# Rock-Tenn Renewable Energy Study

## September 29, 2008

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# Acronyms defined

ARI – Alternative Resources, Inc.
AURI - Agricultural Utilization Research Institute
BACT – Best Available Control Technology
BTU – British Thermal Unit
CEC – County Environmental Charge
CEMS – Continuous Emissions Monitoring System
$CH_4$ – Methane
CHP – Combined Heat and Power
CIP – Conservation Improvement Program
CO – Carbon Monoxide
$CO_2$ – Carbon Dioxide
$CO_2e$ – Carbon Dioxide Equivalent emissions
CRP – Conservation Reserve Program
DDG – Dried Distillers Grain
DNR – Department of Natural Resources
EAW – Environmental Assessment Worksheet
EFG – Environmental Finance Group
EIS – Environmental Impact Statement
EPA – Environmental Protection Agency
ESP – Electrostatic Precipitator
EU – European Standards
FBI – Fluidized Bed Boiler
GHG – Greenhouse Gas
HCl – Hydrochloric Acid
HDR – Engineering Firm Formerly Known as Henningson, Durham & Richardson, Inc.
Hg - Mercury
KWh – Kilowatt Hour
LoTOx – Low Temperature Oxidation
MERP – Metropolitan Emission Reduction Plan
MMBTU – 1 Million British Thermal Units (mm = 1000x1000)
MOU – Memorandum of Understanding
MPCA – Minnesota Pollution Control Agency
MW – Megawatt (1 million watts)
$N_2O$ – Nitrous Oxide
NAAQS – National Ambient Air Quality Standards
NOx – Nitrogen Oxide
NREL – Natural Renewable Energy Laboratory
Port Authority – Saint Paul Port Authority
PM – Particulate Matter
PSI – Pounds per Square Inch
RCAP – Rock-Tenn Community Advisory Panel
RDF – Renewable Development Fund
RDF – Refuse Derived Fuel
RRT – Resource Recovery Technologies, Inc.
RTIN – Rock-Tenn Interested Neighborhoods
SCR – Selective Catalytic Reduction
SECIA – Southeast Como Improvement Association
SNCR – Selective Non-Catalytic Reduction
$SO_2$ – Sulfur Dioxide
USEPA – United States Environmental Protection Agency

## Executive Summary

After a year of study and 24 meetings with citizen volunteers participating as members of the Rock-Tenn Community Advisory Panel (RCAP), as well as input from other interested citizens and the City of Saint Paul, the Saint Paul Port Authority is recommending re-powering Rock-Tenn with discount-priced natural gas, utilizing carbon offsets from renewable biogas. The biogas would be produced at an anaerobic digestion facility to be built in out state Minnesota. The anaerobic digestion facility required would be the largest of its kind in the US.

We believe this solution will help:

- ensure that Rock-Tenn's 475 green-collar jobs stay here in Saint Paul.
- improve air quality in the surrounding neighborhoods.
- protect public health.
- advance our energy independence.
- the State fulfill its pledge to reduce global-warming carbon dioxide emissions 15 percent by 2015.
- promote vital economic development in Minnesota's rural communities while meeting urban needs.

This creative solution is not the only outcome of the collaboration of RCAP and the Port Authority on this study. Based upon other work this past year, Rock-Tenn will have decreased its peak energy demand by approximately 23 percent. In addition, the prospect of utilizing waste heat from Rock-Tenn's manufacturing process to supply heat to a major user or potentially more than 300 commercial and industrial buildings along the Central Corridor could offer significant financial and environmental benefits to the businesses and neighborhoods of Saint Paul.

Rock-Tenn's Saint Paul mill is the largest paper recycling plant in the Upper Midwest. It recycles about 1,000 tons of paper everyday, converting much of it to high-value food-grade boxboard for the region's food manufacturers. It employs 475 people in competitive-paying jobs. About 385 of those positions are union jobs.

It also is one of the largest energy users in the Twin Cities, consuming energy equivalent to that used by about 22,000 homes. In August 2007, Rock-Tenn lost its primary energy source when Xcel Energy's High Bridge coal-fired

power plant was shut down. Steam energy from the coal-fired power plant on Shepard Road traveled along 5.5 miles of pipe to Rock-Tenn's plant near Vandalia Avenue. The pipeline cost Rock-Tenn approximately $40 million when it was constructed in 1984. With the closure of the High Bridge plant, Rock-Tenn began burning a mixture of #6 fuel oil and natural gas to power its operations.

The Minnesota Legislature authorized the Saint Paul Port Authority to oversee a $4 million study of renewable fuel options, increased conservation opportunities and how energy from the site could be used to meet the needs of others. For the past year, a group of 15 citizens, called Rock-Tenn Community Advisory Panel (RCAP), advised the Port Authority in its study on conservation opportunities and waste heat usage options and on a variety of renewable fuel and technology options including the combustion of: corn stover and perennial and switch grasses; farm-processing by-products, construction and demolition wood waste; forest residue and urban wood waste; and refuse derived fuel (RDF). The Port Authority and RCAP explored the application of solar and wind power at Rock-Tenn, and assessed energy production using gasification and anaerobic digestion. The Port Authority with RCAP also researched the environmental consequences and potential health effects of each fuel type to the Twin Cities community, as well as the economic consequences of each option to Rock-Tenn.

As noted in the research and findings, technologies and renewable fuels exist, as do environmental controls and monitoring, to assure technical feasibility and minimal public health and environmental impact.

In today's turbulent energy marketplace, however, the most difficult legislative criteria to address relates to "economic viability." The energy market and costs associated with energy are changing continually. Energy accounts for roughly 20 to 30 percent of Rock-Tenn's production costs and changes in energy pricing do affect its business in an increasingly competitive worldwide marketplace. In the past, oil and gas prices have peaked and then receded. Volatility in pricing occurs daily. Construction costs for energy projects have also increased significantly as costs for commodities have soared.

The Port Authority saw the need for an innovative approach to preserve local jobs and a major paper recycling operation in Minnesota while improving energy conservation measures and reducing the carbon footprint of Rock-Tenn's operations. The Port Authority has continued its research of the production of renewable biogas in rural Minnesota utilizing anaerobic digestion. During the study, RCAP and the Port Authority learned of wet feedstocks suitable for digestion including whole and thin stillage from corn ethanol production as well as other wet agricultural and animal by-products that are available. The Port Authority concluded that it was technically

feasible, economically viable and environmentally sound to offset Rock-Tenn's use of natural gas if the price could be discounted through revenues and carbon credits from a biogas facility in rural Minnesota. Therefore the Port Authority recommends the Saint Paul City Council approve the burning of discounted natural gas in Rock-Tenn's existing generators utilizing revenues and carbon offsets from the Port Authority's participation in the development of a biogas-producing anaerobic digestion facility in rural Minnesota. This recommendation involves a number of Minnesota partners to successfully produce sufficient quantities of clean biogas that results in a competitive energy price to Rock-Tenn over a sustained period of time.

It is impractical for the biogas, produced from the anaerobic digestion of a variety of organic waste materials in rural Minnesota, to be piped directly to Rock-Tenn. Instead, the biogas would be cleaned to natural gas quality and piped into the state's existing natural gas pipeline infrastructure. In this way, carbon neutral biogas from rural Minnesota would offset Rock-Tenn's use of natural gas. The production of biogas would be the least polluting of the available fuel options. Biogas emits very little long-term global-warming carbon dioxide harmful to the environment and public health that is not captured during the growth of the organic material utilized as feedstock. Depending on the method and feedstock, anaerobic digestion also provides benefits to the immediate community including management of undesirable waste, significant cleanup of water, and the production of nutrient rich soil for agricultural uses.

This approach also would use the plant's existing boilers and not require construction of a new energy facility at Rock-Tenn. There is a need to continue energy conservation efforts and the Port Authority strongly recommends the implementation of conservation projects identified for the mill. Increased conservation and energy efficiency efforts that Rock-Tenn had engaged in prior to and with the help of this study will also provide real, measurable and long-lasting energy reduction and cost savings.

The Port Authority also recommends further study of harnessing excess waste heat from Rock-Tenn's operations. Such waste heat could potentially be recaptured and recycled to further reduce the mill's operating costs, as well as to heat commercial and industrial buildings along the Central Corridor. The prospect of a Central Corridor energy district can serve as an environmentally sustainable catalyst for the green manufacturing zone envisioned by the Mayor. And it can amplify the environmental benefits of the Central Corridor light rail line.

Multiple "project partners" are needed to successfully implement the Port Authority's recommendations. Business arrangements need to be negotiated with various project partners including feedstock suppliers, technology vendors and operators, gas distributor and other utility support. Together

these partners will be expected to provide a discount from the fluctuating cost of natural gas to Rock-Tenn. The company has indicated that the steeper the discount from the price of natural gas, the longer the company is prepared to commit to operating in Saint Paul.

A number of variables need to align if this option is to be successful – including the sale of carbon credits to supplement the natural gas-price discount and the successful financing of a large anaerobic digester using U.S. Department of Energy, U.S. Department of Agriculture, or other loan guarantees. Our efforts also would require that Rock-Tenn commit to continue operating the Saint Paul plant for at least 10 years after the biogas delivery system is up and running.

Anaerobic digestion of organic waste materials in rural Minnesota is the cleanest and least environmentally disruptive option to the Twin Cities metro area. If all the conditions are met, it also would be the most cost-effective option for Rock-Tenn. The Port Authority is confident that all of the conditions can be met.

However, should the financials of our preferred option not be realized, the Port Authority would explore two other alternatives. Both would involve the construction of new green energy facilities at Rock-Tenn to generate the thermal (steam) energy it needs.

The first alternative would still be linked to the generation of renewable biogas in rural Minnesota and added to the natural gas grid. But we also would build a new gas-turbine co-generation facility at Rock-Tenn powered exclusively by natural gas. This new electric turbine would generate steam to run both Rock-Tenn's machinery and electricity. Sale of the renewable electricity and carbon credits from a biogas facility would reduce the net cost of the thermal (steam) energy sold to Rock-Tenn. Although this would require a greater quantity of biogas than the continued use of the existing boilers, the new cascaded system would be highly energy efficient, the most energy efficient of all of the options, since the new co-generation plant would also continue to use the existing co-generation plant at Rock-Tenn. In addition to construction of a new plant at Rock-Tenn, it would require securing about 60 percent more biogas for offset and negotiating a power purchase agreement with an electric utility.

The Port Authority's second alternative is the gasification of renewable biomass energy crops such as willow, perennial grasses and forest residues at a new facility to be built on the Rock-Tenn campus. This option would require a loan guarantee form the U.S. Department of Energy in the range of $50 million to $70 million. It would require national Farm Bill financial assistance to establish and harvest energy crops on marginal lands, as well as contracts with farm and lumber cooperatives to accumulate these crops. The capital

cost of the gasification system also would need to be refined to the $60 million to $70 million range.

Until a project is financed to meet Rock-Tenn's energy needs, all other options will remain in the event future consideration is needed.

## Findings

Throughout the study, the Port Authority focused on the legislative directive in Senate File 2096 "to present the findings of its analysis and its preferred alternative for an eligible energy technology fuel mix…The recommendation of the Saint Paul Port Authority concerning its **preferred alternative fuel mix must be based on the alternative that has the least environmental impact consistent with economic viability and technical feasibility of the facility**."

These findings have been made by the Port Authority following the completion of the study, and support the Port Authority's recommendations to the Saint Paul City Council, following RCAP review as well as review by the general public at two public meetings and the District Councils' reviews and resolutions:

1. Rock-Tenn needs 2.0 Million MMBtu (annually) and 275,000 Lbs/Hr (peak) of steam but the mill currently cannot utilize all the low grade waste heat generated by the paper making process. This waste heat should be utilized to the extent possible first at Rock-Tenn and then beyond the site at other neighboring facilities or an energy district.

2. The Port Authority strongly recommends continued aggressive implementation by Rock-Tenn of identified energy conservation efforts and will avoid any contract component that would create a disincentive to implement such measures.

3. Multiple technologies have been determined to be technically feasible to meet Rock-Tenn's energy needs including: anaerobic digestion, conventional combustion, and gasification.

4. Sufficient quantities of renewable fuels are available including sustainably harvested wood, refuse derived fuel (RDF), and wet agricultural fuels which can be utilized in an anaerobic digester to produce biogas.

5. All feasible technologies and scenarios being pursued by the Saint Paul Port Authority will significantly reduce greenhouse gas emissions from the mill's current operations.

6. Consistent with the legislative direction to recommend a preferred alternative that has the least environmental impact consistent with the economic viability and technical feasibility of the facility and since the Twin Cities metropolitan area is in attainment, alternatives that require a new facility on the Rock-Tenn site will utilize the U.S. Best Available Control Technology (U.S. BACT) except that the Port Authority agrees to apply air emissions controls that meet European Standards (EU) if more stringent than U.S. BACT.

7. Transportation and other smaller pollution sources have a greater impact on local air quality than controlled emissions from large industrial sources such as Rock-Tenn.

8. For any new facility, the Port Authority will continue to look at additional emission controls to the extent they are economical. The Port Authority will request and pay for additional monitoring sites.

9. A new gasification facility would add on average 36 to 41 trucks per day hauling dry biomass to Rock-Tenn, about a 0.02 percent increase over the more than 225,000 vehicles that currently travel in the area of Highways 280 and Interstate 94.

10. Regardless of the fuel option selected, there is the potential to utilize waste heat generated by Rock-Tenn operations in a district energy system that will require further study.

11. The use of anaerobic digestion as a renewable technology in this country will continue to grow.

12. Anaerobic digestion allows the use of existing infrastructure to link and use rural resources to meet the energy needs of urban areas.

13. Using biogas generated by anaerobic digestion will not only reduce the use of fossil fuels but also reduces the release of methane gas into the atmosphere that is 21 times more potent greenhouse gas than CO2.

14. The Port Authority has found that the use of any of the feasible technologies and fuels would result in lower emissions from the Rock-Tenn facility.

# I. Introduction

*This report reflects the information that was produced for the Study and considered by the Saint Paul Port Authority and the Rock-Tenn Community Advisory Panel. Research and technical memoranda are discussed throughout the body of this report and are included in the appendices for reference. The foundation of the Study rests squarely in the details of these technical and research memoranda. Readers are encouraged to review this information if more detail is desired.*

## A. Study Goal

The Minnesota Legislature tasked the Saint Paul Port Authority ("Port Authority") with recommending a preferred renewable fuel or renewable fuel mix to power a possible new on-site power plant and to ensure continued operations of Rock-Tenn's paper recycling business in Saint Paul, Minnesota. According to statutory criteria, the preferred renewable fuel or fuels should have the least environmental impact while being technically feasible and maintaining the plant's economic viability.
(For more information see Appendix Ia and Ib)

## B. Rock-Tenn's Energy Needs

The Rock-Tenn plant in Saint Paul is located on 42 acres in the Midway Area/St. Anthony Park district of Saint Paul. Rock-Tenn Saint Paul recycled paper since operations began in 1908 (formerly Waldorf Paper Company), and is currently Minnesota's largest paper recycler, processing about 1,000 tons of paper per day.

Rock-Tenn produces about half of Minnesota's and about 1 percent of the nation's recycled paper.

Rock-Tenn Saint Paul is currently the second largest manufacturing employer in the City of Saint Paul, employing 475 people (earning, on average, $60,000 a year). In 1984, Rock-Tenn invested in a steam line to the Xcel Energy High Bridge Power Plant in the City. This connection to the High Bridge Plant provided Rock-Tenn Saint Paul with reliable, economical, and highly competitive, coal-based 725-degree steam for its operations. In its last year of operations, Rock-Tenn's cost for thermal (steam) energy delivered via the steam line was about $16 million.

As a result of the 2003 Metropolitan Emission Reduction Project (MERP), Xcel Energy constructed a new natural gas-fired combined cycle power plant to replace the coal-fired High Bridge Power Plant. The coal-fired

plant was shut down in the fall of 2007, requiring Rock-Tenn to resume full-time operations of its existing on-site power plant to generate its energy needs until a long-term solution is found. The on-site plant is fueled by natural gas and No. 6 fuel oil, and significantly increases the operating costs of Rock-Tenn Saint Paul, affecting its long-term economic viability, and reducing the net positive effect on air quality from the decommissioning of High Bridge from coal by between 30% and 40%. Rock-Tenn expects thermal energy costs of its use of natural gas and fuel oil to be $24 million in its first year since the switch from the discontinued steam pipeline. (For more information see Appendix Ic)

## C. Statutory Direction

Recognizing that the effect of MERP on Rock-Tenn Saint Paul is financially burdensome, and that it is a vital component of the state's recycling infrastructure, the Minnesota Legislature adopted Senate File No. 2096, providing for the Minnesota Department of Commerce to make a $4,000,000 grant to the Saint Paul Port Authority. The Act requires that the Port Authority convene and regularly involve a citizen advisory committee (which in time has become known as the Rock-Tenn Community Advisory Panel (RCAP)) in developing its study recommendations. The Act also requires that the Port Authority:

1. Assess the economic and technical feasibility of various fuel types to power Rock-Tenn Saint Paul.
2. Provide a full description and analysis of each fuel type and their respective economic and non-economic impacts.
3. Provide a full description and analysis of each fuel type and their respective environmental emissions, including carbon dioxide, and the cost of controlling those emissions that affect human health.
4. Describe public subsidies related to the production and use of each fuel type.
5. Describe potential energy efficiency improvement that can be made to the paper-recycling operation and subsidies available for each improvement.
6. Evaluate additional uses for the steam and electricity produced at the facility and the cost of infrastructure needed to implement the additional uses.

The Port Authority grant can also be used for environmental review, permitting, preliminary engineering, development of project cost estimates and a preliminary financing plan.

## D. Establishing the Rock-Tenn Community Advisory Panel (RCAP)

In May 2006, Rock-Tenn Interested Neighbors (RTIN) was formed to share information, promote environmentally progressive energy sources, consider long-term potential health impacts and monitor the planning and permitting of the Rock-Tenn energy proposals in order to protect the common interests of the neighborhoods.

