



**CLEAN DEVELOPMENT MECHANISM
SIMPLIFIED PROJECT DESIGN DOCUMENT
FOR SMALL-SCALE PROJECT ACTIVITIES (SSC-CDM-PDD)
Version 02**

CONTENTS

- A. General description of the small-scale project activity
- B. Baseline methodology
- C. Duration of the project activity / Crediting period
- D. Monitoring methodology and plan
- E. Calculation of GHG emission reductions by sources
- F. Environmental impacts
- G. Stakeholders comments

Annexes

Annex 1: Information on participants in the project activity

Annex 2: Information regarding public funding



Revision history of this document

Version Number	Date	Description and reason of revision
01	21 January 2003	Initial adoption
02	8 July 2005	<ul style="list-style-type: none">• The Board agreed to revise the CDM SSC PDD to reflect guidance and clarifications provided by the Board since version 01 of this document.• As a consequence, the guidelines for completing CDM SSC PDD have been revised accordingly to version 2. The latest version can be found at http://cdm.unfccc.int/Reference/Documents.

**SECTION A. General description of the small-scale project activity****A.1. Title of the small-scale project activity:**

Argichi Small Hydroelectric CDM project

A.2. Description of the small-scale project activity:

The proposed project activity involves implementation and operation of a 8.5 MW Small Hydroelectric grid connected renewable energy project on the Argichi river, Armenia.

Argichi HPP is located in Gegharkunik marz and embraces middle site of Argichi River. Absolute altitude of the territory varies from 1970 to 2270 m. River Argichi is the largest confluent of lake Sevan. Argichi River is a typical mountain one.

The electricity generated by Argichi SHPP will be sold to the Armenian Electricity Network (AEN).

Purpose of the project activity

The main purpose of the project activity is generation of clean hydroelectric energy and contribution to climate change mitigation efforts.

View of project participants on the contribution of the project activity to sustainable development

Ministry of Environment Protection of Armenia as the DNA has stipulated the following draft¹ indicators (criteria) for assessment of the project's contribution to the country's sustainable development:

1. Social Criteria

“The project has positive effects on social development.”

The project activity will create jobs opportunities in the area with very high unemployment level for skilled and unskilled labor during the construction and operation of the plant.

¹ It is expected that these indicators will be approved in October, 2006



The implementation of the project will benefit the Armenia through development of additional sustainable generation capacity not dependant on the imported energy sources, which will add to the independence of the energy system of the Republic as well. During the project implementation the problem with irrigation will be solved by the Project Host. A new irrigation channel will be constructed for madina village.

Implementation of the project will also contribute to development of experience and intellectual capacity among the local construction workers that will go through a set of trainings, organized by the Project Host during the project implementation, which will help them to become a skilled work force in future as well.

2. Environmental Criteria

“The CDM project leads to positive or decreased negative environmental effects.”

According to the Environmental Impact Assessment conducted for this project, the construction of the Argichi SHPP will not affect the quality of the river water, as well as the well being of the local population.

3. Economic Criteria

“The project has positive effects on the economic development of the country.”

During the operation of the Argichi SHPP the expected tax revenue (including local – property taxes, and state – VAT and income taxes) will account to around \$400,000 USD per annum. The project will attract around \$5,000,000 USD investment.

The project implementation will also generate employment possibilities for the local population which lacks available workplaces in their region.

During the project implementation only locally produced equipment will be used which will benefit the renewable energy technology an intellectual capacity development in Armenia.

4. Policy effect criteria



“The project has positive effects on the achievement of national, regional and sector priority objectives.”

The project complies with the national policy in the energy sector which promotes the development of new renewable energy technologies and

The project activity complies with the Energy Strategy of Republic of Armenia which promotes the development of new renewable energy technologies and capacities. In addition, implementation of the project will also contribute to the sustainable development of Armenia through reducing the dependence on imported energy carriers, such as natural gas, thereby reducing the outflow of capital from Armenia to other countries.

A.3. Project participants:

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)
Republic of Armenia (host)	Private entity: Hydro Corporation CJSC	No
Denmark	Danish Environmental Protection Agency	No
<p>(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required.</p>		

A.4. Technical description of the small-scale project activity:

Argichi SHPP will use the hydro potential of river Argichi. The length of that section is equal to 9 km, and the fall is 287 m. All constructions of the HPP are located in that section. The hydroelectric power station is of derivation type. Its principal units are:

- Head unit
- Pressure derivation water carrier



- Station unit
- Removing water canal.

Argichi SHPP will be equipped with 4 horizontal Pelton turbines with 8.5 MW of nominal power. The electricity will be supplied to Lichk substation which is 7 km distance from the head unit.

The hydro-energy indices of Argichi HPP are as follows:

- Designed pressure – 223.0 m
- Designed outflow – 4.8 m³/sec.
- Generation capacity – 8.56 MW
- Average annual power generation– 29.1 million kWh

A.4.1. Location of the small-scale project activity:

A.4.1.1. Host Party(ies):

Republic of Armenia

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

Gegharkunik Marz

A.4.1.3. City/Town/Community etc:

Verin Getashen village

A.4.1.4. Detail of physical location, including information allowing the unique identification of this small-scale project activity(ies):

