Clean Development Mechanism Evaluation Study – Adoption of Heat Recovery Power Generation within the Chinese Coal-Gangue Brick Sector

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FINAL REPORT

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List of acronyms

ACM	Approved consolidated CDM methodology
AM	Approved large scale CDM methodology
AMS	Approved small-scale CDM methodology
CADA	Carbon Asset Development Agreement
CAPEX	Capital Expenditure
CCPF	China Climate Change Partnership Framework
CDM	Clean Development Mechanism
CER	Certified Emissions Reduction
CGB	Coal Gangue Brick
CO_2e	Carbon Dioxide equivalent
CPA	CDM Programme Activity
D&T	Project Development and Transaction costs
DOE	Designated Operational Entity
EED	Energy and Environmental Research Centre
ERPA	Emission Reduction Purchase Agreement
EUR	Euro
FSR	Feasibility Study Reports
GHG	Greenhouse Gas Emissions
GJ	Giga Joules
HRPG	Heat Recovery for Power Generation
IRR	Internal Rate of Return
Kg	Kilograms
LoA	Letter of Approval
MOA	Ministry of Agriculture
MIIT	Ministry of Industry and Information Technology
MJ	Mega joules
MRV	Measurement, Reporting and Verification
MW	Megawatts
MWh	Megawatt hours
NCV	Net Calorific Value
NDRC	National Development and Reform Commission
NPV	Net present value
OPEX	Operating expenditure
pCDM	Programmatic CDM
PD	Project Developer
PDD	Project Design Document
PMO	Project Management Office
PO	Project owner(s)
PoA	CDM Programme of Activities
RMB	Chinese Renminbi
UNIDO	United Nations Industrial Development Organisation
UNFCCC	United Nations Framework Convention on Climate Change
VSBK	Vertical Shaft Brick Kiln
WHR	Waste Heat Recovery

Figures and tables

Executive summary

China is the world’s largest producer and consumer of building materials. The Chinese clay brick sector consumes around one billion tonnes of clay per year. Recent policies aim to limit the manufacture of clay bricks and encourage the use of industrial waste materials instead, in particular coal-gangue. In 2006, Chinese coal-gangue brick (CGB) production reached 1.42 billion bricks. Of the 80,000 brick enterprises in China, 5,000 are engaged in CGB production. Around 10% of these factories use tunnel kilns, around 60% are ‘small scale’ producing less than 30 million bricks per year; 20 to 30% are ‘medium scale’ producing 30 to 100 million and the remaining ‘large scale’ factories make more than 100 million.

Waste heat recovery for power generation (HRPG) technology is widely used in China in the cement, coke, glass and iron and steel industries as an effective measure to improve efficiency and reduce GHG emissions. Under the China Climate Change Partnership Framework, UNIDO is co-funding two HRPG pilot projects within operating CGB factories of these being ‘Juyi Industrial’ and the second being ‘Yiwang’, both of which are located in Shanxi province, These two pilots will install HRPG boilers and steam turbines in CGB factories that utilise tunnel kilns, aiming to promote sector-wider uptake of HRPG and increase emissions reductions. HRPG is not yet used in CGB production, but Camco estimates that HRPG has the potential to reduce emissions at a site level by between 8 to 15%.

This report is the result of a study into the potential of the Clean Development Mechanism (CDM) to finance CGB HRPG projects in China in order to accelerate the sector-wide uptake of HRPG and reduce GHG emissions. The study uses a detailed cash flow model to analyse CDM potential for the CGB sector and, specifically, at the two pilot sites, applying a range of carbon price scenarios for different CDM development approaches (single project, bundled projects and programmatic CDM).

The conclusions, based upon the technical, operational and economic pilot project data, are as follows.

Many projects would fail the CDM additionality test on financial grounds. Medium to large factories that install HRPG technology with a utilised steam turbine capacity of 0.45 MW or above would be too profitable to be eligible for CDM, providing returns greater the qualifying benchmark of 11% pre-tax (the maximum internal rate of return cut-off value imposed by NDRC).

It is likely that for projects that display financial additionality (i.e. small scale) the CDM would not add value because project development and transaction (D&T) costs are typically too high and the carbon credits generated too few to provide the returns required by CDM developers.

Assuming a single project approach, the Yiwang pilot project marginally fails the financial additionality test but smaller scale projects would likely display financial additionality. Camco’s analysis of D&T costs against CDM returns has shown a sufficient carbon price is necessary to make CDM a worthwhile investment for small scale factory owners (e.g. between RMB 105 per CER on a revenue share basis and RMB 130 on a flat fee basis). Currently, it is unlikely that the project will be able to attain a carbon price sufficient to justify the D&T costs.

The larger Juyi pilot project is not financially additional within the guidelines laid out by the UNFCCC.

Further work could overcome the barriers limiting CDM potential and wider HRPG deployment as follows.

Detailed research into the technical and financial parameters of HRPG technology at different scales, and market profile of the coal-gangue and standard brick making sector in China is absolutely necessary to improve our understanding of the CDM and emission reduction potential for HRPG technology within this sector. The level of uncertainty in the currently available data prohibits the pursuit of private financing and makes the additionality tests uncertain.

Programmatic CDM development could help reduce D&T costs significantly and make small scale projects commercially viable for CDM developers. As yet, no CDM programme is registered in China and none involving energy efficiency or waste heat recovery is being developed. By co-funding the development of a programme for HRPG in the CGB sector, UNIDO could help remove the uncertainty and risks associated with pCDM in order to attract private sector involvement.

1 Introduction

This report has been prepared by Camco, on behalf of the United Nations Industrial Development Organisation (UNIDO).

This assignment contributes to Output 1 'Coal-gangue Brick Sub-sector CDM Potential and Scenario Assessment' of the Year Two Objectives and Deliverables of Outcome Two, 2.1 'Promoting the Adoption of Heat Recovery Power Generation within the Chinese Coal-Gangue Brick-making Sector', of the overall China Climate Change Partnership Framework (CCPF) programme and is led by UNIDO. The Chinese Government has appointed the Ministry of Agriculture (MOA) as the national partner for the project.

Heat recovery for power generation (HRPG) technology is widely used in several industrial sectors in China such as iron and steel, cement and petrochemicals. It has been identified that HRPG is currently not yet used within China's coal gangue brick (CGB) sector due to technical and financial uncertainties that have made the technology marginal.

One of the potential drivers for HRPG is carbon financing that can be accessed through the Clean Development Mechanism (CDM), administered by the United Nations Framework Convention on Climate Change (UNFCCC) under the Kyoto Protocol.

This report will explore the feasibility of CDM for HRPG in the CGB sector and discuss the key barriers and challenges to accessing CDM financing.

1.1 Layout of report

Our report is presented in the following sections:

1. Introduction – sets out the objectives and background to the assignment.
2. Methodology – this includes a description of the methodological approach applied to assess the CDM potential of HRPG technology in the CGB sector in China.
3. Deliverable One – sector CDM potential – this describes the CGB sector-wide analysis undertaken to determine whether CDM is feasible for financing HRPG across the sector.
4. Deliverable Two – pilot site CDM feasibility – this presents the factory-level CDM feasibility analysis of the two HRPG pilot projects located at Yiwang and Juyi in Shanxi.
5. Deliverable Three – CDM model component – this section presents the final deliverable including supporting documentation on the model design, data flow and usage.
6. Conclusions and recommendations

An introduction to the CDM together with related information is provided in the Annex in Section 7.

1.2 Objectives and deliverables

The assignment is arranged into two parts:

- Part one: study of CDM potential within the Chinese brick sector with a special focus on the coal gangue brick sub-sector. This establishes whether CDM is a viable option for HRPG in this sector.
- Part two: factory-level CDM project simulation and model component development. Using a detailed CDM project model, this examines factory-level factors and parameters (e.g. production capacity and kiln size) at two pilot sites to assess feasibility of CDM in terms of project cost and CER volume.

Part One has one deliverable and Part Two has two deliverables described below. The CDM model component (Deliverable Three) is the core quantitative element of the analysis. Deliverables One and Two are based upon the model component and have been organised into discrete work streams for purposes of clarity in this report.

1.2.1 Deliverable One – CDM Potential Sectoral Study within the Chinese Coal-Gangue Brick Sector, including a Section on Regular Clay Brick Production

Using the sector studies and assessments provided by Energy and Environmental Research Centre (EED), the number, size and type of CGB factories in China that could feasibly access CDM financing for HRPG projects has been identified, under three different CDM project development scenarios including single, bundled and programmatic, identifying CDM project costs, GHG emission savings, CER revenue and project value using a range of carbon prices. For those that are not feasible, the barriers have been analysed and mitigation measures proposed. The results indicate and explain to what extent CDM is viable within the CGB sector. Data was not made available on the wider standard brick making sector in China and has not been included in the analysis.

1.2.2 Deliverable Two – Pilot site CDM Feasibility and Assessment Report for Establishing HRPG CDM Projects within the Selected Pilot Coal-gangue Brick Factories

Using the information contained in the feasibility study reports (FSR), the potential for using CDM to finance HRPG pilot projects at the Yiwang and Juyi pilot sites has been assessed, again estimating the Certified Emissions Reduction (CER) revenues for the three CDM approaches across a range of carbon prices. The results indicate the likely success of registering the pilot sites as CDM projects.

