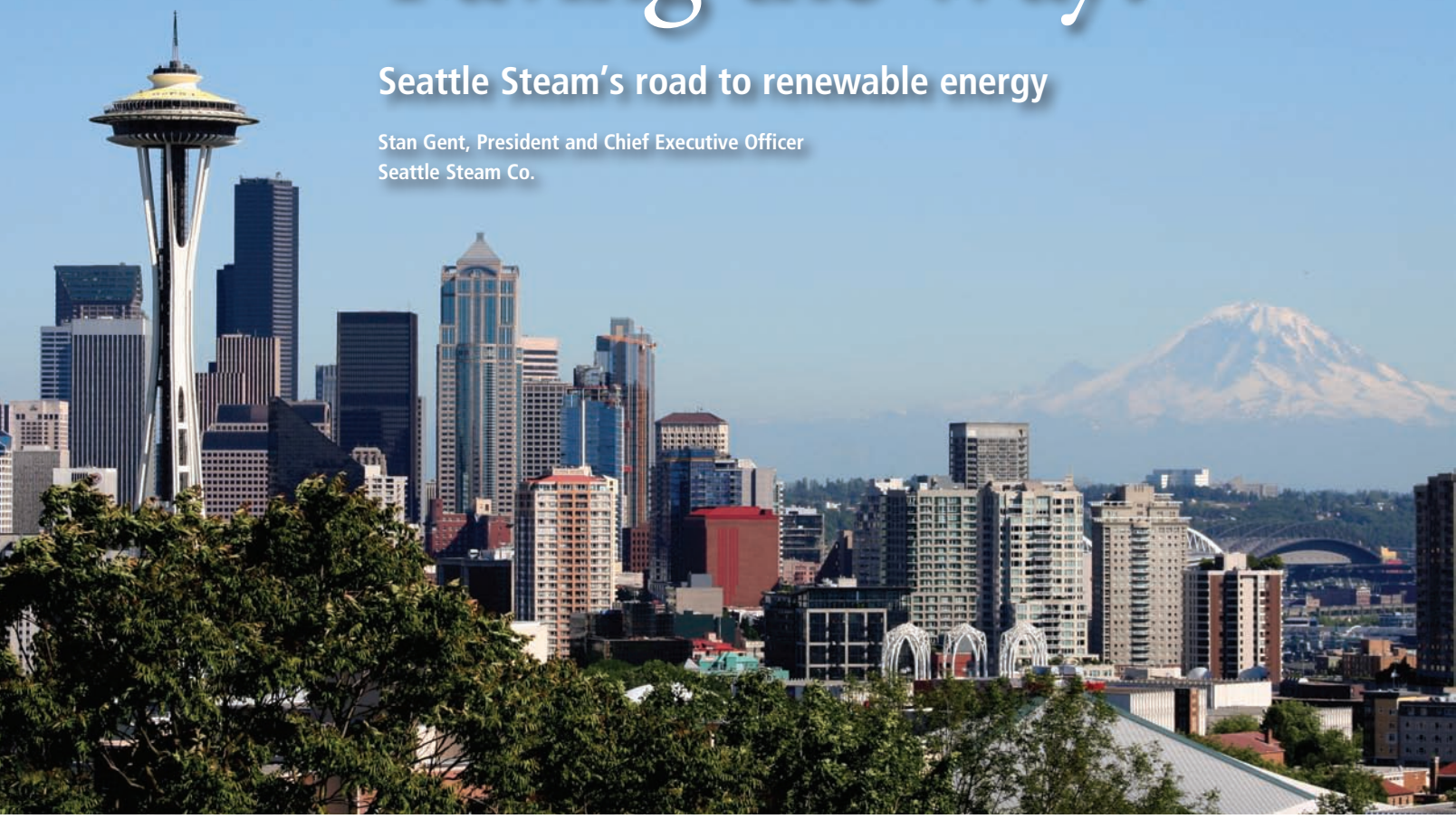
Cover Story

Paving the Way:

Seattle Steam's road to renewable energy

Stan Gent, President and Chief Executive Officer
Seattle Steam Co.



