Public Disclosure Authorized

89752

Executive Summary

of

ENVIRONMENTAL ASSESSMENT

for

China GEF Municipal Solid Waste Management Project

Public Disclosure Authorized

Foreign Economic Cooperation Office

Ministry of Environmental Protection, PRC

July 2014

Table of Content

Abbreviations and Accronynms

APC	air pollution control
Bank	World Bank
BAT	best available techniques
BEP	best environmental practices
CFB	circulating fluidized bed
DongJiao	DongJiao MSW Power Plant
EA	environmental assessment
EHS Guidelines	World Bank Group Environmental, Health and Safety Guidelines
EPB	environmental protection bureau
EMP	environmental management plan
FECO	Foreign Economic Cooperation Office, Ministry of Environmental Protection
KongGang	KongGang MSW Power Plant
MEP	Ministry of Environmental Protection, PRC
MSW	municipal solid wastes
NIP	National Implementation Plan
POPs	persistent organic pollutants
Stockholm Convention	SC
UMB	urban management bureau
WuHua	WuHua MSW Power Plant
XiShan	XiShan MSW Power Plant

1 Introduction

1.1 Background

This document summarizes the environmental assessment of the GEF China Municipal Solid Waste Management Project, highlighting the main issues and conclusions of the Environmental Audit, Environmental Management Plan (EMP), and Social Assessment (SA) reports of the project. According to Chinese Environmental Assessment laws and regulations, and the World Bank's Operational Policy and Bank Procedures OP/BP4.01 Environmental Assessment, the proposed project is Category A for environmental assessment purposes due to the nature of the project.

The National Implementation Plan of the People's Republic of China for the Stockholm Convention on Persistent Organic Pollutants (POPs) lists the municipal solid waste (MSW) disposal sector as one the country's six priority industries for POPs reduction. In order to help China implement its responsibility under the Convention, achieve reduction of dioxin emissions from MSW incineration, the Ministry of Environmental Protection (MEP) and the World Bank work together to promote best available techniques (BAT) and best environmental practices (BEP) in accordance with the Stockholm Convention (SC). Four existing MSW incinerators in Kunming City were identified as candidates for the demonstration of BAT and BEP. With grant financing from the Global Environmental Facility (GEF) complemented with own resources, selected MSW incinerators would improve operations and install necessary equipment to demonstrate operations that are in line with SC BAT and BEP.

Consistent with the World Bank Operational Policy (OP) 4.01 on Environmental Assessment, the appropriate safeguards instrument for this project was determined to be an environmental audit because all four incinerators are existing plants and the proposed physical activities in these incinerators are mainly about equipment enhancement.

Therefore, with the support of the Foreign Economic Cooperation Office (FECO) of MEP, each of the four incinerators prepared an environmental audit report. Based on the findings and recommendations of the environmental audit, a standalone EMP was also prepared for each incinerator. During project preparation, a social assessment and public consultations were carried out and integrated with the environmental assessment process. This EA Executive Summary is prepared based on these reports, as well as project feasibility studies, design and relevant technical studies carried out for the project.

The environmental audit and EMP reports present information on the regulatory framework; incinerator operations; environmental compliance; environmental, health and safety management system, and risk assessment. The reports were reviewed by the World Bank and found to be in compliance with the World Bank safeguards policies and the World Bank Group Environmental, Health and Safety (EHS) Guidelines. The reports were disclosed locally on March 10, 2014 and on March 20, 2014 in InfoShop of the World Bank.

1.2 Project Development Objective

The project aims to build capacity and demonstrate best available techniques (BAT) and best environmental practices (BEP) in municipal solid waste (MSW) incineration in accordance with the Stockholm Convention.

1.3 Project Description

The project includes two demonstration cities and central government departments. The project aims to demonstrate good practices in enhancing enforcement capacity of regulatory authorities, applying BAT/BEP systematically in selected incinerators, and disclosing information to the public. The project's aim is to demonstrate reduction of dioxin emission in MSW incineration, recognizing the increasing trend of MSW in China; rather than support incineration per se. Demonstration activities will take place in existing incinerators with the objective to gradually replicate them in other incinerators in operation in China.

In demonstration city **Kunming**, four existing MSW incinerators may receive GEF funding to invest in enhanced equipment in order to implement operational improvement programs. During the first year of project implementation, each of the four incinerators will be subject to an intensive operational and environmental performance audit to collect and analyze comprehensive data on operating conditions and environmental emissions, and identify areas of improvement. Based on these findings an operational improvement program that is consistent with BAT and BEP will be prepared for each incinerator. Incinerators that commit to implementing these programs and fulfill financial eligibility conditions will be supported during the remainder of the project, including through grant funding for necessary upgrades of equipment relevant for dioxin emission reduction. The project will aim at implementing operational improvement programs in at least three demonstration incinerators.

In **Kunming** the project will also support the Kunming Urban Management Bureau (UMB), Yunnan Provincial Environmental Protection Department (EPD) and Kunming Municipal Environmental Protection Bureau (EPB) to implement an online monitoring system that transmits incinerator operating and emissions data to these authorities for better inspection and public disclosure. All the MSW incinerators in the city will be covered by the online monitoring system regardless they will be financed by the GEF grant or not.

In addition, in **Kunming** the project will support training of regulators and MSW incinerator operators, piloting of integrated permits for MSW incinerators, and public disclosure of emission data.

In demonstration city **Ningbo**, the project will primarily technical assistance activities including an online monitoring system, regulator and incinerator operator training, public disclosure that is similar to Kunming. In addition, the project will support enhancing the capacity of an existing dioxins lab in Ningbo. Taking advantage of an ongoing MSW segregation project financed by World Bank loan, the GEF project will support twining knowledge sharing of Kunming and Ningbo on MSW segregation and an assessment of impact of MSW segregation on dioxins emissions in Ningbo.

At **national level**, the project will support several technical assistance activities on: (i) regional planning of MSW disposal that would identify cost effective disposal options at a regional scale; (ii) the system of statistical indicators and MSW classification; (iii) updating and developing four national-level technical standards for MSW incinerator operations; and (iv) design of systems for online monitoring local regulatory authorities.

By design, the project fully incorporates environmental and social considerations into its physical investment and technical assistance activities. In addition, by engaging the public, the project is expected to raise public knowledge and awareness on the proper operation of MSW incinerators, risks associated with dioxin emissions at different levels, and the importance of public oversight.

1.4 Candidate MSW Incinerators

Four existing MSW incinerators in Kunming were identified during project preparation. These incinerators are relatively new and put into formal operation in the past few years. Specifically,

- Wuhua incinerator was built in December 2007 and put into formal operation in July 2008. Design capacity is 1,000t/d
- Dongjiao incinerator was built in March 2009 and put into formal operation in March 2011. Design capacity is 1,600t/d
- Xishan incinerator was built in August 2012 and put into formal operation in June 2013. Design capacity is 1,000t/d; and
- Konggang incinerator was built in June 2011 and put into formal operation in August 2013. Design capacity is 1,000t/d

Konggang incinerator uses mass burn (moving grate) technology, while the other three incinerators use the circulated fluidized bed (CFB) technology for combustion. All four incinerators have in place air pollution control (APC) equipment that treats flue gases after the combustion process. All the four incinerators generate electricity and sell it to the power grid.

2 Environmental Regulatory Framework

For each incinerator, a full environmental audit was carried out following the Chinese environmental impact assessment regulations and the World Bank safeguards policies. World Bank OP 4.01 Environmental Assessment and requirements regarding information disclosure and public consultation apply to the project. In addition, the World Bank Group Environmental, Health and Safety Guidelines ("EHS Guidelines" hereafter) were taken into account in the EA process.

The project will not involve any new land acquisition and will not trigger World Bank OP 4.12 Involuntary Resettlement, as land acquisition was completed for all four incinerators in Kunming without anticipation to the project. Nevertheless, a review of the land acquisition process was carried out as part of the social assessment. The review indicates that the resettlement process and the compensation paid to the affected people were consistent with the principles of the OP4.12 and the relevant government regulations and laws. There are no ethnic minority communities in the project area.

2.1 Domestic Laws and Regulations

Key Chinese national and sectoral policies, regulations on environmental quality and pollutant discharge/emission standards, and technical guidelines that are relevant to MSW incineration are summarized in Table 2-1.

