Draft
Cellulosic Based Black Liquor Gasification and Fuels Plant Final Technical Report

October 31, 2012

Final Technical Report

Project Title: Cellulosic Based Black Liquor Gasification and Fuels Plant
Award Number: DE-PS36-08GO18124

Recipient: Escanaba Paper Mill

Project Location(s): Escanaba, Michigan

Project Period: 6/1/2008 to 7/30/2009
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Subcontractors: None

Cost-Sharing Partners: Michigan Economic Development Corporation
US/Swedish Bilateral Energy Funding Agreement.

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Note: This report has been closely reviewed and does not contain any protected personal information (Protected PII).

Executive Summary:

The Cellulosic Based Black Liquor Gasification and Fuels Plant Project was developed to construct a black liquor to Methanol biorefinery in Escanaba, Michigan. The biorefinery was to be co-located at the existing pulp and paper mill, NewPage's Escanaba Paper Mill and when in full operation would:

- Generate renewable energy for Escanaba Paper Mill
- Produce Methanol for transportation fuel of further refinement to Dimethyl Ether
- Convert black liquor to white liquor for pulping.

Black liquor is a byproduct of the pulping process and as such is generated from abundant and renewable lignocellulosic biomass. The biorefinery would serve to validate the thermochemical pathway and economic models for black liquor gasification. It was a project goal to create a compelling new business model for the pulp and paper industry, and support the nation's goal for increasing renewable fuels production and reducing its dependence on foreign oil. NewPage Corporation planned to replicate this facility at other NewPage Corporation mills after this first demonstration scale plant was operational and had proven technical and economic feasibility.

An overview of the process begins with black liquor being generated in a traditional Kraft pulping process. The black liquor would then be gasified to produce synthesis gas, sodium carbonate and hydrogen sulfide. The synthesis gas is then cleaned with hydrogen sulfide and carbon dioxide removed, and fed into a Methanol reactor where the liquid product is made. The hydrogen sulfide is converted into polysulfide for use in the Kraft pulping process. Polysulfide is a known additive to the Kraft process that increases pulp yield. The sodium carbonate salts are converted to caustic soda in a traditional recausticizing process. The caustic soda is then part of the white liquor that is used in the Kraft pulping process.

Cellulosic Based Black Liquor Gasification and Fuels Plant project set out to prove that black liquor gasification could produce transportation fuels and produce pulp at the same time. This has the added advantage of reducing or eliminating the need for a recovery boiler. The recovery boiler is an extremely expensive unit operation in the Kraft process and is key to the chemical recovery system that makes the Kraft process successful. Going to a gasification process with potentially higher energy efficiency, improve the pulping process and be more efficient with the use of wood. At the same time a renewable fuel product can be made.

Cellulosic Based Black Liquor Gasification and Fuels Plant progressed with the design of the mill as Chemrec continued to work on their pilot plant data gathering. The design information helped to guide the pilot plant and vice versa.

In the end, the design details showed that the process was technically feasible. However, at the relatively small size of this plant the specific capital cost was very high and could only be considered if the pulp operation needed to replace the recovery boiler. Some of the reasons for the costs being high are attributed to the many constraints that needed to be addressed in the pulping process. Additionally, the Methanol product did not have a vehicle fuel supply chain to enter into. A different product selection could have eliminated this issue. However, with the

selected design, the installation at Escanaba Paper Mill was not economically feasible and the project was not pursued further.

Investigations Conducted to Better Understand the Process

Over the course of the project, xxx major investigations were undertaken to increase the project's understanding of the process and are discussed below:

1. The first investigation was done to develop a FEL-2 level estimate of the Cellulosic Based Black Liquor Gasification and Fuels Plant. This work indicated that there was potential for this type of facility to be economically attractive at Escanaba Paper Mill.

2. As the second investigation, the pilot plant was used. The pilot plant efforts used black liquor at the Piteå, Sweden to test the ability of the gasifier to effectively convert black liquor. These tests were successful, however, the down stream processing of the synthesis gas was not tested.

3. The third investigation was done in conjunction with AMEC to determine the design, location and cost of Cellulosic Based Black Liquor Gasification and Fuels Plant. This work has been submitted to the DOE and a public version is available and is attached to this report.

4. The fourth investigation addressed the in mill work practices and requirements to handle both the products from black liquor gasification and the ability to make up for the energy lost to the process when making Methanol. This work included the estimation of a new biomass boiler at Escanaba Paper Mill as well as other substantial process changes.

5. The fifth investigation was the economics of making either methanol or dimethyl ether. The result of this work was that the methanol market was dominated by low cost, offshore product and was not acceptable for a fuel substitute. Dimethyl ether was shown to be a good fuel substitute, much like propane, but there was no domestic market for this fuel and substantial infrastructure would need to be created to distribute this fuel.

The distribution issues along with the high capital cost lead Escanaba Paper Mill to the conclusion that the project was not feasible in the short term. The project was then terminated.

Technical Effectiveness and Economic Feasibility of the Project

Technically, the project was a success and in showing that black liquor could be successfully gasified. The technologies for the other steps exist, but needed to be tested in the pilot plant. The design was shown to be feasible. The project's Achilles heel was that the capital cost of the project was extremely high, even when compared to the cost of a recovery boiler. Beyond that was the lack of a supply change to market the dimethyl ether product. These issues made the project not feasible to do at Escanaba Paper Mill.

Benefit the Public

Economically, the project would have benefited the residents in the Upper Peninsula of Michigan by securing jobs at Escanaba Paper Mill and associated supply chain. There would have been an increase in the construction trades and engineering work during construction of the facility, thereby increasing the bottom line of any support business. Additional staff would have been hired to operate the facility. A renewable energy system at Escanaba Paper Mill would have been an added benefit that would have contributed to the long term viability of the facility.

Most significantly, the facility would have generated second generation fuels outside of the food chain from a renewable, sustainable resource.

Comparison of the Actual Accomplishments with the Goals and Objectives of the Project:

The primary project goal was to generate a renewable energy from black liquor in an economically feasible way. The second goal was to then replicate the facility in other similar situations across the United States. To support these goals, the following efforts were made to address the DOE barriers thought to be problematic if not addressed.

Another DOE Barrier Im-E: Lack of Industry Standards and Regulations was not found to be an issue for the project. Construction and operation of the plant would be covered under city, state and national permits, and Methanol product characteristics would be regulated by their customers.

The next barrier addressed by the project was DOE's It-C: Risk of First-of-a-kind-Technology. The operation of the pilot plant allowed the project to addressed and mitigate the gasification issue.

Summarize the Project Activities for the Entire Period of Funding:

In June 2007, Cellulosic Based Black Liquor Gasification and Fuels Plant was proposed to Escanaba Paper Mill by Chemrec, Michigan Economic Development Corporation, US/Swedish Bilateral Energy Funding Agreement, and the State of Michigan. From these discussions, a stage gate process of evaluating and testing black liquor gasification to dimethyl ether or methanol was agreed upon with the Escanaba Paper Mill site to be used as the example location to build from.

Cellulosic Based Black Liquor Gasification and Fuels Plant FEL-2 study was done in late December 2007 and this provided enough of a positive outlook to have the project proceed to the next stage.

Cellulosic Based Black Liquor Gasification and Fuels Plant entered into a design period where AMEC was again chosen to develop a Class 10 design and cost estimate. At the same time, Chemrec developed a pilot plant plan at their facility in Piteå, Sweden to do gasification trials using black liquor from an adjacent kraft pulp mill. These trials were done over a several year period of time. These trials only focused on the gasification and did not demonstrate the gas handling.

At the same time, AMEC was completing their Class 16 design an issued a report in June 2009. This report investigated the black liquor gasification process as well as look at the rest of the plant. The balance of plant costs were substantial and included a new boiler.

During the course of the summer of 2009, the issue to product distribution became an important issue. The potential methanol product has a large market, but this is saturated with low cost methanol from stranded fuel sources. While methanol still enjoyed a blender's credit for biofuels at this time it was not included in the standard gasoline specification. The dimethyl ether product has a lot of potential as a fuel replacement like propane and is today a proven diesel fuel, but has no distribution system for the product. These represent significant problems with going to the market. Dimethyl ether was also excluded from the DOE call for proposals 2009.

In June 2009, it became apparent to NewPage Corporation that there was not enough financial incentive for the company to continue to pursue Cellulosic Based Black Liquor Gasification and Fuels Plant and requested a termination of the project.

Identification of Products Developed Under the Award and Technology Transfers

Cellulosic Based Black Liquor Gasification and Fuels Plant did not publish or release any documents other than those provided to DOE for review previously.

Cellulosic Based Black Liquor Gasification and Fuels Plant is mentioned on websites outside of our control. There was no Cellulosic Based Black Liquor Gasification and Fuels Plant website.

Computer Modeling Development:

The Cellulosic Based Black Liquor Gasification and Fuels Plant did not develop computer modeling as part of their project.

Acknowledgment: This material is based upon work supported by the Department of Energy under Award Number DE-PS36-08GO18049; Amendment No. M009.

Black Liquor Gasification Plant Cost Estimate
18,000,000gallons/year Methanol
15,000,000gallons/year Di-Methyl-Ether (DME)
NewPage Escanaba, Michigan Pulp and Paper Plant

DOE Award # DE-FG36-08GO18124

The project goal was to develop a class 20 cost estimate for the construction of a black liquor gasification plant designed to make either 18,000,000 of methanol or 15,000,000 of DME.

The cost to construct this plant in the Escanaba mill consists of two components, each with it's separate cost report.

1. **The liquor gasification and fuels plant cost of $174,400,000.**
2. **The mill work scope at a cost of $96,404,600.**

The total cost of $270,804,600 is higher than what may developed in other locations because of the extensive scope of mill modifications required at the Escanaba mill which is highly developed and has numerous production constraints.
If this project were to be installed at a mill with sufficient hog fuel boiler capacity the cost would be approximately $226,580,000 and if only a recovery boiler constraint existed the cost could be as low as $192,401,000.

The black liquor gasification plant work scope and the mill work scopes are fully developed and listed in this report and the mill costs are developed in the excel spread sheet for the 3 scenarios listed in the above paragraph.

CHEMREC

FEASIBILITY STUDY

COMMERCIAL DEMONSTRATION

BLG PLANT

AT THE NEWPAGE PAPER MILL

IN ESCANABA, MICHIGAN, USA

FINAL REPORT

"DOE VERSION"

This version of the Feasibility Phase II Report excludes technical and commercial information from Vendors.

CONTENT

ABBREVIATIONS/ACRONYMS

AGR	Acid Gas Removal
ASME	American Society of Mechanical Engineering
ASU	Air Separation Unit
BL	Black Liquor
BLG	Black Liquor Gasification
BLGMF	Black Liquor Gasification for Motor Fuel production
BOP	Balance of Plant
CCC	Counter-Current Condenser
CEPCI	Chemical Engineering Plant Cost Index
DCS	Distributed Control System
DME	Di-Methyl Ether
ESD	Emergency Shutdown system
F&G	Fire and Gas
GAN	Gaseous Nitrogen
GHG	Green House Gases
GL	Green Liquor
GOX	Gaseous Oxygen
HAZOP	Hazard and Operability Analysis
HHV	Higher Heating Value (Gross calorific value including heat of steam condensation)
HMI	Human Machine Interface
HP	High Pressure
IMPCA	International Methanol Producers and Consumers Association
I/O	Input/Output
IP	Intermediate Pressure (400 psig, sat´d)
K-O DRUM	Knock-Out Drum
LCV-gas	Low Calorific Value gas
LHV	Lower Heating Value (Heat of combustion excluding the heat of steam condensation)
LIN	Liquid Nitrogen
LOX	Liquid Oxygen
LP	Low Pressure (60 psig, sat´d)
MB&EB	Material & Energy Balances
MCV-gas	Medium Calorific Value gas
MP	Medium Pressure (175 psig, sat´d)
MtDS	Metric tons Dry Substance (Tons Dry Solids)
Mtpd	Metric tons per day
NACE	National Association of Corrosion Engineers
NFPA	National Fire Protection Association
P&ID	Process and Instrument Diagram
PFD	Process Flow Diagram
PSD	Process Shut Down
SAS	Safety Automation System
SIL	Safety Integrity Level
TBD	To be decided
UPS	Uninterrupted Power Supply

WSA	Wet Sulfuric Acid
WW	Weak Wash Liquor
PPE	Personnel protective Equipment

IEC61508 International Electrotechnical Commission Technical Standard 61508 Title: "*Functional safety of electrical/electronic/programmable electronic safety-related systems*"

IEC61511 International Electrotechnical Commission Technical Standard 61511 Title: "*Functional safety - Safety instrumented systems for the process industry sector*".

SIL3 Security Independence Level (Range 1-4). Classification range between 1 (light) and 4 (stringent). See IEC 61511.

EXECUTIVE SUMMARY

Background

In summer of 2007, the idea evolved to develop a US project for realizing a demonstration project producing "green" fuel from biomass – i.e. converting black liquor from a US pulp mill to a fuel. Newpage Corporation and Chemrec jointly started the activities with support from various federal and state organizations in the US and in Sweden.

The Newpage pulp and paper mill in Escanaba, Michigan, USA, was selected as the site for such a potential demonstration plant. The project was developed, starting with a Phase 1 pre-feasibility study showing the technical solution for such a plant and the economics for the plant. The investment cost with a +/- 30% accuracy was scaled to size and indexed to 4th quarter 2007 based on data from a 2005 study. As an additional activity, the product off-take situation and the financial figures for various off-take alternatives were investigated.

The result of the pre-feasibility study was promising and a decision was made in the spring of 2008 to continue with Phase 2 – a feasibility study.

Add a paragraph covering the development phase at Pitea, Sweden and referring to the scale up size for our mill project.

The Chemrec gasifier reactor and gas cooler is under testing in 10250 MBtu/hr (3 MW_{th}) scale or 3.6 gpm (20 Mt/d DS) of black liquor in the DP1 (development plant 1) in Piteå, Sweden. The DP1 gasifier was taken into operation in September 2005 and has since then been in operation for more than 8500 hours (Febr 2009).

One main task for Chemrec is to accomplish a 25x scale-up of the reactor system in the DP1. The scale-up work has been going on in parallel to the Newpage feasibility project. Besides the DP1 activities and the scale-up project, important learnings have been gained in the atmospheric Chemrec reactor for 55 gpm of black liquor (300 Mt/d DS) in Weyerhaeuser New Bern, NC that began operation in the mid 1990´s.

A new project named the BioDME project was initiated in Sept-2008. In the BioDME project, the syngas from DP1 will be used as feedstock for pilot plant scale DME production of 4.4 short tonnes/day (4 MT/d). Start of black liquor derived DME production is scheduled to March 2010.

Objective

The objective for Phase 2 of the project, a BLG (Black Liquor Gasification), plant at the Newpage mill in Escanaba, is to update and refine the engineering for the BLG demonstration plant, define the auxiliary systems in more detail, and estimate the cost for the plant to a more accurate degree +/-20% based on quotations for the actual defined equipment.

The Phase 2 study has been performed as a joint effort between Chemrec AB, Sweden and Newpage Corporation, USA. Chemrec has been supported by the Swedish consultant FB Engineering, for certain key competence areas relevant to these types of chemical plants. FB Engineering has under Chemrec's supervision carried out the engineering and cost estimate of the plant, specifically the Balance of Plant, comprising the support systems that integrate the various plant units into one system and also integrating the BLG plant with the pulp mill. The project specific information of the various units has been received from sub-suppliers and licensors of the equipment. This sub-supplier and licensor information is part of the information in the study, both the technical details and cost estimates.

Background to technical definition

Based on the results from the Phase 1 pre-feasibility study, methanol was selected as the most favorable renewable fuel product from this plant. The off-take situation was analyzed and methanol was found to be the most cost-efficient fuel alternative with well-known handling and logistics and use in the near future when a BLG demonstration plant could start producing fuel for supplies of "green" methanol to the market.

The phase 2 study reflects on the integration to the mill and the need of modifications to the mill to meet the BLG plant requirements, which will result from the introduction of the BLG plant into the mill system.

This phase of the study has put major efforts into the systems – Balance of Plant – which integrate the various units making up the complete BLG plant. These systems are

- the storage system
- the cooling water system
- steam and condensate system
- waste and emission system
- electrical system
- control and automation system
- flare system

The units which combine to the BLG system are

- oxygen production unit (Air Separation Unit)
- gasification unit (Chemrec unit)
- gas cleaning unit (Rectisol unit)
- the sulfur handling unit (Wet Sulfur Acid unit)
- methanol (and DME) synthesis and distillation unit

The figure 1.1 below shows the buildup of the various process units and the systems in the Balance of Plant, supporting the process, and integrating the BLG system plant into the pulp mill.