St. Paul District Councils 11-14 and Southeast Como Improvement Association (SECIA) sent volunteers to meet together as RTIN. RTIN met monthly and in November 2006, hosted a public forum. Following this forum, RTIN began to collaborate with Rock-Tenn and Ever-Green Energy (an affiliate of District Energy St. Paul) on the potential structure for a community advisory process. In December 2006, RTIN submitted joint comments to the Minnesota Pollution Control Agency on the Rock-Tenn boiler permit/MOU.

Saint Anthony Park Community Council initiated the formation of RTIN and partnered with other interested neighborhood groups including Hamline-Midway, Desnoyer Park Improvement Association, Merriam Park, and Southeast Como Improvement Association.

Following the enactment of Senate File 2096, RTIN representatives met with the Port Authority and Rock-Tenn to discuss the intent of the new law in terms of membership on the advisory committee and whether or not the Citizen Advisory Committee, as the parties had contemplated, could serve that purpose. After lengthy discussions, a 15-person committee structure to be known as Rock-Tenn Community Advisory Panel (RCAP) was established by consensus of RTIN and the Port Authority. The RCAP was structured to include representatives from Districts 11, 12, 13, and 14, SECIA, Desnoyer Park Improvement Association, a union representative, a Midway Chamber representative, four at large community members, and three alternates.

Demographic statistics for the four Districts in Saint Paul referenced in the law are shown in the table below. Rock-Tenn resides on the Southern border of District 12. (For more information see Appendix Id)

| Demographics of Districts 11, 12, 13 & 14 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| District | 1999 Median Household Income | Individuals Below Poverty Line | Individuals 25 Years or Older with 4-year College Degree | Population Ethnicity | | | | | | Households with No Vehicle | Residents That Did Not Speak English "very well" |
| | | | | *White* | *Asian* | *Black* | *Latino* | *American Indian* | *Multiracial* | | |
| **11** | $38,327 | 13% | 33% | 74% | 5% | 13% | 4% | 1% | 3% | 18% | 5% |
| **12** | $42,586 | 15% | 66% | 81% | 9% | 5% | 3% | <1% | 2% | 12% | 6% |
| **13** | $41,261 | 15% | 51% | 80% | 3% | 10% | 3% | 1% | 3% | 16% | 6% |
| **14** | $56,155 | 5% | 64% | 92% | 3% | 2% | 2% | 1% | 2% | 7% | 2% |
| **St. Paul Average** | $38,774 | 16% | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/a |

An application form for the four at-large members was made available to the public on May 21, 2007, with applications due on June 22, 2007. The application stated the purpose of the RCAP as follows:

**Purpose**

The Rock-Tenn Community Advisory Panel is being established by the Port Authority, in partnership with St. Paul District Councils 11, 12, 13, and 14, to ensure an open exchange of ideas and information about the development of a renewable energy plant to supply the future needs of Rock-Tenn. This panel will engage in frequent, open and transparent discussions so there is understanding of the planning, benefits and risks associated with the proposed energy changes. These include but are not limited to the timeline, fuel oil transition and monitoring, technology and fuel choices, energy market, project economics, air quality and environmental review and permitting. All Rock-Tenn Community Advisory Panel meetings will be open to the public.

Eighteen applications were received. Copies of the applications with a score card for each were distributed to the four district representatives selected for RCAP by their district councils and the selected representatives from SECIA and Desnoyer Park Improvement Association. District 14 had not acted on its representative, so a board member assigned to environmental issues attended in lieu of their selected representative.

On June 26, the representatives met to discuss the applications with the score cards used to focus the discussion. The Port Authority was present to observe the discussion. Following the group's deliberation, recommendations of four at large members and two alternates were

made to the Port Authority. Lorrie Louder, on behalf of the Port Authority, took the recommendations under advisement and indicated that if the Port Authority ultimately made recommendations other than those of the group, she would be willing to return to the group and discuss the members and alternates convened by the Port Authority.

On July 16, 2007, the Port Authority advised the group of the four members it selected along with three alternates. The group accepted the recommendation of the Port Authority and notice was provided to the members of their selection and information on next steps to anticipate as RCAP's work began. Later in the process, Districts 13 and 14 and the Union named John Curry, George Socha and Bob Ryan, respectively, to the panel as alternates to their respective members.
(For more information see Appendix Ie)

**RCAP Members**

Hamline Midway Coalition (District 11) - Randy Schubring

St. Anthony Park Community Council (District 12) - Matt Hass

Merriam Park Community Council (District 13) - Tim Thoreen

Macalester Groveland Community Council (District 14) - Don Arnosti

Desnoyer Park Improvement Association - Chris Jones

SE Como Improvement Association - Bill Kahn (Replaced Justin Eibenholzl)

Midway Chamber of Commerce - Paul McGinley

Unions, United Steel Workers Local #264 - Gerry Parzino

At-Large Members - Shalini Gupta, Bernie Hesse, Mark Thieroff, Tom Welna

Alternates - Ellen Watters, Allan Schultz, Cathy Boies

## E. RCAP Proceedings

All of the RCAP meetings have been documented by meeting minutes available at the Web site, www.rtadvisory.org. Also available on the website are technical memoranda and PowerPoint presentations. The RCAP convened on August 23, 2007. RCAP met 24 times, usually twice a month. The website hosts project documents, frequently asked question guides, research referenced or distributed, presentations made to RCAP at each meeting, and answers to questions posed by the community and Panel from the project team. (Visit www.rtadvisory.org for more information.)

In principle, the panel believes there should be equal duration of public commitment and the commitment of Rock-Tenn.

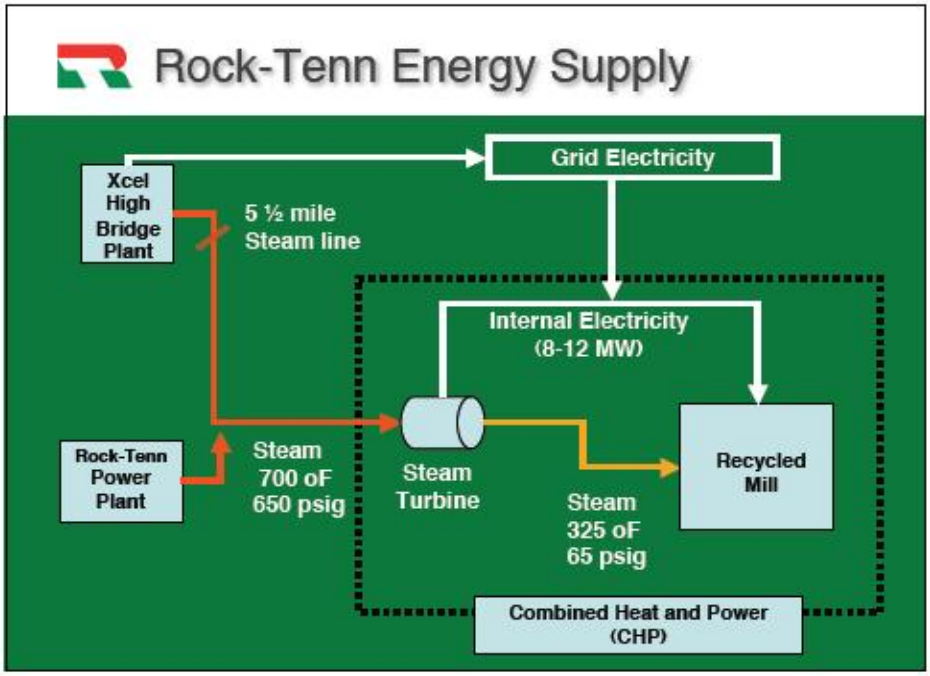
-RCAP Consensus Finding

## II. Rock-Tenn's Energy Demand and Conservation Potential

### A. Historical Energy Usage

The Rock-Tenn mill requires a large amount of thermal and electrical energy to recycle paper. Prior to August 2007, Rock-Tenn utilized steam generated from coal-fired boilers at the Xcel High Bridge Plant and shipped it via a 5.5 mile steam-line to Rock-Tenn. This steam drove a turbine on Rock-Tenn's premises that produced between 8 and 12 MW of electrical energy (enough for nearly half of Rock-Tenn's electrical demand). Once the steam exited the turbine, it was utilized in the recycling process and operations as well as heating the facility buildings. (For more information see Appendix IIa and IIb)

The slide below illustrates the process prior to Xcel High Bridge's retrofit.




### B. Current Energy Needs

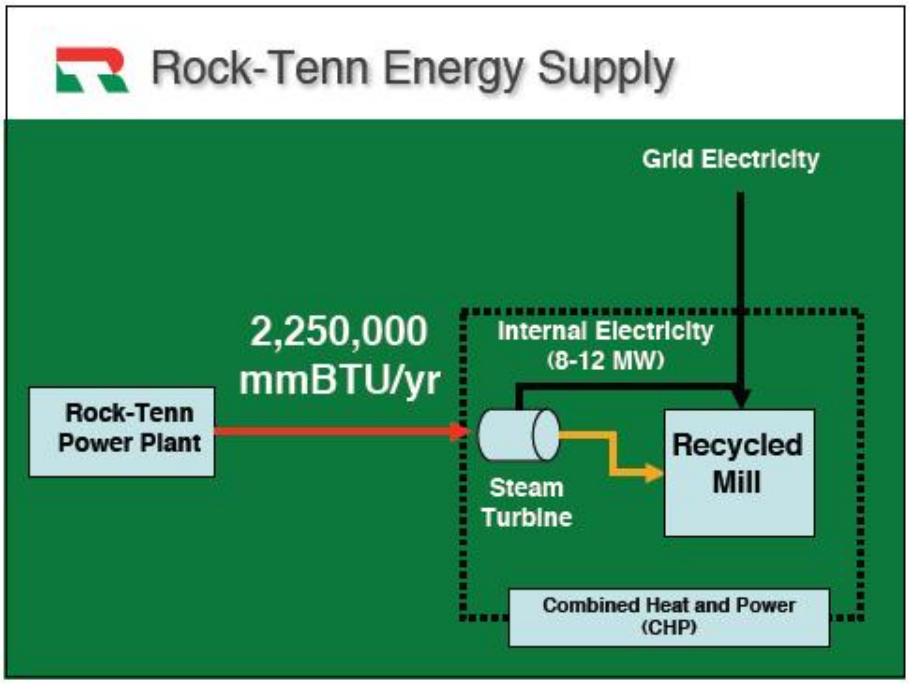
Subsequent to the elimination of the steam service from Xcel's High Bridge Plant in August 2007, Rock-Tenn resumed continuous operations of its on-site power generation facility to produce the necessary steam for the recycling process. This power generating facility consists of four boilers. These boilers were constructed in 1928, 1942, 1947 and 1964. The first three were originally designed to burn coal but retrofitted in 1962 to burn oil. The fourth boiler was designed to burn oil and natural gas. Steam is currently generated from a combination of two of four boilers as weather and demand dictates. This steam is fed into the on-

site turbine and continues through the process in the same fashion as the steam from High Bridge previously took.

RCAP views the search for a cleaner fuel source for Rock-Tenn with a sense of urgency in light of the company's recent increased use of fuel oil and its stated need to lower its projected fuel costs in order to secure the future of the Saint Paul mill.

– RCAP Consensus Finding

The following slide illustrates the process subsequent to the severance of the High Bridge steam line. (Note: The 2,250,000 MMBTU/yr demand has been reduced to approximately 2,000,000 MMBTU/yr through Rock-Tenn's conservation projects.)




Under current operations, the Rock-Tenn mill needs 240,000 lbs/hour of steam at peak demand. This demand is expected to increase to 270,000 lbs/hour of steam within five years. The annual thermal energy needs of the facility are 2,000,000 MMBTU (2,000,000,000,000 BTUs) which is comparable to twice all of Downtown Saint Paul's heating needs.

Historically, paper drying uses 60% of the thermal energy required at Rock-Tenn, heating the buildings on the campus uses approximately 20%, heating the process air uses 15%, and heating the process water uses 5% of the total thermal energy. (For more information see Appendix IIc)

A **BTU** is one British Thermal Unit and a unit of measure that is often used in **thermal** energy applications.

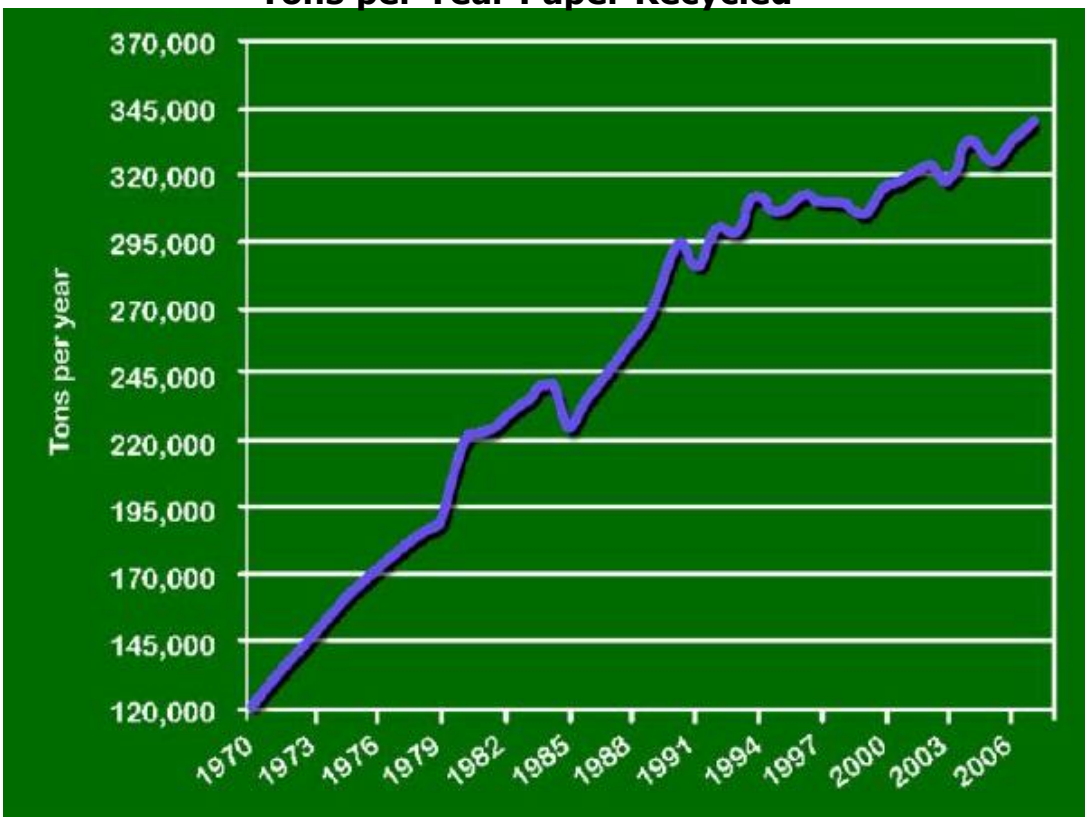
**MMBTU** stands for million BTUs (the M represents the Roman numeral equivalent to a thousand, therefore MM=1000x1000).

A **Watt** is a metric unit of power, usually used in **electric** measurements, which gives the rate at which work is done or energy used. A **Megawatt (MW)** is 1 million Watts.

The Rock-Tenn facility needs 20 MW of electrical power with 8 to 12 MW currently being generated as part of the current generation of steam for the paper recycling process. Remaining electrical needs are met by purchasing from Xcel Energy.

The slide below illustrates the consistent increase in Tons per Year of paper recycled. (For more information see Appendix IIb and IId)

**Tons per Year Paper Recycled**



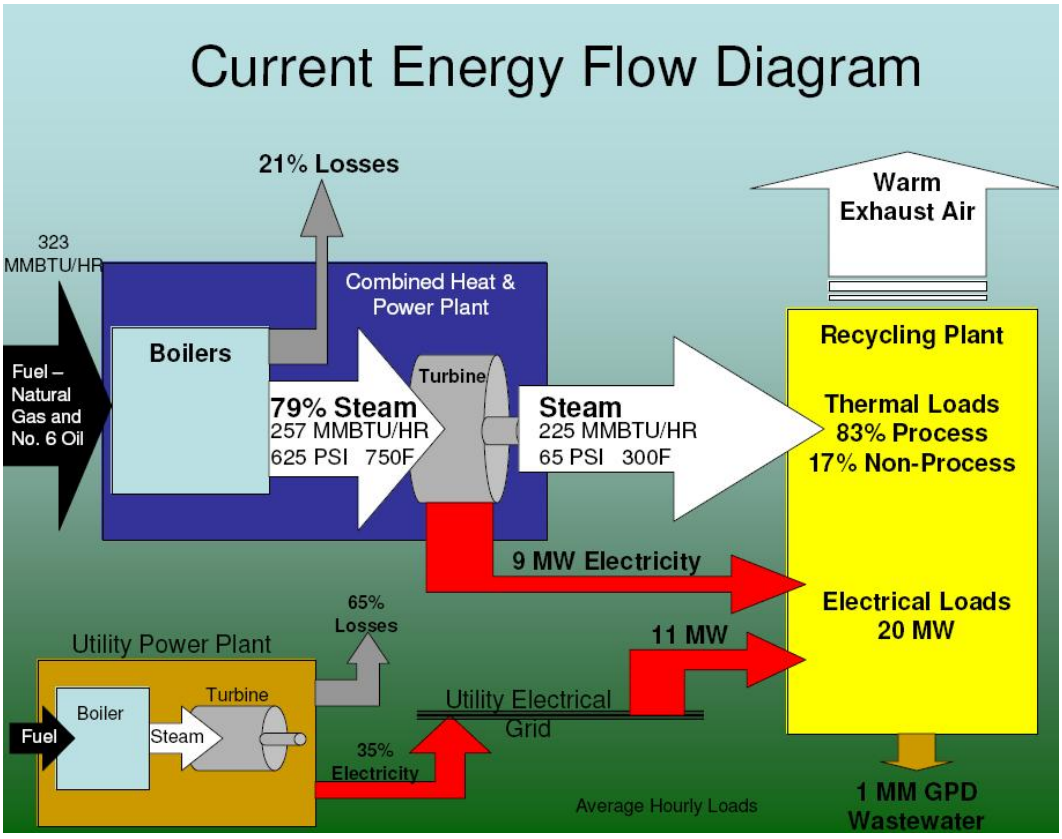
## C. Combined Heat and Power

Cogeneration, also known as combined heat and power (CHP), is a technology used at an energy plant that simultaneously generates both electricity and thermal energy. Conventional power plants generally emit the heat created as a byproduct of electricity generation directly into the environment through cooling towers, as flue gas, or by other means. A CHP plant captures the byproduct (waste) heat for domestic or industrial heating purposes, located within the plant, very close to the plant, or distributed through pipes to remote facilities. As part of the Legislative's direction to the Port Authority, additional uses for the waste heat have been evaluated as part of the Study.