Table 2-1 Relevant Key Chinese Environmental Laws and Regulations on Incineration Facilities

Title	Relevant Articles
Environmental Protection Law of China P. R., issued on Dec. 26th 1989	● All the pollutant discharging must meet the relevant national or local standards. ● All the pollution control facilities must be designed, built, and operated with the major part of the project simultaneously. The project cannot be operated until these pollution control facilities is acceptance by the authorized environmental protection agency.
Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution, issued on Oct. 29th 1996	● New construction projects, expansion or reconstruction projects which discharge atmospheric pollutants shall be governed by the state regulations concerning environmental protection for such projects. ● Where atmospheric pollutants are discharged, the concentration of the said pollutants may not exceed the standards prescribed by the state and local authorities. ● Enterprises shall give priority to the adoption of clean production techniques that are instrumental to high efficient use of energy and to reducing the discharge of pollutants so as to decrease the generation of atmospheric pollutants. ● Units that discharge dust into the atmosphere must adopt measures to remove such dust. The discharge of toxic waste gas and dust into the atmosphere shall be strictly restricted. When such discharge is really necessary, the discharged gas or dust must undergo purification treatment. ● Units that discharge fetor into the atmosphere must take measures to prevent the pollution of neighboring residential areas. ● In the transportation, loading and unloading, and storage of substances that may diffuse toxic or harmful gases or dust, sealing or other protective measures must be taken.
Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste, issued on Apr. 29th 2000	● The necessary supporting installations for the prevention and control of environmental pollution by solid waste specified in the statement of the effect of the construction project must be designed, built and put into operation simultaneously with the main part of the project. The construction project may be put into production or use, only after the installations for the prevention and control of environmental pollution by solid waste are examined and considered up to standards by the competent administrative department of environmental protection that examined and approved the statement of environmental effect. The installations for the prevention and control of environmental pollution by solid waste must be checked and accepted at the same time as the main part of the project is checked and accepted. ● Hazardous wastes must be collected and stored separately according to their different characteristics. It is forbidden to collect, store, transport and treat mixed hazardous wastes of incompatible nature that have not undergone safety treatment.
National catalogue of Hazardous Wastes Inventory, issued on Aug. 1st 2008	● HW18 Residues of incinerating disposal ● 802-002-18 Fly ash from incinerating domestic garbage
Policy on the Treatment and Pollution Control	● MSW incinerators should be built in developed cities with scarce land and the lower calorific value above 5000kJ/kg. ● It is recommended to use grate incinerator. The incinerator which cannot meet the control standard is prohibited. ● Provide for sufficient residence time at least 2 seconds above 850℃ and turbulent mixing in the combustion chamber(s) to complete incineration.

Title	Relevant Articles
off Municipal Solid Wastes, ChenJian[2000] No.120	● The combustion process should be strictly applied with Pollution Control Standard of MSW Combustion to protect the environment by control or treatment on gas, wastewater, bottom ash, fly ash, odor, and noise. ● The semi-wet with bag filter technology is recommended to control the exhaust gas. ● The leachate should be pretreated separately to meet the standard before discharging.
Announcement on Enhancing the EIA Management of biomass power generation project, HuanFa[2008] No.82	● Power generation project of MSW, including the sludge, should apply the following principles: the construction and operation must be under the national and professional standards or regulations with a quantity and quality of the mass. At present, the mineral fuel mass is not allowed except CFB project, while in CFB, the ratio should be less than 20%. ● The pollutant standard should meet the *STANDARD FOR POLLUTION CONTROL ON THE MUNICIPAL SOLID WASTE INCINERATION* (GB18485-2001), while dioxin should meet 0.1ng TEQ/m^3. ● The health protection zone should be no less than 300 m.

2.2 World Bank Safeguards Policies and Environment, Health and Safety (EHS) Guidelines

2.2.1 Compliance with safeguards policies

Table 2-2 shows the compliance analysis with the Bank's safeguard policies.

Table 2-2 Compliance with safeguard policies

Safeguard Policies	Triggered	Compliance
OP/BP4.01 Environmental Assessment	Yes	Category A project. A full Environmental Audit and EMP are prepared for each candidate incinerator; Two rounds of public consultation were carried out during project preparation.
OP/BP 4.04 Natural Habitats	No	The Project does not involve any natural habitats
OP/BP 4.36Forests	No	The project would not finance any activity that may involve a major change or degradation of the important forest area or related major natural habitat as defined in the Policy.
OP 4.09 Pest Management	No	The project would incur neither purchase of any pesticide nor additional pesticide application. No action is required according to the Policy.
OP 4.37 Dam safety	No	There are no dams in the project area.
OP4.11 Physical Cultural Resources	No	Not any cultural heritage or other physical cultural resource has been found. Chance-find procedure is included in the EMP.
OP/BP 4.12 Involuntary Resettlement	No	This project will carry out activities in existing MSW incineration plants, so no land acquisition and resettlement are involved.
OP/BP 4.10 Indigenous Peoples	No	There are no indigenous residents living in the project area or no indigenous residents will be affected by the project.
OP 7.50 Projects on International Waterways	No	There are no international waterways in the project area.
OP/BP 7.60 Disputed area	No	There are no any areas under dispute involved in the project area.

2.2.2 World Bank Group Environmental Health and Safety Guidelines

The World Bank Group Guidelines applicable to this project include the General Guidelines and sub-guidelines related to MSW incineration.

The EHS Guidelines contain performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them.

The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines

are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

The *Environment, Health and Safety Guidelines for Waste Management Facilities* includes measures and performance levels relevant to MSW incineration, including management of air emissions, ash and other residuals, water effluents, noise, and occupational health and safety. These measures have been incorporated into the project EMP. The said Guidelines also make reference to emission standards for MSW incinerators from the European Union and the United States for this sector. A detailed analysis of the two referenced standards and a comparison with applicable Chinese standards and actual emission levels are presented in this report.

2.3 Stockholm Convention

The key relevant articles in Stockholm Convention and the BAT/BEP Guidelines on POPs are as the followings

(1) BEP

- Reducing the overall mass of wastes that have to be disposed of by any means serves to reduce both the releases and residues from incinerators. Diversion of biodegradables to composting and initiatives to reduce the amount of packaging materials entering the waste stream can significantly affect waste volumes. Responsibility for waste minimization lies only to a minor extent with the operator of a waste incineration plant. However, coordination and harmonization of relevant activities on different organizational levels (e.g. operator, local, regional or national level) is of major importance for protection of the environment as a whole.
- Curbside or centralized sorting and collection of recyclable materials (for example, aluminum and other metals, glass, paper, recyclable plastics, and construction and demolition waste) also reduces waste volume, saves valuable resources and removes some non-combustibles. Responsibility for these activities must be coordinated between relevant levels.
- Operators must be able to accurately predict the heating value and other attributes of the waste being combusted in order to ensure that the design parameters of the incinerator are being met. This can be done using the results from a feed monitoring program of key contaminants and parameters where sampling and analysis frequencies and rigor would increase as feed variability increases.
- To achieve optimal prevention of formation, and capture, of chemicals listed in Annex C, proper care and control of both burn and exhaust parameters are necessary. In continuous feed units, the timing of waste introduction, control of burn conditions and post-burn management are important considerations
- These events are normally characterized by poor combustion, and consequently create the conditions for formation of chemicals listed in Annex C. For smaller, modular incinerators operating in batch mode, start-up and shutdown may be daily

occurrences. Preheating the incinerator and initial co-firing with a clean fossil fuel will allow efficient combustion temperatures to be reached more quickly. Wherever possible, however, continuous operation should be the practice of choice. Independent of the operation mode waste should be fed into the combustion system only when the required temperature (e.g. above 850℃) is reached. Upsets can be minimized through periodic inspection and preventive maintenance. Incinerator operators should not feed the waste during filter bypass ("dump stack") operations or during severe combustion upsets.

- Routine inspections by the operator and periodic inspections by the relevant authority of the furnace and air pollution control devices should be conducted to ensure system integrity and the proper performance of the incinerator and its components.
- High-efficiency combustion is facilitated by establishing a monitoring regime of key operating parameters, such as carbon monoxide (CO), volumetric flow rate, temperature and oxygen content.
- Carbon monoxide, oxygen in the flue gas, particulate matter, hydrogen chloride (HCl), sulphur dioxide (SO_2), nitrogen oxides (NOx), hydrogen fluoride (HF), airflows and temperatures, pressure drops, and pH in the flue gas should all be routinely monitored.
- Bottom and fly ash from the incinerator must be handled, transported and disposed of in an environmentally sound manner.
- Regular training of personnel is essential for good operation of waste incinerators. Creating and maintaining public goodwill towards a waste incineration project is critical to the success of the venture.

(2) BAT

- Environmental concerning location is the most important for a new MSW incinerator.
- Proper management of time, temperature and turbulence (the "3 Ts"), as well as oxygen (airflow), by means of incinerator design and operation will help to ensure the above conditions. The type and order of treatment processes applied to the flue gases once they leave the incineration chamber is important, both for optimal operation of the devices and for the overall cost-effectiveness of the installation. Best available techniques involve applying the most suitable combination of flue gas cleaning systems, including the dust (particulate matter) removal techniques, acid gas removal techniques, fuel gas polishing techniques, NOx removal techniques, etc.

