CDM for renewable energy development and application

Experiences from the Asia-Pacific region

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Clean Development Mechanism (CDM) can be one of the important drivers that help to make renewable energy (RE) projects financially viable. However, RE's share is just 1 per cent in Nepal's total energy consumption, which is dominated by traditional forms of energy. Household biogas digesters have been successfully implemented with the support of various agencies. Two biogas CDM projects registered in 2005 bundle 19,396 digesters. Biogas, used as a cooking fuel, reduces the consumption of firewood, kerosene and LPG. Revenue from Certified Emission Reduction (CER) is expected to overcome the barriers at both household and programme levels to continue the biogas programme. Similarly, a bundled micro-hydro CDM project is in the final stage of validation to replace the use of diesel for milling and kerosene for lighting. The CER revenue appears key to minimizing financial and technical barriers in the use of clean energy.

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Introduction

Climate change emerged on the political agenda in the middle of the 1980s, following increasing scientific evidence of human interference in the global climate system and the growing public concern about the environment. The United Nations Environment Programme and the World Meteorological Organization jointly established the Intergovernmental Panel on Climate Change (IPCC) in 1988 to provide policy makers with authoritative scientific information.

In March 1994, the United Nations Framework Convention on Climate Change (UNFCCC) came into force with the objective of stabilizing atmospheric concentrations of GHG at safe levels. To achieve this objective, all

countries have a general commitment to address climate change, adapt to its effects, and report their actions to implement the convention. UNFCCC segregates countries into two main groups: the Annex I (A-I) Parties and the Non-Annex I (NA-I) Parties. It sets the principles of equity and 'common but differentiated responsibilities' that required A-I Parties to take the lead in lowering their GHG emissions to the 1990 levels by the year 2000. The Convention established the Conference of Parties (COP) as its supreme body with the responsibility to oversee the progress towards the aim of the Convention.

During COP 3, a legally binding set of obligations – called the Kyoto Protocol (KP) – was created for 38 industrialized countries and 11 countries in Central and Eastern Europe to reduce their emissions of GHGs to an average of approximately 5.2 per cent below the 1990 levels over the commitment period 2008-2012. KP establishes three cooperative mechanisms designed to help A-I Parties reduce the costs of meeting their emissions targets by achieving emission reductions at lower costs in other countries than they could domestically.

The Clean Development Mechanism (CDM) is one of the most important instruments of the protocol from the perspective of NA-I parties. CDM is a project-based mechanism aimed to help developing countries achieve sustainable development by promoting environment-friendly investment from the governments and businesses in industrialized countries. CDM allows an A-I party to implement a project that reduces GHG or, subject to constraints, removes GHG through carbon sequestration in the territory of a NA-I Party. The resulting Certified Emission Reduction (CER) can then be used by the A-I Party to help meet its emissions reduction (ER) target.

Based on the size, CDM projects are categorized into large-scale and small-scale projects. Registration as a small-scale project entitles project participants to use simplified modalities and procedures to reduce transaction costs. All CDM projects are obliged to follow the guidance and procedures, and apply baseline and monitoring methodologies approved by the CDM Executive Board (EB). A strict and clear project cycle is in place. Once a project meets all eligibility criteria, EB takes a decision to register it. By 15 March this year, 1,448 CDM projects have been registered. Figure 1 shows the percentage of registered projects in different regions while Figure 2 shows the projects in the host countries. The Asia-Pacific region dominates, as 69.8 per cent registered projects are from this region. Among nations, China and India lead as the host parties.

CDM project activities must be hosted by the NA-I Parties, with ratification by KP and establishment of a Designated National Authority (DNA) being the primary conditions. Figure 3 presents region-wise KP parties, parties with DNA, parties with project experience and parties with registered projects.

