

Response to the requests for review of project activity
"Mokpo Landfill Gas Recovery project for Electricity Generation"(2834)

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EMC

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Dear Members of the CDM Executive Board,

We refer to the requests for review of the project activity “Mokpo Landfill Gas Recovery project for Electricity Generation”(2834) and would like to provide the following response to the issues raised.

Question 1: The DOE shall explain how it has validated the accuracy of the financial calculations carried out for the investment analysis, the suitability of the benchmark and the input parameters, in line with the CDM VVM, paras. 109–110, and 112.

EMC Response:

Hanwha Corporation invest the total amount of capital, and it was calculated using a project IRR. EMC validate eligibility focused on consistency/conservativeness/reliability between PDD(with spreadsheet) and FSR(2008.2). And EMC cross-checked with expert interview and research data. EMC validated the appropriateness of the values in PDD and FSR when inconsistencies occurs, in line with the CDM VVM, para. 111(b). Detailed validated activities are as follows.

1) Total amount of investment cost

- EMC carried out analysis to validate appropriateness of the values in FSR. Lack of detail data for investment cost, EMC requested estimated calculation sheet to technical provider, and double checked each parameter.
- EMC performed investment analysis for similar domestic Landfill electricity generation project using "Status of Landfill LFG reusing facilities and technologies¹⁾" to cross-check.
 - Total amount of investment cost for Mokpo landfill was lower than Pohang and same with Jeju. Both of them are landfills that have a same electricity generation capacity.
 - The total amount of investment cost for other project which have a different scale was similar with Mokpo.

1) Sudokwon Landfill Management Corporation, "Status of Landfill LFG reusing facilities and technologies", May 2006

Landfill site		Capacity	Total amount of Investment cost (Million won)
Project	Mokpo	2MW	3,000
Bench-mark project	JeJu	2MW	4,000
	Pohang	2MW	3,000
	Sunchun	1.8MW	2,500
	Sudokwan	6.5MW	10,300
	Sudokwan	3.38MW	4,600
	Sudokwan	50MW	77,300
	Busan	8.7MW	6,000
	Gwangju	1MW	2,919
	Daejun	3.4MW	6,418
	ChungJu	1MW	1,650

Table 1. The comparison of total amount of Investment cost with capacity

- EMC conclude that the total amount of investment cost for Mokpo landfill in FSR and PDD was generally reasonable.
- In related with Sensitivity analysis, much of construction cost was already paid, and the rest of them is predictable, so total amount of cost is less likely happen to decline. Also construction cost has a high possibilities to increase because of increasing of raw materials price. EMC cross-checked with domestic company who is running landfill electricity plant. After interview and cross-check, EMC conclude that there are low possibilities it will cross the bench-mark ratio(5.24%) because decline of investment cost.
 - EMC interviewed with domestic company²⁾ and there was an opinion about landfill construction cost which OM cost has been rosed rapidly because of increasing of raw materials price.
 - EMC also cross-checked using a statistical data from Bank of Korea³⁾. Increasing ratio for imported materials was keep rising from Oct 2007. It was 7.5% at Oct 2007, Dec 15.6%, Jan 21.2% 2008, Feb 22.2% 2009. Statistical analysis data on prices from Bank of Korea predict that prices has a strong tendency to rising.

