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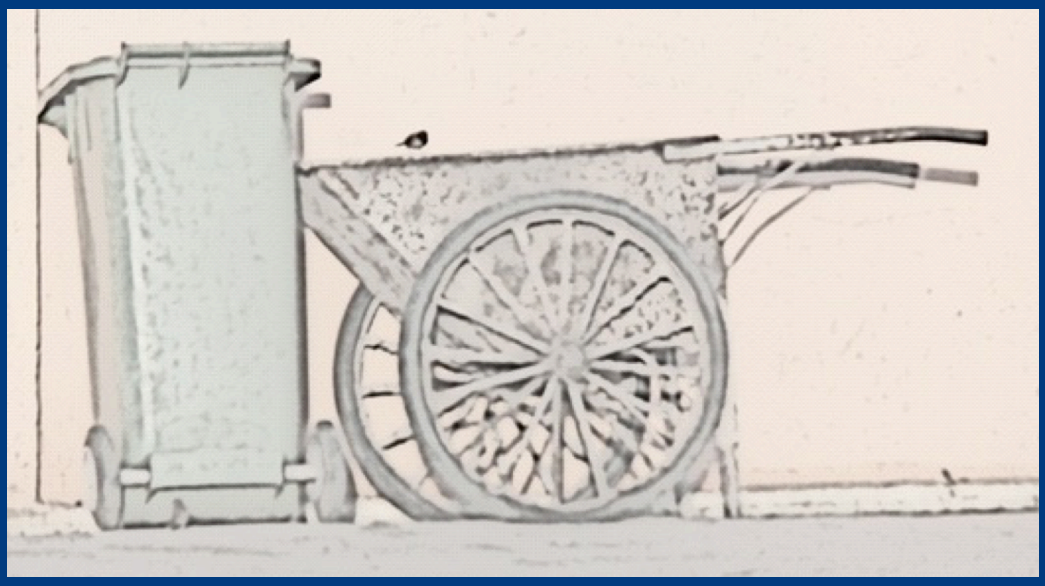
TA-8566 REG: Mainstreaming Integrated Solid Waste Management in Asia - Solid Waste Management Team (46248-001)

GHG Emission Reduction Potential and CDM possibilities for SWM in 5 CSCs



March 2017

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Abbreviations

ACCUs	-	Australian Carbon Credit Units
ADB	-	Asian Development Bank
AUS	-	Australia
BPW	-	Bureau of Public Work
CCER	-	Chinese Certified Emissions Reduction
CO_2	-	Carbon di oxide
CER	-	Certified Emission Reduction
CDM	-	Clean Development Mechanism
COP	-	Conference of Parties
CSC	-	Case study city
DENR-EMB V	-	Department of Environment and Natural Resources Offices - Environmental Management Bureau V
EU	-	European Union
ERF	-	Emission Reduction Fund
ERPA	-	Emission Reduction Purchase Agreement
ETS	-	Emission Trading Scheme
FOD	-	First order decay
GDP	-	Gross domestic product
GHG	-	Greenhouse gases
ISWM	-	Integrated solid waste management
JI	-	Joint Implementation
KAUs	-	Korean Allowance Units
KAZ	-	Kazakhstan
KCUs	-	Korean Credit Units
LAO	-	Local Administration Organizations
LF	-	Landfill
MCDC	-	Mandalay City Development Committee
MRF	-	Material recovery facility
MRV	-	Monitoring, reporting, and verification
MSW	-	Municipal solid waste
NDC	-	Nationally determined contribution
NGOs	-	Non-government organizations
NSWMC	-	National Solid Waste Management Commission

NZ	-	New Zealand
O&M	-	Operation and Maintenance
PHE	-	Public Health and Environment
PPP	-	Private public partnership
QC	-	Quezon city
QCEPWMD Department	-	Quezon City - Environmental Protection and Waste Management
RC	-	Reinforced concrete
R-CDTA	-	Regional Capacity Development Technical Assistance
RDF	-	Refuse derived fuel
SWM	-	Solid waste management
tpd	-	Tons per day
UNFCCC	-	United Nations Framework Convention on Climate Change
WTE	-	Waste to Energy

1. Introduction

Asian Development Bank's (ADB) Mainstreaming Integrated Solid Waste Management in Asia (hereafter "the Project") is a regional capacity development technical assistance (R-CDTA) project. The program aims to support the countries in selecting the case study cities (CSCs) and in supporting these cities to formulate integrated solid waste management (ISWM) strategies. The project will also identify feasible solid waste management (SWM) projects, delineate their structures and provide recommendations on possible policy/regulatory reforms and institutional development to foster private-public partnership (PPP) in this sector.

This project plans for contribution towards the sustainable waste management. The holistic approach on various practices on SWM in the selected CSCs would help in the dissemination and replication of the same in the neighbouring countries and also would increase the investments in the SWM sector.

Under this project, ADB has shortlisted three developing Asian countries and five case study cities (CSCs) from the selected Asian countries, for developing integrated SWM systems/practices to the level of international standard. The three shortlisted countries are:

- The Kingdom of Thailand (herein after as 'Thailand')
- Republic of the Union of Myanmar (herein after as 'Myanmar')
- The Republic of Philippines (herein after as 'The Philippines')

The five selected CSCs from the above Asian countries are:

- Buriram (Thailand)
- Mahasarakham (Thailand)
- Mandalay (Myanmar)
- Quezon city (The Philippines)
- Sorsogon (The Philippines)

The following chapters of this report detail about the proposed SWM projects/practices in the above CSCs, GHG emission reduction potential, Clean Development Mechanism (CDM) aspects associated with the proposed projects, etc.

2. Details of SWM projects in the 5 CSCs

Uncontrolled solid waste disposal and inefficient waste collection are the alarming issues in the selected five CSCs. SWM is a critical task due to increase in population, waste generation per capita, space constraints, etc. Pre-feasibility studies, various workshops and interactions have been conducted in these five CSCs and the possible SWM practices have been zeroed-in. This chapter deals with the proposed SWM practices in each city based on the waste generation, its composition, technical description and cost estimation of the proposed project.

2.1. Buriram SWM project

Buriram Municipality is a middle sized one located in the Buriram Province. It is around 6.0 sq.km covering all of the sub district named “Nai Maung” .The municipal area, also the centre of Buriram province, has various administration offices, schools, colleges, universities, hospitals, healthcare facilities, etc. It is the transportation hub of Buriram province .Since it is a central location for education and transportation, the municipality has to take care of a large amount of waste .

The municipality provides community based waste collection services for its residents .The task is carried out by the Division of public health and environment .MSW is collected twice a day and transported to the landfill using 13 haulage vehicles 8 ,waste compactor trucks and 5open tip trucks. There is no open burning of waste on the site .Overall, the collection and disposal of waste is at a reasonable standard.

The Local Administration Organizations)LAO (are responsible for the management of municipal solid waste, infectious waste generated from hospitals or clinics, and hazardous waste generated from communities including E waste .A number of municipal divisions are involved in solid waste management .The key divisions are the “Division of Public Health and Environment” and the “Division of Public Works”. The Division of Public Health and Environment is responsible for cleaning the public areas in the municipality, collecting and transferring waste to the disposal site .The Division of Public Works is in charge of operation and maintenance of the disposal site.The Municipal Council oversees all the operations. It can constitute ad-hoc committees or working groups to support activities related to solid waste management.

2.1.1. Waste composition:

The composition of waste disposed at the landfill at Buriram is given below.

Table 2-1 Waste composition of Buriram

Waste Type	Percent
Paper/cardboard	11.14
Glass	0.91
Plastic bags	13.80
Aluminium and Other Metal	1.25
Food waste	71.41
Green/Garden waste	0.64
Builders Waste	0
Timber/Lumber	0
Soil and dirt	0
Hazardous Waste	0
Fabric and Leather	0.78
Miscellaneous	0.08 (Rubber)

The Municipality of Buriram is considering alternatives to dispose of a significant portion of both fresh and existing waste to prolong the life of its existing landfill. At present, the mass of fresh waste delivered to the landfill, i.e., around 81 tpd is considered too small to economically operate a WTE plant. Even if the waste tonnage is sufficient, there are other technical impediments in the Northeast Thailand for such plants to connect to the electricity grid. In this situation, the Refuse Derived Fuel (RDF) business would be interesting to the landfill operator, if it is seen economically viable.

- **Technical context**

The RDF manufacturing plant has been proposed to establish at the existing landfill at the Buriram Municipality. Figure 1 shows the process diagram of the proposed RDF plant. The RDF plant includes the following equipment on international standard and they are described in detailed below.

Storage/bunker

Receiving hopper

Pre-shredder

Disc-screen

Air classifier

Overband magnet

Manual sorting

Fine shredder

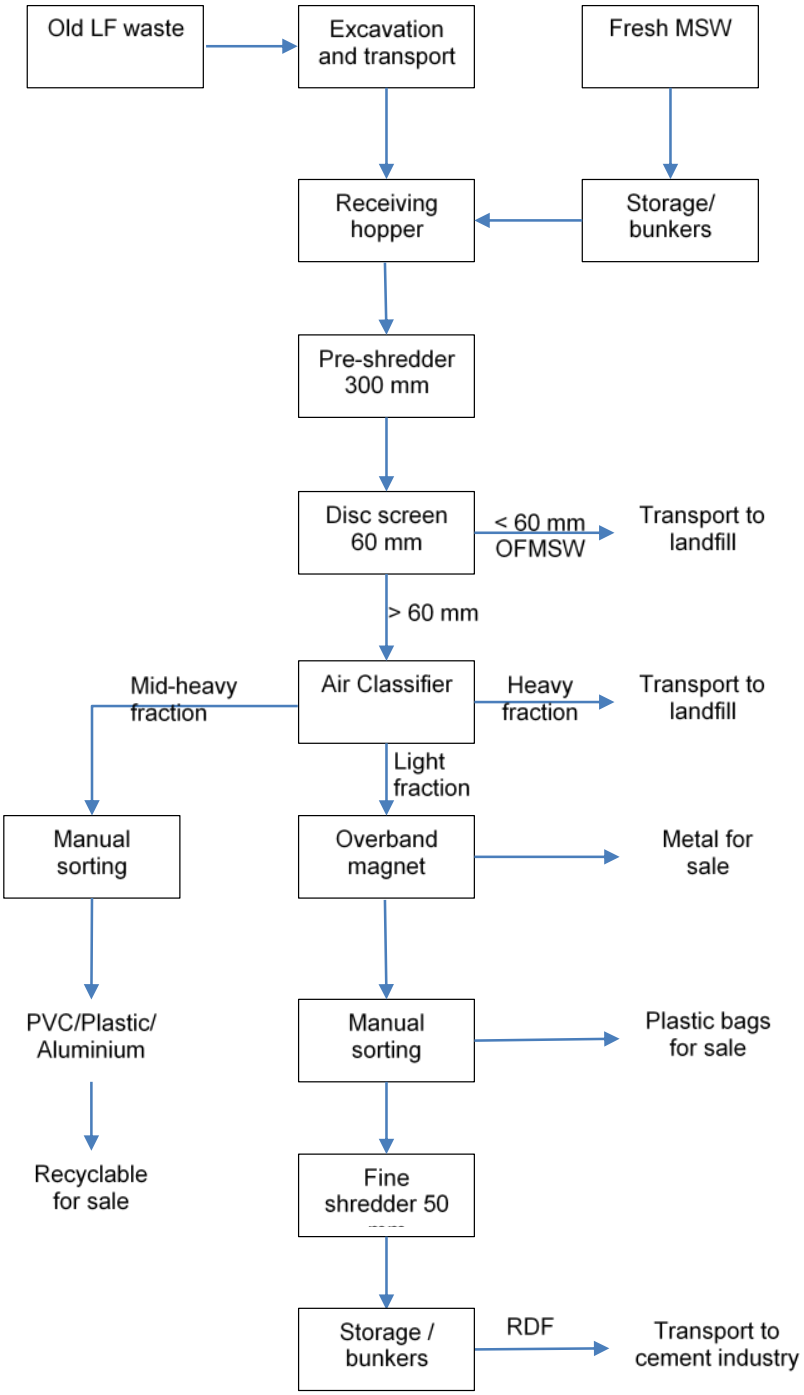


Figure 2-1 Process flow diagram of RDF manufacturing plant

2.1.2. Storage / bunker

The storage or bunker can be separated for the fresh MSW. The bunkers could be constructed with reinforced concrete (RC) with top and front openings. Each bunker should have drainage at the bottom to remove leachate or wastewater. The RC bunker can be made from acid resistant

concrete with a hardened liner surface to minimize corrosion from acidic leachate. The receiving bunker should be designed to have a capacity of 1-3 days.

2.1.3. Receiving hopper

The fresh MSW or the old waste mined from landfill can be taken from the storage/bunker and dropped into the receiving hopper to initiate the process of RDF production. In some configurations, the receiving hopper could be located above the pre shredder or primary shredder which means the waste can be fed directly into the pre/primary shredder.

2.1.4. Pre-shredder

The unit can also be called the primary shredder or bag breaker/opener. It reduces the size of the waste to less than 150 mm. The main aim is to open the big waste bags so that the contents can be sorted out properly using the downstream machines. There are various types of technologies commercially available in the market. In Thailand, most of the pre-shredders are sourced from foreign countries as they are more robust and durable. Most of the pre-shredders use a combination of stationary and moving blades to cut open the big bags. Hence, the wear and tear is high on the blades of the pre-shredder.

2.1.5. Disc screen

This unit does a size separation process with the aim of removing smaller particles (mainly Organic Fraction of MSW) from the fresh MSW stream or old waste. The disc screen contains rotating steel discs to impact the contents of the MSW. The open space between each disc allows the smaller particles to drop down and be transferred to the other processes.

The disc screen is more suitable than a trommel for MSW in Thailand, as the MSW is very wet with a moisture content of around 40-60%.