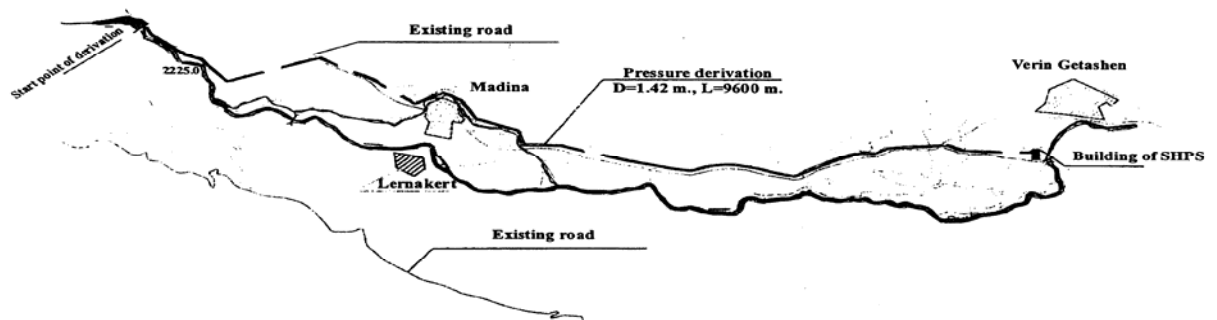
The Argichi SHPP will be located in Gegharkunik marz and embrace middle site of Argichi River. Absolute altitude of the territory varies from 1970 to 2270 m. River Argichi is the largest confluent of lake Sevan. Argichi River is a typical mountain one. The river springs from 2600 m altitude. At the connection point of mountains Geghama and Vardenis it flows south. The total reservoir square of river Argichi reaches 384 km², and its length – 51 km. Average inclination of river Argichi is equal to 0.014, the average height of the reservoir is 2460 m.



The river basin neighbours with the following basins: Kuruget from the east, Baghtak from the northwest, Azat from the west, Vedi from the southwest, and Arpa from the south. Head unit of Argichi HPP will be located 3.5 km up the village Madina.



ARGICHI SHPS
Plan of the Station
M 1:25000



**A.4.2. Type and category(ies) and technology of the small-scale project activity:**

Since, the installed capacity of the proposed project is only 8,5 MW, which is less than the qualifying capacity of 15 MW, the project activity can be regarded as a small scale CDM project activity and UNFCCC indicative simplified modalities and procedures can be applied.

The project activity utilizes the hydro potential of Argichi River for power generation and exports the generated power to the grid. According to small-scale CDM modalities the project activity falls under

Type – I – Renewable Energy Projects and category I-D – Grid connected renewable electricity generation.

The equipment used in the project will be developed and manufactured locally.

A.4.3. Brief statement on how anthropogenic emissions of greenhouse gases (GHGs) by sources**A.4.3. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gas (GHGs) by sources are to be reduced by the proposed small-scale project activity, including why the emission reductions would not occur in the absence of the proposed small-scale project activity, taking into account national and/or sectoral policies and circumstances:**

The proposed project activity generates electricity using hydro potential of Argichi river and exports the generated power to the grid. Therefore, it has not any emissions of anthropogenic greenhouse gas (GHGs) by sources.

The project activity will reduce anthropogenic GHGs emissions as per the combined margin of the Armenian grid, which future capacity additions are expected to be dominated by natural gas based thermal power stations.

The emissions reductions would not occur in the absence of proposed project activity due to the existence of a number of barriers to the implementation of small scale, run of river hydro projects in Armenia. A more detailed of additionality is included in section B3 below.

A.4.3.1 Estimated amount of emission reductions over the chosen crediting period:



Table 1

Year	Estimation of emission reductions (tonnes of CO ₂)
2007	13298.7
2008	13298.7
2009	13298.7
2010	13298.7
2011	13298.7
2012	13298.7
2013	13298.7
2014	13298.7
2015	13298.7
2016	13298.7
Total (tonnes of CO ₂)	132987

A.4.4. Public funding of the small-scale project activity:

Total funding required for the project does not include any public funding from Annex I countries.

Hence, the project proponents hereby confirm that public funding from parties included in Annex-I is not involved in the project activity.

A.4.5. Confirmation that the small-scale project activity is not a debundled component of a larger project activity:

According to the Appendix C of the Simplified Methodologies and Procedures for the small-scale CDM,

this Project activity is not a debundled component of a larger project activity because there is not a registered small-scale CDM project activity or an application to register another small-scale CDM project:

- With the same project participants
- In the same project category and technology/measure;
- Registered within the previous 2 years;



- Whose project boundary is within 1 km of the project boundary of the proposed small-scale activity at the closest point.

Hence, the project is eligible as a small-scale CDM project and can use the simplified modalities and procedures for small-scale CDM project activities.

SECTION B. Application of a baseline methodology:

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

Type I: Renewable Energy Projects

I.D. ‘Grid connected renewable electricity generation’

B.2 Project category applicable to the small-scale project activity:

Category I.D –Renewable electricity generation for a grid

B.3. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered small-scale CDM project activity:

Justification for application of simplified methodologies to the project activity.

The installed capacity of the project is 8.5 MW, which is less than the limiting capacity of 15 MW and is thus eligible to use small-scale simplified methodologies. The project activity is generation of electricity for a grid system using hydro potential. Hence, the type and category of the project activity matches with I.D. as specified in Appendix B of the indicative simplified baseline and monitoring methodologies for small-scale CDM project activities. Justification for additionality of the project under the UNFCCC simplified modalities is to establish the additionality of the project activity according to the Attachment A of Appendix B, which lists various barriers, out of which, at least one barrier shall be identified due to which the project can not occurred any way. The analysis of existing barriers is presented below.

The first step in the process is to list the likely future scenarios. Two scenarios were considered:



Scenario 1. The continuation of current activities – This scenario represents the continuation of current practices, which includes generation of electric energy with significant domination of fossil fuel – natural gas, which currently accounts to around 30% of the total energy generation mix. Besides, there are significant generation capacity additions through one unit of Hrazdan TPP and also on additional unit of Yerevan TPP.

Scenario 2. The construction of the new renewable energy plant – Argichi SHPP. In this scenario, a new source of electricity generation capacity with no carbon emissions will be available that will displace the high carbon intensive electricity generation plants.