> Co-generation (combined heat and power) is the most efficient model to supply energy to Rock-Tenn. Capturing Rock-Tenn's waste heat and selling it to another user provides a mechanism for lowering Rock-Tenn's energy costs.
>
> – RCAP Consensus Finding

Rock-Tenn currently uses a CHP plant to generate all of it thermal energy needs and approximately 40% of its electrical energy needs. The thermal (steam) energy that is generated in the boilers flows into Rock-Tenn's onsite electrical turbine to generate between 8 and 12 MW of electricity. The steam entering this turbine is 750°F and exits the turbine at approximately 300°F. Rock-Tenn pipes this steam to its paper manufacturing processes and utilizes it primarily to dry the recycled medium. This double utilization of the steam for both the electrical need and thermal manufacturing process makes the system 79% efficient instead of the more traditional 35% to 40% for standard electrical generating facilities. (For more information see Appendix IId)

The following diagram illustrates the efficiency of the cogeneration power system at Rock-Tenn. The black arrow shows the fuel input to the boiler, the boiler's efficiency in producing steam and sending it to the turbine, the turbine's electrical generation, the steam continuing to the recycling process and eventually the warm air exhaust.



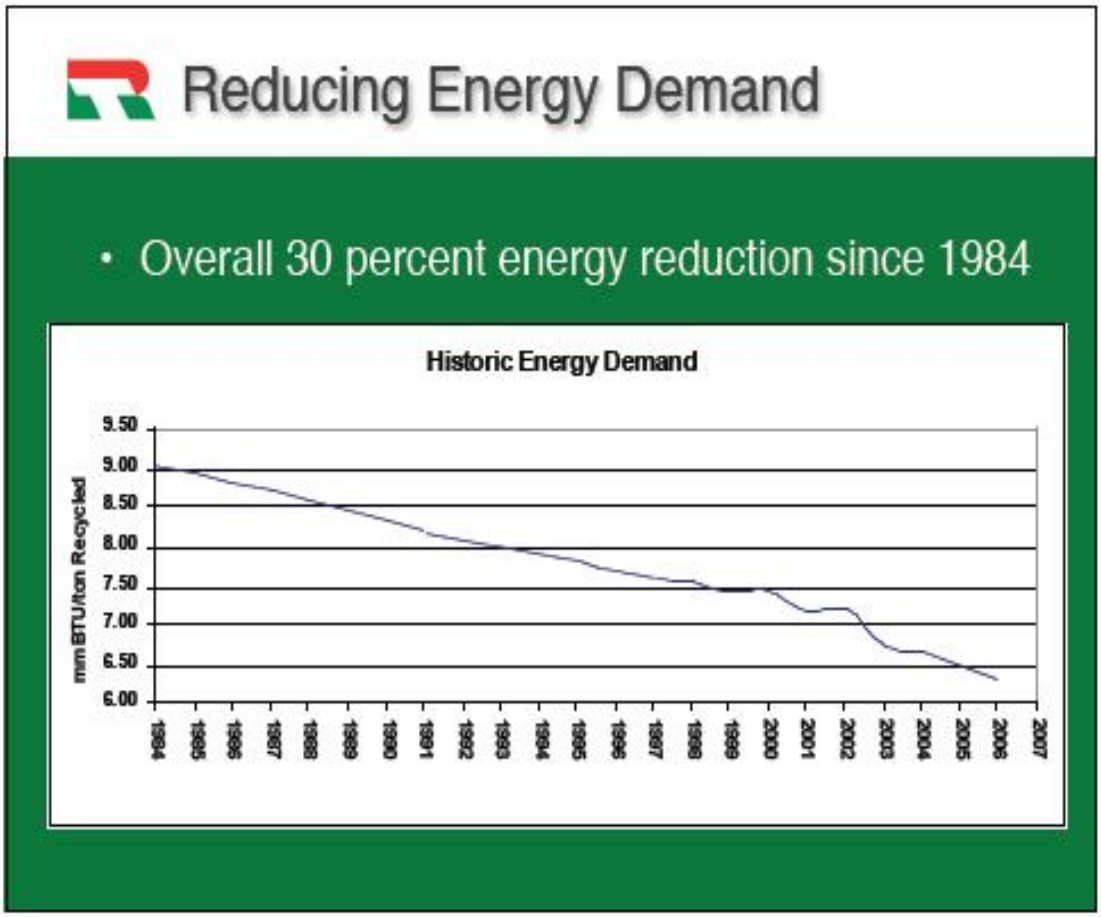

## D. Energy Efficiency Improvements Implemented at Rock-Tenn

Since 1984, the Rock-Tenn facility has improved its operations energy efficiency by more than 30% reducing its energy needs from 9.00 MMBTU per ton of Recycled Product to the current level of 6.40 MMBTU per ton of recycled product. Investments in these energy conservation efforts have resulted in equipment and process control upgrades, improved insulation, heat recovery and water recycling.

Initial estimates presented to RCAP by Rock-Tenn indicated that it expected to be able to achieve an additional 10% to 15% reduction in energy used to generate a ton of Recycled Product by 2010. Though the global rise in energy costs presents increasing challenges in the business community, it provides economic justification for new energy efficiency projects at the facility. In the past year Rock-Tenn has decreased its peak steam by 23% and its annual thermal energy demand from 2,250,000 MMBTUs to 2,000,000 MMBTUs maintaining their production with more reductions planned. (For more information see Appendix IIe)

These past energy efficiency improvements came through a variety of engineered changes to the plants operations. Some of these projects include:

- Press Upgrades
- Dryer Upgrades
- Sheet Forming Upgrades
- Process Control Upgrades
- Insulation Upgrades
- Heat Recovery
- Water Recycling




The slide above shows the increased efficiency in production since 1984

## E. Additional Conservation Opportunities

Two independent engineering firms were contracted to perform a detailed analysis of energy efficiency improvement opportunities at the Rock-Tenn plant for the Study. The following opportunities and analysis are a result of the examinations and analyses of the paper recycling facility by HDR, an internationally recognized engineering firm with 165 offices worldwide and Metso, a technology company that specializes in the paper and pulp

industry with business operations in more than 50 countries around the world. (For information, see appendix IIe & IIf)

## 1. Building Energy Conservation

Building heating represents approximately 17% of the total energy consumed at the Rock-Tenn plant, which is approximately 38.5 MMBTU/hr during the winter months. Additional conservation measures that are being considered or are at the moment being implemented to improve the buildings' efficiency include:

- Reduction of building exhaust volume
- Improvement of make up air usage
- Reduction of space heating loads
- Upgrade or installation of pipe insulation
- Upgrade or installation of pipe insulation
- Improvement of building insulation
- Improvement of make up temperature control
- Implementation of flash steam heat recovery – vent steam air heating condensers

Many of the recently implemented energy conservation strategies have delivered good results. Data from December 2007 shows approximately 15% overall reduction in steam consumption as a result of the building and other energy efficiency improvements that were implemented in 2007. (For more information see appendix IIe)

## 2. Hot Water Heating

Hot water heating was also identified as a potential strategy for further energy efficiency improvement. Hot water heating of the buildings would have the benefits of:

- Reduction in piping losses
- Reduction of flash steam vent losses
- Elimination of steam load from the central plant system
- Reduction in maintenance
- Improvement in heating control and response
- Use of recovered waste heat
- 90% boiler efficiency vs. current 79%

The cost to replace the current building heating system and install a hot water heating system is significant. If energy prices continue to rise, the hot water heating system may be an appropriate capital expenditure for Rock-Tenn. (For more information see appendix IIe)

### 3. Stack Economizer

A stack economizer that would utilize a direct contact condensing unit on the existing boilers has also received attention as a potential method of capturing waste heat and further reducing Rock-Tenn's energy usage. This method of capturing energy after the boiler is technically feasible, but the economics need further analysis. It, in addition to the other heat recovery opportunities that have been identified, recovers more waste heat than Rock-Tenn alone can use. (For more information see appendix IIe)

### 4. Waste Heat Recovery

A study has been implemented that investigates the feasibility of capturing waste heat from the vacuum compressors and exhaust vents on the paper machines. Recovery of waste heat off the paper drying process, in particular, has the potential to capture low-grade heat that could be utilized in the process water heating, building heating, make up air, or sent out of the facility to heat existing buildings and domestic water supply. (For more information please refer to Chapter II, Section F of the study or see appendix IId)

### 5. Process Efficiency Improvements

As part of the engineering studies, the entire steam system was mapped out and reviewed for potential efficiency improvements. The primary energy efficiency improvement recommendations include the following areas of the process:

- Condensate receiver flash steam
- Steam venting from dryer steam systems
- Steam box flows
- Vacuum compressor seal water energy
- Hood exhaust heat recovery
- Process water heating heat recovery

(For information, see appendix IIf)

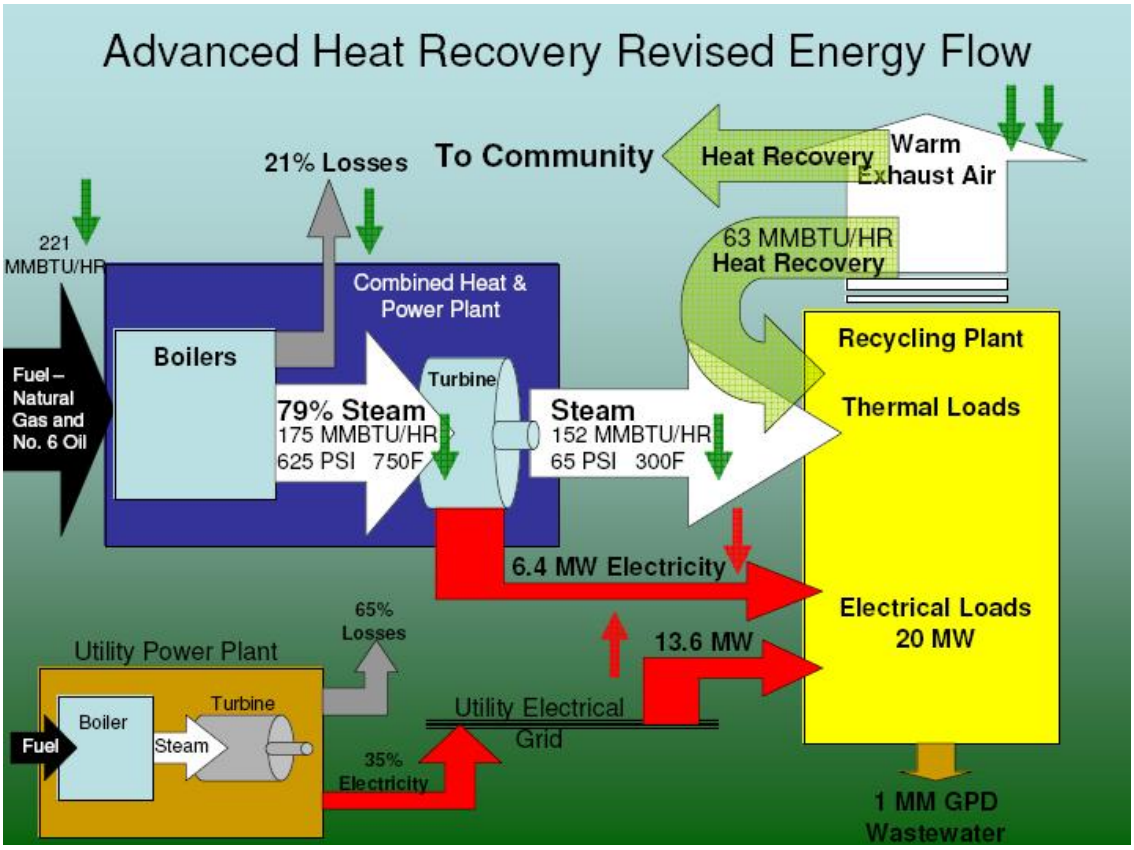
## F. Heat Recovery and District Energy System

The technology of modern-day district energy, also known as district heating and cooling, has been in use since the second half of the 19th century. With roots in the Roman Empire's hot water-heated baths and greenhouses, district energy is an efficient and growing technology that is widely utilized in countries around the world. District energy systems have central thermal energy facilities that generate hot water or steam. This hot water or steam is pumped into a network of pipelines that delivers the heat energy to separate buildings or residences. Once at the building or residence, heat exchangers are used to deliver the heat to the water supply or building heating system.

As suggested in statistics for market penetration in Europe, the significant planning and capital costs required to implement a district energy system are outweighed by the efficiency and conservation gains. District energy systems are often built to utilize the waste heat from an electric power plant making them combined heat and power (CHP) plants. The recovery of thermal energy (heat recovery) after it has generated electricity can double the efficiency of a traditional electrical power plant since this usable heat is usually vented to the atmosphere through cooling towers.

The Rock-Tenn mill's primary energy need is in the form of thermal energy (steam) used to dry the recycled medium (60% of the total energy needed). The amount of steam generated in the on-site boilers is primarily determined by the plant's paper-drying needs. The amount of electricity generated in the back-pressure turbine depends on how much steam is flowing to the drying process. As shown in the diagram below, the steam enters the drying process at approximately 300°F. After it has delivered the energy to the drying process it is no longer high enough quality steam to provide use for the process and exits through the exhaust as water vapor at approximately 135°F. If this energy could be captured, this waste heat could provide enough thermal energy for improved process efficiency and plant energy conservation as well as for an off-site district energy system.

The following diagram illustrates energy flow with advanced heat recovery to a district energy system.




It is important to note that the heat recovery opportunities that have been identified exceed what could be used by Rock-Tenn alone. Recovery of this waste heat would result in warm water that is not suitable for drying of paper, but could be used for process water heating, building heating, and be used by off-site user(s) that would need to be identified.

A district energy system's viability at Rock-Tenn depends upon different variables including the cost and effectiveness of heat recovery technology, heat-recovery system construction and financing costs, district energy distribution system construction and financing costs, operating costs and customer interest. Estimates for the revenue of the current waste heat are $1,000,000/year but are highly dependent on the above and other variables. Heat recovery is fuel independent. Therefore, such estimates have been applied to all technology and fuel options. It is assumed that following Rock-Tenn's drying process, a similar amount of waste heat, regardless of fuel or technology utilized, will be available for possible implementation of a district energy system.

## G. Subsidies Available for Energy Efficiency Improvements

Subsidies that may be available to Rock-Tenn for energy efficiency improvements come from public utilities, the State of Minnesota and the

Federal Government. The following is a brief description of these subsidies and incentives for applicable energy efficiency improvements. (For information see appendix IIg)

### 1. Subsidies Through Public Utility Programs

Rock-Tenn is eligible for the state mandated Conservation Improvement Program (CIP), which requires Xcel Energy to provide a variety of opportunities to Rock-Tenn for efficiency improvements. This program is funded by the 2% of electric and 0.5% of gas gross operating revenue, which Rock-Tenn pays to Xcel at a rate of $0.01073/therm or $300,000/yr for gas and $0.0004/kwh or $40,000/yr for electricity to help fund the program. As a result of remitting these payments, Rock-Tenn is eligible for a variety of subsidies or reimbursements for specific upgrades that have a payback greater than one year. The three programs most appropriate to Rock-Tenn are the Custom Efficiency Proposal – Electric & Gas, Efficiency Proposal – Electric & Gas, and the Process Efficiency – Electric & Gas programs. The estimated total rebates available to Rock-Tenn through these and other CIP programs is $743,106. (For information see appendix IIg)

The Xcel Renewable Development Fund (RDF) is a fund financed by Xcel ratepayers that promotes and attracts renewable energy projects and companies. The Port Authority and Rock-Tenn have not been successful in obtaining funding in the past from the Renewable Development Fund, but Rock-Tenn may be eligible for subsidies through the next round expected in the next year or two.

### 2. State Subsidies and Financial Incentives

The majority of state subsidies and funding is focused on renewable energy production and generation. The CIP conservation program, addressed above, provides the state support for energy efficiency improvements.

### 3. Federal Subsidies and Financial Incentives

The Energy Independence and Security Act of 2007 includes provisions for funding programs that focus on "Recoverable Waste Heat" "Combined Heat and Power (CHP)", "Useful Thermal Energy", and "Waste Energy" which all have applicability for the Rock-Tenn Mill. (For information see appendix IIh)

Electric energy produced from waste energy recovery and useful thermal energy will be reimbursed on a per unit energy basis. While

promising, details on these programs need to be determined by the U.S. Department of Energy, and the funds need to be appropriated by Congress. (For information see appendix IIg)

# III. Fuels

## A. Renewable Energy Sources: Overview

The Minnesota Legislature has directed the Port Authority to present findings of its analysis of "eligible energy technology fuel mixes." Fuel options are defined by Minnesota Statutes Section 216B.1691 and include solar, wind, hydroelectric or biomass. Biomass is further described in statute to include "landfill gas, an anaerobic digester system and an energy recovery facility used to capture the heat value of mixed municipal solid waste or refuse derived fuel…" The Legislature further directed the Port Authority to exclude mixed municipal solid waste from its study.