In 1893, downtown Seattle was getting a new start. Largely devastated by the Great Seattle Fire of 1889, the city was rebuilding: Fire-resistant structures were going up, and a new tram system started operation. A steam engine provided DC power for the tram and heated 17 of the city's new buildings. It was the beginning of district heating service; the beginning of what is now Seattle Steam Co.

Today, the company's district heating system is an integral part of the community's infrastructure, serving 200 buildings through 18 miles of steam pipe. The privately owned system had burned natural gas for more than 30 years. By 2005, however, with prices rising and an increased global focus on environmental impact, the system's owners felt they faced a new era that would require doing business in a carbon-constrained environment.

In 2000, the company had installed a fuel gas heat-recovery system, which effectively made Seattle Steam's gas-fired boiler plant a condensing boiler plant – improving plant operating efficiencies by nearly 7 percent and reducing associated emissions. But the owners wanted to know what they could do next. Seattle Steam responded by analyzing three alternatives to reduce carbon emissions:

- combined heat and power generation
- waste heat recovery from a nearby cement plant
- converting baseload operations to biomass fuel

Low local electricity rates and the relatively long distance from Seattle Steam's plant to the cement plant made the first two alternatives less attractive than converting the company's baseload heat demand to a renewable fuel – in this case, local biomass. The owners examined the options and agreed that using clean urban waste wood as a renewable fuel to reduce annual carbon emissions

by 60 percent would place Seattle Steam Co. in a strong position for a sustainable future. That decision was just the start of the company's journey toward biomass use, which it hopes will pave the way for others and expedite the startup of other biomass-based district energy systems throughout North America.

Can It Be Done?

Seattle Steam got to work and conducted the following tasks in parallel to get the new biomass boiler online as quickly as possible:

- a more in-depth study of the local regional wood supply and demand to indicate fuel availability and cost
- an engineering study to help determine a construction cost estimate
- a community involvement program
- raising of the debt component

Performed by TSS Consultants, the wood supply study confirmed what one would suspect in the Pacific Northwest: There was a ready supply of wood for the plant being contemplated by Seattle Steam. At the time, Tad Mason of TSS noted that the region has a mature market for hog fuel (a coarse, unprocessed mix of bark and wood chips) because of its historical use within the area.

Meanwhile, the engineering team was determining the maximum size of biomass plant that would fit into the space available at the existing steam plant. The existing site could support an 85,000-lb/hr steam boiler complete with biomass- and ash-handling systems. Once the plant's equipment was preliminarily sized and selected, an emissions analysis was conducted, indicating the facility would meet local air emission permit requirements. It helped that the biomass plant would displace an older gas-fired unit so nitrogen oxide emissions would be lower, even though biomass use would introduce new emissions such as particulates, chlorine and sulfur. Final permitting with related agencies went smoothly in 2007, with the first permit received from the Puget Sound Clean Air Agency.

Seattle Steam's community involvement program included public and private meetings with local politicians and neighbors, plus a communications program designed to invite input and critique of the company's plans. This program proved successful. Neighboring businesses were in favor of the project, and when the permitting process began and opened for public comment, no one raised any objections.

Raising the financing for the $25 million program turned out to be much more problematic. Traditional lenders recognized the project's financial returns and benefits but seemed unwilling to lend until it was constructed and proven to work. Project financing also was examined from other less traditional angles with no better results.

In a 2007 meeting with union operating staff, the challenges of finding acceptable financing came up in discussion. A union representative mentioned that Washington Capital Management Inc. (WCM), a Seattle-based institution that manages local union pension funds, might be interested in a union-constructed and -operated project. A few weeks later, WCM contacted Seattle Steam with an offer to review the project's financials. WCM believed that investing in energy infrastructure that provided union jobs both for construction and continuing operations aligned with its investment strategy.

