CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 03 - in effect as of: 28 July 2006

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SECTION A. General description of project activity

A.1 Title of the project activity:

>> Abu Dhabi solar thermal power project
Version 01
09/04/2008

A.2. Description of the project activity:

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The purpose of proposed CDM project activity is to install solar thermal power plant of 100 MWe capacity. In the project activity 624 solar collector assemblies (SCA) will be installed. The efficient parabolic trough collectors will be used for collection of solar energy. In the project activity 120 MVA capacity steam turbine will be installed for the power generation from the solar heat collected from the solar collectors. The solar power plant will be grid connected and natural gas will be used for auxiliary firing. The project activity is first of its kind in the region and will use the latest state of the art, environmental friendly technology for power generation. The installation of project activity will reduce the emissions from the electricity generation which would have been occurred in the gas based power plants connected to grid.

Contribution to sustainable development:

Project proponent has selected eco-friendly technology to establish new paradigms from an environmental perspective while also being committed towards development of the community. Thus the project's contribution towards sustainable development has been addressed based on the following pillars of sustainable development:

Social:

The project activity is generating employment opportunities for professional, skilled and unskilled labour for development, engineering, procurement, construction, operation and maintenance of the project activity. The development of project specific infrastructure will also result in employment and income generation sources for local personnel. In addition various kinds of maintenance work would generate employment opportunities for local contractor on regular and permanent basis.

The project activity results in involvement of international engineering company to study and engineer the project and as such contributed towards capacity building in terms of technical knowledge and managerial skills. The project activity would promote the application of solar energy based power generation.

Economic well being

The deployment of the project activity will contribute towards employment generation at various stages of the development of project activity including construction, operation and maintenance and others.
The development of project infrastructure which includes procurement of equipment, setting up of the project activity will result in temporary employment of local personals. The project proponent will carry out recruitment of personals for operation and maintenance of the project activity. The setting up solar power generation system will result in business opportunities for engineering contractor and will leave provision for future business during the life of the project activity.

Environmental well being
The project activity through adaptation of solar energy based power generation facility would be reducing considerable amount of GHG emission which would have taken place in the pre project scenario of Natural gas/fuel oil based power generation (The power plants connected to grid are using Natural gas and fuel oil for power generation). The project activity apart from reducing greenhouse gas emissions will be contributing towards better quality environment for the employees and the nearby communities mainly due to lowering of harmful pollutants and suspended airborne particulate matter.

Technological well being
Solar energy based power generation system will be a robust and clean technology involving the latest state of art renewable energy options to be used for the purpose of electricity generation. More over the project activity will also act as a clean technology demonstration project to encourage and promote the deployment of efficient renewable energy based power generation plants in other places.

A.3. Project participants:

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Name of Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
United Arab Emirates (host)	• Abu Dhabi Future Energy Company (MASDAR) (PJSC)	No

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

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A.4.1.1. Host Party(ies):

>> United Arab Emirates

A.4.1.2. Region/State/Province etc.:

>> The Emirate of Abu Dhabi

A.4.1.3. City/Town/Community etc:

>> Madinat Zayed

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

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The site at Madinat Zayed is located in the inland of the Emirate of Abu Dhabi at the northern latitude of 23°34' and the eastern longitude of 53°44'. It is 116 km southwest of Abu Dhabi and 6 km from the town of Madinat Zayed on the road from Tarif to the Liwa Oasis.

A.4.2. Category(ies) of project activity:

>> The project activity belongs to Sectoral Scope Number 1: Energy industries (renewable - / non-renewable sources) as per the sectoral scope of the project activities.

A.4.3. Technology to be employed by the project activity:

>> The project activity is 'Parabolic Trough Rankine Cycle Power Plants'. In the project activity parabolic trough solar field will be used for collection of the solar heat and this will supply steam to power plant (Rankine) systems, essentially fulfilling the role of a solar boiler in contrast to fossil-fuel-

fired boilers. A heat transfer fluid, typically oil at temperatures up to 400°C, is circulated through the pipes and then pumped to a central power block area, where it passes through a heat exchanger. The oil's heat is then passed to a working fluid, such as water or steam, which is used in turn to drive a conventional turbine generator. The schematic diagram of the technology used is shown below:

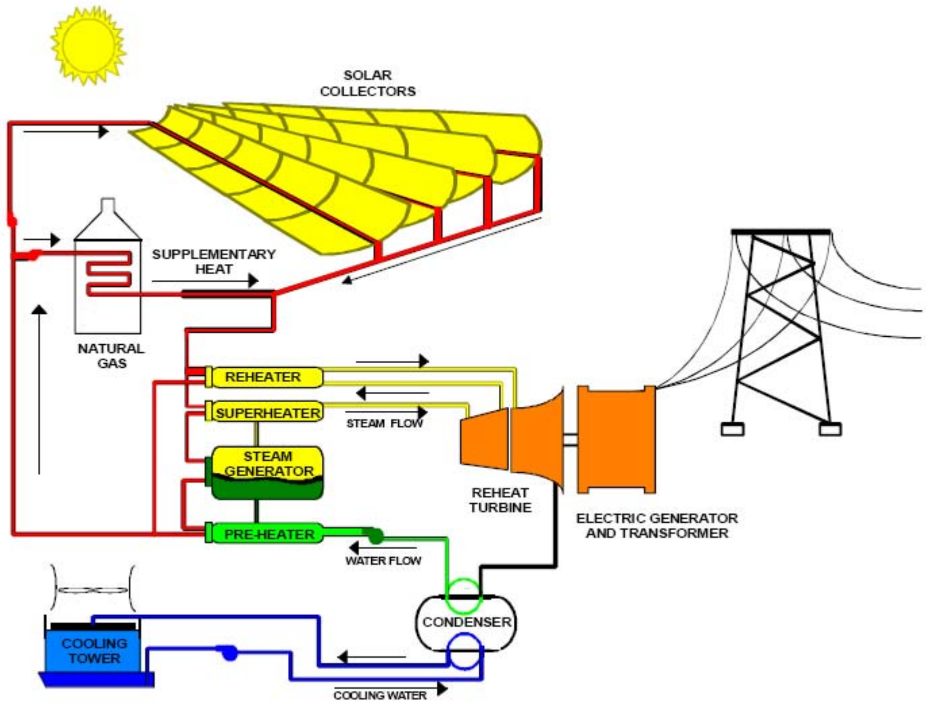

Figure 1-5: Schematic of a SEGS Power Plant

The main components of the solar power generation system are explained below:
1. Solar field: The project activity shall comprise the parabolic trough solar field, the Heat Transfer Fluid (HTF) system and the solar meteo station. In the middle of the solar field are located plant control rooms, Power Block and steam water cycle, Balance of Plant (BoP), auxiliary system and repair shop and spare parts storage.

The basic element of the solar field is the parabolic trough collector. Parabolic trough shaped mirrors are used to focus sunlight on thermal efficient receiver tubes, called heat collecting elements (HCE), that contain HTF. The operation temperatures of parabolic trough HCEs will be in the range from 293 to 393°C for the cold leg and hot leg respectively. The solar field will be composed from 624 Solar Collector Assemblies (SCA). The axes of the SCAs will be horizontal and oriented from North to South. Each

collector in an SCA will be equipped with a hydraulic drive and an individual control unit for tracking. As tracking is done by rotation of the trough around its gravitational axis, the tracking is denominated as "one-axis tracking". One SCA is a line of four parabolic trough collectors, which are arranged in a loop with U-turn. The solar field is divided into 6 sub-fields with a total number of 156 loops. The solar field with control rooms, Power Block and steam/water cycle, Balance of Plant (BoP), auxiliary system and repair shop and spare parts storage covers a total land area of approx. 2 km^2 including space for collectors and access roads.
For the plant control rooms, Power Block and steam /water cycle, Balance of Plant (BoP), auxiliary system and repair shop and spare parts storage, an area requirement of approx. 54,000 m^2 is assumed.

