# Trip of Nickolas Themelis, WTERT Chair, to China, October 18-November 3, 2007 (by Liliana and Nickolas Themelis)

**1. Visit of Covanta subsidiary in Shanghai** (with Dr. Hanwei Zhang of Covanta Energy) Sunday-Monday, October 21-23, 2007

Met with:

**Mr. Hangyan Qu**
Senior representative
Covanta Energy Asia Pacific Ltd., Shanghai Rep. Office
2701 Ascendas Plaza, 333 Tian Yao Qiao Rd.
Shanghai 200030, P.R. China
Tel: 86-21-6426 4768 ext. 206; Fax: 86-21- 6426 4766; e-mail: HQu@CovantaEnergy.com

**Mr. Peter Guo**
Technical Director
Covanta Energy Asia Pacific Ltd., Shanghai Rep. Office
2701 Ascendas Plaza, 333 Tian Yao Qiao Rd.
Shanghai 200030, P.R. China
Tel: 86-21-6426 4768 ext. 207; Fax: 86-21- 6426 4766; e-mail: PGuo@CovantaEnergy.com

**Mr. Sam Xu**
Chief Financial Officer
Covanta Energy Asia Pacific Ltd., Shanghai Rep. Office
2701 Ascendas Plaza, 333 Tian Yao Qiao Rd.
Shanghai 200030, P.R. China
Tel: 86-21-6426 4768 ext. 208; Fax: 86-21- 6426 4766; e-mail: SXu@CovantaEnergy.com

**Ms. Sherry Lee**
HR & Office Manager
Covanta Energy Asia Pacific Ltd., Shanghai Rep. Office
2701 Ascendas Plaza, 333 Tian Yao Qiao Rd.
Shanghai 200030, P.R. China
Tel: 86-21-6426 4768 ext. 210; Fax: 86-21- 6426 4766; e-mail: e-mail: SLee@CovantaEnergy.com

Visited offices of Covanta Energy Asia, Monday, October:
Discussed activities of WTERT and WTERT-China web page.

***General information***; There are about 50 WTEs in China. The rapid development of WTE has been aided greatly by the Renewable Energy policy of the country: Coal-fired power plants receive 4-6 cents/kWh. WTE plants are considered as renewable energy and receive an additional 3 cents per kWh that is 7-9 cents/kWh. Tipping fees range from $10-30/tonne of MSW.

The rapid growth of the WTE industry has also been helped by the relatively low capital cost, estimated by Mr. Sam Xu at about $50,000/tonne of daily of capacity. On the minus side, moisture is high at 40-50% and average plant availability 80-70% vs. 92 of the US mature industry. Covanta US management participated in the international conference in Beijing where WTE was defined as clean and renewable energy.

WTE plants in China are of two main types: Stoker grate and Circulating Fluid Bed. The latter are much smaller and they need coal co-firing, up to 20% of the feed, to make up for the low calorific value.

**2. Visit of WTE facility in Shanghai** (with Dr. Hanwei Zhang of Covanta Energy and Shanghai Covanta people, Monday, October 22, 2007).

There are two WTE plants in Shanghai, the Shanghai Pudong and the Shanghai Puxi facilities. Both plants were originally developed and financed by the Shanghai municipality using foreign soft loans for the delivery of key components.

The Shanghai Puxi project was supported by a soft loan from Spain and the delivery contract was won by Babcock Espanola. The grate technology is the Steinmuller forward motion grate. This plant is now operated by Veolia.

We visited the Shanghai Pudong plant which was supported by a soft loan from France. The delivery contract was awarded to a consortium consisting of Ingerop SA (at that time belonging to the SITA group) and ALSTOM. The grate technology used is the SITY 2000 technology that is presently owned by Martin GmbH). The three grates were built in France but at this time replacement grate bars are supplied to the plant by Chongqing Luneng Environment Industry C. (CLE). At this time, the Shanghai Pudong plant is owned and operated by the Italian company Impregilo; transition of ownership took place after the mechanical warranty period from the original suppliers expired. Impregilo's main line of business is infrastructure and hydroelectric power.

