Grate and Boiler Technology Assessment for a New WTE Plant in the U.S.

Gregory Gesell,
HDR Engineering, Inc.,
8404 Indian Hills Drive
Omaha, Nebraska 68114
(402)399-4978, ggesell@hdrinc.com

Matthew Clark,
HDR Engineering, Inc.,
701 Xenia Avenue South, Suite 600
Minneapolis, Minnesota 55416-3636
(763)591-5400, Matt.Clark@hdrinc.com

Abstract
The Olmsted County Waste-to-Energy Facility (WTE) is in the process of expanding the facility capacity. The original facility began commercial operation in 1987 and consists of two 100 tpd units, equipped with Riley boilers and Takuma grates. The plant was built during the construction boom for WTE plants in the U.S. At that time there were some industry leading technologies, and also were many other players in the field offering European, Japanese, as well as U.S. technologies for the combustion of MSW. The industry has changed since those exciting times when nearly every city and urban county in the country would at least consider WTE. Years of industry stagnation caused by a number of events and trends resulted in the merger, bankruptcy, or pull out of WTE engineering firms in the U.S. market. Today there are only a handful of technologies used and an even smaller fraternity of private operating companies.

Many private and publicly operated WTE facilities continue to operate successfully and recently several are in various stages of facility expansion or new plant development. Olmsted County started this process three years ago laying the groundwork for a facility expansion to double its capacity. Currently, the County is in the engineering phase of the expansion and expects to begin construction in 2007. The engineering effort includes consideration of commercially available combustion technologies and procurement of this equipment. This paper looks briefly at the historical availability of grate and boiler technologies and the findings of the County’s assessment of technologies available in the U.S. market.

Introduction
The Olmsted County Waste-to-Energy (WTE) Facility (Olmsted) is located in Rochester, Minnesota. In 1983, the need was identified to find an alternative to landfilling and a WTE facility appeared to be the best alternative. Olmsted wanted an environmentally sound, socially acceptable, and economically feasible solution to its solid waste problems. The County decided on mass burn technology as the best alternative for their project. The site chosen allowed the facility to produce electricity and to sell steam for nearby Federal and County buildings. Groundbreaking for the original facility occurred in September, 1985 and commercial operation started in 1987.

The Facility consists of two 100 ton per day (tpd) mass burn boilers. The facility was built as a field-erected plant with the traditional tipping floor, pit and crane, grate and boiler systems, ash handling, and air pollution control systems as shown in Fig. 1. The plant operates in a cogeneration mode delivering steam to a district energy system and also generating electricity with a back pressure turbine and a condensing turbine.
The Facility uses a Takuma grate system and a Riley Stoker Corporation boiler. The facility was the first application of a Takuma grate in the U.S. The nickel-chromium alloy grate system is a stepped forward reciprocating inclined system. One of the features of the grate system Takuma offered is a sophisticated automatic combustion control system.

The boilers were provided by Riley Stoker. The design is a vertical boiler with a large first pass and an empty second pass. Superheater, evaporator, and economizer tube bundle sections fill the third and fourth passes. Originally, the facility was outfitted with electrostatic precipitators, however space was left to install spray dryers at a future date. The Facility has since been retrofitted with spray dryers and fabric filters.

**Expansion plans**

After serving the needs of the County for nearly twenty years, the need for additional capacity has arisen. Space was designed into the site and original plant to allow for the addition of an expansion unit. Demand has increased enough to lead to the decision by the County to add a 200 tpd unit, thereby doubling the initial capacity of the facility.

The County established general criteria for the new combustion unit. The Facility has enjoyed the sophisticated combustion controls of the existing plant and required similar features or other enhancements on the expansion unit. Also, the County did not want to install twenty year-old technology but rather employ appropriate improvements in grate and boiler technology that have been developed since the original facility was started up. However, for new technologies, at least five years of operating experience was desired. It was decided that a reciprocating grate of similar operation as the existing units would provide consistency for the operators. The boiler was desired to be generously sized and match the existing steam conditions. Both multi-pass vertical and horizontal boilers were acceptable. Space was tight but could be expanded as needed within limits.