1.2.3 Deliverable Three – CDM Model Component for inclusion into the overall 'Brick Sector Heat Recovery Power Generation Project Feasibility Model' Package

The CDM model component can be applied to any potential CGB HRPG CDM project, by inputting all necessary economic and technical parameters and processing these under one of the three aforementioned CDM project scenarios, in order to determine project feasibility and best economic approach. The model component is in Microsoft Excel format and will be submitted as a soft copy and on CD.

Using the pilot projects as a guide, the key technical and financial parameters of an HRPG project in the CGB sector have been built into a cash flow model. Cash flow analysis is an important tool for assessing CDM potential because proving ‘financial additionality’ is one the key requirements for projects to qualify for CDM carbon financing. The model has been designed so that parameters for any project can be used to show the financial additionality, a key indicator of CDM potential.

Deliverable Two uses the model to determine the CDM potential of the pilot projects. Using the pilot projects to identify relationships between scale, revenues and costs, a linear algebraic model has been created. Based on the extrapolation of these relationships, the model gives a quantitative analysis of the CGB sector, which has been used for Deliverable One.

1.3 Background to the assignment

The following background on coal-gangue and coal-gangue in brick making in China is based on desktop research (Song et al 2009) and the Set One reference material (EED 2009).

1.3.1 Coal-gangue

Coal-gangue is a by product of industrial coal production and is composed of a variety of solid wastes. In 2007, China produced 2.52 billion tonnes of raw coal and 300 million tonnes of coal-gangue. In lieu of a useful purpose, the coal-gangue is left to pile up in the coal producing regions. In 2007, the stock pile of coal-gangue in China had reached 5.0 billion tonnes, covering an area of 30,000. In addition to occupying large areas of land, such large quantities of coal-gangue pose a number of threats to the local environment through air and water pollution. The large piles can also cause a safety hazard by spontaneously combusting or collapsing.

Comprehensive utilisation and management of coal-gangue has been a long term objective for Chinese environmental policy introduced in the 1990s (9th Five Year Plan), but technological constraints have placed some limits on the growth in utilisation of coal-gangue in China. From 1985 to 1995, China consumed around 500 million tonnes of coal-gangue.

With improving technology in utilisation processes and a number of tax breaks and other policy incentives, China has seen a rapid increase in the utilisation of coal-gangue. In 2000, 33.6% of production (or 49 million tonnes) of coal gangue was utilised, compared to 67.5% (108 million tonnes) in 2005.

The 2010 utilisation target is 70%, or 390 million tonnes. Of this 51.3% will be used as low grade fuel in power plants, 23.1% in brick production, and 25.6% for a variety of reclamation and building purposes.

1.3.2 Coal-gangue in brick making

China is currently the world's largest producer and consumer of building materials, and a competitive market exists for directly substitutable materials such as bricks. Coal-gangue is a suitable raw material for making bricks as it has a low heat value (2.09 to 6.27 MJ/kg) and a high carbon content of 6 to 20%.

The market for bricks is dominated by clay. The Chinese clay brick sector consumes around one billion tonnes of clay per annum, resulting in the destruction of approximately 30,000 hectares of agricultural land. The sector is responsible for 30% of combined CO_2 and SO_2 emissions in China's construction materials industry.

Recent policies and regulations issued by Chinese government aim to limit the use and manufacture of clay bricks, due to increased pressure on and destruction of agriculture land, and encourage the use of industrial waste materials instead – notably coal-gangue.

In 2006, Chinese coal-gangue brick production reached 1.42 billion bricks, an increase of 69% compared to 2003. Of the 80,000 or so brick enterprises in China, 5,000 are engaged in coal-gangue brick production. These are mainly located in Sichuan, Shandong, Henan, Liaoning, and Jilin provinces and in the Beijing municipality. Most facilities produce from 60 to 160 million bricks per year.

As discussed, utilisation of coal-gangue in brick making brings a number of environmental benefits by reducing the environmental degradation associated with the mining and manufacture of clay bricks and the storage of large quantities of coal-gangue. Also, as coal-gangue has a high heat value relative to clay, less fuel needs to be used in the brick making process bringing additional environmental benefits.

1.3.3 Reducing GHG emissions in China's brick making sector

Framing the Chinese brick sector in the context of greenhouse gas emissions (GHG), there are four key areas of potential for GHG emissions reduction in the brick making process. These measures apply broadly to the brick making sector, not specifically to CGB:

1. Waste heat recovery (WHR) – the utilisation of waste heat, released during the brick sintering process, to heat water in a boiler to raise steam that can be used to drive a turbine which in turn generates electricity (i.e. HRPG).

2. Fuel switching – utilising a low carbon intensive fuel (e.g. natural gas) for the sintering process, replacing a high carbon intensive alternative (e.g. coal).

3. Raw material switching – replacing low heat value raw materials, such as clay, with energy-containing alternatives, such as coal-gangue. This reduces the amount of heating energy needed in the sinter process and therefore improves overall fuel efficiency.

4. Vertical shaft brick kiln (VSBK) – retrofitting kilns with advanced VSBK technology can increase efficiency by over 30% compared to traditional kilns. VSBK technology is common practice in India, but not common in China.

1.3.4 Waste heat recovery for power generation

This assignment is focused on point 1 above – GHG emissions reduction by utilising waste heat to produce power in brick making in China.

HRPG technology is widely used in several industrial sectors in China such as iron and steel, cement and petrochemicals. It has been identified that HRPG is currently not common practice in China’s brick sector due to technical and financial uncertainties that have made the technology marginal (i.e. the technology is untested in the CGB sector and is too expensive).

2 Methodology

This section outlines the methodology used to assess and analyse the suitability of the CDM to finance HRPG technology in the CGB sector. The methodology has been designed around the three project deliverables and is constrained by the quantity and quality of data available to Camco. The methodology is illustrated schematically in Figure 1. Detailed information on the CDM is included in the Annex.*

The key components of the methodology are as follows:

Data gathering

- Desk review of literature and primary data/information sources.
- Site visit to Juyi Industrial.
- Workshop with UNIDO, the MoA and Xi'an.

CDM research

- Identification and analysis of relevant CDM approved methodology.
- Framing HRPG technology within the CDM guidelines and identify the key parameters and data points needed to prove financial additionality under the relevant approved methodology.
- Considering HRPG projects in the CGB sector under the three different CDM project development approaches (single, bundled and programmatic, see section 2.4) and discussing the cost and revenue components (as well as the different commercial structures) that would be considered by CDM project developer(s) (PD) to decide if CDM projects within the CGB sector would be commercially viable.

Modelling

- Building the individual project CDM feasibility model using the quantitative inputs described above.
- Building the CGB sector CDM feasibility model using the quantitative inputs described above and by making a number of assumptions where data is missing.

The analysis has been built around three different CDM project approaches: single, bundled and programmatic. Financial viability and additionality is then assessed considering scale, investment, PD and transaction costs, emission reductions over a range of carbon prices.

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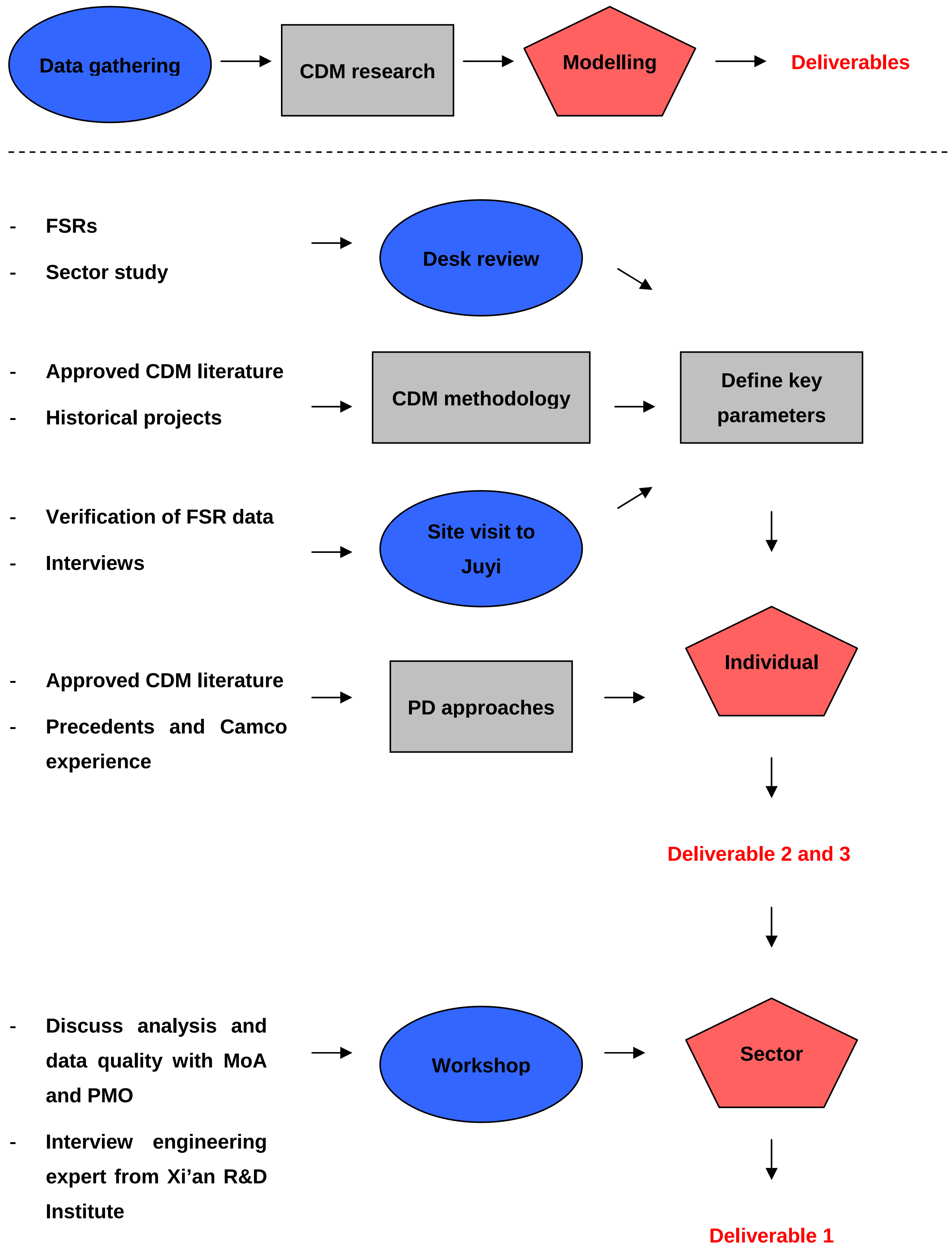
* *All CDM data and statistics referenced in this report are available online at http://cdm.unfccc.int*