2.4 Comparison of Domestic and International Emissions Standards for MSW Incineration

The EHS Guidelines for Waste Management Facilities make reference to European Union[1]

[1] EU Directive 2000/76/EC, applicable to MSW and Hazardous Waste Incinerators

and the United States[2] air emission standards for MSW incineration. Table 2-3 presents a detailed comparison of current Chinese national-level standards with EU and US standards for air emissions for MSW incinerators.

For dioxins, the EU has adopted 0.1 ng TEQ/m3. The United State standard is about 0.2 ng TEQ/m3 (after unit conversion) for new MSW incinerators. A broader review of international and domestic dioxin emission standards show that Japan, Beijing, Shanghai, Hong Kong SAR, China[3] and Taiwan, China have also adopted 0.1 ng TEQ/m3; while the US standard for existing MSW incinerators is about 0.5 ng TEQ/m3.

Chinese national level regulations have two sets of standards for dioxins emission for MSW incinerator. The current national standard, i.e. Standard for Pollution Control on the MSW Incineration (GB18485-2001), was issued in 2001 and stipulated a dioxin emission standard of 1ng TEQ/m3. However, in 2008, MEP issued a document (No. 82, HuanFa [2008]) stipulating that new, power generating MSW incinerators (also known as “Waste-to-Energy“or “WTE”) must meet 0.1 ng TEQ/m3. Therefore, Konggang and Xishan incinerators whose EIAs were approved after the effectiveness of the 2008 MEP document have to meet 0.1 ng TEQ/m3, while Dongjiao and Wuhua incinerators are subject to the 1 ng TEQ/m3 emission limit. During appraisal of the project, MEP issued updated Standard for Pollution Control on the MSW Incineration (GB18485-2014). According to this updated standard, for dioxins the old standard GB18485-2001 will remain effective until December 31, 2015; while starting from Jan 1st, 2016, all existing MSW incinerators will have to meet 0.1 ng TEQ/m3.

The emission standards for conventional air pollutants vary over different sampling durations in a general sense. The old Chinese national standard GB18485-2001 does not specify such durations. The updated GB18485-2014 stipulates such durations. The EHS guidelines partially specify such durations. To make the comparison more meaningful, Table 2-3 includes emission standards of the original EU and US standards that are not quoted by the EHS Guidelines. For example, EU 1-hr average TSP, NOx and SO2 are added. In addition, the US standards use different unit systems that have to be converted to be comparable with Chinese and EU standards.

It should be noted that in the case of EU and US standards, different parameters present different levels and they are associated with different sampling durations. This may reflect differences in country context, assimilative capacity of the environment, and other technical factors such as sampling and monitoring methodologies and combustion techniques.

[2] US EPA Standards of Performance for Large Municipal Waste Combustors, 40 CFR Part 60 Subpart Eb

[3] Hong Kong SAR, China refers to Hong Kong Special Administrative Region of the People's Republic of China

Table 2-3 Comparison of Chinese national standards with EU and US standards for air emissions of MSW incinerators

Parameter			National Standard, GB18485-2001	National Stanard, GB18485-2014	EHS Guidelines (expanded)		
Ref.	Pollutants	Time	mg/m3	mg/m3	EU mg/m3	USA	USA converted (mg/m3)
1	Total Suspended Particulates	1-hr average	80	30	30	20	20
		24-hr average		20	10	n/a	
2	Carbon Monoxide (CO)	1-hr average	150	100	50-150	50-150ppmv	62.5-187.5
		24-hr average		80			
3	Nitrogen Oxides (NOx)	1-hr average	400	300	400	n/a	n/a
		24-hr average		250	200-400	150ppmv	Not Convertible
4	Sulfur Dioxides (SO2)	1-hr average	260	100	200	30ppmv or 80% reduction, whichever is less strigent	85.7 or 80% reduction, whichever is less strigent
		24-hr average		80	50		
5	Hydrochloric Acid (HCl)	1-hr average	75	60	60	25ppm or 95% reduction, whichever is less strigent	40.7 or 95% reduction, whichever is less strigent
		24-hr average		50	10		
6	Mercury (Hg)	Test Average	0.2	0.05	0.05-0.1	0.05 mg/dscm	0.05 or 80%

						or 80% reduction, whichever is less strigent	reduction, whichever is less strigent
7	Lead (Pb)	Test Average	1.6	See below Ref. 11	See below Ref. 10	0.14	0.14
8	Cadmium (Cd)	Test Average	0.1	See below Ref. 9	0.05-0.1 (0.5-8 hr average)	0.01	0.01
9	Tl+Cd	Test Average	n/a	0.1			
10	Total Metals	/	n/a	n/a	0.5-1 (0.5-8 hr average)	n/a	n/a
11	Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V	Test Average	n/a	1.0	n/a	n/a	n/a
12	HF	/	n/a	n/a	1	n/a	n/a
13	Dioxins (incl. furans)	/	1 ng TEQ/m3; 0.1 ng TEQ/m3 for new incinerators built after 2008	0.1 ngTEQ/m3 Test average	0.1 ngTEQ/m3 (6-8 hr average)	13 （ng/m3)(total mass)	0.2 ng TEQ/m3
Note			Effective for existing MSW incinerator until December 31, 2015	To be effective for existing MSW incinerator on Jan 1st, 2016		7%o oxygen, dscm: milligrams per dry standard cubic meter	mg/m3=ppmv*compound molecular weight/22.4

3 Environment and Social Baselines

3.1 Natural and Social Economics Baselines

The city of Kunming is the capital of Yunnan Province in southwest China. Kunming is located in the middle of Yunnan-Guizhou Plateau. Its overall topography is featured with high northern part and low southern part. Most of the city has an altitude between 1,500m and 2,800m. The city presents low latitude-plateau-monsoon weather feature and has an annual average temperature of 15 ^{o}C and an annual precipitation of 1,035mm.

Kunming has a total area of 21,473km^2, divided into 6 districts, 7 counties and a county level city. It has a population of 7.26 million. The urban area has a population of 5.3 million (2013). The city has a GDP of CNY301 billion and an average per capita GDP of CNY 41,458 in 2012. The city is also a critical transport hub in southwestern China by having the fifth largest airport in China, several national expressways, and intensive road networks connecting the remainder of the province.

Kunming has good ambient air quality compared to the rest of China. Based on Kunming Environmental Quality Reports during 2010-2012, pollutants monitored on a daily basis, including PM10, SO2, and NO2, all met applicable national ambient air quality standard. They also show a slightly improving trend over the period. In 2012, the monitored annual average PM10, SO2 and NO2 concentrations were 67, 34, and 36 ug/m3 respectively, while, the national Ambient Air Quality Standard (GB3098-2012, to be effective in Jan 1, 2016) stipulates standards of 70, 60 and 40 ug/m3 for the three air pollutants in Kunming City.

The four candidate MSW incinerators are located in suburban or rural areas in Kunming. Wuhua incinerator is in northwestern Kunming, about 12km from its urban area. Dongjiao incinerator is in eastern Kunming, about 30km from its urban area. Xishan incinerator is in southwestern Kunming, about 50 km from its urban area. Konggang incinerator is in northeastern Kunming, about 50km from its urban area. More physical details of the four incinerators are included in Table 3-1. Figure 3-1 presents the location of the four incinerators

Table 3-1 Physical Features of the Four MSW Incinerators[4]

Items	DongJiao	KongGang	WuHua	XiShan
Location	BaiShuiTang Village, KunMing Economy and Technology Development Zone	YunQiao Village, DaBanQiao Town, GuanDu District, KunMing	KunLu Road Entrance, DaPuJi, WuHua District, KunMing	XiaoHaiKou Village, HaiKou Town, XiShan District, KunMing
Geology and Landform	Mountainous area	Mountainous area	Mountainous area	Mountainous area
Ecology	Evergreen broad leaf trees and bamboo dominate. No precious or protected flora or fauna found in the project area.	Evergreen broad leaf trees and bamboo dominate. No precious or protected flora or fauna found in the project area.	Evergreen broad leaf trees and bamboo dominate. No precious or protected flora or fauna found in the project area.	Evergreen broad leaf trees and bamboo dominate. No precious or protected flora or fauna found in the project area.
Administration and Population	GuanDu District: 522.21km^2 Population: 541 thousand	GuanDu District: 522.21km^2 Population: 541 thousand	WuHua District: 397.86km^2 Population:966 thousand	XiShan District: 881km^2 Population:760 thousand

3.2 Peripheral Environment and Sensitive Receptors

Sensitive environmental and social receptors in the vicinity of the four incinerators are listed in Table 3-2 and Figures 3-2~3-5. Table 3-3 gives approved health protection distance for each incinerator as documented in EIA prepared before building of the incinerators. It is concluded that these incinerators all meet the requirements on health protection distances. In addition, it is noted that Dongjiao incinerator is located by a large sanitary landfill that was closed several years ago. Of the four incinerators, Wuhua is located nearest to the urban area and there are more people live in its vicinity. Other three incinerators are located far away from populated areas.