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A source of energy would be considered as "renewable" if it is a natural resource on earth and it can be naturally replenished in a relatively short time scale. Furthermore, producing energy from renewable sources will not produce harmful pollutants and will not harm ecosystems. Renewable energy (RE) is also called 'clean' or 'green' power and it can be produced using resources like the sunlight, wind, hydrogen, geothermal energy, biomass, flowing rivers and even the power of the ocean. By developing such energy sources, many countries can reduce their dependence on oil and natural gas, creating energy portfolios less affected by price rise.

There is an important and growing economic role for RE systems within the energy sector. This is shown by

Figure 1: Registered projects by region (14 March 2009)

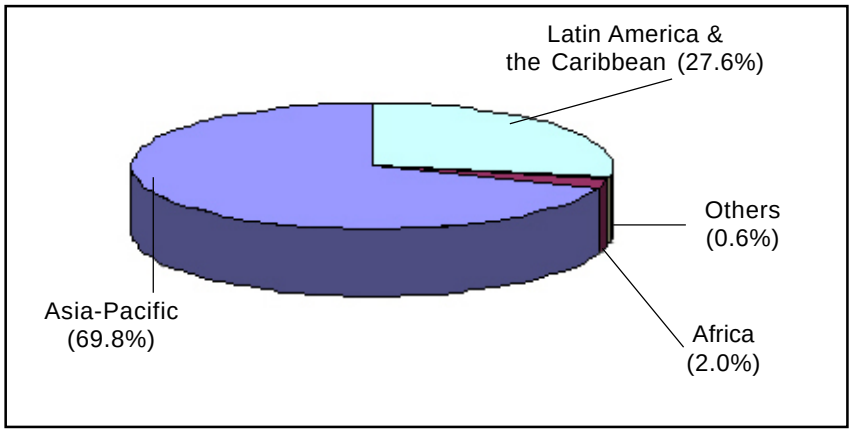


Figure 2: Registered project activities by host party

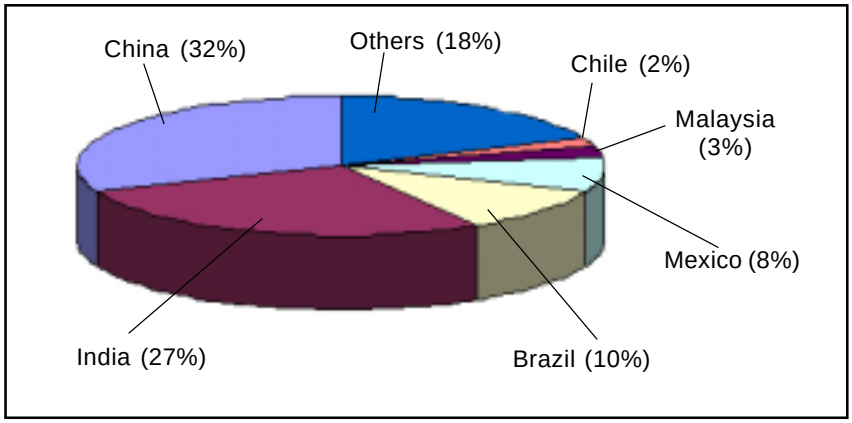
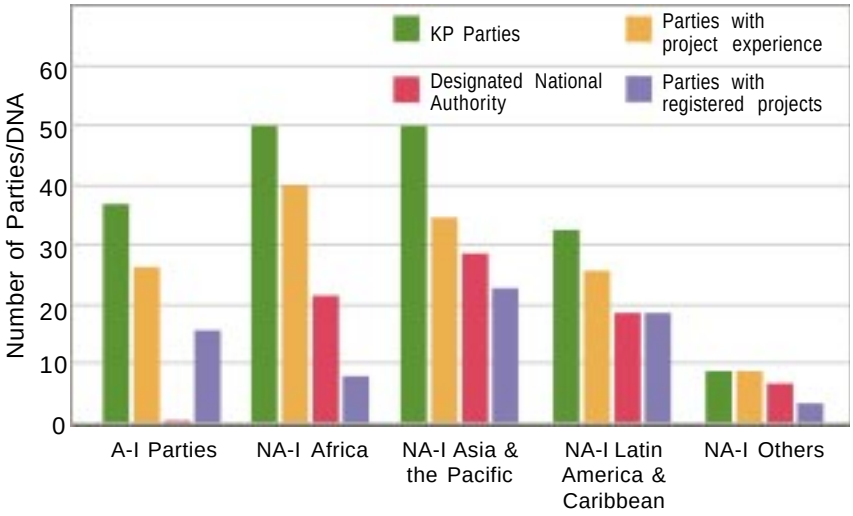