Figure 1: Schematic of methodology and work flow



2.1 Information sources

The following information sources have been used in the data gathering phase of the project.

Set One Material – the sector studies and assessments provided by EED.

Set Two Material – the two FSRs for HRPG projects at Shanxi Juyi Coal-gangue Brick Factory and Shanxi Yiwang Coal-gangue Brick Factory, produced by the Xi'an Company.

Data gathering and modelling workshop – James New (of UNIDO, Beijing) assisted Camco in organising a workshop with Mr Zhou from Xi'an Company and Mr Lao Song of the MOA's Project Management Office (PMO). The objective of the meeting was to discuss the Chinese coal gangue brick sector and the HRPG projects at Jiyu and Yiwang and gather all of the additional information required to enable the completion of Deliverables one, two and three. Preparations were made for the site visit.

Jiyu site visit – together with Xi'an and MOA, Camco undertook a one-day site visit of the site of the coal gangue brick making factory of the Jiyu Company. The site where the new coal gangue brick making factory (using the HRPG technology) is currently under construction was visited. The purpose of this visit was to meet the company, verify the data in the FSR and gather additional information required to assess non-financial requirements and eligibility for the CDM.

2.2 CDM methodology

There are two approved CDM methodologies relevant to industrial HRPG projects, large scale and small scale (UNFCCC/CCNUCC 2007):

- ACM0012 "Consolidated baseline methodology for GHG emission reductions from waste energy recovery projects" – this is a large scale methodology, meaning it is normally only applied to projects achieving emissions reductions of more than 60,000 tonnes CO_2e per year. There are currently 12 ACM0012 projects registered in China under the CDM with 1.3 million tonnes of CO_2e reductions per annum.
- AMS-III.Q "Waste energy recovery (gas/heat/pressure) projects" – this is a small-scale methodology, meaning it is only applied to projects that achieve less than 60,000 tonnes of emissions reduction per year. There are presently only three AMS-III.Q projects registered under the CDM in China.

These are summarised below and explained in greater detail in the Annex.

It is clear from a sector study that HRPG projects in the CGB sector will be considered small scale under the CDM (less than 60kt/yr). AMS-III.Q small scale approved methodology is applied in the analysis. This is advantageous because small-scale CDM has simplified modalities and procedures and so is generally easier to implement than large scale CDM.

2.3 Key parameters and calculations

In order to assess the financial additionality and financial viability of a CDM project, a number of key parameters and data points must be known. Approved methodology AMS-III.Q clearly defines the parameters needed for the additionality argument and CER calculation. The key technical and financial parameters are described Table 9 and Table 10 in the Annex, respectively.

Three key calculations need to be performed to establish CDM potential. First with regard to financial additionality, the expected annual net cash flow resulting from the initial investment (project internal rate of return – IRR) needs to be calculated and compared to the investment benchmark.[†] Secondly, the project developer needs to assess their own investment and expected returns from participating in the project – this is done on the basis of IRR or net present value (NPV) (see Section 2.5). Lastly, the estimated GHG emissions for the assumed baseline scenario (what would have happened without the project) as well as emissions after implementation of the project need to be calculated, to show that the project does indeed result in a net emissions reduction.

2.4 Single project, bundled and programmatic CDM approaches

There are three different CDM development approaches for small-scale CDM. The analysis looks at the potential for CDM in the CGB sector considering each of the approaches in turn. The three approaches are summarised below. Further information on each approach together with lists of relevant projects are included in the Annex.

Single project – This is the ‘normal’ development approach, being the most common. In the single project approach, an approved CDM methodology is applied to a single project at a single location, with the development and transaction costs and project returns attributable to that single project only.

Bundled – The bundled approach allows the packaging up of several similar small scale CDM project activities into a single application provided that projects are not located at the same site. Bundling can bring down the development and transaction costs per project, however the development can be more challenging and therefore incur an overall higher fee than the single project approach. In summary, several rules apply to a bundle of small CDM projects:

- The size of individual small scale CDM projects in a bundle is capped (as identified in Section 2.2), but the size of a bundle of small CDM projects is not.
- A common monitoring plan can apply to a bundle of small projects, and monitoring should be carried out at a statistically significant level.
- A single DOE can both validate and verify a bundle of small projects.

It is also important to distinguish between a large-size CDM project and a bundle of small CDM projects. A small-scale CDM project will fail the “de-bundling test” if there is a registered small-scale CDM project activity or an application to register another small-scale CDM project activity:

- With the same project participants;
- In the same project category and technology/measure; and

[†] *The industry IRR benchmark to test financial additionally of a given projects (as set by NDRC) is 11 %, pre tax.*

- Registered within the previous two years; and
- Whose project boundary is within one km of the project boundary of the proposed small-scale activity at the closest point.

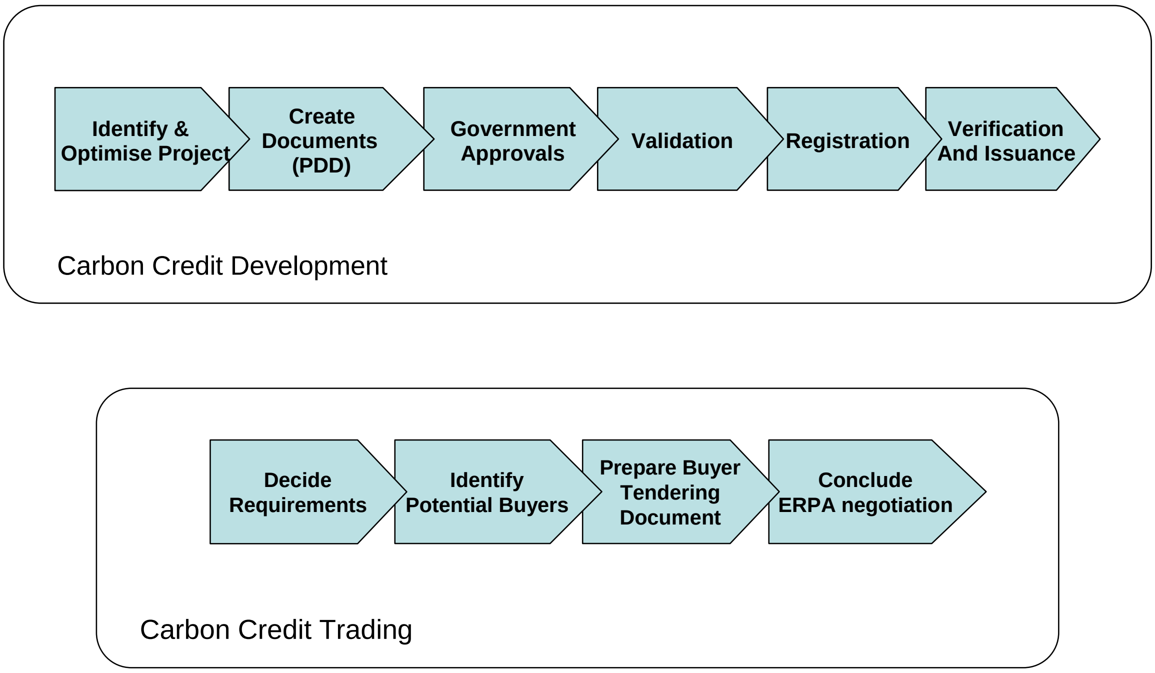
A project would be ineligible as a small-scale CDM project if the project proponent would respond affirmatively to all four criteria. It would instead be considered a large-size CDM project and be ineligible for bundling.

Programmatic CDM or Programme of Activities (pCDM or PoA) – pCDM involves first registering a ‘programme’, which is essentially a project concept, and a set of eligibility criteria that can distinguish additional projects. The programme is registered under the UN following approved CDM guidelines. Once the programme is registered it is possible to ‘fast track register’ individual projects under the program, as the eligibility criteria have been defined and approved, avoiding the need for any further UN approval. This can drastically bring down project development and transaction costs, avoid delays in the registration process and facilitate a scaling up of carbon financing within a sector. In theory, pCDM offers greater flexibility for CDM development within a sector, especially for small scale projects, however in practice programmes have been very difficult to implement (see Section 3.3 on barriers to CDM).