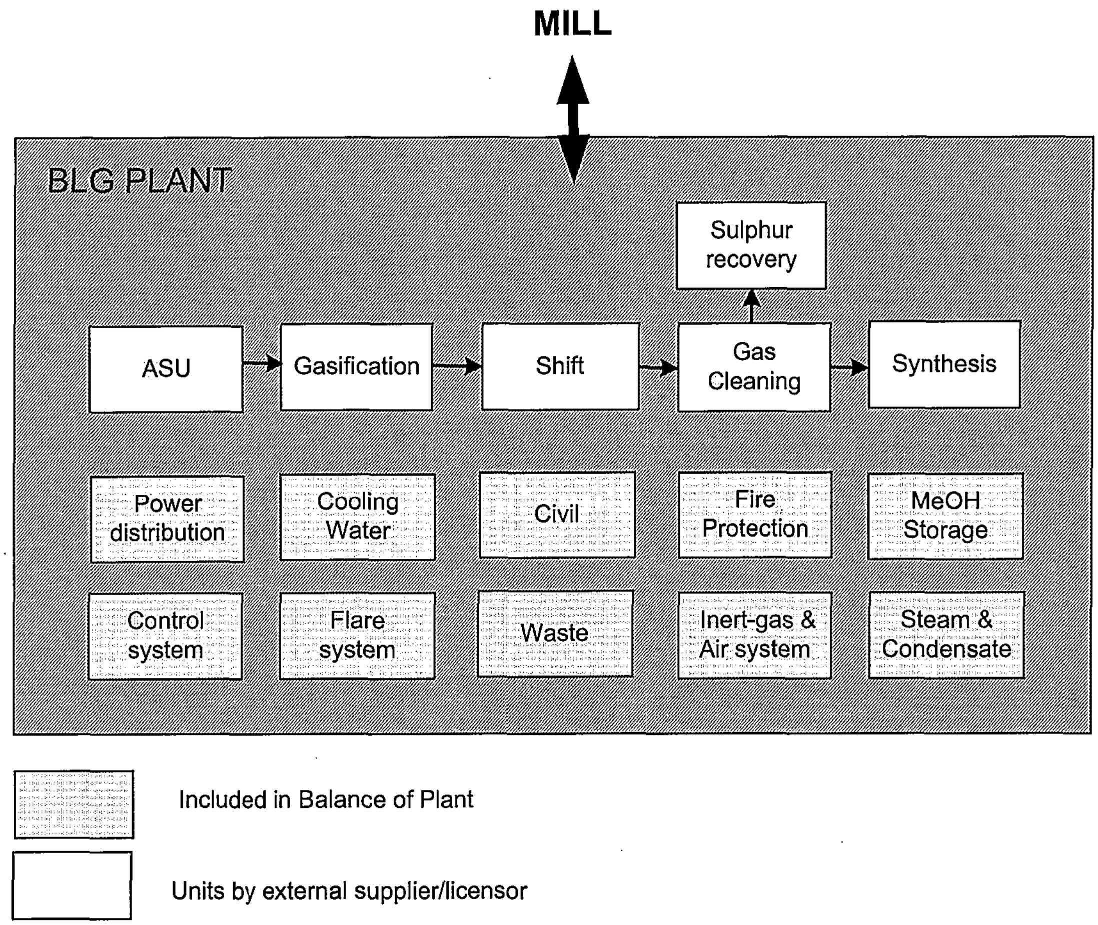


Figure E.1 Description of balance of plant scope in relation to the process units in the BLG-plant concept.

The information for the various units has been received from sub-suppliers' quotations and from budget quotes from potential licensors for the various units. Detailed technical information has not been received. Data required for energy and mass balances to develop base data for the Balance of Plant systems for the integration has been received.

The system for integration – Balance of Plant - has been analyzed and the technical requirements have all been specified. This information has been used to define the systems with function and operational needs, which together with a lay-out, have resulted in the design of pipes (sizes, material, etc.), instruments (type, amount), and equipment such as pumps, valves, tanks, etc. The components have been individually cost-estimated (based on FBE in-house data or actual quotations) and the cost information has been detailed and is accurate for these systems +/- 10%.

The technical design information at the initiation of the study was a preliminary specification with a tolerance band. The technical information received from the sub-suppliers and licensors arrived in the latter part of the study. This information has been adjusted to harmonize with mill systems and balance of plant systems. This has required some recalculations. A second round of discussions with the sub-suppliers and licensors is needed (during the FEED (Front End Engineering Design) study) to fine tune the data and to obtain improved accuracy. The fine tuning of the technical performance will probably have limited influence on the cost estimate.

The information about the units has been received from Linde AG, Air Products and Chemicals Inc., and Haldor Topsoe A/S. The gasification part has been specified by Chemrec and reflects a preliminary basic design of the gasification part.

Due to the situation when the study work started, the workload for many of the potential sub-suppliers and licensors was heavy. In general, the initial response was positive from the candidate suppliers, but after some investigations and internal discussions many of them declined to prepare technical quotations because of too heavy a workload. Therefore, relevant comparisons between both technical solutions and cost levels have not been possible.

The major part of the information about the systems, mainly the gas cleaning, the sulfur handling, and the synthesis, has come from or via Haldor Topsoe, a potential supplier and a Chemrec partner for equipment for a complete plant.

The result of the study is a technically feasible plant for producing methanol from black liquor from the Newpage Escanaba mill. The integration with the mill is feasible and will require mill modifications defined in a separate study by Newpage/AMEC.

The plant layout has been evaluated and the location on top of the hill North of the mill was decided on for further detailing in the study and cost estimation based on this layout.

Cost estimate

The overall investment cost for the BLG plant, according to the result of this study, is 174.4 MUSD. Note: This cost does not include additional owner cost required for an AFE approved project.

The above cost includes a DME part in the synthesis unit which enables the production of both Methanol and DME. The cost estimate in the Phase 1 study also included a combined Methanol and DME synthesis and distillation unit.
It should be explicitly notified that the cost estimate for the Balance of plant does not include the full cost for all equipment for utilities (IE, BOP) and the storage and handling of the DME part, which has to be dealt with in Phase 3.

This cost includes also the site preparation, which was not part of the scope of supply in the Phase 1 study due to the uncertainties with site conditions. The cost for the plant scope (including DME) in this Phase 2 study is 166 MUSD. This should be compared to the result in Phase 1, which was 145.2 MUSD.

Although the cost has increased since the January 2008 Phase 1 report, due to both cost escalations for equipment and for manpower, the majority of the increase is for the estimate of the Balance of Plant part. The cost increase for the BOP is caused by a higher complexity than expected in the pre-feasibility study of both the BOP sub-systems and the larger area for the plot plan, which has resulted in longer pipes, cables, pipe-racks, etc., thus increasing the cost. The original cost figure for this was too low, and with all systems now included, the figure has increased by about 18 MUSD.

Table E.1 below shows the summary of cost items for the BLG plant split up among the various units. The table also shows the cost comparison to the estimate in the previous pre-feasibility study.

TABLE E.1 REMOVED - CONFIDENTIAL INFORMATION FROM VENDORS.

The new cost estimates for the units within the BLG plant are similar to the figures in the Phase 1 study, giving a 2% higher sub-total of 139,2 MUSD compared to 135.9 MUSD in Phase 1. These cost estimates are on the +/- 20% accuracy level and have to be further discussed with the licensors in order to arrive at more accurate total value. This will be accomplished during the FEED engineering phase with a US Consulting Firm.

The current cost estimate is based on the location of the BLG plant at a specific site located uphill the Escanaba pulp mill and with special soil conditions that were not included in the prefeasibility study.

A cost increase of about 3 % or 4 MUSD could be expected compared to the figures calculated for the 4th quarter 2007. However, with the present depressing global financial situation the cost level could decline significantly, but this has not been reflected in the figures above. Another factor that has a strong influence on the cost estimate is the rapid changes of the exchange rates for USD, EUR and SEK. The cost estimate is mainly for European currencies. However, some US costs for equipment are included. For cost basis exchange rates see section 10.10

The cost estimate for the Balance of Plant will be checked further with focus on possible cost reductions for:

- Area reduction for the various units, which would reduce the lengths for pipes, cables, wiring, etc.
- Revised design specification
- Reduced component cost due to economic slowdown.

Next phase and time schedule

The additional activities in the project, to arrive at an improved accuracy in the basic design and a +/- 10% cost estimate require:

- License agreement with the licensors for their respective units and their cost to produce the basic design information for this equipment
- Agreement with a US Consulting Firm to perform the basic design and the +/- 10% cost estimate for the overall plant

It will take about six months for the licensors to finalize their part of these activities. The US Consulting Firm is assumed to start basic engineering work at the same time as the licensor and will need about 3 additional months for completion of the overall basic design and cost estimate after receiving the information from all licensors.

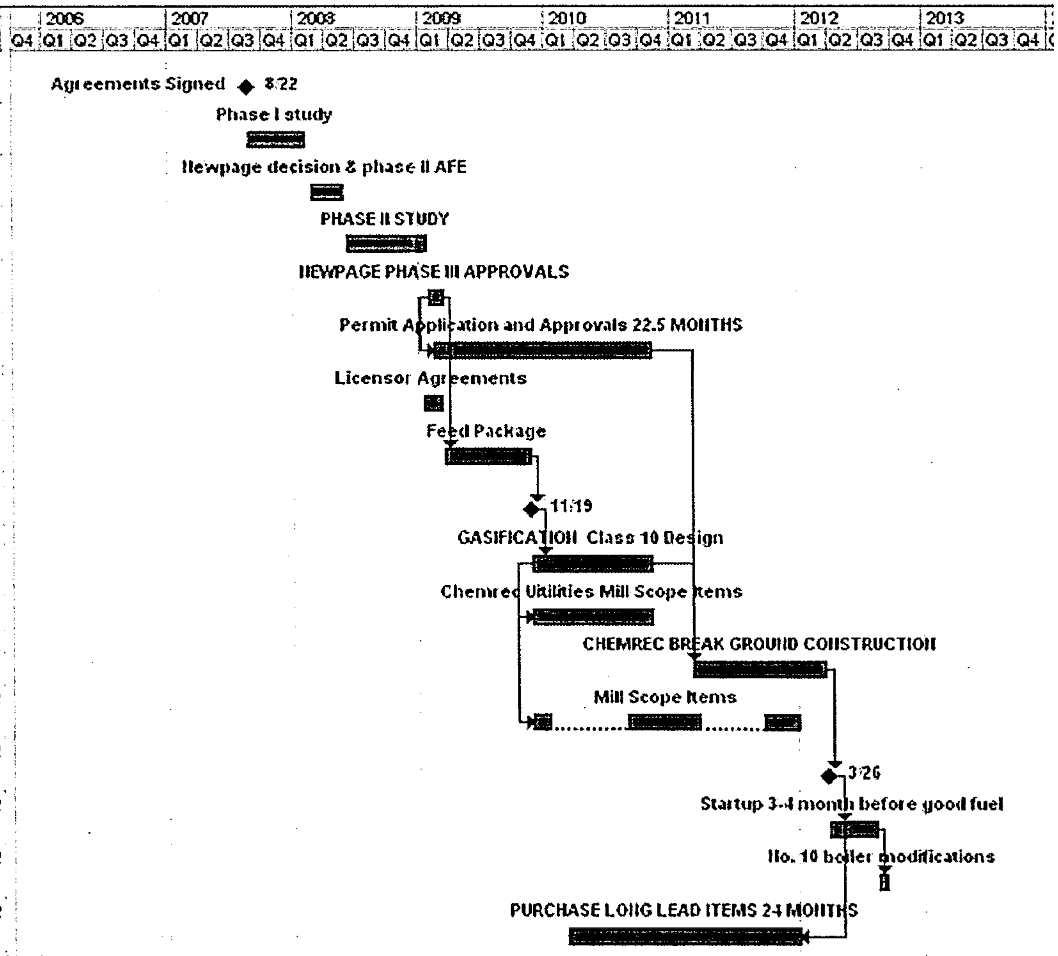
After finalization of the basic design, project approval can be addressed, subject to financing and environmental permits. After that, project execution can start. The total time for project execution is 24-27 months, depending on delivery time for critical equipment such as large compressors, heavy duty pressure vessels, etc.

The schedule in Figure E2 below shows the tentative time schedule for performing the basic design study and the execution of the project.

CI Figure E2: A tentative time schedule time schedule for performing the basic design study and the execution of the project.

Licensor Agreements

Task Name	Start	Finish
Agreements Signed	Wed 8/22/07	Wed 8/22/07
Phase I study	Thu 8/23/07	Mon 2/4/08
Newpage decision & phase II AFE	Fri 2/22/08	Fri 5/23/08
PHASE II STUDY	Tue 6/3/08	Fri 1/23/09
NEWPAGE PHASE III APPROVALS	Thu 1/29/09	Wed 3/11/09
Permit Application and Approvals 22.5 MONTH	Thu 2/12/09	Wed 11/3/10
Licensor Agreements	Mon 1/12/09	Fri 3/6/09
Feed Package	Thu 3/12/09	Wed 11/18/09
NEWPAGE FINAL DECISION TO PROCEED	Thu 11/19/09	Thu 11/19/09
GASIFICATION Class 10 Design	Fri 11/20/09	Thu 11/4/10
Chemrec Utilities Mill Scope Items	Fri 11/20/09	Thu 11/4/10
CHEMREC BREAK GROUND CONSTRUCTION	Tue 3/1/11	Fri 3/23/12
Mill Scope Items	Fri 11/20/09	Thu 1/5/12
STARTUP	Mon 3/26/12	Mon 3/26/12
Startup 3-4 month before good fuel	Tue 3/27/12	Mon 8/13/12
No. 10 boiler modifications	Tue 8/14/12	Tue 9/11/12
PURCHASE LONG LEAD ITEMS 24 MONTHS	Tue 3/2/10	Mon 1/2/12



CAPS

1 INTRODUCTION

The Chemrec/Newpage BLG Plant Feasibility study is the second phase and a continuation of the engineering work of a commercial demonstration scale gasification plant for 500 Mtpd (metric ton per day) of black liquor DS (as dry solids), aimed at the production of renewable automotive fuels integrated with the Newpage Escanaba pulp mill.

In the first phase of the project, pre-feasibility phase 1, which was finalized in January 2008, the indicative cost of investment as well as the plant economics were established to a +/-30% accuracy based on in-house data from a similar project carried out by Chemrec in 2005.

In addition to renewable methanol, the pre-feasibility phase 1 study also evaluated a range of different product alternatives derived from syngas such as ethanol, DME (Di-methyl-ether), Fischer-Tropsch diesel, and synthetic natural gas all produced in a Chemrec pressurized black liquor gasification system. In a product off-take study that was also a part of the pre-feasibility study, methanol turned out to be the most attractive candidate from the renewable fuel alternatives for a demonstration scale implementation in the market taking place in 2011-2012.

An oxygen-blown black liquor gasification unit will handle the recovery of spent cooking chemicals and produce fresh green liquor and in addition produce an energy-rich raw synthesis gas in which the major components are hydrogen (H_2), carbon monoxide (CO) and carbon dioxide (CO_2). The BLG derived raw syngas needs to be cleaned and upgraded and can then be further utilized for the synthesis of all kinds of valuable chemicals, which are currently produced from fossil energy resources but which will be fully renewable as the origin of the black liquor is lignocellulosic material (wood) from forests.

The raw synthesis gas is upgraded by adjusting the H_2 to CO ratio via the CO-shift reaction in a catalytic CO-shift unit. The raw CO-shifted synthesis gas is then cleaned by complete removal of hydrogen sulphide H_2S, carbonyl sulphide COS. Approx 90-95% of the CO_2 is also separated from the syngas in an Acid Gas Removal unit. The removed acid gases are sent to a Sulphur Recovery Unit where the sulphur is recovered as sulphuric acid which then can be used in the pulp mill bleech plant.

Today, methanol is traded as an intermediate chemical feedstock. The global methanol production capacity stands at about 40 million metric tons per year (close to 13 billion gallons). There are ten operating methanol plants in the United States with a combined annual production capacity of nearly 3.7 million metric tons (1.3 billion gallons).

The main objective of the second phase, the project feasibility study, was to establish better accuracy on the investment cost estimate, which has been achieved through basing the estimate on project specific quotations of the units from different candidate vendors for the major units such as: Air separation unit for cryogenic production of pure oxygen, Chemrec gasification unit, Acid Gas Removal, Sulfur Recovery, and finally, the Methanol synthesis unit, which together, form the complete BLGMF plant.

In addition to the plant sub-units, one other important objective of the second phase of the project was to perform a detailed study of the integration system or the BOP (Balance of

Plant). The BOP consists of all the remaining systems, components, and structures that integrate the sub-units into a complete chemical production plant.

At the present time, only budget quotations with +/- 20% cost accuracy were required. It is recognized that the actual specification contains more information than is generally required to generate a +/- 20% cost estimate for a more conventional project feasibility for an N'th type of plant. The reason for this is the nature of the project and the fact that a 500 MtDS BLG plant will be the first of its kind demonstration plant and consist of five sub-units plus the BOP as well as tie-ins and other integration to the pulp mill. Four of the five BLG sub-units are commercially available from different technology vendors and have been used for decades on a large scale in different kinds of industrial applications.

The application of the units in a BLG plant is novel, but a BLG plant will basically be equal to a petrochemical industrial plant running on, for example, residual oil as feedstock. The major difference is the renewable feedstock material. The unit that remains to be demonstrated commercially on an industrial scale is the Chemrec unit, which is the pressurized black liquor gasification process unit. The BLG technology is new but has matured.

Important findings and valuable run-time experiences have been gained in the Chemrec atmospheric air-blown 300 t/d gasification plant in the Weyerhaeuser pulp mill in New Bern, North Carolina that began operation in the mid 1990's and has now accumulated about 60,000 hours. Also, a pressurized oxygen-blown development plant has been in operation in Sweden since 2005 and has logged more than 8,000 operating hours in Pitea. That unit will be the basis for the design and scaled up 25 times.(In brief, there are many similarities between a pressurized and an atmospheric Chemrec gasifier, A 500 t/d pressurized gasifier will be of roughly the same size or even slightly smaller than the 300 t/d atmospheric booster gasifier).

1.1 Project Scope Background

The Newpage Corporation is planning to build a production plant for Methanol (and DME as option) at their site in Escanaba, Michigan, US. The plant is based on Chemrec's design for the gasification of black liquor.

In this study cost of the DME process unit is included and the DME unit is described in the process part. However the process- and utility systems (i.e., BoP) required to support the DME unit are not included in this cost. Furthermore the supporting attachments have not been updated to include the DME capability.

Newpage is considered by many as one of the top paper-making facilities in North America. Today, the company owns 10 strategically located mills in the US and Canada. The Escanaba site produces 2,157 Metric tons of a premium coated two-sided (C2S) quality paper daily.

Due to the growing concern regarding GHG emissions and new attention to the renewable motor fuel market, Newpage is now investigating the potential production of black liquor-based renewable motor fuels such as bio-methanol and DME.

The plant is expected to deliver 18 million US gallons (68,000 m3) of methanol (and as an optional alternative, 15 million US gallons (57,000 m^3) of DME) annually.

The Methanol/DME production plant has the following main process steps:

1. Air Separation unit
2. A. Black liquor gasification and gas cooling
2. B: Green Liquor chemical recovery
3. Synthesis gas CO-shift
4. Acid Gas Removal (AGR)
5. Sulfur recovery
6. Methanol (and DME production as option)
7. Methanol Storage and unloading

1.2 Conditions for Feasibility Study Package

The previous work done on this project is a pre-feasibility study, dated January 22, 2008 and performed by Chemrec. That study has been the starting point for the work done in this feasibility study. All input parameters have been updated and adapted to the specific project.

The majority of the work in this study has been on the Balance of Plant (BOP), which integrates the various units making up the complete BLG plant. The information for the various units has been received from sub-supplier quotations or from budget quotes from potential licensors for the various units. The Chemrec reactor, recovery of green liquor and gas cooling system modeled in 3D with detailed P&Is.