2. Heat Transport System: In the direct operation mode, the heat transfer fluid (HTF) is circulated through the solar field to the steam generation system, where the heat exchanger is in the middle of the solar field.
The cooled down HTF fluid from the heat exchanger is sent to the solar field to be reheated. In this way, the HTF fluid acts as the heat transfer medium between the solar field and steam cycle of the power block, heating up in the solar collectors and cooling down while producing steam for the steam generator. According to the balances, under design conditions, with a solar field supply to the power plant of approximately 286 MW_{th}, gross power generation of 100 MWe is expected.
The distance between the HTF pumps and the endmost loop is approx. 1,390 m, which requires that the operation pressure shall be approx. 22 bar at the max. solar power heat, which is designed of 286 MW_{th} and corresponds with a flow rate of 1.4 m^3/s and a temperature difference of 100 K. The operation pressure of approx. 22 bar requires approx. 2.9 MWe pumping consumption.

3. Mechanical equipment & Integration:

a. Fuel Supply: The required natural gas supply is maximum 10,500 Nm^3/h, which can be covered by the existing supply system with a total capacity of approx. 70,000 Nm^3/h. The existing back up fuel storage might be sufficient for the Solar power plant for its 7 days operation.

b. Cooling water: Cooling water is not available. Dry cooling has been considered. The required area therefore is approx. 2,000 m^2.

c. Potable Water/Waste Water
New water treatment plant and demineralization plant will be installed in the premises.

4. Electrical equipments & Integration: The new steam turbine generator with a capacity of approx. 120 MVA will be connected to the existing GIS substation Madinat Zayet at the 220 kV level. 220 kV will be an adequate voltage level in consideration of a power export of 120 MVA. The substation is located close to the solar plant site and the power connection will be made by single core XLPE cables.

The proposed technology for the project activity is state of the art eco friendly technology.

A.4.4 Estimated amount of emission reductions over the chosen crediting period:

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Years	**Annual estimation of emission reductions in tonnes of CO_{2e}**
2011 (1st January to 31st December)	167971
2012 (1st January to 31st December)	167971
2013 (1st January to 31st December)	167971
2014 (1st January to 31st December)	167971
2015 (1st January to 31st December)	167971
2016 (1st January to 31st December)	167971
2017 (1st January to 31st December)	167971
Total estimated reductions (tonnes of CO_{2e})	**1175797**
Total number of crediting years	7
Annual average over the crediting period of estimated reductions (tonnes of CO_{2e})	**167971**

A.4.5. Public funding of the project activity:

>> No public funding is involved in the project activity

SECTION B. Application of a baseline and monitoring methodology

B.1. Title and reference of the approved baseline and monitoring methodology applied to the project activity:

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Title: "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" ACM0002 ver07

Reference:
http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_323M30IDF1IH6AG3GRCJ4PKR9CKM7P

Other the methodology the following tools will be used for the project activity:-

1. Tool for the demonstration and assessment of additionality (ver 04)
2. Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion (version 01) (EB 32, annex 09)
3. Tool to calculate the emission factor for an electricity system (ver01)

B.2 Justification of the choice of the methodology and why it is applicable to the project activity:

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The project activity is meeting the applicability criteria of approved methodology in following manner:

Applicability Criteria	Justification with respect to project activity
The project activity is the installation or modification /retrofit of a power plant/unit of one of the following types: hydro power plant/unit (either with a run-of-river reservoir or an accumulation reservoir), wind power plant/unit, geothermal power plant/unit, solar power plant/unit, wave power plant/unit or tidal power plant/unit.	The project activity is installation of solar power plant and it fulfils this applicability condition.
In case of hydro power plants: - The project activity is implemented in an existing reservoir, with no change in the volume of reservoir. - The project activity is implemented in an existing reservoir, where the volume of reservoir is increased and the power density of the project activity, as per definitions given in the Project Emissions section, is greater than 4 W/m^2. - The project activity results in new reservoirs and the power	The project activity is solar based power plant and therefore this condition is not applicable for the project activity.

density of the power plant, as per definitions given in the Project Emissions section, is greater than 4 W/m^2.	
The geographic and system boundaries for the relevant electricity grid can be clearly identified and information on the characteristics of the grid is available;	The electricity grid is Abu Dhabi electricity grid and the information on the grid and power plants is publically available.
Applies to grid connected electricity generation from landfill gas to the extent that it is combined with the approved "Consolidated baseline methodology for landfill gas project activities" (ACM0001); and	The project activity is solar based power plant and therefore this condition is not applicable for the project activity.
5 years of historical data (or 3 years in the case of non hydro project activities) have to be available for those project activities where modification /retrofit measures are implemented in an existing power plant.	The proposed activity is new installation not a retrofit or modification; therefore this condition is not applicable for the project activity.

It is clear from the above table that the project activity is meeting all the applicability criteria of the methodology applied and therefore the methodology is applicable for the project activity.

B.3. Description of the sources and gases included in the project boundary

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The spatial extent of the project boundary includes the project power plant and all power plants connected physically to the electricity system that the CDM project power plant is connected to. The greenhouse gases and emission sources included in or excluded from the project boundary are shown in Table below.

	Source	Gas	Included?	Justification/Explanation
Baseline	CO2 emissions from electricity generation in fossil fuel fired power plants that are displaced due to the project activity.	CO_2	Yes	Main emission source.
		CH_4	No	Minor emission source.
		N_2O	No	Minor emission source.
Project Activity	CO2 emissions from combustion of fossil fuels used in the auxiliary firing	CO_2	No	Main emission source.
		CH_4	No	Minor emission source.
		N_2O	No	Minor emission source.

B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:

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According to the description in the approved baseline methodology ACM0002, for the project activities that do not modify or retrofit an existing electricity generation facility, the baseline scenario is the following:
Electricity delivered to the grid by the project activity would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources, as reflected in the combined margin (CM) calculations described in the "Tool to calculate the emission factor for an electricity system".

The proposed project is connected to the Abu Dhabi Grid, therefore Abu Dhabi Grid is considered as the "connected electricity system", which is defined as the "project boundary" of the proposed project. Therefore, being a project with the boundary of Abu Dhabi Grid that does not modify or retrofit an existing electricity generation facility, the baseline scenario of the proposed project can be identified as the following:
Electricity delivered to the grid by the proposed project would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources within the Abu Dhabi Grid, as reflected in the combined margin (CM) calculated described latter.

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality): >>

The project uses the *Tool for the Demonstration and Assessment of Additionality* (version 4) to demonstrate its additionality. The tool includes the following steps:

Step 1: Identification of alternatives to the project activity consistent with current laws and regulations
The objective of the Step 1 is to define realistic and credible alternatives to the project activity(s) that can be (part of) the baseline scenario through the following sub-steps:

Sub-step 1a. Define alternatives to the project activity:
Realistic and credible alternative(s) available to the project participants or similar project developers that provide outputs or services comparable with the proposed CDM project activity are defined below:

1. The proposed project activity undertaken without being registered as a CDM project activity;
2. Construction of an oil/gas fired power plant with equivalent installed capacity
3. Construction of a power plant using other renewable energy with equivalent installed capacity
4. Equivalent electricity service provided by the Abu Dhabi Grid.

The alternative 3 defined above may not be a realistic alternative scenario. In the region there is no other alternative renewable energy source is available. The wind velocity (4 m/s) is less than the threshold limit (5 m/s) at 10 m height. The biomass is not available in the region. Therefore this alternative is not a credible and reliable alternative.

Outcome of Step 1a: Identified realistic and credible alternative scenario(s) to the project activity.

Sub-step 1b. Consistency with mandatory laws and regulations:
All the alternatives defined above are in compliance with the mandatory legislation and regulation of the country.