2.5 CDM project development and transaction costs

All CDM projects incur a number of development and transaction costs. This section will provide an overview of the CDM registration and CER issuance processes, and an estimate of the fees and transaction costs incurred at each stage. The three development approaches described in section 2.4 above are differentiated by their development costs per project.

Figure 2 CDM project development and carbon credit commercialisation process



CDM project developers are in the business of identifying and developing CDM projects. Figure 2 shows the sequential stages of the CDM development process. Costs are incurred at each stage of development; these costs can be split into *project development* and *transaction (D&T) costs*:

- **Project development costs** cover the time and expenses of the project developer.
- **Transaction costs** include the fees and taxes paid to third parties in the validation, registration, verification and issuance of CERs.

A summary of the D&T costs assumed by Camco for this analysis are included in Table 1. The D&T costs are broken down in detail in Table 14 in the Annex.

Table 1 Summary of assumed CDM project development and transaction costs per project

Per project costs	Single project cost	Bundled cost (10 projects)	pCDM cost (500 projects)
Total upfront costs	RMB 500,000	RMB 375,000	RMB 50,000
Total annual costs	RMB 200,000	RMB 100,000	RMB 50,000

These costs need to be covered either commercially, from the sale of CERs, or through a funding mechanism. To put it simply, a project must be of sufficient scale to generate enough CERs to cover the project development and transaction costs, otherwise it is not commercially viable. There are examples of very small-scale CDM projects, but it is likely that these have been funded through development aid or have been developed as part of a capacity building program, where the value added from the learning process is considered to be of greater value than the development and transactions costs of the project.

2.6 Commercial structures

Project development and transaction costs can be paid through two different commercial structures.

Flat fee – Firstly, the project developer (PD) could receive a flat fee for providing their time and expertise to guide the project through the CDM development process, and the fees payable to the UN and the DOE can be paid directly by the project owner or funding entity.

Table 2 Assumed project development flat fee based on a 50% profit margin on top of D&T upfront costs

Per project costs	Single project cost	Bundled cost (10 projects)	pCDM cost (500 projects)
Total upfront D&T costs	RMB 500,000	RMB 375,000	RMB 50,000
Approximate flat fee for project development	RMB 1 million	RMB 750,000	RMB 100,000

Revenue share – The second, and more common approach, is for the PD to agree a revenue share or purchase of the CERs from the project owner (PO). A contract is drawn up at the business development (BD) stage which lays out the terms of agreement called a Carbon Asset Development Agreement (CADA). The price at which the project owner sells the CERs from the project to the PD is then agreed and formalised in a contract called an Emission Reduction Purchase Agreement (ERPA). The revenue share selected in the analysis is based upon a required rate of return of 25% for the PD.

This commercial structure essentially allows the PD to buy the rights to the CERs from the PO at an early stage in the development process, thus taking the risk away from the PO. The price at which the CERs are purchased by the PD from the PO is negotiated.

The PD needs to take a view on a project, and price the ERPA accordingly – dependant on the likelihood of the project delivering CERs, and the expected price that the credits can then be sold for in the market.

Project developers that engage in these commercial arrangements essentially make a margin on the purchase and sale of CERs, by putting at risk development and transaction costs.

The price that the PD is willing to pay for the CERs is linked to the risk inherent in the project, i.e. the riskier a project appears to be, the lower the price the PD is willing to pay. In China, the Government have set a 'floor price' of EUR 8 per CER which places a commercial constraint on project developers; very risky projects are only commercially viable to a PD if they can purchase the CERs at a sufficiently low price, so an EUR 8 floor price effectively excludes projects that in a free market would be priced below this.

2.7 Carbon prices

As discussed in the section above on commercial structures, the carbon price is a key variable in assessing the commercial viability of projects to PDs. The revenue from the CERs depends wholly on the carbon price which needs to be estimated for the full duration of the crediting period (usually 10 years) in order for PDs to evaluate their own risks in taking on a project. The assumed floor price, current market price and upper bound to 2020 are listed in Table 3.

Table 3 The carbon price range used by Camco's in-house risk models has been applied to this analysis

Price point	Value	Details
Floor price	8 EUR / 80 RMB	Set by the Chinese Government
Current market price	13 EUR / 130 RMB	Approximate European Carbon Exchange secondary CER price in December 2009[‡]
Upper bound estimate to 2020	25 EUR / 250 RMB	Estimated from Camco's own forward curve analysis

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[‡] A 'secondary CER' is a CER that has been issued and hence does not carry any inherent registration, delivery or issuance risk. The CER price that is quoted on the major carbon exchanges refers to secondary CERs. A 'primary CER' is a CER that is yet to be issued. Primary CERs are bought and sold in bilateral agreements between project owners and credit buyers. They are priced at a discount to secondary CERs to compensate the buyer for the inherent registration, delivery or issuance risk.

3 Deliverable One – sector CDM potential

Deliverable One – CDM Potential Sectoral Study within the Chinese Coal-Gangue Brick Sector, including a Section on Regular Clay Brick Production*. Using the sector studies and assessments provided by EED, the number, size and type of CGB factories in China that could feasibly access CDM financing for HRPG projects have been identified. For those that are infeasible, the barriers have been analysed and mitigation measures proposed. The results indicate and explain to what extent CDM is viable within the CGB sector.*

Deliverable one is the product of all three of the work flow components of the methodology (as shown in Figure 1). This section of the report describes the work undertaken and conclusions drawn from the data gathering, research and modelling components relevant to Deliverable One. Data was not made available on the wider standard brick making sector in China and has therefore been omitted from the analysis.

3.1 Profile of the coal gangue brick sector

Based on the information provided to Camco by UNIDO, and clarified during the workshops with the MOA and Xi'an (Zhou 2009), a high level overview of the CGB sector has been drawn up, and the potential for HRPG technology has been estimated.

3.1.1 Number of factories

According to statics provided in 2005, there are around 5000 coal-gangue brick factories in China, of which 300 factories belong to or are attached to coal-mines. It is estimated that by the end of 2008, an additional 200 coal-gangue brick factories were set up within coal mine system in China. Most of these factories have applied tunnel kiln technology.

3.1.2 Factory size (production volume)

60% of China's coal-gangue brick making facilities are considered to be 'small scale' with production volume less than 30 million standard bricks per annum; 20 to 30% of facilities are considered 'medium scale' with production volume between 30 to 100 million bricks per annum; the rest of the 10 to 20% of facilities are 'large scale' with production volume higher than 100 million bricks per annum.

3.1.3 Kiln type and waste heat power generation

Typically, coal-gauge brick facilities are designed in a parallel configuration with two tunnel kilns installed side-by-side. The most common tunnel kilns are either 4.6 meters or 6.9 meters in width. It is estimated that a 2 x 4.6 tunnel kiln will produce between 60 and 80 million bricks per annum, and a 2 x 6.9 tunnel kiln will produce upwards of 120 million bricks per annum.

It is anticipated that a new access criterion for CGB factories will be issued in the coming years by Ministry of Industry and Information Technology (MIIT) which will restrict new installations from installing low efficiency equipment, i.e. only tunnel kilns (or more advanced technologies) will be applied.

Currently, there is a low penetration of waste heat recovery and utilisation in the CGB sector. One of the key barriers to the uptake of the technology is inadequate financing.

By capturing the waste heat from the brick making process and utilising it to create electricity, which displaces fossil energy, the technology creates a net reduction in greenhouse gas emissions. This means, in principle, that investments in waste heat recovery and utilisation in a CGB facility could qualify for carbon financing, which rewards investments in low carbon technologies with an indirect subsidy when it can be shown that a more lucrative and carbon intensive alternative investment opportunity has been forgone.

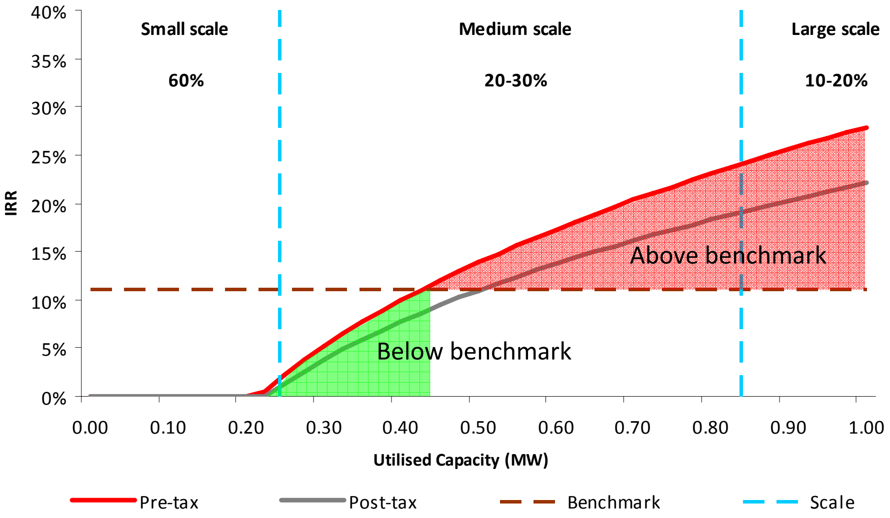
The mechanism through which this indirect subsidy is sought is the CDM (this mechanism is explained in the Annex). The viability and potential for CDM in the coal gangue brick sector is evaluated in the following section.