A detailed grate and boiler specification was developed in an effort to obtain bids from equipment suppliers. Numerous changes have occurred with grate and boiler vendors since the mid-1990’s and certain difficulties developed identifying teams that were in a position to offer a bid. The remainder of this paper discusses the grate and boiler technologies and suppliers investigated in an effort to maximize the number of potential qualified bidders.
At the time the original Olmsted Facility was constructed, a significant number of mass burn field-erected grate and boiler technologies were available depending upon the nature of the project. These included better known companies such as Martin, Von Roll, VKW, Steinmuller, O'Connor, and Detroit Stoker. A number of other lesser known suppliers were also actively marketing and in some cases constructing facilities with their technology. Some of these technologies included Katy Seghers, Takuma, Volund, and Widmer-Ernst, amongst others.

Much has changed since Olmsted Facility began operation. The stagnation of the WTE industry has resulted in numerous suppliers pulling out of the U.S. market. Others went bankrupt or were sold and consolidations have occurred. A few firms that were able to remain active overseas have been able to thrive in European and Asian markets that continued to grow while the U.S. market collapsed. One new technology was started and has had some success by first retrofitting existing plants and later rebuilding a facility.

**Combustion Grate and Boiler Procurement**

As Olmsted County began to look into expansion, a request for budgetary proposals was made in 2004 to selected grate and boiler manufacturers that expressed an interest in the project. Efforts were also made to find other technologies and companies that were qualified to engineer and construct the expansion project. The Olmsted management wanted to see technologies that had demonstrated experience operating a massburn grate and boiler system. Five proposals were received and reviewed. Varying levels of detail were provided, however they did provide a fairly good indication of interest and capabilities at that time. Budgetary proposals were received from:

- Austrian Energy and Environment AG - Von Roll
- Babcock & Wilcox/Volund
- Foster Wheeler Limited
- Riley Power Inc.
- Seghers Keppel Technology, Inc.

All of the proposals contained information that was very useful to Olmsted. They represented technologies that were known in the U.S. and were applied at operating mass bum facilities of a size similar to that under consideration by Olmsted in the U.S. and other parts of the world. For some of the reference projects the partnerships between boiler manufacturers and grate suppliers had not been applied at the same facility.

Based upon the information received from the budgetary proposals and Olmsted’s needs, criteria were established to help qualify acceptable equipment suppliers. As noted earlier, at least five years of operating experience were required. In addition, a dynamic, innovative company was sought that had over the years spent time and research improving their technologies. Starting with the budgetary proposals received, additional potential system suppliers were sought in an effort to expand the base of technologies qualified to propose. Searches were conducted in an effort to track down some of the technologies that had been available in the early 1990’s. Once all known options were investigated, this information was used to narrow the available choices down to the handful that were invited to bid on the grate and boiler system.

Based on the information collected from potential suppliers and the requirements and needs for the Olmsted facility expansion, HDR recommended the following manufacturers be considered to supply the boiler and/or grate for the expansion unit:

- Austrian Energy and Environment AG - Von Roll
- Babcock & Wilcox/Volund
- Babcock Power (Riley Power)
- Fisia Babcock Environment (FBE)
- Seghers Keppel Technologies

This list was much shorter than would have been possible in the early 1990’s and limited the number of potential proposals for a publicly owned and operated facility.

The following sections discuss the various technologies that were identified and some of the features that were important for this project. It should be noted that while some technologies were deemed to be unqualified for this project, these technologies may be fully suited for other applications. Often a combination of a grate and boiler system is presented, however in some cases a boiler or a grate were made available separately.
AE&E Von Roll

AE&E Von Roll is a subsidiary of Austrian Energy and Environment (AE&E) [1]. AE&E is a boiler and air pollution control equipment manufacturer most active in Europe. Von Roll is well known for their grate technology which is used in many of the Wheelabrator facilities in the U.S. It was acquired by AE&E in 2003. Von Roll maintains a licensing agreement with Wheelabrator, however in some cases Von Roll is allowed to offer the technology independently of Wheelabrator. This was important for Olmsted since they wished to remain the owner and operator of the facility. In addition, AE&E Von Roll was willing to consider supplying only the grate if another boiler manufacturer were interested in using the grate in their proposal.

