**Swiss Association
for Quality and Management
Systems (SQS)**

Bernstrasse 103
3052 Zollikofen
Switzerland

T +41 58 710 35 35
F +41 58 710 35 45

www.sqs.ch

Response to Request for Review – 6820 Incheon Metro Line 2

Dear Members of the CDM Executive Board,

Please find the summary of the responses to the issues raised and the action taken to correct the project-related documentation as part of the request for review for requesting registration for the No. 6820 project. The response is in accordance with para 9 a) in the Procedures for Review of Requests for Registration (EB55, Annex 40).

1) The DOE is requested to clarify how it has validated 9 June 2009 to be the project start date as cash outflow is observed in year 2008 in the investment analysis spreadsheet. In case the project start date is revised, please ensure the validity of the input values to the investment analysis and the prior considerations. Please refer to VVM version 1.2 paragraphs 99-103 and Guidelines on the assessment of investment analysis version 5 paragraph 6..

The investment analysis is based on a FSR developed by KDI (Korea Development Institute) published 8/2008 which again is based on the Feasibility Study 2006 and the Revised Master Plan 2007 (see Annex 1: File 55, sheet 7.1.,SQS ref. [79]). The FSR starts with expenses in the year 2008. The project was however delayed and actual start was only 1 year later 2009. In many cases projects start late and FSR based on years might thus be outdated (some FSR therefore use the domination year 1, 2…n).

The project starting date is the date of the signature of the construction contract being 09/06/2009 (see File 15 SQS ref. [22]). This is in accordance with the CDM Glossary of Terms. The actual construction start is, based on the construction contract, 17/06/2009 (see File 15, sheet ID 1.1.). Completion date of construction is 18/11/2014 i.e. operational start 2015 which is 1 year later than in the finance spreadsheet which again shows that the actual investment and start of the project is 1 year later than projected in the FSR for the finance.

SQS together with the local expert analysed the steps before and after the investment decision taken in May 2009 and reviewed the stamped construction contract during the on-site visit.

2) The DOE is requested further substantiate the following input values:
a) the total investment: how it has considered the range of 60-180 million USD for metro lines worldwide (Bus-systems for the future, IEA, 2002) comparable, considering that there are several metro projects in the host country and neighbouring countries;

The investment cost is based on KDI (Korea Development Institute), an independent 3rd Party. To assess the plausibility of the value independent and well known international sources are taken; being the IEA (Files 33a-e, SQS ref.[50-54]) and a published report by B Flyvberg, Comparison of Capital Costs per Route-Kilometre in Urban Rail, EJTIR, 8, no. 1 (2008) (File 47, SQS ref.

[70]) which show that the investment cost of the project with 58 million USD/km (underground metro) is at the lower end of international estimates. The article of Flyvberg includes thereby also the investment cost of Seoul metro network (117km) which is stated to be 65.8 million USD/km in 2002 USD (File 47 SQS ref. [70], Table 3, p.23; this includes not only underground stretches; underground metro is more expensive than elevated or at-level, see IEA source). The most complete and comparable metro network in the same host country thus also indicates the plausibility of the used value.

Busan has with an underground metro an investment cost of 74 million USD/km (See File 36 BUSAN PDD) and is thus in the same range.

Park and Han (2003) estimate the cost of building metros in Korea by 80-100 million USD/km (see cited in J. Pucher et.al., Public Transport Reforms in Seoul, p.56; The study for the state of construction and improvement policy of advanced transit system of Korea, 2003, in addition Annex 2: Public Transport Reforms in Seoul: Innovations Motivated by Funding Crisis. Journal of Public Transportation, Vol. 8, No. 5, 2005, pdf), SQS ref. [105].

See also about the difficulty of comparing investments in metro: http://www.railway-technical.com/finance.shtml.

b) the operational cost: how it has validated: i) the selected domestic metro line and overseas metro lines comparable, and ii) the suitability of the number of employees, salary, electricity cost, maintenance cost;

The operational cost is based on KDI (Korea Development Institute), an independent 3rd Party. As Korea and especially Incheon already have operating metros the operational cost can be estimated fairly well depending on train frequency and demand projections. Operational cost might be lower if passenger numbers are lower than projected. This has been included in the finance model as operational costs have been reduced proportionally to the decrease in passenger numbers. This approach is very conservative as it assumes that all operational costs are variable whilst in practice some are fixed costs (e.g. station maintenance; also electricity consumption is not strictly proportional to passenger numbers).