> The fuel mix selection should decrease reliance on fossil fuels, as long as the shift to renewable fuels doesn't have a greater negative environmental impact than fossil fuels. Natural gas is not an eligible energy under the statute, but is likely to be a part of the solution. Generally, there are concerns in pursuing a non-renewable option that contributes to greenhouse gases.
>
> – RCAP Consensus Finding

RCAP members debated the Legislature's intent of fuels to study. Various definitions of biomass were requested during the discussion. The Port Authority concluded that refuse derived fuel (RDF), as distinct from mixed municipal solid waste, would also be studied.

The following fuels were studied by the Port Authority with the advice of RCAP:

1. Solar
2. Wind
3. Agricultural sources
4. Opportunistic fuel sources
5. Wood fuel
6. RDF

Speakers for RCAP related to fuels included:

- Jeff Haase, MN Department of Commerce
- John Dunlop, Renewable Energy Services
- Carl Nelson, Green Institute

- Steve Taff, University of Minnesota
- Peter Torkelson, Permit Engineer (Formerly MPCA)
- Ken Campbell, Green Institute/Campbell Consulting
- Gary Palmer, Xcel Energy

## B. Solar

For the Study, "solar" was considered both a fuel and a technology.

> "By the time it reaches the Earth's surface, the energy in sunlight has fallen to about 1,000 watts per square meter at noon on a cloudless day."
>
> – Union of Concerned Scientists, October 17, 2007

Solar energy is the conversion of sunlight directly to heat and through photovoltaic effect to electricity. The photovoltaic effect can convert up to 15% of the sun's energy into electricity. Solar electric systems are effective for remote, off-grid small electricity loads and are equal to $60/MMBTU.

Solar thermal is more suitable for water heating systems. If the quality of the heat was great enough, 320 acres of solar panels producing solar thermal would be needed to meet Rock-Tenn's energy needs. During the technology pre-screening it was determined that solar could not meet Rock-Tenn's thermal energy needs.
(For information see appendix IIIa)

## C. Wind

For the Study, "wind" was considered both a fuel and a technology.

> "Minnesota's got wind; installed capacity ranks 4th in the U.S."
>
> - Jeffrey Haase from Minnesota's Department of Commerce.

John Dunlop of Renewable Energy Services advised RCAP that in and near Minneapolis there are poor wind resources which would result in 1/3 less electricity annually per turbine as compared to better Minnesota wind resources, even though the same investment would be required.

The amount of wind required to meet Rock-Tenn's energy needs would be 30 square miles of turbines (45 turbines x 1.65 MW, $3 million each, exclusive of transmission costs and transmission availability).

Electricity would then have to be converted into thermal energy. It was such discussions and information shared during subsequent meetings regarding inefficiencies resulting from electricity production that led to a consensus finding of RCAP that co-generation (combined heat and power) is the most efficient model to supply energy to Rock-Tenn. During the technology pre-screening it was determined that wind could not meet Rock-Tenn's thermal energy needs.

## D. Biomass

Several biomass fuel options were extensively studied. Sources studied included agricultural biomass (agricultural processing by-products, corn stover, perennial/switch grasses); wood fuel; anaerobic digestion feedstock (food processing plants by-products, ethanol production facility by-products, municipal organic wastes, livestock feed by-products, and livestock egests); agricultural processing by-products; construction and demolition wood waste; urban wood waste; and refuse derived fuel (RDF). The Green Institute and Ken Campbell of Campbell Consulting, LLC studied all biomass sources except those for anaerobic digestion and RDF. A biomass fuel plan was prepared including an assessment of agricultural biomass resources and woody biomass. In addition to expanding the initial research and work performed by the Green Institute in 2007, "*Renewing Rock-Tenn: A Biomass Fuels Assessment for Rock-Tenn's St. Paul Recycled Paper Mill*," the biomass fuel plan identified and worked with prospective biomass fuel suppliers to develop cost information and test business propositions for biomass fuel supply contracts. (For more information see Appendix IIIb and IIIc)

### 1. Agricultural Biomass

Although agricultural biomass is getting a lot of attention, there are few industrial-scale, agricultural biomass energy production models that have sustained commercial success and none that could be replicated for Rock-Tenn with a strong likelihood of long-term operational and economic viability. The Biomass Fuel Plan found in Appendix IIIc, focuses on a reasonable range of biomass fuel cost estimates and fuel supply business requirements as well as documents a "bankable" fuel supply for project financing.

To estimate sustainable long-term prices, the full costs of production were considered. The complete Biomass Fuel Plan includes information on multiple agricultural feedstocks including residue (corn stover and cobs), agricultural processing end products, and energy crops (short rotation woody crops and grasses).

The business and logistics of procuring large quantities of agricultural biomass is very challenging. A reliable and cost effective approach may be to contract with farm supply co-operatives (owned and governed by farmers) for aggregation services. A farm supply co-op could aggregate the supply of crop residues (corn stover, corn cobs, straw), damaged and low value hay and dedicated energy crops (willow, switchgrass and other grasses). In addition, ethanol cooperatives and companies could be aggregators of farm-grown biomass fuel. As aggregators, they would be creating new income for their members.

Another option would be for custom harvesters to expand their business to function as biomass fuel suppliers. (For more information see Appendix IIIc)

### a. Agricultural Processing By-Products

Good biomass fuel characteristics can be found in dried distillers grains, corn and oat screenings, corn bran, oat hulls and other similar by-products. Given the earlier study by the Green Institute which determined that significant quantities of these by-products would not be available, combined with a current verification of spot markets, it was determined that agricultural processing by-products are currently too expensive and will likely continue to be too expense in the future as long as livestock feed values are high. (For more information see Appendix IIIc)

### b. Corn Stover

Corn stover has a high potential because millions of tons are produced annually. Although satisfactory in terms of handling and fuel characteristics, collection, transportation and storage costs can be prohibitive. In addition, corn stover left on the field returns nutrients to the soil. Many farmers are not interested in harvesting corn stover because they prefer to leave it on the field for soil nutrient and tilth replenishment and to prevent erosion. When over 30 farmers were interviewed about harvesting corn stover, most were not interested in harvesting. This is primarily due to risking damage to the soil or jeopardizing the following year's yield.

### c. Corn Cobs

Hauling corn cobs would be easier, cleaner, less costly and safer than hauling baled corn stover. Full 25 ton loads of corn cobs could be delivered in enclosed trailers. About three-fourths of a ton of corn cobs can be harvested from each acre but collection of

corn cobs will slow down the harvest. A demonstration project the Fall of 2008 with Chippewa Valley Ethanol Company may help inform this project about farmer income requirements and other issues.

### d. Low Quality Hay

This can be sourced year-round in small amounts.

### e. Energy Crops

In Southern Minnesota, there is limited land on which to grow energy crops without displacing other crops. However, northwest of the Twin Cities there is a lot of marginal farmland on which energy crops may perform better than corn and soybeans.

Farmers and co-op managers are generally skeptical about the immediate prospects for energy crops. Nonetheless, farmers may be enticed to commit acreage to energy crops with financial support from programs such as the Biomass Crop Assistance Program, which was established by the 2008 Farm Bill. (For more information see Appendix IIIc)

## 2. Woody Biomass

Building on the earlier study by the Green Institute, the forms of woody biomass studied to verify supply and demand, analyze costs of production and develop a "bankable" fuel supply plan included research on forest residue, small diameter trees, under-utilized, low value species and low grade pulpwood. Sources of information included the DNR (Minnesota and Wisconsin) USDA Forest Service, Agricultural Utilization Research Institute, and the Natural Resources Research Institute as well as literature review and contact with forest products companies including the logging, lumber, sawmill, fuel pellets, and mulch industries.
(For more information see Appendix IIIc)

### a. Logging Residue

Tops and tree limbs, aka logging residue, is a commonly used biomass fuel especially in northeast Minnesota. NRRI estimates that expected statewide timber harvesting would yield 2.0 million green tons of logging residue per year.

### b. Roundwood

In Minnesota, computer modeling exercises indicate that a statewide harvest of about 12.6 million tons/year could be

sustainable if appropriate mitigation measures are implemented and if these mitigation measures are actually effective. If all of Minnesota's forest products industries were operating at full production, and without reliance on imports, only 9.7 million tons/year of roundwood would be used. Loggers sort saw timber, pulpwood and biomass material. Pricing and proximity to market can affect whether a logger sells marginal pulpwood for biomass fuel.

Also, Wisconsin wood resources remain strong. Wisconsin continues to grow more wood than it removes.

### c. Under-Utilized Species

Minnesota's DNR is promoting commercial interest in harvesting "under-utilized" and low-value species. DNR estimates that approximately 50,000 tons/year of under-utilized species could be potentially available from sustainable harvests in southeast Minnesota.

### d. Sub-Merchantable Trees

These are trees of marketable species that are undersized for saw timber or pulpwood use. Generally, significant quantities of sub-merchantable material are present on logging sites. Whether sub-merchantable trees are taken depends on the timber sale terms and the market value of the sub-merchantable material.

Four wood production regions were studied including Southeast Minnesota, Central Minnesota, Western Wisconsin and Near Northeast Minnesota/Northwest Wisconsin.
(For more information see Appendix IIIc)

Based on the above and other information available in the Biomass Fuel Plan, wood is in abundant supply and could be available at a $40-$50/ton range as a "base price" in five or ten year contracts. Contractual provisions will most likely be needed to adjust this pricing for increased fuel and stumpage costs. This is the price for delivered wood chips at the gate of Rock-Tenn. Delivered wood chips are expected to have moisture content in the range of 42% - 50%. Note: For a gasification technology choice, the wood would have to be dried to possibly as low as 15% moisture content (depending upon the equipment vendor) through a drying process.

### e. Urban and Manufacturing Wood Waste

Currently, clean wood wastes from manufacturing facilities as well as clean demolition materials are in short supply in the metro and immediately surrounding communities. The animal bedding and mulch companies utilize this material for their products inducing a price too high for a biomass energy facility to consistently procure feedstock. However, at any given time, if the price of processed clean wood waste fell below other biomass fuels, a fuels procurement manager may decide to purchase appropriate feedstock if available. However, it is important to note that RCAP's consensus finding related to construction and demolition material was that it is not a viable fuel source on which to spend additional time or consideration. (For more information see Appendix IIId)

### f. Red Pine and Aspen Thinnings

There is chance for some amount of red pine and aspen thinnings from Minnesota plantations to be utilized as biomass. Depending on market conditions and location, this resource could become available as a feedstock for a biomass conversion facility in the future.

### g. Brush and Buck Thorn

Brush harvesting is not currently a viable feedstock mechanism for a biomass energy facility at Rock-Tenn, but improvements in harvesting site selection and systems could produce 800,000 tons/year of brush for a biomass plant. The Minnesota Department of Natural Resources (DNR) as part of Senate File No. 2096 received $500,000 from the legislature to prepare and implement habitat restoration plans and provide roadside access to the byproduct. The restoration activities are to take place on land located within 75 miles of Saint Paul. The primary goal of this effort is to restore valuable habitats. At the same time, woody materials generated are available for energy production.

"The project will help restore healthy native habitats needed by plants and animals, provide an alternative energy source, supplement landowner resources for habitat restoration and management, and reduce the amount of woody biomass that might otherwise be burned on-site because of lack of resources to cut and transport large quantities of material."

- From Questions & Answers, DNR

*(Additional information is available from Barb Spears, Project Manager at DNR.)*

In the first report for the project entitled "Linking Habitat Restoration to Bioenergy: An East-Central Minnesota Partnership", the DNR's work to date indicates there are 7,000 acres of habitat restoration within a 75 mile radius of St. Paul. During Spring and Summer of 2008, various pilot projects are occurring. Costs of pilot projects are being evaluated for future project cost projections. Initial pilots were $21.50 - $23.40/ton. These costs were calculated based on actual costs of cutting, moving and staging the woody plant material for pick up. No transportation, project management or other project-related costs are included.


## 3. Opportunistic Fuel Sources

Opportunistic fuels encompass biomass feedstock that may become affordable at any given time so that a fuels procurement manager could make the decision to acquire them for a biomass energy facility. For example if the harvest of aspen and wood thinnings is tested and approved, suppliers may contact the fuels procurement manager at Rock-Tenn to negotiate a delivery of aspen or wood thinnings on a short-term or case by case basis. A feedstock that is delivered on a regular basis, regardless of quantity, is not considered an opportunistic fuel. (For more information see Appendix IIIc)

## 4. Anaerobic Digestion Feedstocks

Anaerobic digestion is a set of processes in which micro-organisms break-down biodegradable matter in the absence of oxygen. A functioning anaerobic digestion facility keeps the bacteria and micro-organisms healthy at a stable temperature, pH, and nutrient level. The living organisms that break down the feedstock are quite sensitive to the ambient conditions, and must be monitored closely. For this reason, a quality feedstock is most effectively digested at a consistent loading rate. Feedstocks considered during the RCAP process included food processing plant by-products, ethanol production facility by-products, municipal organic wastes, livestock feed by-products, and livestock egests. Due to consistency, amount and availability constraints, municipal organic waste was eliminated from further exploration as a potential feedstock for Rock-Tenn's energy needs. (For further information see Technology section C3 or Appendix IIIe)

Feedstocks that appear viable for an anaerobic digestion facility capable of converting enough energy to power Rock-Tenn include food processing by-products, ethanol production facility by-products, livestock feed by-products, and livestock egests, such as cow manure.

A variety of anaerobic digestion projects were reviewed that included the use of the following feedstocks:

| Anaerobic Digestion Projects | |
|---|---|
| **Anaerobic Digestion Feedstock** | **Rock-Tenn's Energy Needs Offset by Available Biogas** |
| Livestock Manure | 85% |
| Ethanol By-Products | 85% |
| Sugar Beet Processing Tailings | 10% |

An example of a viable anaerobic digestion feedstock that is available in large quantities in this region involves the by-products from corn ethanol production. The process utilized by many corn ethanol production facilities is wet-mill fermentation of the starch from the corn kernel. The by-product from this method is whole stillage which is subsequently separated into a wet distillers grain syrup and thin stillage. The wet distillers grain can be sold directly, dried and sold or mixed with syrup and then dried. Whether wet or dried, the distillers grain is used as livestock feed. Thin stillage is liquid in consistency. The thin stillage is thickened using an evaporator to create syrup. Syrup is either mixed with wet distiller's grains, as mentioned above, or is sold directly for addition to livestock feed

rations. Digesting the thin stillage from a 100 million gallon per year ethanol plant would reduce the energy consumed by the ethanol plant by up to an estimated 25 percent. Digesting the thin stillage would eliminate the need to evaporate large quantities of water from the thin stillage. It is estimated that digestion of the thin stillage would produce sufficient biogas to power the ethanol plant's reduced energy demand and offset approximately 12% of Rock-Tenn's energy need. It is estimated that anaerobic digestion of the whole stillage from a 100 million gallon a year ethanol plant could produce enough biogas to power both the ethanol plant (after conservation) and all of Rock-Tenn's recycling operation, with biogas to spare.

Benefits of digesting the stillage at an ethanol plant include reducing the fixed fossil fuel input of the overall energy output of ethanol from 65% to 5%. It is also an effective and environmentally responsible method to clean and reuse water from the ethanol plant and reduce its water consumption by 50%. The partial or complete elimination of the stillage drying operation from an ethanol plant would reduce the total energy consumed by one-third.

Another viable feedstock for large scale anaerobic digestion is animal egests. Anaerobic digestion of livestock, swine and poultry egests is steadily receiving more attention from investors as the economic and environmental benefits gain acclaim. One of the projects evaluated will utilize animal egests from livestock and poultry farms within a 7-mile radius of the plant. This new anaerobic digestion facility is strategically located in a rural community that has a high density of livestock and poultry growing operations. The livestock operations, in particular, utilize the municipal wastewater treatment system to manage a large portion of the waste from the facilities. The surrounding land, though primarily agrarian, cannot effectively manage the large amount of waste that is produced from these animal production facilities. The excrement is often transported great distances to be spread on agricultural land. The anaerobic digestion facility will use this readily available waste stream to produce methane for delivery into the a natural gas transmission line, provide water cleanup, produce ammonia, phosphorus and potassium, and a nutrient rich soil.

Sugar beet processing plants are currently using anaerobic digestion to supply fuel for their process needs. Though sugar beet processing facilities do not generate enough biogas at one facility to power Rock-Tenn's recycling operation, the Port Authority is confident that enough biogas could be attained from multiple facilities in the region.

## 5. RDF

Refuse derived fuel (RDF) is defined by Minnesota Statute 116.90 as a product resulting from the processing of mixed municipal solid waste in a manner that:

- Reduces the quantity of noncombustible material present in the waste
- Reduces the size of waste components through shredding or other mechanical means
- Produces a fuel suitable for combustion in existing or new solid fuel fired boilers

Enough RDF is produced and, following successful contractual negotiations, could be made available for the project from the RDF processor owned and operated by Resource Recovery Technologies, Inc (RRT) in Newport, Minnesota (15 miles away from Rock-Tenn). Ramsey and Washington Counties are under contract with RRT, who is to process mixed municipal solid waste generated by residential and commercial entities in the two counties. RRT contracts with solid waste haulers operating in the two counties to deliver municipal solid waste to the processor in Newport. RRT also contracts with Xcel Energy to combust the RDF it has produced in Newport into electrical power. Currently, all RDF produced goes to two Xcel Energy owned and operated retrofitted solid fuel boilers in Red Wing and Wilmarth (Mankato) Minnesota.

Minnesota Statutes treat RDF as renewable energy source, and RDF is accordingly an eligible fuel for the proposed power plant. As a practical matter, the Panel does not view RDF as renewable. A large fraction of the energy available from thermal conversion comes from plastics which is currently derived almost completely from fossil fuels.

- RCAP's consensus finding regarding RDF

In 2007, 429,000 tons of mixed municipal solid waste was received for processing. The historical processing rate at Newport is 74%. In 2007, over 300,000 tons of RDF were produced and utilized by Xcel Energy at its two combustion facilities.