AE&E Von Roll provided a budgetary proposal to Olmsted. A large reference list of installations was provided confirming that the technology has been used for similar applications in the U.S. and around the world. Von Roll has numerous WTE grates in more than a dozen facilities in the U.S. including the Broward County, Florida facilities and in smaller units such as McKay Bay, Florida and Claremont, New Hampshire. Most of these plants have been operating for many years and similar technology would be provided to Olmsted. The Von Roll grate is a forward reciprocating design as shown in Figure 2 with an incline of about 18 degrees. The grate design is air-cooled. The boiler included in the proposal had a vertical pass and a horizontal pass with the various tube bundle sections similar to Figure 3. AE&E also has other boiler designs with horizontal or vertical sections for the superheater, steam generator and economizer.

Figure 2. Von Roll Forward Reciprocating Grate System
Babcock & Wilcox Volund

Babcock & Wilcox (B&W) has been a well known supplier of boilers, particularly in the U.S. [2]. A large number of WTE boilers, largely associated with Wheelabrator or some RDF units were built during the late 1980’s and early 1990’s. Since that time, however, the downturn of the WTE and utility industries has been hard on this company. Very few coal fired power plants were built and B&W had to take numerous cost-cutting steps decreasing staff, shops, and peripheral technologies. However, B&W acquired the Joy/Niro spray dryer and air pollution control technologies and developed a relationship with Volund that provided access to the Volund technology [3]. This is one of the oldest mass burn technologies from Europe.

B&W was approached to determine their interest in bidding for the Olmsted expansion. A budgetary proposal was obtained as noted above. Volund actually took the lead on the proposal and B&W was used as the U.S. contact.

In the budgetary proposal reviewed, no specific qualification projects were identified. However, Volund has an extensive list of projects completed, many of which are in the 200 tpd size range. Most of their experience is in Europe, although they have a unit in operation in the U.S. in New Hanover County, North Carolina. Units were installed in Mecklenburg County, North Carolina but they have since been shut down. Numerous older incinerators were built in the U.S. Volund has a long history of waste incineration in Europe. Some of the early designs incorporated a reciprocating grate followed by a refractory-lined kiln. This technology was installed at the original McKay Bay Facility but the technology has since been discontinued and the McKay Bay Facility retrofitted.

Today Volund offers at least four different grate technologies. Two of these are air-cooled and two water-cooled. A number of the technologies that were available in the late 1980’s and early 1990’s were examined in this study. One of these technologies was the Braun and Sorensen grate. Volund lists one air-cooled and one water-cooled grate offerings as “Volund” grates and one air-cooled and one water-cooled grate as a “BS” grate. This grate may be based upon the former Braun and Sorensen technology. Little other information was found regarding this technology. The air-cooled grates are designed to allow water cooling to be added as needed. About half of their more recent projects have used water-cooled grates.
The grate proposed in the budgetary proposal for Olmsted was an air cooled design technology. It is inclined at an angle of about 15 degrees in the combustion zone. The BS grate has a steeper angle of inclination. It is a forward reciprocating grate with alternating fixed and movable rows that are designed to mix and tumble the MSW. The boiler concept was a three-pass European style vertical boiler.

Later, when the Combustion Grate and Boiler Proposal was put out for bid in 2006, Volund was still perceived to be the team leader. By this time the coal utility industry in the U.S. was red hot with numerous air pollution control retrofits and new plant construction taxing the capabilities of nearly all utility related companies. B&W indicated they were willing to work with Volund but Volund would need to prepare the proposal due to B&W’s short resource availability as well as other issues. Ultimately, Volund chose not to bid on this project.

Foster Wheeler Limited

Foster Wheeler (FW) provided a budgetary proposal for the County [4]. No installation list was provided with the proposal; however FW has provided a number of WTE boilers in the U.S. including Camden County, New Jersey, Commerce, California, and Hudson Falls, New York, all of which use Detroit Stoker grates. They have also fabricated boilers for other WTE facilities. FW has had good experience in the U.S. but limited experience in other parts of the world.

FW does not have a captive grate technology. Generally, for their mass burn installations they have used a grate system provided by Detroit Stoker and this is what was offered in their budgetary proposal [5]. The Detroit Stoker grate is a forward reciprocating grate design. Since Detroit Stoker is not as active in overseas markets, little opportunity for development or innovations has occurred.