The metro lines are compared to recently established metro lines or such under construction. The data from the Busan PDD has not been included as the latter is a short line extension and not a full line, thus not making costs comparable. The table below shows the operational costs of all underground metros for which data was available on a comparable basis i.e. FSR was available for the same year to make cost data per passenger comparable:

Table: Comparison of Projected Operational Costs per Passenger (USD per passenger; year 2020)[1]

Metro Incheon Line 2	Metro Mexico Line 12	Metro Buenos Aires	Metro Seoul Line 9	Metro Delhi Phase II
0.29	0.29	0.27	0.19	0.23[2]

Daegu Monorail is elevated, Metro Mumbai 1 and 2 and Gurgaon metro are elevated and thus have a non-comparable operational cost (especially electricity due to ventilation and services, maintenance of stations).

Metro Seoul Line 9 is double tracked which means much more passengers but using the same stations and thus reducing the cost per passenger transported.
DMRC is only partially underground and has thus also lower operational costs.

[1] Based on Feasibility reports for all i.e. projections for all cases; for all based on projection year 2020 to have a fully operational and comparable data year. Exchange rates to USD based on financial assessment report per project; all data based on published PDDs for the respective metros.

[2] See Annex 3: File 47 finance vers. 1.1 DMRC SQS ref.[106] operational cost (9,645 million INR) exchange rate 44 INR/USD (http://www.oanda.com/currency/converter/ for 1.9.2005); see Annex 4: File 2 Passengers and OP costs DMRC.xls, SQS ref.[107] project with growth rate 5.8% per annum (960 million); all 2020.

The number of employees, their salaries, the electricity and maintenance cost (divided by station-, train- and system-maintenance cost) have been taken from the 'Incheon Metro Line 2 feasibility report' of the Korean Development Institute (File 57b, [82]), which was sent to SQS by responding to CL19. These figures were discussed in detail and crosschecked during the on-site visit by the SQS' validation team and the local expert Mr Ko (KFQ). Furthermore the performed assessment is confirmed in writing on 08/11/2012 by the Korean Foundation for Quality (KFQ), regarding the assessment on operational costs analysis for Incheon Metro, in which Mr Ko confirms that the background data for operational costs for Incheon Metro is duly reasonable and correct (see Annex 5: File Incheon Line 2 Operational Cost Evaluation (08 Nov 12)_1.xls).

Based on checks and the information above, SQS considers the expected operational costs of Incheon as plausible in an international context.

c) the fare box revenue: how it has validated the passenger projection. Please refer to VVM version 1.2 paragraph 111..

Passenger projections are based on KDI (Korea Development Institute), an independent 3rd Party. Passenger projections are based on a Master Plan (see Annex 1: File 55, SQS ref. [79] sheet 7.1 attached)

KDI (Korea Development Institute) was established 1971 as the first government-supported but autonomous social science research institute in Korea.

3) The DOE is requested to further substantiate how it has validated the common practice analysis as: a) the set of cities used for comparison includes cities with population less than 1 million while the methodology (page 6) states "If the larger urban zone (LUZ) of the city of the project activity contains more than one million inhabitants, then the set of cities for comparison includes all cities (including the city of the project activity) in the host country with a LUZ that contains more than 1 million inhabitants"; and b) excluding the cities with less than 1 million at the time of the investment decision, there would be 7 cities for comparison out of which 5 cities already have MRTS in place while the methodology states "The proposed project activity is regarded as common practice if MRTS have already been implemented in 50% of the cities in the set of cities for comparison". Please refer to VVM version 1.2 paragraph 120 (a) and ACM0016 version 2 page 6..

The methodology states that the LUZ is required to be taken (which is often larger than the official number of city inhabitants).