2.1.6. Air Classifier

The air classifier is a process which separates MSW mainly based on the density of the contents. This process applies rising air jets to the material stream. As a result, the light fractions are blown upward and the heavy fractions fall down. The light fraction usually contains plastic bags and other plastic materials which are light and have lower density. These materials can be processed into RDF for sale to the cement industries. The heavy fraction is usually a reject or non-biodegradable materials which can be sent to the landfill for final disposal.

2.1.7. Overband magnet

The overband magnet uses a powerful magnet to remove iron from the waste stream and deliver it to a storage area where it can be collected for sale.

2.1.8. Manual sorting

The manual sorting is done by staff on both sides of a long conveyor belt, collecting or removing particular type of waste from the waste stream. For example, in the RDF stream, the staff would remove unwanted materials such as non-metals, ceramic, bones, etc. This unit can be expensive in some advanced countries. Since the labour cost in Thailand is still relatively cheaper, this method would be applied in the near final production stage of RDF. The most important is to train the staff to be careful on what to remove and what not to remove.

2.1.9. Fine shredder

This is to cut the materials into small particles by using rotating blades. The final sizing depends on the purpose of usage of the product. In case of RDF, the buyer may require that the RDF be shredded into a particular size for feeding into the cement kiln or RDF boiler. Hence, it is important to design this system according to the requirements of the buyers.

- **Investment cost**

The investment cost associated with establishment of RDF plant is given below:

Table 2-2 Investment Cost of RDF Plant

Description	Year 1 (USD)	Year 2 (USD)	Total (USD)	Remarks
100 tpd RDF plant for processing fresh MSW and LF mining waste	6,496,660	125,000	6.621,660	Excluding cost on licenses and permits fee

2.2 Mahasarakham SWM project

Mahasarakham Municipality covers an area of approximately 24 sq.km. Most communities are located within the downtown area. Currently, the community is still expanding including residential areas, commercial buildings, factories, hotels, educational institutions and hospitals.

Moreover, Mahasarakham is also one of the educational centres in the Northeast region with many institutes such as the University of Mahasarakham, Rajabhat Mahasarakham University, College of Physical Education, etc. These university students, who mostly come from other areas, are also one of the main waste generators.

Currently, the Mahasarakham Municipality has the responsibility to handle the solid waste that is generated in the municipality which is about 56 tons/day. The waste collection system in the Municipality is predominantly the door to door system. This waste is collected from the 200 litre-bin, 250 litre-bin and also from the commercial areas are served by 4.6 m^3 containers.

The collection fleet includes 17 waste collection trucks (compaction trucks, pick-up trucks, green waste collection truck, and container truck) used for the waste collection in the municipality. At the 11 major street areas, the waste is collected on daily basis. However, for the other areas, the waste is collected once in every 2 days.

This collected waste is transferred and tipped at the Municipality's landfill which is about 12 km away from the city. Currently, the site commits to receive the other wastes from 16 neighbouring municipalities. Based on the current inappropriate method of operation, the Municipality officials consider that the site is almost full and can be operated until 2018. However, due to the limitation in the operating budget, the site has operated between an Open Uncontrolled Dumpsite and a Controlled Dumpsite for a long time. Last year, the Municipality received funding to improve the on-site for constructing soil dikes to prevent the runoff water and for maintenance of some of the operating machineries.

There are two direct divisions responsible for dealing with solid waste management in this municipality. They are Division of Public Health and Environment (PHE) and Division of Bureau of Public Work (BPW). The PHE has the responsibility to clean the streets and footpaths in the

municipality, to collect the waste in the municipality and to transfer the waste to the landfill site. BPW manages the landfill.

The Municipality of Mahasarakham is planning for a major upgrading of its existing landfill facility to bring it in line with the international standards for municipal waste landfills. However, experience from the other municipal governments in Thailand suggests that the best practices for designing, constructing and operating new landfill infrastructures often are not implemented when left to the local government management only. Instead, it is better to outsource the works at least during the construction and early to mid-stage operations.

The Thai central government has recognized that Operation and Maintenance (O&M) of landfill and waste treatment/disposal sites are too complicated for many Local Administrative Organizations (LAOs) to handle (as they actually lack technical knowledge and experience). Hence, in the recent years, the Government has encouraged the LAOs to outsource the waste management services to the private sector and LAOs to become the regulators.

Successful upgrading and sustainable professional operation of the landfill is an important pre-condition to use other disposal techniques such as Refuse Derived Fuel (RDF) and WTE, which the Municipality hopes to explore afterwards.

2.1.10. Waste composition:

The composition of waste disposed at the landfill at Mahasarakham is given below:

Table 2-3 Waste composition of Mahasarakham

Waste Type	Percent (%)
Paper/cardboard	16.99
Glass	1.69
Plastic	21.17
Textile	4.14
Metal	2.17
Food waste	47.09
Green/Garden waste	0.26
Rubber	2.06
Leather	0
Household hazardous waste	1.32
Stone, ceramic	2.28
Miscellaneous	0.83

- **Technical context**

The waste disposal site is currently divided into two completed cells and the current operating cell, separated by a rural road. There is also another undeveloped cell which has some landfill development restrictions at present.

The current dumpsite requires significant remediation before closure, in terms of reducing the slope of the external batters which range from 45° up to the angle of repose for the waste deposited. External batters are not high being less than a maximum of 8 to 10 metres and commonly only 5 or 6 metres high above the surrounding natural ground level.

Once the external batter slopes have been reduced to the required 1 vertical to 2.5 horizontal, then the intermediate soil cover to a thickness of 300 mm needs to be applied. The city will need to determine whether the existing footprint of the waste mound extends beyond the actual property boundaries, and if so, must determine the allowable limit of the remediated site's footprint. At the time of reporting, both solid waste and leachate were observed on the adjacent properties beyond the footprint of the operation.

Cover soil required for the remediation of the site could possibly be found on site. However, this needs to be determined by the city when reviewing the foot print of the cell compared with the property boundary, and possible access to the undeveloped corner block. If there is little other virgin land available within the defined property area, then soil will have to be imported to the site.

The first performance target will be to ensure that all external storm water runoff is directed away from the landfill cells where small valley features may bring rainwater runoff into the cell location. No runoff should be allowed to enter the cell site. The existing external storm water diversion network requires remediation and also is currently carrying large volumes of leachate and solid waste which must be removed.

The second component of landfill development will be the excavation of the base of the first landfill cell to satisfy engineering requirements in terms of slope for requisite lateral drainage of any leachate above the liner, and also the minimum longitudinal slope for achieving pipe flow velocity requirements. The existing waste would be shaped to provide the requisite Vee shape with both lateral and longitudinal fall as required. The V shaped waste would then be proof compacted preferably using a 50 tonne roller to provide a stable base for the placement of the clay liner. Given the observed clay content of the soil on site, a relatively impermeable basal liner will then be constructed on the prepared and sloped base by placing 3 to 4 layers of 200 millimetre thick compacted clay.

A network of leachate drains will then be installed on top of this liner with slotted pipes installed within a gravel surround to maximize leachate interception efficiency. The leachate pipes will direct leachate into a leachate pumping station located at the downstream end of the first cell. Suitable pumping equipment will be installed within the station to facilitate the irrigation of collected leachate during dry weather over previously worked areas or access roads. In wet weather, a reinjection pit will be constructed at the top of the waste mound to allow leachate to be directed into the top of the mound for absorption within the upper drier waste lifts within the cell.

Other engineering activities will be required, such as a provision of suitable water supplies and wastewater management from the ablution facilities and truck cleaning activities, as well as the installation and maintenance of access roads and landfill equipment and the posting of appropriate signage. The existing weighbridge must be either repaired or a new one installed to allow accurate weighing of waste tonnage into the site as this will be the basis of payment for the landfill privatized operation.

The operation of the site will then be in accordance with the accepted Operations Manual and Environmental Management and Monitoring Plan requirements. One of the key aspects will be to ensure regular cover of the exposed waste with appropriate soil to a minimum thickness of 150 mm. Intermediate areas must be covered to a depth of at least 300 mm with final cover being 600 mm thick.

The other key operational strategy will be to maximize the slope of waste batters within the site to minimize rain water infiltration, and therefore, minimizing the volume of leachate formed. External batters should be at the standard site of 1 vertical to 2½ horizontal and with daily working areas and dumping tables having a slope of no less than 5% at any time. Waste on the current site is far too flat which would be maximizing leachate formation. A subset of these activities would include having defined allowable tipping areas rather than allowing waste to be deposited almost anywhere on site, and the establishment of an appropriately sized tipping face to minimize the amount of exposed waste at any time.

Other operational requirements, such as collecting any litter on site due to truck spillage or wind, will be included. General operational requirements should also address flies, rodents and odour issues as appropriate; however these should be readily manageable if the site is operated as described above.

- **Cost estimations**

The capital expenditure associated with rehabilitation of existing landfill plant is given below,

Table 2-4 Capital expenditure of landfill plant rehabilitation

Description	Cost (USD)
Capital expenditure based on design, build and operate model	1,006,130

2.3 Mandalay SWM project

Waste developed in the six townships making up Mandalay is collected by the Mandalay City Development Committee (MCDC) staff, and not the private contractors.

The collection service is notionally door to door, however large areas are serviced by the community bins and informal primary dumping areas located throughout the city. These bins are also used by commercial and institutional waste generators.

The collection fleet is a mixture of waste compactor vehicles, tipping vehicles, hook lift bins with both covered and uncovered containers, small tricycle collection vehicles and push carts. Overall the collection service is barely adequate and requires improvements to bring Mandalay in line with the more progressive cities in the region.

Wastes are taken to one of two dumping sites located in the north and the south of the City, respectively. Both dump sites are operated essentially as uncontrolled open dumps but with some attempts to provide limited compaction and cover.

The available footprint area has been almost fully utilized on both the sides. However, the depth of waste at both sites is less than 10 metres indicating that by operating the sites with the usual compaction and batter slopes, then 3 to 5 years of additional life would be made available without extending the footprint area.

A number of information and education campaigns have been undertaken and materials are being made available for the ongoing campaigns subject to the availability of fund.

Significant recycling occurs at all stages, starting from households sales of high value recyclables to private sector operators going door to door, recovery from the primary dumping locations and from scavenging activities at the final dumping sites.

The MCDC Cleansing Department has indicated interest in the private sector participation in its residential and commercial solid waste collection and street cleaning services citing major performance improvement and cost effectiveness as key policy objectives. Hazardous, hospital and construction wastes are viewed as those requiring specialized collection services and those could be considered for private sector participation at a later stage.

Since waste collection and street cleaning are funded mainly by a dedicated property tax allocation, MCDC does not charge residential customers for collection services, but levies charges on commercial customers. Therefore, a private operator would be paid directly by the City. This, in any event, underscores the objectives of the exercise under which an operator should strive to be identified by customers as a significantly improved and sustainable service provider – not as the agent of the City to replace its allocated solid waste purpose property tax with a new collection charge.

In due course, the City may impose a collection charge as a useful policy, but this is a city financial and tax policy issue not necessarily driven by the introduction of a private sector operator in one district of the City.

The proposed project is to introduce significantly improved service to the residential and commercial customer base that would benefit most and help build popular support for the improvement of services across the City.

As the waste collection and cleaning services are essential city services, a wholesale privatization of the entire city should be avoided initially. Rather a pilot project approach is suggested under which MCDC designates only one out of its six collection Townships for private operation. MCDC has chosen the Chan Aye Thar Zan Township for the proposed pilot status under this study. The township has been chosen due to its higher socio-economic profile in which citizen service demands would be expected to be higher.

This type of customer base would be expected to provide regular feedback on operator performance which will help the City to better assess whether performance targets are being met and when necessary to impose penalties on the private operator.

Waste composition:

The composition of waste at Mandalay is given below:

Table 2-5 Waste composition of Mandalay

Waste Type	Percent
Paper/cardboard	1
Glass	2.3
Plastic	22
Textile	0.4

Waste Type	Percent
Metal	0.1
Vegetables, leaves, street refuse	37.4
Woods, bamboo pieces	17.7
Rubber	1.3
Clay, sand, dust (drainage sludge)	17.8

Technical context

The proposed collection service will be based on the door-to-door collection approach supplemented with community bins, mainly required for hard to access areas and also commercial areas including the markets.

The approach is to move away from the most collection being done from the primary dumping locations, where many of these locations are uncontrolled open areas. This approach results in significant visual impact with large piles of municipal waste being left on the streets during the day, and thereby, influencing the general community to also litter or embark on flies. It has been agreed with MCDC that the focus should be on door-to-door collection as well as a system of bins for community access and commercial enterprise usage to avoid having piles of waste left on the street. Any waste that would not be collected directly from the door-to-door activities would be deposited by the community or commercial ventures in the metal skip bins equipped with lids. This means that there is no visible waste throughout the community, and therefore, in conjunction with a suitable community education campaign, will significantly reduce and eventually eliminate the current system of having open piles of waste on the footpath throughout the township.

A second element of the revised collection system is to reduce the amount of labour intensive activities associated with hand loading of waste from the primary dumping locations into collection trucks. This is both very slow as well as dangerous as MCDC workers are coming into direct contact with the waste. The new approach will be to have trucks equipped with front lifting and rear lifting forks which can lift bins directly into the truck so that there is no need for the workers to contact the waste. There will always be some litter around the bins at the primary dumping skip bins which the workers will have to collect, but this will be a relatively in small quantity and therefore, the risk element is greatly reduced from the current system of hand loading of almost all waste.

The third aspect of the revised approach is the use of waste compactor vehicles rather than open tipping vehicles. This means that the efficiency of the waste collection service is greatly increased as the density of waste within the waste compaction vehicles will be 2 to 3 times as much as achieved in a traditional tipping truck. Therefore, the efficiency of collection in terms of tons hauled to the landfill per trip is greatly increased. This is to be further improved by the use of large compactor vehicles carrying up to 28 cubic metres of waste.

To support these large vehicles that will only be able to access the widest roads is a fleet of smaller vehicles that will load the smaller waste skip bins to be located in the narrower streets. In addition to these smaller compactor trucks, small motorized carts or tricycles will be used to access the alleys and very narrow streets throughout the township. These will be supported by

a number of pushcarts for areas that are pedestrian-only accessible. These vehicles will haul wastes to skip bins located on compactor truck accessible roads.