3.2 Analysis

In summary, based on the data contained in the FSRs, HRPG technology on a typical CGB facility is of insufficient scale to generate enough CERs to justify the transaction costs of CDM.

For this reason, it is unlikely that a PD would develop a HRPG CGB project, on a single project approach basis (see Section 2.4), without being paid a flat fee for the development and transaction costs. The bundled and pCDM approaches are discussed in detail in the next section to establish if, by reducing D&T costs, HRPG in the CGB sector might become commercially viable for a CDM PD.

Figure 3 IRR of HRPG in the CGB Sector at varying scales



By extrapolating the data contained in the FSRs, it is possible to establish a relationship between utilised plant capacity and financial returns. This is illustrated in Figure 3, which splits the sector into small, medium and large scale. It is estimated that a proportion of the medium scale facilities (i.e. approximately 0.25 to 0.85 MW utilised capacity or 30 to 100 millions bricks per annum) could be 'financially additional' (i.e. investment in HRPG technology would generate returns that are below the pre-tax investment benchmark of 11%). As illustrated by the green area under the curve in Figure 3, these projects would be between 0.25 and 0.45 MW utilised capacity which equates to 30 to 55 million bricks per year, assuming a linear relationship between turbine size and size of plant (brick output).

60% of the CGB sector is made up of plants 30 million brick production capacity per annum and below, equivalent to 0.25 MW HRPG projects and below (see Section 3.1.3). The FSR data indicates that investment in HRPG technology on this scale would not generate positive returns and is therefore considered not financially viable.

Further study is required to determine the accuracy of the cost and revenue assumptions for small scale HRPG installations below 0.25 MW. The extrapolation performed in the model provides an estimate based on the capital expenditure (CAPEX) of larger scale projects, so there is an inherent uncertainty that has not been corrected for.

3.3 Barriers and potential mitigation actions

3.3.1 Technical and non-technical barriers for HRPG application

HRPG technology is widely used in China within the cement, coke, iron and steel and float glass industries. The temperature of the flue gas in a tunnel kiln is comparatively lower than that in these other industrial applications, so low-temperature waste heat capturing boilers need to be used. The technology is widely available and there are no significant technical barriers to its application. The key barrier is the availability of skilful and experienced staff for the operation and maintenance of the technology. This barrier can be solved by replicable pilot projects, such as the Juyi pilot project.

The sulphur content of the low grade waste heat from coal-gangue could cause damage to equipment in the form of sulphuric acid. This issue needs to be resolved by the pilot studies as it could increase costs and therefore affect the additionality argument.

3.3.2 Single CDM project approach

As already mentioned, there are various barriers specific to each of the three CDM approaches, single, bundled and pCDM.

For single projects there is a limit to the plant size that would be feasible, below this the transaction costs would be prohibitively high, making small scale coal gangue projects financially unviable. However, financial additionality can only be shown for small scale projects, therefore it is considered not possible to apply the single CDM project approach to coal gangue HRPG projects as (from the analysis) it is estimated that most projects that would overcome the threshold to cover the transactions costs would in fact not be financially additional and therefore not viable CDM projects.

3.3.3 Bundled approach

One way to mitigate the transaction cost threshold barrier is to use a bundled approach which effectively reduces the transaction costs per project by registering several projects under one CDM application.

This approach presents a number of potential issues. If one project is rejected, all the projects in the bundle could be rejected, meaning the registration risk of each project is effectively increased. The risk of failure attached to each project is not pooled, it is in fact aggregated and therefore there needs to be complete confidence in the success of all of the projects in a bundle to justify taking this additional risk.

Bundling requires more than one project owner to be engaged on the same CDM project, and competing commercial interests have been seen to negatively affect bundled CDM projects.

The reduction in transaction costs compared to the single project approach is marginal and can easily be negated by delays caused by one of the projects within the bundle or by increased validation and verification fees if the project sites are located far apart from each other and cannot be visited (by the validator or verifier) in the same trip.

There are no energy efficiency or WHR bundled projects currently registered in China.

3.3.4 Programmatic approach (pCDM)

pCDM involves registering the project concept (referred to as the Programme of Activities document – PoA) and then, once approved, applying the concept to any number of eligible projects (CDM Programme Activity – CPA). This approach brings down the transaction costs per project and shortens project development time scales for CPAs once the PoA has been approved.

Guidance for the development of pCDM has been provided by the UNFCCC, but the approach is yet to be put in to wide scale practice. There are currently only two registered pCDM projects in the world (both in Latin America). Six pCDM projects are under validation in China but it is unclear whether they have been granted LoA approval by NDRC. Details of these projects are listed in Table 13 in the Annex. There are no pCDM projects under development in China related to energy efficiency, HRPG or building materials.

It can be anticipated that the following risks would be most likely to influence the programmatic approach:

Policy/guidance

- Uncertainly over China’s position on pCDM
- Unclear and untested application of the waste heat recovery CDM methodology to pCDM

Project development

- Potentially high cost of PoA/CPA development and monitoring and verification
- Inexperience of both project developers and DOEs
- DOE liability for over-issuance and erroneous inclusion of CPAs within a PoA.

The development of a PoA targeting emissions in the CGB sector utilising HRPG technology could help remove uncertainly and tackle these barriers.

3.3.5 Carbon price risk

The transaction costs of CDM project development need to be recovered through the generation and sale of CERs. If the returns from a project are insufficient to cover the transaction costs then CDM will not be commercially viable. The returns from the sale of CERs depends on the number of credits issued and the carbon price. If we assume that the number of CERs is a constant then the carbon price is the key variable in the calculation of expected returns. If the carbon price is too low then the projects will cease to be commercially viable.

Table 4 Percentage of CERs needed to cover transaction costs at different carbon prices (using FSR data for Yiwang pilot project)

CDM approach	Percentage share (above 75% considered marginal)		
CER Price	**RMB 80**	**RMB 130**	**RMB 250**
Single	**134%**	**83%**	**43%**
Bundled (10 projects)	**81%**	**50%**	**26%**
Programmatic (500 projects)	**25%**	**16%**	**8%**

It can be seen from Table 4 that not only does the development approach offer an opportunity to mitigate the development and transaction costs per project, but the carbon price also has an influence. At the RMB 80 floor price, only pCDM appears viable because less than 75% of CERs would be required to cover transaction costs; at today's CER price (approximately RMB 130), pCDM and bundled appears to be viable and at RMB 250 all three of the development approaches appear to be viable.

The key barrier is that CDM transaction costs are too high in the single project site scenario, therefore the focus needs to be on how would a project owner bring down these costs as a barrier to the project.

The mitigation actions that have been discussed above can be summarised as:

- Reduce project development costs though using bundling or pCDM approach.
- Eliminate transaction costs (i.e. the project owner develops the project single-handed).
- Secure a sale price for the CERs that is sufficiently high to cover the transaction costs. High CER prices may sometimes be negotiated for projects that are deemed to hold extra value, for example projects that confer excellent social sustainable development benefits.

3.3.6 Grid connection and electricity tariff

A CDM HRPG project would require to be grid connected and to receive a certain tariff for electricity generated and sold to the grid. Although national policies are in place to support the uptake of distributed small scale generation, in practice grid companies do not encourage this procedure. Furthermore, the actual tariff received can be significantly less compared to national guidelines. Measures need to be taken to guarantee grid connection for new HRPG CGB projects and a suitable electricity tariff.

3.3.7 Additionality

Additionality is the proof that the implementation of a project results in a net global reduction in emissions. In practice this means that the project must demonstrate that it would not have occurred in the absence of CDM financing. It needs to be shown through quantitative and qualitative evidence that the project would not have been implemented if it were not for the provision of carbon finance and also does not create an increase in emissions elsewhere, outside the project boundary – known as 'leakage'. This is the centre piece of CDM project assessment.

The additionality argument can be split into two parts:

Financial additionally

Financial additionality is a straight forward analysis which must show that a project's financial returns (i.e. IRR/NPV) do not cross the relevant investment 'hurdle rate' or benchmark, meaning that an investor would not proceed with the project without extra financing from CDM. With regard to HRPG technology in the coal gangue brick sector in China, the investment benchmark is provided by NDRC and is set at an 11% return pre-tax. Therefore, if an HRPG project generates financial returns (i.e. IRR) which is below 11%, the project can be considered financially additional. According to the FSRs, both Yiwang and Juyi have IRRs that are above this benchmark and are therefore not additional. However, according to our model, there is a significant portion of the coal gangue brick market that would show financial additionality for the application of HRPG.

The key drivers of IRR are revenues and costs, so for the HRPG technology, the key revenue component is the electricity generated (therefore scale and utilisation) and the price paid for the electricity per MWh, and the key cost components are the CAPEX and OPEX of the plant.

Non-financial additionality (e.g. technology availability, common practice etc)

Non financial additionality is any other evidence of barriers that can be shown as a reason why the project cannot be implemented without CDM financing. The most common non-financial additionality argument centres around the availability and current penetration of a technology. If a project is the 'first-of-its-kind' or advanced foreign technology that is not currently common practice then it can be considered additional.

As previously stated, HRPG technology is widely used in various industrial sectors in China, so therefore it's difficult to justify additionality based on lack of prevailing practice, however it is true that HRPG technology is not being utilised in the CGB sector so it could be possible to articulate an argument based on sufficient evidence to show that the application of HRPG technology within the CGB sector in China is only possible with the additional financial incentive provided by the CDM. HRPG in the CGB sector does also present new technical challenges, such as the high proportion of sulphur in the flue gases.

