORAGE</b>                   |                             |  |                          |                          |                    |
|                                          | Type                        |  | Dumpster                 | Dumpster                 |                    |
|                                          | Capacity                    |  | 20                       | 20                       | cy                 |
|                                          | Storage Time                |  | 260                      | 208                      | hours              |
|                                          | Storage Time                |  | 208                      | 126                      | hours              |
|                                          | Weight Capacity             |  | 5                        | 5                        | tons               |
|                                          | Density                     |  | 20                       | 20                       | lb/ft <sup>3</sup> |
|                                          | Design temperature          |  | 200                      | 200                      | °F                 |

| STEAM CYCLE DESIGN AND POWER GENERATION |                                                     |  |               |                 |                 |          |  |
|-----------------------------------------|-----------------------------------------------------|--|---------------|-----------------|-----------------|----------|--|
| TURBINE                                 |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  | Option 1      | Option 2        |                 |          |  |
|                                         |                                                     |  | Back Pressure | Full Condensing | Max. Extraction |          |  |
|                                         | Gross Power Output                                  |  | 1,060         | 2,414           | 1,602           | kW       |  |
|                                         | Throttle flow                                       |  | 20,000        | 25,000          | 25,000          | pph      |  |
|                                         | Inlet pressure                                      |  | 590           | 590             | 590             | psig     |  |
|                                         | Inlet temperature                                   |  | 750           | 750             | 750             | °F       |  |
|                                         |                                                     |  |               |                 |                 |          |  |
|                                         | Flow to process                                     |  | 18,000        | 0               | 18,000          | pph      |  |
|                                         | Flow to deaerator                                   |  | 2,000         | 3,332           | 2,304           | pph      |  |
|                                         | Controlled extraction pressure                      |  | 20            | 20              | 20              | psig     |  |
|                                         | Temperature                                         |  | 260           | 260             | 260             | °F       |  |
|                                         | Enthalpy                                            |  | 1,167         | 1,167           | 1,167           | Btu/lb   |  |
|                                         |                                                     |  |               |                 |                 |          |  |
|                                         | Exhaust flow to condenser                           |  |               | 21,668          | 4,696           | pph      |  |
|                                         | Exhaust pressure                                    |  |               | 2.0             | 2.0             | In-Hg    |  |
|                                         | Temperature                                         |  |               | 102             | 102             | °F       |  |
|                                         | Enthalpy                                            |  |               | 1,019           | 1,062           | Btu/lb   |  |
|                                         |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  |               |                 |                 |          |  |
| PLANT PERFORMANCE                       |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  | Option 1      | Option 2        |                 |          |  |
|                                         |                                                     |  | Back Pressure | Full Condensing | Max. Extraction |          |  |
|                                         | Capacity Factor                                     |  | 60%           | 30%             | 60%             | %        |  |
|                                         | Gross Heat Input                                    |  | 33.6          | 42.0            | 42.0            | mmBtu/Hr |  |
|                                         | Gross Power Output                                  |  | 1,060         | 2,414           | 1,602           | kW       |  |
|                                         | Auxiliary Power Consumption (Parasitic Load)        |  | 210           | 348             | 348             | kW       |  |
|                                         | Auxiliary Power as a percentage of Gross Generation |  | 20%           | 14%             | 22%             |          |  |
|                                         | Net Generation                                      |  | 850           | 2,066           | 1,254           | kW       |  |
|                                         | Gross Heat Rate                                     |  | 31,698        | 17,399          | 26,217          | Btu/kWh  |  |
|                                         | Net Heat Rate                                       |  | 39,529        | 20,329          | 33,493          | Btu/kWh  |  |
|                                         | Power Plant Net Thermal Efficiency                  |  | 63.8%         | 16.8%           | 54.3%           | %        |  |
|                                         | Power Plant Annual Net Thermal Efficiency           |  | 63.8%         | 41.8%           |                 |          |  |
|                                         | Total Annual Generation (Gross)                     |  | 5,571         | 14,764          |                 | MWh      |  |
|                                         | Total Annual Generation (Net)                       |  | 4,468         | 12,020          |                 | MWh      |  |
|                                         |                                                     |  |               |                 |                 |          |  |
| AUXILIARY EQUIPMENT                     |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  |               |                 |                 |          |  |
| COOLING TOWER                           |                                                     |  | Option 1      | Option 2        |                 |          |  |
|                                         |                                                     |  |               | Full Condensing | Max. Extraction |          |  |
|                                         | Design wet bulb temperature                         |  |               | 70              | 70              | °F       |  |
|                                         | Approach temperature                                |  |               | 10              | 3.2             | °F       |  |
|                                         | Heat load                                           |  |               | 20.4            | 4.8             | mmbtu/hr |  |
|                                         | Cooling water flow                                  |  |               | 2,666           | 2,666           | gpm      |  |
|                                         | Cooling tower make up                               |  |               | 41.9            | 13.1            | gpm      |  |
|                                         | Cooling tower blowdown                              |  |               | 10.4            | 3.2             | gpm      |  |
|                                         |                                                     |  |               |                 |                 |          |  |
| SURFACE CONDENSER                       |                                                     |  |               |                 |                 |          |  |
|                                         | Design Steam flow                                   |  |               | 21,668          |                 | pph      |  |
|                                         | Heat Exchanged                                      |  |               | 20.4            | 4.8             | mmBtu/hr |  |
|                                         |                                                     |  |               |                 |                 |          |  |

|                                    |                                                      |        |            |                 |        |       |
|------------------------------------|------------------------------------------------------|--------|------------|-----------------|--------|-------|
| BOILER MAKE-UP WATER SYSTEM        |                                                      |        |            |                 |        |       |
|                                    | System Type                                          |        |            | Reverse Osmosis |        |       |
|                                    | System Outflow                                       |        |            |                 |        |       |
|                                    |                                                      | Normal |            | 3.4             | 2.0    | 3.8   |
|                                    |                                                      |        |            |                 |        | gpm   |
| COOLING TOWER MAKE-UP WATER SYSTEM |                                                      |        |            |                 |        |       |
|                                    | Source                                               |        |            | City Water      |        |       |
|                                    | Requirement                                          |        |            |                 |        |       |
|                                    |                                                      | Normal |            | 52.3            | 16.3   | gpm   |
|                                    |                                                      |        |            |                 |        |       |
| RO WATER STORAGE TANK              |                                                      |        |            |                 |        |       |
|                                    | Capacity                                             |        | 10,000     | 10,000          | 10,000 | gal   |
|                                    | Storage Time (based on maximum makeup flow above)    |        | 49         | 83              | 44     | hours |
|                                    |                                                      |        |            |                 |        |       |
| PROCESS STEAM / CONDENSATE SYSTEM  |                                                      |        |            |                 |        |       |
|                                    | Steam Pressure                                       |        | 15         |                 |        | psig  |
|                                    | Process Steam Required                               |        | 18,000     |                 |        | pph   |
|                                    | Condensate Return Amount                             |        | 95%        |                 |        | %     |
|                                    | Condensate Capacity                                  |        |            | 17,100          |        | pph   |
|                                    | Temperature                                          |        | 170        |                 |        | °F    |
|                                    |                                                      |        |            |                 |        |       |
| CONDENSATE RECEIVER TANK           |                                                      |        |            |                 |        |       |
|                                    | Type                                                 |        | Tank       |                 |        |       |
|                                    | Capacity                                             |        | 7,500      |                 |        | gal   |
|                                    | Design Temperature                                   |        | 212        |                 |        | °F    |
|                                    | Design Flow                                          |        | 37         |                 |        | gpm   |
|                                    | Storage Time (based on condensate return flow above) |        | 3.4        |                 |        | hours |
|                                    | Polisher Required                                    |        | No         |                 |        |       |
|                                    |                                                      |        |            |                 |        |       |
| DEAERATOR                          |                                                      |        |            |                 |        |       |
|                                    | Type                                                 |        | Spray/Tray | Spray/Tray      |        |       |
|                                    | DA Capacity                                          |        | 20,800     | 26,000          |        | pph   |
|                                    | Operating Pressure                                   |        | 10         | 10              |        | psig  |
|                                    | Operating Temperature                                |        | 240        | 240             |        | °F    |
|                                    | Design Pressure                                      |        | 50         | 50              |        | psig  |
|                                    | Design Temperature                                   |        | 450        | 450             |        | °F    |
|                                    |                                                      |        |            |                 |        |       |
| BOILER FEED WATER PUMPS            |                                                      |        |            |                 |        |       |
|                                    | Number of Pumps                                      |        | 2 x 100%   |                 |        |       |
|                                    | BFP Operating point flow                             |        | 44.0       | 55.2            |        | gpm   |
|                                    | BFP Operating point head                             |        | 1617       | 1624.0          |        | ft    |
|                                    | BFP Design flow                                      |        | 46.2       | 57.7            |        | gpm   |
|                                    | BFP Design head                                      |        | 1780       | 1786.0          |        | ft    |
|                                    |                                                      |        |            |                 |        |       |
| HOTWELL PUMPS                      |                                                      |        |            |                 |        |       |
|                                    | Number of Pumps                                      |        | 2 x 100%   |                 |        |       |
|                                    | Operating Flow Rate                                  |        |            | 43              |        | gpm   |
|                                    | Design Flow Rate                                     |        |            | 46              |        | gpm   |
|                                    | TDH (operating)                                      |        |            | Later           |        | ft.   |
|                                    | TDH (design)                                         |        |            | Later           |        | ft.   |
|                                    |                                                      |        |            |                 |        |       |
| MAKEUP DEMIN. WATER PUMPS          |                                                      |        |            |                 |        |       |
|                                    | Number of Pumps                                      |        | 2 x 100%   |                 |        |       |
|                                    | Operating Flow Rate                                  |        | 3.4        | 3.8             |        | gpm   |
|                                    | Design Flow Rate                                     |        | 3.7        | 4.2             |        | gpm   |
|                                    | TDH (operating)                                      |        | 125        | 125             |        | ft.   |
|                                    | TDH (design)                                         |        | 137.5      | 137.5           |        | ft.   |
|                                    |                                                      |        |            |                 |        |       |
| COOLING WATER PUMPS                |                                                      |        |            |                 |        |       |
|                                    | Number of Pumps                                      |        | 2 x 50%    |                 |        |       |
|                                    | Operating Flow Rate                                  |        |            | 1,333           |        | gpm   |
|                                    | Design Flow Rate                                     |        |            | 1,400           |        | gpm   |
|                                    | TDH (operating)                                      |        |            | 51              |        | ft.   |
|                                    | TDH (design)                                         |        |            | 56              |        | ft.   |
|                                    |                                                      |        |            |                 |        |       |
| CONDENSATE PUMPS                   |                                                      |        |            |                 |        |       |
|                                    | Number of Pumps                                      |        | 2 x 100%   |                 |        |       |
|                                    | Operating Flow Rate                                  |        | 37         |                 |        | gpm   |
|                                    | Design Flow Rate                                     |        | 40         |                 |        | gpm   |
|                                    | TDH (operating)                                      |        | 136        |                 |        | ft.   |
|                                    | TDH (design)                                         |        | 149.6      |                 |        | ft.   |

| UTILITIES                |                                    |  |                                  |                |          |             |
|--------------------------|------------------------------------|--|----------------------------------|----------------|----------|-------------|
| ELECTRICAL REQUIREMENTS  |                                    |  |                                  |                |          |             |
|                          | Supply                             |  |                                  | Later          |          | kV          |
|                          | Generation/Mill Distribution       |  |                                  | Later          |          | kV          |
|                          | Motors                             |  |                                  |                |          |             |
|                          | >200 hp, fixed speed               |  |                                  | NA             |          | VAC         |
|                          | 1/2 - 600 hp, variable speed       |  |                                  | NA             |          | VAC         |
|                          | 1/2 - 200 hp, fixed speed          |  |                                  | 480 or 575     |          | VAC         |
|                          | <1/2 hp                            |  |                                  | 120            |          | VAC         |
| FOUNDATIONS              |                                    |  |                                  |                |          |             |
|                          | Type                               |  | Spread Footing (Assume 2500 psf) |                |          |             |
| FIRE PROTECTION REQUIRED |                                    |  |                                  | Yes            |          | (yes/no)    |
| UNIT HEATERS (qty)       |                                    |  |                                  |                |          |             |
|                          | Type                               |  |                                  | Electric       |          |             |
| PLANT UTILITIES REQUIRED |                                    |  |                                  |                |          |             |
|                          | Electrical                         |  |                                  |                |          |             |
|                          | Voltage                            |  |                                  | See above      |          | Volts       |
|                          | Frequency                          |  |                                  | 60             |          | Hertz       |
|                          | Power                              |  |                                  | Later          |          | kW          |
|                          | Boiler Makeup Water                |  |                                  |                |          |             |
|                          | Source                             |  |                                  | Softened Water |          | (well/city) |
|                          | Pressure                           |  |                                  | 60             |          | psig        |
|                          | Potable/Cooling Tower Makeup Water |  |                                  |                |          |             |
|                          | Source                             |  |                                  | City           |          |             |
|                          | Pressure                           |  |                                  | 60             |          | psig        |
|                          | Compressed Air                     |  |                                  |                |          |             |
|                          | Plant Air Pressure                 |  |                                  | 100            |          | psig        |
|                          | Instrument Air Pressure            |  |                                  | 90             |          | psig        |
|                          | Instrument Air Dewpoint            |  |                                  | -40            |          | °F          |
|                          |                                    |  |                                  |                |          |             |
|                          |                                    |  |                                  | Option 1       | Option 2 |             |
|                          | Total Water Consumption            |  |                                  | 18             | 71       | gpm         |
|                          |                                    |  |                                  |                |          |             |



*Design/Build Engineers & Contractors  
Specialists in Steam and Cogeneration Systems*

*ESI Inc. of Tennessee  
1250 Roberts Blvd  
Kennesaw, GA 30144  
Phone: 770-427-6200  
Fax: 770-425-3660  
[www.esitenn.com](http://www.esitenn.com)*

# Exhibit G – Capital Cost Estimate Breakdown (condensing / extracting facility)

**CAPITAL COST BREAKDOWN (All values are in CAD)**

| Marwood Biomass CHP |                                             |                         |           |             |  |                                  |           |             |
|---------------------|---------------------------------------------|-------------------------|-----------|-------------|--|----------------------------------|-----------|-------------|
|                     |                                             | Option 1 - Backpressure |           |             |  | Option 2 - Condensing/Extracting |           |             |
|                     | BREAKDOWN                                   | EQUIP \$                | LABOR \$  | TOTAL \$    |  | EQUIP \$                         | LABOR \$  | TOTAL \$    |
| 1                   | SITEWORK                                    | \$25,392                | \$0       | \$25,392    |  | \$30,861                         | \$0       | \$30,861    |
| 2                   | CONCRETE AND FOUNDATIONS                    | \$346,354               | \$0       | \$346,354   |  | \$442,060                        | \$0       | \$442,060   |
| 3                   | PLUMBING & SITE SEWER                       | \$19,500                | \$0       | \$19,500    |  | \$19,500                         | \$0       | \$19,500    |
| 4                   | MASONRY                                     | \$0                     | \$0       | \$0         |  | \$0                              | \$0       | \$0         |
| 5                   | STEEL, PLATFORMS, GRATING, ETC.             | \$430,860               | \$222,600 | \$653,460   |  | \$437,610                        | \$222,600 | \$660,210   |
| 6                   | HVAC                                        | \$23,000                | \$24,000  | \$47,000    |  | \$23,000                         | \$24,000  | \$47,000    |
| 7                   | PRE-ENG BUILDINGS, BLDG TRIM & MISC.        | \$270,206               | \$126,150 | \$396,356   |  | \$270,206                        | \$126,150 | \$396,356   |
| 8                   | PAINTING & FINISHES                         | \$58,696                | \$0       | \$58,696    |  | \$70,821                         | \$0       | \$70,821    |
| 9                   | FIRE PROTECTION SYSTEMS                     | \$38,490                | \$52,200  | \$90,690    |  | \$38,490                         | \$52,200  | \$90,690    |
| 10                  | STEAM GENERATION SYSTEMS                    | \$1,295,000             | \$288,000 | \$1,583,000 |  | \$1,430,000                      | \$288,000 | \$1,718,000 |
| 11                  | BURNER FIRING SYSTEMS                       | \$85,000                | \$0       | \$85,000    |  | \$85,000                         | \$0       | \$85,000    |
| 12                  | FANS                                        | \$67,176                | \$45,600  | \$112,776   |  | \$84,441                         | \$45,600  | \$130,041   |
| 13                  | EMISSIONS CONTROL SYSTEMS                   | \$493,417               | \$180,000 | \$673,417   |  | \$578,000                        | \$180,000 | \$758,000   |
| 14                  | FUEL HANDLING SYSTEMS (Receiving & Storage) | \$385,020               | \$14,400  | \$399,420   |  | \$385,020                        | \$14,400  | \$399,420   |
| 15                  | FUEL HANDLING SYSTEMS (Conveying)           | \$406,600               | \$168,000 | \$574,600   |  | \$406,600                        | \$168,000 | \$574,600   |
| 16                  | FUEL HANDLING SYSTEMS (Misc)                | \$102,705               | \$39,000  | \$141,705   |  | \$102,705                        | \$39,000  | \$141,705   |
| 17                  | ASH HANDLING SYSTEMS                        | \$0                     | \$30,000  | \$30,000    |  | \$0                              | \$30,000  | \$30,000    |
| 18                  | WATER TREATMENT                             | \$140,250               | \$40,800  | \$181,050   |  | \$145,250                        | \$44,400  | \$189,650   |
| 19                  | STORAGE TANKS                               | \$57,385                | \$21,000  | \$78,385    |  | \$57,385                         | \$21,000  | \$78,385    |
| 20                  | MISC. AUXILIARY SYSTEMS                     | \$43,070                | \$28,200  | \$71,270    |  | \$49,500                         | \$28,200  | \$77,700    |
| 21                  | PUMPING SYSTEMS                             | \$145,096               | \$14,400  | \$159,496   |  | \$166,864                        | \$21,600  | \$188,464   |
| 22                  | HOPPERS,FLUES, DUCTS, ETC.                  | \$139,735               | \$123,000 | \$262,735   |  | \$139,735                        | \$129,000 | \$268,735   |
| 23                  | STEAM PLANT PIPING & VALVES                 | \$114,816               | \$222,973 | \$337,789   |  | \$147,675                        | \$354,362 | \$502,037   |
| 24                  | INSULATION & LAGGING                        | \$15,737                | \$21,552  | \$37,289    |  | \$19,990                         | \$27,332  | \$47,322    |
| 25                  | ELECTRICAL EQUIPMENT                        | \$141,927               | \$288,737 | \$430,663   |  | \$191,993                        | \$298,473 | \$490,466   |
| 26                  | CONTROL SYSTEMS                             | \$384,604               | \$216,000 | \$600,604   |  | \$434,260                        | \$258,750 | \$693,010   |
| 27                  | INSTRUMENTATION                             | \$239,958               | \$62,700  | \$302,658   |  | \$251,515                        | \$64,275  | \$315,790   |
| 28                  | GENERATING SYSTEMS                          | \$2,402,500             | \$123,000 | \$2,525,500 |  | \$3,426,500                      | \$285,600 | \$3,712,100 |
| 29                  | CONSTRUCTION EXPENSES                       | \$555,620               | \$0       | \$555,620   |  | \$594,138                        | \$0       | \$594,138   |
| 30                  | MISC. AND COMMERCIAL                        | \$55,425                | \$0       | \$55,425    |  | \$57,450                         | \$0       | \$57,450    |

|                                           |               |              |               |               |              |               |
|-------------------------------------------|---------------|--------------|---------------|---------------|--------------|---------------|
| Subtotal Construction (Equip/Mat - Labor) | \$ 8,483,539  | \$ 2,352,312 | \$ 10,835,851 | \$ 10,086,568 | \$ 2,722,941 | \$ 12,809,510 |
| Contingency - CONST                       | \$ 424,177    | \$ 235,231   |               | \$ 504,328    | \$ 272,294   |               |
| Construction Cost TOTAL                   | \$ 11,495,259 |              |               | \$ 13,586,132 |              |               |
| Engineering/PM/OH                         | \$ 605,014    |              |               | \$ 715,060    |              |               |
| CM                                        | \$ 234,597    |              |               | \$ 277,268    |              |               |
| Profit (8%)                               | \$ 1,072,597  |              |               | \$ 1,267,692  |              |               |
| ENG/PM/CM/OH Cost                         | \$ 1,912,208  |              |               | \$ 2,260,020  |              |               |
| BUDGET PRICE                              | \$ 13,407,470 |              |               | \$ 15,846,150 |              |               |
| Budget Accuracy (±%)                      | 20%           |              |               | 20%           |              |               |



*Design/Build Engineers & Contractors  
Specialists in Steam and Cogeneration Systems*

**ESI Inc. of Tennessee**  
1250 Roberts Blvd  
Kennesaw, GA 30144  
Phone: 770-427-6200  
Fax: 770-425-3660  
[www.esitenn.com](http://www.esitenn.com)

# Exhibit H – Scope of Work for Capital Cost Estimate (condensing / extracting facility)

## OPTION 2 –CONDENSING STG FACILITY

### Plant Description

The Option 2 plant is designed with a condensing turbine to generate power and deliver process steam to the host. This adds several pieces of auxiliary equipment to the project but it allows the ability to generate power when process steam needs are discontinued and results in a higher kW generation.

### General Scope

ESI has made an effort to minimize capital cost and maximize conservative equipment selection for this project. We have selected equipment from manufacturers who are industry leaders in the design and manufacture of industrial and utility steam and cogeneration products and equipment. All of the manufacturers specified have many years of similar product application and experience.

ESI has selected equipment performance, standards, design parameters, and weights and materials of construction based upon our experience in designing, building, and operating steam and power systems. These items, as selected by ESI, are easily capable of an equipment life in excess of 30 years, as well as efficient, reliable operation. We have proposed a design that considers optimizing the desired performance of the equipment while maintaining conservative design parameters. These items include such things as conservative furnace liberation rate, absorption rate, flue gas velocities, design temperatures and pressures, materials and weights of construction, conveying speeds, conveyor loading, design margins, etc.

The scope of this combined heat and power generation facility includes, but is not limited to the following equipment, systems, etc., which are described in detail in the Equipment Description section of this proposal:

### Site Work/Civil

- One lot of site grading and preparation for foundations
- One lot of foundations for the new STG, boiler and auxiliary systems
- One lot foundations for new fuel feed hopper
- One lot foundations for hog/screen tower and elevated slab for hog
- One lot underground plumbing for building drains to existing sewer connection

- One lot of site drainage including catch basins for storm water run-off

**Structural/Architectural:**

- One (1) pre-engineered steel structure 36' wide by 37' long by 65' high (eave height) enclosing the boiler with a low bay structure 26' wide by 51' long by 34' high (eave height) enclosing the STG. The steel frame structure will include siding, girts, and metal panel roofing system.
- One (1) lot of HVAC equipment including wall-mounted ventilation supply and exhaust fans and unit heaters. The building ventilation system will offer up to twenty air changes per hour during the summer months and the unit heaters will maintain the building at a minimum 50°F temperature during the winter months.
- One (1) engineered structure 15' wide by 25' long by 40' high (eave height) disc screen and hog tower (roof only, no siding).
- One (1) pre-engineered enclosure 82' wide by 53' long by 20' high (eave height) for the protection of the fuel feed hopper.
- One lot of equipment support steel for all new equipment.
- One lot of platforms, walkways, and ladders for major equipment access.
- One lot of building trim, flashing, personnel and roll up doors for the building.

**STG and Auxiliaries**

One (1) nominal 2.4 MW reaction multistage, multivalve condensing extraction turbine and water to air-cooled generator with the following auxiliaries:

- Gland steam seal and exhaust system
- Lube/control oil system(s) with coolers and filters
- Electro-hydraulic control (EHC) system
- Turbine control panel
- DC battery and charging system
- Generator excitation, protection and control panel
- Line/neutral cabinet

- Vibration and axial displacement monitoring system
- One (1) steam surface condenser
- One (1) cooling tower
- Two (2) 50% capacity cooling water pumps
- Cooling tower chemical treatment system
- Two (2) 100% capacity hotwell pumps for transferring condensate to the deaerator
- One (1) 25-ton two-speed bridge crane and rails for maintenance in the turbine-generator bay

**Electrical, Instrumentation/Controls:**

- One lot of electrical power equipment
- One lot of electrical installation labor and materials including all required cable tray, cable, and conduit.
- One (1) Allen-Bradley ControlLogix PLC-based control system.
- One lot of field instrumentation devices for all new systems described herein.
- One lot of instrumentation installation labor and materials including mounting of field devices, process tubing, and calibration.

**Boiler Island:**

- One (1) 25,000 pph vibrating water-cooled grate, stoker-fired boiler designed for 615 psia 750°F steam generation. The proposed boiler is a bottom supported design with one start-up burner with individual valve racks and flame scanners. The unit is complete with refractory, insulation, casing, sootblowers, superheater, all required trim, and safety relief, vent and drain valves.
- One (1) forced draft (FD) fan including drive with sole plate, damper with actuator, and inlet silencer for supplying underfire air below the stoker.
- One (1) primary economizer for recovering excess heat from the boiler flue gas by preheating the boiler feedwater upstream of the steam drum.

- One (1) overfire air (OFA) fan including drive with sole plate and damper with actuator to provide overfire air in the furnace above the fuel bed.
- One (1) distributor air (DA) fan including drive with sole plate and damper with actuator to provide air to the fuel distributors on the stoker.
- One lot of interconnecting ductwork for the primary combustion air system, complete with dampers and expansion joints as required. This system will include ductwork from the building side wall to the FD fan, from the FD fan to the air heater, from the air heater to the OFA fan, from the OFA fan to the OFA nozzles, and from the inlet of the distributor air fan to the fuel distributors.
- One (1) bottom blowdown tank with tempering system.

#### **Emissions Control Systems:**

- One (1) mechanical collector, to remove particulate from the flue gas stream.
- One (1) electrostatic precipitator (ESP), complete with roof enclosure, to remove particulate from the flue gas stream.
- One (1) induced draft (ID) fan including motor drive with sole plate and damper.
- One lot of interconnecting breeching for the induced draft fan system, complete with dampers and expansion joints as required. This system will include breeching from the generating bank outlet through the economizer, tubular air heater and ID fan to the ESP and stack inlet.
- One (1) new single wall carbon steel stub stack approximately 75' in height complete with test platform attached to the ESP.

#### **Fuel (Biomass) Unloading and Handling System:**

- One (1) biomass receiving fuel feed hopper with live-bottom reclaim hopper and enclosure. The fuel feed hopper will accommodate self-unloading trailers only. The reclaim hopper will convey the biomass to a transfer conveyor.
- One (1) rotary-type disc screen will classify the incoming biomass to bypass the hog.
- One (1) hammermill type wood hog will correctly size the rejects of the disc screen. Sized for 50% of the incoming stream.
- Three (3) belt conveyors for transferring the biomass fuel from the fuel feed hopper to the screen/hog tower, from the screen/hog tower to the boiler, and from the sawmill to

another belt conveyor. These systems will come complete with full belt covers, belt scrapers, and gravity take-up units where required.

- Two (2) electromagnets for removal of tramp metal in the incoming fuel and from the sawdust supply from the sawmill.
- One lot of diverter gates and chutes to interconnect the transfer system.
- One (1) live bottom-metering bin to feed fuel to boiler fuel feed distributors. The bin will provide 10-15 minutes of fuel storage.

#### **Ash Handling System:**

- One (1) bottom ash removal system consisting of one wet ash collection drag conveying ash to one customer-supplied roll-off dumpster.
- One (1) fly ash collection system to convey fly ash from pick-up points at the boiler mud drum hopper, mechanical collector, and ESP to customer-supplied roll-off dumpsters. It consists of the following:
  - One (1) precipitator hopper screw conveyor
  - One (1) precipitator rotary airlock
  - One (1) mechanical collector rotary air lock
  - One (1) mechanical collector screw conveyor
  - One (1) boiler hopper rotary air lock
  - One (1) boiler hopper screw conveyor

#### **Balance of Plant:**

- One (1) spray/tray type deaerator with integrated feedwater storage tank.
- One (1) reverse osmosis (RO) type water treatment system for boiler water make-up complete with forwarding pumps.
- One (1) lot chemical treatment skids including day tank, mixing, and injection pumps.
- One (1) lot sample coolers for operational water testing.
- One (1) FRP demineralized water storage tank complete with forwarding pumps.
- One (1) carbon steel condensate return storage tank complete with forwarding pumps.

- Two (2) multi-stage diffuser type boiler feedwater pumps each capable of delivering 100% of required boiler inlet flow.
- One (1) lot of fire protection systems including wet-sprinkler system for turbine lube oil area, dry-pipe system for conveyor system, fire hose stations on each floor of boiler building, extinguishers for personnel spaces, and a fire loop extension with hydrants for facility perimeter.
- One (1) rotary screw air compressor complete with air receiver and desiccant drying system for supply of plant and instrument air.
- One (1) lot safety shower and eyewash stations.
- One lot of piping including supports and spring cans for new boiler system.
- One lot of piping for distribution and interconnection of new facility with the sawmill.
- One lot of valves, traps, strainers, and control valves for new equipment.
- One lot of insulation and lagging for all hot equipment and piping.
- One lot of field labor for complete system erection.
- One lot of painting for all structural steel, non-insulated piping, and touch-up of all non-insulated equipment.

#### **Engineering and Management Services**

- One lot of Engineering and Design services.
- One lot of Project Management services.
- One lot of Construction Management (Field Supervision) services including full-time on-site management during construction phase of project.
- One lot of Start-up and Commissioning services.
- One lot of Operator Training services.