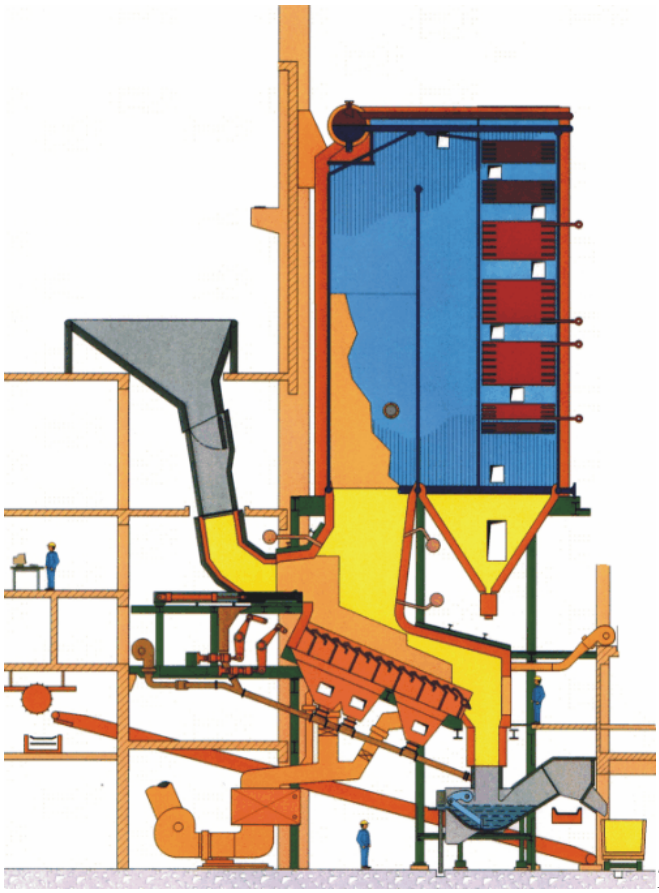
The License Agreement, which includes the SITY 2000 grate combustion technology, is between Martin GmbH and Chongqing Luneng Environment Industry Co., Ltd., a company that is 75% owned by the Chongqing Iron & Steel Group Co., Ltd. (CIS). %. Luneng manufactures in their workshop the grate bars and the grate itself. Martin GmbH has no contractual relationship with Covanta Sanfeng. The SITY 2000 grate is very much like the Martin reverse action gate with the exception that is slightly longer (17 moving and stationary grates instead of the 15 grates used by the Martin RA grate).

The Pudong WTE has design capacity of 1040 tons per day in 3 lines. It was completed in 2002 and occupies a total area of 80,000 m2 (20 acres). The stack is 80 m high which is the standard height in China. The visitors were met by plant manager Mr. Zheng Yiqiang who gave a short description of operation of WTE plant. He came from Taiwan to operate the plant in 2004 and has 15 years of prior experience in operating WTEs,

prior to coming to this plant. The same company that built the Pudong WTE built a second plant of 1200 tonnes/day capacity in Changdou.

The tipping fee paid to the WTE is $30/ton. The plant cost 600 million RMB (about $85 million at 2007 exchange rate). The guaranteed availability was about 85% and the actual availability has been 86-92% since 2004. The plant has a nominal capacity of 1040 t/d but its capacity has been increased to 480,000 tpy at 85% availability. Therefore, at the current rate, the corresponding capital cost is about $55,000 per daily ton.

Mr. Zheng said that in Taiwan the LHV of MSW is 2000 kcal/kg (8.5 MJ/kg) while in Shanghai is close to 1450 kcal/kg (6.4 MJ/kg) because of very effective recycling. The plant has 3 boilers and 2 turbines. Scheduled shut downs for maintenance are 15 days per boiler, twice a year. Production of power for the grid is 87 million kWh per year which corresponds to about 180 kWh per ton of MSW. The price received for the electricity is 0.5 RMB/kWh (about $0.07)



***The Sity 2000 WTE grate***

Because of the high moisture content of the MSW, the leachate collected from the pit amounts to 28% by weight of the MSW. The visitors saw sheets of water running down the wall into the pit after a truck unloaded its contents. The manager commented that the original design did not allow for adequate dewatering of the feed from the pit; there was only one runoff port at the bottom floor of the pit.