Outcome of Step 1b: Identified realistic and credible alternative scenario(s) to the project activity that are in compliance with mandatory legislation and regulations taking into account the enforcement in the region or country and EB decisions on national and/or sectoral policies and regulations.

Step 2. Investment analysis
Determine whether the proposed project activity is economically or financially less attractive than at least one other alternative, identified in step 1, without the revenue from the sale of certified emission reductions (CERs). To conduct the investment analysis, use the following sub-steps:

Sub-step 2a. Determine appropriate analysis method
The *Tools for the Demonstration and Assessment of Additionality* recommends three analysis methods, including simple cost analysis (Option I), investment comparison analysis (Option II) and benchmark analysis (Option III).
The proposed Solar Power Project generates financial and economic benefits through the sales of electricity other than CDM related income therefore the simple cost analysis (Option I) cannot be taken. Out of remaining two options investment comparison analysis (option II) is considered for investment analysis.

Sub-step 2b. Option II. Apply Investment Comparison Analysis

The project activity is generation of electricity from solar based power plant therefore the unit cost of electricity ($/kWh) is considered as the financial indicator for the comparison.

Sub-step 2c. Calculation and comparison of financial indicators
The financial indicator is compared for the oil/gas based power plant with the project activity. It is clear that the alternative 4 is not having any investment therefore the comparison for that is only possible from

the electricity price to the consumer. In the host country electricity is subsidised and therefore the cost is not considered for comparison.

Following general parameter have been used for the economic analysis:

Discount rate (real, on top of inflation) : 8%
Exchange rate : 1 AED = 0.2723 US$
Operating time : 25 years
Construction period : 3 years
Fuel price natural gas : 6.63 AED/MBTU based on 2007
Fuel price LFO : 14.7 US$/GJ
Escalation fuel price : 1.34%/year
Escalation OPEX : 3%/year

Use of LFO instead of natural gas could be required, due to shortage of gas supply in future. All costs are referred to first year of operation (2010), based on given escalation rate. The corresponding cost estimates of CAPEX are shown in following tables.

Cost Estimate CAPEX (EPC Contract)		**Combined cycle gas based power plant**	**Solar Rankine Cycle**
Civil and Structural	**mln $**	**13**	**13**
Solar field preparation and other solar field civil work			3
Solar collector pylon foundations			5
General civil and infrastructure and Power Block and BOP structures		13	6
Solar Field	**mln $**		**171**
Heat collection elements (HCE)			27
Reflectors			38
Metal support structures			53
Drives, electronic and controls			6
HTF interconnecting piping (between collectors)			4
HTF header piping			6
HTF fluid (initial filling)			7
Transport, erection and commissioning			30
Thermal Storage System	**mln $**		

Storage Device incl pumping, transport and commissioning				
HTF System incl. Solar Heat Exchangers	**mln $**			**24**
HTF heat exchangers and tanks				13
HTF pumps				7
Transport, erection and commissioning				4
Power Block	**mln $**		**200**	**61**
Gas turbine generators			85	
Steam turbine generators			15	19
Cooling System incl. Condenser			9	19
HRSG incl. burners			32	
Fuel gas system inkl. back up			8	2
BOP			12	4
Waste water treatment			0	0
Fire protection			2	2
Electrical + I&C			24	10
Transport, Erection & commissioning			14	5
Total Equipment Cost	**mln $**		**213**	**270**
Contractor's (Interface) Engineering	5%		11	13
Contingencies (incl. physical and price)	5%		11	14
Other additions to Cost estimate	0%		0	0
EPC-contract	mln $		**235**	**297**
Owners Cost (Incl. Site Preparation, Consulting				
Service during Implementation)	5%	mln $	12	15
Investment (Total Installed Cost)	**mln $**		**246**	**312**

The OPEX estimation has been based on actual values for solar field cost for O&M as well as typical values for the fossil part of the power plant.

Cost Estimate OPEX			Combined cycle gas based power plant	Solar Rankine Cycle
Fixed O&M Cost (incl. Insurance)		mln$/a	4.3	4.4
Fixed Cost Power Plant	2.0%	mln$/a	4.3	1.3
Fixed Cost Solar Field	1.8%	mln$/a		3.1
Variable Cost	2.5	$/MWh	2.5	0.5
Net Electricity Output		GWh/a	3093	231
O&M Cost (excl. fuel)	**m$/a**		**12.0**	**4.5**
Total O&M Cost in % of EPC Contract	%		5.1%	1.5%
Variable and fixed cost expressed per MWh Cost	$/MWh		3.88	19.58

Unit Cost analysis

Generation Cost		Combined cycle gas based power plant	Solar Rankine Cycle
Investment Cost	mln $	**246**	**312**
Electricity to the grid	GWh/a	**3093**	**231**
Solar generation	GWh/a	0	158
Fossil generation	GWh/a	3093	73
Fuel consumption (in LCV)	GWh/a	5925	140
Fuel Cost per unit LCV	AED/MBTU	6.9	6.9
Exchange rate	AED/$	0.27	0.27
Discount rate (real, on top of inflation)	%/year	8	8
Escalation for fuel (on top of inflation)	%/year	1.3	1.3
Escalation for O&M (on top of inflation)	%/year	3	3
Escalation for consumables (on top of inflation)	%/year	1	1
Project Life Time (after start of operation)	year	25	25
Levelized Electricity Generation Cost (LEC)			
Capital cost	$ / MWh		

Fuel cost	$ / MWh	7 14	126 4
O&M cost	$ / MWh	5	26
Cost of Consumables	$ / MWh	0.1	0.1
Levelized Generation Cost (LEC)	$ / MWh	**27**	**157**

It is clear from the table above that the power generation from gas based power plant is much cheaper (98% of power plants in the grid are gas based) with respect to the solar energy based power generation. The cost per kWh generation in solar plant is five times then the cost of gas based power generation. Therefore it is clear that the solar power generation is not the cheapest option available. Therefore solar based power generation is additional.

Sub-step 2d. Sensitivity analysis

For strengthen the investment analysis sensitivity analysis is also carried out with the possible variation. It is clear from the table below that the solar based electricity generation is not at all lucrative option with respect to gas based power plant and grid. The sensitivity analysis is presented in the table below:

Sensitivity analysis for generation cost			**Combined cycle gas based power plant**	**Solar Rankine Cycle**
Sensitivity of LEC ($/MWh)			$ / MWh	$ / MWh
Price of Fuel year 2010 (AED/MBTU)	**6.9**	**Base gas**	**27**	**157**
	6.9	**Base gas**	**27**	**157**
	20		53	165
	40		94	178
LFO = 14.7 $/GJ = 51,2 AED/MBTU (2007)=53.29 (2010)	53	Base LFO	121	187
	85	High LFO	184	207
Deviation in cost estimate	**0%**		**27**	**157**
	0%	Base	27	157
	15%		28	176
	-15%		26	138
Discount Rate (real, on top of inflation)	**8%**		**27**	**157**
	8%	Base	**27**	**157**

	5%		25	128
	10%		28	179
Deviation in Solar Generation			**27**	**157**
	0%	Base	27	157
	10%		27	147
	-10%		27	169

The sensitivity analysis above shows that the conclusion regarding the financial attractiveness is robust to reasonable variations in critical assumptions.

Outcome of step 2:

Based on the investment comparison analysis and the sensitivity analysis it is concluded that the CDM project activity (alternative ii) is unlikely to be the most financially attractive.

Step 3: Barrier analysis

The additionality of the proposed project activity is supported by the investment analysis presented above. As there are barriers that have implications on the risk assessment of the project, and thus the overall attractiveness of the project, it has been decided to carry out a barrier analysis as well.

Sub-step 3a. Identify barriers that would prevent the implementation of the proposed CDM project activity.

The project activity is first in the UAE and probably in the word as well with such a huge capacity of power generation with solar technology. Although solar is well proven technology but there is not much commercial establishment because of:

1. High initial capital cost
2. Intermittent energy generation
3. Seasonal energy generation

Sub-step 3b. Show that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed project activity).