In summary, the approach is to move towards a door-to-door collection service supplemented by the use of metal skip bins rather than open dumping at the primary dumping locations throughout the township. This will be supported by the mechanized lifting of waste into vehicles which will compact the material, thereby, resulting in a far more efficient system and one with much greater health benefits for the workers. The removal of the primary dumping locations, where waste is merely placed on the footpath for subsequent manual loading by the workers, will also encourage the general community to reduce their current littering and fly attracting dumping activities, resulting in a much more aesthetically pleasing township.

- **Cost estimations**

The capital expenditure associated with the establishment of waste collection process is given below:

Table 2-6 Capital Cost of Waste Collection Process

Description	Cost (USD)
Capital expenditure for waste collection fleet and equipment	3,450,500
Operational expenditure for waste collection	1,396,696

2.4 Quezon City SWM project

Both, the community based and door to door collection services are provided for the residents, depending upon their locations and accessibility. These facilities are provided by one of six private collection companies. There are increasing numbers of recycling bins or green waste repository pits throughout the city at present. The main haulage vehicles are a mix of 6 and 10 wheeler tip trucks and garbage compactor trucks. Quezon City's Landfill is located in Payatas within the city boundary and has operated on the site for over 20 years. Overall, the collection and disposal of waste is of a high standard for a city with this socio-economic profile.

Quezon City is projected to run out of waste disposal capacity at the Payatas landfill within 3 to 5 years and sees a WTE facility as its most viable means of waste disposal thereafter. This creates a strong argument for a project alternative, which minimizes less proven innovative features by using conventional technology, and an international standard commercial contract risk allocation structure. Such alternatives increase the chance of accelerated project development cycles to financial close and construction completion – taking into account the urgent need for at least one long term secure solid waste development asset for the city.

The primary objective of the proposed project is Waste Disposal in Quezon City. Electricity sales are a secondary objective -- intended to be by-product revenue, which would reduce the needed tipping fee component of the project revenue stream.

2.1.11. Waste composition:

The composition of waste at Quezon is given below:

Table 2-7 Waste composition of Quezon

Type of Waste	Percentage

Type of Waste	Percentage
Biodegradable	53.95 %
Recyclable	20.30 %
Plastic	9.64 %
Paper	8.65 %
Glass/Bottle	1.15 %
Metals	0.86 %
Residual	25.76 %

- **Technical context**

An evaluation of the moving grate incineration, fluidized bed incineration and gasification technologies was carried out. Apart from environmental, engineering and cost criteria, specific considerations are placed on the feed-stock types, energy desired, end use requirement, pollution control standards, economic performance and other locally specific factors.

Closing non-sanitary dumpsites and promoting waste recovery are the main MSW management strategies of the Philippines. Payatas Landfill is the existing waste disposal site for QC currently receiving about 1,700 tpd of MSW from the city. It is well-engineered and expected to be closed down by February 2019 if there is no extension or modification, such as extending into other precincts or raising the height of the mounds. Based on the discussion with the Quezon City Environmental Protection & Waste Management Department (QCEPWMD) in August 2016, the City Government is considering proposals from WTE companies or other interested investors, such as the French Government and Japan's Ministry of Environment to develop the Payatas Landfill into a WTE facility.

As the treatment capacity of gasification is normally limited to about 450 tpd, and the commercial operation of gasification technology does not have a sound track record yet due to technical and economic difficulties, the incineration technologies which are able to stably process over 1,700 tpd of MSW shall be more appropriate to be considered by the City Government.

Air emission control could be a main challenge of introducing incineration technologies to QC. The Philippines have issued the Clean Air Act of 1999 (Republic Act No. 8749), which prohibits incineration that emits poisonous and toxic fumes. Upon discussing with QCEPWMD, it was clarified that incineration technologies could be accepted as long as the proposed technology complies with the stringent air emission standard in the Clean Air Act. In response to the standard, effective flue gas treatment systems shall be applied. Fluidized bed incinerators normally generate 15-25% more fly ash than the moving grate reactors, which causes higher

flue gas emission, and thus, making compliance with the standards in the Clean Air Act more challenging.

Moreover, about 25% of coal could be used by the technology as supplementary fuel, which may worsen its environmental impact. Also, extensive pre-treatment will be needed for fluidized bed incinerator which adds up to the capital and operation cost, whilst minimum pre-treatment procedures, if any, is required by moving grate incinerators as long as the gross heating value is sufficient.

As a result, moving grate incineration appears to be a suitable WTE solution for QCEPWMD. The advantages of moving grate incineration are summarized as follows:

- Quezon City has a MSW disposal amount of about 1,700 tpd, the moving grate technology is capable of processing such large tonnage of waste with reliable performance.
- The waste of Quezon City consists of higher moisture content and heterogeneous composition. Moving grate technology shows the highest capability to tolerate the fluctuation of MSW characteristics, with robust performance when handling mixed MSW, whereas operation of the other two technologies require pre-treatment of MSW.
- Moving grate incineration has a strong proven track record during the past decades. There is still a concern on operation failure of the gasification technology due to the unpleasant experience in Germany.
- Moving grate incineration has a better environmental performance than fluidized bed technology with widely available pollution control technologies.

- **Cost estimations**

The capital expenditure associated with WTE plant implementation is given below:

Table 2-8 Capital Expenditure of WTE Implementation

Description	Cost (USD)
Capital expenditure	642,097,052

2.5 Sorsogon SWM project

Solid Wastes Management (SWM) implementation in the City is a partnership between the City Government and barangays[1] with the technical support from the Department of Environment and Natural Resource Offices – Environmental Management Bureau V (DENR-EMB V), National Solid Waste Management Commission (NSWMC), Provincial Government, and non-government organizations (NGOs).

Waste collection is conducted initially by barangays on a house to house basis through personnel called “eco-aides” who employ pedicabs or pushcarts to haul wastes. The collected wastes are either brought in a designated area for temporary storage or in barangay-operated

[1] smallest administrative division in the Philippines

Materials Recovery Facilities (MRFs) where still-useful materials such as tin cans, papers, bottles, etc. are set aside from the residual wastes and sold to junkshops. In the case of the former, wastes are brought in the City-level MRF located in Buhatan to undergo recovery and processing while in the latter, residual wastes are collected by the city garbage trucks for final disposal in the city dumpsite.

City Local Government Unit (LGU) garbage collection services currently cover 55 out of 64 barangays. This involves an average of 18 collection trips per day, 12 of which are being conducted in the central business district where the bulk of socio-economic activities and waste generation takes place.

The City of Sorsogon has decided to construct a new controlled landfill facility. Specific objectives include designing and maintaining landfill configuration, surface water management, leachate management and maximizing the landfill capacity. These objectives are best addressed by a Private contractor taking full control of landfill operations and being compensated (i) for construction and remediation on a milestone basis and (ii) for operations on the basis of fee per ton of new waste and (iii) fee for services with deduction for failure to achieve specified performance targets. This ensures a fixed price for construction and remediation and stability in the year to year solid waste disposal operating budget.

2.1.12. Waste composition:

The composition of waste at Sorsogon is given below:

Table 2-9 Waste composition of Sorsogon

Waste Type	Audit (Percent)
Paper/Cardboard	9.11
Glass	1.59
Plastic bags	18.50
Other plastic (PET)	2.40
Metal Cans	1.75
Food Waste and Green waste	48.34
Fabric and Leather	4.17
Hazardous waste	1.54
Rubber	0.77
Diapers	10.99

Waste Type	Audit (Percent)
Styrofoam	0.84

- **Technical context**

There are three sites associated with the contract for solid waste disposal.

The first site is the old Buena Vista dumping site which was closed in 2014, but has not been fully remediated. Works required at this site include extinguishing the fires on site as the highest priority and then covering the exposed waste at the toe of the batter on the main cell. The amount of work required is minimal and could be easily integrated into the development of the new landfill on the adjacent property, particularly in terms of hauling soil to be used as the cover material in the remediation process.

The current dumpsite at Bato requires significant remediation before closure, in terms of reducing the slope of the external batters which range from 45° up to the angle of repose for the waste deposited. Once the external batter slopes have been reduced to the required 1 vertical to 2.5 horizontal and compacted, then the final soil cover to a thickness of 600 mm needs to be applied. The city will need to determine whether the existing footprint of the waste mound extends beyond the actual property boundaries, and if so, must determine the allowable limit of the remediated site's footprint.

Cover soil required for the remediation of the site could possibly be won on site. However, this needs to be determined by the city when reviewing the foot print of the cell compared with the property boundary. If there is little virgin land available within the defined property area, soil will have to be imported to the site.

In terms of the approach to remediation, it would be appropriate to keep operating the site in parallel as the new landfill is being developed. However, the contractor will be obliged to operate the old Bato dumpsite such that the new waste is placed to provide the required final batter slopes. This placement of new waste would be sensibly integrated with the flattening of the external batter slopes to provide the overall required final configuration and slopes.

Given the small size of the site and the increasingly higher clay content within the soil profile at increasing depth, it is considered that it would be unnecessary to remove all waste and place a basal low permeability liner under the mound area. Similarly, given the small size of the site and its remoteness, it is considered unnecessary to install a perimeter leachate interception drainage system leading to a pump station for leachate irrigation or reinjection during wet weather. The site is simply too small to warrant these extensive engineering interventions and are considered unnecessary with the remediation approach described above.

A controlled landfill will be developed at the new Buena Vista site. The site has good topography in terms of the main valley feature with reasonable slopes and with the head of the valley being within the property boundary.

The first performance target will be to ensure that all the external storm water runoff is directed away from the landfill cell where small valley features may bring rainwater runoff into the cell location. No runoff should be allowed to enter the cell site.

The second component of landfill development will be the excavation of the base of the landfill to satisfy the engineering requirements in terms of slope for requisite lateral drainage and also the longitudinal slope for pipe flow velocity requirements. Given the observed clay content of the soils on site, a relatively impermeable basal liner will then be constructed on the prepared

and sloped base by placing 3 to 4 layers of 200 mm thick compacted clay. The final design requirements will be agreed upon with the DENR during detailed design.

A network of leachate drains will then be installed on top of this liner with slotted pipes installed within a gravel surround to maximize leachate interception efficiency. The leachate pipes will direct leachate into a leachate pumping station located at the downstream end of the first cell. Suitable pumping equipment will be installed within the station to facilitate the irrigation of collected leachate during the dry weather over previously worked areas or access roads. During wet weather, a reinjection pit will be constructed at the top of the waste mound to allow leachate to be directed into the top of the mound for absorption within the upper drier waste lifts within the cell.

Other engineering activities will be required, such as a provision of suitable water supplies and wastewater management from the ablution facilities and truck cleaning activities, as well as the installation and maintenance of access roads and landfill equipment and the posting of appropriate signage.

The operation of the site will then be in accordance with the accepted Operations Manual and Environmental Management and Monitoring Plan requirements. One of the key aspects will be to ensure regular cover of the exposed waste with appropriate soil to a minimum thickness of 150 mm. Intermediate areas must be covered to a depth of at least 300 mm with final cover being 600 mm thick.

The other key operational strategy will be to maximize the slope of waste batters within the site leading to minimization of rain water infiltration, and therefore, minimizing leachate volumes. External batters should be compacted and trimmed at the standard site of 1 vertical to 2½ horizontal and with daily working areas and dumping tables having a slope of no less than 5% at any time. A subset of these activities would include having defined allowable tipping areas rather than allowing waste to be deposited anywhere on the site, and the establishment of an appropriately sized tipping face to minimize the amount of exposed waste at any point of time.

Other operational requirements such as collecting any litter on site due to truck spillage or wind will be included.

Cost estimations

The capital expenditure associated with landfill operation is given below.

Table 2-10 Capital expenditure of landfill operation

Description	Cost (USD)
Capital expenditure based on design, build and operate model	568,350

2. GHG emission reduction potential of the project

The GHG emission reduction in any project depends on the baseline existing scenario and the proposed alternative project technology/practices. The existing scenario of the solid waste disposal, proposed project scenario and GHG emission reduction potential for each of the CSCs are discussed in this chapter.

3.1 Buriram SWM project

2.1.13. Baseline scenario:

The waste generation rate of Buriram city is approximately 90 tpd, with about 58% being recycled while the remaining 42% is disposed in the landfill site at Muang Buriram, Buriram province. This site has been in operation since 2000. The landfill area is 16 hectares, partitioned into 4 phases. The total quantity of solid waste disposed to the sanitary landfill is 86tpd 41) tpd from Buriram municipality and 45tpd from other municipalities/cities .(Currently, the operation is at the final phase area and the Municipality has estimated the remaining life time as 4 years. Overall, the site is reasonably well run but the fundamental operational and design errors cannot be attributed to the budget limitations.

2.1.14. Project scenario:

Buriram is relatively a small city and far too complex to operate sanitary landfill without ongoing external technical support for some years. Also, it yields only little environmental gain from the waste disposed. Only 31% of the waste is organic (~26 tpd) and it is expensive to establish a composting process for such low quantities. The WTE plant requires high capital and operating costs, which makes the process non-viable unless the provincial or national government is committed to subsidize its operation for its life time. Due to the budget limitations and operational difficulties, the controlled landfill is the most appropriate disposal system for the city. Hence, the proposed project in Buriram city will be to install a refused derived facility (RDF) processing plant of capacity 200 tpd in the existing landfill without landfill gas flaring. The other options can be considered for implementation at later stage accordingly.

2.1.15. GHG emission reduction potential:

The emission reduction potential of this project activity is calculated based on the methane emissions from the solid waste disposal.

The project activity involves treating the MSW waste through RDF facility and preventing it from being disposed in the solid waste disposal sites and the methane that would have been generated is avoided from the solid waste disposal site. The amount of methane generated from the disposal of waste at the solid waste disposal site (SWDS) is calculated based on a first order decay (FOD) model. The estimation procedure for emissions from solid waste is furnished in the annex 1. The GHG emission reduction from waste to energy plant is estimated approximately to be 33,174 tCO_2e/year. The estimations are given in Annex 2.