The barriers are as follows:

Financial/economical: This barrier evaluates the viability, attractiveness and financial and economic risks associated with each scenario, considering the overall economics of the project and/or economical conditions in the country.

Technical/technological: This barrier evaluates whether the technology is currently available, if there are indigenous skills to operate it, if the application of the technology is a regional, national or global standard, and generally if there are technological risks associated with the particular project outcome being evaluated.

Prevailing business practice: This barrier evaluates whether the project activity represents prevailing business practice in the industry. In other words, this barrier assesses whether in the absence of regulations it is a standard practice in the industry, if there is experience to apply the technology and if there tends to be high-level management priority for such activities.

With respect to **financial/economical** barriers:

- The continuation of current practices (Scenario 1) does not pose any financial/economical barrier to the project developer, and requires no further financing.
- The construction of the Argichi SHPP (Scenario 2) faces specific financial/economic barriers. The capital costs involved in the project pose a barrier, especially considering the high interest rates prevailing in the lending field of Armenia, and also the fact that the available credit lines are not sufficient to cover the required investment expenditures for this project. The commercial banks in Armenia are not interested in funding these types of projects due to the long-term payback period and high level of required investments. The average interest rate in



commercial banks of Armenia is around 17%², and they are not interested in providing loans with more than 2-3 years crediting period. The commercial banks in Armenia do not provide loans with amounts more than \$500,000 USD (this amount usually ranges \$150,000 USD to \$200,000 USD). It is worth noting that there are no direct subsidies or promotional support for the implementation of independent renewable energy plants.

- The estimated investment for the Argichi SHPP project is equal to \$5.0 million USD, from which the equity financing is equal to \$2,000,000 USD, and the other \$3,000,000 USD was planned to be borrowed from financial institutions. The Project Developer has applied to a number of financial institutions that are currently providing loans for this kind of business activities. All the loan applications were denied or the offered conditions were unacceptable (18-22% interest rate, 3 years crediting period etc), as a result of which the proposed activities were delayed and after paying penalties to the State the Company had to apply to the Public Services Regulating Commission with request to reissue the SHPP construction License.

- The only financial institution which is planned to provide loans for implementation of this kind of projects is Cascade Credit Universal Credit Organization (Cascade Credit UCO). The funds of the Cascade Credit UCO come from the Renewable Resources and Energy Efficiency Fund (R2E2 Fund). But according to the Central Bank regulations the Cascade Credit UCO can not provide loans with more than \$1,000,000 USD limit, because the authorized capital of the Cascade Credit UCO is equal to \$4,000,000, and the loan limit for any credit organization in Armenia should be less than 25%. Thus, in order to implement the Argichi SHPP project the Project Developer would have to apply to a third party lending institution, which would create additional barriers for investments, such as shared collateral contracts, etc.

From the conducted analysis it is evident that the project can not succeed without additional funds that can be provided as a prepayment for the CERs by the Danish Government for the crediting period.

² The Government reports 2005-2006 , www.gov.am



- Another financial/economic barrier to the project activity is demonstrated below through a cash flow analysis.
- Comparing the project results with and without carbon, it is clearly demonstrated that the project would not occur without carbon revenues (see table 3 below).

Table 2: Cash Flow Analysis

	Without Carbon	With Carbon
Net Present Value (NPV)	-\$ -211,417	\$ 123,660
IRR	10.5%	13%
Discount Rate	12%	12%

With respect to the **technical/technological** barrier:

- Neither in the case of Scenario 1, nor in the case of Scenario 2, there are no technical/technological issues. The first case represents a continuation of current practices and does not involve any new technology or innovation. In case of Scenario 2 there are no significant technical/technological barriers as well, as all the technologies involved in this scenario are available in the market, and have been used effectively in Armenia.

With respect to the analysis of **prevailing business practice**:

- In the case of Scenario 1 there are no particular barriers for the continuation of current business practices with operation of existing facilities. In case of Scenario 2 there will be no significant deviations from the existing trend in the energy sector as well.

Table 4 below summarizes the results of the analysis regarding the barriers faced by each of the proposed scenarios. As the table indicates, Scenario 1 faces no barriers, whereas Scenario 2 faces one important barrier – the financial/economic barrier.

Table 3: Summary of Barriers Analysis

Barriers Evaluated	Scenario 1	Scenario 2
	Continuation of current activities	Construction of the Argichi SHPP
Financial/Economic	NO	YES
Technical	NO	NO
Prevailing Business Practice	NO	NO



Other Barriers	NO	NO
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As a result, the analysis of barriers has shown that the most plausible scenario is the Scenario 1 – continuation of current activities. Therefore the Scenario 2 – Project Scenario is not the same as the Baseline Scenario, which are defined as follows:

Baseline Scenario is represented by the continued generation of electric energy using the existing generation facilities and new capacity additions to the grid.

Project Scenario is represented by the construction of the new renewable energy plant – Argichi SHPP, which will displace electricity generated using carbon-intensive fossil fuel, thus resulting in significant GHG emission reductions.

Therefore the project is not the baseline scenario and is additional.

B.4. Description of how the definition of the project boundary related to the baseline methodology selected is applied to the small-scale project activity:

According to methodology AMS-ID, the project boundary encompasses the physical, geographical site of the renewable electricity generation source. Hence, the project boundary is the 10.5 hectare area where the powerhouse and transmission line is placed including the connection point with AEN – Lichk Substation.

B.5. Details of the baseline and its development:

According to the simplified M&P for small-scale CDM, there are two options that can be applied in the selected project category.

“The baseline is the kWh produced by the renewable generating unit multiplied by an emission coefficient (measured in kg CO₂equ/kWh) calculated in a transparent and conservative manner:

(a) A combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) according to the procedures prescribed in the approved methodology ACM0002.