The primary air is preheated to 200°C and one of the operating problems is clogging of the air shutes under the grate. The bunker capacity is small and provides only for 2 days residence time. The steam generated is 400°C and 40 bar pressure. The nominal capacity of the two turbines is 17 Megawatts. This plant serves only the Pudong area of Shanghai. The quality of MSW in Pudong area is much better than in other districts (there is 16 districts in Shanghai) and in 2006 two of the boilers were in operation 365 days. The boilers are operated at relatively low temperature and there is no corrosion problem. The main operating problem is the handling of the leachate.

**3. Visit of Zhejiang University, Thermal Energy Laboratories and Pilot Plant**, in Hangzhou, October 23, 2007

Zhejiang University is a major comprehensive studies university in China. It has 16,000 graduate students. Apart from traditional engineering disciplines, recent research studies incline more towards thermal power generation, CFB combustion, etc, and WTE has become a key state issue. Zhejiang University is located in Hangzhou, a beautiful and prosperous province in southeastern China with rich cultural heritage and fine traditional products such as silk and tea. Honored as "the most beautiful and magnificent city in the world" by the Italian traveler Marco Polo, Hangzhou was the capital of China in the Southern Song Dynasty (1127-1279).

**Met with following faculty:**

**Prof. Kefa Cen,**
Director
Institute for Thermal Power Engineering
Zhejiang University
Hangzhou, 310027
P.R. China
E:mail: kfcen@sun.zju.edu.cn

**Prof. Yong Chi**
Deputy Director
Institute for Thermal Power Engineering
Zhejiang University
Hangzhou, 310027
P.R. China
E-mail: Chiyong@zju.edu.cn

**Prof. Junhu Zhou**
Deputy Director
State Key Laboratory of Clean Energy Utilization
Institute for Thermal Power Engineering
Hangzhou, 310027
P.R. China`
E-mail: enejhzhou@zju.edu.cn

**Assistant Prof. Zhijun Zhou**
Institute for Thermal Power Engineering
Zhejiang University
Hangzhou, 310027
E:mail: zhouzj@cmee.zju.edu.cn

Dr. Zhang of Covanta and Prof. Themelis visited the extensive pilot plant of the Thermal Energy Institute. Profs. Kefa Cen and Themelis signed a collaboration agreement between their respective research groups.

**4. Attendance of ICOPE-2007 (International Conference on Power Energy)**

October 23-27

- **P**resentation of keynote paper by NJT on "Energy and Climate Change Impacts of Thermal Treatment and Landfilling of MSW", October 24
- Participation in meeting "ICOPE International Advisory Committee" (comprises of 25 members of scholars and representative of agencies-domestic and overseas), October 24. Next ICOPE meeting, Japan, October 2009.
- NJT Chair of session: "Alternative Energy", October 25

**5. Visit of Circulating Fluidized Bed (CFB) WTE-"Hangzhou Nengda Green Energy Co., LTD.", located in the South of Yuhang Economic Development Zone, City of Zhejiang (October 25)**

Based on Zhejiang University CFB technology, the Hangzhou Qiaosi Power Plant is a prototype project of 800 tons of MSW/day capacity in a "high-tech" industrial area. The plant occupies an area of 46,00m2 (10.5 acres), floor space of 18,000m2, and it cost 220 million RMB ($31 million).

Approved by the State Planning Commission, the Qiaosi Power Plant is listed as the key specialized plant of the national environment-protection- high-tech industrialization, the 2001 scientific and technological plan of the State Construction Dept., and the "2001 key construction project plan of Zhejiang Province". Based on the Zhejiang University technology, the "fluidized-bed garbage incineration and power generation" the project was to be carried out in two phases. The first stage started in March 2001 and consisted of a 300 t/day and a 200 t/day CFB reactors and two 6 MW extraction & condensing sets. The two units began to generate power on June 28, 2002. In the second phase, a third 300 t/day incinerator was started in November 2003 and a 6 MW turbogenerator was put in operation in September 2004. After the construction of the power plant, the problem of garbage disposal of several districts of Hangzhou was resolved. The plant handles 222,000 tons of MSW annually.