3.2 Mahasarakham SWM project

2.1.16. Baseline scenario:

The waste generation rate of Mahasarakham is approximately 56 tpd and the waste is disposed at the landfill site located at Nongping district, Mahasarakham province. The landfill has been in operation since 1997 with a total area of about 8 hectares, which comprises of 4 disposal zones. Two disposal zones are intermediately covered and the third zone is currently in operation. The landfill site is operating between uncontrolled and controlled disposal site, where majority of the site has uncovered waste placed at very flat slopes, therefore maximizing the leachate generation. Overall, the site is very poorly operated. Fundamental operational and design errors are compounded with the budget limitations also impacting the suitable equipment and material availability such as an adequate supply of soil cover for daily, intermediate and final cover application.

2.1.17. Project scenario:

Mahasarakham authorities encourage composting of waste at household level to minimize the waste quantum. The Waste to Energy plant requires high capital and operating cost, which makes the process unviable unless the provincial or national government is committed to subsidise its operation for its life time. Due to the budget limitations and operational difficulties, the controlled landfill is the most appropriate disposal system for the city. Hence, the proposed project in Mahasarakham city will be a controlled landfill site without any options such as composting, landfill gas flaring, refused derived fuel (RDF) or WTE. These options could be considered later, once the generated waste quantity becomes sufficient.

2.1.18. GHG emission reduction potential:

Since there is no flaring of landfill, composting or any other means of energy generation (power/thermal) proposed in the project activity, GHG emission reduction potential shall be considered negligible.

3.3 Mandalay SWM project

2.1.19. Baseline scenario:

The current waste collection services are generally substandard with generation rate of 177 tons/day. A significant quantity of waste is left on the streetscape as well as being dumped or washed into the local drains and water bodies. The collection fleet is a mix of modern compactor vehicles, but is dominated by old tipper style vehicles which provide no compaction. There are also some hook lift bins servicing hard to reach areas of commercial and institutional waste generators. The operations of both the northern and southern landfills are very substandard. The landfills accept waste from the nearest townships within the city. The landfills are essentially operated as uncontrolled dumps, where both sites have extensive areas of uncovered waste and are placed at very flat slopes and therefore, maximizing leachate generation and associated hazards.

2.1.20. Project scenario:

The proposed project to Mandalay city is effective and efficient waste collection system with modern and high quality haulage equipment and disposal to the existing landfill site. WTE plant, flaring of landfill and composting process are not considered now.

2.1.21. GHG emission reduction potential:

Since the project activity deals only with the waste collection and disposal, GHG emission reduction potential will be negligible.

3.4 Quezon City SWM project

2.1.22. Baseline scenario:

Payatas landfill serves Quezon City (QC) and the site operation has been privatized over the past decade. It continues to be well operated and maintained. This city is well advanced in terms of overall SWM planning and implementation, including having privatized collection activities. Payatas Landfill, the existing waste disposal site for QC which receives about 1,700 tpd of MSW from the city is well-engineered and expected to be closed down by February 2019 if there is no extension or modification, such as extending into other precincts or raising the height of the mounds.

2.1.23. Project scenario:

Closing non-sanitary dumpsites and promoting waste recovery are the main MSW management strategies of the Philippines. The incineration technologies which can stably process over 1,700 tpd of MSW shall be considered by the City Government.

2.1.24. GHG emission reduction potential:

The emission reduction potential of this project activity is calculated based on the methane emissions from the solid waste disposal and electricity consumed by the grid in the absence of project activity.

The project activity involves treating the MSW waste through incineration and preventing it from being disposed in solid waste disposal sites and the methane that would have been generated is avoided from the solid waste disposal site. The amount of methane generated from the disposal of waste at the SWDS is calculated based on the FOD model. The estimation procedure for emissions from the solid waste is given in the annex 3. The GHG emission reduction from the WTE plant is estimated to be approximately 53,499 tCO_2e/year. The estimations are given in Annex 4.

3.5 Sorsogon SWM project

2.1.25. Baseline scenario:

The total waste generated is about 34.8 tpd. The existing final disposal facility in the city is the Bato Dumpsite located in Barangay Bato, Bacon District. It is a controlled dumpsite with a total area of two hectares owned by the City Government and is about 25 kilometres from the city centre. It has been in use since the 1990s as a dumpsite of the then Municipality of Bacon and remained as a disposal facility of the Bacon District after that. In 2014, the City Government has stopped the dumping activities in Buena Vista Dumpsite and has directed the disposal of all wastes in Bato Dumpsite.

2.1.26. Project scenario:

The SWM Plan provides for the improvement of the City Government's waste collection with emphasis on segregation, waste recovery and final disposal systems. This will include acquisition of additional garbage trucks in the next three years to replace old units; operationalization of City material recovery facilities (MRFs), remediation of old Buena vista dumpsite and current dumpsite at Bato and establishment of categorized new Sanitary Landfill in 2018 at Buena vista.

2.1.27. GHG emission reduction potential:

Since there is no flaring of landfill, composting or any other means of energy generation (power/thermal) taking place in the project activity, the GHG emission reduction potential shall be considered negligible.

3. Global CDM situation

At the 1992 Rio Earth Summit, countries agreed to the United Nations Framework Convention on Climate Change (UNFCCC) in response to growing evidence that human activity was contributing to global warming. The UNFCCC contained a non-binding commitment by industrialized countries that they would reduce their emissions of GHGs to 1990 levels by the year 2000. It soon became clear that this was not enough to avoid dangerous climate change. That's why at the first Conference of Parties (COP) in 1995 after the Convention entered into force, Parties began to negotiate a Protocol that would set tighter and legally binding targets for reducing GHG emissions to certain countries.

At the 3rd COP to the Convention in Japan in 1997, Parties agreed on the Kyoto Protocol that set targets for industrialized countries to reduce their domestic emissions by an average of 5% below 1990 levels in the period 2008-2012, known as the first commitment period. To help reduce the cost of meeting these reduction commitments, three market-based "flexible mechanisms" were designed: Emissions Trading (ET), Joint Implementation (JI) and the Clean Development Mechanism (CDM).

While different in operation, these three mechanisms are based on the same principle: to allow industrialized countries to reduce emissions wherever in the world those reductions are cheapest, and then count those reductions towards their national target. JI and the CDM are called "project-based" mechanisms because they fund actual projects; JI generally funds projects in Eastern Europe and the former Soviet Union, while CDM projects can only happen in the developing countries which do not have an emissions reduction target under the Kyoto Protocol. As such, the CDM is the only part of the Kyoto Protocol that directly involves developing countries in reducing GHG emissions. The CDM is also different in that emission reduction credits that have been generated by CDM projects since 2000 can be counted as reductions in the period 2008-2012. Lastly, the CDM has an explicit mandate to promote sustainable development, unlike JI or Emissions Trading.

In the 7thCOP to the UNFCCC in 2001, most of the rules for the CDM were agreed and enshrined in the so-called Marrakesh Accords. These served as the foundation for CDM rules. Parties have since developed that set of rules within the context of the so-called "CDM Reform." The Marrakesh Accords also established the CDM Executive Board to supervise the CDM, under the authority and guidance of the Meetings of the Parties to the Kyoto Protocol.

The Kyoto Protocol entered into force in February 2005. It has been ratified by all Annex I countries except the United States of America. The first CDM project was registered on 18 November 2004, and the next ones followed rapidly. On 6 January 2010, the 2,000th project was registered. So far, all the registered projects have generated more than 365 million certified emission reductions (CERs). Each CER corresponds to 1 ton of CO_2 reduction. The CDM process under UNFCCC is described in detail in Annex 5 and financing mechanisms for CERs are given in Annex 6.

2.1.28. Uncertainty of CDM

As the Kyoto Protocol expired in 2012, the future for second commitment period (2013-2020) of the Kyoto Protocol was unclear. At climate summit in Copenhagen on December 2009, Parties did not agree on any legally binding outcome. In December 2012, at the end of the Doha Conference 2012, an agreement was reached to extend the Protocol to 2020.

In Paris Conference 2015, a new climate treaty called the Paris Agreement (Agreement) for the post-2020 period was proposed. This treaty has legally commenced in November 2016 as sufficient number of countries (Parties) had ratified the Agreement. The CDM's Executive Board

is working on the post-Paris developments to see how the Kyoto Protocol scheme could fit into a new international carbon market regime, while continuing to improve the global carbon market for new sources of demand. The CDM Executive Board is also considering new options to use the CDM as a "tool for other uses", including tapping potential demand from South Korea's ETS and non-carbon market sources including the Green Climate Fund and green bonds[2].

2.1.29. Present status of CDM

As of 31 January 2017, around 7,758 projects are registered under CDM and 190 projects are in pipeline. Around 3,027 projects were issued with approximately 1,700 million CERs. The registered CDM projects in UNFCCC by host countries are shown in Figure 3-1[3].

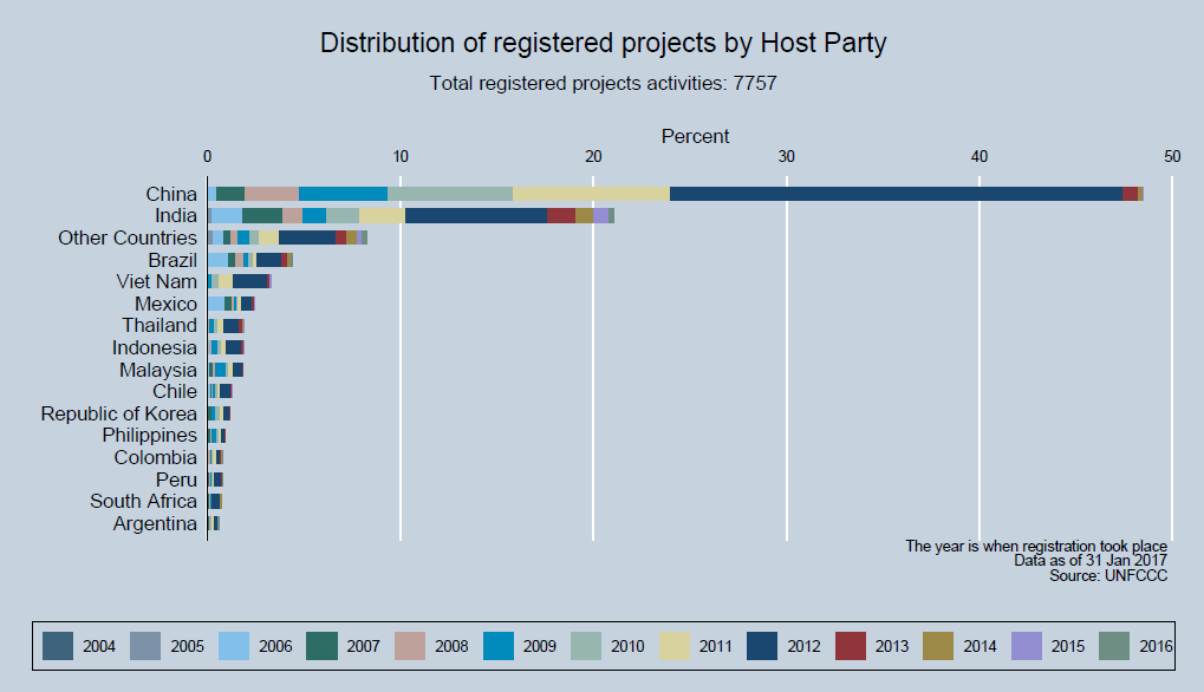


Figure 3-1Registered CDM projects in host countries

From the registered projects so far, it is expected that 7,500 million CERs would be generated by 2020[4]. **Error! Reference source not found.** shows the CERs expected to be issued by 2020 from the CDM projects by project type.

[2] https://carbon-pulse.com/17087/

[3] https://cdm.unfccc.int/Statistics/Public/CDMinsights/index.html

[4] https://cdm.unfccc.int/Statistics/Public/CDMinsights/index.html

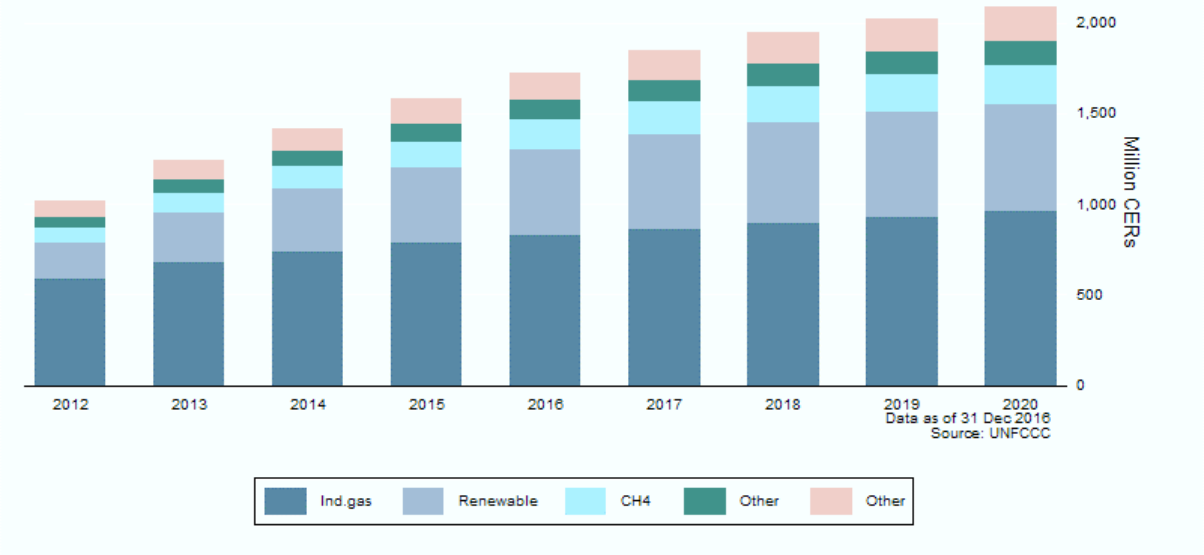


Figure 3-2 Expected CERs issuance by project type until 2020

Voluntary cancellation of CERs has now increased to 17.5 million CERs. In South Korea, the CERs can be converted into Korean Carbon Units if they are from CDM projects in South Korea and are cancelled voluntarily. This has happened already for 11.7 million CERs.