Figure 3: Number of Parties/DNA by region



the fact that over the past few years, the use of RE technologies has expanded rapidly. In 2005, RE supplied 17 per cent of the world's primary energy. Much of this growth in use has occurred in the developing countries, which account for 44 per cent of the world's RE generating capacity. However, despite the abundance of RE resources, Pacific island countries remain almost totally dependent on fossil fuels for meeting their energy needs (SOPAC, 2007). RE is perceived to constitute an important option for mitigating and abating the emissions caused by fossil fuels (Socolow, 1992).

The Millennium Development Goal number seven specifies energy efficiency, carbon dioxide emissions and proportion of forested land as indicators of environmental sustainability. RE technologies that replace traditional biomass contribute to reduce GHGs and improve energy efficiency, furthering the goal of environmental sustainability. GHG reduction is particularly relevant to the developing world, as climate change threatens to disrupt the weakest of economies and is a disadvantage to the poorest of people.

In order to reduce GHGs, optimum harnessing of clean energy is important because RE sources do not discharge any emissions. About 79 per cent reduction in carbon dioxide (CO_2) emission can be obtained inexpensively with RE system. (Nakata and others, 2002)

While lower fuel and operating costs may make RE cost-competitive on a life cycle basis, higher initial capital costs can mean that it provides less generation capacity per initial dollar invested than in conventional energy sources. Thus, RE investments generally require higher amounts of financing for the same capacity. However, as technology improves and the cost of fossil fuels increases, RE will become competitive. Moreover, CDM can be instrumental in making RE projects financially viable.

According to modalities and procedures for CDM, three types of small-scale CDM projects are possible – RE project, energy efficiency improvement projects and other project activities. RE projects are entitled to follow the Approved Small-scale Methodology (AMS), which has five sub-types that cover existing RE technologies.

I.A *Electricity generation by the user.* This category comprises RE generation units that supply individual households/users, or groups of households/users, with electricity. It is applicable only to households and users that do not have a grid connection, except when: (1) a group of households or users are supplied electricity through an isolated mini-grid where the capacity of the generating units does not exceed 15 MW; or (2) the emission reduction per RE-based lighting system is less than 5 tonnes of CO_2 a year and where it can be shown that fossil fuel would have been used in the absence of the project activity. These units include solar power, wind power, hydropower and other technologies that produce electricity, all of which are used on-site. The RE generating units may be new or replace existing generation using fossil fuel.

I.B *Mechanical energy for the user with or without electrical energy.* This category consists of RE generation units that supply individual households or users or groups of households or users with mechanical energy that otherwise would have been supplied with fossil fuel-based energy. These units include technologies such as wind power, hydropower, water mills, solar water pumps and others that provide mechanical energy, all of which are used on-site by the individual household(s) or user(s). Where generation capacity is specified, it shall be less than 15 MW. If the generation capacity is not specified, the estimated diesel-based electricity generating capacity that would be required to provide the same service or mechanical energy shall be less than 15 MW.

I.C *Thermal energy for the user with or without electricity.* This category contains RE technologies that supply individual households or users with thermal energy that displaces fossil fuels. Examples include solar water heaters and dryers, solar cookers, energy derived from renewable biomass for water heating, space heating, or drying, and other technologies that provide thermal energy that displaces fossil fuel. Biomass-based co-generating systems that produce heat and electricity are included in this category. In cases where the thermal generation capacity is specified by the manufacturer, it shall be less than 45 MW.