Washington Capital Management typically finances new union-built commercial buildings, but as Jim Hummer, director, real estate investments shared with a reporter at Eco-Intel.com, the firm occasionally participates in such outside-the-box investments: "Our smaller size means we don't have to precisely define the type of loans we fund. Our primary task is to find good real-estate investments for our clients. We have very experienced people here and we could see this project offered an attractive return." According to Hummer, the interest rate, on a risk-adjusted basis, was higher than what his firm could get on typical commercial mortgages at that time.

In 2008, WCM, on behalf of its pension clients, provided a commercial mortgage loan of $20 million for the biomass boiler project. Seattle Steam put in an initial $5 million. After incorporating fees, soft costs and the interest during construction, Seattle Steam's overall investment will end up at about $10 million.

With permits and funding to build in hand and a guaranteed maximum price contract signed with WCM once financing was in place, Seattle Steam's biomass boiler project officially was given the green light in April 2008. (See table 1 for project timeline.)

Table 1. Milestones en Route to Biomass.

Year	Key Accomplishments
2005	Initial in-house feasibility study evaluating three options and showing biomass feasibility potential.
2006	Feasibility study to determine preliminary cost estimates, wood fuel supply availability and cost, and emission and permitting definition.
2007	Design development.
	Master-use permitting for the site changes.
	Emission permitting.
	Definitive design and final scope, cost and schedule development.
	Financing plan and construction financing agreements.
	Wood-fired system procurement.
2008	Financing closed.
	Construction commencement with gas firing by December 2008.
2009	Project completion and wood firing by year-end.
2010	Commissioning process completed by year-end.
	Construction loan replaced with New Market Tax Credit structured debt.

Source: Seattle Steam Co.

Seattle Steam Co. brought in the largest mobile crane in the Pacific Northwest to lift its new biomass-fired boiler into position at its Western Avenue Plant in downtown Seattle.

From Demolition to Operation

A flurry of activity got the biomass project off to a fast start. Major equipment was procured, and an existing gas-fired boiler was demolished. This boiler, while one of the company's oldest, was still part of its dispatch lineup. Seattle Steam determined that the most economical way to maintain system availability and reliability was to have the new boiler in service firing natural gas the winter following the old boiler's demolition. (The new boiler would be retrofitted to fire biomass the following year.) A cold spring delayed the older boiler's removal, so work had to be expedited to get the new boiler in place and operational on time.

The work site didn't necessarily cooperate, however. After demolition, the challenges of preparing the new foundation in a particularly difficult environment kept the contractors busy. Given the plant's proximity to Elliot Bay in Puget Sound, the water table presented challenges, often flooding the work area during high tide. Though not an unusual situation, this still complicated the project. Pressure grouting of the existing foundation strengthened the existing building while piles were added in the new building to support the new equipment.

With the foundation secure, the new steam boiler was lifted into place in early November 2008, as was the wood combustor, which had to be installed below the boiler even though it would not be used until the following year. This was achieved with little time to spare. The new boiler was on line and firing natural gas in time for the 2008-2009 heating season. (Construction videos are available at www.tinyurl.com/biomassvideo, www.tinyurl.com/baghouse, www.tinyurl.com/silovideo.)

Biomass Takes Center Stage

Construction continued on the wood-firing components of the job through 2009. The largest components,

such as the baghouse filters, were soon slotted into place in the existing 100-year-old building with only fractions of an inch to spare.

In preparation for startup, Seattle Steam issued a wood specification to vendors in the wood supply chain to solicit supply quantities and price. One response came from Cedar Grove Composting, the local company that composts the city's yard waste. Although local regulation would not allow Seattle Steam to burn yard waste, Cedar Grove Composting proposed to supply the woody biomass that remained in the compost they made from the city's yard waste. "When Seattle Steam first approached Cedar Grove Composting, we immediately saw an opportunity to better utilize a waste stream from our business," says Steve Banchero, the company's president and chief executive officer.