The other alternatives are well established and not faced any of the barriers above and therefore can be implemented without these barriers. Only CDM project activity faces the barriers mentioned above.

Step 4: Common practice analysis

Sub-step 4a. Analyze other activities similar to the proposed project activity.

Based on the analysis of similar project activities that rely on similar technologies undertaken in a comparable environment, it can be concluded that similar activities have not been carried out in the relevant region.

Sub-step 4b. Discuss any similar options that are occurring.

No options occurring in the region.

Outcome of Step 4:

The project activity is first of its kind and no common practice is available in the region.

To summarize, it can be proved that the proposed project activity is additional and not (part of) baseline scenario. Without the CDM revenues, the project activity would not be implemented smoothly. Instead, the equivalent electricity service will be provided by the Grid. As a result, the reduction of GHG emissions would not be realized. The above additionality analysis provides sufficient evidence that the registration of the CDM revenues can enable the project to overcome the barriers it faces.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

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Baseline emissions:

The baseline emissions for the project activity will be multiplication of the net electricity exported to grid and the combined margin grid emission factor.

According to ACM0002 Baseline emissions include only CO_2 emissions from electricity generation in fossil fuel fired power plants that are displaced due to the project activity, calculated as follows:

$$BE_y = (EG_y - EG_{baseline}) \times EF_{Grid,CM,y} \qquad (1)$$

Where:

BEy = Baseline emissions in year *y* (tCO_2/yr).

EGy = Electricity supplied by the project activity to the grid (MWh).

$EG_{baseline}$ = Baseline electricity supplied to the grid in the case of modified or retrofit facilities (MWh). For new power plants this value is taken as zero.

$EF_{grid,CM,y}$ = Combined margin CO_2 emission factor for grid connected power generation in year *y* calculated using the version 01 of the “Tool to calculate the emission factor for an electricity system”.

Calculation of $EG_{baseline}$

If the project activity is the installation of a new grid-connected renewable power plant/unit:

$EG_{baseline} = 0$ (2)

Calculation of $EF_{grid,CM,y}$

The grid emission factor calculation will be based on the ‘Tool to calculate the emission factor for an electricity system (ver01)’.

According to the tool the grid emission factor is calculated as per the following six steps:

STEP 1: Identify the relevant electric power system.
STEP 2: Select an operating margin (OM) method.
STEP 3: Calculate the operating margin emission factor according to the selected method.
STEP 4: Identify the cohort of power units to be included in the build margin (BM).
STEP 5: Calculate the build margin emission factor.
STEP 6: Calculate the combined margin (CM) emissions factor.

Step 1: Identify the relevant electric power system: The proposed Project will be connected to the Abu Dhabi Grid. This grid is the electric power system for the project activity. Thus the data of electricity generation, installed capacity and fuel consumption of the power plants is considered for the grid emission factor calculation.

Step 2: Select an operating margin (OM) method:
The calculation of the operating margin emission factor ($EF_{grid,OM,y}$) is based on one of the following methods:
(a) Simple OM, or
(b) Simple adjusted OM, or
(c) Dispatch data analysis OM, or
(d) Average OM.

Any of the four methods can be used, however, the simple OM method (option a) can only be used if low-cost/must-run resources constitute less than 50% of total grid generation in: 1) average of the five most recent years, or 2) based on long-term averages for hydroelectricity production.

In the electricity grid the power plants are mostly oil and gas based. The low cost/must run power plants are very less[1]. Therefore simple OM is used in this case.

For the simple OM, the simple adjusted OM and the average OM, the emissions factor can be calculated using either of the two following data vintages:
• **Ex ante option:** A 3-year generation-weighted average, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation, without requirement to monitor and recalculate the emissions factor during the crediting period, or
• Ex post option: The year in which the project activity displaces grid electricity, requiring the emissions factor to be updated annually during monitoring. If the data required to calculate the emission factor for year *y* is usually only available later than six months after the end of year *y* alternatively the emission factor of the previous year (y-1) may be used. If the data is usually only available 18 months after the end of year *y*, the emission factor of the year proceeding the previous year (y-2) may be used. The same data vintage (y, y-1 or y-2) should be used throughout all crediting periods.

The project proponent is using the renewable crediting period. For the first crediting period ex ante emission factor of the electricity will be used. The project proponent has calculated the emission factor based on the most recent three years data of the power plants.

[1] The excel sheet for the grid data is submitted with the calculation.

Step 3: Calculate the operating margin emission factor according to the selected method

(a) Simple OM

The simple OM emission factor is calculated as the generation-weighted average CO_2 emissions per unit net electricity generation (tCO_2/MWh) of all generating power plants serving the system, not including low-cost / must-run power plants / units. It may be calculated:

- **Based on data on fuel consumption and net electricity generation of each power plant / unit (Option A)**, or
- Based on data on net electricity generation, the average efficiency of each power unit and the fuel type(s) used in each power unit (Option B), or
- Based on data on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system (option C)

Option A should be preferred and must be used if fuel consumption data is available for each power plant / unit. The project proponent is using option A for the simple OM calculation.

Where Option A is used, the simple OM emission factor is calculated as follows:

$$EF_{grid,OMsimple,y} = \frac{\sum_{i,m} FC_{i,m,y} \bullet NCV_{i,y} \bullet EF_{CO2,i,y}}{\sum_{m} EG_{m,y}}$$

Where:

$EF_{grid,OMsimple,y}$ = Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)

$FC_{i,m,y}$ = Amount of fossil fuel type *i* consumed by power plant / unit *m* in year *y* (mass or volume unit)

$NCV_{i,y}$ = Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ / mass or volume unit)

$EF_{CO2,i,y}$ = CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)

$EG_{m,y}$ = Net electricity generated and delivered to the grid by power plant / unit *m* in year *y* (MWh)

m = All power plants / units serving the grid in year *y* except low-cost / must-run power plants / units

i = All fossil fuel types combusted in power plant / unit *m* in year *y*

y = Three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex ante option).

Step 4: Identify the cohort of power units to be included in the build margin

The sample group of power units *m* used to calculate the build margin consists of either:

(a) The set of five power units that have been built most recently, or

(b) The set of power capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

Project participants should use the set of power units that comprises the larger annual generation.

As a general guidance, a power unit is considered to have been built at the date when it started to supply electricity to the grid.

Power plant registered as CDM project activities should be **e**xcluded from the sample group *m*. However, If group of power units, not registered as CDM project activity, identified for estimating the build margin emission factor includes power unit(s) that is(are) built more than 10 years ago then:

(i) exclude power unit(s) that is (are) built more than 10 years ago from the group; and

(ii) include grid connected power projects registered as CDM project activities, which are dispatched by dispatching authority to the electricity system.

Capacity additions from retrofits of power plants should not be included in the calculation of the build margin emission factor.

In terms of vintage of data, project participants can choose between one of the following two options:

Option 1: For the first crediting period, calculate the build margin emission factor *ex-ante* based on the most recent information available on units already built for sample group *m* at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period.

Option 2. For the first crediting period, the build margin emission factor shall be updated annually, *ex-post*, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available. For the second crediting period, the build margin emissions factor shall be calculated *ex-ante*, as described in option 1 above. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.

The project proponent is calculating the grid emission factor ex ante; therefore the first option is used for the Build Margin Calculation.