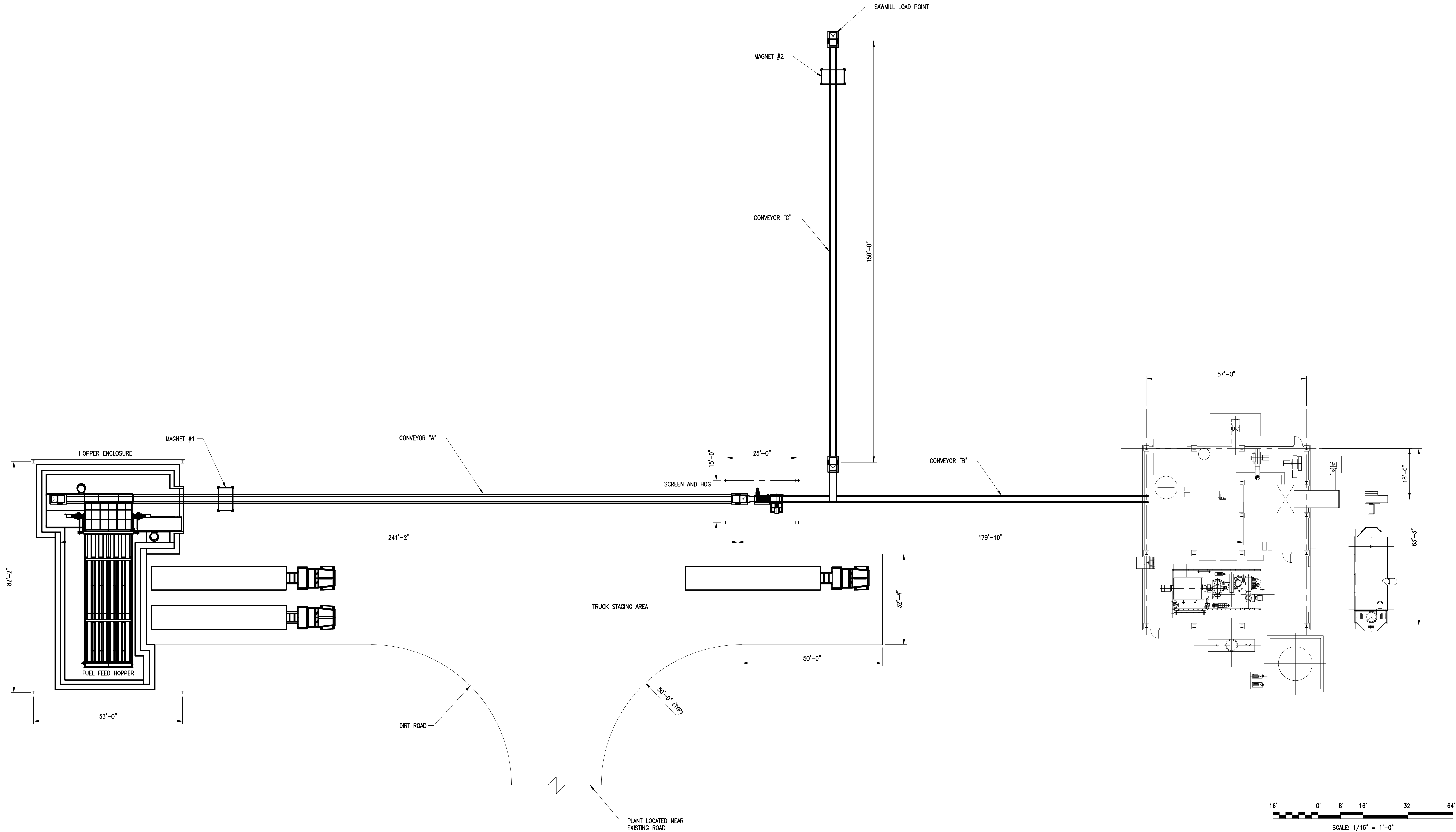
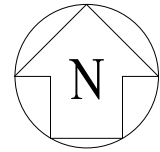


*Design/Build Engineers & Contractors  
Specialists in Steam and Cogeneration Systems*

*ESI Inc. of Tennessee  
1250 Roberts Blvd  
Kennesaw, GA 30144  
Phone: 770-427-6200  
Fax: 770-425-3660  
[www.esitenn.com](http://www.esitenn.com)*

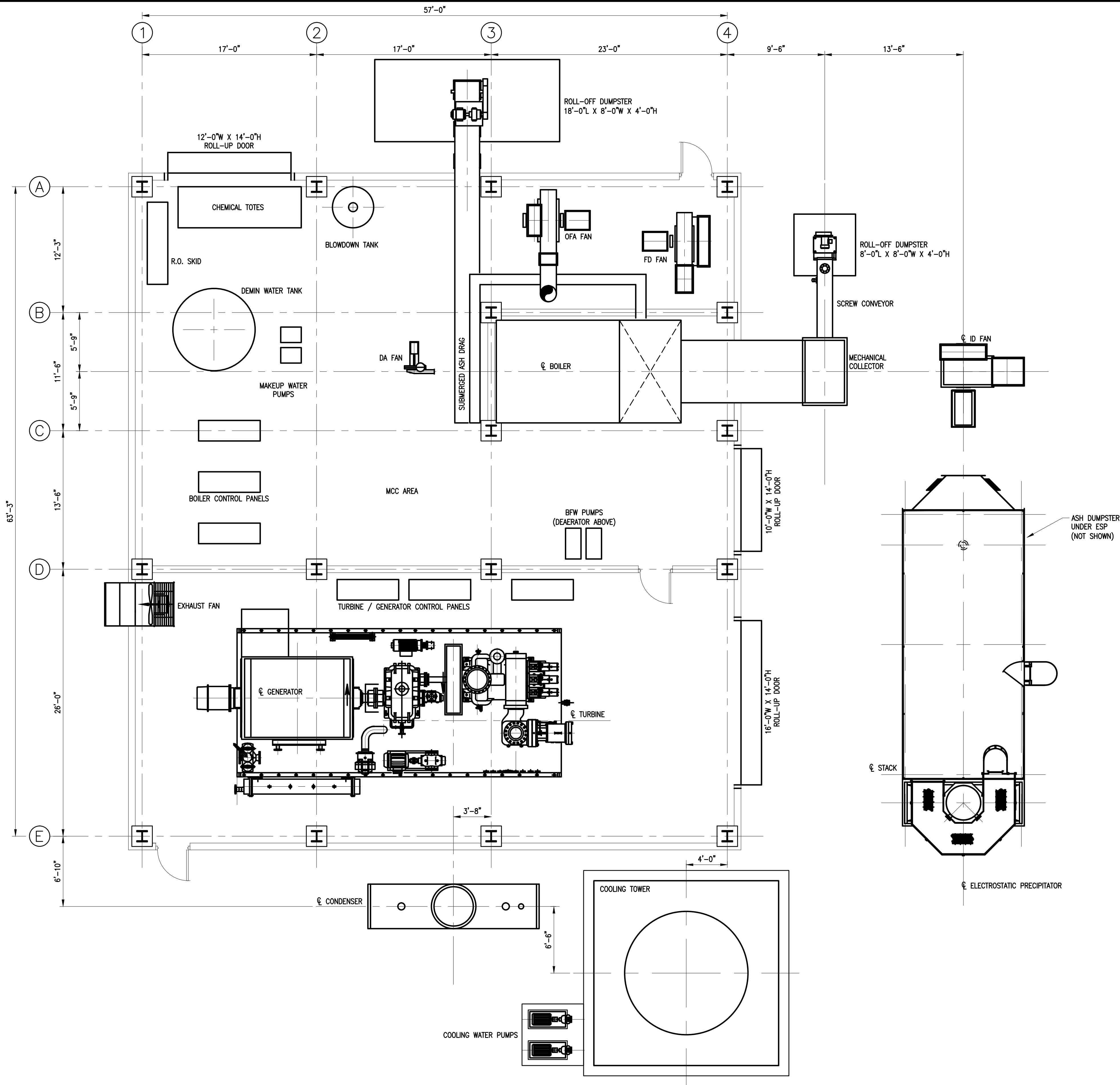
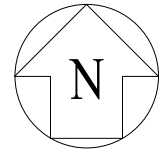
# Exhibit I – General Arrangement Drawings (condensing / extracting facility)

Plotted by Stowers, Jonathan on Monday, March 07, 2011 1:24:46 PM



| REV | DRAWN | DATE     | CHK'D | DATE     | DESCRIPTION                | REFERENCE DRAWINGS                 | NOT FOR CONSTRUCTION | THE DESIGN DATA AND INFORMATION CONTAINED HEREIN IS PROPRIETARY TO ESI INC. OF TENNESSEE. NO PORTION OF THIS INFORMATION SHALL BE RELEASED EXCEPT AS AUTHORIZED THROUGH PRIOR WRITTEN APPROVAL BY ESI INC. OF TENNESSEE. | CHP PLANT<br>SITE PLAN – OPTION 2 |                            |           |
|-----|-------|----------|-------|----------|----------------------------|------------------------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|----------------------------|-----------|
| A   | JRS   | 02/23/11 | TJB   | 03/07/11 | ISSUED FOR CUSTOMER REVIEW |                                    |                      |                                                                                                                                                                                                                          | MARWOOD                           |                            |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          | NOVA SCOTIA                       |                            |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                   |                            |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                   |                            |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                   |                            |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                   |                            |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                   |                            |           |
|     |       |          |       |          |                            | Drawing File Name<br>688002G02.dwg |                      |  ESI Inc. of Tennessee<br>1250 Roberts Blvd.<br>Kennesaw, GA 30144<br>(770)427-6200<br>esitenn.com                                  | SCALE:<br>1/16" = 1'-0"           | DRAWING NO.:<br>688002 G02 | REV:<br>A |

Plotted by Stowers, Jonathan on Monday, March 07, 2011 1:31:59 PM



| REV | DRAWN | DATE     | CHK'D | DATE     | DESCRIPTION                | REFERENCE DRAWINGS                 | NOT FOR CONSTRUCTION | THE DESIGN DATA AND INFORMATION CONTAINED HEREIN IS PROPRIETARY TO ESI INC. OF TENNESSEE. NO PORTION OF THIS INFORMATION SHALL BE RELEASED EXCEPT AS AUTHORIZED THROUGH PRIOR WRITTEN APPROVAL BY ESI INC. OF TENNESSEE. | CHP PLANT<br>BOILER/STG BUILDING – OPTION 2 |                        |           |
|-----|-------|----------|-------|----------|----------------------------|------------------------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|------------------------|-----------|
| A   | JRS   | 02/21/11 | TJB   | 03/07/11 | ISSUED FOR CUSTOMER REVIEW |                                    |                      |                                                                                                                                                                                                                          | MARWOOD                                     |                        |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          | NOVA SCOTIA                                 |                        |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                             |                        |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                             |                        |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                             |                        |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                             |                        |           |
|     |       |          |       |          |                            | Drawing File Name<br>688002G04.dwg |                      |  ESI Inc. of Tennessee<br>1250 Roberts Blvd.<br>Kennesaw, GA 30144<br>(770)427-6200<br>esitenn.com                                  | SCALE:<br>3/16" = 1'-0"                     | DRAWING NO.:<br>688002 | REV:<br>A |



1250 Roberts Boulevard □ Kennesaw, GA 30144  
Ph: (770) 427-6200 Web: [www.esitenn.com](http://www.esitenn.com)  
Fax: (770) 425-3660 E-Mail: [info@esitenn.com](mailto:info@esitenn.com)

# **CHP PLANT FACILITY STUDY**

**Prepared for**

**MARWOOD LTD  
NOVA SCOTIA, CANADA**

**Prepared by**

**ESI INC. OF TENNESSEE**

**Project #688002 rev D**

**MARCH 21, 2011**

## TABLE OF CONTENTS

|                                                   | PAGE   |
|---------------------------------------------------|--------|
| I. Introduction.....                              | I-1    |
| II. Executive Summary .....                       | II-1   |
| III. Design Basis.....                            | III-1  |
| IV. Option 1 – Backpressure STG Facility .....    | IV-1   |
| V. Option 2 – Condensing STG Facility .....       | V-1    |
| VI. Capital Cost Estimate.....                    | VI-1   |
| VII. Operating and Maintenance Cost Estimate..... | VII-1  |
| VIII. Assumptions and Clarifications .....        | VIII-1 |

## APPENDIX

### Drawings

#### Flow Sheets

|           |                                                   |
|-----------|---------------------------------------------------|
| 688002F01 | Fuel Handling Flow Sheet                          |
| 688002F02 | Air and Flue Gas Flow Sheet - Option 1            |
| 688002F03 | Mass & Energy Balance Option 1 – Backpressure STG |
| 688002F04 | Air and Flue Gas Flow Sheet - Option 2            |
| 688002F05 | Mass & Energy Balance Option 2 - Max. Extraction  |
| 688002F06 | Mass & Energy Balance Option 2 - Full Condensing  |

#### General Arrangements

|           |                                          |
|-----------|------------------------------------------|
| 688002G01 | CHP Plant Site Plan - Option 1           |
| 688002G02 | CHP Plant Site Plan - Option 2           |
| 688002G03 | CHP Plant Boiler/STG Building - Option 1 |
| 688002G04 | CHP Plant Boiler/STG Building - Option 2 |

## **INTRODUCTION**

A significant portion of electricity in Nova Scotia is produced from the combustion of coal. Uncontrolled coal combustion emits relatively large amounts of CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, and other pollutants into the atmosphere. To help combat this, the Nova Scotia government has enacted new renewable energy regulations that require power generation from renewable resources to equal 25% of all power generation by the year 2015. As part of the strategy to transition Nova Scotia towards more renewable energy a Community Feed-In Tariff program has been established.

The purpose of this study is to determine values for the capital cost, O&M and principal operating parameters for a new biomass fired CHP facility which The Alliance of Nova Scotia Sawmillers (ANSS) are considering. The ANSS commissioned this study to assist them in their comparison of the proposed plant's generating cost with the NSUARB consultant's model to validate its pricing considerations for the biomass CHP COMFIT rate.

This study is intended to be a Phase I engineering study that contains enough detail for the ANSS to make a reasonably accurate assessment of the cost of generating the electricity from a plant as described in this study. ESI was tasked with analyzing two options for this study. Option 1 utilizes a backpressure steam turbine to generate power and deliver process steam to the host. Option 2 utilizes a condensing steam turbine to allow the facility to generate power when the host is not in operation.

The deliverables for this study were:

- Provide a balance of plant description
- Prepare preliminary layouts and flow diagrams
- Plant Operating Parameters
- O&M Cost Estimate
- Capital Cost Estimate

## EXECUTIVE SUMMARY

### Background

This study was conducted in order to help the ANSS evaluate the biomass CHP COMFIT rate as proposed by the NSUARB. As part of the initial conceptualization, ESI developed mass and energy balance models at 0.5MW, 2MW, and 5MW for both condensing and backpressure machines. Based on the typical steam requirements for sawmills in the group, it was decided to proceed with a more detailed study of the nominal 2MW facility.

### Capital Estimate

Once this determination was made, ESI ran detailed mass and energy balance models for the facility. Using this information ESI developed specifications and solicited quotes for the major pieces of equipment. The balance of plant equipment was cost estimated using quotes for similar equipment in ESI's extensive database (adjusted for sizing and inflation). Using a combination of vendor information from new quotes and information from previous ESI projects, general arrangement drawings were generated to allow material take-offs for construction. Therefore, the EPC budget estimate was generated using information from actual vendor quotes (new and adjusted old) and take-offs for commodity and construction pricing utilizing ESI's database of biomass projects.

The capital cost estimate for equipment is in the  $\pm 10\%$  accuracy range for a brown-field facility with conditions similar to what we have assumed throughout this document. ESI has performed biomass construction projects in Newfoundland, Quebec and Ontario along with engineering for biomass projects in Maine and New Brunswick but not in Nova Scotia – therefore we expect that the accuracy of our construction estimate is in the  $\pm 20\%$  range.

However, since this is a “generic” facility with unidentified geotechnical, infrastructure, and design conditions – this budget should probably be considered  $\pm 25\%$  for the purposes of risk analysis. Varying conditions such as soil conditions, proximity to steam host, existing steam host auxiliary systems (such as fire protection, water supply, sewer systems, etc.), and other factors will be unknown for this facility until a specific site is picked.

### Recommendation

As can be seen throughout this document, based on a “generic” site location and steam host – it appears that the significantly better investment would be the condensing/extracting facility based on economics.

| PRELIMINARY DESIGN BASIS   |                                  |                   |         |               |                 |                 |     |
|----------------------------|----------------------------------|-------------------|---------|---------------|-----------------|-----------------|-----|
| ESI PROJECT NUMBER -688002 |                                  |                   |         |               |                 |                 |     |
|                            | Revision                         |                   | C       |               |                 |                 |     |
|                            | Description                      |                   | Marwood |               |                 |                 |     |
|                            | Revised By                       |                   | JSP     |               |                 |                 |     |
|                            | Checked by                       |                   | TJB     |               |                 |                 |     |
|                            | Revision Date                    |                   | 3/7/11  |               |                 |                 |     |
| LOCATION                   |                                  |                   |         |               | Nova Scotia     |                 |     |
| ELEVATION                  | Plant                            |                   |         |               | 200             |                 |     |
| ENVIRONMENTAL              |                                  |                   |         |               |                 |                 |     |
|                            | Governing Code                   |                   |         |               | NSBCR           |                 |     |
|                            | Seismic Zone                     |                   |         |               |                 |                 |     |
|                            | Sa (.2)                          |                   |         |               | 0.24            |                 |     |
|                            | Sa (1.0)                         |                   |         |               | 0.062           |                 |     |
|                            | Hourly Wind Pressure- 1/10       |                   |         |               | 8.6             |                 | psf |
|                            | Hourly Wind Pressure- 1/50       |                   |         |               | 12.10           |                 | psf |
|                            | Ambient Temperature              |                   |         |               |                 |                 |     |
|                            | Winter DB                        |                   |         |               | -11             |                 | °F  |
|                            | Percentile                       |                   |         |               | 99.0            |                 | %   |
|                            | Summer DB                        |                   |         |               | 84              |                 | °F  |
|                            | Percentile                       |                   |         |               | 1.0             |                 | %   |
|                            | Summer WB                        |                   |         |               | 70              |                 | °F  |
|                            | Ground Snow Load, S <sub>s</sub> |                   |         |               | 50              |                 | psf |
| AVAILIBLTY                 |                                  |                   |         | Back Pressure | Full Condensing | Max. Extraction |     |
|                            | Hours/year (90%)                 |                   |         | 60% = 5256    | 30% = 2628      | 60% = 5256      | hr  |
| FUEL DATA                  |                                  |                   |         |               |                 |                 |     |
| Generic Biomass            |                                  | Ultimate Analysis | Wood    | % Weight      |                 |                 |     |
|                            |                                  | As Received       | Units   |               |                 |                 |     |
|                            |                                  | Moisture          | %       | 50.00         |                 |                 |     |
|                            |                                  | Ash               | %       | 2.50          |                 |                 |     |
|                            |                                  | Carbon            | %       | 25.00         |                 |                 |     |
|                            |                                  | Hydrogen          | %       | 5.00          |                 |                 |     |
|                            |                                  | Nitrogen          | %       | 0.25          |                 |                 |     |
|                            |                                  | Sulfur            | %       | 0.02          |                 |                 |     |
|                            |                                  | Oxygen            | %       | 17.22         |                 |                 |     |
|                            |                                  | Chlorine          | %       | 0.01          |                 |                 |     |
|                            |                                  |                   |         | 100           |                 |                 |     |
|                            |                                  | Heating Value     | Btu/lb  | 4,300         |                 |                 |     |
|                            |                                  | Dry               | Units   | 0.0%          |                 |                 |     |
|                            |                                  | Moisture          | %       | 0.00          |                 |                 |     |
|                            |                                  | Ash               | %       | 5.00          |                 |                 |     |
|                            |                                  | Carbon            | %       | 50.00         |                 |                 |     |
|                            |                                  | Hydrogen          | %       | 10.00         |                 |                 |     |
|                            |                                  | Nitrogen          | %       | 0.50          |                 |                 |     |
|                            |                                  | Sulfur            | %       | 0.04          |                 |                 |     |
|                            |                                  | Oxygen            | %       | 34.44         |                 |                 |     |
|                            |                                  | Chlorine          | %       | 0.02          |                 |                 |     |
|                            |                                  |                   |         | 100           |                 |                 |     |
|                            |                                  | Heating Value     | Btu/lb  | 8600.0        |                 |                 |     |

| BARK - COMPOSITE ANALYSIS |                                   |          |          |        |                            |
|---------------------------|-----------------------------------|----------|----------|--------|----------------------------|
|                           | moisture content (design)         |          | 50.0     |        | %                          |
|                           | Density (conveying)               |          | 15.0     |        | lb/ft <sup>3</sup> - wet   |
|                           | Density (storage)                 |          | 20.0     |        | lb/ft <sup>3</sup> - wet   |
|                           | Density (horsepower)              |          | 25.0     |        | lb/ft <sup>3</sup> - wet   |
|                           | Density (structural)              |          | 35.0     |        | lb/ft <sup>3</sup> - wet   |
|                           | Angle of repose                   |          | Negative |        | degrees                    |
|                           | Size                              |          | 3" minus |        |                            |
| ASH SYSTEM                |                                   |          |          |        |                            |
| ASH                       |                                   | Option 1 | Option 2 | Design |                            |
|                           | Total Ash Production              | 76       | 95       | 157    | lb/hr                      |
|                           | Unburned Carbon in Fly Ash        | 8.0%     | 8.0%     | 8.0%   | %                          |
|                           | (lb/hr)                           | 7        | 8        | 14     | lb/hr                      |
|                           | Total                             | 83       | 104      | 171    | lb/hr                      |
|                           |                                   |          |          |        |                            |
|                           | % Fly Ash                         | 50%      | 50%      | 50%    |                            |
|                           | Fly Ash Production                | 41       | 52       | 86     | lb/hr                      |
|                           | Density                           | 15       | 15       | 16     | lb/ft <sup>3</sup>         |
|                           | Hourly volume                     | 3        | 3        | 5      | ft <sup>3</sup> /hr        |
|                           | Daily production                  | 66       | 83       | 128    | ft <sup>3</sup> /24 hrs    |
|                           |                                   |          |          |        |                            |
|                           | % Removal by Mech. Collector      | 50%      | 50%      | 50%    |                            |
|                           | lb/hr removed by Mech. Collector  | 21       | 26       | 43     |                            |
|                           | lb/hr to the ESP                  | 21       | 26       | 43     |                            |
|                           |                                   |          |          |        |                            |
|                           | Bottom ash production (dry basis) | 41       | 52       | 86     | lb/hr                      |
|                           | % dry solids content              | 45%      | 45%      | 45%    |                            |
|                           | Wet basis                         | 92       | 115      | 190    | lb/hr                      |
|                           | Density                           | 55       | 55       | 55     | lb/ft <sup>3</sup>         |
|                           | Hourly volume                     | 2        | 2        | 3      | ft <sup>3</sup> /hr        |
|                           | Daily production                  | 40       | 50       | 83     | ft <sup>3</sup> /24-hr day |
|                           | Daily production                  | 1.5      | 1.9      | 3.1    | yd <sup>3</sup> /24-hr day |
|                           |                                   |          |          |        |                            |
|                           | Ash factor                        | 3.98     | 3.98     | 6.57   | lb/mmBtu                   |
|                           |                                   |          |          |        |                            |
|                           | Method of Disposal                | Dumpster |          |        |                            |

| BOILER DESIGN                          |                                     |  |                 |                 |                                     |          |
|----------------------------------------|-------------------------------------|--|-----------------|-----------------|-------------------------------------|----------|
|                                        |                                     |  |                 |                 |                                     |          |
| <b>BARK &amp; SAW DUST FUEL BOILER</b> |                                     |  | <b>Option 1</b> | <b>Option 2</b> |                                     |          |
|                                        | Boiler heat input                   |  | 33.6            | 42.0            | mmbtu/hr                            |          |
|                                        | Total Heat Input                    |  | 33.6            | 42.0            | mmbtu/hr                            |          |
|                                        | Fuel Rate PPH                       |  | 7,814           | 9,767           | pph                                 |          |
|                                        | Fuel Rate TPY                       |  | 20,535          | 38,502          | ton/yr at Design Availability hours |          |
|                                        | Boiler steam output                 |  | 20,000          | 25,000          | pph                                 |          |
|                                        | Steam pressure (Outlet of MSSNRV)   |  | 600             | 600             | psig                                |          |
|                                        | Steam temperature                   |  | 750             | 750             | °F                                  |          |
|                                        | Efficiency                          |  | 69.9            | 69.9            | %                                   |          |
|                                        | Continuous Blowdown %               |  | 4               | 4               | %                                   |          |
|                                        | Continuous Blowdown Flow            |  | 800             | 1,000           | pph                                 |          |
|                                        | Combustion air flow                 |  | 30,954          | 38,690          | pph                                 |          |
|                                        | Flue gas flow                       |  | 38,474          | 48,089          | pph                                 |          |
|                                        | Flue gas temperature                |  | 350             | 350             | °F                                  |          |
|                                        | Flue gas volume                     |  | 13,862          | 17,324          | acfm                                |          |
| <b>Start-up Burners</b>                |                                     |  | <b>Option 1</b> | <b>Option 2</b> |                                     |          |
|                                        | Burner input MCR - per burner       |  | 3.4             | 4.2             | mmbtu/hr                            |          |
|                                        | Quantity                            |  | 1               | 1               |                                     |          |
|                                        | Fuel                                |  | Propane         | Propane         |                                     |          |
|                                        | Turndown Limit                      |  | 8:1             | 8:1             | Ratio                               |          |
|                                        | Gas supply pressure(@ Vendor Limit) |  | 40              | 40              | psig                                |          |
|                                        | Static pressue loss (delta P)       |  | 0.5             | 0.5             | 0.5                                 | in. w.c. |
|                                        |                                     |  |                 |                 |                                     |          |

| AIR QUALITY CONTROL               |                                  |                                                 |                                   |                                   |               |            |
|-----------------------------------|----------------------------------|-------------------------------------------------|-----------------------------------|-----------------------------------|---------------|------------|
| <b>MECHANICAL COLLECTOR</b>       |                                  |                                                 |                                   |                                   |               |            |
|                                   |                                  |                                                 | <b>Option 1</b>                   | <b>Option 2</b>                   | <b>Design</b> |            |
|                                   |                                  | Ash mass flow                                   | 41                                | 52                                | 86            | pph        |
|                                   |                                  | Trona mass flow                                 | 0                                 | 0                                 | 0             | pph        |
|                                   |                                  | Total particulate matter                        | 41                                | 52                                | 86            | pph        |
|                                   |                                  | Minimum removal efficiency (for ESP inlet load) | 50%                               | 50%                               | 50%           | percent    |
|                                   |                                  | Dust loading to ESP                             | 21                                | 26                                | 43            | pph        |
|                                   |                                  | Flow gas flow                                   | 38,474                            | 48,089                            | 48,089        | pph        |
|                                   |                                  | Flow                                            | 13,862                            | 17,324                            | 17,324        | acfm       |
|                                   |                                  | Gas temperature                                 | 350                               | 350                               | 350           | F          |
|                                   |                                  | Static pressue loss (delta P)                   | 2.5                               | 2.5                               | 2.5           | in. w.c.   |
| <b>ELECTROSTATIC PRECIPATATOR</b> |                                  |                                                 |                                   |                                   |               |            |
|                                   |                                  |                                                 |                                   |                                   |               |            |
|                                   |                                  | Model                                           |                                   |                                   |               |            |
|                                   |                                  | Case                                            | <b>Option 1</b>                   | <b>Option 2</b>                   | <b>Design</b> |            |
|                                   |                                  | Operating temperature                           | 350                               | 350                               | 350           | °F         |
|                                   |                                  | Gas mass flow                                   | 38,474                            | 48,089                            | 48,089        | pph        |
|                                   |                                  | Gas volume                                      | 13,862                            | 17,324                            | 17,324        | acfm       |
|                                   |                                  | Total PM Inlet Loading                          | 21                                | 26                                | 43            | pph        |
|                                   |                                  | Total PM Inlet Loading                          | 0.62                              | 0.62                              | 1.02          | lb/MMBTU   |
|                                   |                                  | Total PM Outlet Loading                         | 1.01                              | 1.26                              | 1.26          | pph        |
|                                   |                                  | Total PM Outlet Loading                         | 0.030                             | 0.030                             | 0.030         | lb/MMBTU   |
|                                   |                                  | Removal Efficiency                              | 95.1%                             | 95.1%                             | 97.1%         | %          |
|                                   |                                  | Static pressue loss (delta P)                   | 0.5                               | 0.5                               | 0.5           | in. w.c.   |
|                                   |                                  |                                                 |                                   |                                   |               |            |
| MATERIAL HANDLING                 |                                  |                                                 |                                   |                                   |               |            |
| <b>BIOMASS SCALES</b>             |                                  |                                                 |                                   |                                   |               |            |
|                                   | Quantity                         |                                                 |                                   | 0                                 |               |            |
|                                   |                                  |                                                 |                                   |                                   |               |            |
| <b>BIOMASS RECEIVING SYSTEM</b>   |                                  |                                                 | <b>Option 1</b>                   | <b>Option 2</b>                   |               |            |
|                                   | Delivery Source                  |                                                 | Trucks                            | Trucks                            |               |            |
|                                   | Receiving Equipment Type         |                                                 | Fuel Feed Hopper with Live Bottom | Fuel Feed Hopper with Live Bottom |               |            |
|                                   | Quantity                         |                                                 | 1                                 | 1                                 |               |            |
|                                   | Reclaimer Hopper Capacity        |                                                 | 9,000                             | 9,000                             |               | cf         |
|                                   | Reclaimer Hopper Capacity        |                                                 | 68                                | 68                                |               | tons (wet) |
|                                   | Time to Unload Truck             |                                                 | 15                                | 15                                |               | minutes    |
|                                   | Reclaimer Conveying Capacity     |                                                 | 4.2                               | 5.2                               |               | tph (wet)  |
|                                   | Number of Days for Delivery/Week |                                                 | 7                                 | 7                                 |               |            |
|                                   | Delivery Hours per Day           |                                                 | 12                                | 12                                |               |            |
|                                   | No. Trucks to Discharge Per Day  |                                                 | 4.2                               | 5.2                               |               |            |
|                                   | Capacity per Truck               |                                                 | 22                                | 22                                |               | tons       |