Any of the four procedures to calculate the operating margin can be chosen, but the restrictions to use the Simple OM and the Average OM calculations must be considered

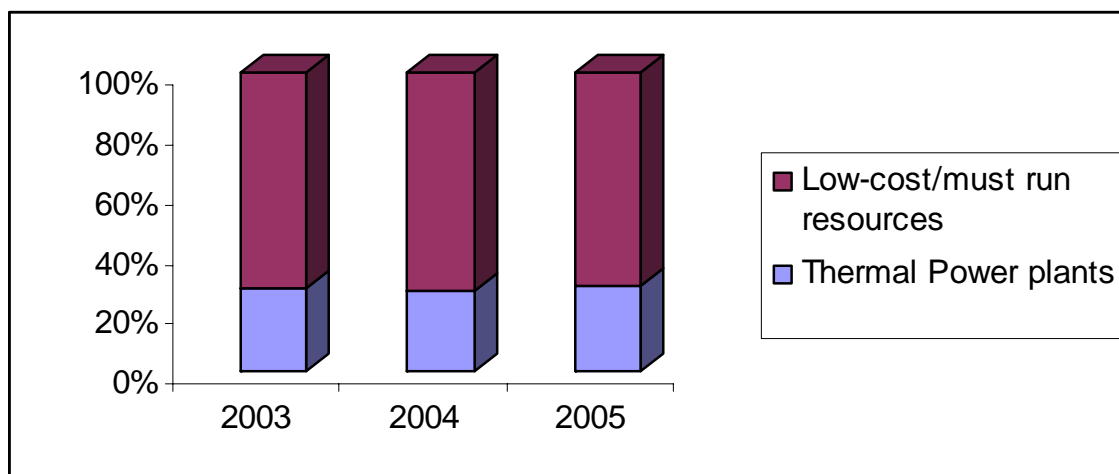
OR

(b) The weighted average emissions (in kg CO₂equ/kWh) of the current generation mix. The data of the year in which project generation occurs must be used.

Option a) is selected for this project because the project will displace mostly fossil-fuel generating sources since they are at the margin of the electricity generation system. Future capacity additions will be predominated on fossil fuel based power plants (particularly it is expected that in 2008-2009 two new thermal power plants will be launched – Hrazdan TPP Unit No5 (450 MW) and Yerevan TPP New Unit (215 MW).

The operating margin is calculated on the basis of the Simple Adjusted OM Method, since no detailed information is available for to apply Dispatch Data Analysis Method. The Simple OM method can not be used because low-cost/must run resources constitute more than 50% of total grid generation (See figure 1 below).

Figure 1.³



SECTION C. Duration of the project activity / Crediting period:

C.1. Duration of the small-scale project activity:

³ Source – PSRC, www.psrc.am

**C.1.1. Starting date of the small-scale project activity:**

01.01.2007 – construction begins on this date.

C.1.2. Expected operational lifetime of the small-scale project activity:

40 years

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

The project activity has chosen a fixed ten-year crediting period as described in C.2.2.

C.2.1. Renewable crediting period:

Not applicable

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

Not applicable

C.2.1.2. Length of the first crediting period:

Not applicable

C.2.2. Fixed crediting period:

10 years-0 months

C.2.2.1. Starting date:

01.01.2008

C.2.2.2. Length:

10 years



SECTION D. Application of a monitoring methodology and plan:



D.1. Name and reference of approved monitoring methodology applied to the small-scale project activity:

Name: **Monitoring methodology for Project activity I.D “Grid connected renewable electricity generation”**

Reference: Article 9 Type I.D. **Appendix B of the simplified modalities and procedures for small-scale CDM project activities.**

D.2. Justification of the choice of the methodology and why it is applicable to the small-scale project activity:

The project activity is generation of electricity for a grid system using water potential. Hence, the type and category of the project activity matches with I.D. as specified in Appendix B of the indicative simplified baseline and monitoring methodologies for small-scale CDM project activities.



D.3 Data to be monitored:



ID number	Data Type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived (electronic/paper)	For how long data to be kept?	Comment
D.3.1	Electricity generation	Electricity supplied to the grid by the project	MWh	M	Hourly	100%	Electronic and paper	During the credit period + two years	
D.3.2	CO ₂ emission factor	CO ₂ emission factor of the grid	t CO ₂ /MWh	C	Monthly	100%	Electronic and paper	During the credit period + two years	
D.3.3	CO ₂ Operating Margin emission factor	CO ₂ operating margin emission factor of the grid	t CO ₂ /MWh	C	Monthly	100%	Electronic and paper	During the credit period + two years	
D.3.4	CO ₂ Build Margin	CO ₂ operating	t CO ₂ /MWh	C	Monthly	100%	Electronic and paper	During the credit period + two years	



	emission factor	margin emission factor of the grid							
D.3.4	Minimum water flow in the river	Minimum water flow in the river of 1.0m ³ /s required for ecological reasons	Min 1,0 m ³ /	M	Daily	100%	Electronic and paper	During the credit period + two years	



D.4. Please describe briefly the operational and management structure that the project participant(s) will implement in order to monitor emission reductions and any leakage effects generated by the project activity:

The Hydro Corporation will appoint a designated engineer on site who will be responsible for collecting and compiling the necessary data for the monitoring plan. The data will be collected in a transparent way and provided to the third party audit entity for the DOE validation and certification.

No leakage is expected.

For the monitoring of electricity generation inspected and certified (according to national regulations) monitoring equipment (electric meter) will be installed in place. The data will be monitored and recorded by qualified engineers according to the monitoring plan. Electric meter readings will be double-checked with the records of the AEN.

The data will be electronically archived. Receipts of electricity sales will be obtained.

The rest of the data to be monitored for the emission factor calculation will be obtained from the Public Services Regulatory Commission of RA.