The BOP design is based on the following process unit and mill information:

- Chemrec unit design package, information from Chemrec AB
- Sour shift unit, information from Haldor Topsoe A/S
- Acid gas removal of Rectisol type, information from Linde AG
- Sulfur recovery of WSA type, information from Haldor Topsoe A/S.
- Chemical AA- grade Methanol synthesis, information from Haldor Topsoe A/S
- Air separation unit, information from Linde Inc.
- Mill information according to Battery Limit List, information from Newpage, AMEC and FB Engineering.
- All discussions throughout the project between Newpage and Chemrec/FB Engineering.

1.3 Project scope of supply

This report describes and covers all parts of a new planned BLG plant at the Newpage site in Escanaba, Michigan.

The scope of supply for the BLG plant is everything within the layout for the plant. The battery limits are defined as the outer boundaries for the plant. The interface to the mill is at a point at the pipe-bridge. A more detailed definition can be found in attachments 3, 7, 8 and 9.

1.4 Process unit evaluation

For acquiring information for the feasibility study, a number of "Process unit suppliers" and various technologies have been scanned during the study. The business situation during the study has affected the work. Several potential suppliers have rejected participation in project, indicating lack of resources (too many projects, many of them in China).

In the feasibility study, both Chemrec and FBE experience has been used to identify and evaluate suppliers and technologies.

In this study, the following suppliers have provided information:

Company	Unit	Supplied info
Linde	ASU	Budget quote (20%)
Air Products	ASU	Budget quote (20%)
Chemrec	Gasification unit	15% Estimate
Linde	AGR/Rectisol	30% Estimate
UOP	AGR/Selexol	Detailed technical information
Chemrec/Haldor Topsoe	WSA	20% Estimate
Chemrec/Haldor Topsoe	Shift Converter	20% Estimate
Chemrec/Haldor Topsoe	MeOH	20% Estimate

Construction estimates are based on Chemrec experience. For further information regarding suppliers, see attachment 4.1.

1.5 Codes and Standards

The assumption for the design of the BLG plant shall comply with applicable US laws, standards and directives. The following standards have been used in guiding the work performed in the study:

- The 2006 Michigan Building Code, R408.30401
- ASME B31.3 Process piping, latest edition
- All applicable standards that are well-known within the line of business
- Newpage Standards

2 PROCESS

2.1 Overall Process description

The renewable energy-rich concentrated black liquor, from the Newpage Escanaba pulp and paper mill, is converted into a syngas (synthesis gas) in a Chemrec gasification plant. The raw syngas is then purified and converted to methanol and/or DME.

The process starts in the Chemrec gasification unit, which is an entrained flow, gasification quench reactor where black liquor is partially oxidized with oxygen generated in an air separation unit on the plant site. The thermo-chemical reaction in the Chemrec gasifier reactor is held at 1800°F and 420 psig and will, in addition to syngas, also produce heat and smelted inorganic salts from the spent pulp cooking chemicals in the black liquor. After leaving the gasifier reactor, the product stream of raw gas and melted salts are rapidly cooled by water injection in the so-called quench section located under the reactor. The salts are then also separated from the syngas and the salts fall down into the dissolving part in the bottom of the quench and form fresh green liquor. The green liquor is sent back to the green liquor stabilization tank in the Newpage Escanaba power house while the hot water- saturated laden raw syngas is cooled by raising MP and LP steam before being further processed in the BLG plant.

The syngas from the gasifier may contain very minor amounts of condensable tars. To ensure the function of downstream processes these have to be removed. This is accomplished by letting the syngas pass through an active carbon filter.

In order to obtain a desired relationship between CO and H_2, the syngas is treated in a catalytic CO-shift reactor where the syngas reacts with steam. Further cleaning of the raw syngas is performed in the Acid Gas Removal unit where the gas is stripped of carbon dioxide and sulfur components such as hydrogen sulfide (H_2S) and carbonyl sulfide (COS). The sulfur components are converted to sulfuric acid of chemical grade in the Sulphur Recovery Unit (WSA).. The cleaned syngas is processed into methanol synthesis and distillation. If desired, it is then possible to produce DME from the methanol.

2.2 Process units

2.2.1 The ASU unit

In the air separation unit, ASU, high purity oxygen is produced via cryogenic distillation. The incoming air is compressed by the main air compressor and a portion of the air is further compressed by a booster air compressor. The incoming air is then cleaned by a set of molecular sieves in order to remove all condensable impurities as well as all remaining inherent moisture. The cleaned air is then cooled to very low temperatures by heat exchange in multiple steps using outlet nitrogen waste for cooling.

A part of the air is allowed to expand through a Joule-Thompson expander that will result in the sharp temperature drop that enables the air to finally condense to a liquid. The condensed air is sent to the distillation column(s) where the oxygen is separated from the nitrogen. The liquid oxygen is then pressurized by HP liquid pumping before being evaporated and sent to ASU battery limits. Most of the nitrogen is evaporated at low pressure and then finally vented to the atmosphere.

The majority of the produced oxygen is used in the gasification unit and the rest is exported to the mill to replace the oxygen imported today. The nitrogen is used in the black liquor gasification unit as purge gas both for start up and shut down and in the gas cleaning unit for continuous use for gas stripping. Nitrogen is also supplied for inert gas use throughout the entire plant where needed. The ASU is using quite a lot of cooling water and its main air compressor is by far the largest electric power consumer in the BLG plant. See more in Section 8 Electrical.

As a backup to the ASU, cryogenic storage tanks for liquid oxygen and nitrogen can be installed. LOX (Liquid oxygen) and LIN (liquid nitrogen) can then be supplied from outside via truck transports. Boil-off for both storage tanks could be filled from the ASU depending on the chosen technical solution for the ASU. The LIN tank is needed to supply HP gaseous nitrogen to the BLG but the need of a LOX tank should be questioned and is only needed to cover the pulp mill need of oxygen during a shut-down of the BLG-plant.

More detailed information about the ASU unit is provided in attachments 4.2 and 11.2.

2.2.2 The Chemrec Gasification unit

This core Chemrec part of the BLGMF plant project is named the Chemrec unit and comprises the black liquor gasification unit and all its supply sub-systems as well as the primary cooling (quench), secondary gas cooling in a counter current gas cooler with heat recovery steam generation and the green liquor handling system.

Raw syngas and fresh green liquor are produced when black liquor is gasified, together with oxygen in the entrained flow gasifier quench reactor. The normal operating conditions in the gasifier are approx. 1800 °F and 420 psig (1000°C and 30 barg). In addition to the oxygen, weak wash and gas condensate are used in the gasification process. Natural/fossil gas is needed as fuel for the start up burner.

A brief technical description of the Chemrec gasification unit and its sub-systems can be found in Section 4.1 – 4.3 in the pre-feasibility study dated Jan 2008, "Chemrec BLG Demonstration Plant at the Newpage Paper mill in Escanaba, MI, USA".More information about the gasification unit is provided in attachments 4.6 and 11.3.

2.2.3 Shift unit

In the catalytic CO-shift reactor, the ratio between carbon monoxide, CO, and hydrogen, H_2, in the synthesis gas is adjusted in order to be fully optimized for production of methanol in the synthesis loop. The CO-shift is performed in an environment with carbon dioxide and sulfur components present, a so-called sour CO-shift. IP steam is fed to the raw gas and is part of the chemical reaction. Steam is generated in the unit and the product gas is cooled in a Co-shift reactor loop by preheat of the incoming reactant gases. The final cooling is then accomplished in an air cooler and finally by a water cooler.

More detailed information about the CO-shift unit is provided in attachment 4.5.

2.2.4 Acid Gas Removal - Rectisol

It is necessary to remove all H_2S and COS and most of the CO_2 from the synthesis gas before the methanol / DME synthesis. The removal of these acid gas components is made in an acid gas removal unit of the Rectisol type. Here, the gas is cleaned from sulfur components and carbon dioxide, CO_2, by absorption in a cold methanol. The Rectisol unit consumes LP and MP steam, LP-nitrogen and cooling water. A technical description of the Acid gas removal unit and can be found in Section 4.4 in the pre-feasibility study, "Chemrec BLG Demonstration Plant at the Newpage Paper mill in Escanaba, MI, USA".

More detailed information about Acid gas removal is provided in attachment 4.3.

2.2.5 Sulfur recovery unit - WSA

The sulfur components that are captured together with CO_2 in the Acid gas removal unit need to be converted into a suitable component in order to be recycled back to the pulp mill. The origin of the sulfur is the pulp cooking chemicals in the black liquor. In order to keep the pulp mill sulfur balance at a constant level, sulfur must not be lost, and for environmental reasons, emission of sulfur components has to be kept at a very low level.

Two types of sulfur recovery units have been studied; a Claus process producing elementary sulfur, and a WSA plant (Wet Sulfuric Acid) process producing sulfuric acid of commercial grade. After evaluation, a WSA type of process was chosen.

In the WSA plant, 99.3% of the sulfur is recovered as concentrated sulfuric acid by incineration followed by an exothermic catalytic reaction of SO_2 to H_2SO_4. The plant uses boiler feed water (400 psig steam is produced), cooling water and natural gas for start-up. The sulfur air emissions are estimated to be 365 lb/day (as SO_2).

More detailed information about the WSA unit is provided in the sulfur recovery unit evaluation and in attachment 4.4.

2.2.6 MeOH production unit

In the methanol synthesis and distillation unit, grade AA Methanol is produced from the cleaned synthesis gas. The methanol synthesis takes place at high pressure, at the 1280 psig (88 barg) level. The synthesis gas is compressed by means of a synthesis gas compressor. The synthesis is performed in a boiling water reactor with the catalyst loaded in tubes and boiling water on the shell side for good temperature control of the exothermic reaction.

The crude methanol contains water and traces of reaction by-products. Upgrading of the methanol to grade AA is done in a two-column distillation system.

Saturated 400 psig steam and purge gas are produced while boiler feed water, LP steam, and cooling water are consumed. The waste streams that are produced are methanol synthesis loop purge syngas, (68% H_2, 16.4% CH_4 ,4.5% N_2, 5.9% CO) and flash gas (28% H_2, 24 % CH_4 ,35% CO_2 and 6% CH_3OH), distillation water, liquid off stream, condensate and blow-down.

More detailed information about the Methanol unit is provided in attachment 4.7.

2.2.7 DME production unit

DME can be produced from raw Methanol. In addition to feedstock methanol, steam and cooling water are consumed. During start-up and shutdown, nitrogen is also used. The generated by-products are 400 psig steam, condensate and DME synthesis loop purge gas. The unit also produces a minor waste water effluent stream.

The DME production unit shall be considered as an option in this work.

More detailed information about the DME unit is provided in attachment 4.8.

2.3 Balance of Plant (BOP)

Balance of Plant comprises the equipment and systems, which ***integrate and support*** the various units forming the complete BLG plant.

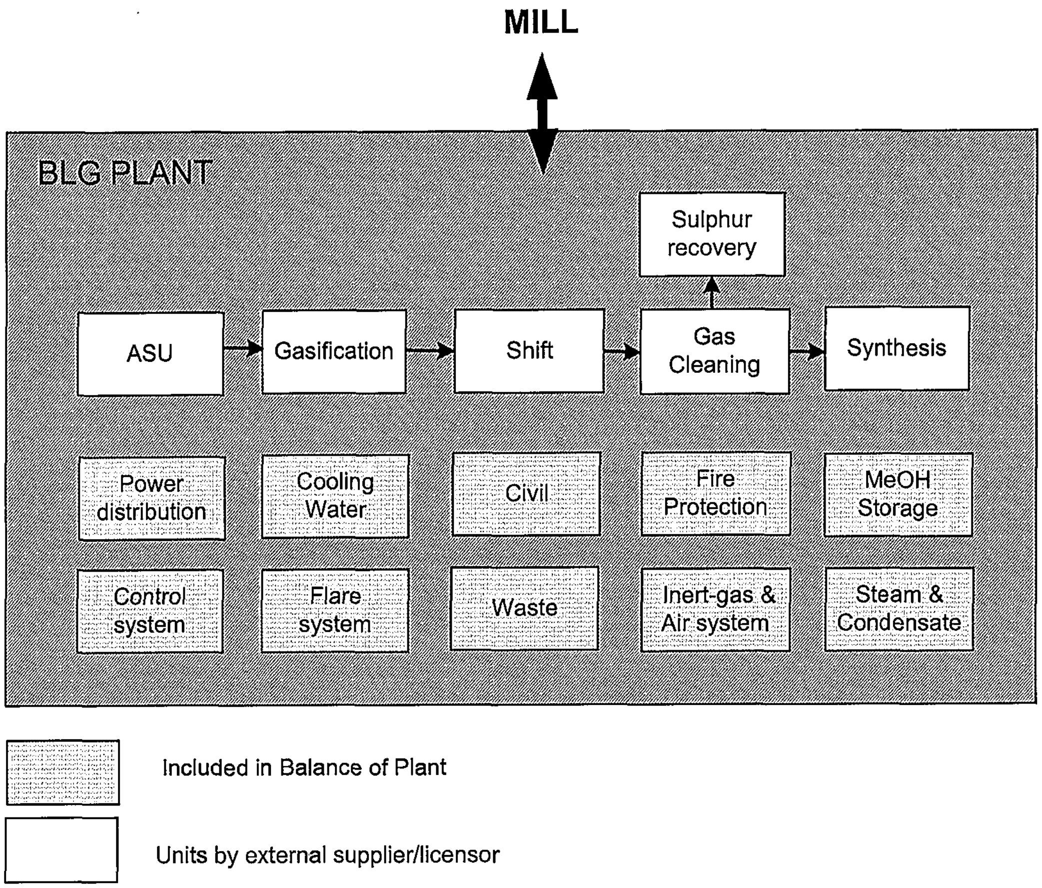


Figure 2.1 Description of balance of plant scope in relation to the process units in the BLG-plant concept.

The systems included in the BOP as shown in the figure above are:

- Methanol storage / load out system
- Cooling water system
- Steam and condensate system
- Flare system
- Waste handling systems
- Inert gas and air system
- Fire protection system
- Power distribution
- Control system
- Foundations and Civil/Structural

For more detailed process information and data see the PFD's for the various systems and processes in attachment 3 and also licensor information about the various units in attachment 11 Major Equipment quotes.

2.3.1 Methanol storage /load out system

The produced methanol from the synthesis unit is treated in the storage area in atmospheric tanks. The methanol stream from the process is first directed into day tanks. After quality control analysis of the methanol, the approved product is directed to a final storage tank for loading on trucks / train for transportation and distribution elsewhere. An off-spec treatment system as well as a methanol supply system's back to mill and AGR unit is included in the design.

2.3.2 Cooling water system

Cooling water is delivered to the process areas in two different qualities and is returned at two different temperature levels. The cooling water from the mill is supplied at low pressure and boosted to the correct pressure within the BLG plant. The major cooling water consumers are the ASU and the final distillation in the methanol synthesis unit.

2.3.3 Steam and condensate system

The steam is delivered from the mill at three different steam levels; LP, MP and IP. Steam is also produced in the process units - LP steam is produced in the gasification unit, MP steam is produced in the methanol distillation and IP steam is produced in the WSA. During normal operation there is a production of LP steam and MP steam and a consumption of IP steam from the mill. De-mineralized water is supplied from the mill. Within the BLG plant the water is de-aerated and boosted to the correct pressure. The condensate is treated in a closed system within the BLG plant.

2.3.4 Flare system

The flare is used for discharge of flammable gases during either start-up/shutdown or emergencies where flammable gases need to be treated to avoid any hazards. Pipes and all the relief valves from the various units are connected to the flare. Natural gas is used as pilot fuel and propane as back-up fuel to the pilot burner to secure the burning of any gases all the time.

2.3.5 Waste handling systems

The various units generate gaseous and liquid waste streams. The waste handling system is designed to handle the gaseous, aqueous and liquid streams separately. Gaseous streams are directed to be burned in the flare system, to be burned in a boiler, to be burned in a waste burner, or directed into the atmosphere if this is acceptable from environmental aspects.

Liquid hydrocarbons are redirected to the gasifier. Salt-containing effluents are recycled to the weak wash /mill liquor system. The other aqueous streams are directed to the existing biological waste water treatment system. All rain water from process areas are handled as waste water. Rain water from other areas like roads, pipe bridges, control and electrical buildings are handled as rain water to a common drain. Waste fire water and foam are handled separately.

2.3.6 Inert gas and air system

The inert gas and air system consists of the inert gas (N_2) and instrument and plant air. The nitrogen gas is provided from a nitrogen storage tank. Nitrogen is delivered to all the process areas from a header. Compressed air is produced in the ASU unit and collected in a buffer tank for safety backup. It can also be provided from the mill for start-up. Instrument and plant air are delivered to all the process areas from two different headers.

2.3.7 Fire Protection system

The fire protection system is designed for handling a fire for each area separately. A shut-down of the BLG plant is made by emergency shut-down or by manual (normal) shut-down. System operation is terminated and no more syngas is produced. A Fire detection system will be installed. All areas need to be cooled during a fire. Cooling of the area will be done by sprayed water. Fire hydrants will cover the areas from two different directions as a minimum. Areas handling flammable liquids that could cause a pool fire will be equipped with foam systems.

2.3.8 Power distribution

The electrical power system for the plant has two high voltage power cables running from one mill source breaker to the 13.8kV switchgear inside BLG. The battery limit for the power system is at the connection point between this 13.8 kV switchgear and the incoming cable. From there it will be split up among three transformer groups:

- One 15MVA transformer to 4.16kV for the biggest consumer objects
- Two 3.5MVA redundant transformers to 480V for the majority of process objects
- One 1.0MVA transformer to a 480/277 V distribution board feeding auxiliary loads.
- A UPS and backup Generator system for critical controls

The power distribution system includes all the electrical equipment to the consumers, including, for example, start up equipment for bigger motors, frequency controllers for pumps, as well as the overall lighting and grounding systems.

Anticipated normal running load is 7.62MW (based on an estimate that 70% of installed power duty for all consumers). The figure based on information from vendors and on nominal flows and pressures was estimated to 7.2 MW as shown in Table 10.3 including a contingency of 500 kW.