| MATERIAL HANDLING                        |                             |  |                          |                          |                    |
|------------------------------------------|-----------------------------|--|--------------------------|--------------------------|--------------------|
| <b>BIOMASS CLASSIFICATION SYSTEM</b>     |                             |  |                          |                          |                    |
|                                          | Material Sizing             |  | 3" Minus                 | 3" Minus                 | inches             |
|                                          | Screen Capacity (unloading) |  | 4.2                      | 5.2                      | tph (wet)          |
|                                          | Rejects Hog Sizing          |  | 2.1                      | 2.6                      | tph (wet)          |
| <b>BIOMASS LONG TERM STORAGE SYSTEM</b>  |                             |  |                          |                          |                    |
|                                          | Fuel                        |  | Logs                     | Logs                     |                    |
| <b>BIOMASS SHORT TERM STORAGE SYSTEM</b> |                             |  |                          |                          |                    |
|                                          | Fuel                        |  | Bark / Biomass           | Bark / Biomass           |                    |
|                                          | Type                        |  | Fuel Feed Hopper         | Fuel Feed Hopper         |                    |
|                                          | Storage Density             |  | 20                       | 20                       | pcf                |
|                                          | Storage Time                |  | 24                       | 18                       | hours              |
|                                          | Storage Capacity Required   |  | 92                       | 86                       | tons               |
|                                          | Storage Capacity Required   |  | 9,162                    | 8,589                    | ft3                |
|                                          | Walking Floor Width         |  | 16.8                     | 16.8                     | ft                 |
|                                          | Walking Floor Length        |  | 46.7                     | 46.7                     | ft                 |
|                                          | Walking Floor Height        |  | 17                       | 17                       | ft                 |
|                                          | Fuel                        |  | Sawdust                  | Sawdust                  |                    |
|                                          | Type                        |  | None                     | None                     |                    |
| <b>BIOMASS RECLAIM SYSTEM</b>            |                             |  |                          |                          |                    |
|                                          | Fuel                        |  | Bark / Market Biomass    | Bark / Market Biomass    |                    |
|                                          | Type                        |  | Walking Floor            | Walking Floor            |                    |
|                                          | Capacity                    |  | 4.2                      | 5.2                      | tph                |
|                                          | Capacity                    |  | 560                      | 700                      | cfh                |
|                                          | Number of Reclaimers        |  | 1                        | 1                        |                    |
|                                          | Fuel                        |  | Sawdust                  | Sawdust                  |                    |
|                                          | Type                        |  | Belt Conveyor            | Belt Conveyor            |                    |
| <b>BIOMASS BOILER FEED SYSTEM</b>        |                             |  |                          |                          |                    |
|                                          | Type                        |  | Live Bottom Metering Bin | Live Bottom Metering Bin |                    |
|                                          | Capacity                    |  | 3.8                      | 4.8                      | tph                |
|                                          | Capacity (Volumetric)       |  | 509                      | 636                      | cfh                |
|                                          | Number of Feeders           |  | 1                        | 1                        |                    |
| <b>BOTTOM ASH COLLECTION SYSTEM</b>      |                             |  |                          |                          |                    |
|                                          | Type                        |  | Submerged Ash Drag Chain | Submerged Ash Drag Chain |                    |
|                                          | Capacity (each boiler)      |  | 115                      | 190                      | pph                |
|                                          | Total Capacity              |  | 115                      | 190                      | pph                |
|                                          | Density                     |  | 45                       | 45                       | lb/ft <sup>3</sup> |
|                                          | Design temperature          |  | 500                      | 500                      | °F                 |
| <b>BOTTOM ASH STORAGE</b>                |                             |  |                          |                          |                    |
|                                          | Type                        |  | 20 cy Dumpster           | 20 cy Dumpster           |                    |
|                                          | Capacity                    |  | 12.2                     | 12.2                     | tons               |
|                                          | Number of Days              |  | 11.0                     | 8.8                      |                    |
|                                          | Density                     |  | 45                       | 45                       | lb/ft <sup>3</sup> |
|                                          | Design temperature          |  | 200                      | 200                      | °F                 |
| <b>FLY ASH COLLECTION SYSTEM</b>         |                             |  |                          |                          |                    |
|                                          | Type                        |  | Mechanical               | Mechanical               |                    |
|                                          | Total Capacity              |  | 41                       | 52                       | pph                |
|                                          | Density                     |  | 20                       | 20                       | lb/ft <sup>3</sup> |
|                                          | Design temperature          |  | 600                      | 600                      | °F                 |
| <b>FLY ASH STORAGE</b>                   |                             |  |                          |                          |                    |
|                                          | Type                        |  | Dumpster                 | Dumpster                 |                    |
|                                          | Capacity                    |  | 20                       | 20                       | cy                 |
|                                          | Storage Time                |  | 260                      | 208                      | hours              |
|                                          | Storage Time                |  | 208                      | 126                      | hours              |
|                                          | Weight Capacity             |  | 5                        | 5                        | tons               |
|                                          | Density                     |  | 20                       | 20                       | lb/ft <sup>3</sup> |
|                                          | Design temperature          |  | 200                      | 200                      | °F                 |

| STEAM CYCLE DESIGN AND POWER GENERATION |                                                     |  |               |                 |                 |          |  |
|-----------------------------------------|-----------------------------------------------------|--|---------------|-----------------|-----------------|----------|--|
| TURBINE                                 |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  | Option 1      | Option 2        |                 |          |  |
|                                         |                                                     |  | Back Pressure | Full Condensing | Max. Extraction |          |  |
|                                         | Gross Power Output                                  |  | 1,060         | 2,414           | 1,602           | kW       |  |
|                                         | Throttle flow                                       |  | 20,000        | 25,000          | 25,000          | pph      |  |
|                                         | Inlet pressure                                      |  | 590           | 590             | 590             | psig     |  |
|                                         | Inlet temperature                                   |  | 750           | 750             | 750             | °F       |  |
|                                         |                                                     |  |               |                 |                 |          |  |
|                                         | Flow to process                                     |  | 18,000        | 0               | 18,000          | pph      |  |
|                                         | Flow to deaerator                                   |  | 2,000         | 3,332           | 2,304           | pph      |  |
|                                         | Controlled extraction pressure                      |  | 20            | 20              | 20              | psig     |  |
|                                         | Temperature                                         |  | 260           | 260             | 260             | °F       |  |
|                                         | Enthalpy                                            |  | 1,167         | 1,167           | 1,167           | Btu/lb   |  |
|                                         |                                                     |  |               |                 |                 |          |  |
|                                         | Exhaust flow to condenser                           |  |               | 21,668          | 4,696           | pph      |  |
|                                         | Exhaust pressure                                    |  |               | 2.0             | 2.0             | In-Hg    |  |
|                                         | Temperature                                         |  |               | 102             | 102             | °F       |  |
|                                         | Enthalpy                                            |  |               | 1,019           | 1,062           | Btu/lb   |  |
|                                         |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  |               |                 |                 |          |  |
| PLANT PERFORMANCE                       |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  | Option 1      | Option 2        |                 |          |  |
|                                         |                                                     |  | Back Pressure | Full Condensing | Max. Extraction |          |  |
|                                         | Capacity Factor                                     |  | 60%           | 30%             | 60%             | %        |  |
|                                         | Gross Heat Input                                    |  | 33.6          | 42.0            | 42.0            | mmBtu/Hr |  |
|                                         | Gross Power Output                                  |  | 1,060         | 2,414           | 1,602           | kW       |  |
|                                         | Auxiliary Power Consumption (Parasitic Load)        |  | 210           | 348             | 348             | kW       |  |
|                                         | Auxiliary Power as a percentage of Gross Generation |  | 20%           | 14%             | 22%             |          |  |
|                                         | Net Generation                                      |  | 850           | 2,066           | 1,254           | kW       |  |
|                                         | Gross Heat Rate                                     |  | 31,698        | 17,399          | 26,217          | Btu/kWh  |  |
|                                         | Net Heat Rate                                       |  | 39,529        | 20,329          | 33,493          | Btu/kWh  |  |
|                                         | Power Plant Net Thermal Efficiency                  |  | 63.8%         | 16.8%           | 54.3%           | %        |  |
|                                         | Power Plant Annual Net Thermal Efficiency           |  | 63.8%         | 41.8%           |                 |          |  |
|                                         | Total Annual Generation (Gross)                     |  | 5,571         | 14,764          |                 | MWh      |  |
|                                         | Total Annual Generation (Net)                       |  | 4,468         | 12,020          |                 | MWh      |  |
|                                         |                                                     |  |               |                 |                 |          |  |
| AUXILIARY EQUIPMENT                     |                                                     |  |               |                 |                 |          |  |
|                                         |                                                     |  |               |                 |                 |          |  |
| COOLING TOWER                           |                                                     |  | Option 1      | Option 2        |                 |          |  |
|                                         |                                                     |  |               | Full Condensing | Max. Extraction |          |  |
|                                         | Design wet bulb temperature                         |  |               | 70              | 70              | °F       |  |
|                                         | Approach temperature                                |  |               | 10              | 3.2             | °F       |  |
|                                         | Heat load                                           |  |               | 20.4            | 4.8             | mmbtu/hr |  |
|                                         | Cooling water flow                                  |  |               | 2,666           | 2,666           | gpm      |  |
|                                         | Cooling tower make up                               |  |               | 41.9            | 13.1            | gpm      |  |
|                                         | Cooling tower blowdown                              |  |               | 10.4            | 3.2             | gpm      |  |
|                                         |                                                     |  |               |                 |                 |          |  |
| SURFACE CONDENSER                       |                                                     |  |               |                 |                 |          |  |
|                                         | Design Steam flow                                   |  |               | 21,668          |                 | pph      |  |
|                                         | Heat Exchanged                                      |  |               | 20.4            | 4.8             | mmBtu/hr |  |
|                                         |                                                     |  |               |                 |                 |          |  |

|                                    |                                                      |        |            |                 |        |       |
|------------------------------------|------------------------------------------------------|--------|------------|-----------------|--------|-------|
| BOILER MAKE-UP WATER SYSTEM        |                                                      |        |            |                 |        |       |
|                                    | System Type                                          |        |            | Reverse Osmosis |        |       |
|                                    | System Outflow                                       |        |            |                 |        |       |
|                                    |                                                      | Normal |            | 3.4             | 2.0    | 3.8   |
|                                    |                                                      |        |            |                 |        | gpm   |
| COOLING TOWER MAKE-UP WATER SYSTEM |                                                      |        |            |                 |        |       |
|                                    | Source                                               |        |            | City Water      |        |       |
|                                    | Requirement                                          |        |            |                 |        |       |
|                                    |                                                      | Normal |            | 52.3            | 16.3   | gpm   |
|                                    |                                                      |        |            |                 |        |       |
| RO WATER STORAGE TANK              |                                                      |        |            |                 |        |       |
|                                    | Capacity                                             |        | 10,000     | 10,000          | 10,000 | gal   |
|                                    | Storage Time (based on maximum makeup flow above)    |        | 49         | 83              | 44     | hours |
|                                    |                                                      |        |            |                 |        |       |
| PROCESS STEAM / CONDENSATE SYSTEM  |                                                      |        |            |                 |        |       |
|                                    | Steam Pressure                                       |        | 15         |                 |        | psig  |
|                                    | Process Steam Required                               |        | 18,000     |                 |        | pph   |
|                                    | Condensate Return Amount                             |        | 95%        |                 |        | %     |
|                                    | Condensate Capacity                                  |        |            | 17,100          |        | pph   |
|                                    | Temperature                                          |        | 170        |                 |        | °F    |
|                                    |                                                      |        |            |                 |        |       |
| CONDENSATE RECEIVER TANK           |                                                      |        |            |                 |        |       |
|                                    | Type                                                 |        | Tank       |                 |        |       |
|                                    | Capacity                                             |        | 7,500      |                 |        | gal   |
|                                    | Design Temperature                                   |        | 212        |                 |        | °F    |
|                                    | Design Flow                                          |        | 37         |                 |        | gpm   |
|                                    | Storage Time (based on condensate return flow above) |        | 3.4        |                 |        | hours |
|                                    | Polisher Required                                    |        | No         |                 |        |       |
|                                    |                                                      |        |            |                 |        |       |
| DEAERATOR                          |                                                      |        |            |                 |        |       |
|                                    | Type                                                 |        | Spray/Tray | Spray/Tray      |        |       |
|                                    | DA Capacity                                          |        | 20,800     | 26,000          |        | pph   |
|                                    | Operating Pressure                                   |        | 10         | 10              |        | psig  |
|                                    | Operating Temperature                                |        | 240        | 240             |        | °F    |
|                                    | Design Pressure                                      |        | 50         | 50              |        | psig  |
|                                    | Design Temperature                                   |        | 450        | 450             |        | °F    |
|                                    |                                                      |        |            |                 |        |       |
| BOILER FEED WATER PUMPS            |                                                      |        |            |                 |        |       |
|                                    | Number of Pumps                                      |        | 2 x 100%   |                 |        |       |
|                                    | BFP Operating point flow                             |        | 44.0       | 55.2            |        | gpm   |
|                                    | BFP Operating point head                             |        | 1617       | 1624.0          |        | ft    |
|                                    | BFP Design flow                                      |        | 46.2       | 57.7            |        | gpm   |
|                                    | BFP Design head                                      |        | 1780       | 1786.0          |        | ft    |
|                                    |                                                      |        |            |                 |        |       |
| HOTWELL PUMPS                      |                                                      |        |            |                 |        |       |
|                                    | Number of Pumps                                      |        | 2 x 100%   |                 |        |       |
|                                    | Operating Flow Rate                                  |        |            | 43              |        | gpm   |
|                                    | Design Flow Rate                                     |        |            | 46              |        | gpm   |
|                                    | TDH (operating)                                      |        |            | Later           |        | ft.   |
|                                    | TDH (design)                                         |        |            | Later           |        | ft.   |
|                                    |                                                      |        |            |                 |        |       |
| MAKEUP DEMIN. WATER PUMPS          |                                                      |        |            |                 |        |       |
|                                    | Number of Pumps                                      |        | 2 x 100%   |                 |        |       |
|                                    | Operating Flow Rate                                  |        | 3.4        | 3.8             |        | gpm   |
|                                    | Design Flow Rate                                     |        | 3.7        | 4.2             |        | gpm   |
|                                    | TDH (operating)                                      |        | 125        | 125             |        | ft.   |
|                                    | TDH (design)                                         |        | 137.5      | 137.5           |        | ft.   |
|                                    |                                                      |        |            |                 |        |       |
| COOLING WATER PUMPS                |                                                      |        |            |                 |        |       |
|                                    | Number of Pumps                                      |        | 2 x 50%    |                 |        |       |
|                                    | Operating Flow Rate                                  |        |            | 1,333           |        | gpm   |
|                                    | Design Flow Rate                                     |        |            | 1,400           |        | gpm   |
|                                    | TDH (operating)                                      |        |            | 51              |        | ft.   |
|                                    | TDH (design)                                         |        |            | 56              |        | ft.   |
|                                    |                                                      |        |            |                 |        |       |
| CONDENSATE PUMPS                   |                                                      |        |            |                 |        |       |
|                                    | Number of Pumps                                      |        | 2 x 100%   |                 |        |       |
|                                    | Operating Flow Rate                                  |        | 37         |                 |        | gpm   |
|                                    | Design Flow Rate                                     |        | 40         |                 |        | gpm   |
|                                    | TDH (operating)                                      |        | 136        |                 |        | ft.   |
|                                    | TDH (design)                                         |        | 149.6      |                 |        | ft.   |

| UTILITIES                          |                              |  |  |                                  |                 |             |
|------------------------------------|------------------------------|--|--|----------------------------------|-----------------|-------------|
| <b>ELECTRICAL REQUIREMENTS</b>     |                              |  |  |                                  |                 |             |
| Supply                             |                              |  |  | Later                            |                 | kV          |
| Generation/Mill Distribution       |                              |  |  | Later                            |                 | kV          |
| Motors                             |                              |  |  |                                  |                 |             |
|                                    | >200 hp, fixed speed         |  |  | NA                               |                 | VAC         |
|                                    | 1/2 - 600 hp, variable speed |  |  | NA                               |                 | VAC         |
|                                    | 1/2 - 200 hp, fixed speed    |  |  | 480 or 575                       |                 | VAC         |
|                                    | <1/2 hp                      |  |  | 120                              |                 | VAC         |
| <b>FOUNDATIONS</b>                 |                              |  |  |                                  |                 |             |
| Type                               |                              |  |  | Spread Footing (Assume 2500 psf) |                 |             |
| <b>FIRE PROTECTION REQUIRED</b>    |                              |  |  |                                  |                 |             |
|                                    |                              |  |  | Yes                              |                 | (yes/no)    |
| <b>UNIT HEATERS (qty)</b>          |                              |  |  |                                  |                 |             |
| Type                               |                              |  |  | Electric                         |                 |             |
| <b>PLANT UTILITIES REQUIRED</b>    |                              |  |  |                                  |                 |             |
| Electrical                         |                              |  |  |                                  |                 |             |
|                                    | Voltage                      |  |  | See above                        |                 | Volts       |
|                                    | Frequency                    |  |  | 60                               |                 | Hertz       |
|                                    | Power                        |  |  | Later                            |                 | kW          |
| Boiler Makeup Water                |                              |  |  |                                  |                 |             |
|                                    | Source                       |  |  | Softened Water                   |                 | (well/city) |
|                                    | Pressure                     |  |  | 60                               |                 | psig        |
| Potable/Cooling Tower Makeup Water |                              |  |  |                                  |                 |             |
|                                    | Source                       |  |  | City                             |                 |             |
|                                    | Pressure                     |  |  | 60                               |                 | psig        |
| Compressed Air                     |                              |  |  |                                  |                 |             |
|                                    | Plant Air Pressure           |  |  | 100                              |                 | psig        |
|                                    | Instrument Air Pressure      |  |  | 90                               |                 | psig        |
|                                    | Instrument Air Dewpoint      |  |  | -40                              |                 | °F          |
|                                    |                              |  |  |                                  |                 |             |
|                                    |                              |  |  | <b>Option 1</b>                  | <b>Option 2</b> |             |
| Total Water Consumption            |                              |  |  | 18                               | 71              | gpm         |
|                                    |                              |  |  |                                  |                 |             |

## OPTION 1 – BACKPRESSURE STG FACILITY

### Plant Description

The Option 1 plant design utilizes a backpressure turbine to generate power and deliver process steam to the host. This eliminates the capital cost of the equipment associated with a condensing turbine (surface condenser, cooling tower, pumps, etc.) but does not allow the ability to generate power when process steam needs are discontinued and results in a lower kW generation. The boiler steam output is ~20% less than Option 2, so there is some impact on the sizing and cost of the auxiliary equipment.

### General Scope

ESI has made an effort to minimize capital cost and maximize conservative equipment selection for this project. We have selected equipment from manufacturers who are industry leaders in the design and manufacture of industrial and utility steam and cogeneration products and equipment. All of the manufacturers specified have many years of similar product application and experience.

ESI has selected equipment performance, standards, design parameters, and weights and materials of construction based upon our experience in designing, building, and operating steam and power systems. These items, as selected by ESI, are easily capable of an equipment life in excess of 30 years, as well as efficient, reliable operation. We have proposed a design that considers optimizing the desired performance of the equipment while maintaining conservative design parameters. These items include such things as conservative furnace liberation rate, absorption rate, flue gas velocities, design temperatures and pressures, materials and weights of construction, conveying speeds, conveyor loading, design margins, etc.

The scope of this combined heat and power generation facility includes, but is not limited to the following equipment, systems, etc., which are described in detail in the Equipment Description section of this proposal:

### Site Work/Civil

- One lot of site grading and preparation for foundations
- One lot of foundations for the new STG, boiler and auxiliary systems
- One lot foundations for new fuel feed hopper
- One lot foundations for hog/screen tower and elevated slab for hog

- One lot underground plumbing for building drains to existing sewer connection
- One lot of site drainage including catch basins for storm water run-off

**Structural/Architectural:**

- One (1) Pre-engineered steel structure 36' wide by 37' long by 65' high (eave height) enclosing the boiler with a low bay structure 26' wide by 51' long by 34' high (eave height) enclosing the STG. The steel frame structure will include siding, girts, and metal panel roofing system.
- One (1) lot of HVAC equipment including wall-mounted ventilation supply and exhaust fans and unit heaters. The building ventilation system will offer up to twenty air changes per hour during the summer months and the unit heaters will maintain the building at a minimum 50°F temperature during the winter months.
- One (1) engineered structure 15' wide by 25' long by 40' high (eave height) disc screen and hog tower (roof only, no siding).
- One (1) pre-engineered enclosure 82' wide by 53' long by 20' high (eave height) for the protection of the fuel feed hopper.
- One lot of equipment support steel for all new equipment.
- One lot of platforms, walkways, and ladders for major equipment access.
- One lot of building trim, flashing, personnel and roll up doors for the building.

**STG and Auxiliaries**

One (1) nominal 1.06 MW single automatic extraction backpressure steam turbine and water to air-cooled generator with the following auxiliaries:

- Gland steam seal and exhaust system
- Lube/control oil system(s) with coolers and filters
- Electro-hydraulic control (EHC) system
- Turbine control panel
- DC battery and charging system
- Generator excitation, protection and control panel

- Line/neutral cabinet
- Vibration and axial displacement monitoring system
- One (1) 25-ton two-speed bridge crane and rails for maintenance in the turbine-generator bay

**Electrical, Instrumentation/Controls:**

- One lot of electrical power equipment
- One lot of electrical installation labor and materials including all required cable tray, cable, and conduit.
- One (1) Allen-Bradley ControlLogix PLC-based control system.
- One lot of field instrumentation devices for all new systems described herein.
- One lot of instrumentation installation labor and materials including mounting of field devices, process tubing, and calibration.

**Boiler Island:**

- One (1) 20,000 pph vibrating water-cooled grate, stoker-fired boiler designed for 615 psia 750°F steam generation. The proposed boiler is a bottom supported design with one start-up burner with individual valve racks and flame scanners. The unit is complete with refractory, insulation, casing, sootblowers, superheater, all required trim, and safety relief, vent and drain valves.
- One (1) forced draft (FD) fan including drive with sole plate, damper with actuator, and inlet silencer for supplying underfire air below the stoker.
- One (1) primary economizer for recovering excess heat from the boiler flue gas by preheating the boiler feedwater upstream of the steam drum.
- One (1) overfire air (OFA) fan including drive with sole plate and damper with actuator to provide overfire air in the furnace above the fuel bed.
- One (1) distributor air (DA) fan including drive with sole plate and damper with actuator to provide air to the fuel distributors on the stoker.
- One lot of interconnecting ductwork for the primary combustion air system, complete with dampers and expansion joints as required. This system will include ductwork from the building side wall to the FD fan, from the FD fan to the air heater, from the air heater

to the OFA fan, from the OFA fan to the OFA nozzles, and from the inlet of the distributor air fan to the fuel distributors.

- One (1) bottom blowdown tank with tempering system.

#### **Emissions Control Systems:**

- One (1) mechanical collector, to remove particulate from the flue gas stream.
- One (1) electrostatic precipitator (ESP), complete with roof enclosure, to remove particulate from the flue gas stream.
- One (1) induced draft (ID) fan including motor drive with sole plate and damper.
- One lot of interconnecting breeching for the induced draft fan system, complete with dampers and expansion joints as required. This system will include breeching from the generating bank outlet through the economizer, tubular air heater and ID fan to the ESP and stack inlet.
- One (1) new single wall carbon steel stub stack approximately 75' in height complete with test platform attached to the ESP.

#### **Fuel (Biomass) Unloading and Handling System:**

- One (1) biomass receiving fuel feed hopper with live-bottom reclaim hopper and enclosure. The fuel feed hopper will accommodate self-unloading trailers only. The reclaim hopper will convey the biomass to a transfer conveyor.
- One (1) rotary-type disc screen will classify the incoming biomass to bypass the hog.
- One (1) hammermill type wood hog will correctly size the rejects of the disc screen. Sized for 50% of the incoming stream.
- Three (3) belt conveyors for transferring the biomass fuel from the fuel feed hopper to the screen/hog tower, from the screen/hog tower to the boiler, and from the sawmill to the another belt conveyor. These systems will come complete with full belt covers, belt scrapers, and gravity take-up units where required.
- Two (2) electromagnets for removal of tramp metal in the incoming fuel and from the sawdust supply from the sawmill.
- One lot of diverter gates and chutes to interconnect the transfer system.

- One (1) live bottom-metering bin to feed fuel to boiler fuel feed distributors. The bin will provide 10-15 minutes of fuel storage.

**Ash Handling System:**

- One (1) bottom ash removal system consisting of one wet ash collection drag conveying ash to one customer-supplied roll-off dumpster.
- One (1) fly ash collection system to convey fly ash from pick-up points at the boiler mud drum hopper, mechanical collector, and ESP to customer-supplied roll-off dumpsters. It consists of the following:
  - One (1) precipitator hopper screw conveyor
  - One (1) precipitator rotary airlock
  - One (1) mechanical collector rotary air lock
  - One (1) mechanical collector screw conveyor
  - One (1) boiler hopper rotary air lock
  - One (1) boiler hopper screw conveyor

**Balance of Plant:**

- One (1) spray/tray type deaerator with integrated feedwater storage tank.
- One (1) reverse osmosis (RO) type water treatment system for boiler water make-up complete with forwarding pumps.
- One (1) lot chemical treatment skids including day tank, mixing, and injection pumps.
- One (1) lot sample coolers for operational water testing.
- One (1) FRP demineralized water storage tank complete with forwarding pumps.
- One (1) carbon steel condensate return storage tank complete with forwarding pumps.
- Two (2) multi-stage diffuser type boiler feedwater pumps each capable of delivering 100% of required boiler inlet flow.
- One (1) lot of fire protection systems including wet-sprinkler system for turbine lube oil area, dry-pipe system for conveyor system, fire hose stations on each floor of boiler building, extinguishers for personnel spaces, and a fire loop extension with hydrants for facility perimeter.

- One (1) rotary screw air compressor complete with air receiver and desiccant drying system for supply of plant and instrument air.
- One (1) lot safety shower and eyewash stations.
- One lot of piping including supports and spring cans for new boiler system.
- One lot of piping for distribution and interconnection of new facility with the sawmill.
- One lot of valves, traps, strainers, and control valves for new equipment.
- One lot of insulation and lagging for all hot equipment and piping.
- One lot of field labor for complete system erection.
- One lot of painting for all structural steel, non-insulated piping, and touch-up of all non-insulated equipment.

#### **Engineering and Management Services**

- One lot of Engineering and Design services.
- One lot of Project Management services.
- One lot of Construction Management (Field Supervision) services including full-time on-site management during construction phase of project.
- One lot of Start-up and Commissioning services.
- One lot of Operator Training services.

## OPTION 2 –CONDENSING STG FACILITY

### Plant Description

The Option 2 plant is designed with a condensing turbine to generate power and deliver process steam to the host. This adds several pieces of auxiliary equipment to the project but it allows the ability to generate power when process steam needs are discontinued and results in a higher kW generation.

### General Scope

ESI has made an effort to minimize capital cost and maximize conservative equipment selection for this project. We have selected equipment from manufacturers who are industry leaders in the design and manufacture of industrial and utility steam and cogeneration products and equipment. All of the manufacturers specified have many years of similar product application and experience.

ESI has selected equipment performance, standards, design parameters, and weights and materials of construction based upon our experience in designing, building, and operating steam and power systems. These items, as selected by ESI, are easily capable of an equipment life in excess of 30 years, as well as efficient, reliable operation. We have proposed a design that considers optimizing the desired performance of the equipment while maintaining conservative design parameters. These items include such things as conservative furnace liberation rate, absorption rate, flue gas velocities, design temperatures and pressures, materials and weights of construction, conveying speeds, conveyor loading, design margins, etc.

The scope of this combined heat and power generation facility includes, but is not limited to the following equipment, systems, etc., which are described in detail in the Equipment Description section of this proposal:

### Site Work/Civil

- One lot of site grading and preparation for foundations
- One lot of foundations for the new STG, boiler and auxiliary systems
- One lot foundations for new fuel feed hopper
- One lot foundations for hog/screen tower and elevated slab for hog
- One lot underground plumbing for building drains to existing sewer connection

- One lot of site drainage including catch basins for storm water run-off

**Structural/Architectural:**

- One (1) pre-engineered steel structure 36' wide by 37' long by 65' high (eave height) enclosing the boiler with a low bay structure 26' wide by 51' long by 34' high (eave height) enclosing the STG. The steel frame structure will include siding, girts, and metal panel roofing system.
- One (1) lot of HVAC equipment including wall-mounted ventilation supply and exhaust fans and unit heaters. The building ventilation system will offer up to twenty air changes per hour during the summer months and the unit heaters will maintain the building at a minimum 50°F temperature during the winter months.
- One (1) engineered structure 15' wide by 25' long by 40' high (eave height) disc screen and hog tower (roof only, no siding).
- One (1) pre-engineered enclosure 82' wide by 53' long by 20' high (eave height) for the protection of the fuel feed hopper.
- One lot of equipment support steel for all new equipment.
- One lot of platforms, walkways, and ladders for major equipment access.
- One lot of building trim, flashing, personnel and roll up doors for the building.

**STG and Auxiliaries**

One (1) nominal 2.4 MW reaction multistage, multivalve condensing extraction turbine and water to air-cooled generator with the following auxiliaries:

- Gland steam seal and exhaust system
- Lube/control oil system(s) with coolers and filters
- Electro-hydraulic control (EHC) system
- Turbine control panel
- DC battery and charging system
- Generator excitation, protection and control panel
- Line/neutral cabinet

- Vibration and axial displacement monitoring system
- One (1) steam surface condenser
- One (1) cooling tower
- Two (2) 50% capacity cooling water pumps
- Cooling tower chemical treatment system
- Two (2) 100% capacity hotwell pumps for transferring condensate to the deaerator
- One (1) 25-ton two-speed bridge crane and rails for maintenance in the turbine-generator bay

**Electrical, Instrumentation/Controls:**

- One lot of electrical power equipment
- One lot of electrical installation labor and materials including all required cable tray, cable, and conduit.
- One (1) Allen-Bradley ControlLogix PLC-based control system.
- One lot of field instrumentation devices for all new systems described herein.
- One lot of instrumentation installation labor and materials including mounting of field devices, process tubing, and calibration.

**Boiler Island:**

- One (1) 25,000 pph vibrating water-cooled grate, stoker-fired boiler designed for 615 psia 750°F steam generation. The proposed boiler is a bottom supported design with one start-up burner with individual valve racks and flame scanners. The unit is complete with refractory, insulation, casing, sootblowers, superheater, all required trim, and safety relief, vent and drain valves.
- One (1) forced draft (FD) fan including drive with sole plate, damper with actuator, and inlet silencer for supplying underfire air below the stoker.
- One (1) primary economizer for recovering excess heat from the boiler flue gas by preheating the boiler feedwater upstream of the steam drum.

- One (1) overfire air (OFA) fan including drive with sole plate and damper with actuator to provide overfire air in the furnace above the fuel bed.
- One (1) distributor air (DA) fan including drive with sole plate and damper with actuator to provide air to the fuel distributors on the stoker.
- One lot of interconnecting ductwork for the primary combustion air system, complete with dampers and expansion joints as required. This system will include ductwork from the building side wall to the FD fan, from the FD fan to the air heater, from the air heater to the OFA fan, from the OFA fan to the OFA nozzles, and from the inlet of the distributor air fan to the fuel distributors.
- One (1) bottom blowdown tank with tempering system.

#### **Emissions Control Systems:**

- One (1) mechanical collector, to remove particulate from the flue gas stream.
- One (1) electrostatic precipitator (ESP), complete with roof enclosure, to remove particulate from the flue gas stream.
- One (1) induced draft (ID) fan including motor drive with sole plate and damper.
- One lot of interconnecting breeching for the induced draft fan system, complete with dampers and expansion joints as required. This system will include breeching from the generating bank outlet through the economizer, tubular air heater and ID fan to the ESP and stack inlet.
- One (1) new single wall carbon steel stub stack approximately 75' in height complete with test platform attached to the ESP.

#### **Fuel (Biomass) Unloading and Handling System:**

- One (1) biomass receiving fuel feed hopper with live-bottom reclaim hopper and enclosure. The fuel feed hopper will accommodate self-unloading trailers only. The reclaim hopper will convey the biomass to a transfer conveyor.
- One (1) rotary-type disc screen will classify the incoming biomass to bypass the hog.
- One (1) hammermill type wood hog will correctly size the rejects of the disc screen. Sized for 50% of the incoming stream.
- Three (3) belt conveyors for transferring the biomass fuel from the fuel feed hopper to the screen/hog tower, from the screen/hog tower to the boiler, and from the sawmill to

another belt conveyor. These systems will come complete with full belt covers, belt scrapers, and gravity take-up units where required.

- Two (2) electromagnets for removal of tramp metal in the incoming fuel and from the sawdust supply from the sawmill.
- One lot of diverter gates and chutes to interconnect the transfer system.
- One (1) live bottom-metering bin to feed fuel to boiler fuel feed distributors. The bin will provide 10-15 minutes of fuel storage.