A. Eurostat, the European Union's (EU) statistical agency, has created the concept of Larger Urban Zone (LUZ) in an effort to harmonise definitions of urbanisation in the European Union and in countries outside this area. These definitions were agreed upon between Eurostat and the National Statistics Offices of the different countries of the European Union at the European Commission's Urban Audit in 2004. Eurostat's objective was to have an area of a significant share of residents commuting into the city, a concept known as the "functional urban region." To ensure a good data availability, Eurostat adjusts the LUZ boundaries to administrative boundaries that approximate the functional urban region.

B. The concept of LUZ needs to be transformed to the traditional definition of city inhabitants. The functional area is therefore taken for the cities for which no metropolitan area statistics are available. The result is depicted below:

Table 1: Metropolitan Population (year 2009) of Korean Cities

Urban Area based on functional area idem to LUZ	Population in millions
SNCA	24.38
Busan Metropolitan City	3.54
Daegu Metropolitan City	2.49
Daejeon Metropolitan City	1.48
Gwangju Metropolitan City	1.43

Ulsan Metropolitan City	1.11
Changwon (only city, 2010)	1.09
Cheongju	1.15
Jeonju	1.39
Cheonan	1.25
Pohang	1.30

File 68b SQS ref. [103]

Therefore we have 11 cities with > 1 million inhabitants, out of which 5 have a MRTS (highlighted in yellow) i.e. less than 50%.

In detail for the below cities which as metropolitan or functional area have >1 million but <1 million when taking only the city population data which is however NOT in line with LUZ as used by the methodology:

Table 2:

			Total population in the metropolitan area
Cheongju (LUZ)	Cheongju city	643,161	1,153,443
	Cheongwon	149,783	
	Boeun	34,845	
	Okcheon	54,117	
	Yeongdong	50,426	
	Jeungpyeong	33,164	
	Jincheon	61,456	
	Goesan	36,775	
	Eumseong	89,716	
Jeonju (LUZ)	Jeonju city	635,007	1,387,253
	Iksan	306,669	
	Gimje	94,770	
	Gunsan	266,922	
	Wanju	83,885	
Cheonan (LUZ)	Cheonan city	540,832	1,245,560
	Gongju	124,172	
	Boryeong	106,754	
	Nonsan	127,097	
	Gyeryong	42,760	
	Geumsan	56,220	
	Yeongi	79,482	
	Buyeo	75,564	
	Seocheon	60,066	
	Cheongyang	32,613	
Pohang (LUZ)	Pohang city	509,475	1,300,503
	Geongju	267,466	

	Youngcheon	103,115	
	Cheongsong	26,917	
	Yeongyang	18,553	
	Yeongdeok	41,710	
	Uljin	52,529	
	Geongsan	236,459	
	Cheongdo	44,279	

File 68b SQS ref. [103]

C. To assess the plausibility a check was performed with the EU LUZ empirical calculations. The plausibility is done by comparing LUZ calculations done in the EU with official city population data and thereby determining an expansion factor to determine LUZ based on city inhabitant data. All cities of the Eurostat database are taken for this purpose. The figures in the Eurostat database are an attempt to reach a compromise between harmonised data for all of the European Union, and with availability of statistical data, making comparisons more accurate. The data used is from the 2006 Urban Audit III, which uses information collected for 2004[3]. The database was made for all cities with > 500,000 inhabitants for which data was available. Eurostat published thereby data for 128 cities. The population of each city is based on national statistics (city population data). The expansion factor is defined as LUZ, namely the population/city. The average expansion factor taking the lower 95% confidence interval for the entire database was 2.1 i.e. to determine the LUZ population, the city population number must be multiplied with the factor 2.1. This is based on the empirical relationship of all Eurostat cities between LUZ and city population taking the lower 95% confidence level (File 68b SQS ref. [103]).

D. The metropolitan data calculated in the first table is thereafter compared with the LUZ population based on the LUZ expansion factor as determined in point C. The table below shows for the relevant cities the population data based on Metropolitan population and a calculated LUZ based on empirical EU data for cities where no metropolitan area information is directly available by the National Statistical Authority and where the core city population is less than 1 million.