2.3.9 Control system

All control and monitoring functions will be implemented in one Distributed Control System (DCS) for the whole production plant. The DCS will include a Human Machine Interface (HMI) between the operators and the process and utilities. The DCS consists of three main parts: operator workplace, process controllers, and remote I/O.

In case the DCS functions are not capable of maintaining the plant within its defined normal operating conditions, a separate dedicated Emergency Shutdown System (ESD) with its defined safety shutdown functions will take action for the purpose of maintaining safety in the plant.

Both the DCS and ESD will have their interface to the different process units at remote I/O cabinets inside the different process units (BLG plant sub-units).

The plant will have a separate control room with all facilities for operation for crews working around the clock. The same building will facilitate the electrical equipment as well. Being the first of its kind plant, it is most important to ensure high comfort with low noise, no vibrations, and with enough space and a good climate (air conditioning) in the local control room.

2.3.10 Foundations and Civil/Structural

The BOP includes the civil engineering aspect with everything from preparation of the site, piling and underground piping to the foundations for the various pieces of equipment in the units. The civil engineering aspect also includes the structural part for the pipes and cables that are distributed around in the overall plant. Additionally, the buildings for the electrical distribution system and the control room are included in the civil engineering elements of the BOP system.

The civil/structural element is highly influenced by the ground and soil conditions for the location of the plant. An analysis of this has been made but deeper investigation is needed to make an accurate engineering and cost estimate.

For more detailed information about civils works, see attachment.10

3 HEALTH, SAFETY AND ENVIRONMENT (HSE)

3.1 Process risk studies

During a feasibility study, the following process risk studies are included:

- Site and type of chemicals handling overall risk assessment
- Safety, Reliability and Maintenance considerations
- Hazop study #1

The overall risk assessment is based on the plot plan, layout and chemicals handled. Also, the impact of the project on the existing environment is studied. This study is the basis for layout work in combining safety and function in a feasible and optimal way.

The safety, reliability and maintenance considerations describe and define the acceptable safety and operability level for the plant. Items taken into consideration include operator knowledge, maintenance planning, rules and regulations, and standards applied. This is the basis for the Hazop studies.

Hazop study #1 is the first study based on PFD and P&ID. This study is performed during the feasibility phase of the project. After defining the level for safety and operability, the design is checked against this level and rerouted to this level. This will also be the basis for the accuracy of the cost estimate.

In this study, due to the planning with time schedule and budget constraints, in a decision was made not to perform a Hazop study and a Risk assessment within this study. A rough risk assessment has been performed for the Chemrec unit but not for the BLG plant as such.

The continued work will initially put more focus on this aspect. The information from the risk assessment and Hazop study should be input to the continued design work.

3.2 Emissions and effluents

3.2.1 Gas and liquids

The gas emissions and liquid effluents from the plant to the environment are:

- Gaseous emissions:
    - Sulfur; mainly as SO_2 and small amounts of H_2S
    - CO_2
    - CO
    - MeOH
    - Other hydrocarbons

- <u>Liquid emissions:</u>
  - Hydrocarbon rich streams
  - Salt- containing effluents
  - Drain water
  - Rain water
  - Fire water
  - Fire water foam

The waste system is designed to handle gaseous, aqueous and liquid streams. The results from the waste handling system (described earlier in the text and also found in attachments) after various treatments are the emissions. Details for the emissions are shown in PFD and P&ID. These documents are the basis for environmental permits. The objective behind the design of the waste systems has been to meet the environmental regulations for the overall mill.

More information is found in attachment 5.0.

3.2.2 Odor

Odor is an critical parameter for this kind of plant. Emissions of sulfur as H_2S should be kept below 5 ppm. One emission stream with possible H_2S odour is the CO_2 vent from the Rectisol unit. Linde's design basis is a unit with a "typical for North America emission level". If this level should exceed a limit of 5 ppm, a sulfur guard bed will be installed. *According to info from supplier the concentration of H_2S is below or equal 2 ppmv.* (The sulfur guard bed is not included in the project scope at this moment.)

3.2.3 Noise

The noise level for the plant is specified to 80 dB at 1 m distance from outside the sound enclosure surface, if any or measuring point. The major noise sources are compressors and pumps. Gas flow at high velocities could also generate high noise levels. Outlets from safety valves are not included in the specification.

The high noise-generating sources will be installed either in sound reducing buildings or will have a sound hood around the actual piece of equipment.

3.3 Fire protection philosophy

CHEMREC

The BLG plant is handling both combustible gases and combustible liquids. The fire protection philosophy and design is in accordance with:

- NFPA Fire protection Handbook and API 2218,
- Fireproofing Practices in Petroleum and Petrochemical Processing Plants
- Mill Insurance Requirements

When a fire occurs, it will be fuel controlled and the area will be cooled. Fuel control will be achieved through an emergency shutdown system. Cooling of the area will be done by water spraying. For fire protection philosophy, see attachment 5.3.

An area classification plan has been made for the plant showing the different hazard zones. The ASU and Liquor storage are non-classified areas. The Chemrec Unit is partly classified. All other process areas are fully classified. For Area Classification documents, see attachment 5.1.

For plant safety reasons, the plant has a fence as outer boundary. There are no fences inside the plant area for CO-leakage areas but the zones where CO-sensors has to be worn are marked with signs. Local CO-sensors and also gas detectors for H_2S, are placed in the plant connected to the safety system.

4 MECHANICAL EQUIPMENT

The following is the description of the detailed work performed for the design and cost estimate for the Balance of Plant for the complete plant.

The information is split up in the areas of:

- Mechanical equipment
- Piping and layout
- Instrument and automation
- Electrical
- Civil and structural steel

This section describes the mechanical equipment included in the project scope of supply.

More detailed information about the mechanical equipment is found in attachment 6.1.

4.1 Active carbon filter

To ensure that the gas has a low level of tars before further downstream processes, an active carbon filter is placed in the gas stream. The filter shall remove most of the tars and particles.

The active carbon filter, 90-C-101, has been specified and technical and cost information has been received from a manufacturer. In the scope, the following is included:

- Filter house in carbon steel
- Active carbon type, Aquacarb 207C
- Tars control

For further information, see in attachments 3 and 11.0.

4.2 Flare

The flare is used for the discharge of flammable gases during either start up/shutdown or emergencies where amounts of flammable gases need to be handled to avoid any hazards.

Information about a self-supported flare (70-M-101) has been received from a manufacturer. The flare tip has a Venturi Flame Holder device for improved combustion. The concentration of H_2S in the syngas is such that NACE standards (National Association of Corrosion Engineers) have to be considered, which means that the cost will be higher than for standard carbon steel materials. The information about the flare contains:

- Self-supported flare stack (28m / 92 ft) with ladders and intermediate and top platforms.
- Flame tip with two pilot burners and Venturi Flame Holder shield
- Purge reduction seal
- Ignition system

See further detailed information in attachment 11.0.

4.3 Heat exchangers

One heat exchanger within the BOP scope of supply is the pre-heater (80-W-200) (for supplementary/temporary preheat during start-up) of the demineralized water to the deaerator. During normal operation, 95-100% of the demineralized water need can be preheated in the Chemrec unit gas cooler and then sent to the deaerator in the BoP. (The remaining demineralized water is needed for BFW-preparation for steam generation in the WSA-plant and MeOH synthesis.

The boiler pre-heater is manufactured according to ASME VIII div 1. The tubes are made of 304 and the shell of carbon steel with painting.

The other heat exchangers in the BoP scope of supply are the evaporators for the liquid oxygen (80-W-101) and liquid nitrogen (80-W-102) and are of standard type and specified by Linde.

More information can be found in attachment 11.0.

4.4 Pressure vessels

Due to the high workload of the manufacturers of pressure vessels it has been difficult to obtain both technical and economical information from the suppliers. The pressure vessels sizes have been dimensioned by the process department using process data and usage of the vessel. The cost estimation program, Aspen Icarus 2006.5, has then been used for the cost figures for the pressure vessels.

The following pressure vessels are included in the BOP scope:

60-B-001 A/B	DME Day Vessel
70-T-101	Knock-Out Drum
80-B-200	Boiler Feed Water Tank
80-B-402	Separation Drum
80-B-601	Compressed Air Buffer Tank
80-B-602	Liquid Oxygen Tank
80-B-603	Liquid Nitrogen Tank

More detailed information about pressure vessels can be found in the equipment list in attachment 6 and in attachment 11.

4.5 Pumps

There are a number of pumps installed in the BOP section of the plant. The pumps handle the transport of media in the process or the transport of media needed as support for the operation.

The pumps handle methanol, DME, cooling water, boiler feed water, condensate, water of various types as well as black and green liquor and weak wash. Chemrec specifically recommends a piston-membrane pump for the high-pressure feeding of black liquor in the Chemrec unit. For pumps in other locations the final pump selection can be discussed with the end-user

Pumps have been specified for the various media. The pumps have mechanical seals and some are designed and manufactured according to API 610. Cost estimates have been made with redundancy at 2 *100% when specified. 2*100% redundancy is recommended not only for the reason to enable maintenance without interruption of operation it is also for minimizing the required down-time. (Replacement of equipment in the black liquor and oxygen feeding system a short plant shut-down will still be necessary in order to switch between A and B equipment.)

More detailed information about the pumps (capacity and power) can be found in the equipment list, attachment 6.

4.6 Stack

A stack is needed to emit the burned gases from the WSA unit at a high level point.

The gases that are coming out of the stack are:

Gas flow:	10000 scf/min (16100 Nm^3/h after 1st revision)
-CO_2	3.09%
H_2SO_4,	5 ppm
Inerts	79.78%
O_2	15.41%
-SO_2,	145 ppm
-H_2O	1.71%

Stack scope:

- 45m / 147.6 feet steel stack. The stack is totally 147.6 feet, divided in three segments for transportation, according to quotation: "Offert 08-2578 FB Engineering AB Michigan USA.doc" in attachment 11/11.0/Stack"
- Load bearing circular casing made of steel S235JRG2. Outer diameter 1.5m / 3.8 feet
- Smoke pipe made of SS2350 inner diameter 0.3m / 1 foot.
- Manhole for cleaning on smoke pipe.
- Ladder on the outside of the stack with safety device.
- Bottom flange for connection to the bolt arrangement in the foundation.
- Bolt arrangement for casting in the concrete.
- Earthing connections. Wires not included.
- Warning lights for airplanes.

A calculation of the stack has been made based on a standard formula. Information is used for a design and cost estimate.

More information can be found in attachment 6.

4.7 Tanks

For the BOP scope of supply there are a number of tanks included for the storage of different media. The tanks will include agitators and heaters depending on media type and need.

Information about the tanks has been received from US suppliers.

The tanks included are:

60-T-001 A/B	MeOH Day Tank
60-T-002	MeOH Storage Tank
60-T-003	MeOH Off Spec Tank
80-T-401	Waste Water Buffer Tank
90-T-101	Weak Wash Tank
90-T-102	Sulphuric Acid (H_2SO_4)Tank
90-T-103	Green Liquor Tank
90-T-104	Wash Tank (Dilute Black Liquor tank)
90-T-105	Black Green Liquor Waste Tank

More information about the tanks can be found in equipment list in attachment 6.

4.8 Other mechanical equipment

Other important types of equipment, which are included in the BOP scope:

- Strainers
- Steam traps
- Valves
- Flame arrestors

All valves and steam traps are listed in the valve list in attachment 7.2.

When the valve type has been chosen, regulations from the petrochemical industry have been used. Newpage has also requested use of certain valves or valve types.

More detailed information of the equipment is found in the equipment list and quotations in attachments 6.1 and 11.

4.9 **Selection of Materials for construction**

The material in the vessels has been chosen depending on what media they will contain. Vessels containing water, DME or Sulfuric acid are made of carbon steel. Vessels with green, black and weak liquors, wash/waste liquid and Methanol are made of stainless steel.

For liquid oxygen and nitrogen, tanks and piping are made of stainless steel. All piping for oxygen gas is made of stainless steel. For nitrogen gas, carbon steel piping is used.

Material in underground piping is based on internal conditions, chemical resistance and installation depth/loading on the top of pipe. Polythene (PE) or polypropylene (PP) is used for the aqua potable, waste water and storm water systems. Manholes can be made of concrete ore PE/PP. Fire water can be made of ductile iron with Tyton joints or PE.

For pipe work and components for the supporting systems, both carbon and stainless steel are used depending on media, according to standards for the type of system.

For further information see the line list in attachment 3.6 and equipment list in attachment 6.1.

5 PIPING AND LAYOUT

5.1 Plot plan selection

During start up of the Feasibility report, three alternative plot sites were identified: a river site, lower site and upper site.

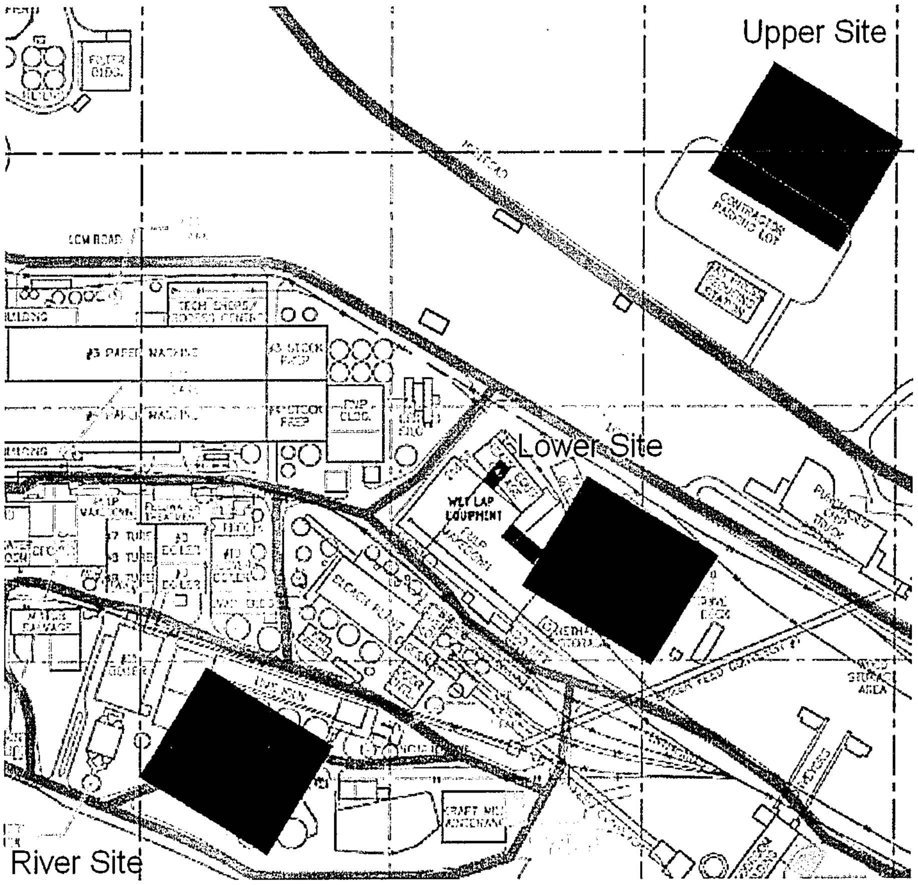


Figure 5.1 showing the map over the different alternative site locations.

The different sites were analyzed based on issues like available space, profile, risk, workflow and further expansion. The analysis resulted in a selection of the upper site for the BLG plant. Both the Lower site and River site were rejected due to available space and further expansion possibilities (among other things).

Further detailed analysis information and evaluation can be found in attachment 7.0.

5.2 **Selected plot plan**

The plot plan has gone through a number of revisions due to updates of various types of information. The sizes of the units have been changed (often increased) due to more detailed information. Limitations from the existing site area have also changed the plot plan.

The following are some assumptions for the plot plan:

Available land area given is limited by "Restricted Covenant Area" north of plant, in combination with existing underground Natural Gas (NG) pipeline, 12" 1200psi as well as NG pressure reducing station south of plant.

Safety distance above ground on both sides of NG-pipeline is 25'.

There is a safety Zone of 200" from each corner of the NG pressure reducing station.

The plant is orientated with consideration to access roads in all 4 directions for construction and maintenance as well as safety/fire fighting.

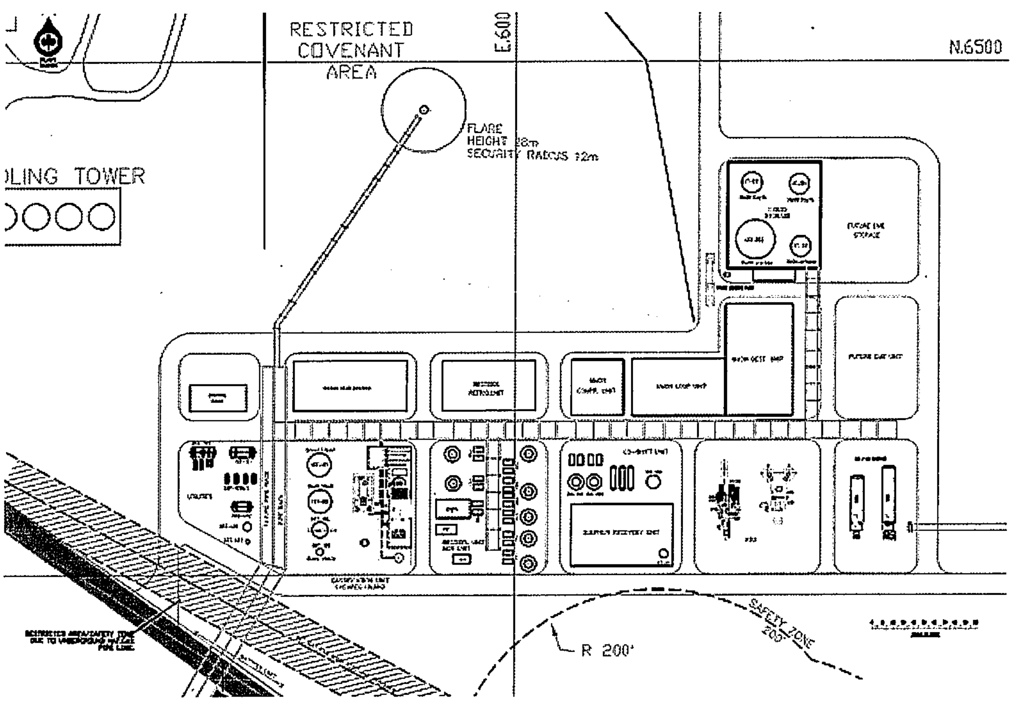


Figure 5.2. The lay-out for the BLG plant including all areas.