Table 3-2 Sensitive Environmental and Social Receptors

Incinerator	No.	name of village	population	location	distance (km)
DongJiao	1	Qingshui	1394	south	2.6
	2	ALa	2371	west	1.1
KongGang	1	ZhangZiGou	107	southeast	1
	2	ShaJing	461	south	1.5
WuHua	1	DaYangTian	500 households	southwest	1
	2	PuJi	500 households	southeast	1
XiShan	1	YunLong	182	south	2.6
	2	TaoShu	527	south	2
	3	DaYingZuang	758	southwest	1.3
	4	XiaoHaiKou	560	west	0.5
	5	XiaDiPing	331	west	2.25
	6	QingYuTang	510	southwest	2
	7	XiaoHeBian	126	northeast	1.42
	8	DianWei	552	north	2.5
	9	Residential area of WuNa Company	2800	southwest	2.7
	10	YunLong primary school	267	south	2.9

The approved protection zones are listed in Table 3-3.

Table 3-3 the approved protection distances

DongJiao	KongGang	WuHua	XiShan	requirement in No. 82, HuanFa [2008]	assessment
800 m	500 m	800 m	500 m	≥300 m	all meet the requirement

[4] In 2012

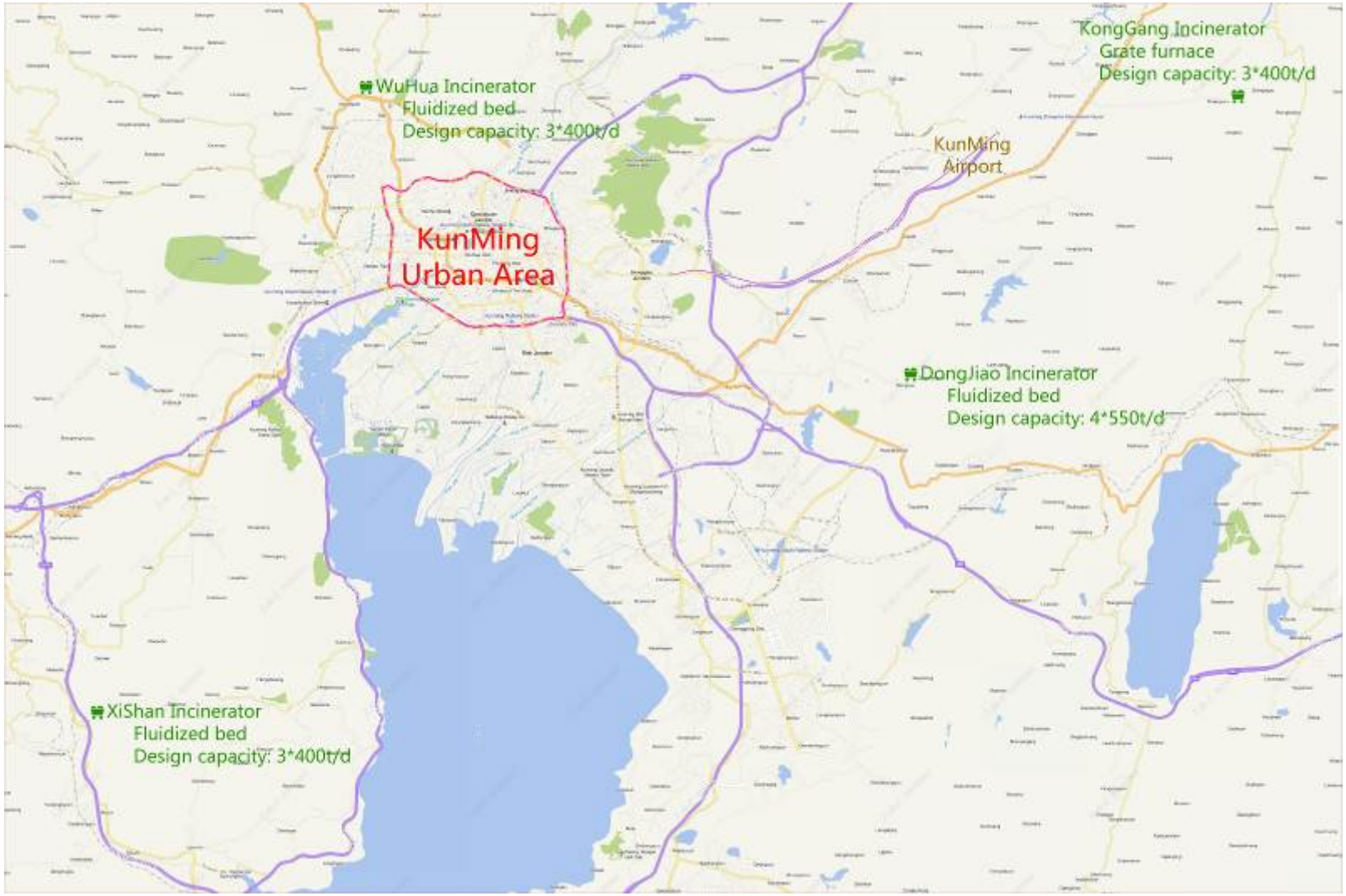

Figure 3-1 Location of 4 Candidate MSW Incinerators in Kunming City

Figure 3-2 DongJiao incinerator and nearby sensitive environmental/social receptor

Figure 3-3 KongGang incinerator and nearby sensitive environmental/social receptor

Figure 3-4 WuHua incinerator and nearby sensitive environmental/social receptor

Figure 3-5 XiShan incinerator and nearby sensitive environmental/social receptor

4 Review of Incinerator Designs and Operations

During project preparation, the design and operational aspects of each candidate incinerator was carefully examined and assessed based on available information. SC BAT/BEP Guidelines and WBG EHS Guidelines are referenced and compared where applicable.

4.1 Incineration Plant Profile

These four companies' information is listed in Table 4-1.

Table 4-1 Company Information

	WuHua	DongJiao	XiShan	KongGang
Owner	KunMing XinXingZhe Environmental resources Production Co., Ltd	KunMing CEC Environmental Protection Co., Ltd	YunNan Green Energy Co., Ltd	KunMing ChongGang Renewable Energy Power Generation Co., Ltd
Address	KunLu Road Entrance, DaPuJi, WuHua District, KunMing	BaiShuiTang Village, ALa Town, KunMing	XiaoHaiKou Village, HaiKou Town, XiShan District, KunMing	YunQiao Village, DaBanQiao Town, GuanDu District, KunMing
Total employees	74	130	66	69
Officially start operation	Jul. 15th, 2008	Mar. 9th, 2011	Jun. 18th, 2013	Aug. 12th, 2013

4.2 Incinerating Facilities

Table 4-2 presents an overview of the four incinerators.

Table 4-2 Information on the Incinerating Facilities

	WuHua	DongJiao	XiShan	KongGang
Combustion Unit	3*400t/d CFB	4*550t/d CFB	3*400t/d CFB	2*500t/d Mass Burn (Grate Furnace)
Power Unit	2*12MW	2*15MW	2*12MW	1*18MW
Approved design capacity	1,000t/d	1,600t/d	1,000t/d	1,000t/d
Operational hours per year	7,900*3	4,800*4	3,000*3	6,900*2
MSW incinerated	1,025t/d in 2012 1,150t/d in 2013	1,527t/d in 2012 1,432t/d in 2013	547t/d in 2012 662t/d in 2013	360t/d in 2013
Power generated	11.6 thousand MW in 2012 12.5 thousand MW in 2013	190 thousand MW in 2012 157 thousand MW in 2013	68.3 thousand MW in 2012 76.9 thousand MW in 2013	47 thousand MW in 2013

As indicated in Table 4-2, three of the four incineration plants in Kunming use CFB furnaces; only the newest Konggang uses mass burn (moving grate) furnace. In general, it is cheaper to build CFB than mass burn furnace. Its combustion is more complete than mass burn because it circulates wastes during burning, which is conducive to mass and heat transfer. A disadvantage of CFB is that its non-stop operating period is considerably shorter than mass burn because CFB has to undertake more frequent maintenance. In addition, CFB is less capable of handling heterogeneous wastes compared with mass burn. SC BAT/BEP guidelines also states that fluidized bed furnaces are well demonstrated for finely divided and consistent wastes, while mass burn incinerators are well demonstrated in the combustion of heterogeneous MSW and have a long operational history.