Step 5. Calculate the build margin emission factor

The build margin emissions factor is the generation-weighted average emission factor (tCO_2/MWh) of all power units *m* during the most recent year *y* for which power generation data is available, calculated as follows:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Where:

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
$EF_{EL,m,y}$ = CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
m = Power units included in the build margin
y = Most recent historical year for which power generation data is available

Step 6. Calculate the combined margin emissions factor

The combined margin emissions factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times W_{OM} + EF_{grid,BM,y} \times W_{BM}$$

Where:

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year *y* (tCO_2 /MWh)
$EF_{grid,OM,y}$ = Operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
w_{OM} = Weighting of operating margin emissions factor (%)
w_{BM} = Weighting of build margin emissions factor (%)
The following default values should be used for w_{OM} and w_{BM}:

Wind and solar power generation project activities: w_{OM} = 0.75 and w_{BM} = 0.25 (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods.
The project activity is solar based power generation and will use the OM:BM in ration of 0.75:0.25.

Project emission

The project activity will use the natural gas for auxiliary firing in the power plant. The project emissions from the fossil fuel used is calculated as per the 'Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion'.
Project emissions from combustion of fossil fuels related to the operation of the solar power plant is calculated as:

$$PE_y = PE_{FC,j,y}$$

CO_2 emissions from fossil fuel combustion in process *j* are calculated based on the quantity of fuels combusted and the CO_2 emission coefficient of those fuels, as follows:

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y}$$

Where:
$PE_{FC,j,y}$ = the CO_2 emissions from fossil fuel combustion in process *j* during the year *y* (tCO_2 / yr);
$FC_{i,j,y}$ = the quantity of fuel type *i* combusted in process *j* during the year *y* (mass or volume unit / yr);
$COEF_{i,y}$ = the CO_2 emission coefficient of fuel type *i* in year *y* (tCO_2 / mass or volume unit);
i = are the fuel types combusted in process *j* during the year *y*.

The CO_2 emission coefficient $COEF_{i,y}$ can be calculated following two procedures, depending on the available data on the fossil fuel type *i*, as follows:

Option A: The CO_2 emission coefficient *COEFi,y* is calculated based on the chemical composition of the fossil fuel type *i*, using the following approach:

If *FCi,j,y* is measured in a mass unit:
$$COEF_{i,y} = w_{C,i,y} \times 44/12$$

If *FCi,j,y* is measured in a volume unit:
$$COEF_{i,y} = w_{C,i,y} \times \rho_{i,y} \times 44/12$$

Where:
$COEF_{i,y}$ is the CO_2 emission coefficient of fuel type *i* (tCO_2 / mass or volume unit);
$w_{C,i,y}$ is the weighted average mass fraction of carbon in fuel type *i* in year *y* (tC / mass unit of the fuel);
$\rho_{i,y}$ is the weighted average density of fuel type *i* in year *y* (mass unit / volume unit of the fuel);
i are the fuel types combusted in process *j* during the year *y*

Option B: The CO_2 emission coefficient $COEF_{i,y}$ is calculated based on net calorific value and CO_2 emission factor of the fuel type *i*

Option A is preferable as per the tool and the same has been used in the calculations.

Leakage emissions:

According to the ACM0002 methodology, the leakage in the construction period of the proposed project is neglected. So the GHG emission within the project boundary is zero, i.e. L_y=0.

Emission reduction:

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y$$

Where:

ER_y = Emission reductions in year *y* (t CO_2e/yr).

BE_y = Baseline emissions in year *y* (t CO_2e/yr).

PE_y = Project emissions in year *y* (t CO_2/yr).

LE_y = Leakage emissions in year *y* (t CO_2/yr).

B.6.2. Data and parameters that are available at validation:

(Copy this table for each data and parameter)

Data / Parameter:	**$EF_{Grid,BM,y}$**
Data unit:	tCO_2/MWh
Description:	Build margin CO_2 emission factor in year *y* (tCO_2/MWh)
Source of data used:	The data used for calculation is from the published government sources
Value applied:	0.708
Justification of the choice of data or description of measurement methods and procedures actually applied :	The data is publically available and is covering all the power plants connected with the grid. The data is authentic and audited.
Any comment:	This value will be used in first crediting period

Data / Parameter:	**$EF_{Grid,OM,y}$**
Data unit:	tCO_2/MWh
Description:	Operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
Source of data used:	The data used for calculation is from the published government sources
Value applied:	0.938
Justification of the choice of data or description of measurement methods and procedures actually applied :	The data is publically available and is covering all the power plants connected with the grid. The data is authentic and audited.
Any comment:	This value will be used in first crediting period

B.6.3 Ex-ante calculation of emission reductions:

>>

Baseline emissions:

$EF_{Grid,CM,y}$ = 0.881 tCO_2/MWh
EGy = 231000 MWh

$$BE_y = (EG_y - EG_{baseline}) \times EF_{Grid,CM,y}$$

= (231000 – 0) x 0.881
= 203511 tCO_2/annum

Project emission

$$COEF_{i,y} = w_{C,i,y} \times \rho_{i,y} \times 44/12$$

$$COEF_{i,y} = 0.000725 \times 44/12$$

$COEF_{i,y}$ = 0.002657

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y}$$

FCi,j,y = 13375370 m^3

$$PE_{FC,j,y} = 13375370 \, x \, 0.002657$$

PE_y = 35540 tCO_2/annum

Emission reductions

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y$$

ERy = 203511 – 35540 – 0
= 167971 tCO2/annum

B.6.4 Summary of the ex-ante estimation of emission reductions:

>>

Year	Estimated Project Activity Emissions (tonnes of CO_2e)	Estimated Baseline Emissions (tonnes of CO_2e)	Estimated leakage(tonnes of CO_2e)	Estimated Emission Reduction (tonnes of CO_2e)
2011 (1st January to	35540	203511	0	167971

31st December)				
2012 (1st January to 31st December)	35540	203511	0	167971
2013 (1st January to 31st December)	35540	203511	0	167971
2014 (1st January to 31st December)	35540	203511	0	167971
2015 (1st January to 31st December)	35540	203511	0	167971
2016 (1st January to 31st December)	35540	203511	0	167971
2017 (1st January to 31st December)	35540	203511	0	167971
Total	**248780**	**1424577**	**0**	**1175797**

B.7 Application of the monitoring methodology and description of the monitoring plan:

B.7.1 Data and parameters monitored:

(Copy this table for each data and parameter)

Data / Parameter:	**EGy**
Data unit:	MWh
Description:	Electricity supplied by the project activity to the grid (MWh)
Source of data to be used:	The data will be monitored from the joint electronic meter installed
Value of data applied for the purpose of calculating expected emission reductions in section B.5	231000
Description of measurement methods and procedures to be applied:	Monitoring: The data will be taken from the installed electronic meter. Data Type: Measured Frequency: Continuous Archiving Policy: Paper & Electronic Responsibility: Manager (power plant). Calibration Frequency: Meter will be calibrated as per the designer specification.
QA/QC procedures to be applied:	Yes, Quality Management System will be used and the same procedures would be available at the project site
Any comment:	Data archived: Crediting period + 2 yrs This data will be crosschecked with the gross generation and auxiliary consumption difference. Lower value of the both will be used in emission

	reduction calculation.

Data / Parameter:	$FC_{i,j,y}$
Data unit:	SCM/yr
Description:	The quantity of fuel type *i* combusted in process *j* during the year *y*
Source of data to be used:	Meter installed in the plant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	13375370
Description of measurement methods and procedures to be applied:	Monitoring: The data will be taken from the installed meter. Data Type: Measured Frequency: Continuous Archiving Policy: Paper & Electronic Responsibility: Manager (power plant). Calibration Frequency: Meter will be calibrated as per the designer specification.
QA/QC procedures to be applied:	Yes, Quality Management System will be used and the same procedures would be available at the project site
Any comment:	Data archived: Crediting period + 2 yrs

Data / Parameter:	$w_{C,i,y}$
Data unit:	(tC / M^3 of gas)
Description:	is the weighted average mass fraction of carbon in fuel type *i* in year *y*
Source of data to be used:	Supplier of fuel to the plant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.000725
Description of measurement methods and procedures to be applied:	Monitoring: The data will be taken from fuel supplier. Data Type: Measured Frequency: once in a month Archiving Policy: Paper & Electronic Responsibility: Manager (power plant). Calibration Frequency: Data is taken from third party.
QA/QC procedures to be applied:	Yes, Quality Management System will be used and the same procedures would be available at the project site
Any comment:	Data archived: Crediting period + 2 yrs

B.7.2 Description of the monitoring plan:

>>

The approved monitoring methodology ACM0002 is used for developing the monitoring plan. Monitoring tasks must be implemented according to the monitoring plan in order to ensure that the real, measurable and long-term greenhouse gas (GHG) emission reduction for the proposed project is monitored and reported.