4.1 CER market price trend

In the first commitment period (2008-2012), CDM is a billion dollar market floated with a price range of 12-16 USD per CER. Post 2012, the CER price drastically started to decline from 4.28 USD to 0.42 USD and still remains the same. The market trend of CER from 2010 to 2016 is shown in Figure 3-3.

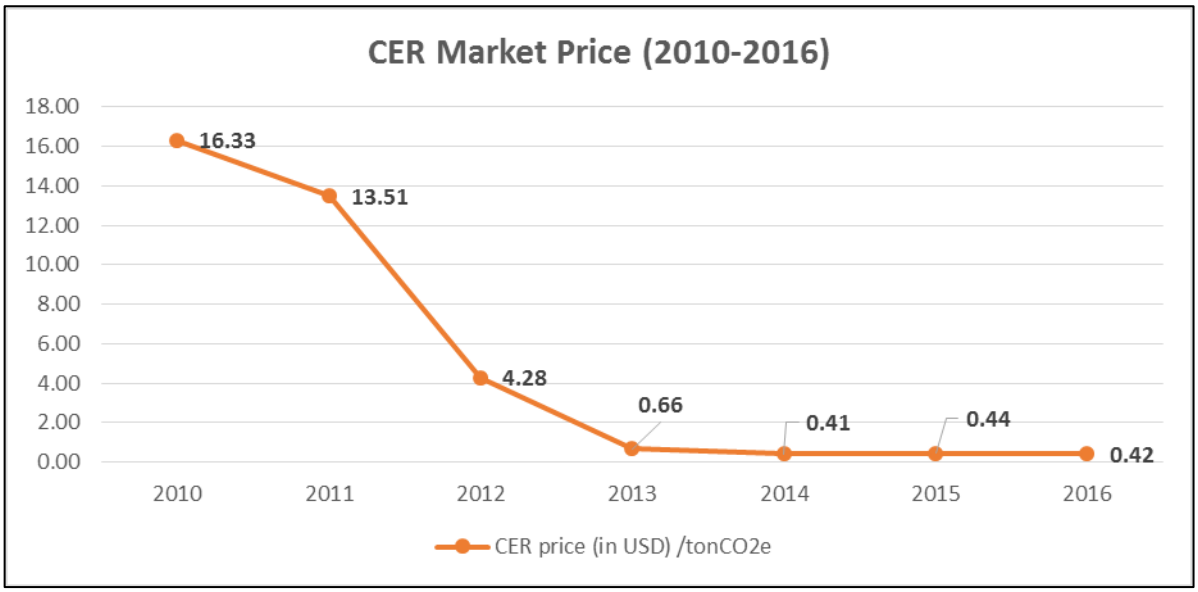


Figure 3-3 CER market trend (2010-2016)

The potential supply of CERs unit 2020 is given in Figure 3-4.

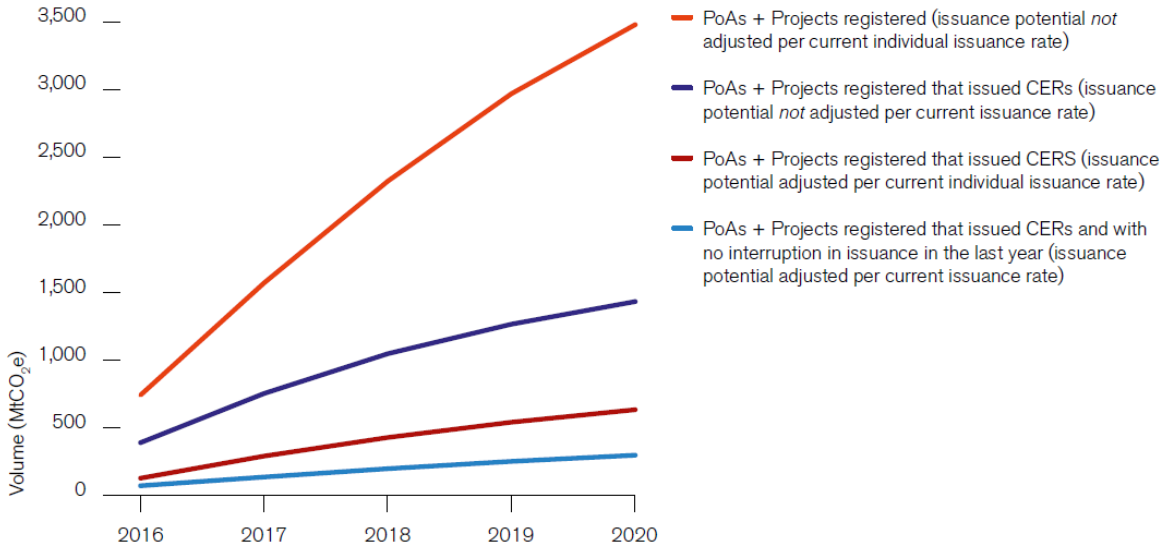


Figure 3-4 Potential CER supply until 2020

Source: Source: Authors, based on UNFCCC data as of August 2016.

4.2 CER price by Institutional Organizations

The purchase of CER mainly takes place by Emission Reduction Purchase Agreement (ERPA). ERPA is a transaction that transfers carbon credits between two parties under the Kyoto Protocol. The buyer pays the seller in exchange for carbon credits, thereby allowing the purchaser to emit more carbon dioxide into the atmosphere. The standards for these agreements are outlined by the International Emissions Trading Association (IETA). This agreement usually involves two countries; however, it may occur between a country and a large corporation.

The World Bank is currently purchasing CERs based on ERPA signed between the two parties at a price of USD 4-8/CER, whereas Asian Development Bank (ADB) is procuring at a rate of around USD 10/CER[5].

4.3 COP 21 and CER price impact

The conference of parties 21 (COP 21) also known as the 2015 Paris Climate Conference, was held in Paris from 30 November to 12 December 2016 attended by 196 countries, with the aim of achieving a legally binding and universal agreement on climate and keeping global warming below 1.5 ^{o}C. The Paris agreement entered into force on 4 November 2016, after ratification by 125 countries accounting for 55% of total greenhouse gas emissions.

[5]The National Grid Improvement Project, Chhattisgarh and Haryana, India

The key outcomes of the Paris agreement are:

Reaffirm the goal of limiting global temperature increase well below 2°C, while urging efforts to limit the increase to 1.5°C

Establish binding commitments by all parties to make "nationally determined contributions" (NDCs), and to pursue domestic measures aimed at achieving them

Commit all countries to report regularly on their emissions and "progress made in implementing and achieving" their NDCs, and to undergo international review

Commit all countries to submit new NDCs every five years, with the clear expectation that they will "represent a progression" beyond previous ones

Reaffirm the binding obligations of the developed countries under the UNFCCC to support the efforts of developing countries, while for the first time encouraging voluntary contributions by the developing countries too

Extend the current goal of mobilizing $100 billion a year in support by 2020 through 2025, with a new, higher goal to be set for the period after 2025

Extend a mechanism to address "loss and damage" resulting from climate change, which explicitly will not "involve or provide a basis for any liability or compensation"

Require parties engaging in international emissions trading to avoid "double accounting"

Call for a new mechanism, similar to the Clean Development Mechanism under the Kyoto Protocol, enabling emission reductions in one country to be counted toward another country's NDC.

2.1.30. CER impact by COP 21

The CDM market remains the same after the successful COP 21. There is no observed increase in the CER price.

4.4 US election and CER price impact

2.1.31. Mr. Donald Trump views on climate change and environment:

Doesn't accept the scientific evidence that climate change is real

Wants to dismantle the Paris agreement

Clean water may be one of the "most important issues that is faced as a nation for the next generation"

Wants to keep public lands in the control of the federal government
The President-elect, Mr. Donald Trump has described climate change as a hoax invented by China to undermine US manufacturing and pledged to withdraw from the world's first comprehensive treaty to tackle GHG, the Paris Agreement.

Mr. Trump implied that the US shouldn't waste financial resources on climate change and should instead use them to ensure the world has clean water, eliminate diseases like malaria, increase food production, or develop alternative energy sources. There is still much that needs to be investigated in the field of climate change.

The signs are pretty obvious that Mr. Trump does not support action on climate change, and that his team will act against it," said Corinne Le Quere, professor of climate change science and policy at the University of East Anglia.

Professor Le Quere said many of the people appointed to senior positions by Mr. Trump had rejected the risks of climate change or had links with the fossil fuel industry. Some of the advisors in Trump's transition team have proposed to cut down climate research at NASA, and they have requested names of scientists working on climate change at the US Department of Energy.

Mr. Trump's administration could cause damage on US-funded climate change research, which would have an impact around the world, including the UK.

If Mr. Trump fails to take climate change seriously, the federal government may do little to address the threat of a warming planet in the next four years. A presidential administration hostile to climate science also threatens to deepen, or at the very least prolong, the skepticism that already exists in American political life. As of today (06 Feb 2017), Mr. Trump has not issued any order to withdraw US from the Paris Agreement.

2.1.32. CER impact

The implications of Mr. Trump's plans to withdraw from the Paris agreement are more complex and speculative. Mr. Jonathan Grant, Director of Climate and Sustainability, PwC, said G20 countries need to reduce their carbon intensity - the amount of CO_2 they emit for every dollar of GDP they produce - by an annual average of 3 percent to meet their Paris agreement targets. Even if the US abandoned the deal it would have a limited direct impact on the overall G20 effort. If all other countries stayed on track to meet their carbon targets, but the US returned to business as usual, the average annual cut for the G20 as a whole would only fall slightly, from 3 percent to 2.8 percent. That is chiefly because of market developments such as the US shale gas boom that has squeezed out coal, the dirtiest fossil fuel, a situation some think unlikely to change no matter what Mr. Trump does. The impact on the global emission projection is pretty small even if the US shelves its Paris target.

4. Other Carbon trading mechanisms

The carbon market deals with two different kinds of markets namely compliance and voluntary carbon markets having unique key components known as cap and trade.

The Cap involves setting a limit on the total quantity of GHG emissions allowed to be released over a given period of time. The trade establishes a market for these permits by allowing organizations to buy and sell depending on whether they have a shortfall or surplus in allowances.

The overall aim of emission trading scheme is to minimize the cost of meeting a set emissions cap. The emissions are traded in one metric ton of CO_2 units internationally after the validation of UNFCCC. Various countries have adopted emission trading systems and carbon taxes as one of the strategies for mitigating climate-change by addressing international GHG emissions.

The total value of the world's emission trading schemes is now around USD 30 billion, with China as the home to the second biggest carbon market after Europe, owing to implementing six carbon markets in Beijing, Guangdong, Hubei, Shenzhen, Shanghai and Tianjin in operation and is expected to launch a national trading system before 2020.

Figure 4-1 shows the emerging and established carbon markets in operation globally where planned or implemented the carbon pricing initiatives like carbon taxes, emission trading systems. etc., take place.

Carbon Emission Trading Systems

The emission trading systems are established to provide a spot market in emissions as well as future and option markets to help discover a market price and maintain liquidity. The market based mechanisms include both international and national trading systems with cost effective climate policy. Some of the market based mechanisms are listed below:

European Union Emission Trading Scheme (EU ETS)

Australian Emission Trading Scheme (AUS – ETS)

China Emission Trading Scheme (C - ETS)

New Zealand Emission Trading Scheme (NZ ETS)

South Korea Emission Trading Scheme (KTES)

Kazakhstan Emission Trading Scheme (KAZ ETS)