2) Operation and management cost

- EMC cross-checked with the average O&M costs of USA 3MW cases are

2) Mr. Byung-Chan Jo, Total E&S

3) Bank of Korea, "statistical analysis data on prices" www.bok.or.kr

- 13.2–16.4% of construction cost⁴⁾⁵⁾. So the O&M costs of this project was little bit higher (19%) than USA case. Considering of "Economies of scale", O&M Costs of this project(2MW) was reasonable, but more cross-check was needed.
- EMC requested evidence for O&M costs and validate appropriateness for each parameters.
 - Project participant, Hanwha Corporation need to pay Mokpo city 6.3% of electricity generation profit as a payment fee⁶⁾. Excluding payment fee to Mokpo city, O&M costs ratio is 16.3% and it is generally reasonable according to US EPA document.
 - EMC cross-checked generator repair cost and engine oil exchange cost using a maintenance schedule which was submitted by GE energy agency. Generator repair cost was 122,500,000 won per 1.065MW. And engine oil need to be changed 14.6 times totally for every 600hours and 1,200,000 won for each time.
 - Capturing pipe expenses is for nine wellhead extension constructions and repair cost for landfill. This expenses was came from operational experience of Sejin company which is a technical provider for this project. EMC cross-checked using a relative report "Status of Landfill LFG reusing facilities and technologies" and it was reasonable.
 - Pre-treatment cost is to purchase desulfurize agent and filter. It was estimated by Sejin and came from it's operational experience. EMC cross-checked using a relative report "Status of Landfill LFG reusing facilities and technologies", and it was reasonable.
 - Salary for operator is 25,000,000 won per year. EMC cross-checked using a average salary data from Korea Engineering & Consulting Association⁷⁾ and it was resonable
 - Annual salary for a primary grade skilled worker is 22,400,000won/year and the minimum salary is 20,000,000 won/year from Korea Engineering & Consulting Association based on 2007. So annual salary was reasonable.
 - Apply 5% for welfare cost to annual salary and there are no regulation or policy for welfare cost. Because 5 to 10% rate is general range for welfare cost in Republic of Korea, So it is reasonable.

4) U.S. EPA "Landfill Methane outreach program, Landfill gas energy cost model, LFG cost, Version 1.4 summary report Appendix 4-A Electricity case studies", 15 Dec 2008

5) Table4-1 of LFG energy project development handbook, EPA

6) Contract between Mokpo city and Hanwha

7) Korea Engineering & Consulting Association (www.kenca.or.kr) "Average salary data for Engineering"

- There were no standardized cost for Postage, Office supplies, Mobile maintenance but EMC cross-checked using other contract documents that those are generally reasonable cost in Republic of Korea.
- Local tax is a rental fee for public property, and payment fee is a landfill gas utilization charge which it need to be paid to Mokpo city for 6.3% of the total sales of electricity. EMC cross-checked using a contract between Mokpo city and Hanwha.
- Insurance cost is a general fire insurance fee and it was 8,000,000 won for each generator come from company standardized regulation. EMC cross-checked with other project and conclude that it is reasonable.
- In related with sensitivity analysis, OM cost had a high possibilities to increase because of increasing of raw materials price. EMC cross-checked with domestic company who is running landfill electricity generation plant. After interview and cross-check, EMC conclude that there are low possibilities it will cross the bench-mark ratio(5.24%) because decline of investment cost.
 - EMC interviewed with domestic company and there was an opinion about landfill construction cost, OM cost has been rosed rapidly because of increasing of raw materials price.
 - EMC also cross-checked using a statistical data from Bank of Korea. Increasing ratio for imported materials was keep rising from Oct 2007. It was 7.5% at Oct 2007, Dec 15.6%, Jan 21.2% 2008, Feb 22.2% 2009. Statistical analysis data on prices from Bank of Korea predict that prices has a strong tendency to rising.

3) Unit price of electricity sales (SMP)

- Unit price of electricity sales was 81.5 won/Kwh in PDD. Project participant submit sperad sheet as an evidence and EMC cross-checked SMP using a data from Electricity exchange statistics system⁸⁾.
- Unit price of electricity sales is 100 won/Kwh in FSR and it was differ from PDD. According to CDM VVM para 111. (b) the values used in the PDD and associated annexes are fully consistent with the FSR, and where inconsistencies occur the DOE should validate the appropriateness of the values.
- Unit price of electricity sales in FSR is rough assumption data that doesn't have a benchmark or evidence. EMC conclude that it is not appropriate and

8) <http://epsis.kpx.or.kr>

accuracy value according to CDM VVM para 109. Even if the unit price of electricity sales was 100 won/Kwh, NPV was still negative value. EMC admitted that using 100 won/Kwh is not appropriate. Because of that reason EMC admitted that using a 81.5 won/Kwh rather than 100 in PDD which is a real unit price of electricity sales at that time was appropriate.