5.3 Plant and equipment layout

Detailed layout as above can be found in attachment 7.1

Space required:

Based on the known footprints of various units, as well as indications from potential suppliers, the size of the units has a good margin. When the final footprints are available, the sizes or spacing of the units might be adjusted.

In a late phase of the project, the requirement for more space for cable trenches and auxiliary electrical equipment located outside of the switchgear building came up. This additional clearance of about 5 ft is not implemented in the existing layout.

Another round of discussions about layout and sizes of the units can reduce spare parts for the equipment and therefore, reduce the cost.

Unit location:

With regard to the process flow, the different units are located with main focus on short interconnecting piping as well as safety requirements.

The most flammable liquid storage, MeOH, and future DME-storage, is located north of the plant for safety reasons.

Green liquor/weak wash and waste liquor storage area, named unit 90, is located close to the gasification area. Hans, what do you mean by unit 90. MLI: Unit 90 consists of various tanks that later on, preferably will be a part of the Chemrec unit as it comprises green liquor stabilizer tank, weak wash liquor tanks as well as waste liquor tank (carbon residue/ contaminated GL-tank) ,

Oxygen plant, ASU, with compressors and storage tanks is located furthermost SE in the plant for safety reasons and short piping route from truck loading station.

All units are separated by access roads for maintenance and safety/fire-fighting. Clearance under pipe rack crossings is approximately 15'.

The clearance over the major roadway South of the plant will be 36 feet, this will be part of AMEC scope of supply at the battery limits.

Control room and switch gear buildings are located in the NW corner of the plant for easy access and in close connection for short cable routing.

5.4 Equipment and Piping layout details

The following describes the assumptions and the result for the items included in the equipment and piping layout.

5.4.1 Pipe racks

From the plant Battery Limit, a pipe rack with two levels, at top level 6000mm (20') has been designed. The free clearance below will be approx 15', width 17', and on the west side, cable trays for instrument/power cables to/from Mill. For further information see attachment 7.4.

A two-level main plant pipe rack runs east-west in the middle of the plant with an access road below. The free clearance is approximately 15', width approximately 16'. From this main pipe rack, liquid storage, other units and the flare are connected with smaller pipe racks running N and S.

For safety/fire reasons, construction material for the pipe rack structure will be concrete.

5.4.2 Storage area

The main liquid storage area for MeOH and future DME is located north of the plant for safety reasons, in consideration of the most prevailing wind direction and distance to the process area. The tanks will be built inside a concrete "basin" with the concrete side wall height determined by the largest tank volume +10% of the smaller tank volume, in case of rupture.

The distributing pumps are located outside the "basin" on a concrete slab for safety reasons.

The truck loading station is located near the pumps with access roads from the north, east or west.

5.4.3 Utility area

The utility area is located at the far western edge of the plant. The following equipment is located close to the Control room and comprises the Boiler Feed Water tank with pre-heater and pumps, Cooling Water pumps, Flare, K-O Drum as well as Waste system tanks, pumps and buffer tank. The waste system tanks will be separated from the other utilities by a concrete "basin".

5.4.4 Flare header

For distribution of combustible gases, a main 12" flare header runs through the plant on top of the main pipe rack to the K-O drum. From the K-O drum a 12" header runs northeast on a smaller pipe rack, across the road and up to the flare in "Restricted Covenant Area".

All units and storage areas are connected to the main flare header.

Condensate from the K-O drum is pumped back to an "Off-Spec Tank" in the MeOH storage.

6 INSTRUMENT AND AUTOMATION

More detailed information about controls and automation and instrumentation is found in attachment 8.

6.1 *Control and Security system*

To perform automatic/manual control actions and monitoring functions ONE Distributed Control System (DCS) (with redundancy for controller and power supply) for the whole BLG plant is selected. The DCS shall be comprised of process and utility control, as well as various subsystems. The DCS shall include the main operator interfaces (HMI) between the operator and the process and utilities. In case the DCS functions are not capable of maintaining the plant within its defined normal operating scope, the Emergency Shutdown System (ESD), with its defined safety shutdown functions, shall take action for purposes of maintaining safety in the plant.

The assumption is an open system, which can communicate with the existing Foxboro and Rockwell systems at the Newpage mill in Escanaba.

The DCS is designed for supplying the whole BLG plant. All non-safety instruments and valves in the BLG Plant are connected to the DCS through remote cabinets with distributed I/O.

The DCS consists of three main parts: Operator workplace, process controllers and remote I/O. Communications between remote I/O and process controllers shall be through dual Profibus fiber cables (redundant). For communication between process controllers and operator workplaces, a redundant fiber Network will be used.

The communication protocol between DCS and local control units shall be the project's standard high-speed I/O bus Profibus DP.

Some custom devices communicate directly with controllers such as, for example, compressor devices, intelligent motor control centers and flare supervision. These I/O are not physical I/O but are included in the dimensioning of the control system. The communication protocol between controllers and local control units (package units) shall be the project's standard high-speed I/O bus, Profibus DP

The ESD is a separate system, although it will be integrated with the control system operator interface with regard to common image handling such as the alarm, first up and action information. All ESD, Fire &Gas and Process Shutdown Loops shall be hardwired and the ESD system shall be designed for safety up to SIL3 in accordance with the standards in IEC61508 and IEC61511.

The ESD is designed for supplying the whole BLG plant. All signals needed for the ESD are connected through remote cabinets with distributed I/O.

The numbers of I/O are estimated, except for Chemrec Unit and balance of plant, where I/O calculations are carried out. The total numbers of I/O in the DCS and ESD system are estimated to be 3,500. There can be considerably more fail-safe I/Os in the ESD after the HAZOP risk identification.

The supply of electric power to the BLG plant will have to be imported from the external grid. The BLG plant itself has no opportunity to generate its own power.

6.1.1 Power supply

The power sources consists of UPS power supply at 115VAC/ 60 Hz and this will supply operator stations, process stations (CPU) and all I/O nodes.

All I/O nodes shall be equipped with dual 24VDC power supply units. This power supply shall be redundant and be replaceable under full operating conditions. Each of this power supply shall be designed for 150% of normal consumption.

Field instruments which require external power supplies and other DC consumers will be powered from three independent 24 VDC isolated power supplies. It shall be possible to exchange one of the three power sources during operating.

As backup to the UPS system there will be a diesel powered generator to ensure that the essential equipments are powered at all times.

6.2 Instruments

6.2.1 General requirements for field instruments (level, temperature, pressure, flow)

Below is a list with minimum requirements related to instrumentation for measurements of level, temperature, pressure, flow, etc.

- Protection in accordance with IEC 60529 Code IP 55, as a minimum
- Instruments shall be standardized to as few types as possible to ease maintenance and storage. All wetted parts of instrument shall be in 316L stainless steel.
- Transmitter housings or covers shall be in stainless steel or polyurethane-covered aluminum. Plastic may be used for temperature transmitters.
- Instrument accuracy shall be specified in accordance with the process/equipment requirements.
- Electronic analog transmitters shall be of the smart type.
- Standard analog transmission and control signals shall be 4-20mA with superimposed Hart signal.
- Signals from package units associated with shutdown functions and implemented in the remote safeguarding system shall be analogue 4-20mA with the switching function performed by a safeguarding system (ESD).
- All field-mounted instrumentation, associated valves and junction boxes should be accessible from the grade or permanent platform.

6.2.2 Fire & Gas

The principle for outdoor fire detectors shall be UV/IR or IR/IR flame detectors. Indoors, the fire detectors shall be of the optical smoke detector type.

The gas detectors shall be of the transmitter type with IR-type sensor s.

The calibration for CO gas shall be 0-100% LEL (Lower explosive level).

6.3 Layout and Function of Control Room Building

The Local Control Room, LCR, shall be designed to enable safe operation of the plant, maintenance administration, emergency handling and communication.

The LCR will be the main control room during the start up and during the test period of the BLG plant (approximately two years). This means the LCR shall meet the requirements for working environment HMI and human factors for operation 24 hours per day. The LCR shall therefore be cautiously designed and at a minimum adhere to the following demands:

- That sufficient facilities exist for radio, telephones, signal lamps, etc.,for communicating with the remote control room and other workstations
- Toilets and dressing rooms.
- Acceptable temperature during daytime and at night
- Desks and chairs shall be adjustable
- Computer monitors shall be the same size, at least 24"
- Keyboards are separated and easy to move without sliding
- Environmental safety systems.

7 ELECTRICAL

More detailed information about electrical systems and cables can be found in attachment 9.

7.1 Electrical Design Philosophy

The main electrical design philosophy is one feeder from the Mill to the 13.8kV switchgear. From there, there will be three (3) transformer groups:

- One 15MVA transformer to 4.16kV for the biggest consumer objects
- Two 3.5MVA redundant transformers to 480V for the majority of process objects.
- One 1.0MVA transformer to a 480/277 V distribution board feeding auxiliary loads.
- A UPS and backup Generator system for critical controls

For backup there will be a UPS system for continuous online use and consisting of two units of 40 kVA each and capable of 30 minutes of operation without having to start the emergency backup generator.

There will be an emergency generator feeding the following priority loads:

- UPS system
- Emergency lighting system
- DC voltage system
- Safety shower and eyewash system

7.2 Electrical One line diagram and load philosophy

The battery limit for power feeding the BLG plant, which is marked on drawings in attachment 9.1, is at the incoming circuit breaker for the 13.8kV switchgear.

The Mill specification for motors is as follows:

- For 480V motors up to 200 Hp.

- For 2300V motors from 250 Hp and up to 2500 Hp.
- For 4160V motors over 3000 Hp

The loads for motors are fed from two separate motor control centers (MCC) as shown in the line diagram and electrical consumer list. The voltages used for MCC are 4160V and 480V.

The voltage 2300V is not used and the few motors between 250 Hp to 450 Hp are connected to the 4160V MCC to save cost and space.

The electrical consumer list shows the best possible estimation of loads. The total load has a major impact on the cost for the MCC.

For further Information, see attachment 9.3.

7.3 Electrical Interface assumptions

The interface between Balance of Plant and Process Units, which has an impact on the cost calculation are as follows:

An estimated length from the switchgear building to each piece of driven equipment on the specific unit for the motor cables is included. Installation of motor cables, starter and grounding wire at motor location for all motors is included.

Feeders for lighting, welding outlets and heat tracing are included to the entrance at each unit and do NOT include installation inside each unit.

Installation of cable raceways is included from the battery limit and to each unit. It does NOT include installation inside each unit.

Grounding and bonding wires are estimated for each unit and are included on the cable list.

An estimated amount of light fixtures for the calculated power demand on each unit is included for lighting. Also, an estimated amount of installed power for electrical heat tracing is included.

See electrical consumer list, attachment 9.3, for this estimation.

8 CIVIL AND STRUCTURAL STEEL

8.1 Soil report and Geotechnical Summary

This geotechnical summary is based on the information from previous Soil Investigations performed during installation of standpipes south of the Aeration Lagoon.

The specific borings used for the geotechnical summary are WW 23-92, WW-24-92 and TW-2A-92. The approximate boring locations are indicated in the Soil Boring Plan and the results are shown in attachment 10.1.

In general, the soil layers consist of fine to medium grained sand to a depth of approximately 50 ft (15m), and overlying gravel and silt to the bedrock (Trenton Limestone) at a depth of approximately 82ft (25m). The sand layers are loose to dense and the gravel/silt layers are very dense according to the nearby borings. There are indications that the upper part (13 ft /4m) of the sand layers is a backfilled material. Some of these layers have been classified as peat (PT). Also, wood and roots are found in these layers.

In the nearby borings, the groundwater table was observed at a depth of 40 ft (12m) below ground level.

In this study, and prior to a complementary soil investigation, the following evaluation and recommendations were used.

In general, piled foundations are recommended for all main structures and machinery. For slabs, lightly and uniformly loaded, underground culverts and road structures, it is recommended to surcharge the soil layers to at least the actual ground pressure and that the slabs be designed to a uniform load distribution.

Existing nearby buildings (Cooling Towers) are founded on the sand and it is therefore necessary to minimize the dynamic forces during piling. A piling system with small soil displacement is recommended such as steel profiles or bored steel pipe piles. For the calculation it is recommended to use bored steel pipes driven into bedrock and designed as end bearing piles. Local experience is most important and might provide other solutions.

For frost considerations, it is recommended that the foundations be extended to a minimum of 5 ft (1.5 m below the new ground level). Shallow foundations and paving may be protected from frost penetration by EPS-plates.

During Basic/ Detailed Design, a detailed geotechnical survey shall be performed including the local consultant's experience and local practices.

8.2 Proposed Soil Investigation Program

The location of proposed complementary borings is shown on the attached Soil Boring Plan 10.1. This proposal is not supposed to be used for tendering but must be adapted to US standards and local practice.

The following should be performed to acquire more information about soil and ground conditions:

- Boring no. 1, 5, 8, 11 and 12 shall be a continued boring log and sampling to a 50 ft (15m) depth below ground. SPT tests and split spoon sampling at every meter.
- Laboratory tests including testing of the aggressiveness to concrete and steel.
- Boring no. 2, 3, 4, 6, 7, 9 and 10 shall be as above, but also continued down to and into bedrock. From a 50 ft (15m) depth, SPT tests and split spoon sampling every other meter. The drilling and sampling shall continue, if necessary, into the limestone.

The local consultant may already have experience in pile penetration into the Trenton limestone in this area and the bearing capacity of driven piles with small displacement.

The Soil Investigation Report shall include evaluation of the results and recommendations for foundation of all parts of the plant as well as the design of road pavement structure. For further information see attachment 10.0.

8.3 Site preparation

A general plan of ground works is shown in attachment 10.2.

8.3.1 Terracing

General terracing of the site is based on one level. This gives the most total cost-efficient use of site area as well as good flexibility in layout design and error safe basic conditions for engineering and construction.

General ground drain-off goes from a 2' higher level at the inner part of site along the main pipe rack towards the outer ring road. The ring road cross fall or ditches catch up the ground drain-off on surface.

The calculation is based on terrace level +694.68 feet (+211.7 m).

The ground in the area is proximally terraced so that mass balance is achieved with a small requirement for sorted gravel.

Soil cut 646,000 ft^3 (18,300 m^3) where 318,000 ft^3 (9,000 m^3) is assumed as good for fill.

Soil fill 707,000 ft^3 (20,000 m^3)

Net fill 388,000 ft^3 (11,000 m^3) from nearby site.

Surplus of low quality soil 328,000 ft^3 (9,300 m^3) can be used as surcharge fill and afterwards dumped for landscaping on site.

The levels can be cost-optimized in basic design after proper soil investigation at the site.

Slope 1:4 is recommended. In this mass calculation slope 1:3 is used.

Usable sorted sand and gravel for structural fill and pavement layers are calculated as reachable from a pit/quarry near the site.

Detailed excavation and backfill within process areas for foundations and pipes etc., is not cost calculated.

Uncertainties

Soil properties at the site.

8.3.1.1 Surcharge fill

To minimize long-term deformations in fill areas, a surcharge fill will be placed for a period of at least one month. For the calculation, an extra 3.3 ft (1.0 m) of fill is placed where the new ground level is more than 3.3 ft (1.0 m) above existing ground. The method is also used at lightly loaded parts of concrete slabs and paving. An extra quantity of 5,000 m^3 is needed and used as above in Section 9.3.1.

8.3.1.2 Unsuitable Soils

At shallow foundation and paving, the existing soil shall be excavated to a depth of 5 ft (1.5 m) below the new ground surface and replaced by non-frost active granular soil. As an alternative to soil-replacement, layers of EPS may be used.

8.3.2 Fencing

The whole site is fenced with a 13 ft (4.0 m) high diamond mesh fencing with security overhang. At the south and east side of the site the fence is placed 33 ft (10 m) from the ring road outside to give space for snow handling.

Entrance to the site is provided with opening gates.

Complete ground work for fencing and gates is cost-calculated.

Uncertainties

Automation of gates and traffic support system.

8.3.3 Roads and loading area

Roads and parking is preliminarily dimensioned for:

- Axle loads of 10 tons and bogie axle load of 16 tons.
- Life: 20 years.
- 50 trucks per day.

- Width of outer roads and inner asphalt pavement along main pipe rack totals 19.7 ft (6.0 m). Outer ring road cross section based on 0.82 ft (0.25 m) reinforce strip of gravel + 18.0 ft (5.5 m) asphalt pavement + 0.82 ft (0.25 m) reinforce strip of gravel.
- Width of asphalt pavement between process areas totals 13.1 ft (4.0 m) cross section based on 13.1 ft (4.0 m) asphalt pavement.
- Slope alongside: minimum 1% and cross fall minimum 2%.
- Minimum curve radius: 82 ft (25 m) at thoroughfare for trucks is recommended, normal standard curve radius 66 ft (20 m) low standard.

Parking area for cars: minimum size length 16.4 ft (5 m) width 8.2 ft (2.5 m) is recommended.

Ground works for complete road and asphalt pavement is cost-calculated.

Uncertainties

Predicting traffic movements and loads.

Layout of roads will be affected if large trucks shall drive within the site.

8.3.4 Future DME areas

Gravel pavement is cost-calculated.

More information can be found in attachment 10.4.

8.4 Underground piping Pressurized piping

A general plan for underground piping is shown in attachment 10.3.

8.4.1 Firewater

Detailed excavation, backfill, pipes and fire hydrants with manually operated fog/ jet water/ foam monitors are cost-calculated within the site area and outside to connection to main system.

More information can be found in attachment 10.4.

The network is laid as a closed loop and has isolation valves to divide the system in sections. The network is connected to the main fire water system at the Newpage plant

Uncertainties

Should design incorporate provisions for drainages of the fire fighting assembly such as dry risers?

Need of extra fire hydrant on the road for connections, or branch to fire hoses?

8.4.2 Drinking water

Detailed excavation, backfill and pipes are cost-calculated within the site area.

More information can be found in attachment 10.4.

8.4.3 O2/N2 culvert

Long distance between O2/N2 storage and truck loading. Detailed excavation and backfill is cost-calculated.

More information can be found in attachment 10.4.

8.5 Underground piping Non-pressurized piping

A general plan for underground piping is shown in attachment 10.3.