The FW boiler presented in the budgetary proposal had a large vertical pass followed by a horizontal superheater and steam generator section and a vertical economizer. FW indicated they feel the horizontal superheater and generator design is superior to a vertical arrangement based on their experience. When preparing to bid, FW expressed interest in the project, possibly using Detroit Stoker grates. Their interest however declined upon review of the requirements for certain financial securities. Detroit Stoker also expressed an interest in the project, but finally they did not submit a proposal.

Riley Power, Inc.

Riley Power, a Babcock Power, Inc. company also provided a budgetary proposal for Olmsted County in 2005 [6]. Babcock Power has survived the lean years when few coal industry and WTE industry units were built the U.S., by restructuring several times. Babcock Power has some international relationships in place. Today, as with other boiler manufacturers, the turnaround in the utility business has stretched the company to provide services. The budgetary packet was brief but highlighted their recently completed installation of four boilers in McKay Bay, Florida. A more complete installation list was not provided. Riley, as Babcock Power was known in the late 1980’s and early 1990’s, provided many boilers equipped with a variety of grates. The boiler presented in the budgetary proposal was a vertical multi-pass design with three empty passes followed by a pass with platen tube bundles and another vertical pass with superheater and economizer tube bundles.

In the budgetary proposal, the grate technology was not clearly defined; however the reference facility, McKay Bay, utilizes Von Roll grates. In addition to Von Roll, Babcock Power has used mass burn grate technologies as varied as Duesseldorf roller grates, Steinmuller, and Martin.

Riley Power, Inc. teamed with Fisia Babcock Environment, GmbH, to provide a proposal for the Combustion Grate and Boiler in Olmsted as shown in Figure 4 [7]. Steinmuller air-cooled grates were proposed for the project. Steinmuller has both an air-cooled and a water-cooled version of the grate technology. The designs are interchangeable if a retrofit is desired after the initial installation. The boiler proposed had three vertical empty passes and a horizontal pass with superheater, generator and economizer sections.
The Steinmuller grate technology has been used in a number of facilities in the U.S. Representative facilities include the Montgomery County, Pennsylvania facility, Long Beach, California, and Portland, Maine. The technology was known to now be in the control of Fisia after several ownership changes transpired in Germany. Initial contact was made to Fisia to determine interest in the project. Fisia indicated they would seek a U.S. partner for the project and ultimately made the grate available to Riley Power for the project.

The grate technology is a forward reciprocating inclined grate that can be obtained as a fully air-cooled design or water-cooled for the sections seeing higher heat release. All of the current U.S. facilities have employed the air-cooled technology. Fisia indicated they would likely use the air-cooled grate but might offer a partially water-cooled design, perhaps as an alternate proposal. The grate technology was determined to be suitable for the project.

Seghers Keppel Technology, Inc.

The last of the budgetary proposals provided by potential equipment suppliers was from Seghers Keppel Technology, Incorporated (Seghers Keppel) [8]. Seghers Keppel provided a very detailed proposal with extensive system description and drawings. Keppel acquired Seghers about four years ago. The company was known as Katy Seghers when it was involved with the Savannah and Davis County, Utah (Wasatch Energy) Facilities. These plants represent the U.S. experience for the technology. Seghers Keppel is a smaller European technology with a number of facilities in Europe. Keppel is a boiler manufacturer, however with limited U.S. resources. A partnership was forged with McBurney Corporation where Keppel's design would be fabricated by McBurney, with Seghers Keppel as the lead for the project [9].

The boiler design consisted of two empty vertical passes followed by a horizontal pass with superheater, evaporator and economizer tube bundle sections.

Seghers Keppel has been actively advancing their grate technology since the early 1990's. Their technology is an inclined forward reciprocating design. Both an air-cooled and a water-cooled version of their grate are available. While interchangeable, the water-cooled grate has fewer tiles to minimize the number of connections and piping. Generally, water-cooled grates are used for higher heat release fuels. Seghers Keppel proposed the water-cooled grate as shown in Fig. 5 for the project because Olmsted County felt they had somewhat elevated waste HHV. Seghers Keppel was willing to offer the air-cooled grate but felt that the advantages of the water-cooled design outweighed the added expense. Both the existing Seghers grates at Savannah and Wasatch Energy use an air-cooled design.