- EMC conclude that it is reasonable for setting a same unit price of electricity sales through whole project lifetime because of high uncertainty of future assumption. EMC carried out linear regression analysis using a publically opened data from 2001 to 2007⁹⁾ to estimate the possibility of increasing. Average unit price of electricity sales is 122 won/Kwh during project lifetime, and IRR is –1.37% which is much smaller figure than benchmark ratio(5.24%). Unit price of electricity sales should be over 140.3won/Kwh to be economically attractive and IRR will cross the benchmark ratio.

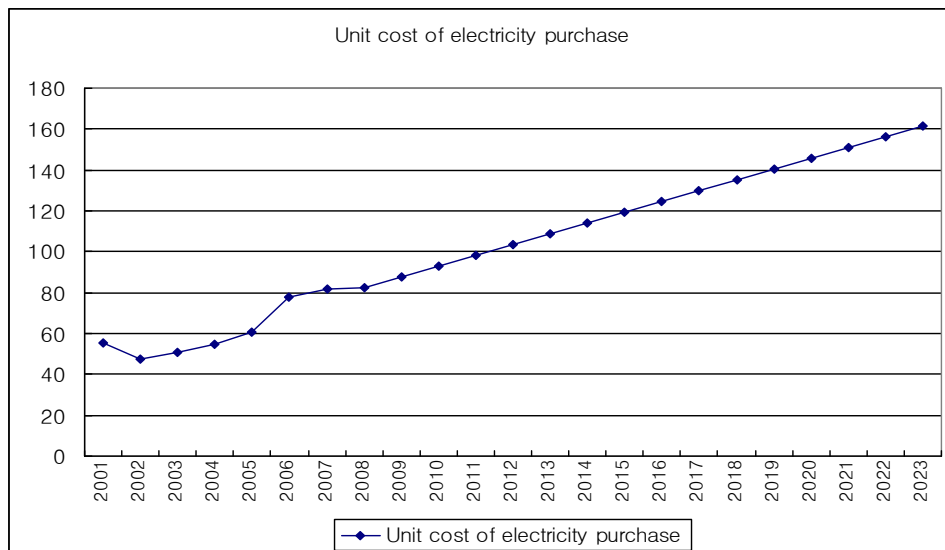


Figure 1. Linear regression analysis using a unit cost of electricity purchase

- There are low possibilities of decreasing for total investment cost, O&M cost, So there are no synergistic effects to increasing unit price of electricity sales. Because above reason, EMC concluded that sensitivity analysis performed appropriately.

4) Corporation Tax

- When profit from electricity generation sale is over 100,000,000 won, Project participant need to pay 25% corporation tax by legal standard. EMC

9) Electricity exchange statistics system (<http://epsis.kpx.or.kr>)

cross-checked with National Tax Service.¹⁰⁾

5) Depreciation period

- Operational lifetime for equipment was 15 years and this parameter was validated other section as a CAR 6, So Setting 15 years as a depreciation period was appropriate.

6) Sales volume of electricity (MWh)

6-1) Maximum limit of LFG input into generator

- Gas volume based on full load situation is between 522 and 450 Nm³/hr. And PDD describe Gas volume as a 16.20 m³/min. EMC converse gas volume unit from Nm³/hr to m³/min and 16.20 m³/min was appropriate, also cross-checked with a generator specification report from GE Energy.

6-2) Fraction of methane in LFG

- PDD suggest 50% for fraction of methane in LFG based on Vol.5, Chapter3, IPCC Guideline 2006 and EMC check the guideline and concluded that it is appropriate.