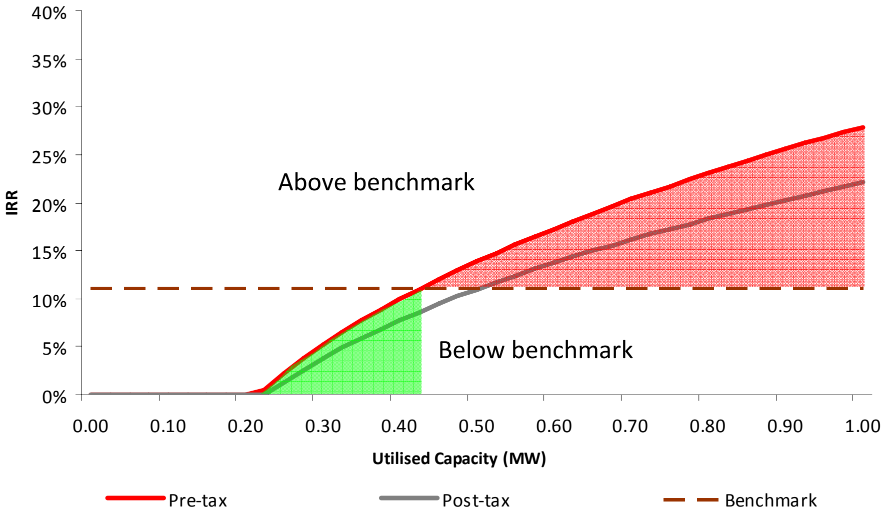
3.4 Conclusions

It can be seen from the analysis that there are two reasons why an HRPG project in the CGB sector would not be eligible for CDM: i) the project is not additional, or ii) the project is too small to be commercially viable.

3.4.1 Project is not financially additional

Figure 4 shows a simple illustration of the results from the analysis shown in Section 3.2. A project's financial returns increase in correlation with scale. The larger the CGB making plant, the larger the HRPG plant and the greater the revenues from the sale of electricity; the larger the HRPG plant, the lower the CAPEX per KW.

Figure 4 Illustration of CDM sector analysis



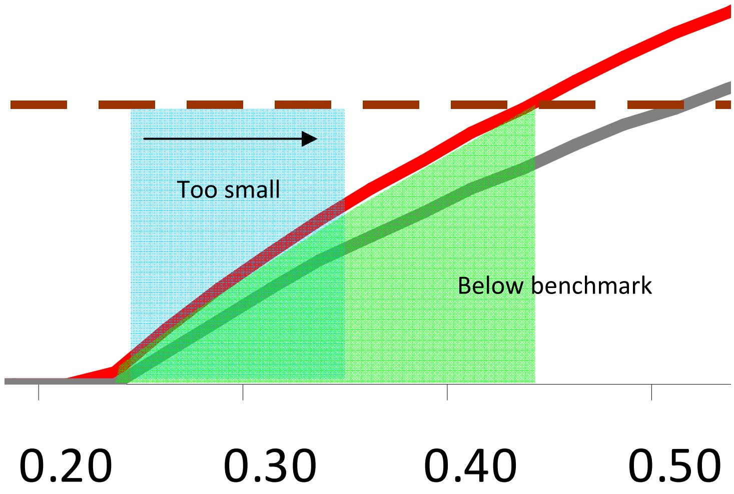
The investment benchmark for the purposes of CDM is 11% pre-tax, as set by NDRC, so it can be seen that there is a cut off point where the pre-tax IRR curve intersects the benchmark. Projects with returns above this point (shaded in red) are considered not financially additional, and projects below this point (shaded in green) are CDM opportunities.

The analysis done using the FSR data suggests that the cut off point is around 0.45 MW HRPG utilised capacity.

3.4.2 Project is too small to be commercially viable

As well assessing CDM potential based on expected returns and the investment benchmark, the analysis went on to consider if projects would generate enough CERs to justify the D&T costs, and therefore be considered commercial opportunities by CDM project developers. Figure 5 is an enlarged view of the 'below benchmark' area in Figure 4 above.

Figure 5 Illustration of CDM sector analysis – close up of projects below benchmark



Projects must be of a sufficient scale to generate enough CERs to justify the D&T costs. The D&T costs vary depending on the CDM approach, as discussed in Section 2.5 and 3.3, so the cut off point at which a project is considered too small and is difficult to define. It can be assumed, however, that the lower the D&T costs per project, the wider the range of capacities that will be viable as CDM projects.

It is true that the sector is stuck 'between a rock and a hard place', with relatively large scale projects (above 0.45 MW utilised capacity) being not financially additional, and small scale projects struggling to cover the D&T costs.

It is not possible with the data provided to quantify the number or precise scale of CGB HRPG projects that would fall in a 'sweet spot' between being large enough to cover the D&T costs and still being small enough to pass the test of financial additionality. In order to get a more accurate view of CDM potential more data is required relating to HRPG projects in the CGB of varying size, scale and utilisation.

4 Deliverable Two – pilot site CDM feasibility

Deliverable two – Pilot site CDM Feasibility and Assessment Report for Establishing HRPG CDM Projects within the Selected Pilot Coal-gangue Brick Factories*. Using the information contained in the feasibility study reports (FSR), the CDM potential for the Yiwang and Juyi pilot projects has been assessed. The results indicate the likely success of registering the pilot sites as CDM projects*

This section summarises the results of our analysis on the potential for the two CGB HRPG pilot plants at Yiwang and Juyi to be developed as CDM projects.

The data contained in the FSRs has been used together with additional information and clarification from the workshops and site visit to run the CDM model component described in Section 5. The model estimates the financial returns of the project and hence indicates whether it is financially additional.

4.1 Yiwang, Shanxi – results of CDM analysis

4.1.1 Performance and power generation

Yiwang is a medium-sized CGB making factory with a production output of over 120,000 bricks per day (about 35 million bricks per year). The recoverable residual heat is around 685 MWh of heat energy per day. For this size of plant and amount of waste heat, the HRPG steam turbine utilised capacity is 0.5 MW giving a net output of 3,326 MWh of electricity (based upon operational hours of 7,200).

4.1.2 CER generation

The estimated annual CERs generated are 3,161 tonnes CO_2e per year.

4.1.3 Financial assessment

Based upon the CAPEX of RMB 7.95 million (of which 70% is spent in year 0 and 30% spent in year 1), the post tax IRR, without CDM revenue, is 11.34% which is marginally above the benchmark (this is equal to the IRR given in the FSR).

Table 5 Financial returns from the HRPG investment including the additional revenue from CDM minus the D&T costs. Red indicates CDM would not add value. Green indicates value added.

Carbon price (RMB)	Flat fee	Revenue share
80	**9.92%**	**10.55%**
130	**11.30%**	**12.09%**
250	**14.84%**	**16.05%**

The threshold carbon price for a flat fee arrangement is RMB 132.70. The CDM would add value if the carbon price is greater than this threshold. For a revenue share arrangement, CDM appears to add value if the carbon price is above approximately RMB 105.

4.1.4 Conclusion

Assuming a single project approach, the financial analysis for the Yiwang factory illustrates that financial additionality can be achieved for projects of a small enough scale, although in this case the IRR is marginally above the benchmark, according to FSR data. Further, our analysis of development and transaction costs against CDM returns has shown a sufficient carbon price is necessary to make CDM a worth while investment for the brick factory owner (due to flat fee development costs of approximately RMB 500,000 upfront, and RMB 200,000 annually). Yiwang requires a carbon price between RMB 105 (on a revenue share basis) and RMB 130 (on a flat fee basis) to achieve a positive NPV for CDM project development. The secondary CER price is currently around RMB 110 (EUR 11), and primary prices are by definition at a discount to this, so it is unlikely that the project will be able to attain a carbon price sufficient to justify the D&T costs.

4.2 Juyi, Shanxi – results of CDM analysis

4.2.1 Performance and power generation

The Juyi plant is much larger than Yiwang, with production output of 277,800 bricks per day making it a very large example (equivalent to around 80 million per year). The recoverable residual heat is around 15,803 MWh of heat energy per day. For this factory size and amount of waste heat, the HRPG steam turbine utilised capacity is 1 MW, giving a net output of 6,779 MWh of electricity per year (again based upon operational hours of 7,200 given in the FSR).

4.2.2 CER generation

The estimated annual CERs generated are 6,441 tonnes CO_2e per year.

4.2.3 Financial assessment

The post tax IRR, without CDM revenue, is 25.38% (this is different to the figure given in the FSR of 28.78% due to uncertainties in tax treatment). This is based upon the CAPEX of RMB 9.95 million (of which 90% is spent in year 0 and 10% spent in year 1).

Table 6 Financial returns from the HRPG investment including the additional revenue from CDM minus the D&T costs. Red indicates CDM would not add value. Green indicates value added.

Carbon price (RMB)	Flat fee	Revenue share
80	**24.97%**	**28.47%**
130	**27.20%**	**30.44%**
250	**32.70%**	**35.28%**

The threshold carbon price for a flat fee arrangement is RMB 91. The CDM would add value if the carbon price is greater than this threshold. For a revenue share arrangement, CDM appears to add value to the project owner regardless of the carbon price.