In developed countries, mass burn is dominating for MSW incineration. While, as of 2010, there were 109 MSW incineration plants in China; 43% use CFB and 54% use mass burn. Mass burn incinerators are more seen in eastern coastal area, particularly in large cities; while CFB incinerators are more seen in middle-size cities and mid-western China. Understanding and experiences to be gained from the project on how to better operate CFB incinerators will be particularly helpful for China.

Figure 4-1 shows the flow scheme of CFB incineration technology and APC facilities in Dongjiao, Wuhua and Xishan incinerator. Figure 4-2 shows the flow scheme of mass burn incineration technology and APC facilities that are used in Konggang incinerator.

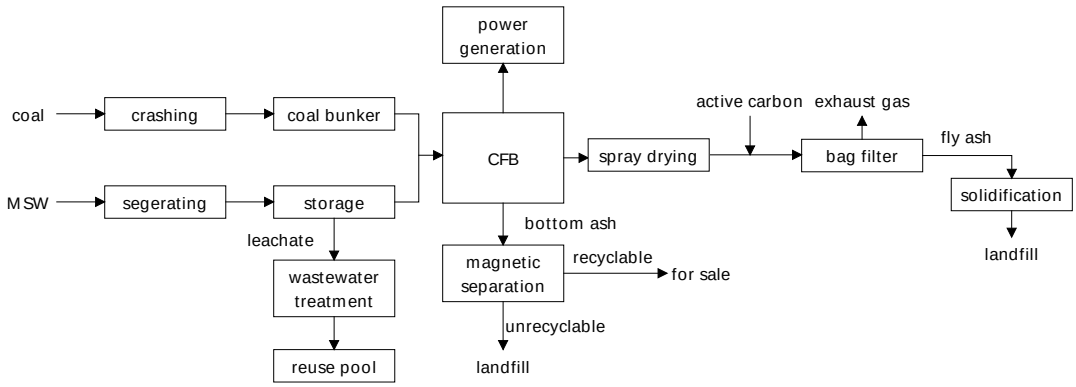

Figure 4-1 simplified flow scheme of DongJiao, WuHua, and XiShan

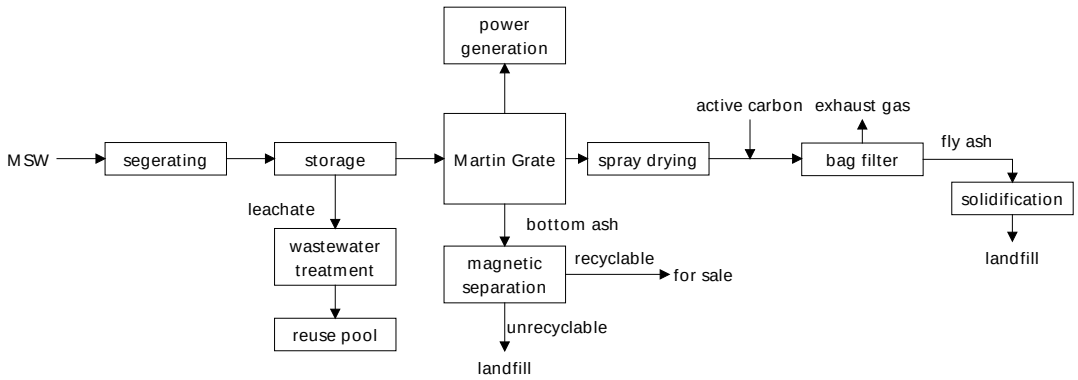

Figure 4-2 simplified flow scheme of KongGang

4.3 Operating Conditions

The key BAT/BEP of MSW incinerator comprises good combustion at furnace followed by effective flue gas treatment at air pollution control facilities. For example, the EU requires that the gas resulting from the MSW incineration process should be raised, after the last injection of combustion air to a temperature of 850 degree Celsius for a period of two seconds. Proper turbulence and adequate oxygen in furnace are also required. Rapid quenching of the flue gas right after leaving all combustion chambers is preferred in order to avoid regeneration of dioxins. APC facilities typically include using lime to remove acidic flue gases, injecting activated carbon to remove dioxin and heavy metals, and a bag house that collects particulates before final emission from the stack.

Key design parameters for each candidate incinerator, including combustion control and use of lime and activated carbon are listed in Table 4-3.

Table 4-3 Combustion conditions and use of lime and activated carbon in each incinerator

	WuHua	DongJiao	XiShan	KongGang
low calorific value	5884 kJ/kg	5024 kJ/kg	5024kJ/kg	4187～9419kJ/kg
chamber temperature	850℃-950℃	860-880℃	850℃-950℃	1000℃
residence time above 850°C	>2s	4.8s	>2s	>2s
ignition loss	≤3%	≤1%	3%	≤3%
temperature of primary air	310℃	175℃	238℃	228℃
temperature of secondary air	250℃	210℃	220℃	170℃
temperature after chamber	850℃	950℃；	850℃	1000℃
temperature after boiler	170℃	170℃；	200℃	210℃
average activated carbon injected	7.5kg/h per incinerator	15.6 kg/h per incinerator	6.5kg/h per incinerator	4 kg/h per incinerator
lime injected	100kg/h per incinerator	400 kg/h per incinerator	210kg/h per incinerator	160 kg/h per incinerator

Overall, these design parameters are consistent with SC BAT/BEP and WBG EHS guidelines. Each incinerator, in its normal operation, runs with these design parameters. However, several issues were identified, including

- Humid and heterogeneous raw wastes compromises optimal combustion conditions;
- CFB furnaces have a considerable frequency of fire-pressing and restart operation that result in unsteady combustion;
- Efficiency of lime and activated carbon dosing may need better control to improve reaction efficiency and respond to extreme conditions;
- Bag house materials and leak detection can be enhanced to improve dust capture efficiency and better respond to extreme conditions.

These issues are directly linked to air emissions and are discussed in detail in Chapter 5 Environmental Audit.

5 Environmental Audit

The environmental audit examined regulatory compliance, management of air emissions, wastewater, solid wastes and other environmental, health and safety issues of the four candidate incinerators in Kunming.

5.1 Project Approvals

A review of EIAs, approvals and environmental acceptance were carried out. All the four incinerators have had their environmental approvals required by domestic regulations. The approvals of EIAs were obtained prior to the construction of those incinerators. After pilot operation, all the four incinerators obtained environmental acceptance after monitoring of emissions and validating the requirements documented in the EIAs and approval documents.

A review of the land acquisition process was carried out as part of the social assessment. The project will not involve any new land acquisition. Land acquisition for purposes of construction of four MSW incineration plants in Kunming City took place prior to this project (2006-2009). The land acquisition was completed without anticipation to the proposed project. Nevertheless, a retroactive review was carried out. The review concluded that compensation has been paid according to relevant government policies and consistent with the principles and requirement of the Bank policy on Involuntary Resettlement OP4.12. There are no pending issues on land acquisition. Furthermore, no new land acquisition is envisaged under the project as there is no expansion of any of the existing incinerators. In addition, there are no ethnic minority communities associated with the project area or activities.

5.2 Pollution Control and Compliance Analysis

Waste streams generated in MSW incinerators include air emissions, fly ash, bottom ash (slag), and other solid wastes, and wastewater. The project is expected to have direct environmental benefits by further reducing dioxins and other air emissions from the demonstration MSW incinerators. As is well known, dioxin is extremely biologically toxic and persistent in the environment. Other polluting emissions from MSW incineration may include particulate matters (measured in Total Suspended Particulates, TSP); acidic pollutants such as SO2, NOx and HCl; and heavy metals, etc. In addition, combustion by-product fly ash often contains dioxins and heavy metals; hence it is considered a major environmental concern and should be properly managed. The four incinerators have proper pollution management facilities and measures to address these environmental issues.

5.2.1 Dioxin Emissions

Dioxins emissions from the four candidate incinerators have been tested at least once a year by accredited monitoring institutes that specialize in dioxins analysis, as required by Chinese regulation. Table 5-1 shows the results of such tests made since the environmental

acceptance monitoring of each MSW incinerator until Jan, 2014. Environmental acceptance monitoring is a precondition of MSW incinerator official operation (Table 4-1 gives the dates of official operation of each candidate MSW incinerator).

Table 5-1 Dioxins Emission Test Results

	WuHua	DongJiao	XiShan	KongGang
Approved emission level(ng TEQ/m3)	1.0	1.0	0.1	0.1
Dioxin Emissions(ng TEQ/m3)	0.057-0.89	0.001-0.187	0.00131-0.078	0.011
Number of tests	12	39	21	1
Number of results exceeding 0.1 TEQ/m3	3	3	0	0

Based on these results of dioxin tests, the following observations are made.