6-3) Self-consumption ratio

- There were no back data for 3% self-consumption ratio. EMC requested evidence or related document. Project participant submitted self-consumption data for 1.065MW facility which was test running at that time. And self-consumption ratio for that was between 2.6 and 2.7%. So choosing a 3% for self-consumption ratio is conservative approach and resonable.

6-4) Methane density

- EMC cross-checked Methane density using an ACM0001(page3), at standard temperature and pressure (0 degree celsius and 1,013 bar), the density of methane is 0.0007168

6-5) Operation time

- Operation hour is same with FSR and spreadsheet which is 8000 hours. It is operation hour except shut down hour for maintenance which is 760 hours

10) www.nts.go.kr

Project Name	Operational Hours
Mokpo	8000
Biogas Technology Group Ras Al-Khaimah Landfill Gas to Energy Project	8000
Landfill Gas Recovery and Utilization at Bukit Tagar Sanitary Landfill, Hulu Selangor	7884
Alton Landfill Gas to Energy Project	7972

7) Benchmark ratio

- PP used 5.24% as a benchmark ratio for Mokpo project. Chinese NDRC published and approve benchmark ratio officially for each project type. In contrast with China there are no approved national authorized benchmark ratio for each project in Republic of Korea.
- So, most of domestic CDM projects are using average government bond or AA–Corporation bond as a benchmark ratio in Republic of Korea. Recent three years average data for AA–Corporation bond was 5.7 and 5.24 for government bond. Choosing a 5.24% which is a government bond is a conservative approach, EMC cross-checked using statistical data from bank of Korea¹¹⁾, so it is reasonable.

Question 2: The DOE shall explain how it has validated the calculation of the ex-ante emission reductions, in particular, that the values of the parameters for the application of the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site" are appropriate, and how the CAR raised related to these parameters were closed, in line with the CDM VVM, paragraphs 38–39

EMC Response:

Project participant used same estimation equation from "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site" in spreadsheet(Attached excel sheet when request for registration). After checking the equation, EMC validate the appropriateness for each parameter.

$$BE_{CH_4,SWDS,y} = \phi \cdot (1-f) \cdot GWP_{CH_4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^y \sum_j W_{j,x} \cdot DOC_j \cdot e^{-k_j(y-x)} \cdot (1-e^{-k_j}) \quad (1)$$

1) ϕ

11) Bank of Korea, Statistical data on bond, www.bok.or.kr

- Project participant used 0.9 and is correspondence with tool. EMC didn't comment about this in validation report because It is not related with CAR/CI.

2) f

- ※ First of all, there is a misprint in page A-35 of Validation report Appendix A. EMC submit revised validation report from F to f. It was caused automatical conversion by MS word programs. EMC correct this in revised validation report.
- Project participant used AMSIII-G ver.4 so EMC request to Project participant to using it's latest version which is Ver.6. According to AMSIII-G ver.6 page2, when no methane is captured and flared f is 0.
- EMC received "Letter of Approval for the Treatment Facilities issued by Chonnam Province to Mokpo City" from Project participant and cross-checked Mokpo landfill site didn't have any treatment except biological treatment facilities for leachate.
- EMC cross-checked using a regular examination report (2008.1) on landfill facilities carried out by Korea Rural Corporation and confirmed Mokpo landfill site didn't have any treatment system such as flared or used in another manner.
- Also, there was no existing treatment facility for LFG when EMC visit the on-site.



Figure 2. Mokpo landfill pictures

3) OX

- According to "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site", OX factor for managed solid waste disposal sites that are covered with oxidizing material such as soil or

compost use 0.1 and use 1 for other types of solid waste disposal sites. Project participant didn't submit relative document, but EMC validate it's appropriateness using an internal technical data base. And this is not related with CAR/CI, so there were no comment in validation report.