Ultimately, Seghers Keppel declined to propose due to issues with developing a U.S. partner for the project.
Other Potential Equipment Suppliers

The search for other technologies or potential bidders was completed in a variety of ways including looking for technologies available in the past in the U.S., technologies that are active in other parts of the world, and potentially new technologies with enough experience to meet the operating criteria. A few other grate technologies were identified that had previously provided equipment for mass burn WTE facilities and they were given consideration.

Barlow Industries

Barlow Industries (Barlow) is a relative newcomer to the WTE industry [10]. The company was founded in 1994 just as the U.S. WTE industry construction of new plants was slowing down. Several facilities have been retrofitted with their Aireal® grate technology. These include modular units in Alexandria (Pope-Douglas Counties) and Perham, Minnesota and one of the Tulsa, Oklahoma field-erected units. The technology is unique in its design. The Aireal® grate system is a steeply inclined design with no moving parts. The grate angle of thirty degrees allows the waste to slide down the surface mostly by gravity. Underfire air and underfire pulse air is designed to aid with mixing the waste and achieving burnout. A clinker roller at the bottom of the grate is operated to maintain bed depth on the grate surface.

The grate technology is designed for an integral waterwall boiler, but does not have an extended operating history in this configuration. At the time of review, the Tulsa waterwall retrofit unit had been in commercial operation for less than a year's time. This unit apparently has a number of differences with what would be proposed for Olmsted and thus the experience was deemed not entirely relevant. Barlow has been in the process of re-building the Harrisburg, Pennsylvania facility with integral field-erected waterwall boilers and their grate technology. The first unit was just coming on-line at the time of review. While the technology showed some promise, outstanding questions related to emissions performance, availability, and grate life could not be fully addressed. Therefore the technology was not further considered for the Olmsted expansion.

Duesseldorf Roller Grates

The VKW, Babcock or Duesseldorf Roller grate system has been used in a number of U.S. facilities and around the world. The technology is unique consisting of a series of large inclined rollers instead of reciprocating grate bars. Generally the technology is used on larger unit sizes than was proposed for the Olmsted expansion. The technology is offered by Fisia Babcock Environment (Fisia). However, Fisia indicated they would likely propose another grate technology for this project. The grate technology was not further pursued for this project.

Martin

Martin grate technology is one of the best known and commonly used technologies in the U.S. and globally [11]. Numerous facilities and units in the size range exist. The technology employs a reverse reciprocating inclined grate. Martin has a licensing agreement in North American with Covanta Energy Corporation (Covanta) [12]. Due to this arrangement availability of the technology can be limited.
Martin has also acquired the rights to the Widmer + Ernst grate technology. This grate is a horizontal reciprocating grate. It offers Martin the capability to provide a significantly different grate design that may be more appropriate for certain facilities.

Since Olmsted County currently owns and operates its facility and intends to continue to do so, Covanta was not interested in offering the technology for the expansion unit.

Mitsubishi Heavy Industries

Mitsubishi has developed a number of projects in Asia [13]. No detailed response regarding the technology that might be offered was received. Mitsubishi may or may not have their own grate and boiler technology that they can use for a facility design in the U.S.

Noell

This grate technology was identified during discussions with Fisia Babcock Environment (Fisia). Fisia is a boiler and industrial equipment manufacturer based in Europe. Application of the technology in the U.S. has not occurred, to date. No installation list was obtained for the technology. It is a forward reciprocating slightly inclined technology. It was stated that it is compatible with the Steinmuller grate technology. However, there are some differences in the basic design. Fisia indicated they would likely not offer this technology for this project.

Takuma

The original boilers at the Olmsted facility use Takuma grates [14]. The Olmsted facility has been very pleased with the performance of the grates. The basic technology is a forward reciprocating inclined grate. The original design incorporated a number of features and controls that operations have found to be useful.