Swiss Emission Trading System

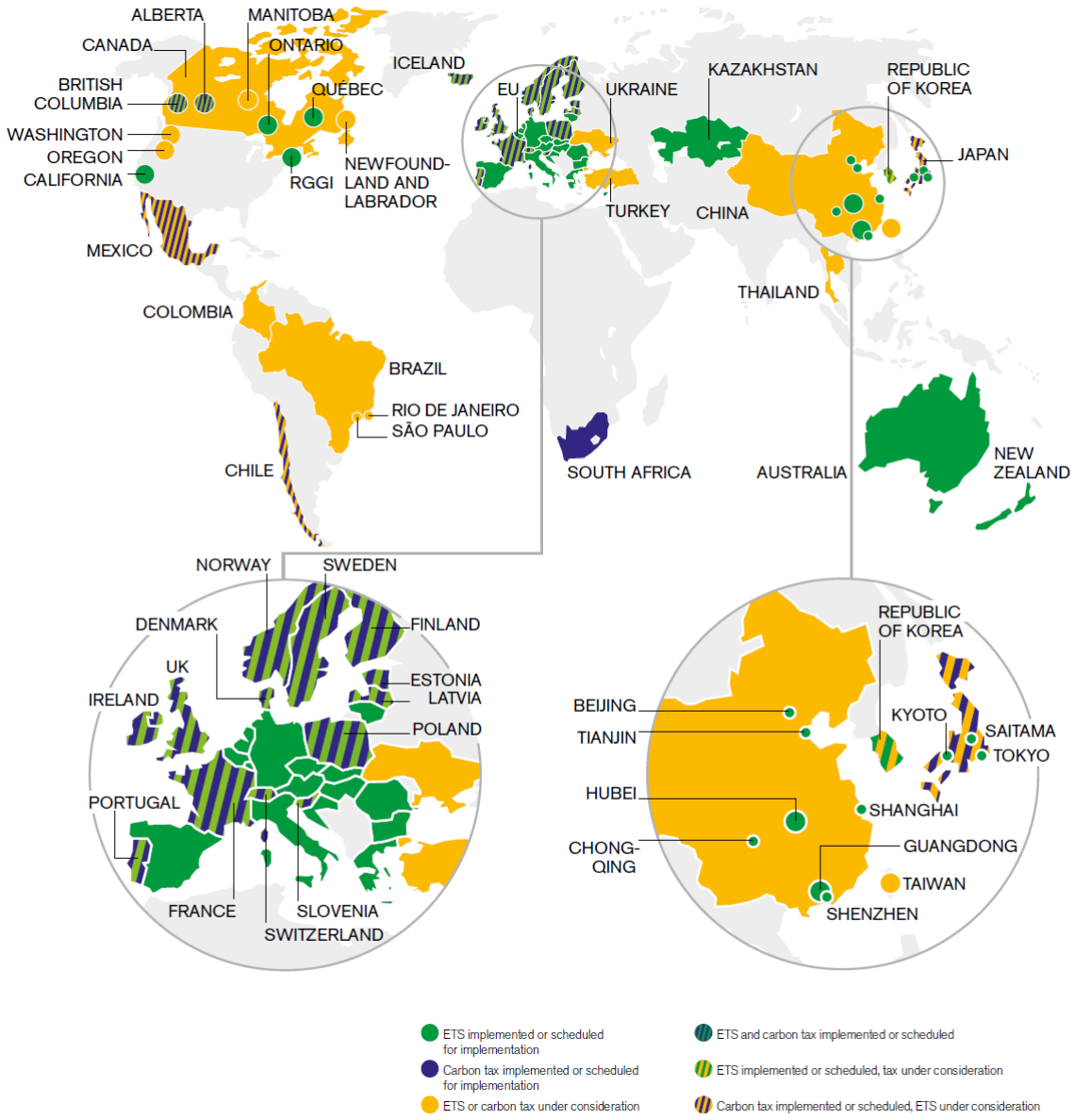


Figure 4-1 Global emission trading mechanisms

5.1 European Union Emission Trading Scheme (EU ETS)

The European Union emission trading scheme (EU ETS) was the first and the largest market for the GHG emission scheme in the world. The EU ETS works on the 'cap and trade' principle. In 2020, emissions from the sectors covered by the EU ETS will be 21% lower than in 2005. By 2030, the Commission proposes, they would be 43% lower.

To provide greater price stability and predictability in the EU ETS, the market stability reserve was legislated in October 2015 and will start shaping the supply of allowances from January 2019. In addition, in July 2015 the European Commission put forward a proposal to revise the EU ETS post-2020. The key changes include an increase in the annual cap reduction factor from 1.74 to 2.2 percent, better targeted and updated rules for free allocation of allowances to sectors at the highest risk of carbon leakage, and the establishment of funds to finance low-

carbon innovation in industry and modernization of the energy sectors in lower-income member states. The proposal does not include any provisions for the use of international credits after 2020. The other two legislative bodies of the EU, the European Council and Parliament, are currently discussing the proposal. So far, the proposal has not led to a significant increase in the EU Allowance (EUA) price, due to the persisting oversupply in the EU ETS. The EUA price was €4/tCO_2e (USD 4/tCO_2e) on August 1, 2016.

A separate proposal for the Effort Sharing Regulation was tabled on July 20, 2016. This legislative proposal establishes the binding emission reduction targets of each of the Member States over the period 2021–2030 for the emissions not covered by the EU ETS. The proposal includes a one-off flexibility mechanism that permits some Member States to use a limited number of allowances from their share of the EU ETS auction volume to meet their emission reduction target in the non-ETS sectors, effectively reducing the allowance supply in the EU ETS.

This mechanism is limited to 100 $MtCO_2e$ EU-wide over the period 2021–2030, or less than 1 percent of the allowance supply in the same period. The European Commission announced cooperative initiatives with China and the Republic of Korea in June and July 2016, respectively.

The cooperation with China focuses on addressing the challenges of implementing an ETS and establishing a dialogue to discuss developments in emission trading. Similarly, the European Commission will provide technical assistance on the implementation of emission trading to the Republic of Korea.

5.2 Australian Emission Trading Scheme (AUS – ETS)

Australian emission trading system or carbon pollution reduction scheme was a proposed cap-and-trade system of emission trading for anthropogenic GHGs introduced by the Australian government in 2010.

The emission reduction fund (ERF) has been used since April 2015 by the Australian Government to purchase Australian Carbon Credit Units (ACCUs) from the approved, voluntary emission reduction projects through an auction.

As of September 1, 2016, the Australian Government has held three auctions and contracted 143 $MtCO_2e$ of emission reductions, which will be achieved over a period of up to ten years. The average price of ACCUs in the latest government auction held in April 2016 was A$ 10/tCO_2e (USD 7/tCO_2e).

The ERF includes the safeguard mechanism, which came into effect on July 1, 2016, launching a baseline and- offset system following the abolishment of the Australian Carbon Pricing Mechanism in 2014. It intends to ensure that emission reductions purchased by the Australian Government are not offset by significant increases in emissions above the business-as-usual levels elsewhere in the economy. The safeguard mechanism requires facilities with annual emissions of over 100 $ktCO_2e$ to limit their emissions to their individual absolute baseline levels. Facilities that exceed their emission baseline levels can purchase and surrender ACCUs for compliance. Facilities can implement emission reduction projects to generate ACCUs for their own compliance. They can also sell these ACCUs to other facilities or the government. There are rules in place to avoid double counting of emission reductions. The Australian government intends to review the ERF and safeguard mechanism in 2017.

5.3 China Emission Trading Scheme (C - ETS)

China is the major contributor of GHG emissions almost around 30%, almost as high as the European Union. As a mitigation measure for climate change, China will launch the international

emission trading system in 2017 for carbon permit trading which will become a second largest emission trading market in the world next to European Union. Adopting a national ETS could provide an effective relief for China's polluted big cities and is one way of helping the Government to reach its ambitious climate goals.

An ETS - also called a 'cap and trade' system - is an economic mechanism to put a limit, or 'cap', on the carbon emissions that every company is allowed to produce in a year. The final goal is to incentivize firms to be far below this limit, achieving a double result: they not only avoid buying new allowances, but can also sell their own. Moreover, the total number of permits - the volume of pollutants every firm can emit in the air - is lowered over time. China has announced it will allow for policy interventions, such as price control mechanisms to ensure stable market conditions and to potentially avoid some of the difficulties that have marred the EU-ETS.

2.1.33. China Domestic Emission Trading Scheme

China has pledged voluntarily under the UNFCCC to lower CO_2 per unit of GDP by 40-45% by 2020 compared to 2005 levels. It has further committed to increase the share of non-fossil fuels in primary energy consumption to around 15% by 2020 and to increase forest coverage by 40 million ha and forest stock volume by 1.3 billion m^3 by 2020 from 2005 levels.

China's 12th Five Year Plan lays out plans to "gradually develop a carbon trading market". China is currently implementing seven pilot emission trading systems (ETS) which are expected to serve as testing ground for a national ETS to be implemented after 2016.

In October 2011, China designated 4 municipalities (Beijing, Chongqing, Shanghai and Tianjin), 2 provinces (Guangdong and Hubei) and the special economic zone of Shenzhen City as regions for ETS pilots.

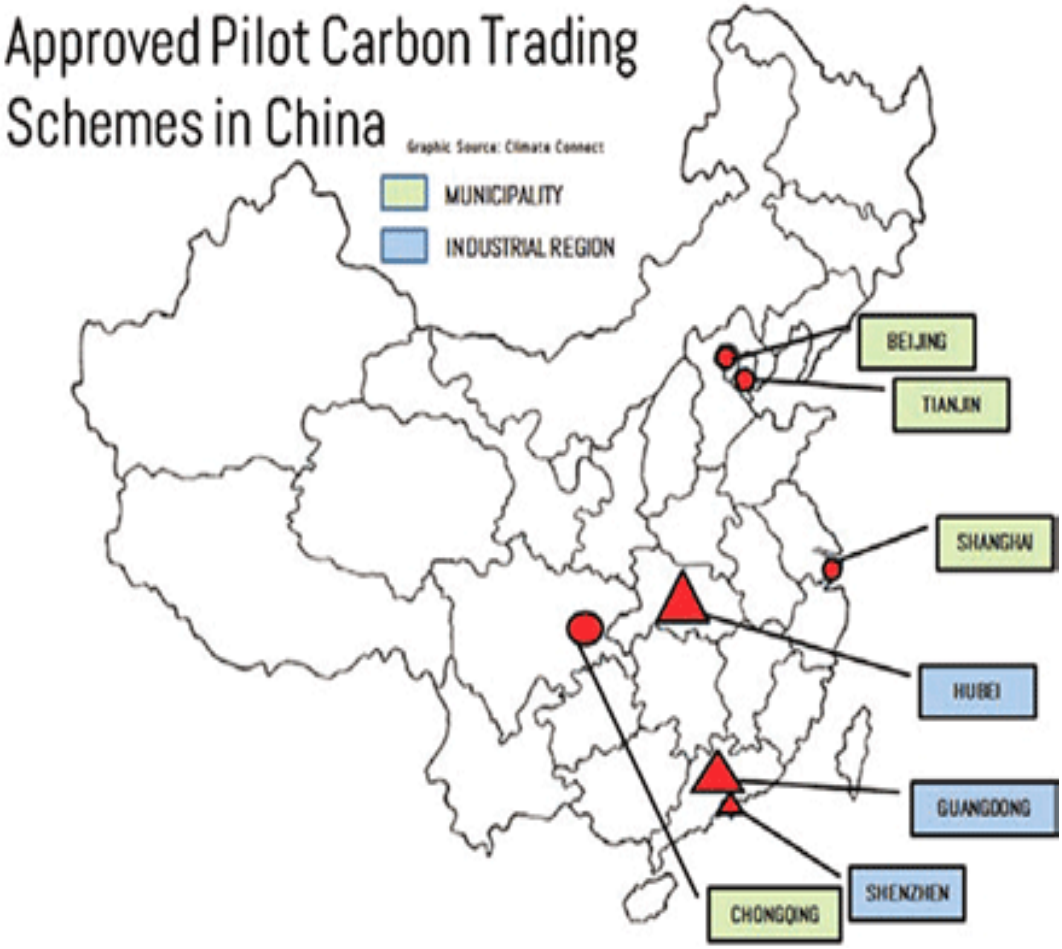


Figure 4-2 China's domestic emission trading

All ETS pilots are expected to allow the use of Chinese Certified Emission Reduction (CCER) offsets. These offsets will be issued under a voluntary, government-administered Chinese offset program that is based on the CDM. The National Development and Reform Commission (NDRC) is expected to act as the ruling body, similar to the CDM Executive Board.

NDRC indicates that issues related to the development of China's ETS include: scope; cap setting; allowance allocation; monitoring, reporting, and verification (MRV), registries, compliance mechanisms, price containment mechanisms, offset mechanisms, market oversight, and participants and trading. Regarding scope, the Chinese government will consider MRV capabilities, cost-effectiveness, and international experiences before determining the national ETS's covered sectors. NDRC states, "the covered sectors should reach certain emissions volume and have significant potentials for emission reductions; otherwise, it would be hard to achieve the objective to cut emissions of GHGs through market mechanism".

Table 4-1 Features of Chinese ETS pilots (2013-2015)

Region	Municipalities				SEZ*	Provinces	
	Beijing	Chongqing	Shanghai	Tianjin	Shenzhen	Guangdong	Hubei
Regions covered	50%	NA	50%	60%	40%	42% -50%	35%

Adopted implementation plans?	Yes	No	Yes	Yes	Yes	Yes	No
Planned Launch	IInd half of 2013	Late 2013	June/July 2013	IInd half of 2013	18 June 2013	September 2013	August 2013
No. of companies trading the emissions	420 – 600	NA	197	120	635	830	NA
Limitation on use of offsets of compliance obligation	10%	5-10%	10%	10%	NA	10%	10 – 15% (unofficial)
Likely to adopt credits	CCERs	CCERs incl. forestry credits	CCERs with limitation on types and origin.	CCERs	CCERs from western china	CCERs incl. forestry credits	CCERs incl. forestry credits

5.4 New Zealand Emission Trading Scheme (NZ ETS)

The purpose of the scheme is to help reduce New Zealand's emissions to below business-as-usual levels and help New Zealand meet its international obligations under the UNFCCC and the Kyoto Protocol. This is achieved by establishing a price on emissions, which creates a financial incentive for emitters to reduce their emissions, invest in clean technology and renewable power generation and plant trees. The NZ ETS works in the principle of cap and trade with mandatory and voluntary opt in.

The Ministry for the Environment administers the Climate Change Response Act, which established the emissions trading scheme. It is also responsible for developing emission unit allocation plans and regulations under the Act, except for those relating to the forestry sector, which are managed by the Ministry for Primary Industries.

The Environmental Protection Authority manages the day-to-day functioning of the emissions trading scheme. It is the main compliance and enforcement agency, responsible for verifying that participants are complying with the scheme. It also runs the New Zealand Emission Unit Register.

International trade of Kyoto credits in the New Zealand Emission Unit Register ceased on November 18, 2015 at the end of the CP1 true-up period. New Zealand AAUs remain eligible to surrender the domestic ETS. The New Zealand Government is currently reviewing the ETS. One outcome of this review is the phase out of the "one-for-two" transitional measure over a three-year period from January 1, 2017 in annual steps. This measure currently allows non-forestry ETS facilities to surrender one emission allowance for every two tons of CO_2e emitted, thereby halving their compliance obligation. The ETS reform is intended to improve the alignment of the New Zealand ETS with the national emission reduction target of 30 percent below 2005 levels by 2030. Partially due to this change, the price for a New Zealand emission allowance has tripled since the start of 2015, increasing to NZD 18/tCO_2 (US$ 13/tCO_2) on August 1, 2016—the highest level in four years.

5.5 South Korea Emission Trading Scheme

South Korea launched new emission trading scheme in 2015 which imposed caps on emissions from 525 of the country's biggest companies and became the world's second biggest carbon market. The new market is a key component in the government's plan to meet a target of limiting climate-changing GHG emissions in 2020 to 30 percent below the current levels.