Population (year 2009) of Korean Cities

Urban Area	**Population in millions metropolitan area**	**Population in millions LUZ**
SNCA	24.38	Not determined
Busan Metropolitan City	3.54	Not determined
Daegu Metropolitan City	2.49	Not determined
Daejeon Metropolitan City	1.48	Not determined
Gwangju Metropolitan City	1.43	Not determined
Ulsan Metropolitan City	1.11	Not determined
Changwon (only city, 2010)	1.09	Not determined
Cheongju	1.15	1.38
Jeonju	1.39	1.35
Cheonan	1.25	1.20
Pohang	1.30	1.08

File 68b SQS ref. [103]

Both approaches show that all included urban areas have a population of > 1 million. Therefore, using 2 different approaches both coincide that the cities listed in the PDD have a population of > 1million in the larger urban area. Thus 11 cities in Korea

[3] See Annex 6: Population information all cities.xls

have a LUZ of > 1 million of which 5 have a MRTS i.e. less than 50% thus proving that the project is not common practice in accordance with the methodology.

SQS concludes that the given common practice analysis is correct because it is based on the population of the LUZ at the time of the investment decision.

4) The DOE is requested to further substantiate how it has validated the identification of the baseline scenario as the DOE has validated only the baseline scenario as per "Step 2: Investment analysis" of the applied methodology while the methodology (page 5) requires to "conduct an investment comparison analysis for all alternatives that are remaining after Step 1" i.e. "realistic and credible alternative scenario(s) to the project activity that are in compliance with mandatory legislation and regulations". Please refer to VVM version 1.2 paragraphs 83-86, Tool for the demonstration and assessment of additionality version 05.2. Step 1 and 2..

In Chapter B5 of the PDD the following alternatives are listed:
1. The establishment of a BRT (Bus Rapid Transit);
2. The establishment of another rail-based MRTS:
3. The continuation of the current public and individual transport systems, including (future) investments in road based infrastructure if applicable;
4. The proposed project activity being implemented at a later date in the future, without being registered as a CDM project activity;
5. The project proposal not implemented as a CDM project activity.

Alternatives 1 and 2 are assessed in Chapter B.4. of the PDD and have been discarded:

Alternative 1 as BRTs due to their limited phd capacity are basically also used for secondary lines in large metropolitan cities in which a rail-based MRTS has already been established. Also with Incheon already having a metro line the connectivity is easier if the same system can be used and buses are thereafter used for secondary routes. For the area in which the metro is planned a BRT system is also considered as non-optimal basically due to the required passenger per hour capacity. BRT or bus lane systems have typical carrying capacities of less than 10,000 passengers per hour per direction (phd) (proven in Table 4 of the PDD). The median value for all included BRTs is 7,000 phd which gives an indication that BRT are basically used for secondary lines in large metropolitan cities and as main lines in smaller and medium sized cities. Also the only operational Korean BRT in Seoul has a capacity of 7,000 passengers per hour and direction only. The capacity of the proposed metro line is 30,000 passengers per hour per direction[4].

Alternative 2 Light Rail Transit (LRT) includes also trams and monorails. This alternative faces similar if not more severe constraints than a BRT. LRTs typically have a capacity of 10-20,000 phd. Also they reach only about half the average speed of metro (this is also true for normal BRT systems) thus not offering the same level of convenience as a metro. Based on above consideration a LRT is not considered as a technically viable solution due to the passenger demand on the corridors on which the metro is built.
Alternative 3 is the baseline situation.
Alternative 4 has been discarded in Chapter B4 respectively is identical with alternative 5.
Following alternatives are thus credible, realistic and comparable:
1. Continuation of the current situation (A3)
2. Project without CDM (A5)

The options BRT (A1), other rail-systems (A2) and the option project in the future without CDM (A4) are not considered credible, realistic or comparable alternatives as outlined in Chapter B.4. of the PDD. They are thus eliminated in Step 1 and not further

[4] File 14 SQS ref. [21]

considered. Step 2 conducts an investment comparison analysis for all alternatives that are remaining after Step 1 in accordance with page 6 of ACM0016:

"Apply Step 2 of the latest approved version of the "Tool for the demonstration and assessment of additionality". Conduct an investment comparison analysis for all alternatives that are remaining after Step 1. Use the NPV as indicator."