- To validate it's appropriateness, EMC surveyed on National relative law(National Waste Control Act, Ministry of Environment)¹²⁾. According to National Waste Control Act, it is mandatory to covered with soil in the managed solid waste disposal sites. EMC concluded that it is appropriate but carry out cross-checking the compliance rate additionally.
- EMC cross-checked Compliance rate using a "2006 Status of national waste generation and treatment"¹³⁾ which was the latest version at that time. EMC could checked every landfill paid for the covering with soil. Also according to "National survey result for landfill treatment system"¹⁴⁾, all of the landfill paid huge amount of money for covering the landfill, and it was 26 million \$ at 2006
- At last, when EMC visit on-site, Mokpo landfill was fully comply with the law. So choosing 0.1 for OX is appropriate.

4) F

- Project participant used default value 0.5 and it is correspondence with tool. EMC didn't comment about this in validation report because It is not related with CAR/CI.

5) DOC_f

- Project participant used default value 0.5 and it is correspondence with tool. EMC didn't comment about this in validation report because It is not related with CAR/CI.

6) MCF

- According to "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site", MCF factor for anaerobic managed solid waste disposal sites is 1.0, 0.5 for semi-aerobic managed solid waste disposal sites, 0.8 for unmanaged solid waste disposal sites and 0.4 for unmanaged shallow solid waste disposal sites. Project participant submit

12) National Waste Control Act, www.me.go.kr

13) Ministry of Environment, 2006 Status of national waste generation and treatment, 2007.

14) Ministry of environment, National survey result for landfill treatment system, Jun. 2007

1.0 for MCF factor.

- According to "National survey result for landfill treatment system" domestic landfill is anaerobic managed solid waste disposal sites.
- EMC interview with landfill experts¹⁵⁾ for cross-check that inside of domestic landfills is anaerobic condition because they cover with cover soil or other cover materials after disposal of waste.
- EMC also cross-checked using a "Letter of Approval for the Treatment Facilities issued by Chonnam Province to Mokpo City", on-site visit and expert interview. It was not related with CAR/CI, so EMC didn't comment about this in validation report.

7) $W_{j,x}$

- Project participant divide raw materials into before and after 2005. EMC approved it's appropriateness based on prohibition law of direct disposal of food waste to landfill site¹⁶⁾. Composition of landfill waste changed significantly after 2005, so fraction of food waste is 0.
- EMC cross-checked with landfill statistics from the Ministry of Environment. EMC requested to change $W_{j,x}$ figure because it was differ with reference.
- Especially, Project participant define "others" as a textile. Because of difference between overseas categorization criteria and lack of domestic analysis standard, Project participant's assumption for others is not conservative and objective.
- Textiles, Garden&Park waste are conservative approach except completely matched waste type(Wood, paper/cardboard, Food waste, Glass, plastic, metal, other inert waste) by overseas categorization criteria and domestic analysis standard. Among them Garden&Park waste has lower DOC_j (20%) value than textiles, so choosing that is more conservative approach and Project participant changed to those data.

8) DOC_j

- Project participant used wet waste value between the values for wet and dry waste. Project participant chooses the wet waste value for conservative approach. But there are no evidence and explanation for that.
- According to National Waste Control Act Annex11, the percentage of water

15) Interview with expert form Total E&S and Expert from EMC

16) Ministry of Environment, Prohibition law of direct disposal of food waste to landfill site, Jan. 2005

content in the waste need to be under 85% when they goes into the landfill. It is hard to distinguish whether it is wet or dry only for National Waste Control Act. Because 50% of water content is general standard for dividing wet and dry. Also there were no characteristic analysis data for Mokpo landfill waste, EMC consider it is conservative for choosing a wet waste value for DOC_j .