#### **Ash Handling System:**

- One (1) bottom ash removal system consisting of one wet ash collection drag conveying ash to one customer-supplied roll-off dumpster.
- One (1) fly ash collection system to convey fly ash from pick-up points at the boiler mud drum hopper, mechanical collector, and ESP to customer-supplied roll-off dumpsters. It consists of the following:
  - One (1) precipitator hopper screw conveyor
  - One (1) precipitator rotary airlock
  - One (1) mechanical collector rotary air lock
  - One (1) mechanical collector screw conveyor
  - One (1) boiler hopper rotary air lock
  - One (1) boiler hopper screw conveyor

#### **Balance of Plant:**

- One (1) spray/tray type deaerator with integrated feedwater storage tank.
- One (1) reverse osmosis (RO) type water treatment system for boiler water make-up complete with forwarding pumps.
- One (1) lot chemical treatment skids including day tank, mixing, and injection pumps.
- One (1) lot sample coolers for operational water testing.
- One (1) FRP demineralized water storage tank complete with forwarding pumps.
- One (1) carbon steel condensate return storage tank complete with forwarding pumps.

- Two (2) multi-stage diffuser type boiler feedwater pumps each capable of delivering 100% of required boiler inlet flow.
- One (1) lot of fire protection systems including wet-sprinkler system for turbine lube oil area, dry-pipe system for conveyor system, fire hose stations on each floor of boiler building, extinguishers for personnel spaces, and a fire loop extension with hydrants for facility perimeter.
- One (1) rotary screw air compressor complete with air receiver and desiccant drying system for supply of plant and instrument air.
- One (1) lot safety shower and eyewash stations.
- One lot of piping including supports and spring cans for new boiler system.
- One lot of piping for distribution and interconnection of new facility with the sawmill.
- One lot of valves, traps, strainers, and control valves for new equipment.
- One lot of insulation and lagging for all hot equipment and piping.
- One lot of field labor for complete system erection.
- One lot of painting for all structural steel, non-insulated piping, and touch-up of all non-insulated equipment.

#### **Engineering and Management Services**

- One lot of Engineering and Design services.
- One lot of Project Management services.
- One lot of Construction Management (Field Supervision) services including full-time on-site management during construction phase of project.
- One lot of Start-up and Commissioning services.
- One lot of Operator Training services.

## CAPITAL COST ESTIMATE

### Option 1

ESI, Inc. of Tennessee estimates the budget capital cost for the complete engineering, procurement, and construction of this new CHP facility as described herein, to be **THIRTEEN MILLION, FOUR HUNDRED SEVEN THOUSAND, FOUR HUNDRED SEVENTY DOLLARS (\$13,407,470 CAD)**.

Following is a spreadsheet that illustrates the approximate cost breakdown of the complete EPC cost estimate for this new CHP facility.

### Option 2

ESI, Inc. of Tennessee estimates the budget capital cost for the complete engineering, procurement, and construction of this new CHP facility as described herein, to be **FIFTEEN MILLION, EIGHT HUNDRED FORTY-SIX THOUSAND, ONE HUNDRED FIFTY DOLLARS (\$15,846,150 CAD)**.

Following is a spreadsheet that illustrates the approximate cost breakdown of the complete EPC cost estimate for this new CHP facility.

**CAPITAL COST BREAKDOWN (All values are in CAD)**

| Marwood Biomass CHP |                                             |                         |           |             |  |                                  |           |             |
|---------------------|---------------------------------------------|-------------------------|-----------|-------------|--|----------------------------------|-----------|-------------|
|                     |                                             | Option 1 - Backpressure |           |             |  | Option 2 - Condensing/Extracting |           |             |
|                     | BREAKDOWN                                   | EQUIP \$                | LABOR \$  | TOTAL \$    |  | EQUIP \$                         | LABOR \$  | TOTAL \$    |
| 1                   | SITEWORK                                    | \$25,392                | \$0       | \$25,392    |  | \$30,861                         | \$0       | \$30,861    |
| 2                   | CONCRETE AND FOUNDATIONS                    | \$346,354               | \$0       | \$346,354   |  | \$442,060                        | \$0       | \$442,060   |
| 3                   | PLUMBING & SITE SEWER                       | \$19,500                | \$0       | \$19,500    |  | \$19,500                         | \$0       | \$19,500    |
| 4                   | MASONRY                                     | \$0                     | \$0       | \$0         |  | \$0                              | \$0       | \$0         |
| 5                   | STEEL, PLATFORMS, GRATING, ETC.             | \$430,860               | \$222,600 | \$653,460   |  | \$437,610                        | \$222,600 | \$660,210   |
| 6                   | HVAC                                        | \$23,000                | \$24,000  | \$47,000    |  | \$23,000                         | \$24,000  | \$47,000    |
| 7                   | PRE-ENG BUILDINGS, BLDG TRIM & MISC.        | \$270,206               | \$126,150 | \$396,356   |  | \$270,206                        | \$126,150 | \$396,356   |
| 8                   | PAINTING & FINISHES                         | \$58,696                | \$0       | \$58,696    |  | \$70,821                         | \$0       | \$70,821    |
| 9                   | FIRE PROTECTION SYSTEMS                     | \$38,490                | \$52,200  | \$90,690    |  | \$38,490                         | \$52,200  | \$90,690    |
| 10                  | STEAM GENERATION SYSTEMS                    | \$1,295,000             | \$288,000 | \$1,583,000 |  | \$1,430,000                      | \$288,000 | \$1,718,000 |
| 11                  | BURNER FIRING SYSTEMS                       | \$85,000                | \$0       | \$85,000    |  | \$85,000                         | \$0       | \$85,000    |
| 12                  | FANS                                        | \$67,176                | \$45,600  | \$112,776   |  | \$84,441                         | \$45,600  | \$130,041   |
| 13                  | EMISSIONS CONTROL SYSTEMS                   | \$493,417               | \$180,000 | \$673,417   |  | \$578,000                        | \$180,000 | \$758,000   |
| 14                  | FUEL HANDLING SYSTEMS (Receiving & Storage) | \$385,020               | \$14,400  | \$399,420   |  | \$385,020                        | \$14,400  | \$399,420   |
| 15                  | FUEL HANDLING SYSTEMS (Conveying)           | \$406,600               | \$168,000 | \$574,600   |  | \$406,600                        | \$168,000 | \$574,600   |
| 16                  | FUEL HANDLING SYSTEMS (Misc)                | \$102,705               | \$39,000  | \$141,705   |  | \$102,705                        | \$39,000  | \$141,705   |
| 17                  | ASH HANDLING SYSTEMS                        | \$0                     | \$30,000  | \$30,000    |  | \$0                              | \$30,000  | \$30,000    |
| 18                  | WATER TREATMENT                             | \$140,250               | \$40,800  | \$181,050   |  | \$145,250                        | \$44,400  | \$189,650   |
| 19                  | STORAGE TANKS                               | \$57,385                | \$21,000  | \$78,385    |  | \$57,385                         | \$21,000  | \$78,385    |
| 20                  | MISC. AUXILIARY SYSTEMS                     | \$43,070                | \$28,200  | \$71,270    |  | \$49,500                         | \$28,200  | \$77,700    |
| 21                  | PUMPING SYSTEMS                             | \$145,096               | \$14,400  | \$159,496   |  | \$166,864                        | \$21,600  | \$188,464   |
| 22                  | HOPPERS,FLUES, DUCTS, ETC.                  | \$139,735               | \$123,000 | \$262,735   |  | \$139,735                        | \$129,000 | \$268,735   |
| 23                  | STEAM PLANT PIPING & VALVES                 | \$114,816               | \$222,973 | \$337,789   |  | \$147,675                        | \$354,362 | \$502,037   |
| 24                  | INSULATION & LAGGING                        | \$15,737                | \$21,552  | \$37,289    |  | \$19,990                         | \$27,332  | \$47,322    |
| 25                  | ELECTRICAL EQUIPMENT                        | \$141,927               | \$288,737 | \$430,663   |  | \$191,993                        | \$298,473 | \$490,466   |
| 26                  | CONTROL SYSTEMS                             | \$384,604               | \$216,000 | \$600,604   |  | \$434,260                        | \$258,750 | \$693,010   |
| 27                  | INSTRUMENTATION                             | \$239,958               | \$62,700  | \$302,658   |  | \$251,515                        | \$64,275  | \$315,790   |
| 28                  | GENERATING SYSTEMS                          | \$2,402,500             | \$123,000 | \$2,525,500 |  | \$3,426,500                      | \$285,600 | \$3,712,100 |
| 29                  | CONSTRUCTION EXPENSES                       | \$555,620               | \$0       | \$555,620   |  | \$594,138                        | \$0       | \$594,138   |
| 30                  | MISC. AND COMMERCIAL                        | \$55,425                | \$0       | \$55,425    |  | \$57,450                         | \$0       | \$57,450    |

|                                           |               |              |               |               |              |               |
|-------------------------------------------|---------------|--------------|---------------|---------------|--------------|---------------|
| Subtotal Construction (Equip/Mat - Labor) | \$ 8,483,539  | \$ 2,352,312 | \$ 10,835,851 | \$ 10,086,568 | \$ 2,722,941 | \$ 12,809,510 |
| Contingency - CONST                       | \$ 424,177    | \$ 235,231   |               | \$ 504,328    | \$ 272,294   |               |
| Construction Cost TOTAL                   | \$ 11,495,259 |              |               | \$ 13,586,132 |              |               |
| Engineering/PM/OH                         | \$ 605,014    |              |               | \$ 715,060    |              |               |
| CM                                        | \$ 234,597    |              |               | \$ 277,268    |              |               |
| Profit (8%)                               | \$ 1,072,597  |              |               | \$ 1,267,692  |              |               |
| ENG/PM/CM/OH Cost                         | \$ 1,912,208  |              |               | \$ 2,260,020  |              |               |
| BUDGET PRICE                              | \$ 13,407,470 |              |               | \$ 15,846,150 |              |               |
| Budget Accuracy (±%)                      | 20%           |              |               | 20%           |              |               |

## OPERATING AND MAINTENANCE COST ESTIMATE

| PREDICTED OPERATING AND MAINTENANCE COSTS FOR FACILITY |                        |                                                          |          |         |         |            |          |
|--------------------------------------------------------|------------------------|----------------------------------------------------------|----------|---------|---------|------------|----------|
| CATEGORIES                                             | DESCRIPTION            |                                                          |          |         |         |            |          |
|                                                        |                        | Hours Per Year                                           |          | 5,256   |         |            |          |
|                                                        |                        | Capacity factor                                          |          | 60%     |         |            |          |
|                                                        |                        | Process Steam Demand                                     | lb/hr    | 21,190  |         |            |          |
| (See Note 1)                                           |                        | Annual Steam Consumption                                 | KLb/Yr   | 111,375 |         |            |          |
| <b>Option 1</b>                                        |                        |                                                          |          | QTY     | \$/Unit | Total Cost | CAD      |
| <i>Fuel</i>                                            |                        |                                                          |          |         |         |            |          |
|                                                        | Fuel Cost              | Fuel Consumed                                            | TPY      | 20,535  | 36.29   | 745.2      | \$000/yr |
|                                                        | Start-Up Fuel          | Fuel Consumed                                            | mmBtu/Yr | 252     | 14.50   | 3.7        | \$000/yr |
| <i>Non-Fuel O&amp;M</i>                                |                        |                                                          |          |         |         |            |          |
|                                                        | Ash Landfill           | Cost of Ash Disposal                                     | TPY      | 200     | 15.00   | 3.0        | \$000/yr |
|                                                        | Raw Water              | Cost of make-up water                                    | KGPY     | 5,346   | 5.00    | 26.7       | \$000/yr |
|                                                        | Sewer                  | Blowdown & Drains                                        | KGPY     | 1,104   | 2.50    | 2.8        | \$000/yr |
|                                                        | Operating Personnel    | Increase from current                                    | #        | 4       | 55,000  | 220.0      | \$000/yr |
|                                                        | Water treatment        | Boiler and RO chemicals                                  | KLb      | 105,120 | 0.30    | 31.5       | \$000/yr |
|                                                        | Annual Maint. & Upkeep | Based on Size (equiv MWh) of facility if full condensing | Eq MWh   | 12,614  | 9.50    | 119.8      | \$000/yr |
| <i>Commercial</i>                                      |                        |                                                          |          |         |         |            |          |
|                                                        | Insurance Cost         | Based on CAPEX of facility                               | \$000    | TBD     | 0.75%   | -          | \$000/yr |
|                                                        | Property Tax           | Based on CAPEX of facility                               | \$000    | TBD     | -       | -          | \$000/yr |
|                                                        |                        |                                                          |          |         |         | 1,152.7    | \$000/yr |
|                                                        |                        | Hours Per Year                                           |          | 7,884   |         |            |          |
|                                                        |                        | Capacity factor                                          |          | 90%     |         |            |          |
|                                                        |                        | Process Steam Demand                                     | lb/hr    | 18,000  |         |            |          |
|                                                        |                        | Annual Steam Consumption                                 | KLb/Yr   | 85,147  |         |            |          |
| <b>Option 2</b>                                        |                        |                                                          |          | QTY     | \$/Unit | Total Cost | CAD      |
| <i>Fuel</i>                                            |                        |                                                          |          |         |         |            |          |
|                                                        | Fuel Cost              | Fuel Consumed                                            | TPY      | 38,502  | 36.29   | 1,397.2    | \$000/yr |
|                                                        | Start-Up Fuel          | Fuel Consumed                                            | mmBtu    | 336     | 14.50   | 4.9        | \$000/yr |
| <i>Non-Fuel O&amp;M</i>                                |                        |                                                          |          |         |         |            |          |
|                                                        | Ash Landfill           | Cost of Ash Disposal                                     | TPY      | 374     | 15.00   | 5.6        | \$000/yr |
|                                                        | Raw Water              | Cost of make-up water                                    | KGPY     | 31,883  | 1.00    | 31.9       | \$000/yr |
|                                                        | Sewer                  | Blowdown & Drains                                        | KGPY     | 3,586   | 0.30    | 1.1        | \$000/yr |
|                                                        | Operating Personnel    | Increase from current                                    | #        | 4       | 55,000  | 220.0      | \$000/yr |
|                                                        | Water treatment        | Boiler, RO and Cooling tower chemicals                   | KLb      | 197,100 | 0.45    | 88.7       | \$000/yr |
|                                                        | Annual Maint. & Upkeep | Based on Size (equiv MWh) of facility if full condensing | Eq MWh   | 18,922  | 10.5    | 198.7      | \$000/yr |
| <i>Commercial</i>                                      |                        |                                                          |          |         |         |            |          |
|                                                        | Insurance Cost         | Based on CAPEX of facility                               | \$000    | TBD     | 0.75%   | -          | \$000/yr |
|                                                        | Property Tax           | Based on CAPEX of facility                               | \$000    | TBD     | -       | -          | \$000/yr |
|                                                        |                        |                                                          |          |         |         | 1,948.0    | \$000/yr |

### Note (1)

Based on matching the steam load to the kilns, and assumed to be 21,190 pph of steam consumption and 5,040 full load hours.

## **ASSUMPTIONS AND CLARIFICATIONS**

1. ESI has not included use taxes, property taxes, or Owner's insurance as part of this project budgetary pricing. We assume owner will provide this information.
2. ESI assumes that the site is level with free and clear access. ESI further assumes that the soil on-site is free of deleterious materials and has made no allowance for over excavation or provision of select backfill. In addition, it is assumed that no dewatering of the site is required to perform the described work.
3. The budgetary pricing includes the required steam blow on the new steam line to the turbine-generator. A silencer has not been provided for the steam blow.
4. Utilities required at building limits:
  - Softened Water – 60 gpm, 60 psig
  - Propane or Fuel Oil for start-up burners
  - Potable Water - 10 gpm, 60 psig
5. We have included 150 linear feet of pipe (beyond the limits of the existing boiler building wall) for each of the following tie-ins:
  - Softened water
  - Steam
  - Condensate
  - Potable water
  - Propane
  - Fire water
6. ESI assumes that the boiler plant will be supplied with a softened water supply at the flow and pressure required for the inlet to the RO system.
7. No oil/water separator is provided for facility drains.
8. No sewer flow monitoring box is included.
9. It is assumed the Host shall supply the following as necessary:
  - All environmental permits.

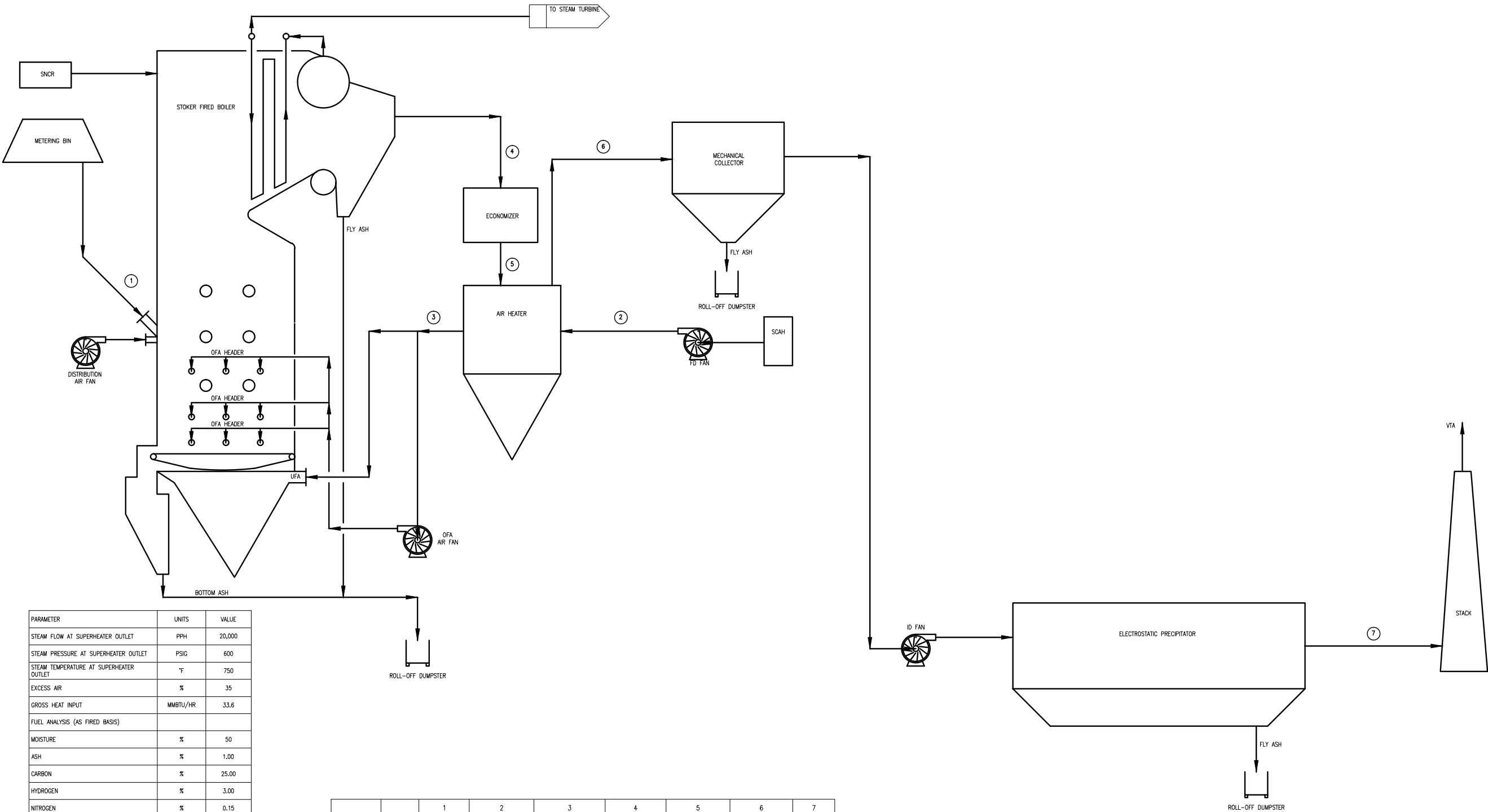
- Environmental compliance testing.
  - Power, water, and compressed air available during the construction period.
  - Fuel, water, electricity, compressed air, lubrication oils, etc., required during start-up and commissioning of system.
  - Fax and phone lines in addition to high speed internet access for ESI and subcontractor construction trailers.
  - Site security during construction.
10. It is assumed that all run-off from the new construction can be collected into the existing storm sewer system. No retention pond or other sitework as required to accommodate storm run-off is included.
  11. We have included a stack 75' tall. Should the final environmental permit require that the stack height needs to be altered, our price offering will be modified accordingly.
  12. ESI presently does not include continuous monitoring equipment which may be required by Canadian or Provincial environmental regulations. Once a final determination is made, we can quote the monitoring equipment if desired.
  13. We have not included any additional fire water supply equipment and we assume adequate fire water flow and pressure is available at the tie-in point from the existing plant system.
  14. We have included heat tracing of only the cooling water lines.
  15. A control room or restrooms have not been included in the pricing.
  16. We have assumed that soil conditions will permit the use of spread footings for all foundations on this project. No piles have been included.
  17. We have assumed there is an existing truck scale at the sawmill. Therefore, we have not included a new truck scale dedicated for fuel trucks for the CHP facility.
  18. Due to the low truck traffic expected, we have not included any new paving for fuel trucks.
  19. We have assumed that sawdust is a very small percentage of the total fuel flow and that the flow of sawdust from the sawmill will be metered. Therefore, we have not provided any storage capacity for this fuel.



Plotted by Stowers, Jonathan on Monday, March 07, 2011 1:20:24 PM

Plotted by Stowers, Jonathan on Tuesday, March 01, 2011 10:42:50 AM

\*\* SAFETY FIRST \*\*



| PARAMETER                               | UNITS    | VALUE  |
|-----------------------------------------|----------|--------|
| STEAM FLOW AT SUPERHEATER OUTLET        | PPH      | 20,000 |
| STEAM PRESSURE AT SUPERHEATER OUTLET    | PSIG     | 600    |
| STEAM TEMPERATURE AT SUPERHEATER OUTLET | °F       | 750    |
| EXCESS AIR                              | %        | 35     |
| GROSS HEAT INPUT                        | MMBTU/HR | 33.6   |
| FUEL ANALYSIS (AS FIRED BASIS)          |          |        |
| MOISTURE                                | %        | 50     |
| ASH                                     | %        | 1.00   |
| CARBON                                  | %        | 25.00  |
| HYDROGEN                                | %        | 3.00   |
| NITROGEN                                | %        | 0.15   |
| SULFUR                                  | %        | 0.03   |
| OXYGEN                                  | %        | 20.8   |
| CHLORINE                                | %        | 0.01   |
| HEATING VALUE                           | BTU/LB   | 4,400  |

|             |       | 1         | 2                      | 3                       | 4                      | 5                      | 6                       | 7           |
|-------------|-------|-----------|------------------------|-------------------------|------------------------|------------------------|-------------------------|-------------|
| DESCRIPTION | UNITS | FUEL FLOW | AIR HEATER INLET (AIR) | AIR HEATER OUTLET (AIR) | ECONOMIZER INLET (GAS) | AIR HEATER INLET (GAS) | AIR HEATER OUTLET (GAS) | STACK INLET |
| MASS FLOW   | PPH   | 7,635     | 30,954                 | 30,954                  | 38,474                 | 38,474                 | 38,474                  | 38,474      |
| TEMPERATURE | °F    | 80        | 80                     | 450                     | 750                    | 600                    | 350                     | 350         |
| GAS VOLUME  | ACFM  | ---       | 7,134                  | 12,023                  | 20,704                 | 18,240                 | 13,862                  | 13,862      |

| REV | DRAWN | DATE     | CHK'D | DATE     | DESCRIPTION                |
|-----|-------|----------|-------|----------|----------------------------|
| A   | JSP   | 01/28/11 | TJB   | 02/28/11 | ISSUED FOR CUSTOMER REVIEW |
|     |       |          |       |          |                            |
|     |       |          |       |          |                            |
|     |       |          |       |          |                            |
|     |       |          |       |          |                            |
|     |       |          |       |          |                            |
|     |       |          |       |          |                            |
|     |       |          |       |          |                            |
|     |       |          |       |          |                            |
|     |       |          |       |          |                            |

| REFERENCE DRAWINGS                 |
|------------------------------------|
|                                    |
|                                    |
|                                    |
|                                    |
|                                    |
|                                    |
|                                    |
|                                    |
|                                    |
|                                    |
| Drawing File Name<br>688002F02.dwg |

NOT FOR CONSTRUCTION

THE DESIGN DATA AND INFORMATION CONTAINED HEREIN IS PROPRIETARY TO ESI INC. OF TENNESSEE. NO PORTION OF THIS INFORMATION SHALL BE RELEASED EXCEPT AS AUTHORIZED THROUGH PRIOR WRITTEN APPROVAL BY ESI INC. OF TENNESSEE.



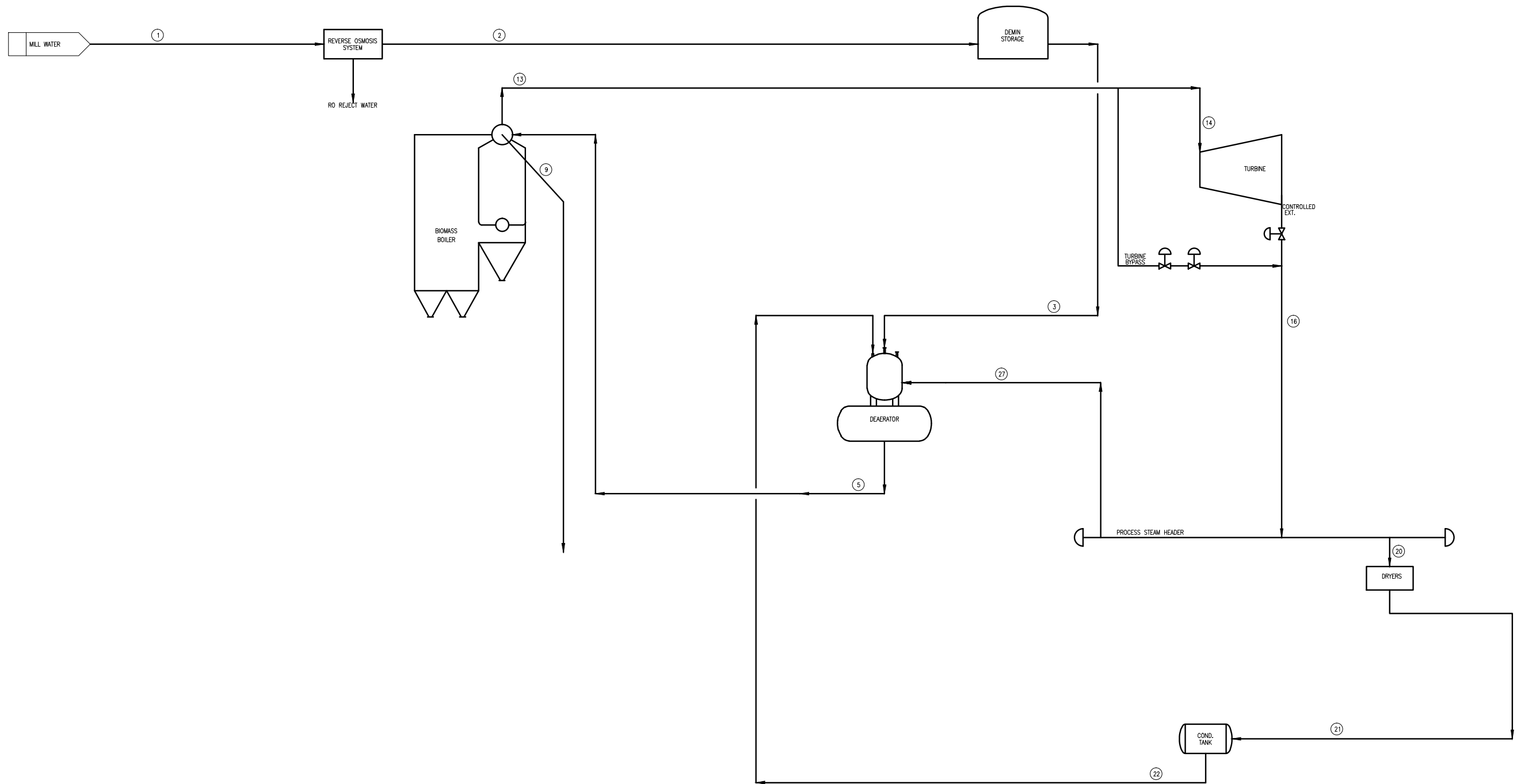
ESI Inc. of Tennessee  
1250 Roberts Blvd.  
Kennesaw, GA 30144  
(770)427-6200  
esitenn.com

AIR & FLUE GAS FLOW SHEET- OPTION 1

MARWOOD  
NOVA SCOTIA

SCALE: None    DRAWING NO.: 688002 F02    REV: A

DRAWING SCALE BASED ON A REPRODUCTION SIZE OF 24"x36"



| DESIGN            | 1    | 2    | 3    | 4 | 5     | 6 | 7 | 8 | 9     | 10 | 11 | 12 | 13     | 14     | 15 | 16   | 17 | 18 | 19 | 20   | 21   | 22   | 23  | 24 | 25 | 26 | 27     | 28 | 29 | 30 | 31 | 40 | 41 |   |   |   |   |   |          | GENERATOR |
|-------------------|------|------|------|---|-------|---|---|---|-------|----|----|----|--------|--------|----|------|----|----|----|------|------|------|-----|----|----|----|--------|----|----|----|----|----|----|---|---|---|---|---|----------|-----------|
| FLOW kpph         | 1.77 | 1.77 | 1.77 |   | 20.8  |   |   |   | 0.80  | -  | -  |    | 20.0   | 20.0   |    | 20.0 |    |    |    | 18.0 | 17.1 | 17.1 |     |    |    |    | 1.95   |    |    |    |    |    |    | - | - | - | - | - | OUTPUT   |           |
| PRESSURE psio     | 75   | 60   | 75   |   | 679   |   |   |   | 623.0 | -  | -  |    | 615    | 605    |    | 35   |    |    |    | 30   | 30   | 90   |     |    |    |    | 33     |    |    |    |    |    |    | - | - | - | - | - | KILOWATT |           |
| TEMPERATURE deg F | 70   | 70   | 70   |   | 257   |   |   |   | 493   | -  | -  |    | 750    | 750    |    | 260  |    |    |    |      |      | 170  | 170 |    |    |    | 260    |    |    |    |    |    |    | - | - | - | - | - |          |           |
| Enthalpy Btu/lb   | 38   | 38   | 38   |   | 227.0 |   |   |   | 480.0 | -  | -  |    | 1380.0 | 1381.0 |    | 1167 |    |    |    | 1169 | 138  | 138  |     |    |    |    | 1167.0 |    |    |    |    |    |    | - | - | - | - | - | 1,060    |           |

[illegible]

REFERENCE DRAWINGS

Drawing File Name  
688002F03.dwg

NOT FOR CONSTRUCTION

THE DESIGN DATA AND INFORMATION  
CONTAINED HEREIN IS PROPRIETARY  
TO ESI INC. OF TENNESSEE. NO  
PORTION OF THIS INFORMATION SHALL  
BE RELEASED EXCEPT AS AUTHORIZED  
THROUGH PRIOR WRITTEN APPROVAL  
BY ESI INC. OF TENNESSEE.