- All incinerators fully met approved dioxins emission standards as per national regulations;
- The two newer incinerators, i.e. Xishan and Konggang, also fully met the most stringent dioxins emission standard of 0.1 ng TEQ/m3 as adopted by EU;
- The two older incinerators, i.e. Wuhua and Dongjiao, had a majority of their dioxin emission test results lower than 0.1 TEQ/m3, which indicates their hardware and operation, if well managed, are capable of meeting the most stringent standard for dioxins.

However, the following need to be taken into account in interpreting these test results. First, during sampling, incineration facilities and air pollution control devices run at normal or optimal conditions; while at other times this may not be the case. This is evident from the fact that some of the dioxin emission test results indicate emissions of 0.001ng TEQ/m^3, which is the theoretical minimum under perfect conditions and then still only when an overdosage of active carbon is used for removal. For more reliable results, under the project, sampling for dioxin stack tests will be done under normal operating conditions, as required by the relevant Chinese regulation.

Furthermore, review of the incinerators' operations showed in the three CFB incinerators (Wuhua, Dongjiao and Xishan) a high frequency of fire-pressing and restarts due to below-capacity waste delivery and blockages caused by highly humid waste and extra-large or incombustible objects due to poor MSW segregation at source. According to the incinerators' operators, a typical fire-pressing and restart cycle includes lowering temperature, stopping garbage feed-in, removing of blockage and increasing the furnace temperature. Therefore, these dioxins test results may have not reflected the full picture of dioxin emissions of these incinerators.[5]

In view of these challenges, the project will take several technical measures to ensure consistent low emissions of dioxins from these incinerators.

[5] It should be noted that dioxin tests require highly specialized specialists and expensive analytical equipment. Dioxins can not be monitored online either. Local environmental authorities often don't have the capacity to do dioxin tests, as is the case in Yunnan Province.

- Dioxin emissions are closely linked with effective flue gas treatment process. Therefore, likely investments in the incinerators include enhancement of activated carbon injection devices and bag house.
- Dioxins emission generation in furnace is closely linked to combustion temperatures and rapid quenching after combustion chamber. Therefore, continuous monitoring of furnace temperatures, as well as operation parameters of flue gas treatment devices, will be supported by the project so that urban management and environmental authorities will be able to closely supervise the operation of these incinerators.
- In the first year of project implementation, a comprehensive review of operating and environmental performance of the four incinerators will be carried out by experienced international consultants. This effort will build on the technical evaluation and environmental audit conducted during project preparation, and will closely examine the operating and emission status of each incinerator over a 9-12 month period. Incinerator-specific operational improvement programs will be developed to address the challenges facing these incinerators and to achieve consistently low emission of dioxins.

The above discussed improvement measures not only address dioxin emissions but also other air emissions as discussed in next section. As per the Standard for Pollution Control on the MSW Incineration (GB18485-2014) issued in May 2014 during the project appraisal, starting from January 1st, 2016, the four existing MSW incinerators will have to meet 0.1 ng TEQ/m3 dioxins emission standard, which is consistent with EU standard.

5.2.2 Emissions of other Air Pollutants

Chinese regulations require that monitoring of other conventional air pollutants be carried out through regular inspection monitoring conducted by local environmental protection bureaus, and online monitoring equipment installed at the incinerators. During the environmental audit process, the EPB inspection monitoring results and online monitoring data from recent years were examined.

1. EPB Inspection Monitoring

Table 5-2 presents results of inspection monitoring on the four incinerators since they were put into formal operation（Table 4-1 gives the dates of official operation of each candidate MSW incinerator）. The Chinese national, EU and US standards are also included for the purpose of comparison. The concentration ranges in the table are maximum values of each test.

Overall observation about these inspection monitoring results can be made, as following.

1) The four incinerators have relatively modern air pollution control (APC) facilities in place, which include dry or slurry Ca(OH)2 (slaked lime) that removes acidic flue gases, i.e. SO2 and HCl; activated carbon injection that adsorbs dioxins and heavy metals; and a bag house that collects particulates. These facilities are critical for the four incinerators to control air emissions effectively. The monitoring results indicate that emissions fully met

limits prescribed by national regulation GB18485-2001 and those prescribed by the incinerators' approved EIA documents. Nevertheless, caveats exist, including inadequate monitoring frequencies and parameters. Project technical assistance for a pilot integrated permit system in Kunming will improve local EPBs' capacity to carry out inspection monitoring.

2) The acidic air pollutant NOx cannot be removed by slaked lime in scrubber. The EHS guidelines recommend combustion-related measures and/or selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) systems for NOx control. Neither SCR nor SNCR is adopted by the four incinerators; and applying the techniques would require substantial investment or changes to furnace. However, NOx emissions from the four incinerators do not seem to be a significant issue. One reason is that NOx is generated significantly at temperature above 1400 degrees Celsius in the furnace; while normally the furnace temperatures in the four incinerators are kept below that level.

3) The Carbon Monoxide（CO） concentration in flue gas reflects the completeness of combustion and is indicative of dioxin existence in flue gas. It is widely acknowledged that when CO concentration is in the range of 50-150 mg/m^3 (as is the EU standard), combustion is complete and dioxins are effectively destructed. However, only Konggang has inspection monitoring data for CO available, and even there, the monitoring data seem to be very low (Table 5.2.) This is another issue that will be addressed under the operational and environmental performance audits under the project.

4) The MEP requirement issued in 2008 only stipulates tightened dioxin emission levels for new incinerators. However, it is reasonable to say that, by tightening dioxin emission levels, other air pollutants are effectively reduced as well. Therefore, Konggang and Xishan's air emissions are obviously lower than Wuhua and Dongjiao.

During the project appraisal, Ministry of Environmental Protection (MEP) issued Standard for Pollution Control on the MSW Incineration (GB18485-2014) issued in May 2014. The existing 4 MSW incinerators will have to meet the new standard starting from January 1st, 2016, while the existing GB18485-2001 will remain effective until December 31, 2015. In general the Chinese new standard is at the same level of EU and US, despite there are differences in several parameters and monitoring durations.

Table 5-2 Other Air Emissions (Based on Inspections Monitoring)

***Note**: Ministry of Environmental Protection (MEP) issued Standard for Pollution Control on the MSW Incineration (GB18485-2014) issued in May 2014. The existing 4 MSW incinerators will have to meet the new standard starting from January 1st, 2016, while the existing GB18485-2001 will remain effective until December 31, 2015.*

	WuHua	DongJiao	XiShan	KongGang	National Standard (GB18485-2001)	National Standard (GB18485-2014)	EU	US (unit converted)
Testing Periods and samples	2010~2013, 4-9 samples per pollutant	2010~2013, 6-18 samples per pollutant	2012~2013, 12-15 samples per pollutant	2013, 12 samples per pollutant	/	/	/	/
Flue gas dust/TSP	16-79.9	10.71-34	18.3-32	1.87-6.19	80	20(24-hr average) 30 (1-hr average)	10 (24-hr average) 30 (1-hr average)	20
CO	n/a	n/a	n/a	6-12	150	100(24-hr average) 80 (1-hr average)	50-150	62.5-187.5
NOx	140-334	19-149	76-178	172-245	400	250 (24-hr average) 300 (1-hr average)	200-400 (24-hr average) 400(1-hr average)	150ppmv (24-hr average)
SO_2	24.1-148	25-211	53-87	7-37	260	80 (24-hr average) 100 (1-hr average)	50(24-hr average) 200 1-hr average)	85.7 or 80% reduction, whichever is less strigent
HCl	0.56-8.09	11.74-33.24	1-4.87	0.88-1.59	75	50 (24-hr average) 60 (1-hr average)	10 (24-hr average) 60 (1-hr average)	40.7 or 95% reduction, whichever is less strigent

Hg	0.031-0.05	0.0438	0.000147-0.0031	Not Detected	0.2	0.05	0.05-0.1	0.05 or 80% reduction, whichever is less strigent
Pb	0.063-0.071	0.0017-0.061	0.00732-0.18	0.016-0.068	1.6	1.0 for (Sb+As+Pb+Cr+Co +Cu+Mn+Ni+V)	0.5-1(0.5-8 hr average) for total metals	0.14
Cd	ND	DL-0.077	0.000144-0.00428	ND-0.00375	0.1	0.1 for (Tl+Cd)	0.05-0.1 (0.5-8 hr average)	0.01
HF	n/a	n/a	n/a	Not detected	n/a	n/a	1	n/a

Notably, for each incinerator the following findings on the results of inspection monitoring should be noted.

1) Wuhua and Dongjiao Incinerators. The maximum tested levels of TSP and SO2 concentration did not fully meet the most stringent levels of GB18485-2014, EU and US, and are also higher than Konggang and Xishan. Wuhua's NOx emission was also higher than Konggang and Xishan.