Pipe slope is not to be below 0.5 %.

Manholes are positioned at the following locations.

- Maximum 90 m apart.
- At dead ends of mains.
- Where a main sewer header changes direction.
- Where there is an abrupt change in elevation or level.

8.5.1 Waste water

Waste water includes water from toilets, sinks, showers, etc., from the control building.

Detailed excavation, backfill, pipes and manholes are cost-calculated within the site area.

More information can be found in attachment 10.4.

8.5.2 Storm water

Storm water includes water from roofs, building foundation drainage and roads caused by precipitation. Storm water led off by pipes via manholes and/or ditches.

Detailed excavation, backfill, pipes and manholes are cost-calculated within the site area.

More information can be found in attachment 10.4.

Uncertainties

Dimensioning parameters for rain / precipitation.

8.6 Cable trenching

A general plan of main cable trenches is shown in attachment 10.5

Detailed excavation, backfill and warning tapes for process cables are cost-calculated within the site area. Complete ground work for manholes with covers, foundations for lightning masts, and pipes for lightning are cost-calculated within the site area.

More information can be found in attachment 10.4.

8.7 Foundation, Infrastructure and Building design

The following describes some details of the foundations, infrastructure and building designs.

8.7.1 Control room building

The building will be constructed in precast concrete elements or a mix of precast and cast in situ reinforced concrete.

The building will be insulated. The roof will be a built-up roof with a slope of 2 to 4%. Spouts/downpipes will be provided to drain the rainwater to the drainage system.

Interior walls will be of the type, masonry or gypsum.

8.7.2 High and Low Voltage Switch Gear Building

Building

The building will be constructed in precast concrete elements or a mix of precast and cast in situ reinforced concrete.

The building will be insulated. The roof will be a built-up roof with a slope of 2 to 4%. Spouts/downpipes will be provided to drain the rainwater to the drainage system.

Interior walls will be of the type, masonry or gypsum.

A suspended floor is to be provided 2' above the concrete floor slab for installation / wiring purposes.

The concrete floor slab is to be constructed 10' above the ground level. This area under the floor slab is to be used for a cable gallery. This area will be surrounded by a security fence.

Transformers

Each transformer shall be installed inside a bay. Roof and walls (on 3 sides) shall be constructed in reinforced concrete. The bays will be closed with a removable fence provided with access doors.

The transformer bays will be designed with reinforced concrete trenches covered by concrete lids for the cables and with oil pits to capture any leakage of oil from the transformers. The pits shall be designed in order to contain the total volume of the corresponding transformers. The oil pits will be filled with hardcore and provided with a drain connected to an oil interceptor tank.

Emergency generator

The emergency generator unit is to be supported on a piled foundation with a thickness of 3' to 4'. Foundations are to be designed with regard to dynamic loads from vibrations.

8.7.3 Pipe racks

The main pipe rack is to be constructed in precast concrete due to the fact that they are exposed to flammable and/or combustible liquids.

The racks are, where possible, to be founded on the piled slabs of the surrounding structures. The remaining rack columns are to be supported on piled foundations. The racks are provided in two layers for the pipes. The spacing between each column frame is to be 20', and where pipes require an extra support, can be added to reduce the spacing to 10'.

The frames are connected with tie beams at each level.

Typical dimensions: Columns 2'*2', beams and tie beams.

The pipe rack to the Flare will be constructed in structural steel, (lattice girders with a span of 52 – 65 ft (16 to 20 meters), supported on piled foundations.

8.7.4 Tank farms, Liquor and MeOH Storage Area

General

Piled slab foundations. Foundation thickness varies from 1' to 2'6" directly under the tanks. The slabs are constructed with a fall to a pump pit. The slabs are to be surrounded by retaining walls with a height 3'6" and a thickness of 10".

The pumps associated to the tanks outside the retention bay are supported on piled slab foundations with a thickness of 1'. A perimeter wall with a height of 2' is to be provided around the pumps.

MeOH Storage Area

The pump for this area is to be provided with a roof and/or walls (weather protection).

8.7.5 Process Areas: gasification, gas cleaning, sulfur handling and synthesis area

General

Piled slab foundations. Foundation thickness varies from 1' to 2'6" The slabs are constructed with a fall to trenches, which are connected to a pump pit.

Gas cleaning and synthesis area

Dynamic effects due to wind gust are to be considered when designing the foundation for the high columns. The piled foundations for the columns have a thickness of 6' to 8'.

8.7.6 Compressor Units

Dynamic loads from the compressors are to be considered when designing the foundations.

The specific loads for the foundations for the big compressor units are:

- MeOH compressor units, (for 1 MW motor size); Foundation thickness 5'
- ASU Area Compressor, (for 5 MW motor size), foundation thickness 7'

8.7.7 Flare

Elevated flare with the riser supported by cables. The cables are attached to the riser at two elevations and are positioned in a triangular plan.

The riser is to be supported on a piled foundation with a thickness 2'. The cables are attached to non-piled concrete foundations.

The principal sketch for the flare support and foundation can be found in attachment 10.6.

9 MATERIAL AND ENERGY BALANCES

9.1 Introduction

This chapter is a summary of the major energy carriers in the BLGMF plant in order to summarize production and consumption data for the project.

The BLGMF plant has been dimensioned to process 30% of the Escanaba mill black liquor (or 1.102 MMlb/day (500 Mtpd) of black liquor, as dry). The implementation philosophy is hence to reduce the black liquor burning rate in the recovery boiler that was built in early 1970´s and not to increase the overall chemical recovery capacity in the mill.

The most important interactions between the pulp mill and the BLGMF are; the exchange of black liquor used as feedstock for the gasification unit, the recycle of regenerated salts in the green liquor from the gasification plant to the pulp mill. There are also several other process streams that integrate the BLGMF plant to the host mill.

Adding a large production unit in an existing mill will have many influences on the mill operation. One issue to address in this study are the potential gaps and bottlenecks that will arise as a result of changes in steam production, power consumption, increased requirements in the recausticizing area (more lime reburning) and also higher need of cooling water.

The Newpage pulp mill in Escanaba, had (2007) an annual production of pulp of approximately 410 000 short tonnes (372 000 Metric tonnes). For the heat and material balance calculations, the theoretical concentration of 71% in the black liquor has been adapted. The existing black liquor concentration is lower (69%) and the higher concentration was assumed for a planned modification of the mill evaporation unit. In addition, the BLG design calculation is based on an averaged composition of the black liquor and does not account for any alterations that could be expected as a result of switching between hardwood and softwood feedstock in the batch digester pulping process in the mill operation.

9.2 Comments to Performance Estimates of the BLGMF Plant units

9.2.1 Air Separation unit

For the ASU, information has been quoted for a 19015 lb/hr O_2 unit (207 tpd) and the utility consumption data has been reported for this size without down-rating. It should be kept in mind that the estimated O_2 consumption in the Chemrec unit is estimated to be only 16718 lb/hr (182.5 Mt/d), which thus leaves a certain margin. Except for the 6500 -8800 lb/d (3 – 4 MT/d) of O_2 desired from the mill, and in order to reduce investment costs, the ASU should preferably be designed only to meet the O_2 demand in the Chemrec unit.

9.2.2 Gasification unit - Chemrec unit

The Chemrec unit has been designed in a separate feasibility study for a scale-up of the Chemrec unit to demo scale of 500 Mtpd. The Chemrec unit engineering study has been performed by Chemrec in parallel to the Newpage phase 2 Feasibility study. An extract of the Chemrec unit feasibility study will be provided separately in Attachment 4.6.

9.2.3 CO shift unit

The CO-shift unit has been designed by HT (Haldor Topsoe), Denmark. A re-iteration (dated jan 2009) of the syngas quality resulted in a reduced dimension of the CO-shift unit. MB&EB data were updated by HT but cost information remains from first issue of calculations based on a less good synthesis gas specification earlier.

9.2.4 Acid Gas Removal unit – Rectisol

The Acid Gas Removal unit is a Rectisol unit designed by Linde AG based on first issue of input data from CO-shift unit from HT. No iteration or update has been possible at this stage but as the amount of sour gas components is 20 % less it will enable a reduction of Sour stripper columns and related equipment.

9.2.5 Wet Sulphuric Acid plant unit – WSA

The Wet Sulphuric Acid plant is based on technical information from HT. The reiteration of the gasifier syngas quality reduced the amount of incoming sulphur with 45% which is significant and therefore the consumption/production figures for the WSA plant have been adjusted to match the new throughput.

9.2.6 Methanol synthesis and final distillation unit

The methanol and DME as well as final product distillation unit is based on technical information from Haldor Topsoe. The methanol plant is designed for production of IMPCA grade methanol or chemical grade, water-free methanol, which puts high demands on the final distillation*. Consequently, the steam and the cooling water consumption will be high. *According to Topsoe, the steam consumption can be reduced x% by selecting a different column configuration.)* In this study, priority was given to minimize investment cost rather than maximizing the energy conservation. The main purpose of choosing grade IMPCA methanol is to ensure a high value commercial chemical product which can be sold for any purpose on the methanol pool market.

*) *The purpose of the BLG-plant is to produce a renewable fuel methanol suitable as a low additive to gasoline and then fuel grade (99.8% purity) methanol will be sufficient enough. During the 1980's, M85 vehicles were tested in Sweden, the water content was then limited to 0.09%wt, (0.15%wt was also mentioned) Acidity was limited to 0.003%wt. No specific problems related to the water content occurred).*

The first iteration of the syngas quality has resulted in an enhanced production of methanol. The first iteration is based on an improved quality of the raw syngas from the Chemrec. As the production is increased the final distillation unit will become larger.

9.2.7 DME synthesis unit

The DME synthesis unit is based on preliminary technical information from Haldor Topsoe. The DME unit will use methanol from the methanol synthesis prior the final distillation. The DME product will be available as 99.6% purity. As DME is included here as an option only, detailed technical information remains to be provided later.

9.3 Consumption figures, production rates, effluents

9.3.1 Consumption figures and production rates

Values given in this chapter refer to steady-state conditions at full load and 100% production of methanol IMPCA grade. In addition, production of DME is included as an option for purpose comparison only. Focus is put on the cross-boundary streams, i.e. internal steams within specific process units such as the Rectisol are not generally reported.

Raw material, fuels and major utility streams consumed at the BLGMF plant are shown in Table 10.1 below.

Table 9.1 ***Consumption figures, feedstocks and utilities***

Stream description	Unit	Value
Black Liquor feed (as dry)	lb/hr	45930
Black Liquor feed (as dry)	(as MTpd)	500
Weak Wash Liquor	GPM	214
Demineralized water	GPM	114
Cooling water (CW need calc. as Δt18°F)	GPM	5437
Cooling water (CW need calc. as Δt= 42°F)	GPM	2350
Oxygen, to gasifier	lb/hr	16750
O_2 to mill, 99%vol	lb/hr	excl
HP -Nitrogen	lb/hr	n.n.f
Process water	GPM	tbd
Pump sealing water	GPM	tbd
Instrument Air	scf/min	280
Natural gas /LPG to flare	lb/hr	20
Fusel oil (liquid off-stream) from distillation (to be fed to gasifier).	lb/hr	x*

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Production figures for main products and utilities resulting from the BLGMF plant are shown in Table 9.2 Production figures. Liquid and gaseous effluents are presented separately in sections and respectively.

Table 9.2 ***Production figures***

Methanol 100%	lb/hr GPM	x*
DME *[Option]*	lb/hr GPM	x*
Steam condensate return to mill*	GPM	127*
Sulphuric Acid, as 98%wt	lb/hr	x*
Purified and conditioned syngas	MMBtu/hr (H_2+CO lhv)	161.48 (47.3)
**) Value does not include the process water (condensate from the CO-shift unit) which will probably be sent to the Chemrec unit. The CO-shift condensate stream was introduced by the CO-shift supplier after the finalization of the Balance of plant study by FBE and is said to contain small amount of H_2S and dissolved gases.*		

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In Table 9.3 he nominal electricity consumption of the different plant units at the BLGMF plant are listed.

Table 9.3 BLGMF plant electric power consumers

Process unit	**kW_e**
ASU (No LOX production)	x*
Chemrec Unit	x*
Acid Gas Removal unit (including 890 kW as stated as "Refrigeration demand at -40°F")***	x*
Synthesis & distillation (incl. syngas	

compressor)	x*
Miscellaneous (CO-shift= x*kW, WSA= x* kW, BoP= x* kW, Contingency margin= 500 kW)	x*
Total consumption	**7200 kW_e**

***) The stated need of refrigeration means that power needed to supply x* kW of refrigeration, ie., *removal of heat* and which will require approx. x* kW of shaft power

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The dominant BLG plant electricity consumer is hence the ASU. Also, the syngas compressor and the refrigeration unit in the Rectisol plant are large consumers.

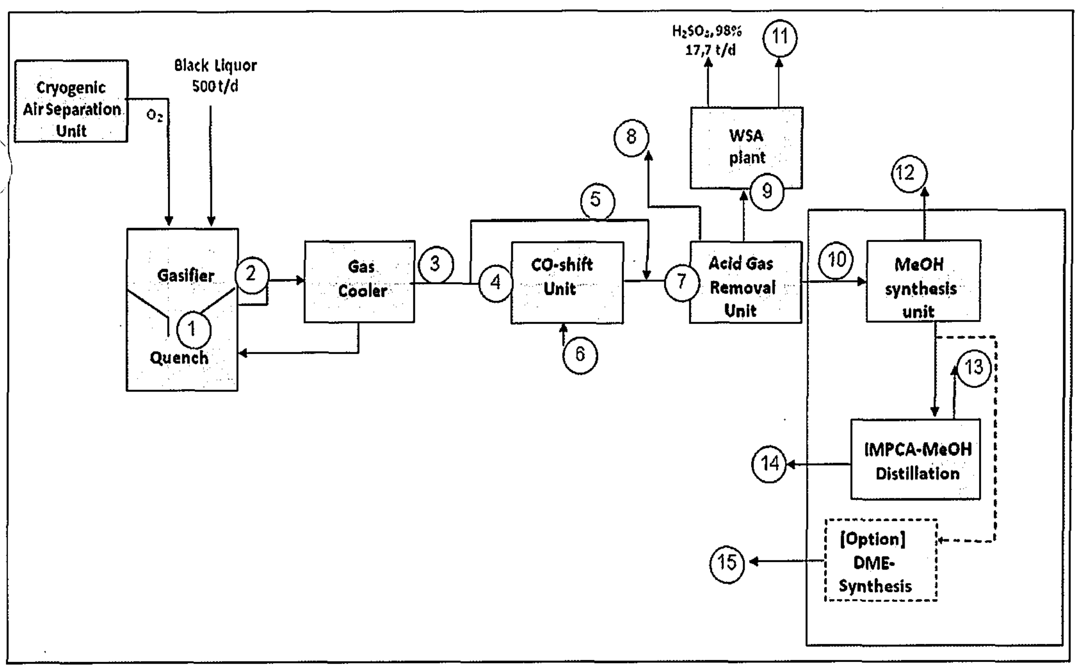

Figure 9.1 A block flow diagram with process notations for relevant process streams for the BLGMF plant with variable production of methanol up to 100% DME. The basis of this scope is the flexibility for a step-wise market introduction of DME as an automotive fuel as the demand gradually increases as the DME fuelled fleet of vehicles is growing.

9.3.2 Gas composition data

Gas compositions for various positions in the process are given in Table 9.4, with numbering according to Figure 9.1.

Table 9.4 *Gas compositions for streams numbered according to Figure 9.1*

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9.3.3 Liquid effluents

Process water drain (condensate from CO-shift, @ 440 psig, 447°F):	x* GPM*
Aqueous off-stream from distillation (to biological treatment):	x* GPM
Higher alcohols from distillation (fed to Chemrec gasifier):	x* lb/hr
Waste water from Rectisol (to biological treatment):	x* GPM

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Table 9.3 Characterisation of combustible gaseous effluents (prior to dilution)

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9.4 Summary of steam producers and consumers

Table 9.4 summarises the steam balance for each and all process units included in the BLGMF plant, showing also the pressure levels.

In Table 9.5 each of the steam qualities are summarised on the respective pressure level. IP and MP steam surplus is expanded and saturated to produce saturated LP steam. Hence, the only steam delivered as shown in Table 9.6. By selecting only one pressure level for steam export, the investment cost is reduced.

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Table 9.5 *Summary of steam producers and consumers (negative sign is consumption figure)*

Process unit	**Pressure [psig]**	**Flow rate [lb/hr] 100%**
Gasification (including BL pre-heating)	175 60	x*
Gas cooling (LMP-steam!)	80 60	x*
Rectisol wash unit	175 60	x*
Water-gas shift	400 60	x*
Wet Sulphuric Acid Plant	400 60	x*
Synthesis and distillation	400 60	x*

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Table 9.6 *Summary of steam production and delivery to New Page Escanaba mill in lb/hr*

	Pressure [psig]	**Flow rate [lb/hr] 100%**
Net steam production	400	(-220)
	175	(-5300)
	80	56880
	60	(-38600)
Net delivery to mill		**12760**

9.5 Efficiencies and yields

The loss of power production from the recovery boiler and the HP steam production has to be compensated for by firing additional biomass and also purchase of electric power from the grid. Depending on the operating mode of the pulp mill and the turbines, the loss of power output from the steam turbine will be mill specific and the required biomass fuel intake in Table 9.7 will have to be carefully estimated by Newpage. The net biomass import is calculated from the difference in steam production that has to be covered, deducting the purge and flash gases gas delivery.

In the lower part of the table, the efficiencies are calculated in two ways. Biomass to fuel considers only the yield of chemicals/fuel, whereas the below figure also includes biomass for power production, covering the internal power requirement. 40% efficiency for the power boiler is assumed. Expressed as equations, the basis is shown below:

$$\eta_{Biomass\ to\ fuel} = \frac{E_{DME} + E_{MeOH}}{biomass\ \ for\ steam} \qquad \left[\frac{LHV}{LHV}\right]$$

$$\eta_{Biomass\ to\ fuel\ (inclpower)} = \frac{E_{DME} + E_{MeOH}}{biomass\ \ for\ steam + \frac{E_{Electric\ power}}{40\%}} \qquad \left[\frac{LHV}{LHV}\right]$$

$$\eta_{BL\ to\ fuel} = \frac{E_{DME} + E_{MeOH}}{BL\ input} \qquad \left[\frac{LHV}{LHV, NHV}\right]$$

Table 9.7 Overall energy balance and efficiencies for the BLG plant production consumption figures. NOTE: *Biomass for power* should be calculated using the electric power efficiency of Boiler no 9 which will be used for firing additional biomass to cover the mill steam and power needs. *For additional electric power* imported from external grid, it is recommended to use an efficiency factor of 1/0.4. Renewable electric power produced in a modern biomass fired boiler will have a power efficiency of approx. 40%.