To utilize RDF at Rock-Tenn for thermal energy and electricity, a fluidized bed boiler has been priced for installation on the facility site with the storage and fuel delivery systems designed and priced

similar to the wood fuel system studied. (The technology is reviewed in Part IV.)

At RRT's Newport facility, waste processing components for producing RDF include:

- Receipt of mixed municipal solid waste
- Removal of bulky items (e.g. furniture, carpeting, etc.)
- Shredding of smaller items
- Extraction of ferrous for recycling
- Removal of fine sediment
- Extraction of aluminum for recycling
- Secondary shredder for sizing

The typical heating value of RDF is 5500 BTUs/lb which is comparable to wood fuel but considerably less than fossil fuels. In Minnesota, an ash management plan is required to be approved prior to construction of an RDF facility and monofills with specifically designed liners are required for disposal of the ash. Over 20 years of testing data of RDF ash leachate in the United States and Europe show low concentrations of heavy metals, such as lead, cadmium, and mercury, as well as dioxins. These concentrations are below levels that would make the ash hazardous. Soluble salt concentrations in RDF ash are high, but except for this, the leach would meet drinking water standards. One way Minnesota has addressed toxicity concerns is by establishing strong regulatory programs for hazardous wastes including extensive source separation collection of waste material that could contribute metals such as lead, cadmium and mercury to the waste stream. These programs provide for proper management of consumer electronics, CRT tubes, lead acid and nickel cadmium batteries, mercury switches and fluorescent light bulbs. (For more information see Appendix IIIf)

## E. Subsidies & Financial Incentives for Use of Renewables

As directed by Senate File 2096, the Port Authority identified various subsidies along with financial incentives for renewables the energy scenarios evaluated. Over the course of the Study, a variety of subsidies and financial incentives have been identified as potential aids to creating an economically viable project. The Port Authority and its

consultants evaluated these opportunities accordingly and came to the following conclusions.

## 1. Subsidies for Forest and Agricultural Biomass Feedstocks

The following are conclusions from the Green Institute memo "Subsidies Available for the Production of Biomass Fuels for a Rock-Tenn Facility".

**a.** There are currently no government payments to encourage the production of corn stover. If one makes the aggressive assumption that some of the subsidies to encourage the production of corn grain should be assigned to the stover, it could result in an equivalent subsidy of approximately $2.80/ton.

**b.** There are currently no broadly applicable programs for direct subsidies for the production of grasses. A limited number of acres of grass production may receive partial CRP payments, but this is not limited to utilization as a biomass fuel.

**c.** There are currently no broadly applicable programs to provide payments for producing forest wood biomass. Limited programs exist to encourage forest thinning in fire hazard areas, but wood harvested under this program is also not limited to utilization as a biomass fuel.

## 2. Carbon Credits

See section on financial analysis for explanation of the value of credits from the mitigation of $CO_2$ emissions as a result of utilizing biomass to replace fossil fuel derived energy.

## 3. Farm Bill Resources: Biomass and Biofuels

### a. Sec. 9011 Biomass Crop Assistance Program

Section 9011 of the 2008 Farm Bill establishes the Biomass Crop Assistance Program that provides resources through a variety of mechanisms to induce biomass crop cultivation. The Department of Agriculture can provide up to 75% of the establishment costs for perennial biomass crop cultivation for either the 5 year annual and perennial crop contract or the 15 year contract for woody biomass. The Department of Agriculture can defray the costs for collection, harvesting; storage; and transportation to a biomass conversion facility. This program excludes current Conservation Reserve Program and Wetland Reserve Program land. (For more information see Appendix IIIg)

### b. Sec. 9004 Re-powering Assistance

This section of the 2008 Farm Bill establishes assistance to encourage the replacement of fossil fuel to operate biorefineries.

### c. Sec. 9005 Bioenergy Program for Advanced Biofuels

This section of the 2008 Farm Bill provides payments to producers of advanced biofuels and takes into account its net renewable content.

## 4. Refuse-Derived Fuel (RDF)

Refuse derived fuel (RDF) behaves differently in the marketplace than other biomass fuels and feedstocks. It has an intrinsically negative value demonstrated by the tipping fees that haulers pay and payments made by counties to support processing programs. Solid waste requires disposal. Every method of solid waste management, such as recycling, composting, waste-to-energy, or landfilling, has costs associated with it. Each waste management method relies on some payment by the waste generator to cover some of the cost of management or disposal. The costs of some management methods, such as recycling or waste-to-energy, are partially borne by local or state government. Thus, RDF has an economic advantage in comparison to other biomass fuel options.

The Ramsey County Environmental Charge (CEC) is a user generation fee that supports many solid waste programs including:

- Household hazardous waste collection sites, programs and outreach
- Residential yard waste collection sites, programs and outreach
- Food waste recycling in schools
- Waste reduction and recycling assistance to cities

The CEC is also the fee utilized to support the processing of municipal waste at the Newport Resource Recovery Facility. RRT operates the Resource Recovery Facility in Newport, MN. Each hauler delivering waste to the facility pays a tipping fee directly to RRT and Ramsey County pays a fee to RRT using CEC-collected funds for processing services provided by RRT. The County also pays a hauler rebate to each hauler delivering waste to RRT. Funds for the hauler rebate come from the CEC as well. The tipping fee is the primary source of revenue and the CEC is secondary. RRT uses these payments to

provide RDF processing and combustion services. (For more information see Appendix IIIh)

# IV. Technologies

## A. Evaluation of Technologies to Serve Rock-Tenn's Thermal Energy Needs

Upon commencement of the study, RCAP members and the Port Authority identified a variety of technologies for further study. Early on, RCAP members shared the concern that the Study should not be limited to combustion technologies. With this input, the following technologies were identified for consideration:

1. Solar
2. Wind
3. Plasma Arc
4. Pyrolysis
5. Algae Fuel
6. Stoker Solid Fuel Boiler
7. Bubbling/Circulating Fluidized Bed Boilers
8. Gasification
9. Anaerobic Digestion

Speakers for RCAP meetings related to technologies included:

- Jeff Haase, Department of Commerce: Technology – Wind/Solar
- Jack Greenshields and Gary Myhrman, Rock-Tenn: Technology – Thermal Energy
- Jim Osborn, Alternative Resources, Inc.: Technology – Advanced Thermal Conversion
- John Dunlop, Renewable Energy Services: Technology – Wind/Solar
- Jerod Smeenk, Frontline: Technology – Gasification
- Zack Hansen, Ramsey County: Technology - Waste Management System and the RDF Component
- Peter Torkelson, Permit Engineer (Formerly MPCA): RDF
- Dr. Patrick Hirl, Stanley Consultants: Technology – Anaerobic Digestion
- Matt Clark, HDR: Technology – Conventional Combustion & Feasibility/Site Logistics

## B. Prescreening

### 1. Solar and Wind

After receiving information on solar electric, solar thermal, local wind and imported wind in late 2007, RCAP members reached consensus that solar and wind could not directly serve Rock-Tenn's thermal energy needs. Solar or wind could perhaps contribute to portion of Rock-Tenn's electrical or thermal energy needs, but RCAP members acknowledged that co-generation (combined heat and power) is the most efficient means to supply energy to Rock-Tenn. The Port Authority focused its technology research and provided information to RCAP accordingly. Rock-Tenn was also advised against developing a wind energy project onsite due to the danger that falling ice shards, equipment failure and inclement weather could pose to people and structures at and surrounding the facility.

> "Wind energy in the Metro Area would produce 30% less electricity per turbine compared to Southwest Minnesota and would require 160 acres of obstruction-free wind per turbine."
>
> - John Dunlop, President of Renewable Energy Services and Technical Services Engineer with the American Wind Association.

As part of evaluating various energy conservation measures that could be used at the plant, a passive solar wall was strongly considered by Rock-Tenn as an opportunity for conservation of energy needed to heat make-up air used in the process. However, the presence of significant amounts of waste heat that could be recovered from the process and used for this purpose resulted in Rock-Tenn not pursuing this technology at this time. The inherently finite resources available for plant upgrades will continue to be utilized to provide the best savings for the investment.

### 2. Advanced Technologies

Three advanced technologies were initially examined for their ability to meet Rock-Tenn's thermal energy needs and were removed from further consideration based upon the following conclusions:

| | |
|---|---|
| **Algae Fuel**—An organism that converts sunlight into oil (biofuel). | University of Minnesota scientists advised that this technology is still 5 to 10 years out. |
| **Pyrolysis**—A process that converts carbon and hydrogen in solid fuels into a gas. | Not currently in widespread commercial use in US or at sufficient scale with a demonstrated track record to serve Rock-Tenn's needs. |
| **Plasma Arc**—Breaking down solid fuels into an elemental gas using an electrical arc. | Although used successfully in destruction of materials, the plasma arc has the high power requirements to produce syn-gas and no large scale operations were identified. |

## C. Feasible Technologies: General Overview

The following technologies were determined to be feasible to generate the large amount of thermal energy needed by Rock-Tenn and thus more significant engineering, design and site-layout and pricing was performed:

- Conventional Combustion
- Gasification
- Anaerobic Digestion

For those technologies where the facility would be constructed at Rock-Tenn, the following statements apply:

a. Rock-Tenn's existing site and infrastructure is sufficient to support a project.

b. Although two plant sizes were studied and can be found in the appendices, Rock-Tenn advised that due to seasonal needs and the facility's 24/7 operations, the size of the facility must meet its peak energy demand of 235,000 lbs/hour and its annual energy requirements of 2 million MMBTU.

c. Fuel storage and handling requirements were developed and are applicable to all remaining technologies that utilize dry biomass and

sized to meet Rock-Tenn's requirements. Onsite storage of two and a half days of fuel in an existing warehouse along Vandalia is planned.

d. Material handling systems were also designed and budgeted to adapt to the various technologies.

e. Fuel deliveries would be through Vandalia Street near the current existing entrance.

"A proposed new power plant with a lower steam capacity than 270,000(+) lbs/hr would either require us to continue to operate our own power plant or limit our ability to grow and increase our recycling. This would ultimately add to the overall air emissions and diminish the long term viability of Rock-Tenn's facility."

- Dave Briere, General Manager, Rock-Tenn Saint Paul

## 1. Conventional Combustion

Conventional combustion refers to conversion technologies that have a long track record of success. In conventional combustion technologies, combustion takes place in a furnace followed typically by heat recovery from the generation of steam in tubes located in the furnace. For the study, three conventional boiler technologies were evaluated, stoker, bubbling bed and circulating fluidized bed. Conceptual designs were developed for each. (The basis for designs including plant components, fuel delivery systems, and ash handling are all provided in Appendices IVa, IVb, IVc, IVd and IVe)

a. *Stoker Solid Fuel Boiler* – Stoker solid fuel boilers are in widespread commercial use. A stoker solid fuel boiler would utilize the existing turbine generator. It is flexible operating on solid fuels including wood and agricultural biomass with up to 40-45% moisture content. Quality of agricultural biomass is, however, limited to about 30% by weight due to the potential for slagging on the boiler tubes. Volume of air to the grates is controlled promoting uniform combustion and a more stable steam flow. Over fire air (above the grates) minimizes unburned gases. The boiler tubes transfer the heat to steam for the turbine

b. *Bubbling Fluidized Bed Boiler* - A bubbling fluidized bed boiler would also utilize the existing turbine generator and has a great deal of operating history. The process contains a mixture of particles suspended in an upwardly flowing gas stream that exhibits fluid-like properties, which also improves emissions performance. Fluidized bed boilers are able to combust biomass

fuels with varying heat and moisture content. Boiler tubes transfer the heat to steam for the turbine.

c. *Circulating Fluidized Bed Boiler* - A circulating fluidized bed combustor is similar to the bubbling except there are no boiler tubes and thus no heat transfer in the combustion area. Instead, hot flue gases pass through a waste heat boiler. These systems are more modular and typically available at lower cost.

| ***Type: Conventional*** | ***Efficiency*** | ***Reliability*** |
|---|---|---|
| *Stoker* | *70 – 75%* | *~90%* |
| *Bubbling Fluidized Bed* | *70 – 75%* | *~90%* |
| *Circulating Fluidized Bed* | *70 – 75%* | *>90%* |

## 2. Gasification

Gasification is a process that converts carbonaceous materials into a synthetic gas (syngas) by reacting the raw material at high temperatures with a controlled amount of oxygen, the syngas is then combusted in gas fired boilers. The gasification technology is capable of providing the necessary syngas to generate the thermal energy needed by Rock-Tenn. According to Alternative Resources, Inc. (ARI) and recent studies ARI has performed for City of New York, Los Angeles County and the City and County of Santa Barbara, California, gasification has demonstrated sufficient scale and operations for continued consideration. HDR, technology consultant for the Study, concurs although notes that gasification has a less proven record for the scale of the project needed by Rock-Tenn and may have stricter fuel size/moisture criteria. (For more information see Appendices IVa , IVb, IVc, IVd, IVe and IVf)

According to Jerod Smeenk with Frontline Bioenergy, two of four primary gasification types are appropriate for Rock-Tenn: Updraft and Fluidized Bed applications. Updraft is a simple type and fuel flexible but produces high amounts of tar. Fluidized bed gasification is fuel flexible, creates moderate tar and offers syngas applications that mean existing boiler systems can be utilized. For Rock-Tenn, the gasification system process would include the following steps:

Step One: Fuel composition and moisture content are essential so dryers are used to achieve 15% moisture content. Flue gas is used to dry the fuel.

Step Two: Fuel is fed into the reactors, which are the heart of the

two-stage reaction system.

Step Three: Fuel is introduced into the first reaction system and creates a producer gas.

Step Four: The syngas exits the first system and is channeled into a heat recovery steam generator (basically another boiler), which uses the hot syngas to create steam. The syngas has a BTU value of about 250 BTUs per cubic foot, which is a fraction of natural gas BTU value of 1000 BTU's per cubic foot.

Step Five: Then the producer or syngas is sent through a pressurized fabric filter to remove ash, char and tar.

Step Six: The syngas is combusted at its lower temperature in the existing conventional Rock-Tenn boilers. The boilers would need to be retrofitted with new burners.

Step Seven: The steam from Rock-Tenn's boilers is combined with the steam produced by the heat recovery steam generator and introduced into Rock-Tenn's existing steam turbine generator.

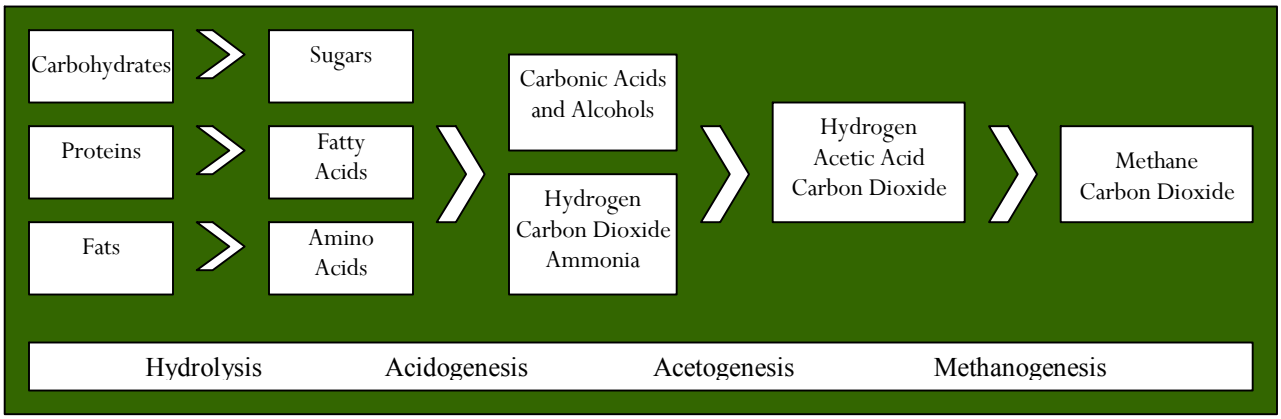
(Appendices IVa, IVb, IVc, IVd, IVe and IVf contain the basis for design including plant components, fuel delivery, and char and tar management.)

### 3. Anaerobic Digestion

Large-scale anaerobic digestion is a process where bacteria are used to convert feedstock to produce biogas. Typical biomass feedstocks include agricultural or food processing by-products that are low in plant fiber and high in water content. These feedstocks are digested in a series of sealed tanks with varying moisture levels, temperatures and mixtures of enzymes and microbes. The feedstock goes through a series of transformations as it is digested eventually releasing methane and carbon dioxide as by-products of the decomposition, which are captured.

The CO2 and CH4 (methane) gas produced is not, however, initially compatible with standard natural gas in a pipeline. In addition, the biogas produced does not have the equivalent energy content since it contains 600 BTUs/cubic foot versus 1000 BTUs/cubic foot for natural gas. Biogas from a digester can be used directly in a properly designed boiler or electric generator without prior cleanup, but it must be cleaned to pipeline standards to be introduced into a natural gas pipeline. Cleanup of the biogas entails removing $CO_2$, water and

sulfur, and pressurizing it to pipeline standards. Once the cleanup and pressurization has occurred, biogas from a renewable anaerobic digestion facility is equivalent to the energy content of traditional fossil fuel-derived natural gas and is suitable for introduction into the natural gas pipeline grid.




Unlike the thermal conversion processes outlined above where the biomass is less than 50% moisture, the feedstock utilized for anaerobic digestion needs to be high in water naturally, or water needs to be added to the process. The Twin Cities does not have sufficient quantities of a viable feedstock, thus, the Port Authority focused on out state facilities, where the potential to identify sufficient feedstock suitable for anaerobic digestion was greater. (See earlier section on fuels suitable for anaerobic digestion or appendix IVg)

## D. Air Pollution Control for Feasible Technologies

Air emissions and their health impacts were a key concern for all Study participants. A variety of speakers and significant research was provided on air emissions, controls available and potential health impacts. Article V, Emissions Analysis and Health Impacts, provides additional discussion on those pollutants and others and their potential health impacts.

This sub-section of the Study is to provide information on how air pollution control was addressed when designing and pricing the feasible technologies scenarios for continued consideration.