2) Xishan Incinerator's TSP and SO2 did not fully meet the most stringent levels of GB18485-2014, EU and US either, but overall were lower than Wuhua and Dongjiao.

3) Heavy metals covered by the inspection monitoring include Hg, Pb and Cd. Except that Xishan's Pb emission did not fully meet US standards, and Dongjiao's Cd emission did not fully meet US standards, the rest of the monitoring results met GB18485-2014, EU or US standards.

4) Konggang Incinerator's air emissions obviously are the lowest among the four; and basically can fully meet the EU and US standards.

It should be noted that available inspection monitoring reports are limited. In particular, Wuhua, the oldest incinerator of the four, had only 4-9 results to report over the period of 2010-2013. This may indicate inadequacy of inspection monitoring.

2. Online Monitoring

All four incinerators have installed the required online monitoring equipment and transmitted data to local environmental protection bureaus continuously. Online monitoring covered TSP, CO, NOx, SO2, HCl, O2 and flue gas flow rate. The environmental audit reviewed 1-2 year data recorded in the four incinerators, and found the emissions levels of each incinerator were generally consistent with inspection monitoring. However, it is also noted that some online monitoring data were either too high or too low, indicating the maintenance and validation of this online monitoring equipment may not be adequate.

3. Conclusions and Recommendations

For conventional air pollutants other than dioxins, the aforementioned issue of reliable monitoring is still valid. Therefore, enhanced online monitoring and operating audit in the first year project implementation will cover these air pollutants. The incinerator-specific operating improvement program will also aim to achieve consistent low emission of these air pollutants and meet newly issued Standard for Pollution Control on the MSW Incineration (GB18485-2014) by January 1st, 2016.

5.2.3 Odor Control

Odor and other air pollutants, including H2S, NH3 and TSP, arise from non-point sources such as garbage pit (bunker) at pretreatment unit. Local communities are sensitive to odor if the smell is obvious. As previously discussed, all four incinerators have a protection distances ranging from 500-800m that comply with domestic regulations. The four

incinerators have odor control measures, such as maintaining bunkers in a negative-pressure condition, fully-closed bunker and spraying of plant extract liquid to remove odor. Monitoring of the above mentioned air pollutants at the boundary of an incineration plant met domestic standards.

Figure 5-1 Spraying of plant extract liquid through fans at offloading area (Xishan Incinerator)

Odor does not seem to be an issue at Konggang and Dongjiao as these plants are located far away from populated areas. Specifically, Dongjiao is located by a former landfill that was closed several years ago. Local communities used to be disturbed by strong odor from the landfill. Dongjiao planted and maintained woods on top of the closed landfill (see photo below), which helped suppress odor significantly and are much welcomed by local communities, according to public consultations carried out during project preparation.

Figure 5-2 A closed landfill revegetated

Among the four incinerators, Wuhua has the most populated communities in its vicinity. Wuhua used to receive complaints from local communities for odor. It installed odor control facilities (plant extract spraying) in August 2013. As of April 2014, no complaint on odor

has been reported. During public consultations, people living in the vicinity of Xishan incinerator also indicated there was smell from the incinerator. The follow-up survey shows that there are other industrial facilities in the area that may be sources of the odor. Close monitoring of odor and control measures shall be continued during the operation of those incinerators.

5.2.4 Fly Ash and Solid Wastes

According to Stockholm Convention BAT/BEP Guidelines, fly ash is disposed of in dedicated landfills in many countries. However, pre-treatment is likely to be required for this to constitute BAT. Treatment and disposal options for solid residues from flue gas control systems include solidification or stabilization with Portland cement (or other pozzolanic materials), alone or with additives or a number of thermally based treatments, followed by appropriate disposal (based on anticipated releases from the treated residuals). Some residues with low levels of contamination may require no treatment before disposal in a landfill, based on an assessment of their contaminant release potential.

Solid wastes in the four incinerators include fly ash and bottom slag generated from combustion, sludge from leachate treatment and garbage. Bottom slag is a non-hazardous solid waste and can be recycled. The four incinerators manage slag separately from fly ash and send it to construction material plants. Garbage and sludge are incinerated in the incinerators.

Table 5-3 Fly Ash and Slag in 2013

Solid Wastes (t/a)	WuHua	DongJiao	XiShan	KongGang
Fly ash	16,960	24,972	16,960	5,655
Slag	21,486	52,552	21,500	50,994
Sludge	/	1,200	/	400

Fly ash collected at the bag house often contains heavy metals and dioxins; hence it is considered hazardous solid waste. CFB incinerators (i.e. Wuhua, Dongjiao and Xishan) produce more fly ash as a result of more complete combustion in furnace, accounting for about 6-8% of the MSW incinerated in weight; while the grate incinerator (Konggang) produces less, accounting for around 3%. Fly ash shall either be sent to local hazardous waste treatment facility or to a landfill on the condition that it meets the specifications set at the landfill. Kunming's current hazardous waste treatment facility was put into operation in 2012 and its capacity is inadequate to receive the fly ash produced in these incinerators. Therefore, the four incinerators all adopted onsite solidification of the fly ash by mixing them with cement and chelating agent in order to stabilize the fly ash. The solidified fly ash from all four incinerators is sent to Kunming Xijiao Landfill for final disposal.

According to leaching toxicity tests, the solidified fly ash of the four incinerators meets the Standard for Pollution Control on the Landfill Site of MSW (GB16889-2008). Therefore it is appropriate to dispose the solidified ash in the landfill.

Figure 5-3 Fly ash solidification workshop and stabilized fly ash in Konggang Incinerator

5.2.5 Wastewater Management

Wastewater generated in the four incinerators includes leachate from garbage pit. Often raw MSW is quite humid and has to be retained in the garbage pit for 3-5 days before it can be fed into the furnace. Leachate generated through the dewatering process has to be properly managed.

Wuhua does not have a leachate treatment system. By design, its leachate is fed into the furnace for burning. In case the leachate amount is too large, the leachate is transported to a designated leachate treatment facility. Its domestic wastewater is discharged into the municipal sewer system. Dongjiao, Xishan and Konggang all have leachate treatment facilities that comprise anaerobic digestion, aerobic, and membrane processes such as membrane biological reactor (MBR) or nanofilter. Final discharges meet reuse standards and are used in the plants. There is no outlet wastewater discharges to the environment from these three incinerators. Overall, the wastewater streams in the four incinerators are well managed.

Dongjiao nanofilter system

Dongjiao aerobic nitrification tank

From left to right: leachate-anaerobic-aerobic-nanofiltered-tap water

Treated wastewater reused at fountain in Xishan

Figure 5-4 Wastewater Treatment in Kunming MSW Incinerators

5.2.6 Noise

Noise does not tend to be an issue at all four incinerators. Sources of noise include crushers, draft fan, turbine and other mechanical equipment. Noise control measures taken by the incinerators include sound insulation, damping pad and silencer, etc. Monitoring of noise have been carried out regularly, and no noncompliance has been reported.

5.3 EHS Management System

Each candidate incinerator has established environmental, health, safety and emergency response system in accordance with national and local requirements, including an environmental and safety office with dedicated staff, environmental management and occupational safety regulations, operational monitoring and emergency management plan.

The dedicated staff is trained regularly to understand the law and regulation on incinerator, and is responsible to the daily maintenance of pollution control equipment, online

monitoring equipment, emergency reaction, etc.

As mentioned before, local EPBs have carried out inspection monitoring to each incinerator. Intervals of such inspection monitoring are uneven, ranging from 4 months or even more.

All pilot incinerators have compiled a site specific safety and emergency response procedures manual.

5.4 Findings and Issues

Based on the environmental audit and technical evaluation carried out during project preparation, the following conclusions are made.

- By design, all four incinerators have adopt "3T+E" incineration technology, i.e. after the last injection of air the gas is raised to a temperature of 850 degrees Celsius; residence time is 2 seconds; adequate gas-solids turbulence; and excessive air to keep oxygen concentration at 6~11% in the flue gas. These incineration conditions can minimize the formation of dioxins in the furnace. The four incinerators also adopt rapid quenching of the flue gas after leaving all combustion chambers in order to minimize reformation of dioxins at the temperature range of 200-400 degrees Celsius.
- At flue gas treatment stage, all four incinerators use activated carbon injection plus a bag house. The activated carbon significantly improves capture of super fine particulates that attach the majority of dioxins and heavy metals. In addition, all four incinerators use semi-dry scrubber to remove acidic gases (SO2 and HCl).