1. Responsibility

Overall responsibility for daily monitoring and reporting lies with the project owner. A CDM group will be established within the owner company to carry out the monitoring work. Its staffs will be trained by the experts.

2. Installation of meters

The metering equipment will be properly configured and checked annually according to the requirement from regulatory authority. The metering equipment will be checked by the project owner and electricity grid comapny before operation. A pair of meters with an accuracy of 0.5s is installed for the measurement of gross electricity delivered to the grid.

3. Reporting

The specific steps for data collection and reporting are listed below:
Electricity grid company, together with the project owner reads the main meter and records data on the end of the month. Project owner reads the backup meter and records data on the last day of every month. Electricity grid company supplies readings to the project owner and provides invoice.

Project owner records the data of net electricity delivered to the grid. Project owner provides two meters' readings and photocopies of invoices to DOE for verification. Should any previous months reading of the main meter be inaccurate by more than the allowable error, or otherwise functioned improperly, the grid-connected electricity generated by the proposed project shall be determined by:

First, by reading the backup meter, unless a test by either party reveals it is inaccurate;
If the backup system is not with acceptable limits of accuracy or is otherwise performing improperly the proposed project owner and grid company shall jointly prepare an estimate of the correct reading; and
If the proposed project owner and the grid company fail to agree the estimate of the correct reading, then the matter will be referred for arbitration according to agreed procedures.

4. Calibration

The Power Interchange Agreement between the Project Owner and electricity grid company defines the metering arrangements and the required quality control procedures to ensure accuracy. The metering equipment are calibrated and checked annually for accuracy. The metering equipment shall have sufficient accuracy so that any error resulting from such equipment shall not exceed 1% of full-scale rating. Calibration is carried out by the grid company with the records being supplied to the project owner, and these records will be maintained by the project owner and the appointed third party. Both meters shall be jointly inspected and sealed on behalf of the parties concerned and shall not be interfered with by either party except in the presence of the other party or its accredited representatives.

5. Data management system

Physical document such as paper-based maps, diagrams and environmental assessments will be collected in a central place, together with this monitoring plan. In order to facilitate auditors' reference of relevant literature relating to the project, the project material and monitoring results will be indexed. All paper-based information will be stored by the technology department of the project owner and all the material will have a copy for backup. And all data including calibration records is kept until 2 years after the end of the total credit time of the CDM project.

B.8 Date of completion of the application of the baseline study and monitoring methodology and the name of the responsible person(s)/entity(ies)

>>

Abu Dhabi Future Energy Company (MASDAR)
Date of completion of baseline: 20/02/2008
The information of the responsible person is referred in annex 1.

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

>> The project activity is expected to start construction on 1st March 2009.

C.1.2. Expected operational lifetime of the project activity:

>> 25 years

C.2 Choice of the crediting period and related information:

C.2.1. Renewable crediting period

C.2.1.1. Starting date of the first crediting period:

>> 01/01/2011 or the actual starting date of project activity.

C.2.1.2. Length of the first crediting period:

>> 7 years 0 months

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>> Not applicable

C.2.2.2. Length:

>> Not applicable

SECTION D. Environmental impacts

>>

D.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

>>

Power generation from renewable energy source i.e. solar will have a positive effect on the environment. In particular, a positive effect is expected on the living conditions of the employees, animals and birds living the nearby area through reduction of thermal pollution, SO_X, NO_X and particulates. Reduced local air pollution through reduction in natural gas/fuel oil (in near by power plants) is expected to have a positive impact on animal life.

The solar plant design is carried out taking into consideration of latest HSE Practices. The project proponent will submit the Environment Impact Assessment report to environmental agency, Abu Dhabi.

The approval of this PDD by the UAE DNA is considered evidence of its desirable nature and positive contribution toward sustainable development.

D.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

>> The project activity is solar energy based power generation and reducing the natural gas/fuel oil based power generation. No significant environmental impacts are envisaged in the project activity.

SECTION E. Stakeholders' comments

>>

E.1. Brief description how comments by local stakeholders have been invited and compiled:

>>

The project activity will be implemented at Madinat Zayed near the existing natural gas/fuel oil based power plant. The stakeholders identified for the project activity are:

a. Local population
b. Municipality
c. Employees working in the power plant
d. Government/Environmental agency of UAE
e. Equipment supplier
f. Consultants

The project proponent will send letters to the stakeholders mentioning about the project activity and its environmental impacts after the approval from the municipality. In response of the letters comments from the stakeholders will be received and complied in the MASDAR's corporate office.

E.2. Summary of the comments received:

>>

The project activity is new state of the art technological innovation in Abu Dhabi. The project proponent is not expecting any negative comment for the project activity.

E.3. Report on how due account was taken of any comments received:

>>

The project proponent will submit the comment during the validation site visit.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Abu Dhabi Future Energy Company (MASDAR)
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Represented by:	Carbon Management Unit
Title:	Project Manager
Salutation:	Mr.
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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

There is no public funding for the project activity.

Annex 3

BASELINE INFORMATION

DETERMINATION OF THE EMISSION FACTOR OF THE ABU DHABI GRID

The emission factor (EF) of the Abu Dhabi electrical grid is determined in accordance with "Tool to calculate the emission factor for an electricity system (Version 01)", approved by the CDM Executive Board. The Tool describes how to determine the CO_2 emission factor for the displacement of electricity generated by power plants in an electricity system, by calculating the "operating margin" (OM) and "build margin" (BM) as well as the "combined margin" (CM), and consists of the following steps:

STEP 1: Identify the relevant electric power system
STEP 2: Select an operating margin (OM) method
STEP 3: Calculate the operating margin emission factor according to the selected method
STEP 4: Identify the cohort of power units to be included in the build margin (BM)
STEP 5: Calculate the build margin emission factor
STEP 6: Calculate the combined margin (CM) emission factor

The analysis carried out in each of the steps is explained below:

STEP 1: Identify the relevant electric power system

The project activity is located in Madinat Zayed and will provide electricity to the Abu Dhabi regional grid operated by ADWEA. As specified in the Tool, the project electricity system is defined as the spatial content of power plants that are physically connected through transmission and distribution lines to the project activity and that can be dispatched without significant transmission losses. Similarly, connected electricity systems are defined as electricity systems that are connected by transmission lines to the project electricity system. Power plants within each of the connected electricity system can be dispatched without significant transmission constraints but transmission to the project electricity system has significant transmission constraints.

The DNA of the UAE has not published any delineation of relevant project electricity systems and connected electricity systems. In lack of such guidance, the following criteria are suggested to determine the existence of significant transmission constraints:

i. In case of electricity systems with spot markets for electricity: there are differences in electricity prices (without transmission and distribution costs) of more than 5 percent between the systems during 60 percent or more of the hours of the year.

ii. The transmission line is operated at 90 % or more of its rated capacity during 90 % or more of the hours of the year

The first criterion (i) does not result in a clear grid boundary. Four different entities are responsible for different regional grids within the UAE: Abu Dhabi Water and Electricity Authority (ADWEA), Dubai Water and Electricity Authority (DEWA), Sharjah Water and Electricity Authority (SEWA) and the Federal Water and Electricity Authority (FEWA). These regional grids are not operated with spot markets for electricity, and dispatch decisions are being made centrally within each regional grid. The regional grids have recently been connected through high voltage transmission lines, but prices still differ between regions and are affected by political considerations. As end-user prices are kept relatively constant, one can conclude that price differences of more than 5 % exist for more than 60 % of the year. This is however not due to significant transmission constraints, but political considerations.