I.D *Grid-connected renewable electricity generation.* This category encompasses RE generation units,

such as photovoltaic, hydro, tidal/ wave, wind, geothermal and renewable biomass, that supply electricity to and/or displace electricity from an electricity distribution system that is or would have been supplied by at least one fossil fuel-fired generating unit. If the unit added has both renewable and non-renewable components (e.g. a wind/diesel unit), the eligibility limit of 15 MW for a small-scale CDM project activity applies only to the RE component. If the unit added co-fires fossil fuel, the capacity of the entire unit shall not exceed the limit of 15 MW.

I.E *Switch from non-renewable biomass for thermal applications by the user.* This includes small thermal appliances that displace the use of non-renewable biomass by introducing new RE end-user technologies. Examples of such technologies include biogas stove and solar cooker. If any similar registered small-scale CDM project activities exist in the same region as the proposed project activity, then it must be ensured that the proposed project activity is not saving the non-renewable biomass accounted for by the other registered project activities. Project participants should be able to show, using survey methods, that non-renewable biomass has been employed since 31 December 1989.

Case studies from Nepal

The overall energy consumption of Nepal is largely dominated by the use of traditional, non-commercial forms of energy such as fuel wood, agriculture residues and animal waste. However, this is showing a decreasing trend, whereas the share of RE technologies has increased albeit at a slow pace. RE has reached about 1 per cent of overall energy consumption as compared with 0.53 per cent in 2005. Nepal imports petroleum products and coal to meet all of its fossil fuel demand.

The Alternative Energy Promotion Centre (AEPC) is an executive agency for all RE technologies in Nepal. At present, biogas, improved cooking stoves and a few solar cookers have been promoted as cooking energy that reduces the use of non-renewable biomass (NRB) in rural areas and of fossil fuel in semi-urban areas. Micro-hydro, solar photovolaic and improved water mill units have been distributed for lighting, operation of electrical appliances and running micro-income generating enterprises in off-grid rural areas, thus reducing the use of fossil fuels like kerosene and diesel. Solar thermal is promoted for water heating and drying crops. These RE technologies have contributed not only to the socio-economic development of rural households, but also to GHG reduction. Ultimatley, they also help meet the goal of UNFCCC / KP to reduce GHG concentration in the atmosphere.

Biogas CDM project

The technology used in the Biogas Support Programme (BSP) in Nepal involves household biogas digesters with a sludge and gas holding capacity range of 4-10 m^3. The biogas plants are based on a uniform technical design and are built and installed following established technical standards. These digesters include a mixer for the preparation of the digester feedstock at the inlet, the main digester and an overflow for the digestion product. The digester itself is a closed underground container made of concrete or other materials. The feedstock consists mainly of cattle and human excreta to which water is added. About 70 per cent plants are connected with toilets for the production of biogas (Figure 4). The biogas is extracted from the digester and transported to a stove. The digester has an overpressure, which creates a stable flow of gas for use in the cooking stoves. The fixed dome model has become quite popular, as they are easier to construct, operate and maintain using indigenous raw materials.

BSP has been implemented in Nepal since 1992 and is supported by the Government of Nepal and two international donors KfW[1] and SNV/ DGIS[2]. Biogas Sector Partnership Nepal (BSP/N) has been assisting AEPC to implement the programme. The target group of the programme are households that have at least two heads of cattle and currently use non-renewable biomass products and/or fossil fuels.

BSP/N conducts R&D for optimization of biogas system operation,

[1] Kreditanstalt für Wiederaufbau (Reconstruction Credit Institute), a development bank of Germany.

[2] SNV is Netherlands Development Organization; DGIS is the Ministry of Foreign Affairs of the Netherlands.