9) k_j

- Although Korea Meteorological Administration is the authorized institution for atmospheric statistics of Korea but Project participant submitted wrong name for same institution. So EMC requested to Project participant to correct the name of institution.
- Used data must be average based on long term statistics, there were no indication on the number of years have been measured given in PDD. For cross-check, EMC searched presented value and cross-checked as the 30 year average through verification with data from Korea Meteorological Administration web site¹⁷⁾. So EMC requested to add above information to the revised PDD.
- According to statistical data from Korea Meteorological Administration, EMC conclude below.
 - MAT(Mean annual temperature) = $13.8 \leq 20$
 - MAP(Mean annual precipitation) = 1125.1
 - PET (Potential evapotranspiration) = 1164.2
 - $MAP/PET = 0.966415 < 1$

MAT value is smaller than 20, So it is Boreal and Temperate. When MAP/PET is smaller than 1, it is Dry in Boreal and Temperate.

10) Calculation formula : existing waste amount

- There is a difference between Ministry of Environment and National Institute of Environmental Research published data related with the quantify of waste disposed to landfill. Project participant choose data from National Institute of Environmental Research and it is conservative approach because of lower emission reduction.
- EMC cross-checked using interview with local expert¹⁸⁾ and confirmed that

17) www.kma.go.kr

18) Interview with Prof. Seng-Muk Lee, Seoul national University

statistical data might be differ from each other because of collecting method and calculation unit. And both data published from government agency. So EMC conclude for the conservative approach it is appropriate choosing a data from National Institute of Environmental Research which brings lower emission than the other.

※ Additional Error in calculation formula : $BE_{CH_4,SWDS,y}$ formula

- EMC cross-checked PDD and relative document thoroughly again during reporting for request of review, and find a additional mistake when calculating $BE_{CH_4,SWDS,y}$. While updating spreadsheet, linked a wrong data in calculation. EMC submit revised PDD, revised spreadsheet and revised validation report for that.

Question 3: The DOE shall explain why the monitoring plan does not provide for the monitoring of (a) the required parameters under the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site"; and (b) methane emission that would be captured and destroyed to comply with national or local safety requirement or legal regulations ($MD_{reg,y}$)

EMC Response:

(a) the required parameters under the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site"; and

1) f

- According to AMS III.G_version6, since there were no flaring facilities in project site, f is 0%. EMC request to Project participant to submit revised PDD after described about f in table.

2) W_x , $p_{n,j,x}$, z

- Analysis on composition of Landfill, Mokpo city need to report to the Ministry of Environment every year. and according to those data Ministry of Environment publish "Status of waste disposal and treatment" for each landfill site.
- EMC cross-checked using a relative document from Mokpo city and a government officer interview for composition analysis method and period of analysis.

- The report related with composition analysis to Ministry of Environment follow procedure of National Waste Control Act. Project participant will use it's analysis data for calculation.
- Project participant suggested that they do not need monitoring methodology but they have to use nationally approved data. EMC validated it was appropriate at that time. But EMC submit revised PDD with W_x , $p_{n,j,x}$, z in table.

3) GWP_{CH4}

- EMC submit revised PDD with GWP_{CH4} in table.

(b) methane emission that would be captured and destroyed to comply with national or local safety requirement or legal regulations (MD_{reg,y})

- EMC validated at the time of the site visit that there was no LFG collection system(neither active nor passive) installed in the baseline scenario. Therefore it is justified that the Adjustment Factor is set at 0. In ACM0001_version 5 it is stated "In cases where regulatory or contractual requirements do not specify MD_{reg,y} an "Adjustment Factor"(AF) shall be used and justified, taking into account the project context". Project participant applied 0% AF to the project since there are no regulatory or contractual requirements which specify MD_{reg,y} and neither an active nor a passive LFG capturing system is installed in the site in the baseline scenario. This was validated by EMC during on-site visit and cross-checked using a "Letter of Approval for the Treatment Facilities issued by Chonnam Province to Mokpo City".
- So, Mokpo project's MD_{reg,y} is 0 because AF value is 0. EMC already cross-checked using CAR2, CI4. And it doesn't need to be in PDD when the value is zero. But EMC submit revised PDD with MD_{reg,y} in table.

We hope that the clarifications above have addressed all the issues raised and we look forward to the registration of this project.

Yours sincerely

27 November 2009

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