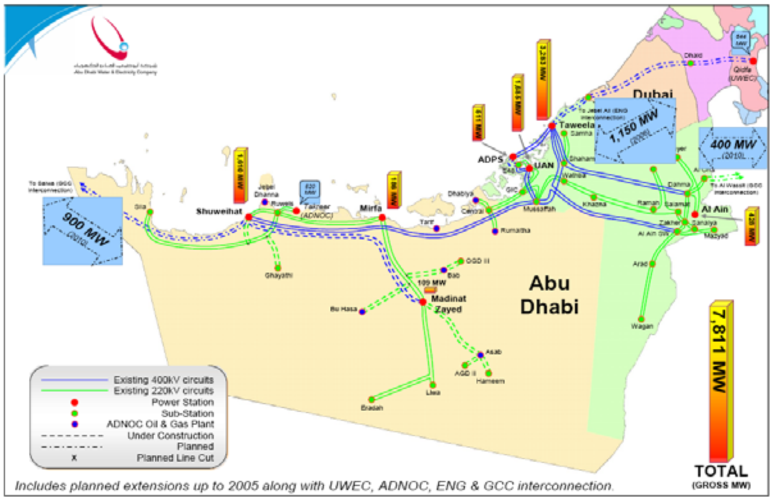
The second criterion (ii) does not provide a clear grid boundary either. Regional transmission lines are available and have spare capacity, but the current utilization level can not be explained by differences in real transmission costs alone. As there is no liberalized market for electricity between the regional grids, utilization of transmission capacity is mainly a result of long term commercial negotiations between the four authorities.

As the two criteria above do not result in a clear identification of a grid boundary, the project electricity system is defined as the Abu Dhabi regional grid controlled by ADWEA. The appropriateness of this choice is supported by the fact that the Abu Dhabi grid is a net exporter of electricity through interconnections to the neighbouring grid systems:

- **Taweelah to Jebel Ali, Dhaid and Qidfa 400 kV (ENG interconnection).** The transmission to Jebel Ali (DEWA) was finalized in 2006 as the first part of a national grid system, and has a total transmission capacity of 1,150 MW. Between May and December 2006, DEWA imported a total of 2.0 GWh from the Abu Dhabi grid[2].
- **Shuweihat to Salva (Qatar) 400 kV (GCC interconnection).** This transmission line is planned for 2010, and is expected to have a total transmission capacity of 900 MW. No historical transfers.
- **Al Ain to Al Wassit (Oman) 400 kV (GCC interconnection).** This transmission line is planned for 2010, and is expected to have a total transmission capacity of 400 MW. No historical transfers.

[2] Source: http://www.adwec.ae/statistics/pdf/98-06/Electricity_Tables_Part3.PDF

The picture below illustrates the Abu Dhabi grid and location of connected power plants[3]:



The project electricity system is defined by the following power plants/units, which are all connected through transmission and distribution lines to the project activity and can be dispatched without significant transmission losses:

Unit (m):	Name of plant/unit:	Company:	Power capacity*:
1	Abu Dhabi Gas Turbines	Bainounah Power Company	239 MW
2	Abu Dhabi Steam Turbines	Bainounah Power Company	120 MW
3	Al Ain	Bainounah Power Company	352 MW
4	Taweelah B	Taweelah Asia Power Company	881 MW
5	Taweelah B2 Extension	Taweelah Asia Power Company	351 MW
6	Al Mirfa	Al Mirfa Power Company	186 MW
7	Madinat Zayed	Al Mirfa Power Company	109 MW
8	Taweelah A2	Emirates CMS Power Company	763 MW
9	Taweelah A1	Gulf Total Tractebel Power Company	1,415 MW
10	Shuweihat S1	Shuweihat CMS International Power Company	1,577 MW
11	Umm Al Nar East A	Arabian Power Company	120 MW
12	Umm Al Nar East B	Arabian Power Company	120 MW
13	Umm Al Nar 1-6	Arabian Power Company	360 MW
14	Umm Al Nar 7-8	Arabian Power Company	360 MW

[3] Source: ADWEA ”Prospects for electricity trade between GCC countries”, http://www.adwec.ae/maps_graphs/files/Prospect_for_Electricity_Trade_between_GCC_Countries_Presentation.pdf

15	Umm Al Nar 9-10	Arabian Power Company	130 MW
16	Sas Al Nakhl	Arabian Power Company	1,710 MW
-	**System Total**	**Under ADWEC dispatch regime**	**7,776 MW**

** Source: http://www.adwec.ae/statistics/pdf/98-06/Capacity_Tables2006.PDF*

Electricity transfers currently only takes place to connected electricity systems, i.e. as electricity export. Electricity exports are not subtracted from electricity generation data used for calculating and monitoring the electricity emission factor.

Although the current grid structure in only utilized to export electricity from the Abu Dhabi grid, future transmission capacity expansions that significantly increase import from (then) connected electricity systems will need to be considered as build margin emission sources in the future.

STEP 2: Select an operating margin (OM) method

Within the project electricity system, all power plants/units are essentially of the same type (primarily natural gas fired cogeneration facilities). All units are dispatched throughout the year[4], and no units are thus considered to be low-cost/must-run resources. As a result, all the four methods mentioned in the Tool can be used to calculate the OM (including the simple OM method).

Given the data availability for power plants/units within the project electricity system, the simple OM method is selected for the proposed project activity. For the simple OM method, Option A is chosen as the most appropriate:

Option A: The simple OM emission factor is calculated *"based on data on fuel consumption and net electricity generation of each power plant/unit"*.

The Tool specifies that the emission factor can be calculated using either an ex-ante or an ex-post option. In this CDM-PDD, the ex-ante option is selected to determine the OM. The vintage chosen for calculation is 2004 to 2006, which are the latest years for which statistical data are available from ADWEC at the time of submission.

STEP 3: Calculate the OM emission factor according to the selected method

Based on the simple OM method Option A, the OM emission factor is calculated as:

[4] See http://www.adwec.ae/statistics/ for monthly variations in generation.

(5-1) $$EF_{grid,OMsimple,y} = \frac{\sum_{i,m} FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{\sum_{m} EG_{m,y}}$$

Where:

$EF_{grid,OMsimple,y}$	Simple operating margin CO_2 emission factor in year y (tCO_2/MWh)
$FC_{i,m,y}$	Amount of fossil fuel type *i* consumed by power plan/unit m in year y (mass or volume unit)
$NCV_{i,y}$	Net Calorific Value (energy content) of fossil fuel type *i* in year y (GJ/mass or volume unit)
$EF_{CO2,i,y}$	CO_2 emission factor of fossil fuel type *i* in year y (tCO_2/GJ)
$EG_{m,y}$	Net electricity generated and delivered to the grid by power plant/unit m in year y (MWh)
m	All power plants/units serving the grid in year y except low-cost/must-run power plants/units
i	All fossil fuel types combusted in power plant/unit m in year y
y	Three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (in this CDM-PDD equivalent to 2004 to 2006)

When calculating the OM emission factor, the following data have been used:

Emission factors:
In the power plants/units connected to the project electricity system, the following fuels are utilized according to ADWEC statistics for the three most recent years:

Fossil fuel type *i*:	$EF_{CO2,i,y}$**:**
Natural gas	0.0543
Gas oil	0.0726
Fuel oil	0.0755
Crude oil	0.0711

The CO_2 emission factor of each fossil fuel type *i* is taken as the IPCC default value at the lower level of the 95 % confidence interval as provided in table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories.