The minimum water flow in the river of 1.0m³/s required for ecological reasons will be monitored by the Hydro Corporation personnel and Ministry of Environment Protection.

D.6. Name of person/entity determining the monitoring methodology:

Name of the person

Karen Arabyan

Company: *Arjermek LLC*

Address: *Hrazdan TPP territory-3, Hrazdan City, Kotayk marz, Republic of Armenia*

tel +37491 201796

e-mail: arabyan_k@rambler.ru

SECTION E.: Estimation of GHG emissions by sources:

E.1. Formulae used:

E.1.1 Selected formulae as provided in appendix B:

**E.1.2 Description of formulae when not provided in appendix B:****E.1.2.1 Describe the formulae used to estimate anthropogenic emissions by sources of GHGs due to the project activity within the project boundary:**

Emissions by sources of GHGs due to the project activity within the project boundary are zero since the project activity is run-of-the river hydroelectric project. Thus no formulae are used.

E.1.2.2 Describe the formulae used to estimate leakage due to the project activity, where required, for the applicable project category in appendix B of the simplified modalities and procedures for small-scale CDM project activities:

The equipment which will be used is not equipment transferred from another activity or the existing equipment. Hence, leakage calculation is not required.

E.1.2.3 The sum of E.1.2.1 and E.1.2.2 represents the small-scale project activity emissions:

The net project activity emissions are zero.

E.1.2.4 Describe the formulae used to estimate the anthropogenic emissions by sources of GHGs in the baseline using the baseline methodology for the applicable project category in appendix B of the simplified modalities and procedures for small-scale CDM project activities:

The power generation mix in the energy sector of Armenia is the following:

- 30% thermal power plants using natural gas a fuel source
- 40% nuclear power plant
- 30% hydroelectric power plants (small- and large-scale)

Taking into consideration the fact that most of the generation facilities and their equipment (more than 95%) are very old, the majority of those being constructed during the mid-soviet period, and the fact that the new generation units are under construction at the Hrazdan TPP and the Yerevan TPP and about 40 new small HPPs has got licenses for construction, the power generation mix will be significantly changing in the nearest future. Thus it makes sense to calculate the baseline in the year, in which project generation



occurs, calculating the emission factor based on the ex post monitoring during the crediting period. The data necessary for ex post calculation is publicly available in Armenia and can be provided by PSRC upon request. The current data on Armenian power plants will be used prior to the point at which the first new plant will be added to the grid and start producing electricity. Each month the project proponent will update the information on newly constructed and commissioned power plants with the PSRC and recalculate emission factor.

Table 3 provides key data on power plants in Armenia.

Table 3.⁴

Name and Type	Installed Capacity, Mw	Year of start-up	Generation, mln kWh		
			2003	2004	2005
<u>Thermal</u>					
Hrazdan TPP	1100	1966-1974	1305.6	1390.7	1435.5
Yerevan TPP	550	1963-1965	215.6	224.9	391.7
Vanadzor TPP ⁵	96	1964-1976	-	-	-
<u>Hydro</u>	1058.52				
Sevan Hrazdan	556	1949-1965	505.2	533	519.2
Cascade					
Vorotan	400	1970-1989	1302.4	1268.4	1027.6
Cascade					
Dzora HPP	76	1932-1933	63.8	69.8	70.0
Small HPPs	26.52		110.8	143.7	155.8
<u>Nuclear</u>					
Metsamor Unit 2	408	1980 (1995) ⁶	1997.6	2402.8	2716.3

Table 4 provides key data on thermal power plants fuel consumption and own consumption (PPOC) energy own consumption in Armenia.⁷

Table 4.

⁴ Source - PSRC

⁵ out of operation

⁶ Metsamor Unit 2 was recommissioned in 1995

⁷ Source – Public Services Regulating Commission (PSRC)



Name and Type	Fuel type	Fuel Consumption, g_{eqv}/kWh_e			PPOC, %		
		<u>2003</u>	<u>2004</u>	<u>2005</u>	<u>2003</u>	<u>2004</u>	<u>2005</u>
Hrazdan TPP	Natural gas	373.7	383.4	384.8	7.3	7.7	8.3
Yerevan TPP		386.0	359.9	397.8	11.9	11.6	13.7

The formulae used to estimate the anthropogenic emissions by sources of GHG's in the baseline is based on the project's baseline calculation described in methodology AMS-ID, for a system where **not** all generators use exclusively fuel oil and/or diesel fuel.

The total baseline emissions

$$BE_y (tCO_2/yr) = EG_y * EF_y$$

Where,

BE_y - Baseline emissions in year y (tCO₂)

EG_y (MWh/yr) - Electricity generated by the project in year y;

EF_y (tCO₂/MWh) - CO₂ emission factor of the grid.

The emission factor EF_y of the grid is calculated as the weighted average of the Operating Margin emission factor (EFOM, y) and the Build Margin emission factor (EFBM,y):

Step 1 – Calculation of the Operating Margin (OM).

The approved methodology ACM0002 outlines four two options for data vintages for calculating the approximate operating margin emission factor and the weighted average emission factor:

- (ex-ante) the full generation-weighted average for the most recent 3 years for which data are available at the time of PDD submission, if or,
- the year in which project generation occurs, if EFOM,y is updated based on ex-post monitoring.

The choice between ex-ante and ex-post vintage should be specified in the PDD, and cannot be changed during the crediting period.

Due to the aforementioned reasons the Project Developer decided to choose the Option 2 for calculation of the simple-adjusted Operating Margin.



For the calculation of the Simple Adjusted OM the power sources (including imports) should be separated in low-cost/must-run power sources (k) and other power sources (j).