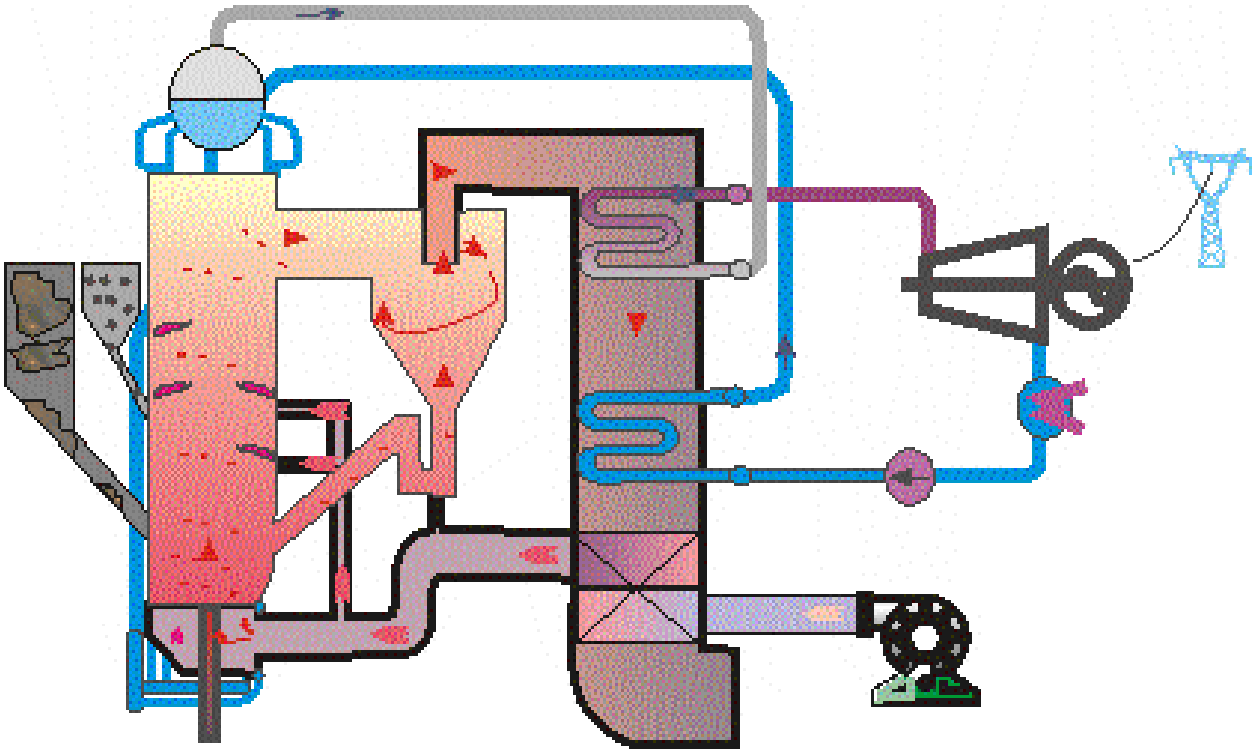
**Brief description of CFB feed and gas control system**

MSW is collected from various places, weighted, unloaded at the garbage platform and is transported by belt conveyor to the pit. Before loading to the CFB reactor, non-combustible materials such as construction waste and metal pieces are removed. The MSW is supposed to be shredded but the operation was discontinued during our visit although they stated that more recent plants incorporate shredders. During combustion,

20% of coal is added to increase the heat value. The coal addition stabilizes the combustion temperature of the incinerators, helps combustion, and increases the thermal efficiency of electricity generation. Each CFB unit is provided with two feeders one for MSW and the other for coal. They preheat the combustion air up to 200oC.

Each CFB unit is equipped with a $Ca(OH)_2$ dry scrubber and fabric filter baghouse. The dry dust particles collected in the bag filters are conveyed by compressed air to the bulk ash storage tank, while the clean flue gas is discharged through a 60 m stack (originally a regulation 80-m stack that was shortened because of adjacent air traffic). The net electricity to the grid is 450 kWh per ton MSW plus 0.2 ton of coal.

Two lines of the three were in operation during our visit.