After much product analysis, Seattle Steam decided it could blend this special wood source with more traditional waste wood sources to make a good quality fuel at a lower-than-anticipated price. The plant did have to be modified to handle some of the product's special characteristics, but it was warranted given the large availability of this previously underutilized product.

With plant construction still in process, Seattle Steam contracted with Cedar Grove, plus other vendors of more traditional urban waste wood (pallets, construction demolition woods, storm debris, etc.), to fuel the new boiler when operations began. The biomass was to be delivered to the new fuel handling facility across the street from the plant.

The facility was designed to allow deliveries from a wide range of suppliers during the normal workweek. The staging facility would also be used to blend wood from different suppliers and manage the wood flow process – from receipt of the wood (weigh scales, quality management, etc.) to its delivery to the plant each night.

Seattle Steam's new fuel handling facility is adjacent to one of its customers, the Four Seasons Hotel. The facility quickly took shape in 2009, with construction of the storage silo (right) attracting community attention. Uniquely, the roof section went up first, and the silo was built from the top down by jacking up each course of the tank over the eight-week construction time frame.

System Snapshot: Seattle Steam Co.
System Owner: Seattle Steam LP
System Operator: Seattle Steam Co., Seattle, Wash.

Startup Year	1893
Number of Customers	167
Number of Buildings Served	201
Total Building Space Served	18 million sq ft
Central Plant/Type	Western Avenue Plant – Gas- and biomass-fired boilers
Central Plant Capacity	602,000 lb/hr steam, 4 boilers
Number of Satellite Plants	1
Satellite Plant Capacity	100,000 lb/hr steam, 1 boiler
Total Number of Boilers	5 boilers
Total Annual Energy Sales	
(or energy delivered)	10,764 MMBtu total from all plants
Fuel Types	natural gas, biomass
Distribution Network Length	18 trench miles piping
Piping Type	direct-buried carbon steel
Piping Diameter Range	4 to 18 inches
System Pressure	15 & 140 nominal psig
System Temperature	360 degrees F

Source: Seattle Steam Co.

Seattle Steam opted to have a fully computerized database management system developed to use radio frequency identification technology to track and manage all fuel-related matters. The company felt that traditional wood management programs were too low-tech for its needs and would require additional labor to support them.

As a result, the company hired UtilityStudio to adapt the program Seattle Steam uses to track and manage customer energy sales into a wood management system capable of interfacing with its

Seattle Steam uses urban waste wood as the fuel source for its new boiler. The wood comes in all shapes and sizes (left) before it is processed to meet the company's boiler specifications (right).

accounting system. The resulting system handles billing and records management that logs the test results of each supplier's wood and the wood blend going to the plant each night. "This was the first time we were asked to complete a wood management database instead of our more traditional energy management programs," says Gary Michaels, president of UtilityStudio. "It proved challenging and interesting to track not only the fuel but the associated test results that define the fuel into one easy-to-use system."

With the wood supply in order and construction of the wood-related equipment completed, the new boiler switched over from firing natural gas to biomass in December 2009. Commissioning then began.

The Reality of Operation

While the switch represented the end of construction, it was just the beginning of Seattle Steam's most important work: using biomass to provide steam to customers. This is where the company's operations crew was, and remains, key. The operating team had carefully watched construction and made sure that the plant was built in a way that they could optimally operate and maintain it. The team's comments and concerns were integrated along the way, including adjustments to platforms and valve locations. When operation officially began, they were familiar with the plant, but since wood is not a homogenous fuel like natural gas, they knew operating procedures were about to change.

Working with urban waste wood can be messy. As a result, it took some time for the company to meet performance and emission standards and work with wood suppliers to learn the limitations of the process so they could ensure the wood was not overly contaminated with stones and metals. Enforcing standards with wood suppliers meant Seattle Steam had to terminate some contracts and find new suppliers willing to meet the demanded quality.