For the Armenian grid hydro and nuclear power sources can be considered as low-cost/must-run power sources

The **Simple Adjusted OM** was derived using the following formulae:

$$EF_{OM, simple_adjusted, y} = (1 - \lambda_y) \cdot \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum_j GEN_{j,y}} + \lambda_y \cdot \frac{\sum_{i,k} F_{i,k,y} \cdot COEF_{i,k}}{\sum_k GEN_{k,y}}$$

where

$F_{i,j,y}$ is the amount of fuel i (in a mass or volume unit) consumed by relevant power sources j in year(s) y ,

j refers to the power sources delivering electricity to the grid, not including low-operating cost and must-run power plants, and including imports to the grid,

$COEF_{i,j,y}$ is the CO₂ emission coefficient of fuel i (tCO₂ / mass or volume unit of the fuel), taking into account the carbon content of the fuels used by relevant power sources j and the percent oxidation of the fuel in year(s) y , and

$GEN_{j,y}$ is the electricity (MWh) delivered to the grid by source j .

$F_{i,k,y}$, $COEF_{i,k}$ and GEN_k are analogous to the variables described for above for plants k ; and

$$\lambda_y = \frac{\text{number of hours per year for which low-cost / must-run sources are on margin}}{8760 \text{ hours per year}}$$

where lambda (λ_y) should be calculated as follows:

Step i) Plot a Load Duration Curve. Collect chronological load data (typically in MW) for each hour of a year, and sort load data from highest to lowest MW level. Plot MW against 8760 hours in the year, in descending order.

Step ii) Organize Data by Generating Sources. Collect data for, and calculate total annual generation (in MWh) from low-cost/must-run resources (i.e. $\sum_k GEN_{k,y}$).

Step iii) Fill Load Duration Curve. Plot a horizontal line across load duration curve such that the area under the curve (MW times hours) equals the total generation (in MWh) from lowcost/must-run resources (i.e. $\sum_k GEN_{k,y}$).



Step iv) Determine the "Number of hours per year for which low-cost/must-run sources are on the margin". First, locate the intersection of the horizontal line plotted in step (iii) and the load duration curve plotted in step (i). The number of hours (out of the total of 8760 hours) to the right of the intersection is the number of hours for which low-cost/must-run sources are on the margin. If the lines do not intersect, then one may conclude that lowcost/must-run sources do not appear on the margin and λy is equal to zero. Lambda (λy) is the calculated number of hours divided by 8760.

As it was mentioned, two new Thermal Power Plants will be launched in 2007 in Armenia: Yerevan TPP new unit and Hrazdan TPP Unit 5. As the data on future generation mix is not available the project developers used model in their calculations based on the following assumptions:

- 1) ratio of electric energy generated by thermal power plants on the grid out of total electric energy will remain at level 28-30%
- 2) specific fuel consumption in new thermal power plants will be 320g_{eqv}/kWh
- 3) The new thermal power plants will replace the generation capacity of existing thermal power plants by 50%, i.e. will comprise 14% of future generation.
- 4) The fuel consumption in existing thermal power plants and PPOC will be 380g_{eqv}/kWh and 7% in average.
- 5) Lambda dispatch factor will be on the same level in comparison with 2006.

$$NCVi = (0.380 + 0.320) / 2 = 0.350 \text{ kgce or } 10,255 \text{ MJ}$$

The quantity of CO₂ generated when combusting this amount of gas is as follows:

$$COEF_i = NCVi \cdot EFCO_{2,i} \cdot OXID_i$$

$$COEF_i = 10,255 \times 10^{-6} \text{ TJ} \times 15.3 \times 0.995 \times 44 / 12 = \mathbf{0.572 \text{ t CO}_2 / \text{MWhe}} \text{ or } \mathbf{572 \text{ t CO}_2 / \text{GWhe}}$$

In the formula:

15.3 - tC/TJ (carbon emission factor) in the case where gas is used as fuel;

EFCO_{2,i} = 15.3 x 44/12 = 56,1t CO₂/TJ of natural gas;

OXID_i = 0.995 - fraction of carbon oxidized in the case where gas is used as fuel;

44 - molecular weight of CO₂;

12 - atomic mass of carbon.



This is emission factor for generated electricity. To convert this to the grid delivered electricity, the power plants own consumption (7%) have to be considered (i.e. delivered electricity is app. 0,93 of the total generated electricity). The emission factor for delivered electricity is accordingly higher:

$$\text{COEF}_i = 0.572/0,93 = 0.615 \text{ t CO}_2/\text{MWh}^8$$

The previous figure has to be modified by a lambda factor calculated on the basis on the number hours that low-cost/must-run power sources are on the margin. Lambda was calculated in accordance with the steps described above. The data were provided by state enterprise Energy Strategy Centre⁹ (which is responsible for collection and analysis of statistic information on electricity and heat energy demand and supply in the Republic of Armenia).