Early in the RCAP process, the Port Authority indicated its willingness to incorporate into its findings and recommendations that alternatives

requiring a new facility on the Rock-Tenn site will utilize the U.S. Best Available Control Technology Standard (U.S. BACT) except that the Port Authority would support the application of air emissions controls that meet European Standards (EU) if more stringent than U.S. BACT.

## 1. Overview

Air emissions are dependent upon fuels, energy conversion technology and emissions control technology. For purposes of identifying necessary air pollution control equipment for each of the feasible technologies, the likely fuel or fuel mix was considered as well as the air regulations assuming Best Available Control Technology (BACT) unless European Standards (EU) were found to be more stringent and then EU standards were used if the facility was to be sited at Rock-Tenn.

BACT is an analysis that considers proven technology, technical feasibility, economic feasibility and secondary environmental impacts. Several technologies may be technically feasible; a few less may be economically feasible. The best performing, economically feasible control is selected as BACT by setting the best emission limit that can be feasibly achieved. Cost feasibility thresholds vary by pollutant. For example, CO control may be deemed economically infeasible at greater than $200/ton CO removed, while the NOx control threshold may be more like $10,000/ton. As technologies advance, control efficiencies improve, the cost per ton of pollutant removed decreases and, as time passes, BACT can become more and more restrictive.

Criteria pollutants ($SO_2$, $NO_x$, PM) were considered along with hazardous air pollutants (dioxins and furans, HCl and Hg) and greenhouse gas emissions ($CO_2$). Generally for large, biomass-fired combustion unit stack emissions, recent BACT standards are the same or more stringent than European standards.

Some examples include:

| MMBTU | $SO_2$ | $PM_{10}$ | $NO_x$ |
|---|---|---|---|
| EU | 0.4 | 0.02 | 0.16 |
| BACT | 0.02 | 0.02 | 0.09 |

However this was not the case for some pollutants of concern related to utilizing RDF. Since the Port Authority committed to the

RCAP, and to the neighboring communities represented by the RCAP, to apply BACT unless EU standards for stack emissions were more stringent, Alternative Resources, Inc. prepared a conceptual design for a conventional RDF combustion system including a fluidized bed boiler with SNCR to control NOx, a dry scrubber for acid gas control, a baghouse for particulate control and carbon injection for mercury control to meet EU standards, which are more stringent.

**RDF Emissions Rate Limits in Lb/MMBTU**

| | $SO_2$ | $NO_x$ | $PM_{10}$ | CO | HCl | Dioxins/ Furans | Mercury |
|---|---|---|---|---|---|---|---|
| **BACT** | 0.03 | 0.44 | 0.042 | 0.11 | 0.056 | 2.4E-10 | 2.8E-07 |
| **EU** | 0.042 | 0.17 | 0.0084 | 0.042 | 0.0084 | 8.4E-11 | 4.2E-05 |

## 2. Emission Control Technologies

The following table provides the expected emission control equipment to be applied to the various technologies. For this purpose, emission controls are categorized in four different ways: particulate matter, acid gases, nitrogen oxides, and organics.

As noted in the grid below, the following emission controls for each technology and fuel type are prospective based on recent BACT determinations for similar projects. The final determination regarding best controls is an outcome of the permitting process.

**Prospective Control Technologies**

| Combustion Technology → | Fluidized Bed & Wood | Gasification & Wood | Fluidized Bed & RDF |
|---|---|---|---|
| Emission Control Technologies | • SNCR<br>• Spray Dryer<br>• Baghouse | • Low $NO_x$ Burner<br>• Ultra Low $NO_x$ Burner<br>• Baghouse After Producer Gas Cooler<br>• Baghouse After the Wood Dryer | • SNCR<br>• Dry Scrubber with Lime<br>• Baghouse |

Controls needed for emissions from an anaerobic digester will be primarily feedstock and process dependent and will be determined by the owner of the digester during the permitting processes with the MPCA and the community where it is located. Given the Port Authority's recommendation, Rock-Tenn would continue to use their existing boilers to fire natural gas with no anticipated changes in air pollution control equipment or emissions. In the event that a new gas-fired combustion turbine was constructed on the Rock-Tenn campus to improve the economics of the project, more biogas would be used to offset the increased use of natural gas to generate both the thermal (steam) energy required by Rock-Tenn and electricity that would be sold to an electrical utility as renewable or "green" energy.

## 3. Control Technologies

The control technologies referenced above have the following emission control efficiencies:

- SNCR – Selective Non-catalytic Reduction (50% - 70% NOx control via ammonia injection)
- Spray dryer (sorbent slurry injection – usually lime – for $SO_2$ and acid gas control in conjunction with a fabric filter; 80-90% control)
- Baghouse or fabric filter (particulate control; typically 99%+ efficient)

- ESP – electrostatic precipitator (particulate control by charged particle attraction; 95-99% control)

- Wet ESP (particulate control by charged particle attraction and cleansing of collector surfaces with water; 95-99% control; better control of aerosols)

- SCR – Selective Catalytic Reduction (NOx control via ammonia injection in the presence of a precious metal catalyst; 70-90%)

- LoTOx – Low Temperature Oxidation (NOx control via ozone injection in conjunction with wet scrubbing of resulting nitrates; 50-95% control)

- Wet Scrubber (multi-pollutant control, e.g. particulate (98-99% control), $SO_2$ and acid gases (80-90% control), NOx in combination with LoTOx)

- Low NOx and Ultra Low NOx burners (NOx reduction via combustion control by optimizing fuel/air mixture; 25-85% control)

**4. Continuous Emission Monitors (CEMS)**

Certain pollutants can be continuously measured and operations adjusted to operate within permit limits. Currently, CEMS are available to monitor $SO_2$, NOx, CO, VOC and opacity. CEMS for particulate and mercury are new technology and are beginning to be applied; however, at this time, particulate monitors measure only filterable particulate and currently the cost of mercury CEMS makes them prohibitive to all but the largest emission source applications. For pollutants where CEMS are not available, regular stack testing by independent testing labs is performed to assure a facility remains in compliance with its permit.

## V. Emissions Analysis and Health Impacts

The Minnesota Legislature directed the Study to provide a full description and analysis of each fuel type and their respective environmental emissions, including carbon dioxide, and the cost of controlling those emissions that affect human health. The Port Authority, RCAP, and the community adopted this common goal of understanding emissions and potential human health impacts. Air emissions are dependent upon fuels, energy conversion technology and emissions control technology. The current air quality conditions and surrounding contributors, which were examined by Barr Engineering early in the process, are also relevant. Additional research and experts analyzed potential air quality impacts of a new facility as fuel and technology scenarios were refined.

For the purposes of understanding emissions and potential human health impacts, the Study examined air emissions and controls, potential health impacts, and additional priorities to be examined during environmental review.

Speakers for RCAP meetings related to emissions and human health included:

- Dr. Greg Pratt, U of M Adjunct Professor/MPCA
- Dr. Paul Connett, Professor of Chemistry, St. Lawrence University
- John Curry, spokesperson for Neighbors Against the Burners (subsequently chosen by District 13 as an RCAP alternate to Tim Thoreen)
- Dr. John Adgate, Associate Professor, U of M Division of Environmental Health Sciences, School of Public Health
- Richard Hardegger, Joel Trinkle, and Cliff Twaroski, Barr Engineering
- Dr. Harry Debye, Barr Engineering Toxicologist
- Dr. Ian Greaves, Professor, U of M School of Public Health
- Dr. Gurumurthy Ramachandran, Professor, U of M School of Public Health
- Mike Mondloch and Heather Magee-Hill, Minnesota Pollution Control Agency

## A. Air Emissions Overview

The Environmental Protection Agency (EPA) defines an emission as "[p]ollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts." The EPA is concerned with the impacts of air emissions on human health and has set health-based limits regulating the amount of seven pollutants that can be present in the air we breathe. The EPA refers to this set of principal air pollutants as criteria pollutants and they are: carbon monoxide (CO), lead (Pb), nitrogen oxides (NOx), ozone ($O_3$), which is controlled by limiting precursor volatile organic compounds (VOCs), particulate matter ($PM_{10}$ and $PM_{2.5}$), and sulfur dioxide ($SO_2$). There are also a large number of compounds emitted to the air that have been determined to be hazardous which are called air toxics, or hazardous air pollutants. All of Minnesota is currently in attainment with the national ambient air quality standards for the criteria pollutants. An attainment area is described by the MPCA as "[a] geographic area in which levels of a criteria air pollutant meet the health-based primary standard (national ambient air quality standard, or NAAQS) for the pollutant." Ambient concentrations of many pollutants are monitored at sites throughout Minnesota. (This and other pertinent information is available at www.pca.state.mn.us/data/eduAIR) With respect to the prospect of emissions from a selected energy technology alternative, the Port Authority has committed to the more stringent of U.S. BACT and the EU standards.

During the course of RCAP discussions, primary focus was given to particulate matter, greenhouse gases and dioxins.

### 1. Particulate Matter

> "Primary outdoor sources of particulate are transportation, agriculture and industry."
>
> – Dr. Gregory Pratt, University of Minnesota/ MPCA, October 22, 2007

Particulate matter includes dust, dirt, soot, smoke and liquid droplets and the composition of these particles can include heavy metals and mercury. Control technologies for industrial sources focus on capturing particles emitted by a pollution source. Barr Engineering addressed controls for particulate emissions, including fine particulate and nano-particles (less than 1.0 micron in diameter) to

emphasize that no emissions control system will provide zero emissions and that the particulate emitted after the control device will consist of fine particulate, which becomes more difficult to collect with decreasing particle size.

Nanoparticles will be formed by the combustion of any fuel (coal, wood, natural gas, gasoline) and thus result from forest fires, power plants, industries and motor vehicles. The current best practice for controlling nano-particles from a combustion source is optimizing energy efficiency and good combustion practices.

The EPA recently issued final rules to add $PM_{2.5}$ to the list of pollutants that must be considered for large projects that are permitted under the New Source Review program. As a result, new projects are required to include $PM_{2.5}$ emissions information, apply best available control for $PM_{2.5}$ and demonstrated modeled attainment with the new $PM_{2.5}$ ambient air quality standard. The New Source Review program previously regulated only the $PM_{10}$ fraction of particulate emissions. (See more information at http://www.pca.state.mn.us/air/permits/nsr/nsr-pm25revisions.html)

2. **Greenhouse Gases ($CO_2$, methane, nitrous oxide and fluorinated gases)**

Defined by the USEPA as: "[a]ny gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), chlorofluorocarbons (CFCs), hydro chlorofluorocarbons (HCFCs), ozone ($O_3$), hydro fluorocarbons (HFCs), per fluorocarbons (PFCs), and sulfur hexafluoride ($SF_6$)." Although not yet regulated, greenhouse gas control focuses primarily on $CO_2$ and methane emissions, which can be reduced by optimizing energy efficiency, including good combustion practices. In addition, an anaerobic digester or a gasification process can minimize methane releases by avoiding operational upsets. One advantage offered by the use of RDF to fuel an energy plant is that it significantly reduces the need for landfills for solid waste disposal. The decomposition of solid waste in landfills can harm underground water quality if not properly contained and generates methane, a potent greenhouse gas that escapes to the atmosphere unless collected.

3. **Dioxins and related compounds**

The term "dioxin" is commonly used to refer to a family of toxic chemicals that share a similar chemical structure and impact human health through a similar epidemiological mechanism. Dioxins have

been characterized by EPA as likely human carcinogens believed to increase the risk of cancer at background levels of exposure.

### 4. Additional emissions considered

As noted by Dr. Paul Connett in his presentation to RCAP on November 12, 2007, three things are needed to protect the public from toxic emissions, including strong regulations, adequate monitoring, and tough enforcement. Pursuant to a request from the RCAP, a listing of pollutants and potential health impacts was provided for the panel to deliberate and to use to differentiate the energy plant scenarios being considered by the Port Authority. These pollutants and health impacts were discussed by multiple panels of experts representing the medical, environmental health and toxicology fields. In particular, dioxins and furans were of primary concern. Additional health concerns are discussed in the following sections. Projected controlled emission rates and additional pollutants assessments are available in the Scenario Grid in Appendix Va and Barr Engineering Technical Memos in Appendices Vb, Vc, Vd, Ve and Vf.

## B. Summary of Emissions Analysis

During the course of scenario development, the Port Authority created a grid to compare the benefits and impacts of fuel and technology options. This grid served as the primary tool for the RCAP to compare the remaining options that were technically and economically viable and to begin assessing their environmental impact, which included the potential impacts on human health. The grid assessed overall air quality, emission control technologies, and expected controlled emission rates for health risk assessment. With this input, the following pollutants were identified in the scenario grid:

- PM 10
- PM 2.5
- Nitrogen Oxide
- Sulfur Dioxide
- Carbon Monoxide
- Volatile Organic Compounds
- Dioxins
- Mercury
- Hydrogen Chloride

## C. Health Impacts

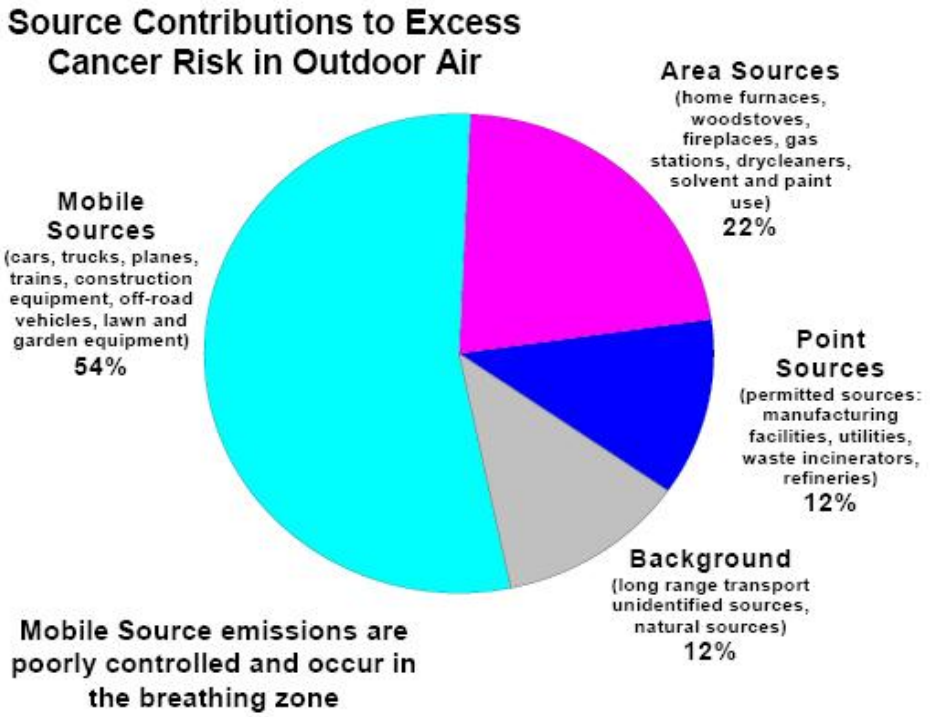
The potential impacts on human health were the shared priority of the Port Authority, the RCAP and the community. The common understanding was that risk assessment will occur during environmental review and permitting if the project proceeds to that phase. The human health risk analysis would include a detailed emissions inventory, exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis. This information would be most accurately determined during a risk assessment with complete information about fuel characteristics, exhaust stack parameters, emission rates, dispersion modeling output, and other factors.

From the advice given to the RCAP by Dr. Greaves and others, a comprehensive quantification of actual emissions of all potential scenarios was not practical. To address the concerns and responsibilities of the RCAP on behalf of the larger community, the Port Authority offered an approach used by the USEPA to assess risk drivers qualitatively. This assessment included the EPA's use of a Risk Driver Identification Methodology and Barr's development of a three-step evaluation for the RCAP. Experts confirmed that this is standard methodology. Step 1 identifies the chemicals from fuel combustion and the available health-based toxicity values for those chemicals. Step 2 involves assigning the chemicals to each energy scenario given the available emission rates. Step 3 identifies the potential health risk driver pollutants by combining emissions and toxicity data. As noted, there are some limitations to this approach as the risk driver tables do not account for actual exposures but rather for emissions out of the stack, toxicity data is not available for all chemicals and the number of chemicals measured as emissions from fuel combustion varies significantly between types of fuel. (For the three-step risk driver pollutant assessment and an in-depth review of the risk driver information made available to the RCAP, see appendices Vb, Vc, Vd, Ve and Vf)

Dr. Greaves indicated that the purest fuels like natural gas would be best for public health and to minimize emissions. Fuel complexity means greater risk; yet, experts concur that biogas and woody and agricultural biomass options fired in a new combustion system, with the best available emission controls, would reduce pollutant concentrations and exposure compared to current levels.

According to Dr. John Adgate, speaking on interpreting health risk results, the number and type of people affected and the seriousness of the effects need to be studied. MPCA policy requires some form of risk management action if risk is greater than 1 in 100,000. During

subsequent RCAP meetings and discussions on health risks, the focus was on the health impacts of emissions. Previously, Dr. Greg Pratt discussed health risks on October 22, 2007, and provided the RCAP with the following source contributions to excess cancer risk in outdoor air. Dr. Pratt also reminded the panel that when interpreting and making decisions, the analysis of health risks in concert with other variables like economics and greenhouse gas emissions is important before establishing public policy.




Source: Dr. Gregory Pratt

The fact that automobiles or mobile sources are the largest contributors of $PM_{2.5}$ was confirmed by several experts throughout the Study. According to Dr. Greaves, this creates risk particularly to people already affected by lung and heart disease. Other daily risks were confirmed by Dr. Ramachandran who stated that a number of studies with the University of Minnesota and the MPCA consistently show higher concentrations for indoor air pollutants than outdoor pollutants.
(For more information see Appendix Vg)

## D. Environmental Review and Permitting

The purpose of environmental review is to gather information, understand the environmental impacts of a project, identify ways to protect environmental resources, inform the public, and guide governmental units in permitting. Environmental review is initiated if a project has mandatory requirements, the proposer volunteers for review; the Responsible Government Unit (RGU) determines a discretionary requirement, or the public petitions for review. During environmental review the public is informed about possible environmental impacts of a project as well as ways to protect the environment.