The abovementioned technologies, in combination, can help those incinerators meet relatively stringent air emission standards at reasonable costs. A review of international MSW technologies shows that the *semi-dry scrubber+activitated carbon injection+baghouse* process is the most common flue gas treatment technologies for MSW incineration, and is recommended by USEPA and EU. In 2001, this combined process accounted for 75% of all in the world. In recent years, acidic gas removal has drawn more attention and more advanced technologies such as wet gas scrubbing and SCR (selective catalytic reduction) or SNCR (selective non-catalytic reduction) have been used in developed countries. However, wet gas scrubbing and SCR require high capital investment and result in more complicated operation and operating costs, and thus have been rarely used in China in MSW incinerators. In recent years, the SNCR technology, which balances the NOx removal efficiency and cost/operating complexities compared to SCR, is more seen in new MSW incinerators built in large cities such as Beijing and Shanghai. None of the four incinerators in Kunming has used SNCR or wet gas scrubbing, their NOx and SO2emission levels do not seem to be a significant issue compared to EU or US standards and in view of the ambient air quality in Kunming. If legally required, there is the option to retroactively fit in advanced NOx removal facilities.

The environmental audit and technical evaluation of the four incinerators also examined operating data, instrument and control system, emission monitoring data of the four incinerators in Kunming. Several rounds of interview and technical discussions with the

incinerator operators were carried out during project preparation. It is noted that each incinerator has maintenance plans to examine its operation and make improvements as needed. For example, some incinerators installed odor removal facilities in response to public concerns, and shredder to deal with abnormal-sized garbage. Based on the overall operating track records and the discussions, it is considered that those incinerators are adequately managed by well-trained and experienced operators, albeit at uneven levels. Several measures to improve flue gas treatment are proposed, including using Polytetrafluoroethene (PTFE) coated bag and bag leaking detection, improving activated carbon injection and lime dosing.

However, several aspects may have compromised the incinerators' capacity to operate at their best conditions consistently.

- The four incinerators often received highly humid and abnormal-sized garbage due to poor at-source segregation in the city, which compromise good combustion and result in frequent fire-pressing and restart in furnaces. The below photo shows segregated abnormal-sized objects at pre-treatment unit in Xishan incinerator. Compared to mass burn furnace, CFB furnace (i.e. Wuhua, Dongjiao and Xishan) are less capable of dealing with the abnormal-sized garbage. According to the information provided by incinerator operators, CFB furnaces experienced fire-pressing/restart once a day to three days in order to remove big object stuck at furnace slag outlet. The fire-pressing/restart operation may result in uncertain emissions. The poor at-source segregation is a common issue facing Chinese cities, and will probably continue in coming years because changing social behavior is difficult.

Figure 5-5 Sorted Garbage at Xishan Incinerator

- The incinerators' instrumentation and automatic control system shall be further enhanced. Precise and reliable measurement of operating parameter, such as furnace temperatures and CO concentration, are good indicators of combustion conditions. It is noted that in at least two incinerators the thermometers for flue

gas, after second-injection of air, may need to be put at a higher location in order to accurately measure the temperatures. There is also a lack of CO measurement after furnace. If reliable measurements of the parameters are in place, and corresponding control loops built into the incinerators' control strategy, the incinerators can achieve more steady operation and better manage low quality garbage.

- Environmental monitoring seems to be inadequate due to technical and capacity constraints. Per Chinese regulation, the inspection monitoring carried out by local environmental bureaus is the basis for environmental enforcement. Investigation of the inspection monitoring results shows that the inspection intervals were uneven. Some incinerators received quarterly inspections, others were inspected even less. This is common elsewhere in China because local environmental monitoring stations are often overwhelmed and give priority to ambient environmental quality monitoring and national/provincial key emission sources such as big power plant or heavy industries. In addition, the online monitoring equipment in the four incinerators don't work well all time; some monitoring results seem to be either too low or too high, indicating there is room for improving maintenance and validation. Furthermore, online monitoring shall be expanded to cover operating parameters and made accessible to the UMB and EPB, which will enable them to better enforce.
- Incinerator operators' knowledge of process control, comprehensive application of BAT/BEP and environmental compliance need to be further enhanced. Systematic and regular training are needed.
- In addition to technical measures, international experience shows that close public oversight is critical to the incinerators' environmental compliance. This is also a best environmental practice highlighted by Stockholm Convention BAT/BEP guidelines. The public oversight approaches were developed through public consultation during project preparation (see Section 6).

6 Public Consultation

6.1 Public Consultation and Information Disclosure

During project preparation, two rounds of public consultations were conducted in accordance with World Bank OP 4.01. Social assessment was considered part of environmental assessment process, and the public consultations were carried out in an integrated manner to address the social and environmental concerns of the public. A combination of questionnaire surveys, focused group meetings, interviews and public meetings was carried out. The first round of public participation was carried out in May, 2013; the second round was carried out in March 2014 when the draft full environmental audit, environmental management plan and social assessment reports had been disclosed locally on March 10, 2014.

The public consultations show that communities lack knowledge of MSW incineration, dioxins and other air emissions from MSW incinerators. They also lack confidence in the information shared with the public on the environmental management and emissions of the incinerators. These findings reinforced the fact that public reactions against dioxin emissions from MSW incinerators have become more common in China's large cities in recent years.

Based on the public consultations, the social assessment concluded that women know less than men about hazardous emissions from MSW incinerators, but women expressed more concern about the impacts on health and quality of life. Women were also less aware than men of environmental information disclosed by incinerators and less satisfied with the information disclosed.

Of the four incinerators, Wuhua incinerator has mostly populated communities in its vicinity, and the opinions obtained from the people consulted show obvious concerns to the MSW incineration. However, through the public consultations, people consulted understood the objectives, approaches and design of the project, and expressed welcome to the project and willingness to join the designed public engagement programs.

Information disclosure has been carried out as part of the environmental and social assessments through public bulletins, internet and at village offices. All draft full environmental audit reports, environmental management plans and social assessment reports were made available locally on March 10, 2014, and in the InfoShop on March 20, 2014, and as such, are accessible to the general public.

Group meeting in Wuhua

Group meeting in Xishan

Group meeting in Dongjiao

Group meeting in Konggang

Figure 6-1 Group meetings of the second round public consultation

6.2 Public Engagement Plan

Based on the public consultations carried out during project preparation, a comprehensive public engagement program was developed and incorporated in the project design, including: 1) information disclosure and public participation program including public disclosure of real-time incinerator emission and operating data, dioxin monitoring data, knowledge dissemination of MSW incineration and health impacts, MSW segregation and its linkage with incineration, interactions between incinerators and nearby communities, and 2) grievance redresses mechanism that includes a telephone hotline, document filing and specialized complaint institution located at incinerators, community/village, environmental protection bureau, urban management bureau. The budget for the public engagement plan is included in the project.

7 Environmental Management Plan

7.1 EMP Design

The project will be implemented in two phases. The first phase will be an operating and environmental performance audit in the first year of project implementation, emission targets for each incinerator will be determined and are expected to meet or close to US and EU standards that are referenced in the EHS Guidelines. In the second phase the project will implement operational improvement programs in selected incinerators among the four in Kunming. Incinerators that commit to implementing these programs and fulfill financial eligibility conditions will be supported, including through grant funding for necessary upgrades of equipment relevant for dioxin emission reduction.

The project by nature can be considered action plans to help the incinerators improve its operations and environmental compliance. The EMP includes the following aspects. An EMP for each incinerator was prepared by incorporating designed project interventions. Key highlights of the EMP include the following.

- BAT/BEP and other mitigation measures. The EMP includes mitigation measures that address environmental compliance associated with MSW incineration. Applicable domestic regulations, Stockholm Convention BAT/BEP and WBG EHS guidelines were taken into account in designing these mitigation measures.
- Monitoring Plan that includes existing inspection monitoring, online monitoring and additional dioxin stack monitoring, online monitoring of operating parameters supported by the project.
- Public Engagement plan that is developed based on public consultations carried out through social assessment and environmental audit process.
- Capacity training plan that includes existing training programs in the incineration plants and operator/regulator training supported by the project.

7.2 Institutional Arrangement

MEP/FECO will be responsible for overall environmental management during project implementation. Kunming and Ningbo have established project management offices to manage the project implementation including investment and TA activities. In Kunming, each incinerator will be responsible for the implementation of its site-specific EMP. Environmental management responsibility will be built into the project management structure within MEP/FECO, provincial/local EPBs, and participating incinerators' management, through their existing environmental management office and dedicated staff. Environmental mitigation measures developed in the EMP will be fully incorporated into the environmental, health and safety management systems.

7.3 EMP Budget

The GEF grant for the project is USD12 Million, while counterpart funding for equipment enhancement at the MSW incinerators will be provided by the incinerators themselves. In

total the project costs will be USD 60 million. Each incinerator will receive USD 1-2 million GEF grant. Operational costs of the incinerators will be fully borne by the incinerator owners.