Production	
Methanol production (LHV)	x* MMBtu/hr
DME production **[option]**	x* MMBtu/hr
Methanol synthesis and flash gas (to boiler#10)	x* MMBtu/hr
Consumption	
Black liquor, LHV	263.4 MMBtu/hr
Additional boiler fuel in the mill	**By Newpage**
Electric power consumption (gross)	7.2 MWe
Steam export to mill	15.35 MMBtu/hr
Energy Efficiencies (LHV basis)	
Biomass to fuel (excl biomass f power)	**TBD**
Biomass to fuel (incl. biomass f power (see NOTE!)	**TBD**
Black Liquor to fuel (Methanol production)	51.9%

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10 PROJECT COST ESTIMATE

10.1 Project cost estimate – general

The cost estimate for the complete BLG plant is made up of the following parts:

Cost for BLG plant sub-units

Included:

- Air Separation Unit
- Gasification unit (Chemrec unit)
- Shift unit
- Acid Gas Removal unit (Rectisol unit)
- Sulfur Recovery unit (WSA unit)
- Synthesis unit (MeOH synthesis unit)

Cost for the Balance of Plant

- Included is the cost for all required support systems with all pieces of equipment including vessels and pumps, piping and valves, instruments, electrical equipment, cables, control system, structure, foundations and pipe-rack, civil engineering including site preparation and roads, etc.

Cost for project and engineering

- Included are the procurement and engineering costs for the project for all units.

Other project costs

- Included are costs for transport, cranes, scaffolding, as well as licensing fees applicable for the various units

Contingency costs and other costs

- As the cost estimate is a +/-20% estimate there are no contingency costs added to the project cost.

10.2 Cost estimate for the process units

10.2.1 ASU

Full budgetary quotations from different suppliers have been received for the ASU.

Included in quotation:

- Equipment items for the plant within the limits of the unit
- Instrumentation and control
- Engineering

Not included in quotation:

- Civil work
- Erection of the plant
- Transportation

A detailed description of the quotation can be found in attachment xx

10.2.2 Gasification unit – Chemrec unit

Preliminary design of the gasification unit has been made as a separate activity by Chemrec. Documentation of the gasification unit will be delivered to Newpage separately.

Included:

- Equipment
- Engineering

- Erection
- License fees

Not included:

- Civil
- Control and automation system
- Transportation

For more information see separate documentation in attachment xx

10.2.3 Gas cleaning unit – Rectisol unit

The cost estimate is supplied by Linde.

Included:

- Equipment
- Engineering
- Transportation
- Control and automation system

Not included:

- Civil
- Construction
- License fees.

For more information see attachment xx

10.2.4 *Shift unit, sulfur handling unit and methanol synthesis unit* – Haldor Topsoe equipment

Information has been supported by Haldor Topsoe for the CO-shift unit, the sulfur handling unit and methanol synthesis unit including distillation.

Included:

- All items

For more information see attachments 4.4, 4.5, 4.7 and 4.8

10.3 Cost estimate for Balance of Plant

The costs for all equipment within the Balance of Plant have been estimated. The costs for equipment have been received from quotes. RFQ (request for quotation) documents have been sent to potential suppliers and a number of quotes have been received. For the cost items where no response has been received, the Aspentech Icarus database has been used to estimate costs.

This database gives all costs for standard type equipment such as pipes, cables, instrument, etc. For the balance of plant equipment, details for installation cost, erection cost, civil work, etc., are included in each item.

The cost estimate for Balance of Plant has been carried out at a very detailed level and the accuracy level for this section is considered to be high, +/- 10% level.

10.4 Other costs

The costs for engineering, procurement and project work, as well as for other costs such as transportation and cranes, it was not possible to make a more detailed cost estimate. Therefore, these costs are estimated from experience values for similar projects and for the sections where experience values are used there is an information gap about the details included. The overall result is acceptable for the +/- 20% cost estimate level.

10.5 Currency exchange rate considerations

The current global financial situation shows very unstable exchange rates for the currencies that are valid for the quoted equipment. Another factor is the price level of raw material that varies a great deal from time to time.

The cost figures for the different sections in the overall cost estimation include costs from both European and US suppliers. Current exchange rates have been utilized in order to establish a final cost figure. The final cost table contains all cost data in their respective currencies and the values can be changed for a sensitivity analysis to reflect the variations in exchange rates.

10.6 Cost level and change

The 2008 volatile situation in the world economy has resulted in high price budget quotes for all kinds of equipment. When the cost estimates were requested in the middle of the 3rd quarter of 2008, prices were still on a high level and then still increasing rapidly. Consequently, the budgetary cost information obtained does not reflect the recent rapid down-turn noted by Haldor Topsoe in the last few months.

The cost for equipment and labor are forecasted to be reduced further during 2009. This should be taken into consideration as sensitivities in the overall cost when deciding on the continuation of the project.

10.7 European and US costs

In order to establish a reliable cost estimate for a project located in the US, efforts have been made to obtain quotes for the US market and from US suppliers. For certain equipment it has been successful and cost data were provided in US dollars. However, even for delivery to a US installation, the cost data from some suppliers are still in local currency such as SEK or EUR. These costs will be influenced by exchange rate variations.

The estimated labor costs are based on Swedish conditions, both regarding engineering and labor rates. In the next phase these costs should be replaced by US estimates.

NOTE: Cost are based on fourth quarter 2008 exchange rates.

10.8 Contingency and escalation considerations

The study objective was to arrive at a +/-20% accuracy in the quotations from the vendors excluding all contingency factors.

Cost escalation has been considered. The phase 1 study was based on Q4 2007 cost level and this phase 2 study related to Q4 year 2008 cost level. Based on the CEPCI index figures the estimate made of the cost escalation is about 3 %, which is where the 2008 level was before the recent drastic down-turn in the global economy has had any impact on costs.

10.9 Accuracy in overall cost estimates

The objective for the overall cost estimate was to arrive at a +/-20% cost accuracy based on Chemrec's work supported by FB Engineering, but before involving a US contractor.

The cost information obtained from the licensors indicates a level of +/- 20% from Haldor Topsoe and a level of +/- 30% from Linde.

The cost for the gasification unit – Chemrec's part – has been estimated at a +/-15% level. However, due to on-going work with the scale-up and final design of both the reactor and the gas cooling equipment, the accuracy level can still be improved. The other parts of the

Chemrec system has a more detailed design, and experience values from the existing test DP-1 (Development plant 1) equipment has added information for a more accurate cost estimate.

The cost for the Balance of Plant equipment is made at a very detailed level with good accuracy. AT +/- 10%. Data and experience from plants with similar equipment exists, along with cost data for the equipment from suppliers or databases. Most of the pieces of equipment are of a standard type, e.g., valves, pipes, cables and instruments not specifically designed for this plant and in these cases standard data can be used.

Due to the reasons mentioned above the overall cost accuracy at this stage of the study is at the +/-20% level, indicating a better precision for the gasification section and the Balance of Plant section, a moderate accuracy for the ASU and a somewhat less accurate level for the gas cleaning section (Rectisol), the Shift unit, the WSA unit and the Methanol synthesis unit (Haldor Topsoe equipment).

10.10 Comparison to earlier study results

The overall investment cost for the BLG plant as the result of this study is 174,4 MUSD.

The above cost includes a DME part in the synthesis unit which enables the production of both Methanol and DME. The cost estimate in the Phase 1 study also included a combined Methanol and DME synthesis and distillation unit.
It should be explicitly notified that the cost estimate for the Balance of plant does not include the full cost for all equipment for utilities and the storage and handling of the DME part, which has to be dealt with in Phase 3.

This cost includes also the site preparation, which was not part of the scope in the Phase 1 study due to the uncertainties with site conditions.

The cost for the plant scope including DME in this Phase 2 study is 166 MUSD. This should be compared to the result in Phase 1, which was 145.2 MUSD.

Base currency values are:

- USD/SEK = 8.10
- EUR/SEK = 10.50
- USD/EUR = 1.30

Although the cost has increased since Phase 1 reporting in January 2008 due to cost escalations for both equipment and manpower, the majority of the increase is for the estimate of the Balance of Plant section. The cost increase for the BOP is caused by higher complexity than expected in the pre-feasibility study of the BOP sub-systems and also a larger area for the plant, which has resulted in longer pipes, cables, pipe-racks, etc. The original cost figure for this was too low, and with all systems now included, the figure has increased by about 18 MUSD.

The table 11.1 (****REMOVED)*** below shows the summary cost items for the overall plant, split up in the various units. The table also shows the estimate in the previous pre-feasibility study.

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Table 10.1 Summary cost items for the overall plant, split up in the various units. The table also shows the estimate in the phase1 pre-feasibility study dated Jan 2008.

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The new cost estimate for the various units within the BLG plant are similar to the figures in the Phase 1 study with some values higher and some values lower giving a 2% higher a sub-total at 139,2 MUSD compared to 135.9 in Phase 1. These cost estimates are in the +/- 20 % level and have to be further discussed with the licensors in order to arrive at a more accurate total value.

The cost items that were evaluated in addition to the above total cost (not included in earlier estimations), and which have required more attention are: soil investigation, piling and excavation, which require quite an extensive effort due to the uphill location with special soil conditions. The total amount for the site preparation is about 8,4 MUSD.

A cost increase of about 3% or 4 MUSD could be expected compared to the figures calculated in the 4th quarter of 2007. However, with the present depressed global financial situation the cost level could decline significantly, but this has not been reflected in the above figures. Another factor that has a strong influence on the cost estimate is the rapid change of the exchange rates for USD, EUR and SEK. The cost estimate is mainly in European currencies. However, some US costs for equipment are included.

10.11 **Possible cost reductions**

The Balance of Plant system has been analyzed to find possibilities to reduce the cost.

The three major items where reduction possibilities are found are:

1. Reduction of layout area
2. Revised design specification
3. Reduced component cost due to economic slowdown

NOTE: Safety and Best Practice must be considered.

10.11.1 Reduction of layout area

The plot plan areas for each unit in the BLG plant have to some extent been estimated. The pre-feasibility study included estimated areas from earlier vendor based information in previous studies. In this study revised layout requirements were obtained for ASU, the

Chemrec unit and the Sulfur recovery unit, but information about the plot plan requirements for the Shift unit, Rectisol unit and Methanol unit are preliminary figures. As a result, the indicated layout area compared to the phase 1 study was increased dramatically.

Our assessment is that most of the layout areas can be reduced at least 25%.

The lay-out in the pre-feasibility study was based on previous work in the two year long RENEW project which at its turn was based on technical information from ALL vendors (Linde, Haldor Topsoe, Claus supplier (Uhde). Looking back, the weaker part of the RENEW study was Balance of plant part of the work..

In the current phase 2 feasibility project that lasted approx 6 months, the plot plan requirements from different vendors was not elaborated to a detailed level.

A revised layout with smaller areas for the units will reduce costs due to:

- *Less site preparation*
- Smaller foundations
- Reduced pipe length
- Reduced cable length and smaller cable sizes without excessive voltage drop

10.11.2 Revised design specifications

A revision of the design specification can have a significant influence on cost due to a reduced number of components or sizes of components. However, the redundancy, plant availability, or operability may be affected as a consequence. Therefore reduced cost has to be evaluated against performance requirement.

We cannot compromise environmental in any way. We have stated many times during our meetings both in person and via teleconference that we do not want the neighbors to our plant to experience any odors or new discharges due to the operation of this new gasification plant.

10.11.3 Reduced component cost due to economic down-turn

When estimating the cost, the price for equipment or standard materials was estimated without any discounts. The price is the standard level or quote level. No discussion about a discount has been made. One example is that no quotes for electric cables were received from a US supplier due to major variations in base material prices.

When the project is executed, a reduced price level should be possible to achieve due to the possibility of coordinated procurement of materials and equipment for all units in the plant.

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11 PROJECT EXECUTION

11.1 Activities

This feasibility study concludes Phase 2 of the project with a +/- 20 % cost estimate for a design of a plant for the specific site at the Escanaba mill and technical information and data from sub-suppliers and licensors, based on specifications for this design. The integration to the mill has been considered in the design of the plant.

The purpose of the next phase of the project is to arrive at an improved accuracy in the basic design and a +/-10% cost estimate as a basis for a board decision for full project execution. This will require

- License agreements with the licensors for the special units as well as their engineering work to produce the basic design package for their respective unit
- An agreement with a contractor to perform the basic design and the +/-10% cost estimate for the overall plant.

The result of the basic design will be utilized to provide information for the board decision. In parallel activities for obtaining a permit and grant funding for the project will be carried out. The permit is essential as there are restrictions regarding starting project execution without approval. The grant funding is of great importance for the funding of the project.

Another simultaneous activity is the product off-take work, which has the objective of identifying off-take agreement options and economics including green credits for the different products.

11.2 Project schedule

The time schedule for the activities for the basic design and the full project execution is shown in the figure below.

The work of the licensors to finalize their task with a basic design package is expected to last about 6 months. The US Consulting Firm (see general comment at the beginning of this report) is assumed to start basic engineering work at the same time as the licensor and will need about 3 additional months for completion of the overall basic design and cost estimate after receiving the information from all licensors. An Estimate from the US Consulting Firm is required be proceeding.

A critical path item can be the availability of the licensors to perform the basic design package. {This can be addressed with the US Consulting Firm as an initial requirement as part of the scope of work and feed package schedule of deliverables) Also, the availability of the selected contractor is of importance for the time schedule.

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In the feasibility phase the licensors have already been involved with supplying information about their equipment and several contractors have been presented the project and are aware of its time schedule.

The time schedule outlines negotiations and agreements with licensors and contractors within a short period in early 2009 followed by the start of the activities in order to be able to have the full project information ready for board approval by the end of 2009.

Execution of the full project is then assumed to go on during 2010 and 2011 with commissioning and startup in the spring of 2012 after a project execution period of 24-27 months.

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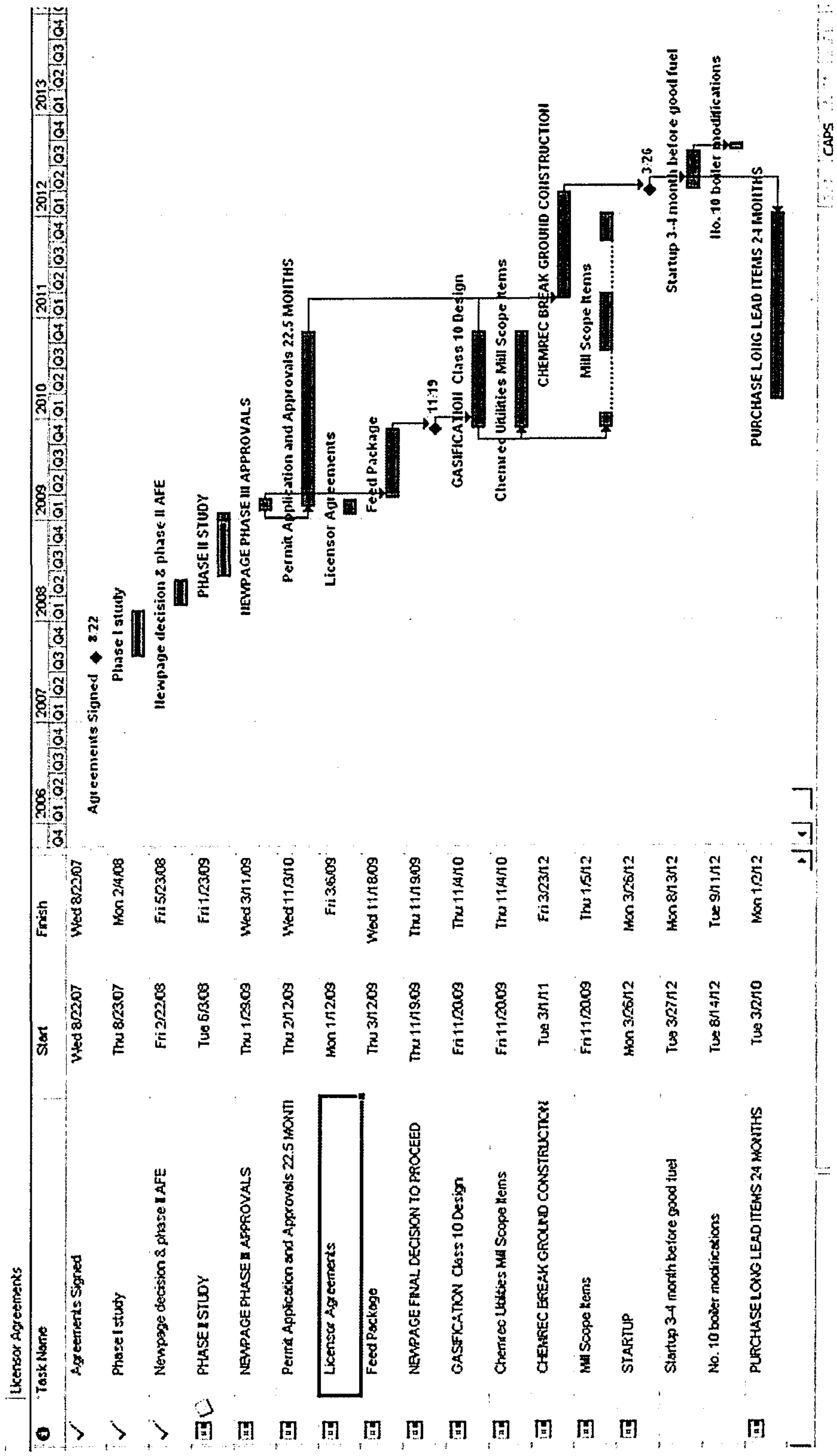

Figure 11.1 A tentative time schedule time schedule for performing the basic design study and the execution of the project.