Figure 4: A toilet connected to a mini biogas plant

facilitates and provides technical assistance to Nepal Biogas Promotion Association (NBPA) and biogas companies (BCs), and carries out quality control and regular monitoring of biogas. NBPA, an umbrella organization of biogas companies, has been promoting biogas use in coordination with biogas companies, motivating users, executing skill enhancement packages for masons and supervisors, and providing business promotion services to BCs. BCs construct quality biogas plants as per the demand of farmers, who are working closely with biogas users. Only pre-qualified companies are eligible for the construction of biogas systems and manufacture of biogas appliances. The manufacturing companies produce biogas appliances such as stove, dome gas pipe and mixer. BCs disseminate information, promote market prospects and construct quality biogas plants, train users on how to operate and maintain the plants, and deliver after-sales and other services.

Two CDM projects have been registered, bundling 19,396 biogas digesters that cover BSP digesters implemented between 1 November 2003 and 6 April 2005 where average annual ER per plant is 4.99 tCO_2eq. A revision of the applied methodology – AMS-I.C – prevented continued development of the BSP project under CDM. The deadlock was cleared with the approval of AMS-I.E later. However, according to the new methodology, the average ER is about 2.5tCO_2eq/year per plant, which is about 50 per cent less when compared with the ER based on previous methodology.

AEPC has developed Programme of Activities (PoA) for CDM, bundling new biogas digesters. However, the CDM EB is yet to decide on CDM PoA procedures. Because of the methodological restrictions of PoA, only the replacement of NRB is counted as emission reduction under the CDM. The biogas project has a range of sustainable development benefits, which are fully attributed to the CDM project. These include:

- Improved living conditions in and around households owing to a significant reduction of smoke from biomass-based cooking;
- Reduced deforestation, preventing loss of biodiversity and soil erosion;
- Reduced time spent on fuel collection and less dependence on purchased fuels;
- Improved sanitary conditions, in particular when connecting the toilet to the digester;
- Improved safety (less fire incidents); and
- Improved fertilizer quality and reduced dependence on purchased chemical fertilizers.

Although over 185,000 digesters have already been implemented, the programme has not become economically viable. Digesters are more expensive now due to increased raw material costs, and the average investment costs have increased by 42 per cent over the last three years. On the other hand, the digesters implemented were adopted by households that are less capital-constrained. The target group of future digesters need to be poorer households located in more remote areas. However, the increased remoteness would raise the costs of digester installation, although the households are poorer. To maintain a minimum pace of digester implementation, subsidies should bring the investment costs to a level that poor households also could afford.

If households continue using NRB, they would not have to invest in a digester. The financial benefits of a digester to a household are very little since households tend to gather the firewood themselves and hardly use purchased wood or fossil fuels. Subsidy is thus important to overcome the investment barrier at the household level. Without CDM, the subsidy on household level is inadequate to bring down the price of a digester to an affordable level. Therefore, AEPC intends to allocate the CDM revenue to remove this barrier and ensure continued digester implementation, also to poorer and more remote parts of Nepal.

To ensure continued improvement of the digester technology and its adaptation to the Nepalese conditions, a coordinated monitoring programme was developed that covers all digesters installed under the programme. Subsidy disbursement requires coordination at programme level. As donors usually prefer to fund actual investments, they tend to finance the subsidies rather than the programme management. BSP, the only donor that provides programme funding, is likely to end its financial support by the end of 2009. The disengagement of BSP will also erode confidence in the technology provided. In addition, potential users would lack access to information that allows them to make investment decisions.

AMS-I.E. requires use of the emission factor of a fossil fuel to calculate the baseline emissions (CDM Type I.E methodology). The actual baseline is the replacement of NRB. As the most likely fossil alternative, kerosene is the realistic baseline in the Nepalese context since it is widely available.

The performance of bio-digesters, occurrence of leakage and continued displacement of NRB are assessed based on the annual biogas user survey (BUS). To ensure an unbiased and objective assessment, an independent agency is employed for the survey. A structured questionnaire is used to collect data and information for the assessment. Based on the indicators proposed in AMS-I.E., the NRB survey confirmed that firewood scarcity has been increasing since December 1989 (IEDI, 2008). The trends since 1989 in distance travelled and time taken for gathering firewood are monitored through BUS to keep a tab on the continued NRB use by households. Non-user households are also included in the surveys.