ESI Inc. of Tennessee  
1250 Roberts Blvd.  
Kennesaw, GA 30144  
(770)427-6200  
esitenn.com

MASS & ENERGY BALANCE  
OPTION 1 – BACKPRESSURE STG

MARWOOD  
NOVA SCOTIA

SCALE:

None

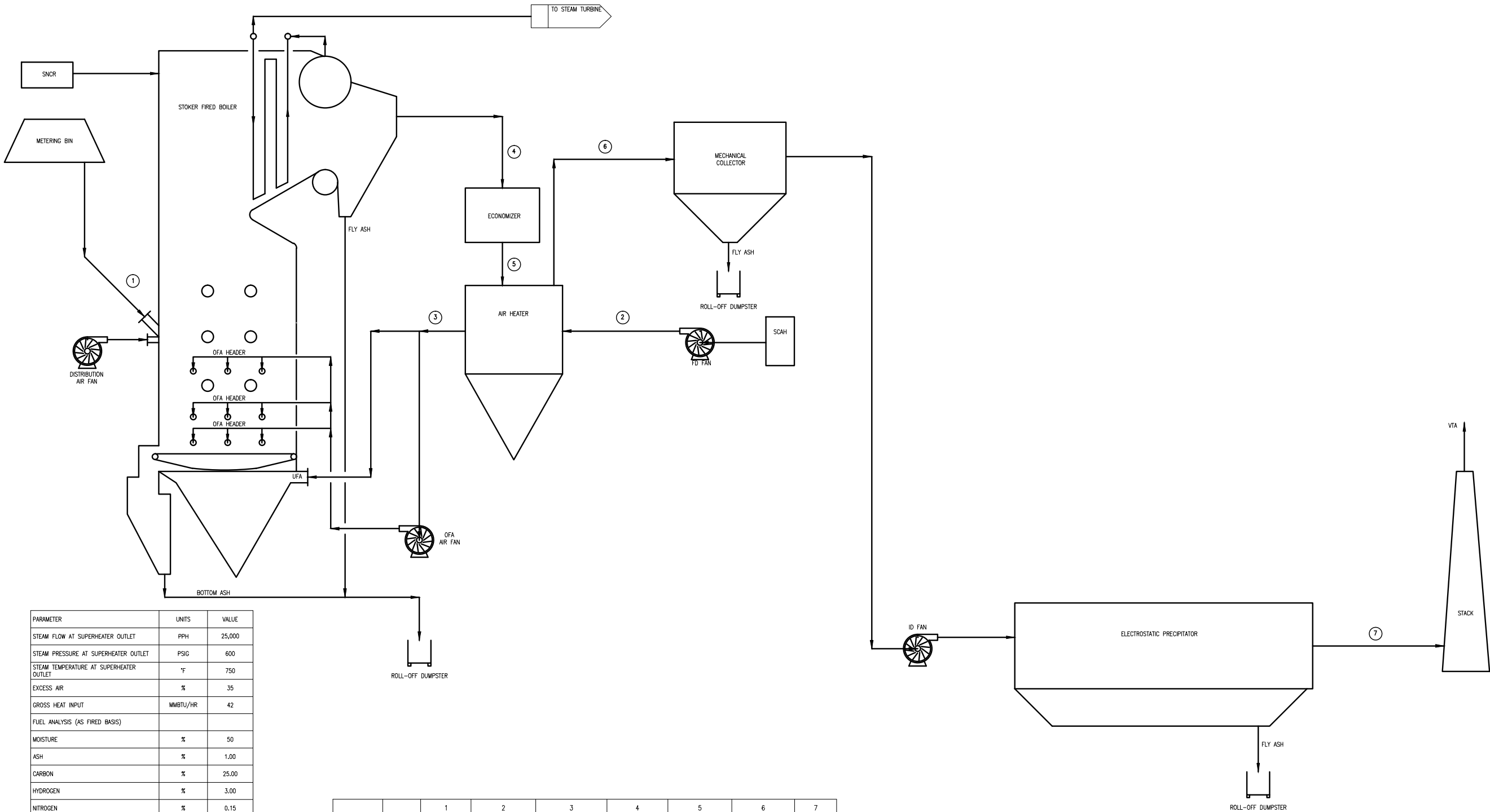
DRAWING NO.:

0.: 688002 F03

REV  
E

Plotted by Stowers, Jonathan on Tuesday, March 01, 2011 10:44:40 AM

\*\* SAFETY FIRST \*\*



| PARAMETER                               | UNITS    | VALUE  |
|-----------------------------------------|----------|--------|
| STEAM FLOW AT SUPERHEATER OUTLET        | PPH      | 25,000 |
| STEAM PRESSURE AT SUPERHEATER OUTLET    | PSIG     | 600    |
| STEAM TEMPERATURE AT SUPERHEATER OUTLET | °F       | 750    |
| EXCESS AIR                              | %        | 35     |
| GROSS HEAT INPUT                        | MMBTU/HR | 42     |
| FUEL ANALYSIS (AS FIRED BASIS)          |          |        |
| MOISTURE                                | %        | 50     |
| ASH                                     | %        | 1.00   |
| CARBON                                  | %        | 25.00  |
| HYDROGEN                                | %        | 3.00   |
| NITROGEN                                | %        | 0.15   |
| SULFUR                                  | %        | 0.03   |
| OXYGEN                                  | %        | 20.8   |
| CHLORINE                                | %        | 0.01   |
| HEATING VALUE                           | BTU/LB   | 4,400  |

|             |       | 1         | 2                      | 3                       | 4                      | 5                      | 6                       | 7           |
|-------------|-------|-----------|------------------------|-------------------------|------------------------|------------------------|-------------------------|-------------|
| DESCRIPTION | UNITS | FUEL FLOW | AIR HEATER INLET (AIR) | AIR HEATER OUTLET (AIR) | ECONOMIZER INLET (GAS) | AIR HEATER INLET (GAS) | AIR HEATER OUTLET (GAS) | STACK INLET |
| MASS FLOW   | PPH   | 9,543     | 38,690                 | 38,690                  | 48,089                 | 48,089                 | 48,089                  | 48,089      |
| TEMPERATURE | °F    | 80        | 80                     | 450                     | 750                    | 600                    | 350                     | 350         |
| GAS VOLUME  | ACFM  | ---       | 8,917                  | 15,027                  | 25,879                 | 22,796                 | 17,324                  | 17,324      |

| REV | DRAWN | DATE    | CHK'D | DATE    | DESCRIPTION       |
|-----|-------|---------|-------|---------|-------------------|
| A   | JSP   | 1/28/11 | TJB   | 2/28/11 | ISSUED FOR REVIEW |
|     |       |         |       |         |                   |
|     |       |         |       |         |                   |
|     |       |         |       |         |                   |
|     |       |         |       |         |                   |
|     |       |         |       |         |                   |
|     |       |         |       |         |                   |
|     |       |         |       |         |                   |
|     |       |         |       |         |                   |
|     |       |         |       |         |                   |

| DESCRIPTION |
|-------------|
|             |
|             |
|             |
|             |
|             |
|             |
|             |
|             |
|             |
|             |

| REFERENCE DRAWINGS |
|--------------------|
|                    |
|                    |
|                    |
|                    |
|                    |
|                    |
|                    |
|                    |
|                    |
|                    |

NOT FOR CONSTRUCTION

THE DESIGN DATA AND INFORMATION CONTAINED HEREIN IS PROPRIETARY TO ESI INC. OF TENNESSEE. NO PORTION OF THIS INFORMATION SHALL BE RELEASED EXCEPT AS AUTHORIZED THROUGH PRIOR WRITTEN APPROVAL BY ESI INC. OF TENNESSEE.



ESI Inc. of Tennessee  
1250 Roberts Blvd.  
Kennesaw, GA 30144  
(770)427-6200  
esitenn.com

AIR & FLUE GAS  
FLOW SHEET- OPTION 2

**MARWOOD**

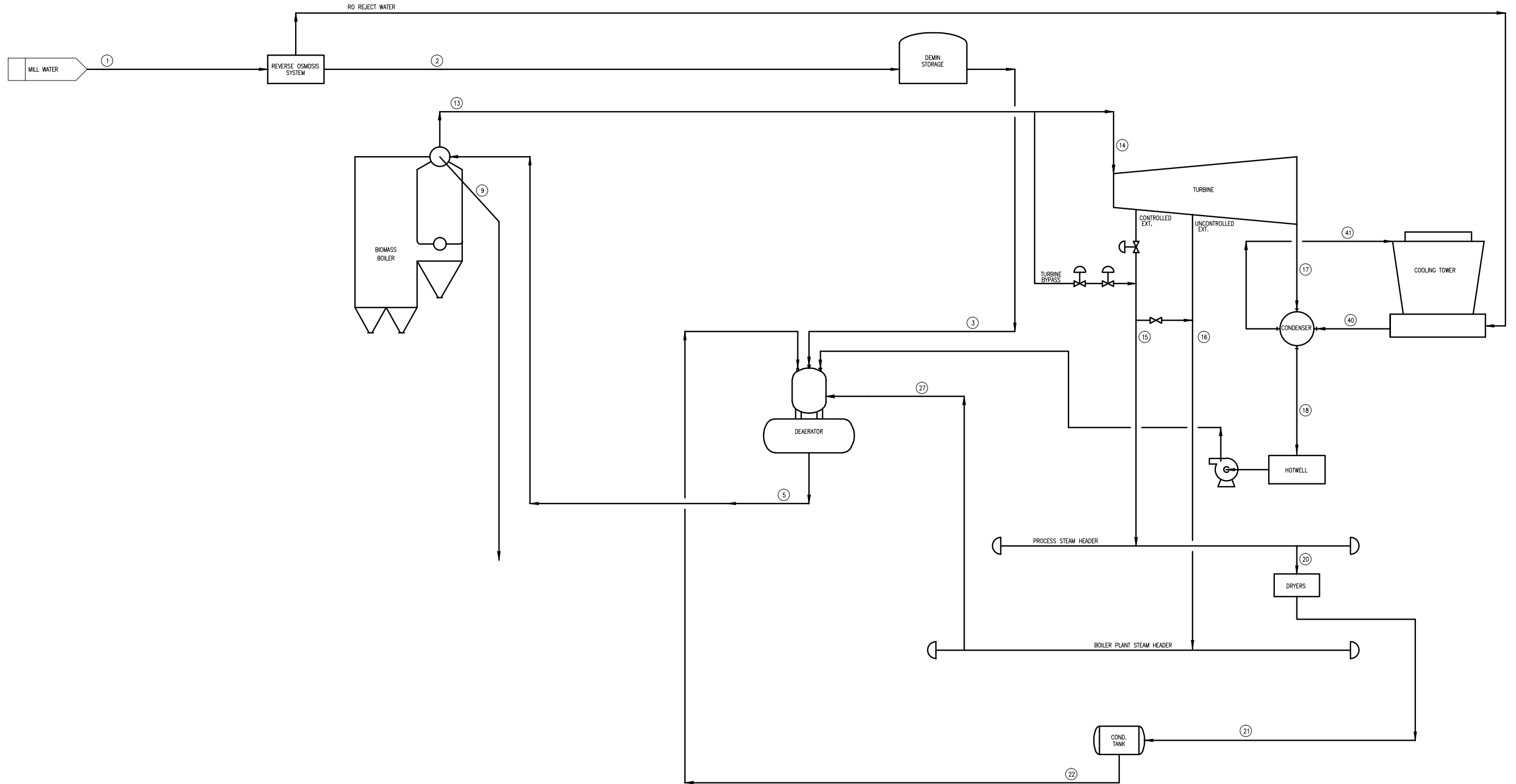
NOVA SCOTIA

SCALE: None

DRAWING NO.: 688002 F04

REV: A

DRAWING SCALE BASED ON A REPRODUCTION SIZE OF 24"x36"



| DESIGN            | 1    | 2    | 3    | 4 | 5     | 6 | 7 | 8 | 9     | 10 | 11 | 12 | 13     | 14     | 15     | 16     | 17     | 18   | 19 | 20     | 21   | 22   | 23 | 24 | 25 | 26 | 27     | 28 | 29 | 30 | 31 | 40     | 41     |   |   |   |   |   |   | GENERATOR |
|-------------------|------|------|------|---|-------|---|---|---|-------|----|----|----|--------|--------|--------|--------|--------|------|----|--------|------|------|----|----|----|----|--------|----|----|----|----|--------|--------|---|---|---|---|---|---|-----------|
| FLOW kphh         | 1.93 | 1.93 | 1.93 |   | 26.0  |   |   |   | 1.0   | –  | –  |    | 25.0   | 25.0   | 18.0   | 2.34   | 4.70   | 4.70 |    | 18.0   | 17.1 | 17.1 |    |    |    |    | 2.30   |    |    |    |    | 1327.4 | 1327.4 | – | – | – | – | – | – | OUTPUT    |
| PRESSURE psia     | 75   | 60   | 75   |   | 679   |   |   |   | 623.0 | –  | –  |    | 615    | 605    | 35     | 35     | 1.0    | 1.0  |    | 30     | 30   | 90   |    |    |    |    | 25     |    |    |    |    | 73     | 76.5   | – | – | – | – | – | – | KILOWATT  |
| TEMPERATURE deg F | 70   | 70   | 70   |   | 240   |   |   |   | 493   | –  | –  |    | 750    | 750    | 260    | 260    | 102    | 102  |    | 260    | 170  | 170  |    |    |    |    | 260    |    |    |    |    | 30     | 30     | – | – | – | – | – | – |           |
| Enthalpy Btu/lb   | 38   | 38   | 38   |   | 209.0 |   |   |   | 480.0 | –  | –  |    | 1380.0 | 1381.0 | 1167.0 | 1167.0 | 1062.0 | 70.0 |    | 1169.0 | 138  | 138  |    |    |    |    | 1170.0 |    |    |    |    | 41.0   | 44.5   | – | – | – | – | – | – | 1,602     |

[illegible][illegible]

NOT FOR CONSTRUCTION

THE DESIGN DATA AND INFORMATION  
CONTAINED HEREIN IS PROPRIETARY  
TO ESI INC. OF TENNESSEE. NO  
PORTION OF THIS INFORMATION SHALL  
BE RELEASED EXCEPT AS AUTHORIZED  
THROUGH PRIOR WRITTEN APPROVAL  
BY ESI INC. OF TENNESSEE.



ESI Inc. of Tennessee  
1250 Roberts Blvd.  
Kennesaw, GA 30144  
(770)427-6200  
esitenn.com

MASS & ENERGY BALANCE  
OPTION 2 - MAX. EXTRACTION

MARWOOD  
NOVA SCOTIA

SCALE:

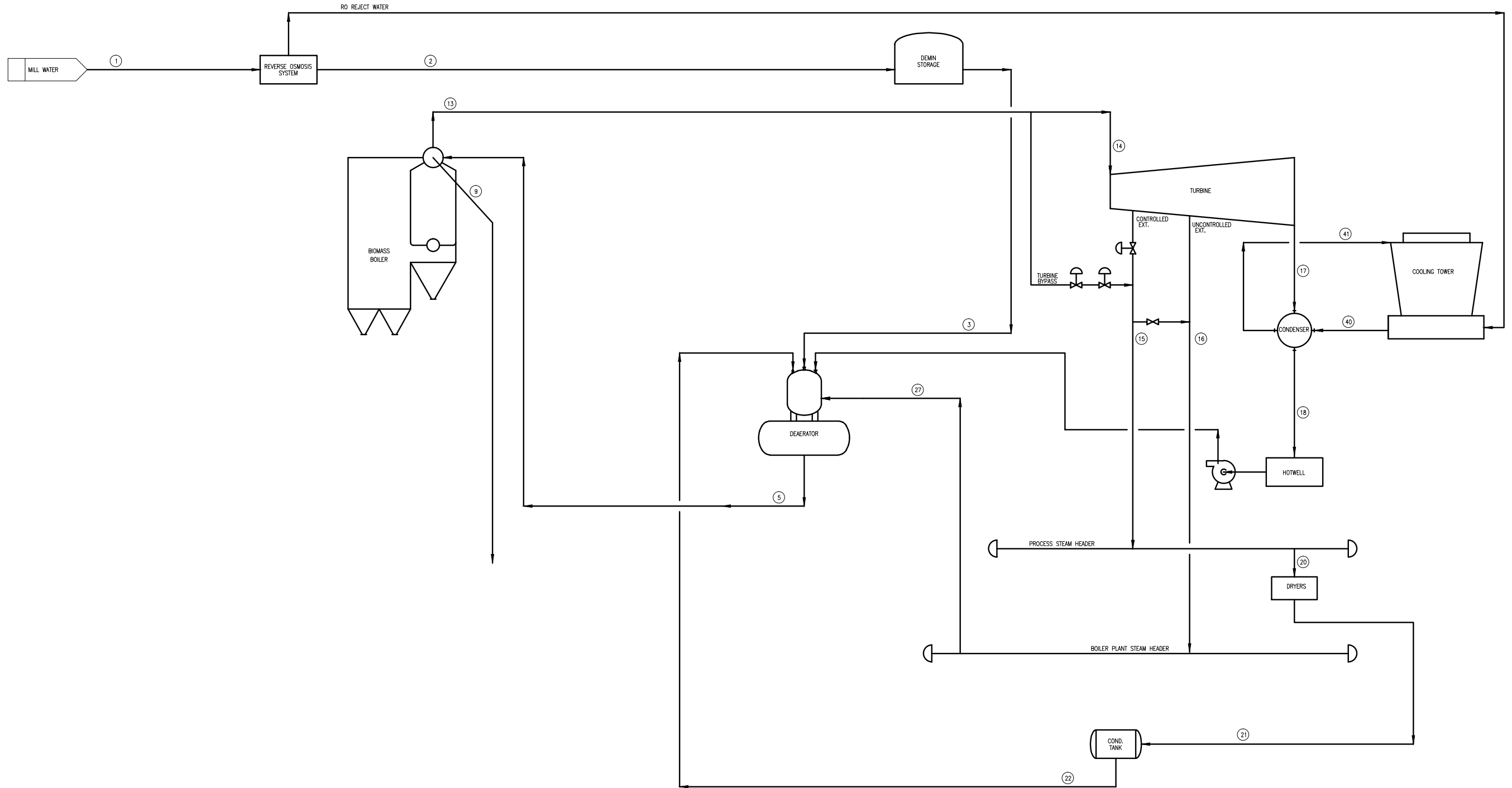
None

DRAWING NO.:

688002 F-05

CC

DRAWING SCALE BASED ON A REPRODUCTION SIZE OF 24"x36"



| DESIGN            | 1    | 2    | 3    | 4 | 5     | 6 | 7 | 8 | 9     | 10 | 11 | 12 | 13     | 14     | 15     | 16     | 17     | 18    | 19 | 20     | 21  | 22  | 23 | 24 | 25 | 26 | 27     | 28 | 29 | 30 | 31 | 40     | 41     |   |   |   |   |   | GENERATOR |          |
|-------------------|------|------|------|---|-------|---|---|---|-------|----|----|----|--------|--------|--------|--------|--------|-------|----|--------|-----|-----|----|----|----|----|--------|----|----|----|----|--------|--------|---|---|---|---|---|-----------|----------|
| FLOW kpph         | 1.03 | 1.03 | 1.03 |   | 26.0  |   |   |   | 1.0   | –  | –  |    | 25.0   | 25.0   | 0.0    | 3.33   | 21.67  | 21.67 |    | 0.0    | 0.0 | 0.0 |    |    |    |    | 3.33   |    |    |    |    | 1327.4 | 1327.4 | – | – | – | – | – | OUTPUT    |          |
| PRESSURE psia     | 75   | 60   | 75   |   | 679   |   |   |   | 623.0 | –  | –  |    | 615    | 605    | 35     | 35     | 1.0    | 1.0   |    | 35     | 30  | 90  |    |    |    |    | 25     |    |    |    |    | 80     | 95.3   | – | – | – | – | – | –         | KILOWATT |
| TEMPERATURE deg F | 70   | 70   | 70   |   | 240   |   |   |   | 493   | –  | –  |    | 750    | 750    | 260    | 260    | 102    | 102   |    | 260    | 170 | 170 |    |    |    |    | 260    |    |    |    |    | 30     | 30     | – | – | – | – | – | –         |          |
| Enthalpy Btu/lb   | 38   | 38   | 38   |   | 209.0 |   |   |   | 480.0 | –  | –  |    | 1380.0 | 1381.0 | 1167.0 | 1167.0 | 1009.0 | 70.0  |    | 1169.0 | 138 | 138 |    |    |    |    | 1170.5 |    |    |    |    | 48.0   | 63.3   | – | – | – | – | – | –         | 2,414    |

[illegible]

|                                    | REFERENCE DRAWINGS |
|------------------------------------|--------------------|
|                                    |                    |
|                                    |                    |
|                                    |                    |
|                                    |                    |
|                                    |                    |
| Drawing File Name<br>688002F06.dwg |                    |

NOT FOR CONSTRUCTION

THE DESIGN DATA AND INFORMATION  
CONTAINED HEREIN IS PROPRIETARY  
TO ESI INC. OF TENNESSEE. NO  
PORTION OF THIS INFORMATION SHALL  
BE RELEASED EXCEPT AS AUTHORIZED  
THROUGH PRIOR WRITTEN APPROVAL  
BY ESI INC. OF TENNESSEE.



ESI Inc. of Tennessee  
1250 Roberts Blvd.  
Kennesaw, GA 30144  
(770)427-6200  
esitenn.com

MASS & ENERGY BALANCE  
OPTION 2- FULL CONDENSING

MARWOOD  
NOVA SCOTIA

SCALE:

None

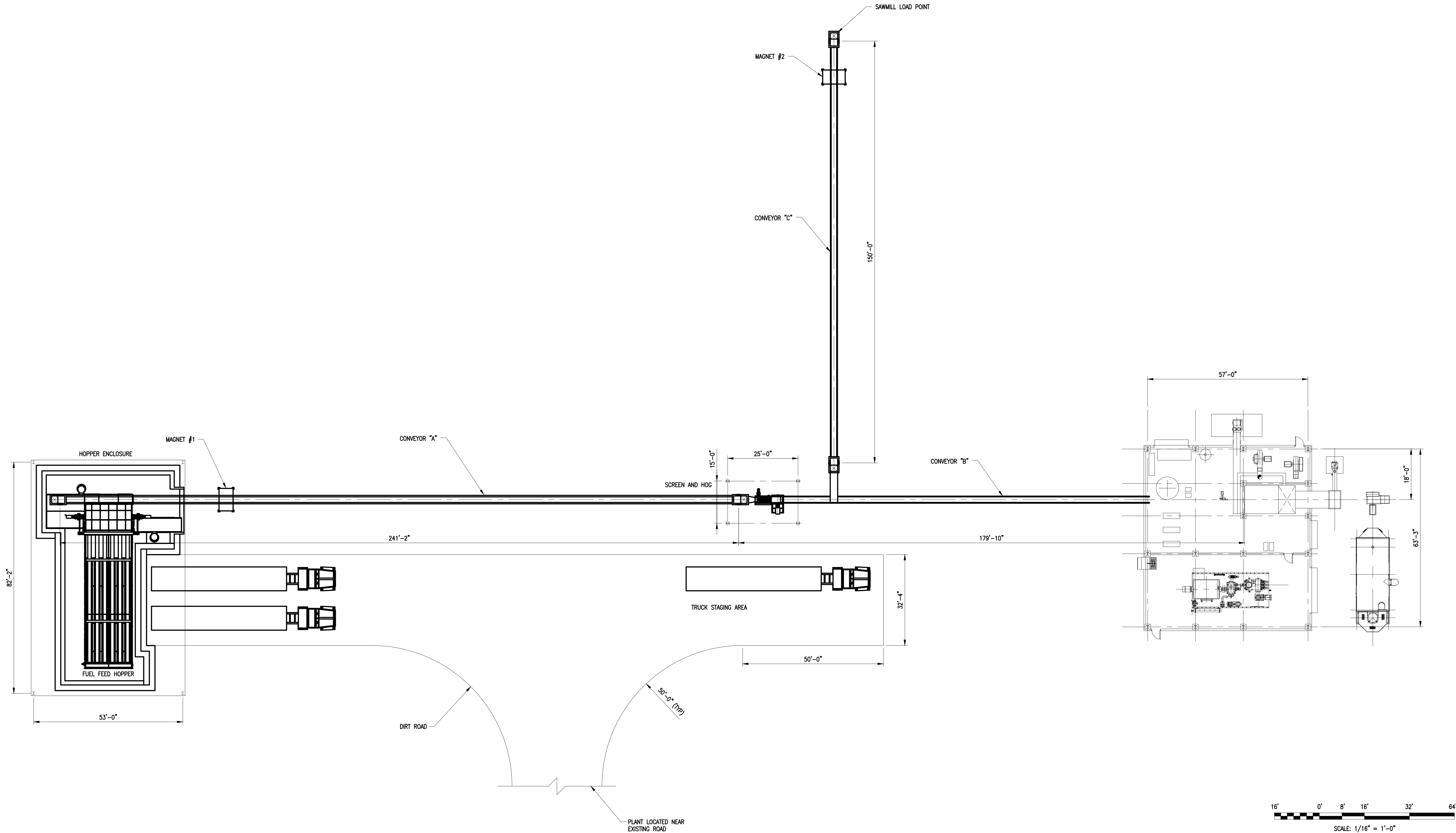
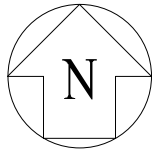
DRAWING NO.:

688002 F-06

REV: C

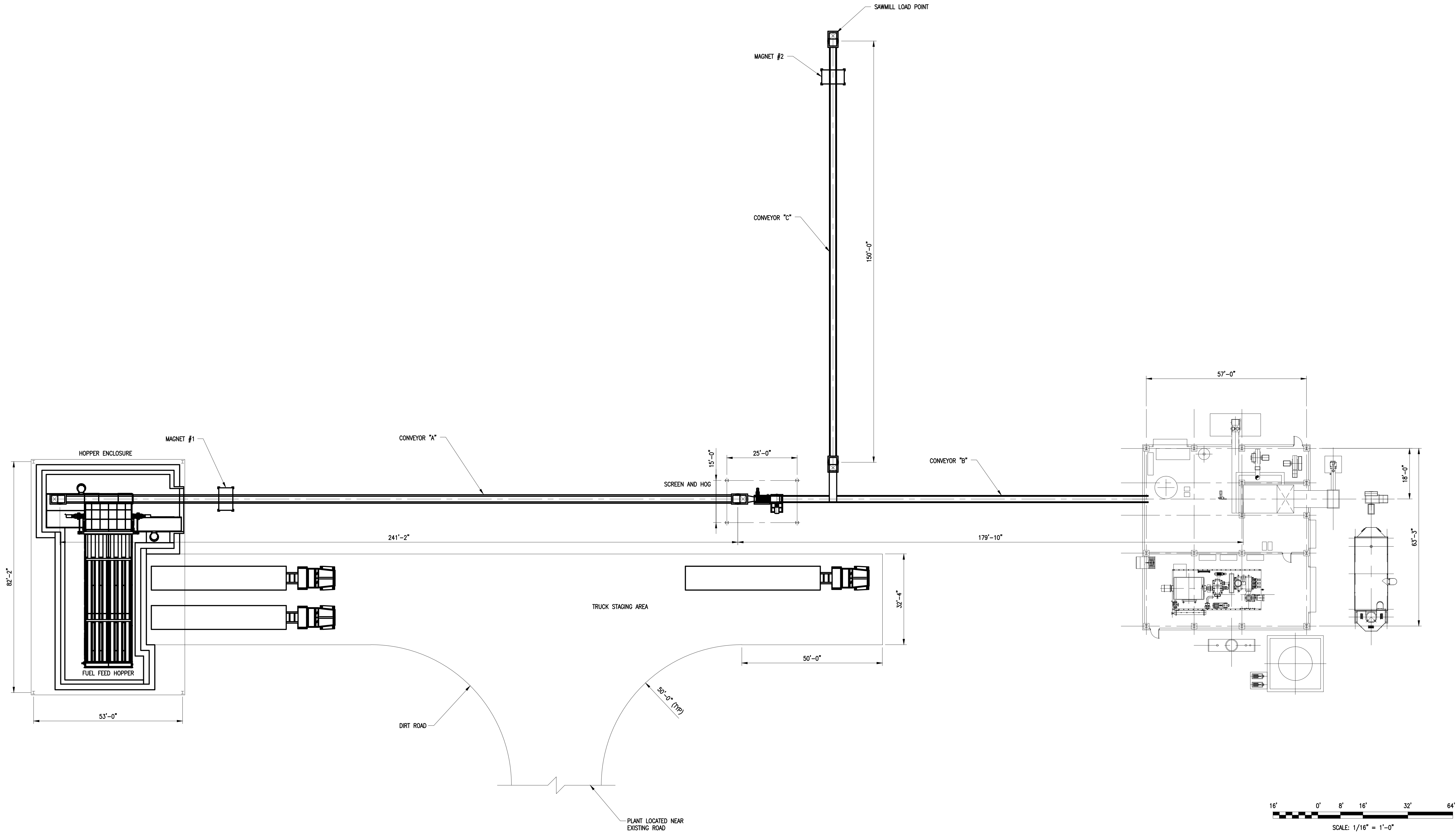
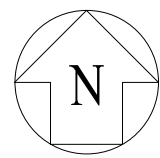
DRAWING SCALE BASED ON A REPRODUCTION SIZE OF 24"x36"