Step 1 is performed in B.4. of the PDD and Chapter B.5. then resumes the result of Chapter B.4. As only 1 alternative to the baseline remains after step 1 only for this alternative the financial analysis is performed.

5) The DOE is requested to clarify how it has validated that the baseline emissions from the buses have been calculated in line with the applied methodology. Equations 4 and 6 (or 7) of the applied methodology states that EFPkm,i,y of the baseline buses should be calculated from EFkm,i,y for vehicles using each type of fuel based on the specific fuel consumption of the vehicle, NCV of the fuel and the number of vehicles the type of fuel. However, in the spreadsheet, EFPkm,i,y for baseline buses is calculated by dividing the sum of the emission from the total diesel consumption and CNG consumptions by buses by the total passenger-km of all buses. Please refer to VVM version 1.2 paragraph 90..

SQS has re-calculated the baseline emissions from the buses and has found that the calculation performed in the PDD is mathematically identical with the calculation given in the approved methodology. This can be seen by the following considerations:

$$EF_{PKM,i,y} = \frac{EF_{KM,i,y}}{OC_i}$$ (is formula 4 of methodology)

$$OC_B = \frac{PBL_B \cdot TDBL_{P,B}}{DD_B}$$ (is formula 5 of methodology)

$$EF_{KM,i,y} = (IR_i)^{t+y} \cdot \frac{\sum_x \left(SFC_{i,x} \cdot NCV_{x,y} \cdot EF_{CO2,x,y} \cdot N_{x,i}\right)}{N_i}$$ (is formula 7 of methodology)

Formula 6 is not used

In the spreadsheet the calculation for EFkm, B is mathematically identical with the methodology.

The calculation in the spreadsheet for EFKM for buses is as follows (year 2015 taken as example) (see "Baseline Emission Factor" box B108)

$$EF_{KM,B,2015} = (FC_D \times SW_D \times NCV_D \times EF_{CO2,D} + FC_{CNG} \times SW_{CNG} \times NCV_{CNG} \times EF_{CO2,CNG} + EF_{CH4,CNG} \times DD_{B,CNG})$$
$$/(DD_{B,D} + DD_{B,CNG}) \times (IR_B)^{t+y}$$

SW is the specific weight of each fuel. This needs to be included as diesel is expressed in litres and CNG in m3 whilst the NCV in MJ/kg.

EFCH4,CNG multiplied with DDCNG buses is required as the CH_4 emissions need to be included for CNG units based on Table 1 of the methodology. IPCC expresses CNG emissions of buses in terms of CH_4 per km and therefore this addition needs to be made to the formula.

SFC as specific consumption is idem to total fuel / total distance i.e. FC / DD. The methodology has the formulae based on SFC as in many cases total fuel and total distance are not known and therefore the SFC is determined based on samples. In the case of Incheon however, we know the total fuel consumed by the diesel and the CNG buses. The total fuel consumed by diesel buses is multiplied with NCV and EF and thus gives us the total CO_2 emissions of diesel buses. The same is valid for CNG units. Thus we have the total emissions of all buses (CBNG plus diesel) which is then divided by the total distance driven of all buses (CNG plus diesel) resulting in the EF per km of buses. See also formula (8) of the methodology which has the same procedure if various bus sizes are used. The number of vehicles per fuel type is not required as the total distance is idem to distance per unit multiplied with the number of units.

Furthermore, in the spreadsheet the calculation for EFPKM,B is mathematically identical with the methodology.
The calculation in the spreadsheet for EFPKM for buses is as follows (year 2015 taken as example) (see "Baseline Emission Factor" box B117)

$$EF_{PKM,B,2015} = \frac{(FC_D \times SW_D \times NCV_D \times EF_{CO2,D} + FC_{CNG} \times SW_{CNG} \times NCV_{CNG} \times EF_{CO2,CNG} + EF_{CH4,CNG} \times DD_{B,CNG})}{DD_B} /$$

$$\frac{PBL_B \times TDBL_B}{DD_B} \times (IR_B)^{t+y}$$

The first part of the formula is again the EFKM and the second part is OCB (formula 5 of the methodology). DDB (idem to sum of distance driven diesel plus distance driven CNG buses) eliminates itself mathematically as it is in the counter and the denominator.