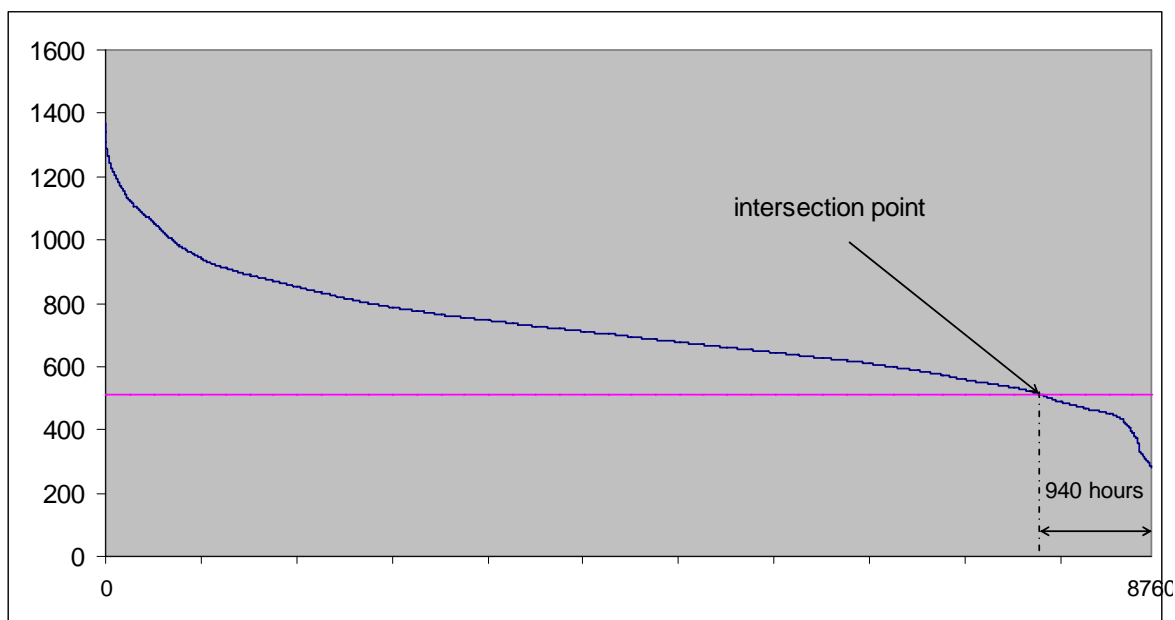
The following result of calculation was obtained:

The number of hours for which low-cost/must-run sources are on the margin for 2005 = 935 (See figure 2).

Figure 2.

⁸ Influence of power import is not considered, because Armenian energy system is an exporter of power in the region (after the nuclear unit recommissioning).

⁹ www.energinst.am



Lambda for 2005 =940/8760=0.11.

Therefore,

Operating Margin=0.615*(1-0.11)=0.547 t CO₂/MWh

Step 2 – Calculation of the build margin (BM).

According to the Approved Methodology ACM0002 the Build Margin emission factor (EF_{BM,y}) is calculated as the generation-weighted average emission factor (tCO₂/MWh) of a sample of power plants m, as follows:

$$EF_{BM,y} = \frac{\sum_{i,m} F_{i,m,y} \cdot COEF_{i,m}}{\sum_m GEN_{m,y}}$$

where **F_{i,m,y}**, **COEF_{i,m}** and **GEN_{m,y}** are analogous to the variables described for the simple OM method above for plants m.

Project participants shall choose between one of the following two options. The choice among the two options should be specified in the PDD, and cannot be changed during the crediting period.

Option 1. Calculate the Build Margin emission factor EF_{BM,y} ex-ante based on the most recent information available on plants already built for sample group m at the time of PDD submission.



The sample group m consists of either the five power plants that have been built most recently, or

the power plant 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 from these two options that sample group that comprises the larger annual generation.

Option 2. For the first crediting period, the Build Margin emission factor $EF_{BM,y}$ must be updated annually ex-post for the year in which actual project generation and associated emissions reductions occur. For subsequent crediting periods, $EF_{BM,y}$ should be calculated ex-ante, as described in option 1 above. The sample group m consists of either the five power plants that have been built most recently, or the power plant 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 from these two options that sample group that comprises the larger annual generation.

For the project Option 2 is chosen and the Build Margin emission factor $EF_{BM,y}$ will be updated annually ex-post for the year in which actual project generation and associated emissions reductions occur.

According to the information provided by PSRC the future capacity additions will be as presented in the Table 5.¹⁰

Table 5.

	Name and Type	Installed capacity, Mw	Generation , mln kWh
	<u>Hydro</u>		
1	Talin	5.14	28.4
2	Chichan	0.6	3.5
3	Apres	1.5	11.7
4	Hermon	1.2	4.1
5	Getik-1	6.5	21.1

¹⁰ The power plants which have licenses for construction



6	Getik-2	0.9	4.3
7	Aghstev-6	6.52	16.8
8	Meghri	2	11.5
9	Pambak	21	79.2
10	Bovadzor	0.38	1.8
11	Manushakadzor	0.35	1.433
12	Kurtan-1	0.67	2.9
13	Kurtan-2	5.2	17
14	Ayri	1.1	4.6
15	Argichi	8.6	29.1
16	Rine	0.09	0.8
17	Tatev	2.35	13
18	Eghvard	0.9	4
19	Spitak-1	0.5	2.3
20	Chanachchi	1.4	6.2
21	Jradzor	4.84	17.3
22	Hoktember	0.06	0.5
23	Ler Eks-1	0.28	2.4
24	Ler Eks-2	0.25	2.2
25	Ler Eks-3	0.37	2.7
26	Ler Eks-4	0.23	1.8
27	Ler Eks-5	0.24	1.8
28	Ler Eks-6	0.34	2.6
29	Vahagni	1	8
30	Sandaghbyur	0.66	2.4
31	Dzor-Dzor	0.3	1.8
32	Elegis-1 (retrofit)	3.16	5.3
33	Amasia	0.9	1
34	Sisakan	0.5	1.9
35	Eghvard-2	9.31	18.2
36	Geghi-1	4.09	15.4
37	Haghpat-1	0.32	1.05
38	Haghpat-2	1.9	8.09
39	Aygezard	0.84	3.32
40	Saravan	2.488	7.7
41	Aghstev-1	3.6	14.4
42	Jermuk-2	2.35	10.2
43	Gevorgavan	0.06	0.32
44	Pambak-1	1.91	13.9



45	Tej	2.26	7.01
46	Ajgedzor-2	2	6
47	Hnevank-1	0.967	5.75
48	Hnevank-2	0.5	2.7
Total		112.625	429.473
<u>Thermal</u>			
49	Hrazdan unit5	215	717.75
50	Yerevan TPP New Unit	400	195.85
Total		615	913.6

As the sample group which will consist of the five most recently built power plants is unknown at the moment of PDD submission, it is assumed that the generation of the power plant capacity additions in the electricity system which will comprise 20% of the system generation will comprise larger annual generation.