Schematic diagram of Zhejiang CFB WTE Process

The CFB temperature was 880$^{o}$C. The combustion chambers were not housed in a building. The equipment appeared to be older than its five years in operation and we were told that the expected lifetime of the combustion chambers was 5-6 years. We were told that only the fly ash (25,000 tons/year or 10% of the MSW by weight) was landfilled while the bottom ash (12,000 tons/year) was used for road construction. The bottom ash exiting the ash hopper was red hot and was loaded into hand buggies that were then transported manually and emptied at an ash pile. Some metals were noticed. The fly ash was collected in small hoppers and then conveyed pneumatically in a large hopper from which flowed by gravity to 20-ton trucks that transport it to the landfill; there are 4-5 truck loads per day.

The plant is owned by a company that produces electrical equipment (Nengda Huawei Equipment). The facility employs 130 people and serves a population of about one million (i.e. generation is about 0.22 tonnes per capita). The City pays 25 million RMB per year i.e. about 120 RMB or $18/ton of MSW. Apparently, the bottom ash is sold for road construction at 15 RMB/ton ($2/ton). Despite its heavy metal content, and the Chinese regulation that fly ash should be landfilled, some of the fly ash is also used for brick fabrication and, surprisingly, commands a higher price than the bottom ash.

We were told that in all there are about 30 CFB WTEs for MSW combustion in China and another six are being built. This was the only CFB plant we saw in China, apart from the two pilot operations in Hangzhou and Beijing.

**6. Visit of Chongqing University of Science and Technology(CQUST)** in Chongqing October 28-30.
Met with following faculty:

**Prof. Zhu Xincai**
Chongqing University of Science & Technology
1 Shiyou Rd, Yuzhong District
Chongqing 400042, P.R. China
E:-mail: cqgzzxc@163.com.
www:cqust.cn

**Prof. Yan Xinping**
Chongqing University of Science & Technology
1 Shiyou Rd, Yuzhong District
Chongqing 400042, P.R. China
E:mail: yanxpcn@yahoo.com.cn

**Prof. Prof. Ding Youqing** dingyouqing@msn.com

**Ms. Eriy Tian**
Office of International Corporation
1 Shiyou Rd, Daping
Yuzhong District, Chongqing
400042, P.R. China
E:mail: merryeriy@yahoo.com.cn

**Brief description of CQUST:**

The Chongqing University of Science and Technology (CQUST) **is** a very old university dating back to the Ding Dynasty (12$^{th}$ century). The university campus covers an area of nearly 1.6 million m2 (400 acres) and a total floor space of 300,000 square meters. The new campus located in College City of Chongqing, with nearly 1,000,500 square meters, is currently under construction, and students started moving there in 2006. This new campus will become the main campus when construction is completed.

Currently, the university has a faculty of 650 and a student body of 14,000 –to be expanded to 40,000 in the new campus- and is responding to the demands of the national and regional economic and social development. Chongqing City is the center of a metropolitan area of 30 million inhabitants and has seen a dramatic economic change since 1997, when the city became one of the four municipalities administrated by the central government (with Beijing, Shanghai and Tianjin).

With the economic growth and waste generation of 180 million tons of MSW, 90% of which is landfilled, the central government has paid more attention to the waste and found that WTE is the best way to treat MSW, with regard to the air pollution and clean energy. Until five years ago, WTE technology was imported. Now, the central government has urged domestic companies to develop their own technologies according to the local waste composition which differs from the composition of western MSW.

The first institute of this kind is being built at the new Campus of CQUST University. The institute has a faculty of over 20. Some of them have spent some time abroad so as to acquire the knowledge and experience on sustainable waste management. The objective of the WTE institute is to provide viable suggestions to the government in regard with waste management solution. The faculty of the WTE Research Center have written feasibility studies of waste treatment and look for feedback from research associates and visiting professors from overseas in order to upgrade it. Also, some projects come from the Technical Committee of the Government, such as waste combustion research, waste components and pre-treatment, and waste combustion device. The Center has also proposed shredder and other equipment and has acquired 45 patents.

The major problem in implementing WTE technology was said to be lack of professionally trained engineers. It takes a long time to train a person to work on WTE. Internships and scholarships are part of the proposed agenda as well. Overall, the visit of Prof. Themelis was very much appreciated and collaboration with the Earth Engineering Center of Columbia University and with WTERT was considered to be a resource to CQUST. The WTERT organization can provide guidance in the research areas of the WTE institute led by Prof. Zhu Hincai of CQUST University.