Therefore, both formulae are idem to the methodology.

6) The DOE is requested to clarify how it has validated the following values determined ex-ante:
a) specific fuel consumption of LNG taxis sourced from Korea Energy Economics Institute, 2009 as a lower value (77 g/km) was reported for the same item sourced from the same reference for another similar project validated by the same DOE and it is not clear whether this was the most recent data available at the start of validation in November 2011.

This is not LNG but LPG.
Korea Energy Economics institute reports in the mentioned source (Korea Energy Economic Institute, Energy Consumption Survey, Table 1-2-2, 2009, SQS ref. [6]) the values for each major city (in total for 16 individual cities). Therefore the values for Incheon are not the same as for other cities (see Annex 7: "File 1 taxi data", SQS ref. [6]). The report is dated 4/2009. No later report was available. The methodology states: "National or international data from studies not older than 3 years". The project was entered for validation 11/2011 and therefore a report 04/2009 is less than 3 years and in line with the methodology. The IR (annual improvement rate) based on the methodology is thereafter applied.

The report provides data of private taxis and corporate taxis. Therefore the SFC is determined as total fuel consumed corporate + total fuel private divided by total distance corporate + total distance private.

b) specific Fuel Consumption for motor cycles, Korea Energy Economics Institute, 2000 as it is not clear whether this was the most recent data available at the start of validation in November 2011.

This is an error in the spreadsheet. The PDD was corrected (in the Annex of referenced literature the year is correct). The data is from the same report as for SFC taxis i.e. 4/2009. No later report was available. The methodology states: "National or international data from studies not elder than 3 years" years. The project was entered for validation 11/2011 and therefore a report 04/2009 is less than 3 years and in line with the methodology.

c) occupancy Rate of the passenger cars, sourced from Korea Transport Institute, 2010 as it appears that two other similar projects validated by the same DOE have used the same reference but different values of 1.21 and 1.31 accordingly. Please refer to VVM version 1.2 paragraph 91..

Occupation rates are different for each city. National values should not be used.

The report of the Korea Transport Institute has data for various cities in the same table. The following cities are included:

Seoul
Busan
Daegu
Incheon
Gwangju
Daejeon
Ulan
Gyeonggi
Gangwon
Chungbok
Chungnam
Jeonbok
Jeonnam
Gyeongbok
Gyeongnam
Jeju

The data per city by logic is not the same, however the reference source or document is the same. See below the original table from the original document SQS ref. [11] (see Annex 8: "File 5 occupation rate cars"):

Classification	OC
Seoul	1.2
Busan	1.3
Daegu	1.21
Incheon	1.25
Gwangju	1.2
Daejeon	1.27
Ulan	1.34
Gyeonggi	1.27
Gangwon	1.38
Chungbok	1.31

Chungnam	1.33
Jeonbok	1.26
Jeonnam	1.32
Gyeongbok	1.3
Gyeongnam	1.31
Jeju	1.43
Average	1.26

The Validation Report has been amended to reflect the issues raised. The document is re-submitted in both clean and tracked-changes versions as part of the RfR process. If further information is required, Hanspeter Graf will be the contact person for the review process. He is available to address any questions the Executive Board may wish to clarify during its considerations.

Thank you.

Yours sincerely,

Silvio Leonardi	Hanspeter Graf	Oliver Stankiewitz
Member of the Executive Board	Lead Auditor	Reviewer

Supporting documents:

Annex 1: File 55 sheet 7.1
Annex 2: Journal of Public Transportation, Vol. 8, No. 5, 2005
Annex 3: File 47 finance version 1.1 DMRC
Annex 4: File 2 Passengers and OP cost DMRC
Annex 5: File Incheon Line 2 Operational Cost Evaluation (08 Nov 12)_1
Annex 6: Population information all cities
Annex 7: File 1 taxi data
Annex 8: File 5 occupation rate cars (KOTI.Brief 2010)