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ATTACHMENTS

No.	Description	Note
1.0	WBS Structure	N/A
1.1	Project organization	N/A
1.2	Project Overall Schedule	N/A
1.3	Project Cost Estimate	X*
1.4	Project Risk Analysis	N/A
2.0	Feedstock Specifications	X*
2.1	Product Specifications	X*
3.0	Process description BOP	X*
3.1	Block diagram	X*
3.2	PFD incl. material & heat balance	X*
3.3	Process P&ID	X*
3.5	Battery Limit list	X*
3.6	Line list	X*
4.1	Supplier List Process Units	X*
4.2	ASU	X*
4.3	AGR	X*
4.4	Sulfur recovery	X*
4.5	Shift Converter	X*
4.6	Gasification Unit (Chemrec Island)	X*
4.7	MeOH Synthesis	X*
4.8	DME Synthesis	X*
5.0	Emissions, effluents and waste materials, PFD	X*
5.1	Electrical Area classification	X*
5.2	Hazard Study incl. HAZOP	X*

5.3	Fire protection philosophy	X*
5.4	Risk Register for Project	X*
6.0	Mechanical and Process Equipment datasheets	X*
6.1	Equipment list	X*
7.0	Plot plan selection	X*
7.1	Layout	X*
7.2	Valve list	X*
7.3	Piping/layout design sections	X*
7.4	Piping Battery Limit section	X*
7.6	Material Take-off	X*
7.7	Non-destructive test	X*
8.0	Control system layout	X*
8.1	Control and Safety System philosophy	X*
8.2	Emergency Shutdown and SIS philosophy	X*
8.3	Instrument air consumption calculations	X*
8.5	Instrument index	X*
8.6	Layout of Control Room and Equipment Room.	X*
8.7	Instrument cable list	X*
8.8	Instrument Cable layout	X*
8.9	Product data sheets	X*
8.10	Hook-ups	X*
9.0	Electrical design philosophy	X*
9.1	Battery Limit one line diagram	X*
9.2	Electrical Switchgear building layout	X*
9.3	Consumer list	X*
9.4	Electrical equipment list	X*

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9.5	Electrical Cable layout	X*
9.6	Electrical data sheets for major equipment	X*
9.7	Cable routing layout	X*
9.8	Lightning layout	X*
9.9	Grounding layout	X*
10.0	Previous soil investigations report	X*
10.1	Soil boring plan	X*
10.2	Layout road and infrastructure including site preparation and leveling drawing	X*
10.3	Layout underground piping plan	X*
10.4	Sections underground piping and cable trenches	X*
10.5	Cable trench plan	X*
10.6	Flare support and foundation	X*
11.0	Major equipment quotes including evaluation	X*
11.1	Process Unit Evaluation	X*
11.2	ASU unit	X*
11.3	Gasification unit (Chemrec)	X*

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1. EXECUTIVE SUMMARY

1.1. Introduction

NewPage Corporation is planning to construct a commercial Black Liquor Gasification Motor Fuels (BLGMF) demonstration plant designed for 1.0 mmlbds/day of black liquor consumption. The BLGMF Island is defined by the system technology vendor, Chemrec, AB.

The integration of the BLGMF plant within the existing NewPage mill will impact various unit operations in the mill. This study of the balance of plant outside the BLGMF Island identifies projects for potential gaps and bottlenecks that will arise as a result of changes in steam production, power consumption, increased requirements in the recausticizing, evaporators and bark handling areas, and also higher need of cooling water.

1.2. Scope of Project

During the course of the study, the project scope was modified to suit the requirements dictated by the BLGMF plant provided by Chemrec as the process balances were established.

NewPage decided to organize the BOP scope into various projects by specific mill areas. This study is structured as stand-alone areas, with varying levels of definition and capital cost estimate accuracy.

AMEC's study included participation by several parties, including Chemrec, FB Engineering, Jansen and NewPage. Chemrec and FB Engineering have submitted their report and capital cost estimate separately. The contents of this report include "balance of plant" (BOP) scope, for which AMEC was contracted through NewPage. The BOP scope consisted of sub-contract efforts compiled by Jansen, previous estimates compiled by NewPage, and a turnkey quote from A.H. Lundberg Associates. These efforts are incorporated into this report document.

1.3. Summary

The table below represents the breakdown of the various projects, their estimate class and estimated capital expanse and total cost.

No.	Description	Class	Expense	Capital	Indirects	Estimated TIC
1	Lime Mud Drying & Kiln Upgrades	+/-10%	$424,000	$10,099,100	$2,786,100	$13,309,200
2	Causticizer Addition	+/-10%	$197,300	$252,800	$207,300	$657,400
3	Green Liquor Clarifier Feedwell	+/-10%	$21,800	$452,400	$159,400	$633,600
4	Boilout Tank	+/-40%	$54,600	$1,449,000	$571,400	$2,075,000
5	Green Liquor Stabilization Tank	+/-20%	$57,800	$1,872,300	$733,400	$2,663,500
6	No. 9 Power Boiler Economizer	+/-10%	$172,400	$2,886,000	$810,500	$3,868,900
7	No. 10 Recovery Boiler NCG System	+/-10%	$30,600	$2,295,900	$774,200	$3,100,700
8	No. 9 Power Boiler Air System & Sootblowers	+/-10%	$126,400	$2,546,500	$679,000	$3,351,900
9	No. 11 Power Boiler Hydrograte & Air System	+/-10%	$73,900	$11,804,400	$3,147,700	$15,026,000
10	No. 10 Recovery Boiler Upgrade	+/-10%	$118,400	$7,754,500	$2,086,400	$9,959,300
11	Evaporator Concentrator	+/-10%	$0	$6,163,400	$1,220,800	$7,384,200
12	No. 9 Power Boiler Ash System	+/-40%	$34,900	$481,100	$196,100	$712,100
13	No. 11 Power Boiler Bark Delivery	+/-10%	$26,500	$2,038,000	$702,800	$2,767,300
14	Woodyard Bark Handling	+/-40%	$12,000	$1,921,000	$735,000	$2,668,000
15	No. 11 Power Boiler Main Steam Line	+/-10%	$47,100	$918,900	$304,800	$1,270,800
16	Sulfur Addition System	+/-20%	$9,500	$153,200	$71,700	$234,400
17	Cooling Tower	+/-20%	$558,500	$1,567,700	$807,900	$2,934,100
18	TDF Feed System	+/-40%	$750,000	$0	$0	$750,000
19	Methanol Rail Car Loading	+/-20%	$101,000	$1,401,900	$571,200	$2,074,100
20	Relocated Heavy Equipment Repair Garage	+/-40%	Deleted	Deleted	Deleted	Deleted
21	Biorefinery Project BOP	+/-20%	$60,000	$9,909,800	$3,788,600	$13,758,400
22	No. 11 Boiler FD Fan	+/-40%	$60,800	$1,157,200	$462,800	$1,680,800
23	No. 11 Boiler Economizer & MDC	+/-40%	$68,400	$3,935,100	$1,521,400	$5,524,900

AMEC SCOPE TOTAL PROJECT COST		$ 96,404,600.00	$ 52,180,000.00	$ 18,001,000.00
Description	Class	Escanaba Mill Scope	Mill Scope WITH bark boiler capacity	Mill Scope in location with only recovery boiler constraint
Kiln Upgrades	+/-10%	$ 13,309,200.00	$ 13,309,200.00	
Causticizer Addition	+/-10%	$ 657,400.00	$ 657,400.00	
Green Liquor Clarifier Feedwell	+/-10%	$ 633,600.00	$ 633,600.00	
Boilout Tank	+/-25%	$ 2,075,000.00	$ 2,075,000.00	
Green Liquor Stabilization Tank	+/-20%	$ 2,663,500.00	$ 2,663,500.00	
No. 9 Power Boiler Economizer	+/-10%	$ 3,868,900.00		
No. 10 Recovery Boiler NCG System	+/-10%	$ 3,100,700.00		
No. 9 Power Boiler Air System & Sootblowers	+/-10%	$ 3,351,900.00		
No. 11 Power Boiler Hydrograte & Air System	+/-10%	$ 15,026,000.00		
No. 10 Recovery Boiler Upgrade	+/-10%	$ 9,959,300.00		
Evaporator Concentrator	+/-10%	$ 7,384,200.00	$ 7,384,200.00	
No. 9 Power Boiler Ash System	+/-40%	$ 712,100.00		
No. 11 Power Boiler Bark Delivery	+/-10%	$ 2,767,300.00	$ 2,767,300.00	
Woodyard Bark Handling	+/-40%	$ 2,668,000.00	$ 2,668,000.00	
No. 11 Power Boiler Main Steam Line	+/-10%	$ 1,270,800.00	$ 1,270,800.00	
Sulfur Addition System	+/-20%	$ 234,400.00	$ 234,400.00	$ 234,400.00
Cooling Tower (-$1MM synergy expected with WE blr)	+/-20%	$ 2,934,100.00	$ 1,934,100.00	$ 1,934,100.00
TDF Feed System (will WE cover this cost)	+/-40%	$ 750,000.00	$ 750,000.00	
Methanol Rail Car Loading	+/-20%	$ 2,074,100.00	$ 2,074,100.00	$ 2,074,100.00
Relocated Heavy Equipment Repair Garage	+/-40%			
Biorefinery Project BOP	+/-20%	$ 13,758,400.00	$ 13,758,400.00	$ 13,758,400.00
#11 Boiler FD Fan	+/-40%	$ 1,680,800.00		
#11 Boiler Economizer and Mechanical Dust Collector	+/-40%	$ 5,524,900.00		

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Cellulosic Based Black Liquor Gasification and Fuels Plant Final Technical Report

October 31, 2012

Final Technical Report

Project Title: Cellulosic Based Black Liquor Gasification and Fuels Plant
Award Number: DE-PS36-08GO18124

Recipient: Escanaba Paper Mill

Project Location(s): Escanaba, Michigan

Project Period: 6/1/2008 to 7/30/2009
Date of Report: October 31, 2012
Written by: Doug Freeman – Principle Investigator
Program Manager: Michael Fornetti – Principle Investigator
Principal Investigators: Michael Fornetti

Subcontractors: None

Cost-Sharing Partners: Michigan Economic Development Corporation
US/Swedish Bilateral Energy Funding Agreement.

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Note: This report has been closely reviewed and does not contain any protected personal information (Protected PII).

Executive Summary:

The Cellulosic Based Black Liquor Gasification and Fuels Plant Project was developed to construct a black liquor to Methanol biorefinery in Escanaba, Michigan. The biorefinery was to be co-located at the existing pulp and paper mill, NewPage's Escanaba Paper Mill and when in full operation would:

- Generate renewable energy for Escanaba Paper Mill
- Produce Methanol for transportation fuel of further refinement to Dimethyl Ether
- Convert black liquor to white liquor for pulping.

Black liquor is a byproduct of the pulping process and as such is generated from abundant and renewable lignocellulosic biomass. The biorefinery would serve to validate the thermochemical pathway and economic models for black liquor gasification. It was a project goal to create a compelling new business model for the pulp and paper industry, and support the nation's goal for increasing renewable fuels production and reducing its dependence on foreign oil. NewPage Corporation planned to replicate this facility at other NewPage Corporation mills after this first demonstration scale plant was operational and had proven technical and economic feasibility.

An overview of the process begins with black liquor being generated in a traditional Kraft pulping process. The black liquor would then be gasified to produce synthesis gas, sodium carbonate and hydrogen sulfide. The synthesis gas is then cleaned with hydrogen sulfide and carbon dioxide removed, and fed into a Methanol reactor where the liquid product is made. The hydrogen sulfide is converted into polysulfide for use in the Kraft pulping process. Polysulfide is a known additive to the Kraft process that increases pulp yield. The sodium carbonate salts are converted to caustic soda in a traditional recausticizing process. The caustic soda is then part of the white liquor that is used in the Kraft pulping process.

Cellulosic Based Black Liquor Gasification and Fuels Plant project set out to prove that black liquor gasification could produce transportation fuels and produce pulp at the same time. This has the added advantage of reducing or eliminating the need for a recovery boiler. The recovery boiler is an extremely expensive unit operation in the Kraft process and is key to the chemical recovery system that makes the Kraft process successful. Going to a gasification process with potentially higher energy efficiency, improve the pulping process and be more efficient with the use of wood. At the same time a renewable fuel product can be made.

Cellulosic Based Black Liquor Gasification and Fuels Plant progressed with the design of the mill as Chemrec continued to work on their pilot plant data gathering. The design information helped to guide the pilot plant and vice versa.

In the end, the design details showed that the process was technically feasible. However, at the relatively small size of this plant the specific capital cost was very high and could only be considered if the pulp operation needed to replace the recovery boiler. Some of the reasons for the costs being high are attributed to the many constraints that needed to be addressed in the pulping process. Additionally, the Methanol product did not have a vehicle fuel supply chain to enter into. A different product selection could have eliminated this issue. However, with the

selected design, the installation at Escanaba Paper Mill was not economically feasible and the project was not pursued further.

Investigations Conducted to Better Understand the Process

Over the course of the project, xxx major investigations were undertaken to increase the project's understanding of the process and are discussed below:

1. The first investigation was done to develop a FEL-2 level estimate of the Cellulosic Based Black Liquor Gasification and Fuels Plant. This work indicated that there was potential for this type of facility to be economically attractive at Escanaba Paper Mill.

2. As the second investigation, the pilot plant was used. The pilot plant efforts used black liquor at the Piteå, Sweden to test the ability of the gasifier to effectively convert black liquor. These tests were successful, however, the down stream processing of the synthesis gas was not tested.

3. The third investigation was done in conjunction with AMEC to determine the design, location and cost of Cellulosic Based Black Liquor Gasification and Fuels Plant. This work has been submitted to the DOE and a public version is available and is attached to this report.

4. The fourth investigation addressed the in mill work practices and requirements to handle both the products from black liquor gasification and the ability to make up for the energy lost to the process when making Methanol. This work included the estimation of a new biomass boiler at Escanaba Paper Mill as well as other substantial process changes.

5. The fifth investigation was the economics of making either methanol or dimethyl ether. The result of this work was that the methanol market was dominated by low cost, offshore product and was not acceptable for a fuel substitute. Dimethyl ether was shown to be a good fuel substitute, much like propane, but there was no domestic market for this fuel and substantial infrastructure would need to be created to distribute this fuel.

The distribution issues along with the high capital cost lead Escanaba Paper Mill to the conclusion that the project was not feasible in the short term. The project was then terminated.

Technical Effectiveness and Economic Feasibility of the Project

Technically, the project was a success and in showing that black liquor could be successfully gasified. The technologies for the other steps exist, but needed to be tested in the pilot plant. The design was shown to be feasible. The project's Achilles heel was that the capital cost of the project was extremely high, even when compared to the cost of a recovery boiler. Beyond that was the lack of a supply change to market the dimethyl ether product. These issues made the project not feasible to do at Escanaba Paper Mill.

Benefit the Public

Economically, the project would have benefited the residents in the Upper Peninsula of Michigan by securing jobs at Escanaba Paper Mill and associated supply chain. There would have been an increase in the construction trades and engineering work during construction of the facility, thereby increasing the bottom line of any support business. Additional staff would have been hired to operate the facility. A renewable energy system at Escanaba Paper Mill would have been an added benefit that would have contributed to the long term viability of the facility.

Most significantly, the facility would have generated second generation fuels outside of the food chain from a renewable, sustainable resource.

Comparison of the Actual Accomplishments with the Goals and Objectives of the Project:

The primary project goal was to generate a renewable energy from black liquor in an economically feasible way. The second goal was to then replicate the facility in other similar situations across the United States. To support these goals, the following efforts were made to address the DOE barriers thought to be problematic if not addressed.

Another DOE Barrier Im-E: Lack of Industry Standards and Regulations was not found to be an issue for the project. Construction and operation of the plant would be covered under city, state and national permits, and Methanol product characteristics would be regulated by their customers.

The next barrier addressed by the project was DOE's It-C: Risk of First-of-a-kind-Technology. The operation of the pilot plant allowed the project to addressed and mitigate the gasification issue.

Summarize the Project Activities for the Entire Period of Funding:

In June 2007, Cellulosic Based Black Liquor Gasification and Fuels Plant was proposed to Escanaba Paper Mill by Chemrec, Michigan Economic Development Corporation, US/Swedish Bilateral Energy Funding Agreement, and the State of Michigan. From these discussions, a stage gate process of evaluating and testing black liquor gasification to dimethyl ether or methanol was agreed upon with the Escanaba Paper Mill site to be used as the example location to build from.

Cellulosic Based Black Liquor Gasification and Fuels Plant FEL-2 study was done in late December 2007 and this provided enough of a positive outlook to have the project proceed to the next stage.

Cellulosic Based Black Liquor Gasification and Fuels Plant entered into a design period where AMEC was again chosen to develop a Class 10 design and cost estimate. At the same time, Chemrec developed a pilot plant plan at their facility in Piteå, Sweden to do gasification trials using black liquor from an adjacent kraft pulp mill. These trials were done over a several year period of time. These trials only focused on the gasification and did not demonstrate the gas handling.

At the same time, AMEC was completing their Class 16 design an issued a report in June 2009. This report investigated the black liquor gasification process as well as look at the rest of the plant. The balance of plant costs were substantial and included a new boiler.

During the course of the summer of 2009, the issue to product distribution became an important issue. The potential methanol product has a large market, but this is saturated with low cost methanol from stranded fuel sources. While methanol still enjoyed a blender's credit for biofuels at this time it was not included in the standard gasoline specification. The dimethyl ether product has a lot of potential as a fuel replacement like propane and is today a proven diesel fuel, but has no distribution system for the product. These represent significant problems with going to the market. Dimethyl ether was also excluded from the DOE call for proposals 2009.

In June 2009, it became apparent to NewPage Corporation that there was not enough financial incentive for the company to continue to pursue Cellulosic Based Black Liquor Gasification and Fuels Plant and requested a termination of the project.

<u>Identification of Products Developed Under the Award and Technology Transfers</u>

Cellulosic Based Black Liquor Gasification and Fuels Plant did not publish or release any documents other than those provided to DOE for review previously.

Cellulosic Based Black Liquor Gasification and Fuels Plant is mentioned on websites outside of our control. There was no Cellulosic Based Black Liquor Gasification and Fuels Plant website.

<u>Computer Modeling Development</u>:

The Cellulosic Based Black Liquor Gasification and Fuels Plant did not develop computer modeling as part of their project.

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