Plotted by Stowers, Jonathan on Monday, March 07, 2011 1:27:25 PM



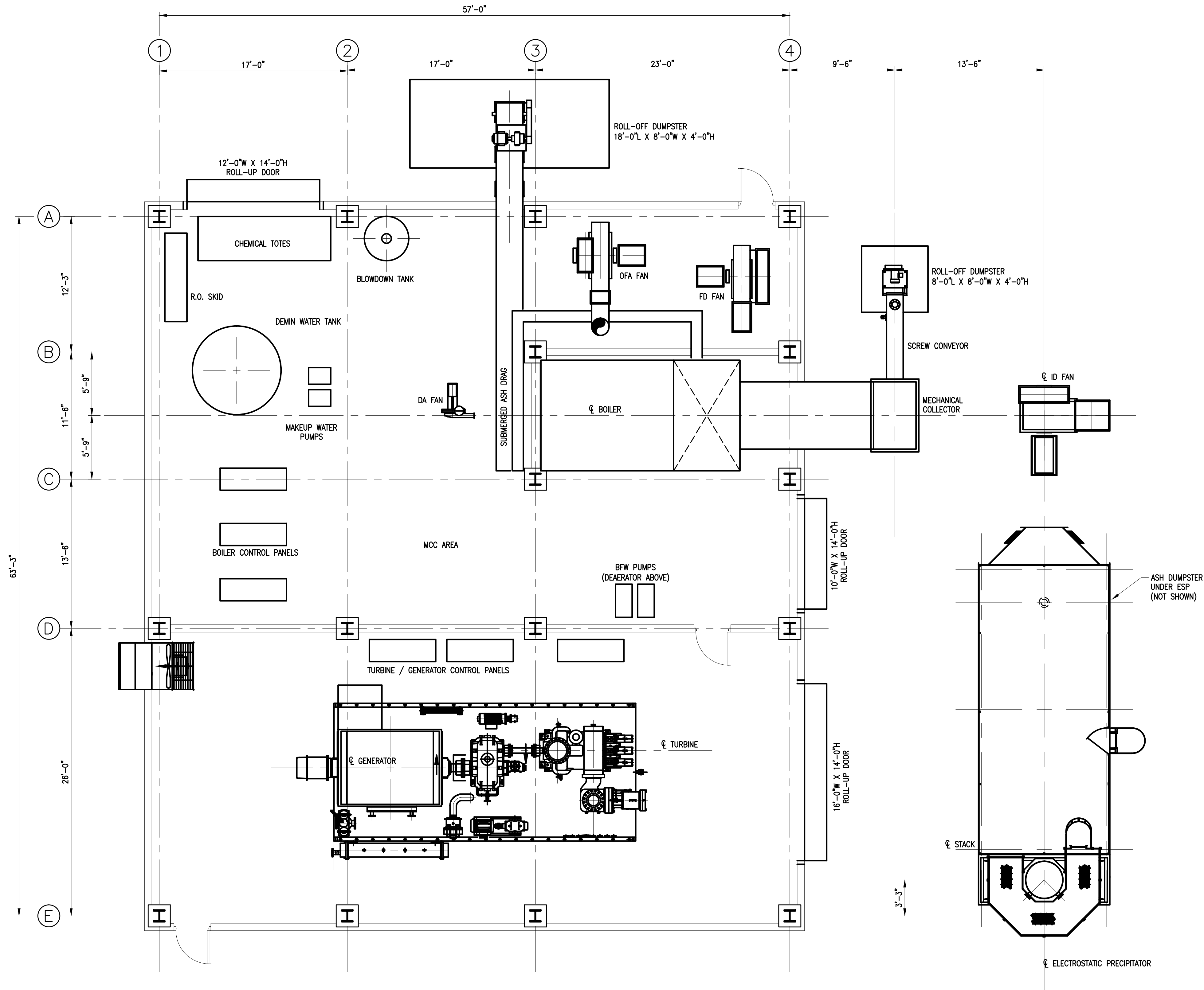
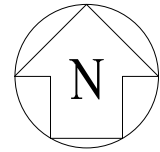
| REV | DRAWN | DATE     | CHK'D | DATE     | DESCRIPTION                | REFERENCE DRAWINGS                 | NOT FOR CONSTRUCTION | THE DESIGN DATA AND INFORMATION CONTAINED HEREIN IS PROPRIETARY TO ESI INC. OF TENNESSEE. NO PORTION OF THIS INFORMATION SHALL BE RELEASED EXCEPT AS AUTHORIZED THROUGH PRIOR WRITTEN APPROVAL BY ESI INC. OF TENNESSEE. | CHP PLANT<br>SITE PLAN – OPTION 1                                                                     |                         |                        |           |
|-----|-------|----------|-------|----------|----------------------------|------------------------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|-------------------------|------------------------|-----------|
| A   | JRS   | 02/23/11 | JSP   | 03/07/11 | ISSUED FOR CUSTOMER REVIEW |                                    |                      |                                                                                                                                                                                                                          | MARWOOD                                                                                               |                         |                        |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          | NOVA SCOTIA                                                                                           |                         |                        |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          | ESI Inc. of Tennessee<br>1250 Roberts Blvd.<br>Kennesaw, GA 30144<br><br>(770)427-6200<br>esitenn.com | SCALE:<br>1/16" = 1'-0" | DRAWING NO.:<br>688002 | REV:<br>A |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                                                                                       |                         |                        |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                                                                                       |                         |                        |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                                                                                       |                         |                        |           |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                                                                                       |                         |                        |           |
|     |       |          |       |          |                            | Drawing File Name<br>688002G01.dwg |                      |                                                                                                                                                                                                                          |                                                                                                       |                         |                        |           |

Plotted by Stowers, Jonathan on Monday, March 07, 2011 1:24:46 PM



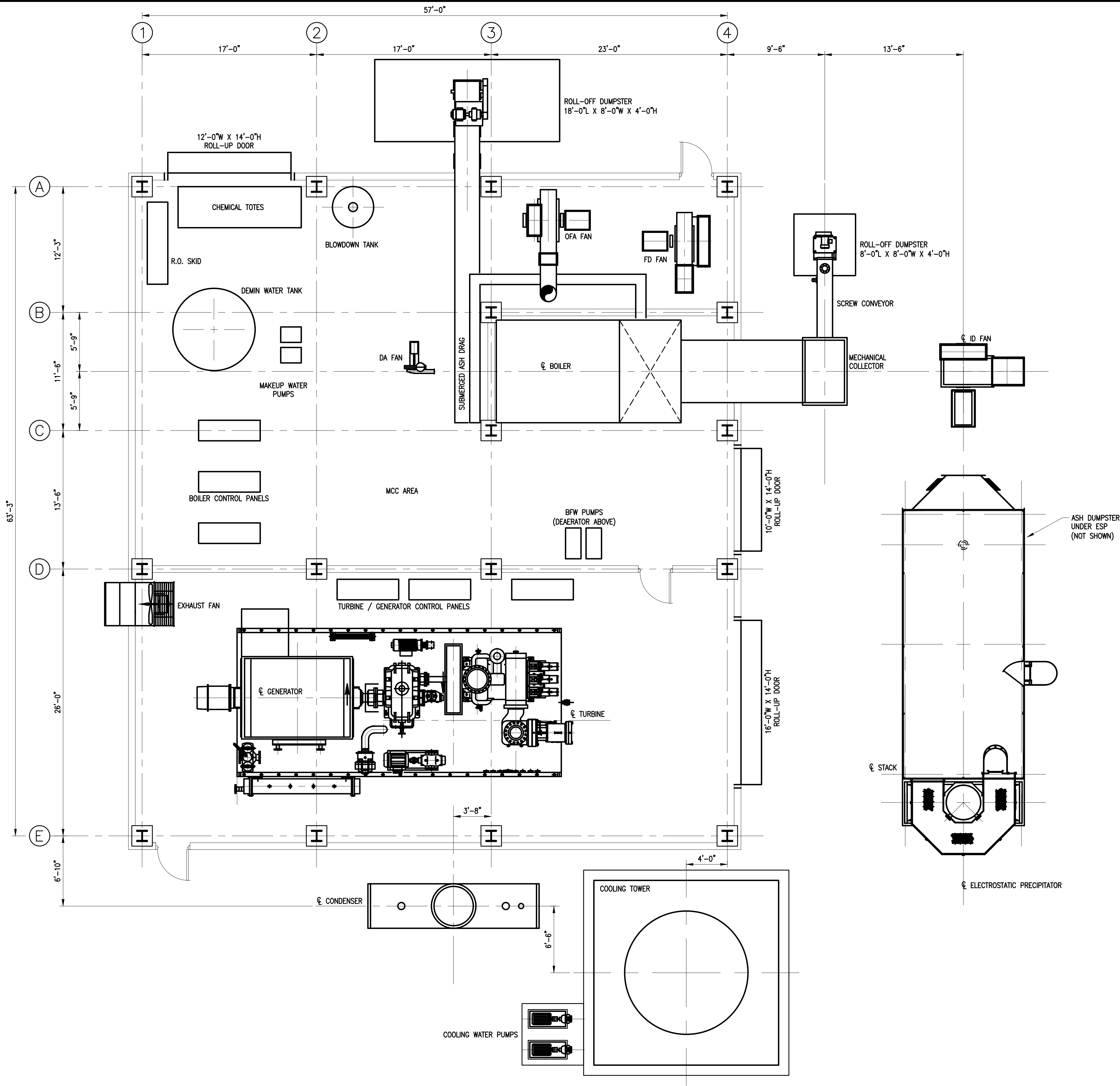
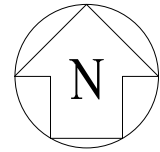
| REV | DRAWN | DATE     | CHK'D | DATE     | DESCRIPTION                | REFERENCE DRAWINGS                 | NOT FOR CONSTRUCTION | THE DESIGN DATA AND INFORMATION CONTAINED HEREIN IS PROPRIETARY TO ESI INC. OF TENNESSEE. NO PORTION OF THIS INFORMATION SHALL BE RELEASED EXCEPT AS AUTHORIZED THROUGH PRIOR WRITTEN APPROVAL BY ESI INC. OF TENNESSEE. | CHP PLANT<br>SITE PLAN – OPTION 2                                                                                                                                                       |               |              |        |
|-----|-------|----------|-------|----------|----------------------------|------------------------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|--------------|--------|
| A   | JRS   | 02/23/11 | TJB   | 03/07/11 | ISSUED FOR CUSTOMER REVIEW |                                    |                      |                                                                                                                                                                                                                          | MARWOOD                                                                                                                                                                                 |               |              |        |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          | NOVA SCOTIA                                                                                                                                                                             |               |              |        |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |  ESI Inc. of Tennessee<br>1250 Roberts Blvd.<br>Kennesaw, GA 30144<br>(770)427-6200<br>esitenn.com | SCALE:        | DRAWING NO.: | REV: A |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                         | 1/16" = 1'-0" | 688002 G02   |        |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                         |               |              |        |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                         |               |              |        |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                         |               |              |        |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                         |               |              |        |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                         |               |              |        |
|     |       |          |       |          |                            | Drawing File Name<br>688002G02.dwg |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                         |               |              |        |

Plotted by Stowers, Jonathan on Monday, March 07, 2011 1:31:05 PM



| REV | DRAWN | DATE     | CHK'D | DATE     | DESCRIPTION                | REFERENCE DRAWINGS                 | NOT FOR CONSTRUCTION | THE DESIGN DATA AND INFORMATION CONTAINED HEREIN IS PROPRIETARY TO ESI INC. OF TENNESSEE. NO PORTION OF THIS INFORMATION SHALL BE RELEASED EXCEPT AS AUTHORIZED THROUGH PRIOR WRITTEN APPROVAL BY ESI INC. OF TENNESSEE. | CHP PLANT<br>BOILER/STG BUILDING – OPTION 1                                                                                                                                             |        |              |      |   |
|-----|-------|----------|-------|----------|----------------------------|------------------------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------|------|---|
| A   | JRS   | 02/21/11 | TJB   | 03/07/11 | ISSUED FOR CUSTOMER REVIEW |                                    |                      |                                                                                                                                                                                                                          | MARWOOD                                                                                                                                                                                 |        |              |      |   |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          | NOVA SCOTIA                                                                                                                                                                             |        |              |      |   |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |  ESI Inc. of Tennessee<br>1250 Roberts Blvd.<br>Kennesaw, GA 30144<br>(770)427-6200<br>esitenn.com | SCALE: | DRAWING NO.: | REV: |   |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                         | None   | 688002       | G03  | A |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                         |        |              |      |   |
|     |       |          |       |          |                            |                                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                         |        |              |      |   |
|     |       |          |       |          |                            | Drawing File Name<br>688002G03.dwg |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                         |        |              |      |   |

Plotted by Stowers, Jonathan on Monday, March 07, 2011 1:31:59 PM



| REV                                | DRAWN | DATE     | CHK'D | DATE     | DESCRIPTION                | REFERENCE DRAWINGS | NOT FOR CONSTRUCTION | THE DESIGN DATA AND INFORMATION CONTAINED HEREIN IS PROPRIETARY TO ESI INC. OF TENNESSEE. NO PORTION OF THIS INFORMATION SHALL BE RELEASED EXCEPT AS AUTHORIZED THROUGH PRIOR WRITTEN APPROVAL BY ESI INC. OF TENNESSEE. | <div><div><div>STEAM &amp; POWER</div><div>ESI</div><div>SPECIAL FORCES</div></div><div>ESI Inc. of Tennessee<br/>1250 Roberts Blvd.<br/>Kennesaw, GA 30144<br/>(770)427-6200<br/>esitenn.com</div></div> | CHP PLANT<br>BOILER/STG BUILDING – OPTION 2 |           |  |
|------------------------------------|-------|----------|-------|----------|----------------------------|--------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|-----------|--|
| A                                  | JRS   | 02/21/11 | TJB   | 03/07/11 | ISSUED FOR CUSTOMER REVIEW |                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                                           | MARWOOD                                     |           |  |
|                                    |       |          |       |          |                            |                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                                           | NOVA SCOTIA                                 |           |  |
|                                    |       |          |       |          |                            |                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                                           |                                             |           |  |
|                                    |       |          |       |          |                            |                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                                           |                                             |           |  |
|                                    |       |          |       |          |                            |                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                                           |                                             |           |  |
|                                    |       |          |       |          |                            |                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                                           |                                             |           |  |
| Drawing File Name<br>688002G04.dwg |       |          |       |          |                            |                    |                      |                                                                                                                                                                                                                          | SCALE:<br>3/16" = 1'-0"                                                                                                                                                                                   | DRAWING NO.:<br>688002                      | REV:<br>A |  |
|                                    |       |          |       |          |                            |                    |                      |                                                                                                                                                                                                                          |                                                                                                                                                                                                           | G04                                         |           |  |

**NOVA SCOTIA UTILITY AND REVIEW BOARD**  
**IN THE MATTER OF THE ELECTRICITY ACT**

and

**IN THE MATTER OF a hearing to determine**  
**Renewable Energy Community Based Feed-in Tariffs**

**Direct Testimony of Fenton Travis**

**Q. Mr. Travis please state your name, occupation and business address.**

A. I am Fenton C. Travis. I am a Project Manager for Marwood Ltd., 66 Pleasant Valley Road, Brookfield, Nova Scotia.

**Q. Summarize your education and professional experience.**

A. I received a Mechanical Engineering degree from the University of New Brunswick along with a Diploma in Technology Management. I am a Certified Energy Manager accredited by the Association of Energy Engineers. I am a Professional Engineer registered in the province of New Brunswick.

I have worked in the forestry industry for eight years with Marwood Ltd. My duties at Marwood have included implementation of a maintenance management software system, product design, machine design and the management of a variety of projects for expansion of manufacturing capacity at our plants. I have most recently had experience managing the development of a 25 MW biomass power plant intended to be constructed in the province of New Brunswick. I was responsible for all aspects of developing the project including sourcing experts, executing engineering studies, assessing the market, acquiring transmission access, assessing and acquiring biomass fuel supply, site selection, execution of environmental impact assessments, organizing project finance experts, developing & submitting proposals and managing government relations. I am currently managing Marwood's interest in constructing a combined heat and power (CHP) facility at its Brookfield site in the province of Nova Scotia, along with managing the development of a large scale bioenergy project to be located in the province of New Brunswick.

**Q. Who is Marwood?**

- A. Marwood is a forestry company started by the Creelman family in the 1920's in the province of Nova Scotia. Marwood produces a suite of value added wood products such as; dimensional lumber, wharf timbers, utility poles, wood siding, deck components, wood pellets and a number of other forest products. The company operates three manufacturing sites in Nova Scotia and three sites in New Brunswick.

**Q. Who is the Alliance of Nova Scotia Sawmillers (ANSS)?**

- A. The ANSS is a group of companies that own forest products manufacturing facilities located in Nova Scotia that have unified to ensure that the COMFIT CHP rate set by the NSUARB is an accurate reflection of the rate necessary to have such projects successfully developed in the province. The group includes Marwood Ltd., Ledwidge Lumber Company Ltd., Elmsdale Lumber Company Ltd., Harry Freeman & Son Ltd., J.D. Irving, Limited (Truro) and Groupe Savoie Inc.. Members of the group operate sawmills and other value add forestry manufacturing facilities in Nova Scotia.

**Q. Has ANSS participated in the COMFIT process to date?**

Yes, members of the ANSS have participated in the process from the Dr. Wheeler-led stakeholder sessions up to and including the technical conferences with Synapse. The ANSS has made two written submissions to Synapse regarding the biomass CHP COMFIT and they are attached as Appendix A and B.

**Q. Were there any particular concerns identified by ANSS in its submissions to Synapse in the development of a biomass CHP tariff?**

- A. Yes. We outlined at the outset that current information on capital cost, fuel supply, O&M estimates and other related variables were very important.

“In accordance with our concern for local and current information, our group will be executing an engineering study with a Nova Scotia based engineering firm to determine key parameters of the cost of generation for CHP. This will include a capital cost estimate, fuel supply requirements, O&M estimates and all other related variables in determining the cost of generation”.

We also highlighted that fuel supply risk was the single largest risk to CHP plants.

**Q. Did the initial draft tariff respond to those concerns?**

- A. No. We asked IRs to flesh out the basis for the assumptions and the underlying data but we did not receive any data or any breakdown of the cost components. Attached as Appendix C are the Responses to IRs provided to ANSS by Synapse.

**Q. Having now received the final tariffs from Synapse, do they address the issues raised by ANSS?**

**A.** In part.

1. Significant components of the capital cost estimate for the CHP plant appear to be missing from the Synapse estimate as identified in the ESI Study.
2. Costs for producing the extraction steam in the Synapse model are fully allocated to the heat users. Both electricity and heat are generated from this shared resource and the cost should therefore be divided evenly.
3. Parasitic power losses appear to be absent from the COMFIT calculation and need to be included. ESI has provided these losses as 14% of the gross energy of the plant. ANSS also suggests that the plant purchase the parasitic power from the grid which will reduce the COMFIT cost to the ratepayer compared to self-consuming.
4. The Plant capacity factor has been estimated by Synapse at 85%, however, ESI believes a plant capacity factor of 90% is reasonable and attainable. ANSS recommends that the UARB adopt the 90% capacity factor estimate from ESI.
5. Boiler engineer regulations have been incorrectly interpreted by Synapse and have resulted in an incorrect analysis of the labour requirement. Based on the regulations and salary estimates provided by the Nova Scotia Institute of Power Engineers ANSS recommends the labour cost for the “boiler only scenario” be \$40,000 and that the labour cost for the CHP plant be \$214,000.
6. Based on the ESI Study, Synapse has over-estimated the boiler efficiency of the CHP plant at 80%. The boiler efficiency should be adjusted to the 69% that ESI has calculated in its study. Fuel requirements and all other variables affected by this change should be recalculated based on the 69% boiler efficiency.
7. Based on the ESI study it appears that Synapse has omitted the cost of operating expenses such as: Ash Landfill, Make-up Water, Sewer, Water Treatment and has underestimated the cost of plant maintenance. ANSS recommends that the Board adopt the ESI study estimates for these costs, (adjusted for size difference).
8. Synapse has indicated that financing of 60% debt and 40% equity at a cost of debt of 9.5% is possible. Based on the testimony of Jeff Bodington, ANSS recommends that the Board assume biomass CHP plants will be financed with 100% equity.
9. Based on the testimony of Jeff Bodington if the CPI/Diesel escalator is the only fuel hedge, then the cost of equity should be adjusted from 13% as indicated by Synapse to 17.5%.

10. Alternatively, change the CPI/Diesel escalator to a CPI/Diesel escalator plus a re-opener every two years to provide an adequate fuel hedge, such that the cost of equity is 13%.

#### **COSTS OF CONSTRUCTION AND OPERATION**

**Q. What has the ANSS done to understand the costs associated with constructing and operating a CHP plant?**

- A. In order to determine an appropriate CHP COMFIT rate, a sufficiently detailed study was required to determine critical cost components and overall system parameters. The ANSS sought out an engineering procurement and construction (EPC) firm that had substantial expertise and experience with biomass CHP plants and chose ESI Inc. (ESI) of Tennessee to perform the study (the “ESI Study”).

**Q. When was the ESI Study performed?**

- A. The ANSS commissioned the ESI Study in January of 2011 and it was completed in March of 2011.

**Q. How does the Synapse capital cost estimate compare with the ESI estimate in its Study?**

- A. The ESI Study evaluates a 2.414 MW condensing turbine while the Synapse analysis is for a 2.05 MW condensing turbine, therefore, an adjustment is required to evaluate the two on a per MW cost. The ESI cost estimate, adjusted to a comparable scale of 2.05 MW, is \$13,456,757; the Synapse estimate is \$7,740,000. This extreme difference in the capital cost estimate appears to stem from the fact that Synapse has left out numerous items in the capital cost estimate, as identified by ESI.

**Q. How does the Synapse estimate for operating and maintenance costs compare to the ESI estimate in its Study?**

- A. As with the capital cost estimate, it appears as though Synapse has left out operating cost items such as Ash Landfill, Make-up Water, Sewer and Water Treatment. It would also appear as though Synapse has under-estimated the cost of maintenance in the plant as well.

**Q. Steam from CHP plants is used for both electricity generation and process heat, how does Synapse deal with the allocation of cost of this shared resource?**

- A. Synapse is proposing to have all of the costs of generating the steam for extraction paid for by the heat user as, from the Synapse perspective, a heat user would have had to construct fuel and maintain a biomass boiler to supply steam for its process anyway. Synapse suggests that the additional cost of adding a power plant is all that the rate payer should bear.

One could justifiably take this exact argument that Synapse makes for its current proposal and reverse it: the cost that the heat user should pay is the additional cost required to build a biomass CHP plant to produce electricity compared to what it would have cost to

build a biomass plant producing electricity only. This scenario operates under the assumption that one would have had to build a biomass power plant (electricity only) to supply the desired renewable energy for the COMFIT and therefore the additional expense of getting the same electricity from a biomass CHP plant is all the cost that the heat user should pay. The plant is simply extracting heat from steam that would have otherwise been produced to generate renewable electricity for the COMFIT.

**Q. Does ANSS agree with this approach?**

- A. No. Since the purpose of the COMFIT is to procure renewable electricity, the ANSS does not believe that it is justifiable to approach the evaluation from the perspective of a boiler only scenario which would produce no electricity. Instead, ANSS believes there is greater merit in evaluating the situation from the perspective that a biomass power plant is required to be constructed to produce electricity and only the added expense of CHP should be borne by the heat user.

There is a significant element of subjectivity in evaluating which approach is most equitable to divide the cost. The scenario as proposed by Synapse attempts to put all of the cost of the shared steam resource on the heat user to keep electricity rates lower and the reverse approach attempts to put the cost of the shared steam resource on the electricity rate payer to keep its heating costs lower. What is not subjective, however, is that two products are being produced from the same steam resource and both the heat user and electricity rate payer would have otherwise borne the full cost of the steam if they were generating heat and electricity independently from one another. Because they share the steam, they should both benefit from sharing the cost of producing it.

The method that Synapse has proposed to deal with the steam cost simply forces the heat user to bear an unfair and disproportionate share of the cost for generating the shared steam resource. Having the heat user bear the production cost of the shared steam is no more justifiable than having the rate payer bear the entire cost.

Indeed, Synapse agreed some portion of the steam generated in a COMFIT CHP plan would benefit electricity users (Synapse (ANSS) IR-13(b)).

**Q. How does ANSS propose the cost to produce steam be allocated?**

- A. In our view, the splitting of the cost is the only equitable way to deal with this issue. We would propose that the cost required to generate steam in extraction mode be split evenly between the electric rate payer and the heat user such that both proponents benefit equally from CHP.

**Q. Do you believe the “Net of steam-only scenario” assessment performed by Synapse is appropriate?**

- A. No. We believe the “Net of steam-only scenario” costs should be split evenly as previously outlined and not allocated 100% to the heat user. If the “Net of steam-only scenario” costs are divided evenly we believe that this is a fair way to calculate the COMFIT rate.

**Q. Do you believe that the “Net of steam-only” costs are accurately estimated?**

A. The “net of steam” cost analysis requires an evaluation of the boiler costs. ESI has not performed this analysis and we therefore cannot positively identify if the Synapse estimate regarding “Net of steam-only” costs are accurate. However, based on the omissions of Synapse regarding the CHP plant, we believe it is highly probable that Synapse has underestimated the “Net of steam-only” costs. ESI has the ability to accurately estimate the costs of the “Net of steam-only scenario” and we would recommend further investigation to determine these costs.

**Q. Is an 85% plant capacity factor a reasonable estimate for the operation of a CHP plant of this size?**

A. ESI has indicated that it believes a 90% plant capacity factor should be attainable.

**Q. Has Synapse included an assessment of the power required to operate the CHP plant?**

A. I do not see where Synapse has accounted for parasitic power losses associated with operating the power plant in their model. This is a significant omission that must be addressed, as ESI has determined that it represents a consumption of 14% of the gross electricity produced by the CHP plant. There are two options to account for parasitic power load.

1. The plant can purchase power at the rate specified by NSPI based on the plants rate class.
2. The plant can consume its own energy.

Option 1 provides the least cost to rate payers compared with self-consuming the electricity produced from the plant. Regardless of which way it is dealt with, the parasitic power loss must be accounted for in the calculation of the COMFIT rate.

**Q. What is Synapse’s assessment of the labour required to operate a 2.05 MW CHP plant in Nova Scotia?**

A. Synapse estimates that labour to operate in the “boiler only scenario” is \$300,000 and that labour to operate in the CHP scenario is \$350,000.

**Q. Is this accurate in your experience?**

A. No. All boilers operated by ANSS members are operated by one 4th class boiler engineer. The labour cost of a 4<sup>th</sup> class boiler engineer in the experience of Marwood is about \$40,000 per year. Therefore, the cost estimate by Synapse for the “boiler only scenario” is approximately \$260,000 too high.

**Q. At what pressure do current ANSS boilers operate?**

A. All boilers operated by members of the ANSS operate at a pressure of 15 psi or below. Based on the companies which shared their boiler details with the ANSS there are no

boilers that operate with steam requirements beyond 18,000 lbs/hr. Two of the six members of the ANSS operate much smaller facilities and the other mills operate in the 18,000 lbs/hr range.

**Q. What is the significance of pressure in relation to labour costs?**

- A. Supervision of Fired Power, Boiler Plants is regulated under the *Technical Safety Act* and its Regulations. Boilers operating over 15 psi in the province of Nova Scotia are considered to be “Fired Power Boiler Plants” and at the scale contemplated in the Synapse model must have continuous supervision by a boiler engineer of the appropriate classification.

Based on Nova Scotia Regulations<sup>1</sup>, to operate a 2.05 MW CHP plant, as contemplated by the Synapse model, one 2nd class boiler engineer is required as chief of staff. The remaining hours may be staffed by 3rd class boiler engineers. One of these individuals is required 24/7. Based on an hourly wage estimate of \$27-35 for a 2<sup>nd</sup> class boiler engineer and \$20-25 for a 3<sup>rd</sup> class boiler engineer (the figures for which were provided to me in response to an enquiry to the Nova Scotia Institute of Power Engineers), the labour cost to employ these individuals is approximately \$189,760 to \$239,810<sup>2</sup> per year. This is a cost range of 1.5¢/kWh to 1.9¢/kWh compared to the cost of a single employee at 0.3¢/kWh.<sup>3</sup>

**Q. Do you think this labour requirement is reasonable?**

- A. It seems excessive given the size of the plant. The requirement for 24 hour supervision of the plant puts a significant labour cost burden on rate payers for plants of this scale. We would recommend that the Department of Labour & Safety review the boiler engineer requirements to determine if a small plant of the COMFIT scale could operate safely with reduced supervision in the same manner we operate our heating boilers today.

**Q. Why did the ANSS not respond to Synapse’s request for information regarding the group’s existing boilers?**

- A. The ANSS had a number of telephone discussions with Synapse where the boiler sizes and operating pressures of our facilities were discussed. It was our understanding that Synapse had the information based on these phone conversations and therefore we did not respond in writing. The ANSS also invited Synapse to come to one of our sawmills in the Halifax region during one of the stakeholder sessions, however, Synapse did not take up the invitation for a site visit.

---

<sup>1</sup> Power Engineers Regulations, Q1.C. 2011-29 (January 18, 2011, effective April 1, 2011), N.S. Reg. 12/2011.

<sup>2</sup> \$214,000 is the midpoint of the range assuming: 8760 hrs/yr; one 2<sup>nd</sup> class boiler engineer works 40 hrs/wk x 52 wks/yr is required and the balance of the supervised hours (6680) will be performed by 3<sup>rd</sup> class boiler engineers.

<sup>3</sup> Based on the Synapse COMFIT model and estimate of 12,636 MWh/yr production from the plant.

**Q. Has Synapse accurately estimated the boiler efficiency of the CHP plant?**

A. Based on the study done by ESI the efficiency of the boiler, estimated by Synapse at 80%, is an overly optimistic estimate. ESI has calculated that the efficiency of a boiler at the proposed size using green wood as fuel would be 69%. ESI provides a calculation and reasoning for their estimate in their testimony. This estimate is further supported by the United States Department of Agriculture, (USDA), which estimates a conversion efficiency of green wood at 50% moisture content to be 67%. The USDA data is attached as Appendix D. A change in efficiency from 80% to 69% means that more fuel is required to produce the same amount of electricity.

#### **FINANCIAL**

**Q. What did ANSS do to address the financial variables in the CHP COMFIT model?**

A. We met with individuals from Scotia Capital to obtain their advisement regarding the financing of a biomass CHP plant at the proposed scale. Scotia Capital indicated that the project was too small for them to finance and recommended we speak with a firm that finances smaller projects. Scotia Capital recommended we speak with Bodington & Company. On Scotia Capital's advice we retained Jeff Bodington, an investment banker whose firm provides investment banking services to the electric power industry. His evidence is filed concurrently on behalf of ANSS.

**Q. What, if any, changes did Mr. Bodington recommend to the CHP biomass model?**

A. In Mr. Bodington's opinion, the market data does not support debt financing of such a project. He recommends an assumption of 100% equity. In his view, if the CPI/diesel escalators are the only means to address fuel risk, then the cost of equity should be adjusted to 17.5%.

**Q. Why does ANSS not consider the New Page/NSPI CPI/Diesel escalator to adequately mitigate fuel escalation risk?**

The ANSS believes that the CPI/Diesel index is likely an adequate index to track the cost of harvesting wood. The problem with the index is that the cost of harvesting wood is not related to its market price as the market price of wood is governed by the principles of supply and demand.

It is helpful to illustrate the supply and demand economics of the forestry industry through examples.

#### Example 1 – Increase Supply Where Demand is Constant

Assume that demand for lumber increases significantly and sawmills respond by increasing their production and harvesting more sawlogs. As a result of the increase in sawlog harvest there is production of more low grade wood. The supply of low grade wood increases in the market and without a corresponding demand increase the price of biomass would drop. This is unrelated to harvesting cost.

### Example 2 – Increase in Demand Where Supply is Constant

A University constructs a biomass CHP plant to provide heat to its campus and generate renewable electricity. At the same time two sawmills within range of the university begin to operate their newly constructed CHP plants. The lumber market remains constant and no extra supply of low grade wood enters the market. Demand has increased, however, supply from the market has not. The result is an increase in the price of low grade wood. This increase in price has no relation to CPI or Diesel.

Asking a biomass CHP COMFIT participant to guarantee the price of electricity for 20 years based on a CPI/Diesel escalator for the cost of fuel is the same as asking NSPI to guarantee the electricity rates at today's price for 20 years based on an escalator that tracks the cost of mining coal. The price of mining coal, or drilling for oil, or extracting natural gas has little to do with its market price. Market price of coal, oil or gas is driven by demand in the precise manner as supply and demand drives the price of wood. A biomass CHP proponent's fuel risk is no different than NSPI's and we need a mechanism to deal with risk in the same manner that it does. NSPI essentially operates on an annually adjusted feed-in tariff rate with a flow through of its fuel costs.

**Q. What mechanism would the ANSS suggest to deal with the fuel risk?**

A. We would suggest two possible solutions to mitigate fuel risk:

1. A fuel adjustment mechanism whereby the cost of fuel is simply passed through to the electricity rate as is done with NSPI.
2. The CPI/Diesel index is implemented with a periodic re-opener to adjust the price of the fuel in the event the index is not working properly (this could be an adjustment up or down).
  - (a) All CHP COMFIT participants would be required to submit cost information for all fuel purchases to the board.
  - (b) This pricing information would be collected over the re-opener period and would be used to readjust the fuel cost as necessary.
  - (c) The frequency of the re-opener would have to be sufficient to have a material effect on the fuel supply risk.
  - (d) The re-opener would have to be consistent and not subject to being cancelled or substantially altered.
  - (e) Proponents would be naturally incented to try and get their fuel cost below other CHP producers to gain advantage thus ensuring natural market forces to drive lowest cost fuel sourcing.