The information is collected for either an Environmental Assessment Worksheet (EAW) or Environmental Impact Statement (EIS). An EAW is a brief document used to assess environmental effects and mitigation by responding to a list of standard questions, which may determine the need for an EIS. An EAW is triggered by the potential pollutant emissions, electric generating capacity, or the waste-to-energy capacity. An EAW reviews stationary source air emissions, human health screening risk assessment, cumulative impacts and other potential environmental impacts. The environmental review is closely tied to the permitting process. The emissions calculations for review are based on the potential to emit or limited potential to emit. An emission limit may reflect an agreement to emit beneath a specific level for an hourly or annual rate. An EAW process can extend from 4 – 12 months, with a 30-day comment period upon completion. The need to proceed to an EIS is made by the RGU. An EIS is a more comprehensive review of impacts and evaluation of alternatives typically initiated on larger projects and usually requiring more than 1 year to complete. The MPCA Citizens Board makes the final determination regarding the adequacy of the review. The work of the RCAP is very similar to the work of an environmental review and will be considered in any subsequent environmental review. (For more information see Appendices Vh and Vi)

There are two primary programs that regulate the air permitting process. The federal New Source Review (NSR) construction permitting program is split into non-attainment NSR and Prevention of Significant Deterioration (PSD). Non-attainment NSR is required for projects sited in parts of the country that are not in compliance with National Ambient Air Quality Standards (NAAQS). Minnesota is in compliance with all of the NAAQS; therefore, proposed projects in this state are reviewed under the PSD provisions to prevent air quality being impacted beyond an allowed increment of new emissions. NSR is a preconstruction review program that regulates criteria pollutants including nitrogen oxides, sulfur dioxide, carbon monoxide, Particulate matter ($PM_{10}$ and

$PM_{2.5}$). NSR also requires an evaluation of best available control technology (BACT). A BACT review analyzes the pollutant emission levels of the proposed process and determines best level of control achievable based on the technical feasibility and cost effectiveness of the control technologies available. (For more information see Appendices Vh and Vi)

New projects must also be evaluated for applicability to the National Emission Standards for Hazardous Air Pollutants (NESHAP) or Maximum Achievable Control Technology (MACT), New Source Performance Standards (NSPS), state standards of performance and Compliance Assurance Monitoring (CAM).

A PSD construction permit addresses requirements of the preconstruction review, specifies the emission limits, operating, monitoring record keeping and reporting requirements and conditions reflecting environmental review (including additional controls). Only a permit can enforce conditions, whereas an EAW or EIS cannot. Public participation during environmental review and permitting includes 30-day public notice and opportunity to comment on scoping documents, the EIS and air permits and public meetings to hear explanations of planned projects and proposed measures to address environmental impacts. The public can also work through the MPCA Citizen's Board or contested case hearing processes to comment on draft environmental determinations and permits. (For more information see Appendices Vh and Vi)

# VI. Non-Economic Impacts

Non-economic impacts of the construction of a renewable energy facility at Rock-Tenn have been evaluated throughout the Study and RCAP process. These non-economic impacts include truck traffic, odor, noise, air emissions and greenhouse gas mitigation. Information on these topics was made available to the RCAP by HDR in Appendices VIa, VIb, Barr Engineering in Appendix VIc, The Green Institute in Appendix VId and Environmental Finance Group in Appendix VIe.

## A. Truck Traffic

Rock-Tenn is immediately bordered by and adjacent to Interstate 94 and Trunk Highway 280. The number of vehicles per day on I-94 between TH280 and Vandalia in 2006 was 171,000. The number of vehicles per day on TH280 was 55,000. Currently both I-94 and TH280 exceed these numbers substantially, but the traffic flow is expected to recede to historical levels after the 35W Bridge is re-opened.

Additional truck traffic was modeled and evaluated for the potential renewable fuel scenarios. For conventional combustion of biomass fuels, including agricultural, wood and RDF, additional truck traffic is projected to range between an average of 32 to 41 trucks per day including ash disposal.

(Rail receiving options of fuel feedstock deliveries were reviewed. The existing rail line east of building #2 was considered to meet Federal Rail Administration guidelines with a few exceptions. Railcars with necessary turning radius would have to be purchased by Rock-Tenn and additional analysis would be needed if rail unloading is deemed desirable.)

## B. Odors

Rock-Tenn's recycling operation consists of an industrial process that involves breaking down paper to fiber and subsequently pressing and drying that fiber into new medium. In an effort to address any odors in the immediate vicinity of the plant and surrounding community, Rock-Tenn has developed a program and trained staff members to monitor the ambient air in specific locations for odors associated with Rock-Tenn's process. Due to the nature of the Midway District of St. Paul and companies surrounding Rock-Tenn, odors that are detected by Rock-Tenn's "nasal rangers" are not often generated by the recycling process.

New energy facility options were also addressed in the context of additional odor impact on Rock-Tenn's immediate vicinity. Odors from the conventional combustion of wood and agriculture by-products are often related to decomposition in the fuel storage facility. Preliminary site-work identified that the current structure at the southeast corner of the 42-acre property could be appropriate, with retro-fits, as a solid-fuel storage facility capable of holding an approximate three-day supply of fuel.

A gasification facility using wood and agricultural biomass has some technical constraints concerning the feedstock preparation. A gasification facility at Rock-Tenn would require the biomass feedstock to be at or below 22% moisture content. The wood biomass available to power this energy facility would likely have a moisture content of ~45%. It is clear that a feedstock drying facility would be necessary to facilitate proper feedstock handling and utilization. An onsite drying facility could utilize a portion of the waste heat recovered from the process to dry the feedstock. However, drying of the feedstock onsite could emit an odor. Measures to control and avoid odor impacts on the neighborhood would need to be addressed in the energy facility design.

Odor from RDF storage and handling is a concern that has been addressed as the industry has matured and the process has been refined. One of the main sources for odor problems in older RDF facilities was in the fuel handling and storage areas. Any new RDF facility is designed to be under constant negative air pressure to draw odors from the fuel supply areas into the combustion process and be eliminated.

## C. Noise

Noise impact on the immediate vicinity is a constant concern of most urban industrial facilities like Rock-Tenn. Rock-Tenn's recycling process operates heavy machinery 24/7/365 days per year. Over the past several years Rock-Tenn has taken steps to reduce the noise impact on its immediate neighbors. An example of Rock-Tenn's efforts is replacing the reverse signal alert on its front-end loaders and other heavy equipment with signals that utilize a static noise instead of a high-pitch beep. The static noise signals are highly effective at short range alerts, but the noise dissipates quickly. These signals have proved to be quite helpful in mitigating noise impacts on Rock-Tenn's neighbors. Detailed design of any new renewable energy generating plant would need to consider if mitigation is required. Any new facility is not expected to add significantly to the current ambient noise environment.

## D. Air Emissions

The 2003 Metropolitan Emissions Reduction Plan (MERP) committed Xcel Energy to replacing the coal-fired Xcel High Bridge power plant with a natural gas fired combined-cycle power plant. This retrofit significantly reduced the emissions from this power plant into the environment. An unintended consequence of this retrofit was Rock-Tenn's loss of low-cost steam from the High Bridge plant. A result of this decision is Rock-Tenn's full time operation of its existing boilers on a mix of relatively high-sulfur #6 fuel oil and natural gas. These boilers are sound and well operated and use complete combustion practices for emission controls. (For more information on emissions please refer to the previous section) Any new renewable energy facility at Rock-Tenn will significantly reduce most criteria pollutants from the levels generated to meet the recycling plant's thermal (steam) energy both prior to and after the High Bridge retrofit. Preliminary estimates of pollutants have been discussed throughout the study and in RCAP meetings, but it has become clear that the full extent of air emission reductions from any new renewable energy facility will not be confirmed until a fuel and technology is selected and the environmental review and permitting process is completed.

## E. Greenhouse Gas Mitigation

The term *greenhouse gas* has become familiar to industry and public alike. Citizen awareness of the cause and effect relationship between greenhouse gas (GHG) release and damage to the environment has grown considerably in the last decade. Currently the U.S. does not have a federal regulation that limits GHG release. The June 6$^{th}$ debate in the 111$^{th}$ Congress of the Lieberman-Warner Climate Security Act (S. 2191) did garner a majority in favor, but not enough to override a filibuster. Any subsequent future federal action to mitigate greenhouse gas emissions will likely enhance the financial viability of this project.

The Port Authority contracted with the Green Institute to perform a lifecycle analysis of the GHG emissions from the carbon uptake during growth, production and delivery of the fuel options. This study evaluated the carbon dioxide equivalent emissions ($CO_2e$), which include nitrous oxide ($N_20$) and methane ($CH_4$) converted to their relative GHG impact as carbon dioxide. For the purposes of this study, the Green Institute used the IPCC conversions for greenhouse gasses as follows: methane is 23 and nitrous oxide 296 times more potent of a GHG pollutant as carbon dioxide. The $CO_2e$ value in the table below represents this relationship. As the table shows, biomass fuel options

sequester carbon during their growth cycle providing for a far more advantageous fuel for GHG mitigation.
(For more information see Appendix VId)

| | Forest wood | Grasses | Corn stover | Natural gas | Fuel Oil |
|---|---|---|---|---|---|
| Carbon uptake | (195) | (227) | (219) | -- | -- |
| Production/delivery | 18 | 28 | 17 | 21 | 23 |
| At plant & fuel processing | n/a | n/a | n/a | n/a | n/a |
| $CO_2$ emissions from combustion | 195 | 227 | 219 | 117 | 161 |
| $N_2O$ and $CH_4$ emissions from combustion | 21 | 21 | 21 | 1 | 0 |
| **Net $CO_2e$ release** | **39** | **49** | **38** | **139** | **184** |

Barr Engineering provided literature values for $CO_2$ emissions from fuel combustion as follows (note: figures are not a result of a full lifecycle assessment):

| $CO_2$ Emission Rates by Fuel Type | |
|---|---|
| Coal (sub bituminous) | 212.7 lb/MMBtu |
| #6 Fuel Oil (residual oil) | 173.9 lb/MMBtu |
| Natural Gas | 117.1 lb/MMBtu |
| Municipal Solid Waste | 91.9 lb/MMBtu |
| Biomass | 0 |
| Wood | 0 |

(For more information see Appendix VIc)

[1] $CO_2$ content of fuels for wood, fuel oil and natural gas from Energy Information Administration ( www.eia.doe.gov/oiaf/1605/coefficients.html); corn stover and grasses were derived from AURI fuel content testing conducted by Minnesota Valley Testing Laboratories, July 2007 based on molecular ratio of $CO_2$ to C. Combustion assumes 100% oxidation level.

# VII. Financial Analysis

## A. Overview

The Legislature in Senate File No. 2096 directed the Port Authority to make a recommendation as follows: "The recommendation of the St. Paul Port Authority concerning its preferred alternative fuel mix must be based on the alternative that has the least environmental impact consistent with the economic viability and technical feasibility of the facility." Technologies and fuel mixes were scrutinized during the early stages of the project to determine their technical feasibility and environmental impact. Focus on economic and financial cost analysis did not begin until the options had been limited to the technically feasible fuel and technology alternatives that would minimize environmental impact. The following four scenarios were analyzed and presented to RCAP:

- 275,000 lb/hr Fluidized Bed Wood Biomass Combustor
- 195,000 lb/hr Fluidized Bed Wood Biomass Combustor
- 275,000 lb/hr Wood Biomass Gasifier
- 275,000 lb/hr Fluidized Bed RDF Combustor
- Biogas generated by anaerobic digestion offsetting natural gas in existing Rock-Tenn boilers
- Biogas generated by anaerobic digestion offsetting natural gas in gas-turbine with heat recovery steam generator (HRSG)

To further improve the analysis, four fossil-fuel based scenarios were also analyzed. These petroleum scenarios provided the proverbial measuring stick against which any renewable energy option would be evaluated. The fossil-fuel scenarios are significant only in as much as they represent the business as usual approach and are firmly entrenched as the reliable, relatively inexpensive and consistent means to attain energy within the manufacturing industry.

In order to provide an effective side-by-side comparison of the vastly different scenarios, specific details that alter the cost of the steam output (MMBtu) were delineated. These details included:

- Efficiency of the energy conversion
- Percentage of specified fuels utilized

- Quantity of fuel necessary
- Operating and maintenance costs
- Total Project costs

**1. Efficiency of Energy Conversion**

The efficiency of the specific scenario is necessary to consider when planning for how much energy the specific system can produce and the facility size necessary. This efficiency percentage also helps determine the amount of feedstock that will need to be utilized for a given amount of energy demand.

**2. Percentage of Specified Fuel**

Each technology and fuel has a different maintenance and operating schedule. When a facility is down for maintenance, the plan is to run natural gas as a back-up fuel to provide for the continuous thermal and electrical demand of Rock-Tenn's recycling process. Since natural gas is a more expensive fuel to purchase, the different maintenance schedules affect the overall cost per MMBtu for each scenario. In all renewable scenarios, some amount of natural gas or fuel oil will be utilized by Rock-Tenn. Such use is typically during start up and shut down and maintenance of the renewable portion of the facility operations. In the case of anaerobic digestion or gasification, such use of fuel oil will also include times when the use of natural gas is controlled by Xcel.

**3. Quantity of Fuel**

The cost for each fuel (biomass and petroleum) varies widely not only because of fuel price but also quantities needed. The amount of each fuel purchased for each scenario affects the overall cost per MMBTU of each scenario.

**4. Operating and Maintenance Costs**

Operating and Maintenance Costs in the financial model include labor, maintenance and repair, electricity costs, equipment replacement, non-energy costs and ash disposal. More information concerning the operating and maintenance costs and the values utilized in the financial model can be found in the assumptions of the financial analysis. (For more information see Appendix VIIa)

### 5. Total Project Costs

Total project costs is a category that includes construction costs with escalation percentage, contingency percentage, schedule of construction, interest earnings for construction, interest expense for construction, engineering and financing costs. The details for the cost used as a total project cost can be found in the assumptions of the financial analysis. (For more information see Appendix VIIa)

## B. Subsidies and Financial Incentives

At the core of the Rock-Tenn project economics are two numbers that determine financial viability: the price of steam under current operations and the price of steam resulting from each of the scenarios. Due to the direction from S.F. 2096, renewable fuels have been the focus for any new energy facility; pitting the price of steam from renewable sources directly against the price from fossil fuels. In the energy marketplace, a variety of reasons lend to fossil fuels' traditionally dominant position. Maturity of infrastructure, energy density, ease of transportation, and preferential treatment from the U.S. government worth an estimated $250 billion a year all help provide a stable footing for fossil fuels to compete.
(For more information see Appendix VIIb)

As the supply of fossil fuels becomes strained and prices subsequently rise, renewable energy has responded by rapidly developing new infrastructure and technology. The financial modeling performed on the above scenarios in comparison to the four fossil fuel scenarios illustrate the difference in cost of steam a new facility is to the existing operations. Financial incentives and subsidies might provide the necessary boost to make a renewable scenario financially viable and a project successful. Incentives or subsidies that were modeled include a government guarantee of the bonds, an investment grade rating of the borrower, RDF payment, carbon emission reduction credits, and district energy system revenue. The impact of these incentives and subsidies can be ascertained by reviewing the summary of financial models. (For more information see Appendix VIIc)

### 1. Interest Rate Sensitivity Analysis

Once the total project costs were identified, a sensitivity analysis focused on the interest rate percentage of the revenue bonds was performed on each scenario. The sensitivity analysis investigated expected interest rates with a government guarantee, investment grade backing, or neither.

### 2. Government Loan Guarantees

A government guarantee for this project would more likely be available for a scenario with a technology that is immature on a large scale, groundbreaking, or has few reference plants in operation at the same or higher capacity than Rock-Tenn's energy needs. The government guarantee is likely to have a 5.50% interest rate for both of the wood biomass fluidized bed scenarios as well as the wood biomass gasification scenario.

### 3. Investment Grade

An investment grade interest rate would be possible in the event that an approved backer carried the risk of the project. In the event that an investment grade interest rate is acquired for the project, 7.00% is a likely rate for the three wood biomass options and 6.00% for the RDF option. RDF could generate a lower interest rate due to the reliable fuel stream, as well as many reference projects of similar size currently in operation in the U.S. and around the world.

### 4. Absence of Investment Grade or Government Guarantee

In the event that neither a government guarantee nor an investment grade rate is possible for the project, a 9.00% interest rate is expected for general revenue bonds for the three wood biomass scenarios and 7.50% for the RDF scenario. As previously explained, the RDF scenario could generate a lower interest rate due to the tax-exempt nature of bonds sold for solid waste projects.

## C. Other Financial Incentives

### 1. Farm Bill Resources: Biogas (Anaerobic Digestion and gasification)

The Farm Bill of 2008 provides for guarantees for loans to fund the development, construction and retrofitting of commercial-scale biorefineries using eligible technology. These loan guarantees can provide a guarantee for up to 80% of the expenditure.
(For more information see Appendix VIId)

### 2. Sec. 9012 Forest Biomass for Energy

The Department of Agriculture is authorized to utilize $15,000,000 each year from 2009-2012, to "conduct a competitive research and

development program to encourage use of forest biomass for energy."

Priority for Project Selection:

**a.** "Develop technology and techniques to use low-value forest biomass, such as byproducts of forest health treatments and hazardous fuels reduction, for the production of energy."