Micro-hydro CDM project

In Nepal, micro-hydro has been defined as hydropower plants that have a capacity ranging from 5-500 kW. AEPC has been promoting the off-grid micro-hydro project in rural Nepal based on community demand. The implementation of these micro-hydro plants (MHP) are being done through two of AEPC's projects: Rural Energy Development Programme (REDP) and Mini-grid Support Programme (MGSP).

AEPC has developed micro-hydro CDM project bundling a number of

Figure 5: Micro-hydropower project – a forebay (left); turbine generator (centre) and power transmission lines across hilly terrain (right)

plants, which will be constructed in the II phase of Energy Sector Assistance Programme (ESAP) and the III phase of REDP. The project expects to reduce GHG emissions through the replacement of fossil fuel, especially diesel and kerosene used for lighting and milling. The project activities are targeted at off-grid rural communities situated across several regions of the country. Such off-grid RE systems contribute directly to the sustainable development in the country:

- Reduction in fossil fuel consumption by replacing use of diesel with electricity in agro-processing mills and household lighting, and kerosene for household lighting;
- Plants constructed under the project will be managed and operated by the community or private entrepreneurs leading to local empowerment;
- People will receive training for operation, repair and maintenance for the smooth operation of the plant, which will enhance the skill set of local people;
- Electrical end-use enterprises will be supported to increase the plant factor, which will lead to different opportunities for self-employment at the local level; and
- The market of micro-hydropower components will flourish, as the large number of installations will raise the number of local manufacturers, suppliers and installers, thereby creating jobs for many and helping to lower the cost of the components.

AEPC is responsible for the overall planning, implementation and monitoring of the programme. REDP and MGSP provide technical support, including community mobilization, to promote the micro-hydro technologies and carry out regular monitoring to ensure quality of the system. The Technical Review Committee checks the technical, socio-economic, financial and environmental aspects of the project report submitted for implementation. AEPC has pre-qualified private companies to carry out feasibility survey, manufacture the equipment and install the plant following standard guidelines.

MHP has gained popularity as one of the best rural electrification technologies in Nepal owing to the availability of water resources and the hilly terrain of the country. The baseline approach adopted for the micro-hydro CDM project is based on the 'AMS-I.A – Electricity generation by the user'. It is estimated that the proposed project activity will lead to the emission reduction of about 39,635 tCO_2eq annually. However, in actual terms, CO_2 reductions will be based on the annual meter readings of each MHP.

The proposed micro-hydro activity is demand-driven with communities making the final decision on whether or not to invest in a MHP scheme. The construction of a MHP requires considerable amount of upfront capital and investment in addition to the subsidy provision from the government. The high upfront investment cost of a micro-hydro project is thus a barrier for its adoption by rural communities in the country. The communities have to, in addition to their cash and in-kind contribution, raise money through commercial loans from local banks, the magnitude of which differ across the micro-hydro schemes, depending upon the sizes of the schemes and paying capacities of the communities. Most common plant sizes in practice are 15 kW and 30 kW: each 1 kW of installed micro-hydro capacity can serve an average of 9 households. The installation cost per kW of micro-hydro project ranges from US$1,900 to US$3,521 depending on the size of the plant, geographic remoteness, specific characteristics of the plant and its design. The government subsidy at US$141 per household but not exceeding US$1,197/kW covers 35-55 per cent of the installation cost and the community has to invest the remaining amount. In addition, the annual operation and maintenance costs are estimated to be 3 per cent of the total capital cost. Communities therefore have to manage the remaining 45-65 per cent of the installation cost.