- Q. **What is the revised COMFIT rate that the ANSS would suggest based on the changes you have proposed to the Synapse model?**
- A. We are currently working on revising the Synapse model with the inputs and recommendations in the ESI and Bodington evidence and will file that as soon as it is complete.

# The Alliance of Nova Scotia Sawmillers

## Submission 1 to NSUARB and Synapse

Prepared by

Fenton Travis, P.Eng

November 29, 2010

## **Introduction**

The Alliance of Nova Scotia Sawmillers (ANSS) is a group of forest industry companies that have unified to pursue the common goal of ensuring that there is a COMFIT available for biomass CHP and that the rate set for the COMFIT represents an accurate assessment of CHP generation costs in Nova Scotia, while providing a fair rate of return to the project proponent. The group consists of, but is not limited to the following companies; Marwood Ltd., J.D. Irving, Ledwidge Lumber Company, Elmsdale Lumber Company, Freeman and Son Ltd. and Groupe Savoie. These six companies are all privately owned companies that have been operating in Nova Scotia and the Atlantic Canada region for many generations.

Our group would like to commend the NSUARB and Synapse for the selection of a transparent process to determine the COMFIT rates for the various renewable technologies. We are very pleased to learn that the actual models used to develop the price of the COMFITs will be available for our review and input. Given our group's diversity and wealth of experience in the forestry industry, we believe that we can make a significant and beneficial contribution to determining a fair COMFIT rate for CHP plants in the province.

## **Evaluation of Criteria for FIT Rate Model**

In determining how the model should be developed to calculate the COMFIT rate for the various technologies, we believe the model should be developed with a reasonable level of detail to ensure that the tariff is representative of the actual costs associated with generating the electricity. Taking into account the expected scale of the projects is an obvious important consideration given that projects are limited in size based on the restraints of the distribution system, which is approximately 6MW. We do not believe that it is necessary to make a trade offs between transparency of the model and the level of precision.

Models for each technology should be developed separately as there are significant differences between wind, tidal, hydro and biomass. Each technology has varying degrees of risk associated with it and will therefore receive varying treatment from lenders regarding capital structure, interest rates, and other financial variables. Rates of return on equity should also vary between technologies. Technologies such as biomass CHP that depend on fuel supplies have inherently more risk than other non-fuel dependant technologies.

## **Tariff Differentiation**

The cost of generating electricity from wind, tidal, hydro and biomass are uniquely different and will therefore require different tariffs based on the renewable energy types. It is also reasonable to differentiate the tariff based on

size as large projects typically generate electricity at lower cost than smaller projects. We would suggest setting a CHP COMFIT rate based on using the economic benchmark of a 2MW plant. Most sawmills within our group have the fiber supply and heat load to match a plant in this range. We cannot speak to the size range that would be appropriate for community groups, but clearly they will require consideration in determining the appropriate benchmark size for evaluation of the CHP COMFIT.

### *Biomass Gasification*

In addition to differentiation based on size and renewable energy type we feel that it is important to consider differentiation based on alternative technologies within a renewable energy type. We are specifically referring to the advancements made in producing electricity through biomass gasification as it pertains to the biomass CHP COMFIT. Biomass gasification is not a new technology, however, the process of firing the biomass syngas in an internal combustion engine to produce electricity has only recently become commercially available. Based on information that we have received from vendors of the technology and our knowledge of conventional systems, there are clear environmental and business advantages to providing a COMFIT that would support the use of gasification for CHP. A gasification CHP plant in the 2MW range is capable of achieving an efficiency of approximately 62% versus a conventional Rankine Cycle system that would achieve efficiencies of between 32% and 36%. Gasification technology requires less biomass fuel to produce the same amount of renewable energy, thereby putting less pressure on Nova Scotia's biomass resources. Additionally, lower fueling requirements reduces fuel supply exposure risk to the developer. Gasification plants also have considerably improved emissions compared to conventional combustion systems. The production of carbon monoxide from gasification plants is only 3% of what conventional combustion plants emit. The emission of volatile organic compounds (VOCs) are also dramatically reduced and are measured at only 2% of conventional system emissions.

Based on a very preliminary analysis of the cost of generating electricity using gasification compared with conventional technology it would appear that a higher COMFIT price would be required to support the gas technology. This is primarily due to the considerably higher capital and operating cost of the gasification systems. As fuel prices escalate, the gap in price between the technologies closes as the gasification systems require substantially lower amounts of fuel and hence become more competitive with increased fuel prices.

A CHP COMFIT that is not designed to allow developers to use gasification will incent investment in inferior technology. We would ask that Synapse consider evaluating a separate gasification COMFIT on the basis that it may provide greater value to the rate payer over and above a simple evaluation of \$/kWh.

## **Data Granularity**

Our preference is toward a model that allows for enough detail to provide a fair representation of the cost of generating electricity with a CHP plant. We would error on the side of greater detail rather than less. The Vermont model appears to have reasonable granularity based on the information shown in the presentation.

## **Data Sources**

The Vermont model appears to provide reasonable sources to derive data for the model. It is important that capital cost estimates, O&M costs, capital structure estimates, borrowing rates and all other variables are drawn from information that is current and relevant to Nova Scotia. Borrowing rates in Vermont may not reflect the debt markets in Canada and market information drawn from 3 years past may not be relevant today.

In accordance with our concern for local and current information, our group will be executing an engineering study with a Nova Scotia based engineering firm to determine key parameters of the cost of generation for CHP. This will include a capital cost estimate, fuel supply requirements, O&M estimates and all other related variables in determining the cost of generation. We will also be consulting members of the Canadian financial community to acquire reasonable estimates regarding financial variables such as capital structure and lending rates. In addition to the capital cost, O&M and financial details, the single largest factor in determining the generation cost for a CHP plant will be the input fuel cost. A value for this fuel will have to be determined based on the market price of biomass in Nova Scotia. Consulting the forestry industry regarding the cost of biomass will be essential as the majority of biomass sold in the market is forestry related.

## **Capital Structure**

The capital structure will vary based on the different technologies and their respective levels of risk. Lower risk technology such as wind will presumably require lower levels of debt than a biomass CHP plant that has a somewhat higher risk profile. Canadian lenders should be consulted on this aspect of the input as they will ultimately set the rules for the capital structures. We would recommend that Synapse seek out lenders who have participated in financing projects for the Ontario FIT. These lenders should be able to provide relevant advice on expected capital structures specific to Canada. Our group will seek consultation from the Canadian commercial banks that we currently do business with to provide additional insight on this issue.

## **Treatment of Other Incentives**

We are not aware of any particular incentives that would significantly alter the evaluation of a COMFIT for CHP. For this reason we would not consider inclusion of incentives in the development of the model of particular importance.

## **Rate of Return on Equity and Risk Assessment**

Nova Scotia is a jurisdiction whose electricity is supplied by a monopoly utility that is regulated by the NSUARB. The NSUARB has established a rate of return on equity of 9.35% for the electric utility. This rate of return is included in the setting of electricity rates in Nova Scotia and is a fundamental component of the rate. Presumably, the return on equity that the board has set for the utility is a rate that they deem fair to attract investment based on the risks associated with the utilities business. We believe the ROE rate established by the NSUARB for the electric utility sets a precedence for evaluating the ROE for all other power producers in the province that are subject to regulated electricity prices. This, in our view, would include those companies operating under the COMFIT.

The utility is permitted to mitigate a significant amount of business risk through two primary mechanisms, rate increase applications and the fuel cost adjustment mechanism. The fuel cost adjustment mechanism allows the utility to mitigate the single largest risk associated with power generation, the variable cost of fuel. The mechanism allows the utility to recover revenue for fuel expenses beyond what was contemplated by the rate, or reimburse excess revenue where fuel expense was below what was contemplated by the rate. In either scenario, the risk of fuel expense is mitigated by the fuel adjustment mechanism and is not born by NSPI. A regulated utility essentially receives a feed-in tariff based on the cost of generation plus a return, with the added advantage of being permitted to increase the feed-in tariff through rate applications and eliminating fuel supply risk using the fuel adjustment mechanism. We believe this to be the ultimate low risk scenario that sets the bar for generators in Nova Scotia.

Projects developed under the COMFIT that are deemed to have greater risk than the established utility model, should receive a comparably higher ROE based on the additional risk. If the utility model of risk mitigation is not contemplated for the CHP COMFIT the developers of biomass CHP projects will be subject to significantly higher fuel supply risk, interest rate risk, risk related to government policy changes and many other related risks. There are potential measures that can be put in place to reduce these risk factors. An escalator based on CPI for the fuel portion of the CHP COMFIT has been used in other jurisdictions and was mentioned as a possible scenario by Synapse. It is important to note, however, that this mechanism falls well short of mitigating risk as effectively as a fuel cost adjustment mechanism or rate increase applications. If a CPI index on fuel were contemplated for the CHP COMFIT a ROE greater than the utility rate would be needed in order to incent investment for the enhanced risk. The ROE for the

developer of a CHP plant should be directly proportional to the risk associated with the project where the utilities ROE rate is the benchmark for lowest risk. Each element of risk born by the developer above that of the utility model, should result in a relative increase in the ROE above the utility rate. All mechanisms put in place to reduce the developers risk should also reduce the ROE accordingly.

Given the choice, we would choose to accept the risk model developed for the utility and in turn would accept their ROE rate. We view the two extremities of risk at the low side with the utility model and at the high side with a non-escalating fixed price contract. While applying the utility model to the COMFIT may not be practical, other ways exist to mitigate risk for the developer that would fall between the two extremities. We are currently in the process of considering potential mechanisms to mitigate risks associated with CHP plants, but given the short deadline for submitting the written response, we were unable to provide suggestions beyond what is included in this submission.

## **Fuel Supply Risk**

Fuel supply risk is the single largest risk to developers of combined heat and power plants. While many sawmills generate a biomass fuel supply stream as a result of their sawmill operations, a significant portion of the fuel is committed for sale to large users in the pulp and paper sector for the operation of their CHP plants. The sale of the sawmill biomass to these pulp and paper companies is typically connected to the sawmill's ability to negotiate the purchase of sawlogs from the land that the pulp and paper companies own. Sawmill biomass is also connected to the negotiations of the sale of wood chips to the pulp and paper companies. In some instances, the sawmill may be able to successfully negotiate the termination of the biomass supply agreements with the pulp and paper companies, however, in many cases, the sawmill will be required to continue supplying the pulp and paper companies with biomass to maintain wood chip markets and continued access to critical sawlog supplies. Most sawmills will be operating their CHP plants on a combination of biomass from the sawmill in combination with biomass purchased from the market. The ratio of sawmill derived biomass compared with market purchases is different for each sawmill and will be primarily dependant on the sawmill's ability to recover biomass supply being sold to pulp and paper companies.

It is also important to consider that municipalities, universities, aboriginal groups and other non-forest industry groups could have limited access to their own fuel supply and will have enhanced risk where they may be required source up to 100% of their fuel from the Nova Scotia biomass market.

## **Government Policy Risk**

The risk associated with the development of a biomass CHP plant is in large part greater than other technologies due to the significant influence that government policy has on biomass fuel prices. While all technologies are subject to government policy risk in some form or another there is an acute risk in Nova Scotia surrounding biomass policy.

The Nova Scotia government has placed a cap on the amount of forest biomass that can be used to qualify towards renewable energy under the provincial plan. The consumption cap is set at 500,000 dry tonnes annually above historical averages for the province. Electricity generated from fuel exceeding this cap will not qualify for the CHP COMFIT. Fuel supply caps will put upward pressure on the market price of biomass as more projects come online into the future and demand for biomass increases. The NSUARB has recently approved a 60MW biomass power project that is an example of such a project. The effects of capping the supply chain for biomass are comparable to the effects that OPEC oil production caps have on the price of oil. In addition, some aspects of biomass harvesting policy have not yet been determined by the Nova Scotia Department of Natural Resources, thus further increasing the risk for the developer. Should a more stringent and costly policy be implemented regarding forest harvesting, further upward pressure will be applied to the market price of biomass. The Nova Scotia government has recently purchased a significant amount of private land and is in the process of turning more government owned land into protected areas where forest harvesting is not permitted. Again, these government policy initiatives restrict supply and will influence biomass markets.

All of these policy changes by government will have measureable effects on the market price of biomass in Nova Scotia. Biomass CHP developers are unable to predict what future policies governments will enact and are therefore subject to these considerable risks. These risks have the same affect and are as equally unpredictable as global policy changes that affect prices for fossil fuels. Nova Scotia's electric utility is permitted to mitigate these risks through the fuel adjustment mechanism and rate increase applications. If similar mechanisms are not contemplated for developers of CHP plants then ROE must be adjusted accordingly.

## **Working Capital Risk**

Interest rate risk on working capital is particularly important for a CHP plant as the plant will require an inventory of fuel to ensure uninterrupted production of electricity and steam. Interest rates on working capital loans will fluctuate based on the prime lending rate in Canada plus a premium negotiated with the lender. The fluctuation of interest for the working capital provides a source of risk for the CHP plant developer over and above other technologies that do not require the financing of fuel inventories.

## **Debt Risk**

Debt to finance the construction of the plant also has interest rate risk associated with it. A proponent may borrow debt from a lender with an amortization period of 20 years, however, the interest rate negotiated with the lender may remain fixed for a term that is less than the amortization period (perhaps 5 years). At the end of the interest term a new interest rate is negotiated on the balance of the debt remaining at interest rates based on the market at the time. Given the current state of the US and other economies around the world, in conjunction with the large amounts of money being printed by these governments, it is not unreasonable to assume a situation where interest rates rise rapidly over a short period of time. The utility model mitigates this risk by allowing for rate increase applications at the NSUARB. A potential mechanism that the COMFIT could use to mitigate this risk is to allow for escalation in price based on the prime lending rate in Canada.

## **In Closing**

The Alliance of Nova Scotia Sawmillers is available to provide input into all areas regarding the development of the CHP COMFIT. We would invite Synapse to contact us at any point during the development of the CHP COMFIT for advisement on areas where we have significant expertise.

February 7, 2011

Fenton Travis  
Alliance of Nova Scotia Sawmillers  
PO Box 338 Station A  
Fredericton, NB  
E3B 4Z9

Geoff Keith  
Synapse Energy Economics  
22 Pearl Street  
Cambridge, MA 02139

Dear Geoff,

Please find below an explanation of why the Alliance of Nova Scotia Sawmillers believes very strongly that there should not be a minimum efficiency target set for the biomass CHP COMFIT. When you have had a chance to review this document please call me such that we can discuss any questions you may have regarding our point of view.

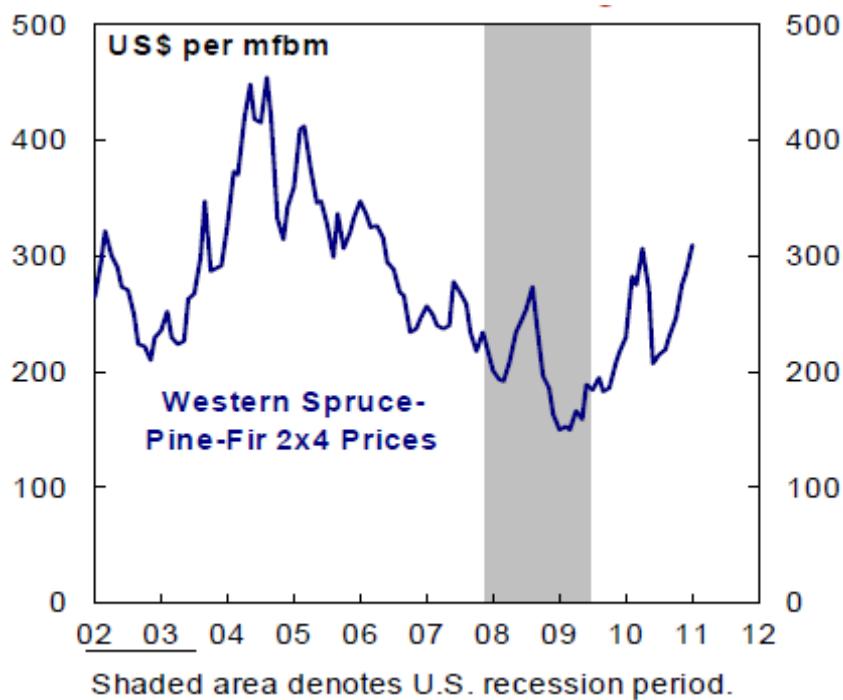
### **Why a Backpressure Turbine Does Not Make Sense for This Application**

A backpressure turbine operates in conjunction with the demand from the heat load. Steam from a boiler is sent to the turbine and then onto the heat load at the specific requirement of the process. The capacity factor of the turbine is therefore directly linked to the capacity factor of the heat load. For a sawmill running its dry kilns under normal conditions this may be in the range of 55% to 65%. The other hours of the year that the kilns would not be operating would be related to; loading time, unloading time, holidays and maintenance.

The problem with choosing the backpressure design, which is directly linked to the heat load capacity, is that there is no normal operating conditions that can be predicted for a sawmill. Outside of the predictable down time hours mentioned above, the production of lumber from the sawmill is entirely dependant on demand from the lumber market. With a backpressure turbine, the production of electricity is linked to the operation of the dry kiln, which is directly linked to the amount of lumber that the sawmill is producing, which is linked to the demand from the lumber market. Therefore, the production of electricity from a backpressure turbine is directly linked to demand from the lumber market. When the lumber market is poor, which it has been for the past number of years, sawmills will shutdown until market prices recover to a point where the plant returns to profitability. This occurs more frequently than we would like and has been the case

recently and throughout history. We can see this in Figure 1.0 which depicts the lumber market over the past 10 years.

**Figure 1.0 Western SPF Lumber Price History USD per 1000 board feet**



If a sawmill is required to use a backpressure turbine and market conditions force a shut down at the mill, there will be no revenue from the power plant to cover its fixed costs. These costs would include; debt service, boiler engineers that staff the operation of the plant, interest on operating capital used to build a fuel inventory and other related costs. This situation quickly compounds an already bad problem at the sawmill by piling on losses from the power plant. All fixed costs for the power plant need to be paid whether it is generating electricity or not. Even if the sawmill does not shut down but is operating at half capacity, this dramatically affects the capacity factor of the power plant to the point where it again becomes unprofitable.

Our businesses are unable to support this kind of operating risk where the production of electricity is linked to the operation of the sawmill and hence the lumber markets. It is already difficult enough to fight through bad markets without severely compounding the problem by adding losses from a power plant. We would be unable to develop CHP projects under these circumstances as we simply cannot add anymore risk to our businesses beyond what we already manage each day.

As it stands today, most of the sawmills in our group are operating at 50% to 60% of full operational capacity. Shortly after we began the COMFIT process one of the members of our group had to shut their sawmill down as a result of the lumber markets. This mill has been shutdown for approximately 2 months and has not yet come back online. The situations we have outlined here are not hypothetical, they are our current reality.

It is also important to consider the implication of this technology choice from the perspective of a lender. If the ability of a sawmill to pay back a loan is linked to the operation of the power plant and the power plant is linked to the lumber market, then it follows that the operational risk of the power plant is equal to the risk of the lumber market. A lender will identify this risk very quickly. If this risk is combined with the risk associated with fuel cost escalation it is reasonable to ask whether financing of these projects could be achieved at all. So long as the operation of the power plant is coupled to the risk of operating a sawmill, we do not believe projects will receive financing.

### **Why a Condensing Turbine with Extraction Makes Sense**

In order for sawmills to participate and for projects to be able to attract debt the operation of the power plant has to be decoupled from the operation of the sawmill. A condensing turbine with extraction allows for this level of flexibility as it can produce electricity independently of the heat load. When the dry kilns at a sawmill are operating, an extraction of steam can be taken from the turbine and sent to the process while at the same time generating electricity. When the kilns are being loaded and unloaded or are down for maintenance, no extraction is taken and the turbine runs in full condensing mode producing electricity only. More importantly, if the sawmill is experiencing difficult market conditions and has to shut down for a period of time, the power plant is still able to produce electricity providing revenue to support the operation of the plant. Additionally, while the sawmill is shut down and losing money, the power plant will be earning a profit, which will effectively reduce the financial strain when the mill is down. This considerably improves the ability of Nova Scotia sawmills to withstand difficult market conditions. The backpressure turbine, on the other hand, only exacerbates the financial stress to the operator and significantly reduces a mill's ability to withstand poor market conditions. Even in a situation where the mill is not shut down but is operating at half capacity, the condensing turbine has the ability to shift more production to electricity and maintain a strong revenue stream to support the operation of the power plant. This allows for very flexible operation of the power plant, which is entirely independent of the difficulties the sawmill may be experiencing. This kind of decoupling of the operation of the power plant from the sawmill is critical in order to attract debt and reduce operational risk for the owner.

The flexibility of the condensing with extraction design allows for the power plant to maintain a much higher capacity factor than with the backpressure design. Higher capacity factors in power plants result in lower cost of electricity to rate payers.

The condensing turbine design also offers the ability for participation from other community organizations that may not have the heat load capacity factor to generate economically with the backpressure design. An example of this is a CHP plant supplying energy to a heating system from a municipality, university or other community organization. Because heat from the CHP system is only required during the shoulder months and winter months of the year its capacity factor would be very low, perhaps at around 35%. With a condensing turbine the community organization would be able to

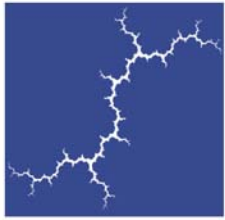
shift production to electricity according to the seasonal demands, thereby making their project economical.

### **What About Efficiency?**

If we can agree that the condensing turbine with extraction is the only practical technology that will allow for the development of these projects, we can discuss the issue of minimum efficiency requirements. The efficiency of a CHP plant using condensing with extraction is a direct function of the amount of heat sent to the process versus electricity generated. The use of heat in a process is more efficient than the production of electricity in a turbine and therefore as electricity generation goes up overall efficiency goes down. The difficulty with guaranteeing a minimum efficiency is this; the overall efficiency of the CHP system is directly related to how much heat is used in the process, which is directly related to the production of lumber at the sawmill, which is directly related to demand from the lumber markets. The sawmill has no ability to guarantee the efficiency of the CHP system as it has no control over how much process heat it will use given this is entirely dependant on lumber market demand. The only thing we can guarantee is that when our dry kilns require heat to manufacture our products we will supply the process with heat from our CHP system. We cannot offer any better or any worse. For this reason we would strongly recommend that there not be a minimum efficiency standard.

There is also another critical factor to consider when contemplating efficiency. The impression that we have been given from the Department of Energy surrounding the efficiency debate is that it is somehow bad or environmentally harmful to produce electricity only from a biomass CHP plant. It is important to remember that every MWh of biomass electricity generated is directly replacing a MWh of electricity from a coal plant. Regardless of what efficiency the electricity was generated at it avoided the permanent introduction of CO<sub>2</sub>, SO<sub>x</sub> and mercury into the atmosphere. If you put an efficiency standard in place that prevents a biomass plant from generating in electric only mode you will be by default choosing to support coal. We do not believe that this is consistent with the intent of renewable energy policy in Nova Scotia. From an environmental perspective, these projects should be encouraged to produce as much energy as they can, whether it is heat or electricity or both.

Yes, it is preferable to maximize the environmental benefit of the energy and to the extent that our processes will allow us to do so, we will. However, in striving for high efficiency it is important not to loose site of the ultimate goal, which is to use less fossil fuel.



**Synapse**  
Energy Economics, Inc.

## **Responses to COMFIT Information Requests**

**Submitted by Synapse Energy Economics**

**January 24, 2010**



22 Pearl Street  
Cambridge, MA 02139

[www.synapse-energy.com](http://www.synapse-energy.com)  
617.661.3248

#### **4. IRs from the Alliance of Nova Scotia Sawmillers (ANSS)**

ANSS IR 1. Reference Draft COMFIT Tariffs: Initial Calculations and Discussions, p. 7, Table 1,

(a) Why has Synapse assumed 100% corporate ownership of biomass CHP projects?

Answer: Ownership is restricted for all COMFIT technologies except biomass CHP. A number of privately-owned lumber processing facilities in the Province appear to be viable steam hosts. At the November 18 Technical Session we stated that we may assume a private-sector owner when calculating the biomass CHP rate, and we encouraged any other organizations considering such a project to contact us. No one contacted us or provided any information in their Initial Submission in response to this request. Since we circulated the draft tariffs, several stakeholders have indicated that they believe one or more community-based organizations (as defined in the Regulations) would consider a biomass COMFIT project, depending on the rate established. We are continuing to research this question and remain open to changing our initial assumption.

(b) Does Synapse believe that the Regulations stipulate this?

Answer: No.

(c) Does such an assumption exclude the community organizations that the community feed-in tariff was originally designed for?

Answer: To the extent that community-based organizations would face higher costs than a corporation in developing a biomass CHP project, this assumption would make it more difficult for them to cover their costs with the COMFIT rate than a corporation.

ANSS IR 2. Reference, p.4 states that the ROE for biomass CHP projects is derived with the assumption that developers will undertake size risk, portfolio risk and development risk.

(a) What mechanisms are available to account for fuel risk?

Answer: At this point we are considering three mechanisms to account for fuel costs risk. First, fuel costs could be escalated in the model at inflation plus some increment to account for some risk. Second, fuel costs could be indexed to the Consumer Price Index and the price of diesel fuel, as the Board approved in the Port Hawkesbury/New Page proceeding. Third, an independent third party could be retained to research the cost of biomass in the province, review each COMFIT project's actual fuel costs (on a confidential basis) and make recommendations to the Board regarding fuel cost adjustments.

(b) Please list the pros and cons of each mechanism?

Answer: Escalating fuel costs in the model to account for risk is attractive in that it is simple and it provides certainty. Its weaknesses lie in the uncertainty around the proper increment by which to escalate costs and the fact that it could provide unreasonable profits for biomass projects if market prices for biomass fall. Both of these weaknesses could be addressed to some extent by providing for a periodic review of the risk factor included in the COMFIT rate and the opportunity for adjustment of that factor.

Indexing fuel prices to the CPI and the cost of diesel fuel is more complex than escalating fuel prices in the model; however it is less complex than establishing an auditor to review COMFIT project's actual costs. A weakness of this approach is that it accounts for the cost of the labor and fuel needed to harvest biomass but not the biomass fuel itself.

Hiring a third-party auditor to audit COMFIT projects' fuel costs and make recommendations to the Board would add costs and complexity to the COMFIT program implementation. This is a weakness relative to the other two approaches. Also, given the extent to which biomass fuel costs are treated as confidential, the auditor may have difficulty establishing a reliable market price of biomass against which to benchmark project's actual costs. (Non-COMFIT biomass projects would have no obligation to report their fuel costs to a COMFIT auditor.)

Regarding all three of these mechanisms, our conversations with lenders will be an important reference point for our proposal.

(c) Is there any reason that fuel risk should not be accounted for?

Answer: Based on our discussions to date with lenders, we believe it will be appropriate to shield project developers from a significant amount of fuel cost risk.

(d) What mechanism is proposed by Synapse to eliminate fuel risk by the biomass CHP developer?

Answer: Synapse has not yet decided what mechanism to propose to address fuel cost risk, and we are also still researching how much fuel cost risk needs to be removed from projects to make them financeable at reasonable terms. We expect to discuss this issue with stakeholders at the January 31 Technical Session.

ANSS IR 3. Reference, p. 2, Synapse comments that “Regarding a fuel adjustment mechanism, first we note that adjusting COMFIT rates to reflect projects’ actual fuel costs could impose significant administrative costs. Second, we note that companies treat biomass fuel costs as confidential, and this has made it very difficult to project prices...”

(a) Please provide the basis for the first proposition regarding administrative costs.

Answer: In order to adjust rates to reflect project’s actual fuel costs, the Board would have to determine each project’s actual fuel costs. This could be done in periodic fuel adjustment proceedings for each project, and this could impose significant administrative costs. Hiring a third-party auditor to review COMFIT projects’ fuel costs and report to the Board would also impose administrative costs. Whether or not these costs would be “significant” could be debated, and if we propose this mechanism, we would expect to debate this question.

(b) Please provide details of the cost estimate and indicate the amount of the estimate.

Answer: As noted in our report discussing the draft rates, the fuel cost used was based on anecdotal evidence, rough estimates provided verbally by several people. We are currently collecting more information on biomass fuel costs in Nova Scotia.

(c) Is Synapse aware of current biomass prices in the market?

Answer: We have more information on fuel prices now than we did when we circulated the draft tariffs, and we expect to continue adding to this information.

(d) To the extent such biomass is currently bought and sold, is Synapse aware whether or not such contract terms could be filed in confidence with the Board?

Answer: We believe that these terms could be filed in confidence with the Board.

ANSS IR 4. Reference, p. 2, with respect to the fuel adjustment mechanism, Synapse comments that “.....a superior approach might be to escalate these costs within the model by a factor designed to account for this risk.”

(a) Please explain what Synapse means by “superior”? From whose perspective?

Answer: Our analysis of mechanisms to mitigate fuel cost will consider the need to balance several objectives, including establishing rates that support efficient and well managed COMFIT projects, not unduly burdening NSPI ratepayers, minimizing complexity and transaction costs and being

consistent with precedent the Board has set in previous decisions. So the “superior” method is the one that we believe most appropriately balances these objectives.

- (b) What factor is contemplated by Synapse that would eliminate fuel cost risk for proponents that would be superior to a fuel adjustment mechanism?

Answer: The factors we are currently considering to address fuel cost risk are discussed in our answer to ANSS IR 2. We remain open to considering other proposals. We have not made a final decision on which mechanism to propose in our final tariff recommendations, nor have we determined how much fuel cost risk needs to be removed from biomass projects to make them financeable at reasonable terms.

ANSS IR 5. Reference p. 5, Synapse has indicated that it interviewed lenders active or intending to be active in Nova Scotia and other Canadian renewable energy markets with respect to determining important financial variables in the models.

- (a) Please provide the names of the lenders with whom Synapse has spoken.

Answer: During our initial research we did not get statements in writing from sources nor did we clarify with them whether they were willing to be named and quoted. As our research progresses we are striving to get information in writing from named sources which we will be able to circulate or, short of that, to have sources agree to be named and quoted regarding specific information provided verbally.

- (b) In what form did the interviews take place? (telephone, questionnaire...?).

Answer: All of the research with lenders we did prior to releasing the draft tariffs took place by telephone.

- (c) Please provide a copy of the standard questions (if any), along with all written responses or notes.

Answer: The following is a representative set of questions we asked lenders in our discussions prior to circulating the draft tariffs.

- Are you aware of the Nova Scotia FIT program (if not, we provided an overview of key features)?
- Are you active in lending to renewable energy projects now?
- Would your lending institution lend to Nova Scotia projects under this program? What is your minimum transaction size?
- What value would you typically assign to the following parameters that are in our rate setting model:
- Amount - How much (in terms of % of total capital) can a project can borrow? What is a typical debt/equity ratio?
- Tenor - How long is the debt tenor?
- Type of loan – recourse or non-recourse?