Therefore future build margin will be as presented in table 6.

Table 6,

Name	Type	Generation, (% of total)
Hrazdan TPP	Thermal power plant	11
Yerevan TPP	Thermal power plant	3
Small Hydro	Hydro power plants	6

$NCV_i = 0.320 \text{ kgce or } 9,376 \text{ MJ}$

The quantity of CO_2 generated when combusting this amount of gas is as follows:

$$COEF_i = NCV_i \cdot EFCO_{2,i} \cdot OXID_i$$

$$COEF_i = 9376 \times 10^{-6} \text{ TJ} \times 15.3 \times 0.995 \times 44/12 = \mathbf{0.523 \text{ t } CO_2/MWhe \text{ or } 523 \text{ t } CO_2/GWhe}$$

In the formula:

15.3 - tC/TJ (carbon emission factor) in the case where gas is used as fuel;

$EFCO_{2,i} = 15.3 \times 44/12 = 56,1 \text{ t } CO_2/TJ$ of natural gas;

$OXID_i = 0.995$ - fraction of carbon oxidized in the case where gas is used as fuel;

44 - molecular weight of CO_2 ;

12 - atomic mass of carbon.



As the thermal power plants will comprise 70% of future build margin, future build margin will result in a value of $0.523 \times 0.7 = 0.367 \text{ t CO}_2$.

As mentioned above the emission factor EF_y of the grid is calculated as the average of the Operating Margin emission factor (EFOM, y) and the Build Margin emission factor (EFBM, y):

$$EF_y = 457 \text{ t CO}_2/\text{GWh}$$

The baseline emissions are estimated to be 132987 t CO₂ over the ten year crediting period.

E.1.2.5 Difference between E.1.2.4 and E.1.2.3 represents the emission reductions due to the project activity during a given period:

132987 t CO₂

E.2 Table providing values obtained when applying formulae above:

Year	Estimation of baseline emissions (tonnes of CO ₂ e)	Estimation of project activity emission reductions (tonnes of CO ₂ e)	Estimation of Leakage (tonnes of CO ₂ e)	Estimation of emission reductions (tonnes of CO ₂ e)
2008	13298.7	0	0	13298.7
2009	13298.7	0	0	13298.7
2010	13298.7	0	0	13298.7
2011	13298.7	0	0	13298.7
2012	13298.7	0	0	13298.7
2013	13298.7	0	0	13298.7
2014	13298.7	0	0	13298.7
2015	13298.7	0	0	13298.7
2016	13298.7	0	0	13298.7
2017	13298.7	0	0	13298.7
Total (tonnes of CO ₂)	132987	0	0	132987

Please note – estimation of GHG emission reductions is made for reference purposes only - actual emission reductions will be determined based on measurement results on ex-post basis.

SECTION F.: Environmental impacts:

F.1. If required by the host Party, documentation on the analysis of the environmental impacts of the project activity:



All power generation projects carried out in Armenia are required to conduct an environmental impact assessment in conformity with Order on Environmental Protection.

The project compiled the environment impact assessment report (EIA) in July 2006 and submitted it to the Commission in Ministry of Nature Protection which is responsible for EIA.

The Commission has given the positive opinion for the project (see Annex 2).

The followings are main restrictions and requirements set by the ministry of environment protection

1. Maintaining one cubic meter per second water level at the river for environmental purposes.
2. Construct a fishpass
3. Improve surrounding environment of the HPP (plants, green lawns, bushes, trees, etc) by investing 11,561.09 thousand AMD (approx. USD 30 000).

The minimum water flow in the river of 1.0m³/s will be regularly monitored by the local environmental authorities and the data will be submitted to Ministry of Nature Protection.

The construction of the fishpass, as well as improvement of surrounding environment of the HPP are included in design solutions of Argichi SHPP. The construction report and expertise are required for commission of hydro plant.

SECTION G. Stakeholders' comments:

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

Hydro Corporation organized stakeholder consultation with objective to inform interested stakeholders on the environmental and social impacts of the project activity and discuss their concern regarding project activity. Invitations for stakeholders were sent one week before the meeting. On the day of the meeting representatives of Hydro Corporation presented project activity to the stakeholders and requested their suggestions/objections.

The meeting is recorded and is available on request.

Invitations were sent out to:

Representatives of neighboring villages (Madina, Verin Getashen)

Municipality of Martuni city



Ecological Dept of Gegharcunic Marz

Ministry of Nature Protection

Ministry Of Energy

Public services regulating commision

NGOs

Armenian Electricity Network (AEN)

The following issues were discussed during the meeting: project impact on ecology, social-economic situation, and government policy for renewable energy projects in Armenia, existing barriers for renewable energy projects implementation.

G.2. Summary of the comments received:

As a result of the meeting with the stakeholders the following comments were received:

1. Due to fact that Armenia in future will face problems with energy generation (Armenian Nuclear Power Plant will be shut down in 2014) the project will contribute to the economic development in Armenia.
2. As Armenia has no own resources of fossil fuels use of renewable energy becomes very important.
3. The project design is developed in correspondence with existing legislation.
4. The project will provide good job opportunities for the local populace.
5. The project activity doesn't require displacement of any local population. Therefore the project will not cause problems on local populace. On the other hand creation of new vacancies, education and solving the problem with irrigation will improve their quality of life.
6. The project will not have adverse impact on ecology. Rather, it will reduce GHG emissions in the country.

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

No major concern was raised during the meeting and satisfactory answers were provided issues discussed during the meeting.

**Annex 1****CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY**

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

Total funding required for the project does not include any public funding from Annex I countries.

Hence, the project proponents hereby confirm that public funding from parties included in Annex -I is not involved in the project activity