Prof. Themelis presented a lecture to three hundred faculty and students in Chongqing University City, titled "Industrial Ecology and Energy Recovery from Municipal Solid Wastes". He then received a "Honorary Professor" certificate from CQUST and was interviewed by local press and TV (October 30).

A collaborative agreement was drafted and signed by Prof. Yan, VP of CQUST for CQUST and Prof. Themelis on behalf of EEC/Columbia. The first part of this agreement is for CQUST to undertake the formation of the WTERT-CHINA web page. Since the return of Prof. Themelis to the U.S. the two parties have started to work on this project and the preliminary edition can be seen at www.wtert.cn.

**7. Meetings with Sanfeng Covanta and Chongqing Iron and Steel people, October 29-30.**

**Met with following people from Chongqing Sanfeng Covanta Environmental Industry Co., LTD,** October 30, 2007

**Mr. Lei Qinping**
Vice Chairman/General Manager
Chongqing Iron & Steel Tech Bld, Village #2
Dayan, Dadukou, 400080
Chongqing, P.R. China
E-mail: leiqp@sancov.com
Web:www.sancov.com

**Mr. Smile Liu**
Vice General Manager
Vice Chairman/General Manager
Chongqing Iron & Steel Tech Bld, Village #2
Dayan, Dadukou, 400080
Chongqing, P.R. China
E-mail: liusm@sancov.com

**Mr. Si Jingzhong**
Technical Majordomo
Director of Technology
Chongqing Iron & Steel Tech Bld, Village #2
Dayan, Dadukou, 400080
Chongqing, P.R. China
E-mail: sijz@sancov.com

**Mrs. Tang Guohua**
Director, Human Resources
Chongqing Iron & Steel Tech Bld, Village #2
Dayan, Dadukou, 400080
Chongqing, P.R. China
E-mail: tanggh@sancov.com

## 8. Visit of Chongqing Tongxing WTE Plant

This facility was by far the best-looking WTE plant that we saw in China and one of the best we have seen anywhere. It is a joint venture headed by Chongqing Steel which includes Sanfeng Covanta, one of 20 subsidiaries of Chongqing Iron & Steel Co. The plant started operations in March 2005 and is using the Alstom SITY2000 design of Martin GmbH. Nearly all the equipment was fabricated locally to Martin specifications and, according to Covanta engineers, is as good as the equipment built in the west.

The nominal capacity of the plant is 1200 tonnes of MSW/day in two lines but it now operates at average feed rate of 1400 t/d. There is provision for athird line in the future. As in the case of the Shanghai MSW, the water content of the MSW is very high but

there are better provisions for collecting and treating the leachate which amounts to 20% of the MSW weight. The stack is 80 m high.

There is manual sorting of recyclable material at the collecting station from where the MSW is transported to the WTE. The plant handles 50% of the waste generated in the Chongqing municipality. Sludge from the leachate treatment is apparently used in brick fabrication and they are studying the beneficial use of the fly ash collected in the baghouse (2-3% by of the MSW by weight). The bottom ash amounts to 25% of the MSW weight and is used in construction.

The capital cost was stated to be 350 million RMB, i.e. only $42,000 per tone of nominal daily capacity. The tipping fee is only 60 RMB /tonne ($9/tonne). There are two turbines of 12 MW capacity each. The plant generates about 240 kWh for the grid while their own use amounts to about 50kwh/tonne.

After the visit of the WTE plant, we met with Mr. Lei. Apparently the government wants to phase out CFB combustion that requires up to 20% coal addition because of concern for sulfur and GHG emissions. Future WTEs will have to be based on stoker (mass-burn) technology, such as is used at the Chongqing WTE. The Martin technology adopted by Sanfeng Covanta is suitable for high water content, low heating value Chinese MSW. The waste burns steadily without needing to use auxiliary fuel.