4.2.4 Conclusion

Assuming that the FSR data reflects the true financial parameters, the Juyi pilot project is not financially additional within the guidelines laid out by the UNFCCC (see Section 3.3.6). Although the expected number of CERs is sufficient to add value to the project owner considering the D&T costs, it is not a viable CDM project due to the lack of financial additionality.

5 Deliverable Three – CDM model component

***Deliverable Three – CDM Model Component for inclusion into the overall 'Brick Sector Heat Recovery Power Generation Project Feasibility Model' Package.** The CDM model component can be applied to any potential CGB HRPG CDM project, by inputting all necessary economic and technical parameters and processing these under one of the three aforementioned CDM project scenarios, in order to determine project feasibility and best economic approach.*

This section presents an overview of the CDM model component including schematic diagram and descriptions of each sub component.

5.1 Overview

The CDM model component has been developed using Microsoft (MS) Excel. This model has been executed to assess whether or not the HRPG CDM projects are feasible across the CGB sector (Deliverable one) and to determine the CDM feasibility for the two HRPG pilot projects (Deliverable Two). This generic model can be applied to any given CGB factory. The model input parameters are based upon the AMS III.Q approved small-scale CDM methodology.

By inputting all necessary economic and technical parameters for a given HRPG project into the model, the IRR, the potential number of CERs that could be generated from the CDM and added CER revenue can be calculated automatically. The model outputs can be used by factory project owners or CDM developer to support CDM-related decision making, as follows:

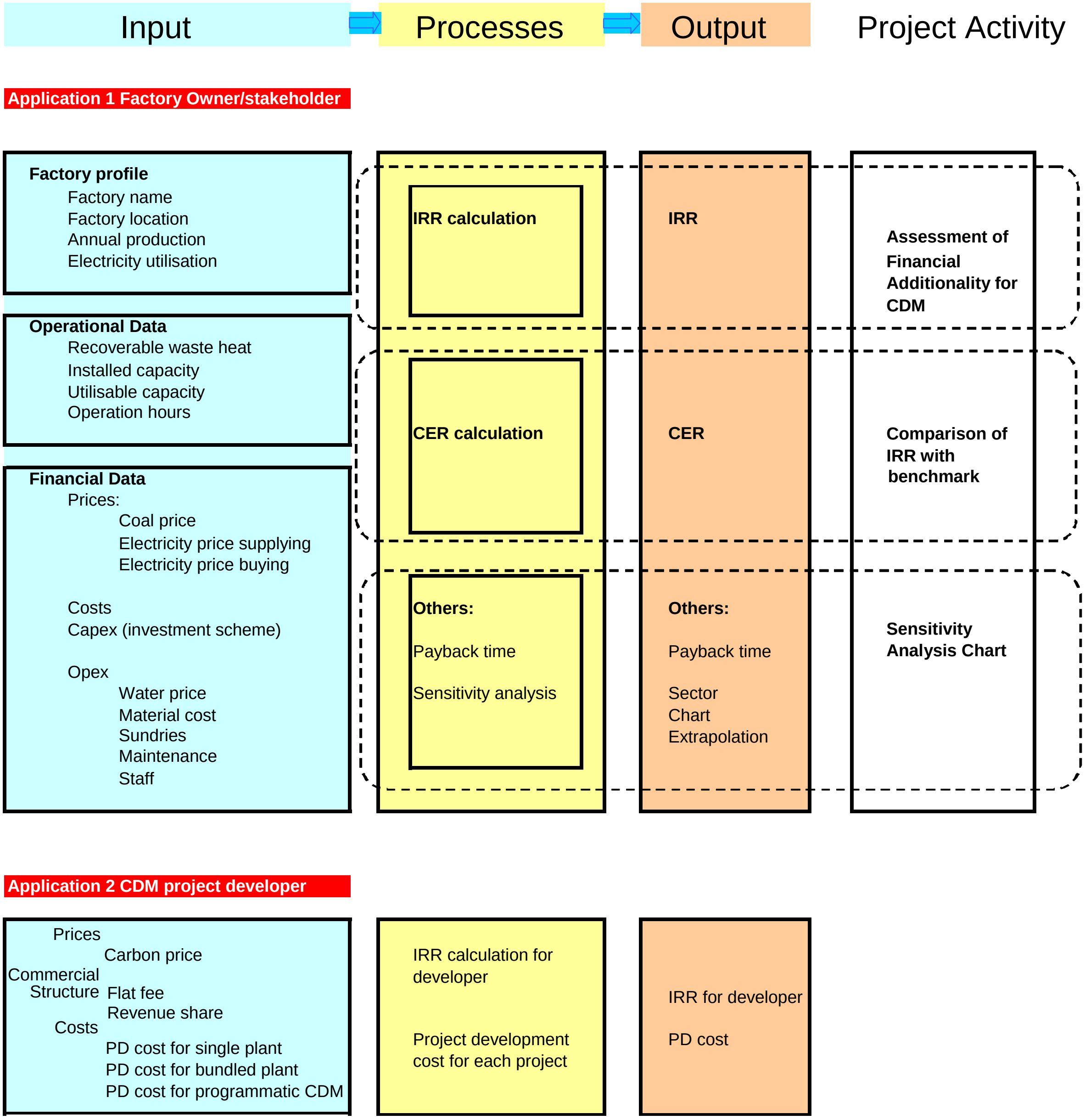
- The financial eligibility for CDM for a proposed HRPG CDM project can be evaluated by calculating the IRR (without additional project income from CERs) and comparing this with the current industry benchmark.
- Whether or not the CDM adds commercial value to a project can be determined by calculating the number of CERs that could be generated, and their potential value, under one of three CDM PD approaches, and then calculating the IRR with CER revenue included.
- For the project developer, the commercial value for a project can be examined over two commercial structures (flat fee and revenue share).
- A sensitivity analysis can be carried out by altering any one of the input variables (e.g. electricity buy and sell price, and carbon price).

5.2 Description of model and subcomponents

A simple and user-friendly version of the model has been created which uses pop-up dialogue boxes to request all data input parameters required from the user for a given CGB HRPG project. The calculations are then initiated automatically and the resulting CERs and IRR are displayed.

The model consists of three subcomponents: inputs, processes and outputs, as illustrated in Figure 6.

Figure 6 Schematic diagram of the CDM model component displaying inputs, calculations and outputs



5.2.1 Inputs

The necessary parameters are arranged into factory profile, operational parameters and financial parameters. All of these parameters shall be provided by the user. A screen shot of the *Input* worksheet is shown in Figure 7 showing the input cells highlighted in light blue.

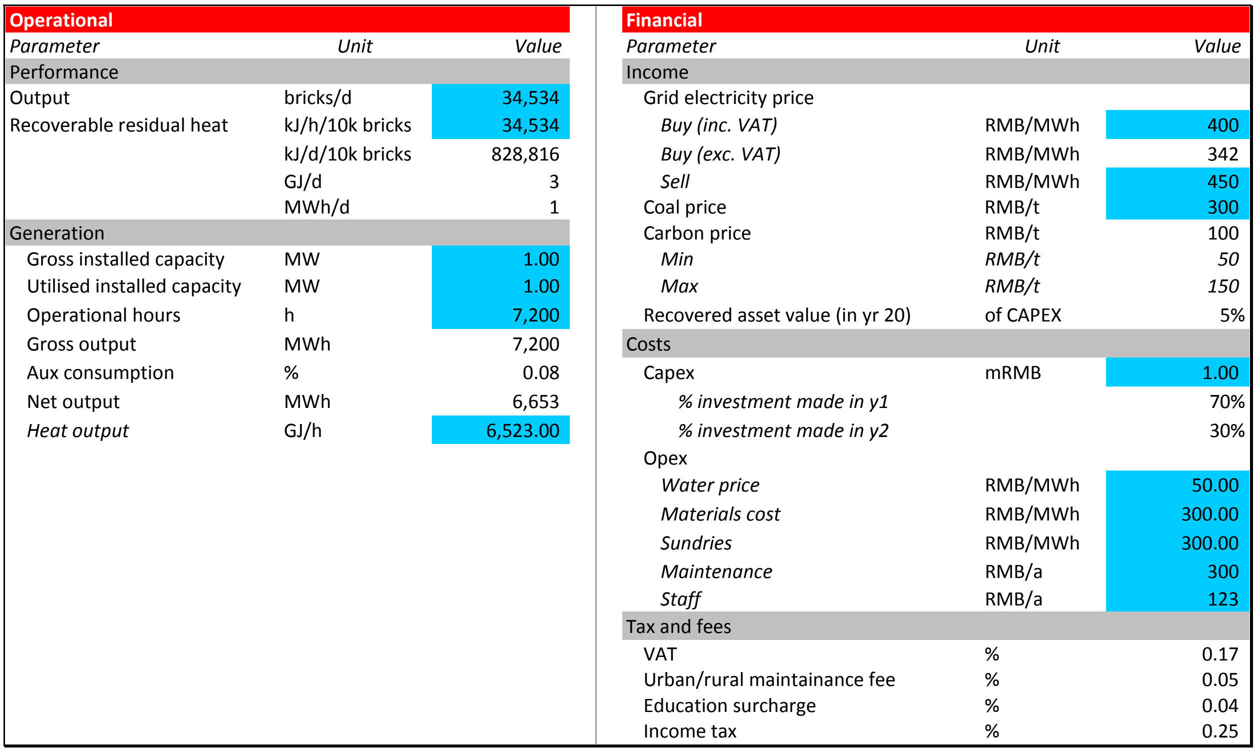
Factory profile

The profile specifies the physical characteristics of a factory. Information can be input via keyboard into text fields or the input options can be selected using the drop-down menu provided. These include:

- Factory name and location – electricity grid emissions factors for China, published by NDRC, are used in the CER calculation and are dependent on the selected location.