Considerable effort was expended to contact Takuma. Takuma has been active in the Asian markets but due to the lack of construction in the U.S. had not maintained most ties to the Olmsted facility or its ASME boiler stamp. Takuma did express an interest in the project. However, the lack of a U.S. partner with a boiler stamp slowed their efforts. Takuma apparently was not able to resolve their needs and ultimately did not propose.

Boiler Manufacturers

A few additional boiler manufacturers and fabricators were also investigated to determine whether any existed that had experience with the design of WTE facilities that had not responded to the budgetary proposal. The intent was to determine if it may be possible to define other teams so that as many qualified bidders would be available as possible. Again a review of past boiler manufacturers was completed, as well as to see if some overseas manufacturers might be interested in the project.

Alstom Power

Alstom Power (Alstom) was approached to gauge interest in the Olmsted expansion project [15]. Alstom indicated that they are very busy with the utility industry at this time. They were focusing on the coal industry and were not pursuing WTE at the time of contact. Alstom does claim experience from the Combustion Engineering refuse derived fuel (RDF) plants however it was not possible to verify experience with a mass burn facility boiler design.

Fisia Babcock Environment

As noted above, Fisia Babcock Environment (Fisia) was contacted because they could offer several grate technologies including one of the Steinmuller, Noell, or Duesseldorf grate technologies with boilers and APC equipment. Fisia also is a boiler manufacturer based in Europe. The Fisia team has been assembled from resources from Steinmuller, Noell, and Deutsche Babcock as well as other companies that were merged when some of these firms had financial struggles. The boilers in some cases have an open first pass with a horizontal boiler section for steam generation using rappers for cleaning. Fisia also has boiler designs with a multi-pass vertical style boiler. Generally the boiler would have two or three empty passes followed by superheater, evaporator, and economizer sections. It was not clear which boiler arrangement might be proposed if Fisia chose to bid.

Fisia indicated that they had worked with Babcock Power in the past but a U.S. link was
not identified initially. Ultimately, Fisia did partner with Babcock Power with the team providing the Steinmüller grate system and three empty pass boiler followed by a horizontal section with the tube sections.

Indeck Keystone Energy

Indeck Keystone Energy was identified as a possible boiler supplier for the Olmsted Facility [16]. Indeck has its roots in the former Zum Company who fabricated numerous WTE boilers in the U.S. Indeck has an arrangement with Barlow to provided boilers for future projects. However, Indeck did not provide the boilers at Harrisburg for the Barlow retrofit. The boiler design would likely be a multi-pass vertical design.

Mitsubishi Heavy Industries

As for grate technologies, Mitsubishi was looked at as a possible boiler supplier. E-mail communication was established with Mitsubishi, and Mitsubishi expressed some interest in the project. No detailed response regarding the Mitsubishi technologies was received.

Conclusion

Much has transpired with the grate and boiler equipment suppliers since the mid-1990's when the last new facilities were built in the U.S. Many of the grate technologies that were available have changed ownership with consolidation resulting in one company offering more than one grate model. This was almost unheard of during the last wave of WTE plants. Water-cooled grates have become more prevalent in Europe but have yet to be applied in the U.S. Some suppliers did not have capabilities in the U.S. market and were not in a position to fill these gaps. For as much change as has occurred within the ranks of grate manufacturers, the downturn and change has been greater for the boiler suppliers. Companies of unquestioned clout and strength in the early 1990's have since struggled financially and/or been through consolidation. Some were still unable to provide the service they once did while others are so busy today with the rapid expansion of the utility industry that they are not considering WTE opportunities.

The request for proposals was sent to all the companies that were qualified and appeared to be in a position to bid. A pre-bid meeting was set and all potential bidders were required to send a representative to qualify for bidding. This was done to gauge interest as well as convey important information. Babcock & Wilcox or Volund did not attend this meeting. Prior to receipt of bids, Seghers Keppel decided that they would not propose on the project as well. Proposals were received from two teams: Riley Power teamed with FBE supplying a Steinmüller grate and Von Roll with Austrian Energy as the boiler supplier. Bids were evaluated and the Olmsted County expansion is proceeding ahead with the Von Roll proposal. Von Roll has been requested to complete certain engineering phases but has not received a full notice to proceed. Olmsted continues to work on obtaining the final permit and County Board approvals that will allow the project to advance to full construction.

References