Under the scheme, South Korea's power generators, petrochemical firms, steel producers, car makers, electro-mechanical firms and airlines have been given a fixed amount of permits to cover their emissions for the next three years.

The government has set the total amount of allowed emissions for the 2015 to 2017 (Phase I) period at 1.687 million tCO_2e, including a reserve of 89 million tCO_2e for market stabilization measures, by early action and new entrants. Any company emitting more than they have permits to cover must buy allowances from others in the market.

No transactions took place between January 16 and October 6, 2015, and the total transaction volume of Korean Allowance Units (KAUs) in 2015 was 0.3 $MtCO_2e$, representing a small share of the 573 $MtCO_2e$ cap. In 2016, trade remains limited - as of August 1, 2016 the most recent trade took place on July 22, 2016 at KRW 17,000/tCO_2e (US$15/$tCO_2e$).

The limited allowance trade due to a perceived shortage in the market has led to high demand for Korean offset credits over the past year, including Korean CERs, which are also eligible for compliance under the ETS. The transaction volume of Korean Credit Units (KCUs) was almost three times as high as KAUs at 0.9 $MtCO_2e$. KCUs are now priced at a similar level to KAUs.

To address the perceived shortage in the allowance market, the government auctioned 900 $ktCO_2e$ KAUs from the market reserve in June 2016. Participation in these auctions was limited to the companies in the ETS that had an allowance shortage of greater than 10 percent in 2015. This restriction resulted in only about 270 $ktCO_2e$ KAUs being sold. In August 2016, the government also relaxed the rules for ETS participants to earn credits from emission reductions before the ETS was launched. These measures essentially increased the supply of emission allowances.

Furthermore, several changes to the Korea ETS were announced on May 17, 2016, including the transfer of responsibility to the Republic of Korea ETS from the Ministry of Environment to the Ministry of Strategy and Finance. In addition, as of June 1, 2016 companies can borrow up to 20 percent of KAUs from the future year's allocation, up from 10 percent. At the same time, Korea is focusing its efforts on meeting its INDC pledge to reduce GHG emissions by 37 percent below business-as-usual levels by 2030.

5.6 Kazakhstan Emission Trading Scheme (KAZ ETS)

The Kazakhstan's emissions trading scheme started on 1 January 2013 and covers 55% of the country's total GHG emissions. The overall objective is a 15% emission reduction below 1992 level by 2020. The 178 companies participating in the first phase of the scheme emitted a total of 147 million tCO_2e in 2010.

Kazakhstan has suspended its ETS for two years starting from January 1, 2016 to address the imbalances in the system. Over this period, the government will revise the rules on the issuance of emission allowances, free allocation and the price stabilization reserve. These new rules will also reflect changes to the economy that have taken place since the Kazakhstan ETS rules were designed. During the suspension period, ETS facilities do not have a compliance obligation, but they are nonetheless required to report their emissions.

5.7 Swiss Emission Trading System

On March 23, 2016, Switzerland announced plans to revise the Federal Act on the Reduction of CO_2 Emissions (CO_2 Act). A public consultation on the revision of the CO_2 Act will be held until November 2016. This revised CO_2 Act proposes among other things, a potential step-wise increase in the carbon tax rate for the period after 2020 to up to CHF 240/tCO_2e (US$ 246/tCO_2e). The last increase in the tax rate took place on January 1, 2016 from CHF 60/tCO_2e (US$ 62/tCO_2e) to CHF 84/tCO_2e (US$ 86/tCO_2e), after a government review found that Switzerland's GHG emissions were higher than the targeted levels for 2014. The next review of the tax rate will be conducted based on emissions from 2016 and tax rates may have to be adjusted again on January 1, 2018, depending on the evolution of Switzerland's GHG emission trajectory. The carbon tax revenues are redistributed and do not feed into the federal budget.

Following the negotiations which started in 2011, Switzerland and the EU reached an agreement on January 25, 2016 to link their ETSs. The agreement needs to be signed and ratified by both sides before it can enter into force. The timeline for this step is open. When the agreement enters into force, Switzerland needs to have the aviation sector integrated into its ETS to be consistent with the sectoral coverage of the EU ETS.

5. Relevant UNFCCC CDM methodologies for SWM projects

The UNFCCC CDM Board has approved methodologies to cater to the emission reductions from the solid waste and other means of waste handling for large scale and small scale applications. The approved CDM methodologies for SWM projects are given in the following table,

Table 5-1 Approved CDM Methodologies for SWM Projects

Large scale methodologies	
ACM0001	Flaring or use of landfill gas -Version 17
ACM0006	Consolidated methodology for electricity and heat generation from biomass -Version 12.1.0
ACM0012	Waste energy recovery -Version 6.0
ACM0018	Electricity generation from biomass residues in power-only plants -Version 3.0
ACM0022	Alternative waste treatment processes -Version 2.0
Small scale methodologies	
AMS III.E	Avoidance of methane production from decay of biomass through controlled combustion, gasification or mechanical / thermal treatment -Version 17.0
AMS III.F	Avoidance of methane emissions through composting -Version 12.0
AMS III G	Landfill methane recovery -Version 9.0
AMS III H	Methane recovery in wastewater treatment -Version 18.0
AMS III L	Avoidance of methane production from biomass decay through controlled pyrolysis -Version 2.0
AMS III Q	Waste energy recovery -Version 6.1
AMS III AJ	Recovery and recycling of materials from solid wastes -Version 5.2

The detailed versions of approved methodologies are given in the Annex 7.

6. Assessment on CDM possibilities for the projects

In general, the CH_4 emission (which is 21 times more harmful than CO_2e) is generated from organic wastes under limited supply for air, i.e., under landfill conditions. From open dumping, organic wastes decompose mostly as CO_2. As per CDM methodologies, there is a significant GHG emission reduction when methane generation is reduced through avoided waste dumping (such as RDF), capture of landfill gas and flaring, composting, etc.

This chapter explains the CDM possibilities of the proposed project in each CSCs and their revenue potential through the GHG emissions reductions. The guidelines under UNFCCC framework are referred for this assessment. The CER generation estimations are through avoided decay emissions (methane) of the organic wastes.

7.1 Buriram SWM project

The proposed project activity involves treating the MSW waste through RDF facility and preventing a portion of waste from being disposed in the disposal sites and the methane that would have been generated will be avoided from the solid waste disposal site. The amount of methane generated from the disposal of waste at the SWDS is calculated based on a first order decay (FOD) model. The GHG emission reduction from waste to energy plant is estimated to be approximately 33,174 tCO_2e/year. The estimations procedure for emissions from solid waste is given in the annex 1.

Considering a lifetime of 10 years (normal CDM crediting period), the project would generate around 331,740 CERS. The potential revenue generation under two different market conditions in provided in table below:

Condition	CER Price (USD)	Total CERs	Estimated revenue (USD)
Current market price	0.42	331,740	139,330
Average institutional offer price	5	331,740	1,658,700

These are preliminary estimations only. A detailed study for the CDM possibility shall be carried out during the implementation phase.

7.2 Mahasarakham SWM project

In the baseline scenario, uncontrolled landfill is practiced. In the project activity, controlled landfill is proposed. There is no effective waste reduction to disposal site or capturing of landfill gas. Therefore, the GHG emission reduction is negligible and thus, no CER/CDM benefits can be acquired for this project.

7.3 Mandalay SWM project

In the baseline scenario, poor waste collection and landfill disposal is practiced. In the project activity, the improved waste collection process and landfill disposal is proposed. There is no effective waste reduction to disposal site or capturing of landfill gas. Therefore, the GHG emission reduction is negligible and thus, no CER/CDM benefits can be acquired for this project.

7.4 Quezon City SWM project

The proposed project activity involves waste incineration facility and prevents a portion of waste from being disposed in the disposal sites and the CH_4 that would have been generated will be avoided from the solid waste disposal site. The amount of CH_4 generated from the disposal of wastes at the SWDS is calculated based on the FOD model. The GHG emission reduction from WTE plant is estimated to be approximately 379,697 tCO_2e/year. The estimations procedure for emissions from solid waste is given in the annex 2.

Considering a lifetime of 10 years (normal CDM crediting period), the project would generate around 3,796,975 CERS. The potential revenue generation under two different market conditions in provided in table below:

Table 6-1 Potential Revenue Generation

Condition	CER Price (USD)	Total CERs	Estimated revenue (USD)
Current market price	0.42	3,796,975	1,594,730
Average institutional offer price	5	3,796,975	18,984,874

These are preliminary estimations only. A detailed study for CDM possibility shall be carried out during the implementation phase.

7.5 Sorsogon SWM project

In the baseline scenario, poor waste collection and the landfill disposal is practiced. In the project activity, the improved waste collection process with waste segregation, material recovery and landfill disposal is proposed. The material recovery would involve recycling of inorganic waste fractions. There is no effective organic waste reduction to the disposal site or capturing of landfill gas. Therefore, the GHG emission reduction is negligible and thus, no CER/CDM benefits can be acquired for this project.

Annex 1: Procedures for estimating GHG reduction potential from RDF project

The GHG emission reduction potential of Refused Derived Fuel (RDF) processing is estimated using CDM methodology "AMS III.E. Avoidance of methane production from decay of biomass through controlled combustion, gasification or mechanical/thermal treatment, Version 17.0."

In the case of project activities such as combusting, gasifying or mechanically/thermally treating (RDF), only the freshly generated wastes, the baseline emissions at any year y during the crediting period is calculated using the amount and composition of wastes combusted, gasified or mechanically/thermally treated since the beginning of the project activity (year "x=1") up to the year y, using the first order decay model.

$$BE_y = BE_{CH4,SWDS,y}$$

Where:

BE_y	=	Baseline emissions at year *y* during crediting period (t CO_2e)
$BE_{CH4,SWDS,y}$	=	Yearly Methane Generation Potential of the wastes diverted to be disposed in the landfill from the beginning of the project (x=1) up to the year *y*, calculated according to the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" (t CO_2e)

The emission from solid waste is calculated using the CDM tool "Emissions from solid waste disposal sites." The amount of CH4 generated from the solid waste is calculated using the following equation:

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1 - f_y) \cdot GWP_{CH4} \cdot (1 - OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1 - e^{-k_j})$$

Where:

φ_y	Model correction factor to account for model uncertainties for year y;
f_y	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year y;
GWP_{CH4}	Global warming potential of methane;
OX	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste);
F	Fraction of methane in the SWDS gas (volume fraction);
$DOC_{f,y}$	Fraction of degradable organic carbon (DOC) that can decomposes under the specific conditions occurring in the SWDS for year y (weight fraction);
MCF_y	Methane Correction Factor for year y;
$W_{j,x}$	Amount of solid waste type j disposed or prevented from disposal in the SWDS in the year x;
DOC_j	Fraction of degradable organic carbon in the waste type j (by weight);
k_j	The decay rate for the waste type j (1/yr),
j	Type of residual waste or type of waste in the MSW;
x	Year in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (x = 1) to the year y (x = y);
y	Year of the crediting period for which methane emissions are calculated

Annex 2: Potential GHG emission reduction estimations for RDF facility project

Sample estimations:

The GHG emission reduction potential of RDF processing is estimated using the CDM methodology "AMS III.E. Avoidance of methane production from decay of biomass through controlled combustion, gasification or mechanical/thermal treatment, Version 17.0."

In the case of project activities like combusting, gasifying or mechanically/thermally treating only freshly generated wastes, the baseline emissions at any year y during the crediting period is calculated using the amount and composition of wastes combusted, gasified or mechanically/thermally. Therefore,

$$BE_y = BE_{CH4,SWDS,y}$$

Assumptions:

Parameter	Value
φ_y	0.85
f_y	0
GWP_{CH4}	21
O_X	0.1
F	0.5
$DOC_{f,y}$	0.5
MCF_y	1

Digested waste type j	DOC_j	k_j (WET)
Wood and wood products	0.43	0.035
Pulp, paper and cardboard (other than sludge)	0.40	0.07
Food, food waste, beverages and tobacco (other than sludge)	0.15	0.4
Textiles	0.24	0.07
Garden, yard and park waste	0.2	0.17
Glass, plastic, metal, other inert waste	0	0

Waste generation:

Year	Waste generation (tons/year)
1	32,850
2	36,500
3 onwards	73,000

Waste composition:

Type	Percent
Paper and Paper pulp	11.1%
Food waste	71.4%
Textiles	0%
Garden waste	0.6%
Glass, plastics and metals	16.8%

The emission from the solid waste disposal at SWDS is calculated using the CDM tool "Emissions from solid waste disposal sites, Version 7." The amount of methane generated from solid waste is calculated using following equation:

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1 - f_y) \cdot GWP_{CH4} \cdot (1 - OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \, e^{-k_j \cdot (y-x)} \cdot (1 - e^{-k_j})$$

GHG Emission Reduction Potential in SWM

Emission reduction potential from solid waste disposed (FOD method)

Year	1	2	3	4	5	6	7	8	9	10
Waste (tons)	32,850	36,500	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000
1	6,777									
2	4,688	7,530								
3	3,277	5,209	15,061							
4	2,322	3,641	10,418	15,061						
5	1,673	2,580	7,282	10,418	15,061					
6	1,229	1,858	5,159	7,282	10,418	15,061				
7	924	1,366	3,717	5,159	7,282	10,418	15,061			
8	713	1,027	2,732	3,717	5,159	7,282	10,418	13,805		
9	565	792	2,054	2,732	3,717	5,159	7,282	9,254	13,805	
10	460	628	1,585	2,054	2,732	3,717	5,159	6,203	9,254	13,805

Emission reduction potential for 10 years

Year	Emission reduction potential ($BE_{CH4, SWDS,y}$)(tCO_{2e})
1	6,777
2	12,218
3	23,546
4	31,441
5	37,013

6	41,007
7	43,927
8	44,853
9	45,360
10	45,595
Total	**331,737**

Average GHG emission reduction potential from RDF plant per year is 33,174 tCO2e.