The primary financial institution involved in financing the micro-hydro sector in the country is the Agricultural Development Bank of Nepal, which provides loan at the commercial interest rate of 12-13 per cent per annum. A financial analysis has been carried out for four typical categories of MHP (16 kW, 25 kW, 50 kW and 75 kW) based on the average technical, operational and financial parameters extracted from a group of plants from each category to determine the project's internal rate of return (IRR) and net present value (NPV), over a 15-year period, with and without the carbon revenues, as per the EB guidelines. The IRRs for the four categories of plants range from 10.1 per cent to 11.4 per cent without carbon revenues and from 12.2 per cent to 13.4 per cent with carbon revenues.

A substantial community mobilization effort is necessary before the

communities start to invest in micro-hydro projects, to generate solidarity among them. If this community mobilization cost were to be borne by the community, the IRRs would further reduce, which would make it more difficult for the community to install MHP. For rural communities in Nepal, MHP construction without the support of carbon revenues is not a financially attractive course of action. They will opt for diesel power in the absence of the proposed CDM project activity.

This project activity has a strong quality control and assurance framework whereby only high quality products are delivered to investing communities. A separate set of standards is prepared and implemented for the MHP. Procedural guidelines for carrying out preliminary and feasibility studies are available for practical use. The guidelines include standard design aids with a built-in expert system. Furthermore, guidelines on tariff setting and social mobilization, standard bidding and contract agreement formats are prepared as part of the quality assurance system.

Since rural communities cannot discern the quality of the technology on their own, AEPC undertakes the technical review of all plants to be constructed before approving them for subsidy and will also allow only pre-qualified companies to carry out design, manufacture, installation and supply of MHP in villages. Besides technical assurance, AEPC provides technical training within its programmes to MHP operators and managers.

Figure 6: A microenterprise that uses micro-hypropower

Moreover, with the support of CDM, community will get technical support for operation of its MHP for the whole duration of the crediting period. Previously, the plants were getting support for only one year after installation, thereby lowering the sustainability aspect of the system.

Verification is carried out in each scheme to check the power output as designed. The supplier can be penalized for providing reduced amount based on the reduced kW. There is also a system for qualifying manufacturers, installers and surveying companies based on their performance indicators. A pool of quality inspectors supervises and assists in the construction works. Regular monitoring of the schemes is done during and after construction by the district staffs to verify their construction as per design and their sustainable operation.

All plants under the project will be fitted with energy meters to indicate the amount of energy (in kWh) they consumed within the credit period. The project's user committee will set up a procedure to record and maintain a log wherein the daily meter readings are maintained. For a more systematic approach to data keeping and log book keeping, AEPC will make log books and distribute it to all micro-hydro projects. It will also provide training to the operators for proper method of meter reading and maintaining the log book.

The first set of data will be prepared at the plant by the operator. The operator will be responsible for maintaining a standard log book. Each log entry, done on a daily basis, has to be signed by the operator. The technical staff at the district office will verify the log entry at the plant and will have to countersign the log if he/she agrees to its validity. Thereafter, it is the responsibility of the technical staff to bring the log to the district headquarters and enter the data into the database and communicate the meter reading data to AEPC on a half yearly basis. All the meter reading data that arrives at AEPC will be entered into the main database. As ER is directly related to the energy consumption at the plant, the meter data will be the prime basis for preparing the annual ER report.

Conclusion

CDM is intended to contribute towards meeting the target of KP, in particular, and the objectives of UNFCCC, in general. CDM RE projects are eligible to follow the simplified modalities and procedure, as they fall within the ambit of small-scale projects. RE projects do not seem financially attractive as the initial investment is higher than other projects. CDM seems essential in making these projects financially viable. CDM PoA is more applicable for RE projects although one of the de-bundling criteria is not favourable for household-level micro RE activities – that the distance between two CDM PoAs should be more than 1 km.

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Note: The author has used information from several publications and documents of the Alternative Energy Promotion Centre and Biogas Sector Partnership, as well as the website and data base of the United Nations Framework Convention on Climate Change.❐