Even though Cedar Grove uses a magnet to sift through what's left of the yard waste after composting, some nonmagnetic metals still get through to Seattle Steam. Interestingly enough, Seattle Steam has found forks, knives and spoons when cleaning out ashes from the combustor. Conjecture is that homeowners accidentally toss them when scraping food waste off their plates into the compost bin. But all in all, as everyone gets more experienced with the requirements and process, wood supply quality continues to improve.

> In 2011, Seattle Steam will likely use its wood-fired boiler more than 80 percent of the time.

This is particularly important, as burning wood is a complex science where a deep understanding of the combustion process is necessary for successful operation. To ensure reliable service, boiler and combustor commissioning involves a series of different steps to see how the equipment reacts when it is brought offline and back online as part of a planned outage scenario. As a result of performing these exercises, corrections have been made to Seattle Steam's combustion process, and the operators are rightfully proud of these accomplishments.

Throughout the yearlong commissioning process, Seattle Steam used the wood-fired boiler 30 percent of the time. In 2011, usage will likely increase to more than 80 percent.

Measuring Success

Real success sometimes is measured by the ability to make decisions mid-project that change the project's course. In a project like this one, which was not a cookie cutter replica in any sense, this was even more the case. Every single step was analyzed to ensure everything was on track.

One important change was made to control acid gas emissions. As recommended by a University of Washington study, the company opted for a semidry absorption scrubber system rather than a bicarbonate injection system. The scrubber was deemed the best method to prevent the creation of a detached plume that could result from the interaction of ammonia, from urea injection to control NOx, and hydrochloric acid, formed by chlorine-contaminated wood (not uncommon in the Pacific Northwest forest), after the gases left the smokestack. This type of adjustment has helped optimize system operations and control emissions.

Positive changes were also made to the project's debt. Completion of construction recently allowed Seattle Steam to replace the construction loan with a New Market Tax Credit (NMTC) structured debt. At closing, the NMTC debt raised more than $6 million in federal tax exemptions that were injected as equity into the project. This complex refinancing was possible because of the location of the steam service district in relation to qualified census tracts (those that showed average income below a defined level).

But what is the result of the overall project now that commissioning is drawing to a close? The project is meeting its financial goals without increasing costs to the customers, plus a good first year of operation has put Seattle Steam well on track to meeting its 60 percent carbon reduction goal.

Seattle Steam's carbon emissions are monitored through The Climate Registry via annual audits conducted in September. Although the past year's certified results won't be available until early 2011, the results will immediately be made available to Seattle Steam's customers, many of whom now track their carbon annually. They will each receive specific information about how much Seattle Steam reduced their respective carbon footprints over the past year.

The company is committed to a reliable, consistent operating performance that will keep emissions down, carbon footprints reduced and customers satisfied – a good path for others to follow.

Stanley Gent, P.Eng., joined Seattle Steam Co. as president and chief executive officer in 2004. He previously was president of Comfort Link, a district cooling company located in Baltimore, Md. During the 1990s, when he was employed as vice president of engineering and development for Chicago-based Unicom Thermal Technologies, Gent became a leader in the development of a variety of district cooling systems. He may be reached at sgent@seattlesteam.com.

Recycling Goes Full Circle

The Virginia Mason Medical Center in Seattle marked Earth Day 2010 with an open house, inviting Seattle Steam and other key organizations to participate and share information with the medical center's employees and guests. On Facebook, the medical center wrote that "Seattle Steam will tell its story of preserving resources for future generations."

Seattle Steam staffed a table, answered questions and told its compelling story. Virginia Mason Medical Center's nonhazardous waste is collected by Cedar Grove Composting. Cedar Grove in turn provides waste wood from the compost to Seattle Steam, which then burns the biomass to produce steam. That steam provides heat to Virginia Mason Medical Center, one of Seattle Steam's customers, bringing the cycle full circle. The poster replicated here helped Seattle Steam convey its message.