**b.** "Develop [a] process that integrates production of energy from forest biomass into biorefineries or other existing manufacturing streams." (For more information see Appendix VIId)

### 3. Federal Biomass Research and Development Assistance

Over the next five years, the Secretary of Agriculture will dispense between $118,000,000 and $258,000,000 of appropriated and discretionary monies to fund the Biomass Research and Development Initiative "under which competitively awarded grants, contracts, and financial assistance are provided to, or entered into with, eligible entities to carry out research and development and demonstration of (A) biofuels and biobased products; and (B) the methods, practices, and technologies, for the production of biofuels and biobased products." (For more information see Appendix VIId)

### 4. Tax Exempt Financing

It has been determined that a project with waste as a primary feedstock is eligible for tax exempt financing. Waste feedstocks under consideration include anaerobically digested swine and livestock manure, ethanol bi-product and refuse derived fuel from city wastes. The tax exempt financing is illustrated in the comparative financial model with a reduction of the Revenue Bond Interest rate from 9% to 7.5%.
(For more information see Appendix VIId)

### 5. RDF Payment

RDF demonstrates unique behavior in commerce as compared with the other fuels evaluated throughout the study. As discussed in the fuel section of this report, RDF is the only fuel considered that provides a revenue stream instead of a cost to the facility. To model the price a new energy facility could expect to receive from an RDF processor, the Port Authority met with RRT which owns and operates the Newport processing plant. $12-$20 per ton was determined to be a reasonable range for the RDF payment. The

$16 per ton median of the range was utilized as the appropriate figure for the model. For a 275,000 lb/hr, 2,000,000 MMBtu facility, the $16 per ton payment provides $3,282,051 per year incentive lowering the cost of MMBtu (steam) by $1.64.

## 6. CO2 Emissions Reduction Credits

Value from carbon emissions rarely made it onto the balance sheets of energy projects in the U.S. until recently. Traditionally, carbon emissions have been an externality to the detriment of the environment. Carbon emission trading markets developed in Europe as a result of the Kyoto Protocol's stiff regulation on the Annex-1 (developed) signatory country's emissions limits. This trading market provided the basis for smaller niche trading exchanges to develop in non-EU countries like Canada and the U.S. A project's carbon credits are evaluated, and verified before they can be traded on these markets. Once the credits are placed on the market, buyers interested in offsetting GHG pollution or investing in the future value of carbon offsets purchase the credits for a price per ton of $CO_2e$ mitigated.

The Port Authority contracted with EFG Carbon to evaluate the potential value from carbon credits for the modeled scenarios. $20 per ton of $CO_2e$ was provided as a reasonable figure, over the life of the project, to evaluate the carbon.
(For more information see Appendices VIIe and VIIf)

## 7. District Energy System Revenue

As discussed previously, district energy costs and subsequent revenue are contingent on different variables including cost and effectiveness of heat recovery technology, heat recovery system construction and financing costs, district energy distribution system construction and financing costs, operating costs and customer interest. The $1,000,000/year revenue figure was applied to all scenarios since it is a technology independent option.

## VIII. The Saint Paul Port Authority's Findings and Recommendations

Throughout the study, the Port Authority focused on the legislative directive in Senate File 2096 "to present the findings of its analysis and its preferred alternative for an eligible energy technology fuel mix…The recommendation of the Saint Paul Port Authority concerning its **preferred alternative fuel mix must be based on the alternative that has the least environmental impact consistent with economic viability and technical feasibility of the facility**."

After a year of study and 24 meetings with citizen volunteers participating as members of the Rock-Tenn Community Advisory Panel (RCAP), as well as input from other interested citizens and the City of Saint Paul, the Saint Paul Port Authority, consistent with the directive of Senate File 2096, is recommending re-powering Rock-Tenn with discount-priced natural gas, utilizing carbon offsets from renewable biogas. The biogas would be produced at an anaerobic digestion facility to be built in out state Minnesota. The anaerobic digestion facility required would be the largest of its kind in the US.

This solution will help:

a. ensure that Rock-Tenn's 475 green-collar jobs stay here in Saint Paul

b. improve air quality in the surrounding neighborhoods

c. protect public health

d. advance our energy independence

e. the State fulfill its pledge to reduce global-warming carbon dioxide emissions 15 percent by 2015

f. promote vital economic development in Minnesota's rural communities while meeting urban needs

### A. Findings

In support of this recommendation and other recommendations and outcomes of the Study discussed below, the following findings have been made upon the completion of the Study, and these findings support the Port Authority's recommendations to the Saint Paul City Council, following RCAP review as well as review by the general public at two public meetings and the District Councils' reviews and resolutions:

1. Rock-Tenn needs 2.0 Million MMBtu (annually) and 275,000 Lbs/Hr (peak) of steam but the mill currently cannot utilize all the low grade waste heat generated by the paper making process. This waste heat should be utilized to the extent possible first at Rock-Tenn and then beyond the site at other neighboring facilities or an energy district.

2. The Port Authority strongly recommends continued aggressive implementation by Rock-Tenn of identified energy conservation efforts and will avoid any contract component that would create a disincentive to implement such measures.

3. Multiple technologies have been determined to be technically feasible to meet Rock-Tenn's energy needs including: anaerobic digestion, conventional combustion, and gasification.

4. Sufficient quantities of renewable fuels are available including sustainably harvested wood, refuse derived fuel (RDF), and wet agricultural fuels which can be utilized in an anaerobic digester to produce biogas.

5. All feasible technologies and scenarios being pursued by the Saint Paul Port Authority will significantly reduce greenhouse gas emissions from the mill's current operations.

6. Consistent with the legislative direction to recommend a preferred alternative that has the least environmental impact consistent with the economic viability and technical feasibility of the facility and since the Twin Cities metropolitan area is in attainment, alternatives that require a new facility on the Rock-Tenn site will utilize the U.S. Best Available Control Technology (U.S. BACT) except that the Port Authority agrees to apply air emissions controls that meet European Standards (EU) if more stringent than U.S. BACT.

7. Transportation and other smaller pollution sources have a greater impact on local air quality than controlled emissions from large industrial sources such as Rock-Tenn.

8. For any new facility, the Port Authority will continue to look at additional emission controls to the extent they are economical. The Port Authority will request and pay for additional monitoring sites.

9. A new gasification facility would add on average 36 to 41 trucks per day hauling dry biomass to Rock-Tenn, about a 0.02 percent

increase over the more than 225,000 vehicles that currently travel in the area of Highways 280 and Interstate 94.

10. Regardless of the fuel option selected, there is the potential to utilize waste heat generated by Rock-Tenn operations in a district energy system that will require further study.

11. The use of anaerobic digestion as a renewable technology in this country will continue to grow.

12. Anaerobic digestion allows the use of existing infrastructure to link and use rural resources to meet the energy needs of urban areas.

13. Using biogas generated by anaerobic digestion will not only reduce the use of fossil fuels but also reduces the release of methane gas into the atmosphere that is 21 times more potent greenhouse gas than CO2.

14. The Port Authority has found that the use of any of the feasible technologies and fuels would result in lower emissions from the Rock-Tenn facility.

## B. Recommendations

The Port Authority saw the need for an innovative approach to preserve local jobs at the major paper recycling operation in Minnesota while improving energy conservation measures and reducing the carbon footprint of Rock-Tenn's operations. The Port Authority has continued its research of the production of renewable biogas in rural Minnesota utilizing anaerobic digestion. During the study, RCAP and the Port Authority learned of wet feedstocks suitable for digestion including whole and thin stillage from corn ethanol production as well as other wet agricultural and animal by-products that are available. The Port Authority concluded that it was technically feasible, economically viable and environmentally sound to offset Rock-Tenn's use of natural gas if the price could be discounted through revenues and carbon credits from a biogas facility in rural Minnesota. Therefore it recommends the Saint Paul City Council approve the burning of discounted natural gas in Rock-Tenn's existing generators utilizing revenues and carbon offsets from the Port Authority's participation in the development of a biogas-producing anaerobic digestion facility in rural Minnesota. This recommendation involves a number of Minnesota partners to successfully produce sufficient quantities of clean biogas that results in a competitive energy price to Rock-Tenn over a sustained period of time.

It is impractical for the biogas, produced from the anaerobic digestion of a variety of organic waste materials in rural Minnesota, to be piped directly to Rock-Tenn. Instead, the biogas would be cleaned to natural gas quality and piped into the state's existing natural gas pipeline infrastructure. In this way, carbon neutral biogas from rural Minnesota would offset Rock-Tenn's use of natural gas. The production of biogas would be the least polluting of the available fuel options. Biogas emits very little long-term global-warming carbon dioxide harmful to the environment and public health that is not captured during the growth of the organic material utilized as feedstock. Depending on the method and feedstock, anaerobic digestion also provides benefits to the immediate community including management of undesirable waste, significant cleanup of water, and the production of nutrient rich soil for agricultural uses.

This approach also would use the plant's existing boilers and not require construction of a new energy facility at Rock-Tenn. There is a need to continue energy conservation efforts and the Port Authority recommends the implementation of conservation projects identified for the mill. Increased conservation and energy efficiency efforts that Rock-Tenn had engaged in prior to and with the help of this study will also provide real, measurable and long-lasting energy reduction and cost savings.

The Port Authority also recommends further study of harnessing excess waste heat from Rock-Tenn's operations. Such waste heat could potentially be recaptured and recycled to further reduce the mill's operating costs, as well as to heat commercial and industrial buildings along the Central Corridor. The prospect of a Central Corridor energy district can serve as an environmentally sustainable catalyst for the green manufacturing zone envisioned by the Mayor. And it can amplify the environmental benefits of the Central Corridor light rail line.

Multiple "project partners" are needed to successfully implement the Port Authority's recommendations. Business arrangements need to be negotiated with various project partners including feedstock suppliers, technology vendors and operators, gas distributor and other utility support. Together these partners will be expected to provide a discount from the fluctuating cost of natural gas to Rock-Tenn. The company has indicated that the steeper the discount from the price of natural gas, the longer the company is prepared to commit to operating in Saint Paul.

A number of variables need to align if this option is to be successful – including the sale of carbon credits to supplement the natural gas-

price discount and, more importantly, the successful financing of a large anaerobic digester using U.S. Department of Energy, U.S. Department of Agriculture or other loan guarantees. Our efforts also would require that Rock-Tenn commit to continue operating the Saint Paul plant for at least 10 years after the biogas delivery system is up and running.

Anaerobic digestion of organic waste materials in rural Minnesota is the cleanest and least environmentally disruptive option to the Twin Cities metro area. If all the conditions are met, it also would be the most cost-effective option for Rock-Tenn. The Port Authority is confident that all of the conditions can be met.

However, should the financials of our preferred option not be realized, the Port Authority would explore two other alternatives. Both would involve the construction of new green energy facilities at Rock-Tenn to generate the thermal (steam) energy it needs.

The first alternative would still be linked to the generation of renewable biogas in rural Minnesota and added to the natural gas grid. But we also would build a new gas-turbine co-generation facility at Rock-Tenn powered by natural gas. This new electric turbine would generate both steam to run Rock-Tenn's machinery and electricity. Sale of the renewable electricity and carbon credits from a biogas facility would reduce the net cost of the thermal (steam) energy sold to Rock-Tenn. Although this would require a greater quantity of biogas than the continued use of the existing boilers, the new cascaded system would be highly energy efficient (the most energy efficient of all of the options) since the new co-generation plant would also continue to use the existing co-generation plant at Rock-Tenn. In addition to construction of a new plant at Rock-Tenn, it would require securing about 60 percent more biogas for offset and negotiating a power purchase agreement with an electric utility.

The Port Authority's second alternative is the gasification of renewable biomass energy crops such as willow, perennial grasses and forest residues at a new facility to be built on the Rock-Tenn campus. This option would require a loan guarantee form the U.S. Department of Energy in the range of $50 million to $70 million. It would require national Farm Bill financial assistance to establish and harvest energy crops on marginal lands, as well as contracts with farm and lumber cooperatives to accumulate these crops. The capital cost of the gasification system also would need to be refined to the $60 million to $70 million range.

Until a project is financed to meet Rock-Tenn's energy needs, all other options will remain in the event future consideration is needed. Should all of the three recommendations not be found to be successful, the public process would be reopened.

Finally, this creative solution is not the only outcome of the collaboration of RCAP and the Port Authority on this study. Based upon other work this past year, Rock-Tenn will have decreased its peak energy demand by approximately 23 percent. In addition, the prospect of utilizing waste heat from Rock-Tenn's manufacturing process to supply heat to a major user or more than 300 commercial and industrial buildings along the Central Corridor could offer significant financial and environmental benefits to the businesses and neighborhoods of Saint Paul.

## IX. Rock-Tenn Community Advisory Panel Comments and Supplemental Recommendations

On August 18, 2008 the Rock-Tenn Community Advisory Panel (RCAP) finalized their review of the report on the Rock-Tenn Energy Facility Study authored by the Saint Paul Port Authority. By consensus, RCAP approved the following recommendations to be included as Chapter IX of the report and forwarded to District Councils 11, 12, 13 & 14 as well as the Saint Paul City Council.

The following points were unanimously approved by the RCAP:

### Recommendations

1. RCAP endorses the preferred option put forth by the SPPA to offset the combustion of natural gas with the production of biogas derived from anaerobic digestion.

2. In the event that the preferred recommendation is not successful, RCAP endorses alternative #1 with the assurance that the fuel used by the turbine will be exclusively natural gas (or biogas).

3. RCAP cannot give unqualified support to Alternative #2 due to the lack of sufficient information on environmental performance and economics. Of the solid-fuel combustion options gasification has the potential to be the most benign. However, if this alternative is explored, RCAP recommends that it be reconvened to vet the economic and environmental details.

4. RCAP recommends the continued pursuit of energy conservation. It will produce the greatest savings and most positive environmental and health impact.

5. Process heat reuse and recycling can reduce total energy demands at Rock-Tenn by at least 20%, while providing a large amount of surplus low-temperature heat for sale to and use in the surrounding area. Reduced demand, plus surplus energy sales will contribute to lowering Rock-Tenn's overall energy costs. RCAP encourages Rock-Tenn and partners to distribute to other users any surplus low-grade energy that may be available as a result of continued conservation efforts.

6. Minnesota statutes treat RDF as a renewable energy source, and RDF is accordingly an eligible fuel for the proposed power plant. As a practical matter, the RCAP does not view RDF as renewable. A large fraction of the energy available from the thermal conversion of this

material comes from plastic, which is currently derived almost completely from fossil fuels.

7. RCAP recommends that Refuse Derived Fuel (RDF) be removed from future consideration as a fuel source for Rock-Tenn.

**Qualifying Statements**

The statements below apply to all our findings and recommendations and serve as overall statements regarding implementation of the next stage of the project.

1. In principle, RCAP believes there should be equal duration of public commitment and the commitment of Rock-Tenn.

2. RCAP, in its approval of the findings and recommendations, assumes that on-site use of fuel oil at the Rock-Tenn plant site will be minimized.

3. RCAP has not reviewed the data about the potential environmental impacts of any anaerobic digestion facilities. The endorsement of any of the Study's recommendations and alternative proposals should not be seen to imply that we have reviewed the environmental impacts of biogas production.

4. As the project proceeds, the development of each option must include a process for gathering local input, participation and support.

5. Appropriate environmental safeguards should be used to assure that any biogas facility (anaerobic digesters) manufacturing biogas for Rock-Tenn meets the highest health and environmental standards achievable in the community where the facility is located.

**Additional Findings**

1. RCAP supports implementation of comprehensive zero waste strategies for the city of Saint Paul.

2. RCAP endorses solar, wind and metropolitan area biogas production because of the environmental and health benefits they provide. We recommend they be included as strategies in meeting Rock-Tenn's overall energy needs if doing so can add value to the economics of the current or future facility.

## X. Report Appendices Outline

### I. Introduction

Ia SF 2096
Ib 2007 Renewable Energy Objectives
Ic Historical Timeline
Id Demographics of affected districts
Ie RCAP Outline

### II. Rock-Tenn's Energy Demand and Conservation Potential

IIa Current Manufacturing Process Memo
IIb Rock-Tenn Energy Presentation
IIc Energy Recap Letter
IId January 14th RCAP Presentation
IIe HDR Tech Memo #1
IIf 2008 Metso Tech Memo
IIg Schedin Tech Memo (available energy efficiency subsidies)
IIh 2007 Energy Independence and Security Act

### III. Fuels

IIIa Dec 10th RCAP Presentation – John Dunlop
IIIb 2007 Green Institute Report "Renewing Rock-Tenn"
IIIc Green Institute Biomass Fuel Plan
IIId RCAP Consensus Finding Document
IIIe April 7th RCAP Presentation - Pat Hirl
IIIf Beneficial Use and Recycling of Municipal Waste Combustion Residues
IIIg 2008 United States Farm Bill
IIIh Ramsey County Public Health CEC Webpage

### IV. Technologies

IVa HDR Tech Memo #3
IVb Appendix A
IVc Appendix B
IVd Appendix C
IVe Appendix D
IVf ARI - Identification and Evaluation of Advanced Conversion Technologies
IVg April 7th RCAP Presentation - Pat Hirl

## V. Emissions Analysis and Health Impacts

Va Scenario Grid
Vb Barr Step 1
Vc Barr Step 2
Vd Barr Step 3
Ve Barr Toxicity Assessment
Vf Barr Step 3 Supplemental Evaluation Memos
Vg October 22nd RCAP Presentation - Dr. Greg Pratt
Vh February 25th RCAP Presentation – Mike Mondloch
Vi February 25th RCAP meeting minutes

## VI. Non-Economic Impacts

VIa HDR Tech Memo #3
VIb Appendix A
VIc Barr CO2 Emissions by Fuel Type Memo
VId Green Institute Assessment of Pre-Plant Environmental Impacts of Biomass Memo
VIe Environmental Financial Group – Greenhouse Gas Emissions Accounting

## VII. Financial Analysis

VIIa Project Economics Spreadsheet
VIIb The Economist, June 19, 2008. *Special Report: The Future of Power*
VIIc Project Economics Summary of Results
VIId 2008 United States Farm Bill
VIIe EFG Carbon GHG Accounting Memo
VIIf EFG Carbon GHG Financial Analysis Memo

## VIII. The Saint Paul Port Authority's Findings and Recommendations

## IX. Rock-Tenn Community Advisory Panel Comments and Supplemental Recommendations

## X. Public Input

Xa Public Input Collected During Public Comment Period