Fuel consumption:

Data on fuel consumption of fossil fuel type *i* is published by ADWEC[5] as MMBTU/yr per plant/unit. The consumption of fuels for the last three years converted to GJ of energy per power plant/unit is:

2004 (GJ):				
m	$FC_{gas,m,2004} \cdot NCV_{gas,2004}$	$FC_{gasoil,m,2004} \cdot NCV_{gasoil,2004}$	$FC_{fueloil,m,2004} \cdot NCV_{fueloil,2004}$	$FC_{crudeoil,m,2004} \cdot NCV_{crudeoil,2004}$
1	3,550,499	1,126	0	0
2	11,944,336	0	0	166,879
3	5,870,941	14,095	0	0
4	48,628,325	8,824	0	342,841
5	17,146,824	3,457	0	0
6	13,732,630	4,670	0	0
7	4,097,932	1,117	0	0
8	48,439,992	103,639	0	0
9	72,194,929	75,111	0	0
10	38,431,459	0	0	0
11	17,917,069	3,151	0	0
12	20,075,284	427	0	0
13	31,894,439	0	0	165,872
14	26,634,449	0	0	0
15	9,034,083	0	0	0
16	0	0	0	0
Tot	**369,283,191**	**215,618**	**0**	**675,591**

2005 (GJ):				
m	$FC_{gas,m,2005} \cdot NCV_{gas,2005}$	$FC_{gasoil,m,2005} \cdot NCV_{gasoil,2005}$	$FC_{fueloil,m,2005} \cdot NCV_{fueloil,2005}$	$FC_{crudeoil,m,2005} \cdot NCV_{crudeoil,2005}$
1	439,475	4,058	0	0
2	9,474,192	0	0	636,706
3	2,105,520	9,067	0	0
4	46,785,879	7,675	0	344,387
5	23,475,691	2,881	0	0
6	9,140,583	3,003	0	0

[5] See http://www.adwec.ae/statistics/

7	1,356,343	358	0	0
8	52,946,789	0	0	0
9	63,371,268	31,806	0	0
10	62,715,121	529,010	0	0
11	13,058,645	170	716	0
12	20,540,199	170	716	0
13	25,145,463	0	0	271,573
14	27,612,559	0	0	0
15	8,872,245	0	0	0
16	468,858	0	0	0
Tot	**367,508,830**	**588,199**	**1,433**	**1,252,666**

2006 (GJ):				
m	$FC_{gas,m,2006} \cdot NCV_{gas,2006}$	$FC_{gasoil,m,2006} \cdot NCV_{gasoil,2006}$	$FC_{fueloil,m,2006} \cdot NCV_{fueloil,2006}$	$FC_{crudeoil,m,2006} \cdot NCV_{crudeoil,2006}$
1	1,146,888	383,806	0	0
2	9,739,832	0	0	924,800
3	272,878	456,088	0	0
4	48,347,915	64,246	0	9,311,755
5	20,121,353	46,816	0	0
6	10,693,898	70,932	0	0
7	1,335,457	655	0	0
8	50,522,328	3,175,529	0	0
9	57,742,615	1,296,062	0	0
10	75,910,327	6,887,358	0	0
11	11,864,083	102,514	0	0
12	21,177,829	8,728	0	0
13	16,578,479	0	0	17,956,635
14	13,893,977	0	4,946,294	0
15	5,076,382	0	1,531,849	0
16	13,854,729	0	0	0
Tot	**358,278,972**	**12,492,735**	**6,478,143**	**28,193,190**

Electricity generation:

The net electricity generated and delivered to the grid by power plant/unit m in year y is defined as the gross kWh generation minus the auxiliary electricity consumption (both types of data are available from ADWEC). Based on ADWEC's statistics, the net electricity generation for each of the last three years are:

m	$EG_{m,2004}$ (MWh):	$EG_{m,2005}$ (MWh):	$EG_{m,2006}$ (MWh):
1	216,401	20,612	87,918
2	453,612	351,584	325,230
3	367,749	141,441	39,719
4	2,157,248	2,191,326	2,773,189
5	1,028,707	1,549,705	1,276,570
6	256,794	304,769	159,178
7	259,997	98,275	94,721
8	3,677,748	4,428,218	4,468,690
9	5,764,179	4,619,059	4,249,835
10	2,794,248	5,179,000	6,899,152
11	688,750	477,692	334,659
12	505,111	531,006	597,715
13	912,663	698,861	1,356,084
14	1,317,533	1,021,008	788,363
15	415,646	342,047	305,177
16	0	36,265	688,331
Tot	**20,816,385**	**21,990,869**	**24,444,529**

Calculation of OM emission factor:

The data above can be utilized to calculate the generation weighted OM emission factor according to Equation 5-1. The results are as following:

OM emission factor:	**Calculated value:**
$EF_{grid,OMsimple,2004}$	0.966
$EF_{grid,OMsimple,2005}$	0.913
$EF_{grid,OMsimple,2006}$	0.935
Generation weighted OM last three years:	**0.938**

STEP 4: Identify the cohort of power units to be included in the build margin (BM)

The sample group of power units *m* used to calculate the build margin consists of either:

a. The set of five power units that have been built most recently, or
b. The set of power capacity additions in the electricity system that comprise 20 % of the system generation (in MWh) and that have been built most recently.

Given the limited number of power plants/units in the project electricity system, option a) is impractical as this would include facilities built several years ago. Applying option b), the power units included in the sample group *m* include:

- Shuweihat S1 (2003)
- Sas Al Nakhl (2006)

These two plants delivered a total of 7,587,483 MWh of electricity to the project electricity system in 2006, comprising 31 % of ADWEC's total supply. The criterion specified in option b) is thus met.

STEP 5: Calculate the build margin emission factor

The build margin is the generation-weighted average emission factor (tCO_2/MWh) of all power units *m* during the most recent year *y* for which power generation data is available, calculated as follows:

(5-2)

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \cdot EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Where:

$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year y (tCO_2/MWh)
$EG_{m,y}$	Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
$EF_{EL,m,y}$	CO_2 emission factor of power unit *m* in year y (tCO_2/MWh)
m	Power units included in the build margin
y	Most recent historical year for which power generation data is available

The CO2 emission factor of each power unit m should be determined analogous to the procedure to determine the simple operating margin, using for y the most recent historical year for which power generation data is available. For year 2006, the emission factor of the two power plants to be included in the build margin is:

m	$EG_{m,2006}$	$EF_{EL,m,2006}$	$EG_{m,2006} \cdot EF_{EL,m,2006}$
10	6,899,152	0.67	4,621,953

16	688,331	1.09	752,312
Tot	**7,587,483**		**5,374,312**

The build margin can thus be calculated as:

(5-3) $$EF_{grid,BM,2006} = \frac{\sum_m EG_{m,2006} \cdot EF_{EL,m,2006}}{\sum_m EG_{m,2006}} = \frac{5{,}374{,}312}{7{,}587{,}483} = 0.708$$

STEP 6: Calculate the combined margin emissions factor

The combined margin emissions factor is calculated as follows:

(5-4) $$EF_{grid,CM,y} = EF_{grid,OM,y} \cdot w_{OM} + EF_{grid,BM,y} \cdot w_{OM}$$

Where:

$EF_{grid,OM,y}$	Operating margin CO_2 emission factor in year y (tCO_2/MWh)
$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year y (tCO_2/MWh)
w_{OM}	Weighting of operational margin emission factor (%)
w_{BM}	Weighting of build margin emission factor (%)

As the proposed project activity is solar power generation, the weights are set to:

$$w_{OM} = 0.75$$
$$w_{BM} = 0.25$$

Applying these weights with the calculated operating- and build margin emission factors, the combined margin emission factor can be calculated as:

(5-5) $$EF_{grid,CM,2006} = 0.938 \cdot 0.75 + 0.708 \cdot 0.25 = 0.881$$

Annex 4

MONITORING INFORMATION

Monitoring will be done as per section B.7.2.

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