- DSCR - What are the minimum and average Debt Service Coverage Ratios?
- Interest rate - What is the all-in interest rate for this type of debt?
- DSRA - How many months of P&I is required for the Debt Service Reserve Account?
- Up-front fees - What are the up-front fees associated with this type of debt?
- Closing costs - What are typical closing costs (legal, consultants, etc.) with these types of loans?
- How would any of these values differ for community-based projects (where the owners could be governments, universities, First nations or other non-profit entities)? What risk premium, if any, is associated with these projects?
- Which other lenders should we reach out to?

ANSS IR 6. Reference p. 3, Synapse has indicated that initial discussions with lenders suggest that a 60%/40% debt to equity ratio would be acceptable for COMFIT projects.

(a) In the course of discussions with lenders regarding debt to equity ratios for CHP plants, what fuel risk mitigation measure was explained to the lender by Synapse?

Answer: In our initial discussions with lenders, we were not able to cover several of the important issues in which we are interested, including mechanisms to address fuel cost risk. We are now focusing on this issue with them.

(b) Was there a separate assessment of debt to equity ratios for each technology? Please explain why or why not.

Answer: This is another issue we were not able to cover in initial discussions but are covering now.

ANSS IR 7. Reference p. 4, Risk Factors

(a) Does Synapse assume that proponents developing biomass CHP plants will have project management skills and resources beyond other technology developers for the COMFIT? What is the basis for that assumption?

Answer: In our initial draft rates, we did assume this to be true, because we assumed that developers of biomass CHP plants would be corporations in the forest products industry, and that on balance, the other groups listed in the Regulations would have less well developed project management skills and resources. For a discussion of why we assumed that biomass projects would be developed by corporations, see our response to ANSS IR 1(a). As noted in that response, we have been advised that some community-based groups are considering developing biomass CHP plants for the COMFIT, and although we have not heard from these groups directly, we are reevaluating this assumption.

(b) Is it Synapse's assumption that no Aboriginal groups, Municipalities, Universities or other community groups will construct a CHP plant in Nova Scotia?

Answer: See our answers to ANSS IRs 1(a) and 7(a).

ANSS IR 8. Reference p. 4, Risk premium

- (a) Please explain qualitatively and quantitatively how Synapse derived the risk premiums assigned to wind farms and hydro projects versus biomass CHP.

Answer: Our assumptions on the cost of both debt and equity were based on initial discussions with stakeholders and lenders. Qualitatively, our thinking is laid out in section 2b of our report on the draft tariffs. There was no quantitative analysis.

- (b) Have investors and lenders been consulted on what they think the risks are for the various technologies? Please elaborate in your answer on the steps taken.

Answer: We were able to talk with members of several lending institutions before the draft tariffs were due. In these initial discussions we did not cover details such as their perception of risks across the different technologies. As we continue discussions with these lenders, and contact additional ones, we are focusing on key details like this one.

- (c) What “additional data will be sought in the coming weeks”? If this additional data has been secured, please provide a copy or summarize the information obtained.

Answer: Again, our current discussions with lenders are going into much greater detail than our initial ones. We are soliciting information on the specific aspects of a COMFIT project that would influence the lending rate. This includes aspects such as the entity developing the project, the resource and technology, the treatment of fuel costs for biomass CHP and the terms of the COMFIT contract. We expect to be able to provide an update on this research at the 1/31 Technical Session.

ANSS IR 9. Reference pp.8-9 Interconnection costs

- (a) Why has Synapse assumed that biomass CHP plants will be located on facilities that are currently connected to the distribution system?

Answer: In the case of a wind, hydro or tidal project, electricity must be generated where the resource is located. The energy resource cannot be transported. We assume that many of the best sites for these resources are located some distance from the existing grid. In the case of a biomass CHP project, the energy resource can be transported to the plant. The key siting constraint for CHP is the location of the steam host. We assume that all viable steam hosts in the Province have electricity service – that they are currently connected to NSPI’s grid.

- (b) If the average interconnection cost for projects in Nova Scotia has been \$250,000 why has Synapse estimated an interconnection cost of \$110,000 to be suitable for biomass CHP projects?

Answer: The estimated average interconnection costs provided by NSPI (\$250,000) included a number of projects that would have necessitated, or did necessitate, a significant line extension. Because our biomass CHP rate calculation was based on a model plant located on the distribution

system, we removed nearly all of the cost of the required NSPI facilities. We are continuing to discuss this assumption with NSPI.

- (c) Please provide all data and information underlying the assumed components of the costs of interconnection in Table 2, p.9.

Answer: The interconnection costs assumed in our draft rates were based on a phone conversation with NSPI staff, and that discussion was summarized in our report on pages 8 through 10. We did not receive anything in writing from NSPI (about interconnection) prior to circulating the draft rates.

- (d) Has Nova Scotia Power Inc. (NSPI) been consulted regarding the assumed components of the costs of interconnection in Table 2, p.9? Please provide copies of NSPI's estimates of average generator interconnection cost and system upgrades relied upon by Synapse?

Answer: Yes. After our phone call with NSPI staff, they reviewed and edited our draft text on the interconnection process and their cost estimates. Since the draft rates were circulated we have spoken to NSPI staff again to refine our estimates, and we have requested more detailed information from them about the components of their cost estimates and about the interconnection costs they have quoted to projects in the past. We will include in future reports or testimony any non-confidential information NSPI provides to us.

ANSS IR 10. Reference p.10, preconstruction development costs (cell B5)

Please describe all factors and data reviewed to estimate these costs including environmental engineering consultation, environmental impact study, site selection, contract legal fees, environmental legal fees, engineering consultation, engineering feasibility study, engineering investment grade study, bid package preparation costs, accounting services, business plan preparation, travel expenses, administration costs, etc.

Answer: We were not able to research preconstruction development costs in detail prior to distributing draft rates. The figure used in the draft calculations was a preliminary estimate, calculated as 20% of Equipment and Installation costs. We are currently researching these costs in more detail with stakeholders and others.

ANSS IR 11. Reference p.11, (cell B44 and Tax Depreciation Worksheet)

- (a) Why is it assumed that biomass CHP plants benefit from accelerated depreciation while other technologies do not?

Answer: The biomass CHP rate was calculated assuming that the developer is a taxable corporation. The other rates were calculated assuming a non-taxable owner. We continue to research both of these assumptions and may change them.

- (b) Is the underlying assumption that only corporations will be undertaking biomass CHP projects under the COMFIT?

Answer: See our answer to ANSS IR 1(a).

- (c) Please provide the relevant tax regulations and calculations supporting the annual tax depreciation.

Answer: As noted on page 11 of the draft, we assumed that most, but not all, of a COMFIT biomass project would be eligible for Class 43.1 accelerated tax depreciation. The provisions for accelerated depreciation are set out in Schedule II of the Income Tax Regulations (C.R.C., c. 945). In the same paragraph on page 11 we note that this “is a placeholder assumption, and more research is needed to determine the required depreciation treatment of this equipment.” We have refined our assumptions about depreciation and the revised drafts we circulate will reflect this.

ANSS IR 12. Reference p.11, (cell F15 Insurance), Synapse assumes insurance costs at 4% of hard costs based on Vermont data, noting “more work is needed to refine this assumption”. Has Synapse consulted insurance companies or brokers in Nova Scotia or elsewhere in Canada? What steps does Synapse propose to refine this assumption?

Answer: Synapse has not yet consulted insurance companies or brokers in Canada regarding insurance costs for COMFIT projects. We will do this as soon as possible.

ANSS IR 13. Reference p.14-15, biomass CHP inputs, “Since the host facility benefits from the steam produced, and not electric ratepayers, we do not include these costs in the COMFIT rate....The cost of the fuel yard, fuel handling equipment and the boiler and related equipment are not included.”

- (a) Given that turbines require steam to generate electricity, and steam is generated by boilers fed by materials handling equipment from fuel yards, on what basis does Synapse conclude that electric ratepayers do not benefit from the production of steam?

Answer: We agree that some portion of the steam generated in a COMFIT CHP plant would benefit electricity ratepayers. Given this, it would be appropriate to allocate some portion of boiler-related O&M costs to the cost of electricity. In the case of a project consisting of a new boiler and turbine, we propose that some portion of the boiler cost should be allocated to the cost of electricity. Where generating equipment is added to an existing boiler to create a CHP plant, we propose that the full cost of any boiler modifications necessary to generate electricity should be included in the cost of electricity.

- (b) Would Synapse agree that there is, at least, a shared benefit between the host facility and electric ratepayers?

Answer: We would agree that some portion of the steam generated in a COMFIT CHP plant would benefit electricity ratepayers.

ANSS IR 14. Reference, p.15, and footnote 5

- (a) Please provide a copy of the referenced *US EPA, Biomass Combined Heat and Power Catalog of Technologies, September 2007*.

Answer: We will distribute this with these responses.

- (b) Why did Synapse escalate costs from the 2006 EPA data to 2009, rather than 2011 or an estimated construction year? What is the confidence level of Synapse in the reliability of 2006 cost data from the US in the Nova Scotia market?

Answer: We agree that it makes sense to escalate costs to 2011 dollars. Regarding the data taken from EPA 2007, we are collecting more current data, and data from sources in Canada, including Nova Scotia. We do not expect to rely heavily on EPA 2007 for assumptions in our final tariff proposal.

- (c) Does Synapse have information based on Canadian plants? Is it available?

Answer: Synapse now has some information on biomass CHP plants in Canada, and we expect to be getting more in the coming weeks.

- (d) Who were the “knowledgeable people in the US and Nova Scotia” and what input did each provide to the cost and performance assumptions?

Answer: During our initial research we did not get statements in writing from sources nor did we clarify with them whether they were willing to be named and quoted. As our research progresses we are striving to get information in writing from named sources which we will be able to circulate or, short of that, to have sources agree to be named and quoted regarding specific information provided verbally.

ANSS IR-15. Reference pp. 15-16, Tables 6,7 Biomass CHP Input Assumptions

- (a) Please provide all underlying data, variables, numbers and assumptions regarding the cost estimate for Equipment and Installation.

Answer: In our draft calculations, “Equipment and Installation” included the cost of the turbine, the balance of electric plant, installation and interconnection. The turbine cost was taken from EPA 2007 Table 7.4, for the 0.5 MW turbine. The figure from this table (\$425,000) was multiplied by 1.06 to convert from 2006 to 2009 dollars. The balance of electric plant and installation costs were very preliminary Synapse assumptions. Balance of plant was estimated as 80% of turbine costs, and installation was estimated as 10% of the sum of turbine and balance of electric plant costs.

**Table 1. Components of Equipment and Installation Costs**

| Component                 | Cost        |
|---------------------------|-------------|
| Turbine                   | \$450,500   |
| Balance of electric plant | \$360,400   |
| Installation              | \$81,090    |
| Interconnection           | \$110,000   |
| Total                     | \$1,001,990 |

(b) Provide all underlying data, variables, numbers and assumptions regarding the cost estimate for O&M (FIT Model, line 20).

Answer: EPA 2007 estimates turbine O&M costs at \$4.00 per MWh. For a turbine this small, this figure seemed low, and several people knowledgeable about steam turbines agreed and advised us to assume \$5.00 per MWh. The figure used in the model (\$19,710) is the product of \$5.00 per MWh multiplied by annual energy (3,942 MWh).

(c) Provide all underlying data, variables, numbers and assumptions regarding the cost estimate for Major maintenance.

Answer: Major maintenance was assumed to be a turbine overhaul in year ten. The cost of \$10,000 was a preliminary Synapse assumption, subject to further research.

(d) Provide information regarding the type of biomass used in the EPA 2007 study, the fuels proximate and ultimate analysis and the region from which the fuel was procured.

Answer: As noted on page 78, the EPA 2007 study includes representative data for typical projects. It does not make detailed assumptions about fuel sources. The information provided about the fuel for the 100 ton-per-day boiler include: dry energy content (8,500 Btu), moisture content (50%) and as received energy content (4,250 Btu). (See Table 7-3).

(e) Provide all underlying data, variables, numbers and assumptions regarding the cost estimate for the Balance of electric plant.

Answer: We did not have time to research the costs of the balance of plant equipment, and the figure used (\$360,400) was a very preliminary estimate. It was calculated as 80% of turbine costs.

(f) Provide all variables, numbers and assumptions regarding the cost estimate for installation.

Answer: The figure used for installation (\$81,090) was a very preliminary estimate, subject to further research. It was calculated as 10% of the sum of turbine and balance of electric plant costs.

(g) Please provide the underlying data and analyses to estimate fuel cost expense (FIT Model, line 19).

Answer: The last row in Table 7 of our draft report shows annual fuel costs to electricity production at \$74,709. We estimated this using a fuel cost of \$3.50 per mmBtu and by apportioning total losses to steam and electricity production using the percentages of steam and electricity produced. So 8% of total losses were allocated to electricity production, and 92% of losses were allocated to steam. Total heat input to electricity production (allocated losses plus electricity output) was multiplied by \$3.50 per mmBtu to get total fuel costs for electricity production. Table 2 shows all the data behind this calculation.

**Table 2. Data for Calculation of Fuel Costs Allocated to Electricity**

| <b>Assumption</b>                                | <b>Value</b> | <b>Source</b> |
|--------------------------------------------------|--------------|---------------|
| Boiler fuel use (mmBtu/hr)                       | 35.4         | Table 7-6     |
| Annual operation (hrs)                           | 7,883        | Table 7-6     |
| Annual fuel use (mmBtu)                          | 279,076      | Calculated    |
| Annual process steam out (mmBtu)                 | 162,400      | Table 7-6     |
| Annual electricity output (MWh)                  | 3,942        | Table 7-6     |
| Annual electricity output (mmBtu)                | 13,450       | Calculated    |
| Total energy output (mmBtu)                      | 175,850      | Calculated    |
| Steam % of total output                          | 92%          | Calculated    |
| Electricity % of total output                    | 8%           | Calculated    |
| Losses (mmBtu)                                   | 103,226      | Calculated    |
| Losses allocated to steam (mmBtu)                | 95,330       | Calculated    |
| Losses allocated to electricity (mmBtu)          | 7,895        | Calculated    |
| Total heat in to steam production (mmBtu)        | 257,730      | Calculated    |
| Total heat in to electricity generation (mmBtu)  | 21,345       | Calculated    |
| Assumed fuel cost (\$/mmBtu)                     | \$3.50       | Assumed       |
| Annual fuel cost for steam production (\$)       | \$902,056    | Calculated    |
| Annual fuel cost for electricity production (\$) | \$74,709     | Calculated    |

As shown in Table 7 of our report, we intended to use a fuel cost of \$3.50 per mmBtu. However, due to a transcription error, \$3.00 per mmBtu was entered into the model. Rerunning the model with fuel at \$3.50 per mmBtu provides an energy rate of \$75 per MWh rather than \$72 per MWh. As we discuss below, we consider the fuel cost estimate of \$3.50 per mmBtu to be very preliminary and subject to further research.

- (h) Please provide all available analyses of the assumption fuel costs will escalate at the rate of inflation. What is the projected rate?

Answer: The general rate of inflation assumed in the model is 1.92%, taken from NSPI's 2009 IRP Update (page 53). We assumed that the cost of fuel would increase at the rate of inflation, because future fuel costs will have to be paid in future years' dollars, not current dollars. We made no projection of changes in the real (i.e., inflation adjusted) cost of fuel.

- (i) Please provide details regarding the process heat application contemplated in the EPA 2007 report and the characteristics of the heat required to the process, maximum steam required, minimum steam required, average steam required, number of hours per year that the process is under full load, seasonal effects and all other related information.

Answer: The report states only the following assumptions about the process heat application: "The estimates are based on steam conditions that might be typical for a process heating-only application in the small 100 tons/day biomass unit (250 pounds per square inch gauge [psig] saturated steam), and higher steam pressures (750 psig) for a steam turbine CHP configuration in the larger units." See page 38.

(j) Supply the calculation for Annual process steam out.

Answer: Annual process steam out is taken from EPA 2007 Table 7-6.

(k) Supply the calculation for Losses.

Answer: Losses (103,226 mmBtu) were calculated as total heat input (279,076 mmBtu) minus total energy output (175,850 mmBtu). Total energy output is the sum of process steam out (162,400 mmBtu) and electricity generation (13,450 mmBtu). EPA's figure for electricity generation (3,942 MWh) was converted to mmBtu using a factor of 3,412 Btu/kWh. See also the answer to question (g) above.

(l) Supply the calculation for Input to steam.

Answer: Input to steam (257,730 mmBtu) was calculated as total steam output (162,400 mmBtu) plus 92% of total losses (95,330 mmBtu times 92%, or 87,703 mmBtu). The steam percentage of total output (92%) is calculated as steam output (162,400 mmBtu) divided by total output (175,850 mmBtu). See also the answer to question (g) above.

(m) Supply the calculation for input to electric.

Answer: Input to electric (21,345 mmBtu) was calculated as total electric output (13,450 mmBtu) plus 8% of total losses (95,330 mmBtu times 8%, or 7,895 mmBtu). The electric percentage of total output (8%) is calculated as electric output (13,450 mmBtu) divided by total output (175,850 mmBtu). See also the answer to question (g) above.

(n) Supply the calculation for Electric heat rate.

Answer: The electric heat rate (5,415 Btu/kWh) was not a specific input to the model, but the implied heat rate can be calculated using model inputs. It is total energy input to electricity generation ( $21,345 \times 10^6$  Btu) divided by total electricity generation ( $3,942 \times 10^3$  kWh). See also the answer to question (g) above.

ANSS IR 16. Reference, p.17, Synapse indicates that based on anecdotal evidence it estimates the delivered cost of biomass in the province at about \$5.25 per mmBtu, and the non-delivered cost at \$3.50 per mmBtu. Please provide the source of that evidence as well as calculations, assumptions and methodology used to derive these estimates.

Answer: The term "anecdotal evidence" was intended to convey that this assumption was not based on robust data and that more work is needed to improve it. We are engaged in that work now. Regarding sources, during our initial research we did not get statements in writing from sources nor did we clarify with them whether they were willing to be named and quoted. As our research progresses we are striving to get information in writing from named sources which we will be able to circulate or, short of that, to have sources agree to be named and quoted regarding specific information provided verbally.

ANSS IR 17. Did Synapse interview anyone from the Nova Scotia forestry industry who currently supplies biomass to the market regarding his knowledge of the price of delivered biomass?

Answer: We were not able to interview anyone from the Nova Scotia forestry industry before circulating our draft rates. We expect to do so during the next several weeks.

ANSS IR 18. Reference, Biomass CHP FIT Model, why does Synapse not account for a contingency (Cell 16F)?

Answer: That cell appears under O&M costs in the model inputs. We do not believe that projects usually include a contingency fund for O&M, and we may remove this cell from the model. We welcome comment on this decision. We plan to include a construction contingency allowance in "Equipment and Installation."



## Efficiency, Heating Values (Gross and Net), and Cost Comparisons for Various Fuel Types

| TYPE OF FUEL          | Wood                           |                                    |                                    |                      | Softwood<br>(kiln dried)<br>(13% MC) <sup>a</sup> | Hardwood<br>(kiln dried)<br>(8% MC) <sup>a</sup> | Wood<br>pellets<br>(premium) <sup>b</sup> | Natural<br>gas                        | Electricity     | Firewood<br>(seasoned)<br>(20% MC) <sup>a</sup> | Switchgrass<br>(ovendried) | Bituminous<br>coal   | Shelled<br>corn<br>(15% MC) | Fuel oil          |                   | Propane          |
|-----------------------|--------------------------------|------------------------------------|------------------------------------|----------------------|---------------------------------------------------|--------------------------------------------------|-------------------------------------------|---------------------------------------|-----------------|-------------------------------------------------|----------------------------|----------------------|-----------------------------|-------------------|-------------------|------------------|
|                       | Green<br>(50% MC) <sup>a</sup> | Semidried<br>(30% MC) <sup>a</sup> | Air-dried<br>(20% MC) <sup>a</sup> | Ovendried<br>(0% MC) |                                                   |                                                  |                                           |                                       |                 |                                                 |                            |                      |                             | #2                | #6                |                  |
| GROSS HEATING VALUE   | 8,600,000 Btu/ton              | 12,040,000 Btu/ton                 | 13,760,000 Btu/ton                 | 17,200,000 Btu/ton   | 15,824,000 (Btu/ton)                              | 15,996,000 (Btu/ton)                             | 16,400,000 (Btu/ton)                      | 1,025,000 (Btu/1000 ft <sup>3</sup> ) | 3,412 (Btu/kWh) | 20,000,000 (Btu/cord)                           | 15,500,000 (Btu/ton)       | 30,600,000 (Btu/ton) | 392,000 (Btu/bu)            | 138,800 (Btu/gal) | 150,000 (Btu/gal) | 91,300 (Btu/gal) |
| EFFICIENCY            | 67%                            | 74%                                | 77%                                | 80%                  | 78%                                               | 79%                                              | 83%                                       | 80%                                   | 98%             | 77%                                             | 80%                        | 85%                  | 80%                         | 83%               | 83%               | 79%              |
| NET HEATING VALUE     | 5,740,000 Btu/ton              | 8,950,000 Btu/ton                  | 10,560,000 Btu/ton                 | 13,800,000 Btu/ton   | 12,300,000 Btu/ton                                | 12,600,000 Btu/ton                               | 13,600,000 Btu/ton                        | 820,000 Btu/1000 ft <sup>3</sup>      | 3,340 Btu/kWh   | 15,300,000 Btu/cord                             | 12,400,000 Btu/ton         | 26,000,000 Btu/ton   | 314,000 Btu/bu              | 115,000 Btu/gal   | 124,000 Btu/gal   | 71,900 Btu/gal   |
| <i>\$/million Btu</i> | <i>\$/ton</i>                  | <i>\$/ton</i>                      | <i>\$/ton</i>                      | <i>\$/ton</i>        | <i>\$/ton</i>                                     | <i>\$/ton</i>                                    | <i>\$/ton</i>                             | <i>\$/1000 ft<sup>3</sup></i>         | <i>\$/kWh</i>   | <i>\$/cord</i>                                  | <i>\$/ton</i>              | <i>\$/ton</i>        | <i>\$/bu</i>                | <i>\$/gal</i>     | <i>\$/gal</i>     | <i>\$/gal</i>    |
| 1.0                   | 5.74                           | 8.95                               | 10.56                              | 13.77                | 12.30                                             | 12.62                                            | 13.61                                     | 0.82                                  | 0.003           | 15.35                                           | 12.40                      | 26.01                | 0.31                        | 0.11              | 0.12              | 0.07             |
| 1.5                   | 8.61                           | 13.43                              | 15.84                              | 20.66                | 18.45                                             | 18.94                                            | 20.42                                     | 1.23                                  | 0.005           | 23.02                                           | 18.60                      | 39.02                | 0.47                        | 0.17              | 0.19              | 0.11             |
| 2.0                   | 11.48                          | 17.91                              | 21.12                              | 27.55                | 24.60                                             | 25.25                                            | 27.22                                     | 1.64                                  | 0.007           | 30.70                                           | 24.80                      | 52.02                | 0.63                        | 0.23              | 0.25              | 0.14             |
| 2.5                   | 14.35                          | 22.38                              | 26.40                              | 34.44                | 30.75                                             | 31.56                                            | 34.03                                     | 2.05                                  | 0.008           | 38.37                                           | 31.00                      | 65.03                | 0.78                        | 0.29              | 0.31              | 0.18             |
| 3.0                   | 17.22                          | 26.86                              | 31.68                              | 41.32                | 36.90                                             | 37.87                                            | 40.84                                     | 2.46                                  | 0.010           | 46.05                                           | 37.20                      | 78.03                | 0.94                        | 0.34              | 0.37              | 0.22             |
| 3.5                   | 20.08                          | 31.33                              | 36.96                              | 48.21                | 43.05                                             | 44.18                                            | 47.64                                     | 2.87                                  | 0.012           | 53.72                                           | 43.40                      | 91.04                | 1.10                        | 0.40              | 0.43              | 0.25             |
| 4.0                   | 22.95                          | 35.81                              | 42.24                              | 55.10                | 49.20                                             | 50.50                                            | 54.45                                     | 3.28                                  | 0.013           | 61.39                                           | 49.60                      | 104                  | 1.25                        | 0.46              | 0.50              | 0.29             |
| 4.5                   | 25.82                          | 40.29                              | 47.52                              | 61.98                | 55.35                                             | 56.81                                            | 61.25                                     | 3.69                                  | 0.015           | 69.07                                           | 55.80                      | 117                  | 1.41                        | 0.52              | 0.56              | 0.32             |
| 5.0                   | 28.69                          | 44.76                              | 52.80                              | 68.87                | 61.50                                             | 63.12                                            | 68.06                                     | 4.10                                  | 0.017           | 76.74                                           | 62.00                      | 130                  | 1.57                        | 0.57              | 0.62              | 0.36             |
| 5.5                   | 31.56                          | 49.24                              | 58.08                              | 75.76                | 67.65                                             | 69.43                                            | 74.87                                     | 4.51                                  | 0.018           | 84.42                                           | 68.20                      | 143                  | 1.72                        | 0.63              | 0.68              | 0.40             |
| 6.0                   | 34.43                          | 53.72                              | 63.36                              | 82.64                | 73.80                                             | 75.74                                            | 81.67                                     | 4.92                                  | 0.020           | 92.09                                           | 74.40                      | 156                  | 1.88                        | 0.69              | 0.74              | 0.43             |
| 6.5                   | 37.30                          | 58.19                              | 68.64                              | 89.53                | 79.94                                             | 82.06                                            | 88.48                                     | 5.33                                  | 0.022           | 99.77                                           | 80.60                      | 169                  | 2.04                        | 0.74              | 0.80              | 0.47             |
| 7.0                   | 40.17                          | 62.67                              | 73.92                              | 96.42                | 86.09                                             | 88.37                                            | 95.28                                     | 5.74                                  | 0.023           | 107                                             | 86.80                      | 182                  | 2.20                        | 0.80              | 0.87              | 0.50             |
| 7.5                   | 43.04                          | 67.15                              | 79.20                              | 103                  | 92                                                | 95                                               | 102                                       | 6.15                                  | 0.025           | 115                                             | 93.00                      | 195                  | 2.35                        | 0.86              | 0.93              | 0.54             |
| 8.0                   | 45.91                          | 71.62                              | 84.48                              | 110                  | 98                                                | 101                                              | 109                                       | 6.56                                  | 0.027           | 123                                             | 99.20                      | 208                  | 2.51                        | 0.92              | 0.99              | 0.57             |
| 8.5                   | 48.78                          | 76.10                              | 89.76                              | 117                  | 105                                               | 107                                              | 116                                       | 6.97                                  | 0.028           | 130                                             | 105                        | 221                  | 2.67                        | 0.97              | 1.05              | 0.61             |
| 9.0                   | 51.65                          | 80.57                              | 95.04                              | 124                  | 111                                               | 114                                              | 123                                       | 7.38                                  | 0.030           | 138                                             | 112                        | 234                  | 2.82                        | 1.03              | 1.11              | 0.65             |
| 9.5                   | 54.52                          | 85.05                              | 100                                | 131                  | 117                                               | 120                                              | 129                                       | 7.79                                  | 0.032           | 146                                             | 118                        | 247                  | 2.98                        | 1.09              | 1.18              | 0.68             |
| 10.0                  | 57.39                          | 89.53                              | 106                                | 138                  | 123                                               | 126                                              | 136                                       | 8.20                                  | 0.033           | 153                                             | 124                        | 260                  | 3.14                        | 1.15              | 1.24              | 0.72             |
| 11.0                  | 63.12                          | 98.48                              | 116                                | 152                  | 135                                               | 139                                              | 150                                       | 9.02                                  | 0.037           | 169                                             | 136                        | 286                  | 3.45                        | 1.26              | 1.36              | 0.79             |
| 12.0                  | 68.86                          | 107                                | 127                                | 165                  | 148                                               | 151                                              | 163                                       | 9.84                                  | 0.040           | 184                                             | 149                        | 312                  | 3.76                        | 1.37              | 1.49              | 0.86             |
| 13.0                  | 74.60                          | 116                                | 137                                | 179                  | 160                                               | 164                                              | 177                                       | 10.66                                 | 0.043           | 200                                             | 161                        | 338                  | 4.08                        | 1.49              | 1.61              | 0.93             |
| 14.0                  | 80.34                          | 125                                | 148                                | 193                  | 172                                               | 177                                              | 191                                       | 11.48                                 | 0.047           | 215                                             | 174                        | 364                  | 4.39                        | 1.60              | 1.73              | 1.01             |
| 15.0                  | 86.08                          | 134                                | 158                                | 207                  | 184                                               | 189                                              | 204                                       | 12.30                                 | 0.050           | 230                                             | 186                        | 390                  | 4.70                        | 1.72              | 1.86              | 1.08             |
| 16.0                  | 91.82                          | 143                                | 169                                | 220                  | 197                                               | 202                                              | 218                                       | 13.12                                 | 0.054           | 246                                             | 198                        | 416                  | 5.02                        | 1.83              | 1.98              | 1.15             |
| 17.0                  | 97.55                          | 152                                | 180                                | 234                  | 209                                               | 215                                              | 231                                       | 13.94                                 | 0.057           | 261                                             | 211                        | 442                  | 5.33                        | 1.95              | 2.10              | 1.22             |
| 18.0                  | 103                            | 161                                | 190                                | 248                  | 221                                               | 227                                              | 245                                       | 14.76                                 | 0.060           | 276                                             | 223                        | 468                  | 5.64                        | 2.06              | 2.23              | 1.29             |
| 19.0                  | 109                            | 170                                | 201                                | 262                  | 234                                               | 240                                              | 259                                       | 15.58                                 | 0.064           | 292                                             | 236                        | 494                  | 5.96                        | 2.18              | 2.35              | 1.37             |
| 20.0                  | 115                            | 179                                | 211                                | 275                  | 246                                               | 252                                              | 272                                       | 16.40                                 | 0.067           | 307                                             | 248                        | 520                  | 6.27                        | 2.29              | 2.48              | 1.44             |
| 30.0                  | 172                            | 269                                | 317                                | 413                  | 369                                               | 379                                              | 408                                       | 24.60                                 | 0.100           | 460                                             | 372                        | 780                  | 9.41                        | 3.44              | 3.71              | 2.16             |
| 40.0                  | 230                            | 358                                | 422                                | 551                  | 492                                               | 505                                              | 544                                       | 32.80                                 | 0.134           | 614                                             | 496                        | 1040                 | 12.54                       | 4.58              | 4.95              | 2.87             |
| 50.0                  | 287                            | 448                                | 528                                | 689                  | 615                                               | 631                                              | 681                                       | 41.00                                 | 0.167           | 767                                             | 620                        | 1301                 | 15.68                       | 5.73              | 6.19              | 3.59             |
| 60.0                  | 344                            | 537                                | 634                                | 826                  | 738                                               | 757                                              | 817                                       | 49.20                                 | 0.201           | 921                                             | 744                        | 1561                 | 18.82                       | 6.87              | 7.43              | 4.31             |

<sup>a</sup>Wet basis.<sup>b</sup>Presently, wood pellets come in two forms—standard and premium. There is no difference in the energy content per pound between the two. The major difference is the amount of ash. To be classified as premium, pellets must have an ash content less than 1%.