Annex 3: Procedure to estimate GHG emission reduction potential from the Waste to Energy (WTE) project

The GHG emission reduction potential of solid wastes destructed at the WTE plant is estimated using the CDM methodology "ACM0022 Alternative waste treatment processes - Version 2.0"

The emission from solid waste is calculated using the CDM tool "Emissions from solid waste disposal sites, Version 7." The amount of methane generated from solid waste is calculated using following equation:

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1 - f_y) \cdot GWP_{CH4} \cdot (1 - OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1 - e^{-k_j})$$

Where:

φ_y	Model correction factor to account for model uncertainties for year y;
f_y	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year y;
GWP_{CH4}	Global warming potential of methane;
OX	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste);
F	Fraction of methane in the SWDS gas (volume fraction);
$DOC_{f,y}$	Fraction of degradable organic carbon (DOC) that can decomposes under the specific conditions occurring in the SWDS for year y (weight fraction);
MCF_y	Methane Correction Factor for year y;
$W_{j,x}$	Amount of solid waste type j disposed or prevented from disposal in the SWDS in the year x;
DOC_j	Fraction of degradable organic carbon in the waste type j (by weight);
k_j	The decay rate for the waste type j (1/yr),
j	Type of residual waste or type of waste in the MSW;
x	Year in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (x = 1) to the year y (x = y);
y	Year of the crediting period for which methane emissions are calculated

The emissions associated with the electricity generation is calculated using the CDM tools (i) Tool to calculate baseline, project and/or leakage emissions from electricity consumption and (ii) Tool to calculate the emission factor for an electricity system. The emissions from the electricity generation are calculated using following equation and grid emission factor is the carbon emission factor for the Philippines national grid.

$$BE_{EC,y} = EG_{t,y} \cdot EF_{grid,CM,y} \cdot (1 + TDL_{k,y})$$

Where:

$BE_{EC,y}$	Baseline emissions associated with electricity generation in year y (t CO_2)
$EG_{t,y}$	Electricity generated by the alternative waste treatment option t and exported to the grid in year y (MWh)
$EF_{grid,CM,y}$	Grid power emissions factor in year y (tCO2/MWh)
$TDL_{k,y}$	Average technical transmission and distribution losses for providing electricity to source k in year y
k	Sources of electricity consumption in the baseline

Annex 4: Estimation of GHG emission reduction potential from WTE power plant

Sample estimations:

The GHG emission reduction potential of solid waste destructed at waste to energy plant is estimated using CDM methodology "ACM0022 Alternative waste treatment processes - Version 2.0.

Assumptions:

Parameter	Value
φ_y	0.85
f_y	0
GWP_{CH4}	21
O_X	0.1
F	0.5
$DOC_{f,y}$	0.5
MCF_y	1

Digested waste type j	DOC_j	k_j (WET)
Wood and wood products	0.43	0.035
Pulp, paper and cardboard (other than sludge)	0.40	0.07
Food, food waste, beverages and tobacco (other than sludge)	0.15	0.4
Textiles	0.24	0.07
Garden, yard and park waste	0.2	0.17
Glass, plastic, metal, other inert waste	0	0

Waste generation:

Year	Waste generation (tons/year)
1 onwards	620,500

Waste composition:

Type	Percent
Paper and Paper pulp	11.1%
Food waste	54%
Textiles	0%
Garden waste	25.8%
Glass, plastics and metals	11.7%

The emission from the solid wastes disposed at the SWDS is calculated using the CDM tool "Emissions from solid waste disposal sites, Version 7." The amount of methane generated from solid waste is calculated using following equation:

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1 - f_y) \cdot GWP_{CH4} \cdot (1 - OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \, e^{-k_j \cdot (y-x)} \cdot (1 - e^{-k_j})$$

Year	1	2	3	4	5	6	7	8	9	10
Waste (tons)	620,500	620,500	620,500	620,500	620,500	620,500	620,500	620,500	620,500	620,500
1	123,185									
2	89,250	123,185								
3	65,639	89,250	123,185							
4	49,072	65,639	89,250	123,185						
5	37,331	49,072	65,639	89,250	123,185					
6	28,914	37,331	49,072	65,639	89,250	123,185				
7	22,800	28,914	37,331	49,072	65,639	89,250	123,185			
8	18,294	22,800	28,914	37,331	49,072	65,639	89,250	88,650		
9	14,922	18,294	22,800	28,914	37,331	49,072	65,639	59,424	88,650	
10	12,357	14,922	18,294	22,800	28,914	37,331	49,072	39,833	59,424	88,650

Emission reduction potential from SWDS for 10 years:

Year	Emission reduction potential ($BE_{CH4, SWDS,y}$) (tCO_{2e})
1	123,185
2	212,435
3	278,074
4	327,146
5	364,477
6	393,390
7	416,190
8	399,949
9	385,045
10	371,596
Total	**3,271,487**

The emissions associated with the electricity generated is calculated using the CDM tools (i) Tool to calculate baseline, project and/or leakage emissions from electricity consumption and (ii) Tool to calculate the emission factor for an electricity system. The emission from electricity generation is calculated using following equation and grid emission factor is the carbon emission factor of Philippines national grid.

$$BE_{EC,y} = EG_{t,y} \cdot EF_{grid,CM,y} \cdot (1 + TDL_{k,y})$$

Assumptions:

Capacity of WTE plant - 20 MW

Grid emission factor - 0.52

(The Philippines)

$TDL_{k,y}$ - 3%

GHG Emission Reduction Potential in SWM

Emission reduction potential from electricity generation for 10 years:

Year	Emission reduction potential ($BE_{CH4, SWDS,y}$)(tCO_{2e})
1	75,070
2	75,070
3	75,070
4	75,070
5	75,070
6	75,070
7	75,070
8	75,070
9	75,070
10	75,070
Total	**750,700**

Total GHG emission reduction potential

For 10 years,

Emissions from SWDS	3,271,487 tCO2e
Emissions from electricity generation	525,488 tCO2e
Total	3,796,975 tCO2e

Average GHG emission reduction potential from WTE plant per year is 379,697 tCO2e.

Annex 5: Clean Development Mechanisms

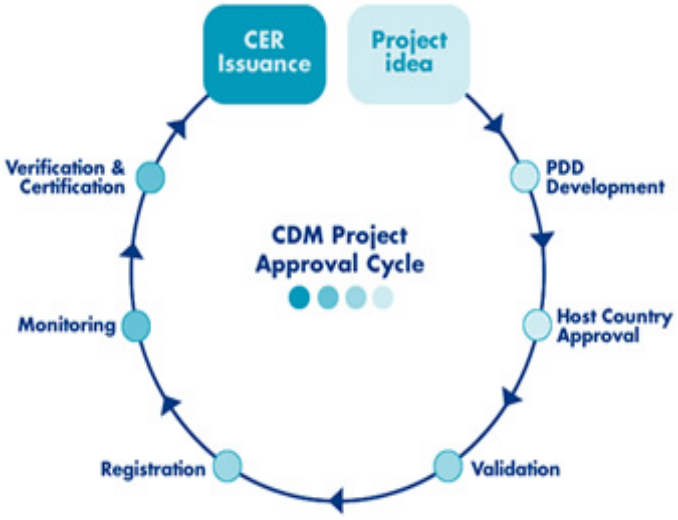
Clean Development Mechanism

For any project to be eligible under the carbon emission trading, it has to satisfy two critical criteria such as additionality and sustainable development.

- Additionality: the projects must lead to real, measurable, and long-term benefits related to the mitigation of climate change. The additional greenhouse gas reductions are calculated with reference to a defined baseline.

- Sustainable development: the projects must result in the improvement of social, economic and environmental status of the implemented countries.

A typical CDM project starts with project design and conceptualization. Then the project must be approved by the host country authority. After that the project documents must be prepared and registered with the appropriate selected methodologies of CDM. Project can be implemented as per design and planning, followed by the monitoring and evaluation. The verification of carbon emissions mitigated is usually carried out by a third party verifier. A general project cycle under CDM is presented as below:



CDM project cycle

Carbon credit or certified emission reduction (CER)

A carbon credit is a type of a tradable greenhouse gas emission reduction unit issued to projects under the Kyoto Protocol in 2005. The targets cover six main greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydro fluorocarbons (HFCs); per fluorocarbons (PFCs); and sulphur hexafluoride (SF_6). One carbon credit is equivalent to one tonne of carbon dioxide (CO_2) equivalent mitigated under the project. It is a key component of

national and international emissions trading schemes that have been implemented to mitigate global warming. They provide a way to reduce GHG emissions on an industrial scale by capping total annual emissions and letting the market assign a monetary value to any shortfall through trading.

Carbon credits thus generated can be exchanged between businesses or bought and sold in international market at the prevailing market price. Participating companies can make profits by selling the carbon credits to the developed countries to meet their emission targets. For projects that face severe financial barriers, the sale of carbon credits generated throughout their life time shall be additional incentive or income. This would encourage shareholders, financial institutions, banks, etc. as added advantage in risk mitigation mechanism and make them come forward more readily to fund such projects.

An Emission Reduction Purchase Agreement (ERPA) can be signed by project owner with the potential buyers for purchase of carbon credits. The ERPA will detail the conditions, clauses under which the carbon credits will be purchased and also the estimates price per carbon credit. This ensures that carbon credits would be sold and thus conforming the future incomes of the projects.

Major benefits of carbon credits

Apart from financial incentive through sale of carbon credits, it also has other added advantages as below:

- Attract capital for projects that assist in the shift to a more prosperous but less carbon-intensive economy
- Encourage and permit the active participation of both private and public sectors
- Provide a tool for technology transfer, if investment is channelled into projects that replace old and inefficient fossil fuel technology, or create new industries in environmentally sustainable technologies; and
- Help define investment priorities in projects that meet sustainable development goals.

There are various international carbon mechanisms other than CDM under practice each one suitable for specific project conditions such as listed below:

1. Joint Implementation (JI): Credits issued for emission reductions or removals achieved under the JI mechanism.
2. Voluntary Carbon Standard (VCS): VCS provides a robust, global standard and programme for approval of credible voluntary offsets. VCS offsets must be real, additional, measurable, permanent, independently verified and unique.
3. NSW Greenhouse Gas Reduction Scheme (GGAS): The first third party certified forestry carbon credits traded globally. Assessing abatement projects, accrediting parties to undertake eligible projects and then create certificates, and monitoring compliance with GGAS.
4. The Social Carbon Standard: It utilizes a set of analytical tools that assesses the social, environmental and economic performance of projects

5. The Gold Standard: Gold Standard is a non-profit foundation under Swiss law and is funded by public and private donations. Working in the Clean Development (CDM), Joint Implementation (JI) and voluntary markets to provide high quality premium carbon credits.

Annex 6: Financing mechanisms of CERs

Financing Mechanisms of CERs

The following table presents the potential funding agencies, standards and ERPA purchase options available for carbon emission projects.

S. No.	Description	Eligible Project	Governance	ER Standards	Beneficiaries	Upfront
1	Asia Pacific Carbon Fund	Energy Efficiency, Renewable Energy and Methane Capture and Utilization	ABD	Kyoto Protocol Mechanisms	Public and Private Entity	25% of CER
2	Future Carbon Fund	Energy Efficiency, Renewable Energy and Methane Capture and Utilization	ABD	Kyoto Protocol Mechanisms (post 2012)	Public and Private Entity	75% of CER
3	Prototype Carbon Fund	Energy Efficiency, Renewable Energy and Methane Capture and Utilization	World Bank	Kyoto Protocol Mechanisms - JI & CDM	Public and Private Entity	<25% of CER
4	The Netherlands Clean Development Mechanism Facility (NCDMF)	Geothermal, Wind, Solar, and Small-Scale Hydro-Power, Biomass, Fossil Fuel Switch, Methane Recovery, Energy Efficiency and Sequestration	World Bank	CDM and JI	Public and Private Entity	Based on due diligence and WB approval.
5	Italian Carbon Fund	HFC-23 Destruction, Energy Efficiency, Hydropower, Urban Landfill Gas, and Gas Recovery.	World Bank	CDM and JI	Public and Private Entity	Based on due diligence and WB approval.
6	The Netherlands European Carbon Facility (NECF)	Renewable Energy, Energy Efficiency, Waste Management	World Bank	JI - countries with economies in transition.	Public and Private Entity	Based on due diligence and WB approval.
7	Danish Carbon Fund (DCF)	Waste Management, Energy Efficiency, Renewable Energy, Oil and Gas And Hfc-23 Reduction.	World Bank	CDM & JI	Public and Private Entity	Based on due diligence and WB approval.

S. No.	Description	Eligible Project	Governance	ER Standards	Beneficiaries	Upfront
8	Spanish Carbon Fund (SCF)	Waste Management, Energy Efficiency, Renewable Energy, Oil and Gas And Hfc-23 Reduction.	World Bank	CDM,JI and European Union Trading System	Public and Private Entity	Based on due diligence and WB approval.
9	Multilateral Carbon Credit Fund (MCCF)	Energy efficiency, Renewable energy, Landfills, Biogas, Fuel Switch and Sequestration	European Investment Bank (EIB)	Joint Implementation (JI)	Public and Private Entity	Prior to the registration of CDM and JI projects.
10	EIB Post-2012 Carbon Credit Fund	Renewable Energy, Energy Efficiency, Fuel Switch, Fugitive methane, including landfill gas and coal bed methane, Land use, land use change and forestry (LULUCF), Carbon Capture and Storage (CCS)	European Investment Bank (EIB)	CDM & JI projects > 250,000 tCO_2 CERs	Public and Private Entity	Forward agreement with the project owner
11	Thailand Carbon Fund	Renewable Energy, Energy Efficiency, Waste Management	Securities and Exchange Commission (SEC).	CDM and JI	Public and Private Entity	CERs, Asset finance and Equity
12	Sri Lanka Carbon Fund	Waste Management, Energy Efficiency, Renewable Energy, Oil and Gas And Hfc-23	Sri Lanka Carbon Fund (Private) Limited	CDM and JI	Public and Private Entity	-