**9. Meeting with Mr. Dong Lin, CEO of Chongqing Iron and Steel Group (CIS)**

**Brief description:**
CIS is a large state-owned steel producer with over 100 years of history. In addition to the steel business, CIS has comprehensive strengths in equipment manufacturing, machinery processing, project design, construction and operation. The annual revenue of the CIS is over RMB 14 billion ($2 billion).
Sanfeng Covanta is a new star in the Chinese WTE industry and integrates the best technology, equipment and operating experience from China and in the world:

- The German Martin Waste-to-Energy technology;
- The most advanced stoker manufactured in China by CIS Covanta Sanfeng ;
- The seasoned experience of Covanta Energy on investing and operating WTEs.

As one of the leading companies in the Chinese WTE industry, Sanfeng Covanta has led the editing work for National Stoker Standards, the writing of Assessment Standard for Waste to Energy Plants and the O & M, Security and Technology Regulations for WTE Plants in China.
**Characteristics of Martin Grate**:
Inclined Reverse Grate (movement)
Low Maintenance fee;
High-efficiency air-cooling grate;
Longevity of grate bars>10yrs

**10.Visit of Thermal Physics Energy Lab of Chinese Academy of Sciences** in Beijing, October 31

As pre-arranged by Mr. Nicholas Motsos of Financial Sciences in Beijing, Prof. Themelis presented at the Academy an invited lecture titled "Global Waste Management and Greenhouse Gases. Afterwards he visited with Prof. Xiao the laboratories and pilot plants of the Thermal Physics Energy Lab. The primary WTE technology developed at this lab is Circulating Fluid Bed combustion. We met with

**Prof. Yunhan Xiao**
Deputy Director
Institute of Engineering Thermophysics
Chinese Academy of Sciences
52 Sanlihe Rd.
Beijing, PRC 100080
e:mail: yhxiao@cashq.ac.cn

**Prof. Yongjie NA**
Institute of Engineering Thermophysics
Chinese Academy of Sciences
P.O. Box 2706
Beijing, PRC 100080
e:mail: nayongjie@mail.etp.ac.cn

**Prof. Junqiang Zhu**
Institute of Engineering Thermophysics
Chinese Academy of Sciences
P.O. Box 2706
Beijing, PRC 100080
e:mail: zhujq@mail.etp.ac.cn

**11. Visit of Bolang Engineering Co.**

November 2, 2007

Met with:
**Mr: Zhou Songtao**
Director/General Manger
Beijing Bolang Environmetal Engineering & Technology Ltd.
Room 625, High Technology Bld., #229
Bel Si Huan Zhong Lu
Hai Dian District
Beijing, PRC 100083
e:mail: stzhou@bolang.com.cn

**Ms. Wang Fang**
Project Manager
Beijing Bolang Environmetal Engineering & Technology Ltd.
Room 629, High Technology Bld., #229

Bel Siu Huan Zhong Lu
Hai Dian District
Beijing, PRC 100083
e:mail:kfcwf_516@163.com

**Brief description of mission:**

Bolang was founded in 1994. It has concentrated on thermal processing of MSW but also involved in other activities. Government is a shareholder along with some private group. Prof. Xiao is the chief scientist and the major supporter to this company with his research group on CFB. Bolang is the first that stated in environmental area. There is 94 employees and over 50% are with graduate degree. CFB is the key technology (MSW, biomass, medical waste, wet degradation technology that is similar to BMT in EU); later it incorporated with ITT (Institute of Thermal Treatment). In 1997, the first test was passed of CFB in China with capacity of 100 tonnes of MSW/day. Temperature: 850-950oC; fluidization velocity of 4m/s, granular material (0-13mm). Combustion efficiency 95-99%. Apparently, there are now 50 CFB MSW plants in China. The largest one operates at 500 tones/day with two lines (300+200) and was built in 1999. The key point of their CFB technology is to pre-treat the MSW by means of "wet degradation", thus lowering its moisture content. MSW in China contains a lot of inorganic construction material that must be separated and sent to landfills. All plants are based on the use of coal as a fuel. Plants are designed and constructed by Bolang to reach a high calorific value of 7000J/kg, but ordinarily the heating value is low and therefore 15% of coal addition is required to maintain steady combustion. An estimated 80% of the electricity generated goes to the grid. is needed. 80% of made electricity goes out.

LNT/NJT Dec. 21, 2007