- Options for electricity utilisation – if electricity generated is consumed at the factory, then an emissions factor will be used instead of the nationally issued factor.
- Brick production volume – the recoverable waste heat is dependent on annual production volume. This influences the HRPG steam turbine utilised capacity, and in turn has a direct impact on the number of CERs generated.

Figure 7 The CDM model component inputs worksheet showing the operational and financial parameters



Operational		
Parameter	*Unit*	*Value*
Performance		
Output	bricks/d	34,534
Recoverable residual heat	kJ/h/10k bricks	34,534
	kJ/d/10k bricks	828,816
	GJ/d	3
	MWh/d	1
Generation		
Gross installed capacity	MW	1.00
Utilised installed capacity	MW	1.00
Operational hours	h	7,200
Gross output	MWh	7,200
Aux consumption	%	0.08
Net output	MWh	6,653
Heat output	GJ/h	6,523.00

Financial		
Parameter	*Unit*	*Value*
Income		
Grid electricity price		
Buy (inc. VAT)	RMB/MWh	400
Buy (exc. VAT)	RMB/MWh	342
Sell	RMB/MWh	450
Coal price	RMB/t	300
Carbon price	RMB/t	100
Min	*RMB/t*	*50*
Max	*RMB/t*	*150*
Recovered asset value (in yr 20)	of CAPEX	5%
Costs		
Capex	mRMB	1.00
% investment made in y1		70%
% investment made in y2		30%
Opex		
Water price	RMB/MWh	50.00
Materials cost	RMB/MWh	300.00
Sundries	RMB/MWh	300.00
Maintenance	RMB/a	300
Staff	RMB/a	123
Tax and fees		
VAT	%	0.17
Urban/rural maintainance fee	%	0.05
Education surcharge	%	0.04
Income tax	%	0.25

Operational parameters

These parameters are relevant to factory operation:

- Recoverable waste heat: used to calculate thermal production and the amount converted to electricity.
- HRPG installed and utilised capacity: the heat recovery boiler and steam turbine is sized and selected by the factory owner based upon various factors (e.g. standard sizes and types are available on the existing market). The utilised capacity is dependent on the amount of recoverable waste heat generated.
- Operational hours – this is used to calculate the total annual power generation from HRPG.

Financial parameters

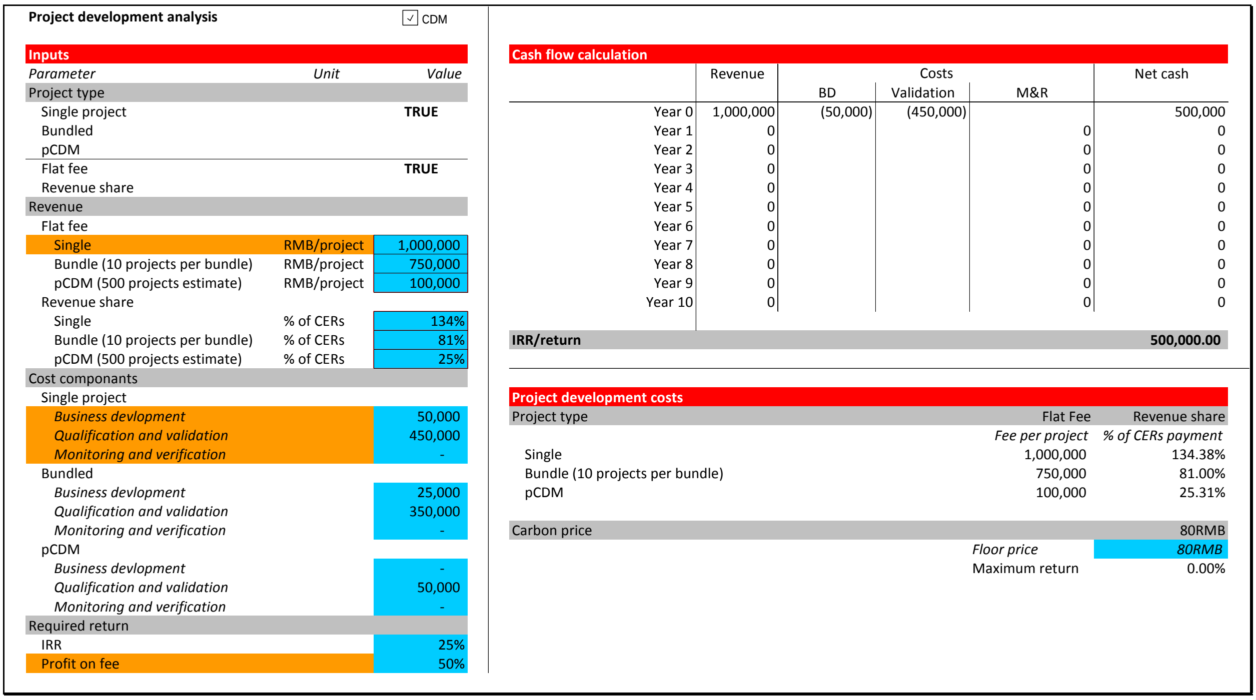
- Coal price – these prices are applied to calculate income. If the factory has its own power plant then HRPG will reduce coal use and make a cost saving based upon the coal price input.

- Electricity buy and sell price – Alternatively, if the HRPG will reduce the amount of electricity purchased from the grid, then the buying price input will determine the cost saving. If electricity is sold to grid, then the sell price is applied to calculate additional income.
- Capital investment and operational costs (CAPEX and OPEX) – Capital costs for HRPG may appear in different investment schemes (e.g. in year one the majority of investment is paid off and a minor part is left for year two). Operation costs include water, material, sundries, maintenance and staff expenses. All costs are in RMB.

CDM project developer input

The PD subcomponent (included in the '*PD'* worksheet*)* allows the PD parameters to be input and the project IRR (with CDM financing) to be calculated. A screen shot of the PD worksheet is displayed in Figure 8. The appropriate CDM approach can be selected (either *single, bundled or programmatic*). The revenue option can be selected. For the *flat fee* option, the cost per project can be preset for single, bundled and pCDM approaches (the assumed default values are given in Section 2.5). For the *revenue share* option, the percentage can be preset (the commercial structure is explained in Section 2.6). Likewise, the D&T cost attributes, the required rate of return on the developer's investment and required profit margin on the fee can also be preset (and again the default values are considered reasonable based upon Camco's experience). Finally, the carbon price is selected.

Figure 8 CDM project development input



Project development analysis ☑ CDM

Inputs		
Parameter	*Unit*	*Value*
Project type		
Single project		**TRUE**
Bundled		
pCDM		
Flat fee		**TRUE**
Revenue share		
Revenue		
Flat fee		
Single	RMB/project	1,000,000
Bundle (10 projects per bundle)	RMB/project	750,000
pCDM (500 projects estimate)	RMB/project	100,000
Revenue share		
Single	% of CERs	134%
Bundle (10 projects per bundle)	% of CERs	81%
pCDM (500 projects estimate)	% of CERs	25%
Cost componants		
Single project		
Business devlopment		50,000
Qualification and validation		450,000
Monitoring and verification		-
Bundled		
Business devlopment		25,000
Qualification and validation		350,000
Monitoring and verification		-
pCDM		
Business devlopment		-
Qualification and validation		50,000
Monitoring and verification		-
Required return		
IRR		25%
Profit on fee		50%

Cash flow calculation

	Revenue	Costs			Net cash
		BD	Validation	M&R	
Year 0	1,000,000	(50,000)	(450,000)		500,000
Year 1	0			0	0
Year 2	0			0	0
Year 3	0			0	0
Year 4	0			0	0
Year 5	0			0	0
Year 6	0			0	0
Year 7	0			0	0
Year 8	0			0	0
Year 9	0			0	0
Year 10	0			0	0
IRR/return					**500,000.00**

Project development costs

Project type	Flat Fee	Revenue share
	Fee per project	*% of CERs payment*
Single	1,000,000	134.38%
Bundle (10 projects per bundle)	750,000	81.00%
pCDM	100,000	25.31%

Carbon price	80RMB
Floor price	*80RMB*
Maximum return	0.00%

5.2.2 Calculations

The *Calculations* subcomponent calculates the IRR, CERs, payback time and sensitivity analysis automatically.

Number of certified emissions reductions

The formulae used to calculate the CERs generated by a given HRPG project are based on the equations provided in ASM.III.Q CDM methodology. There are a number of equations that can be applied depending on the factory's energy source. If the project utilises its own power plant then the coal saving is used in the CER calculations, for example. The captive plant efficiency is assumed to be 30%, the net calorific value (NCV) of coal is 20 MJ/kg, and carbon factor for coal is 0.096 tonnes CO_2/GJ. If the project uses electricity solely from the grid then the grid emissions factor is used.

Internal rate of return

Based on operational and financial input data, the IRR is calculated using the MS Excel IRR function. According to guideline issued by the NDRC and the Ministry of Construction (Chinese Government),[4] the lifetime of plant is 20 years. The depreciation rate for fixed assets is 5% for 15 year. Tax rates are based on power generation industries.

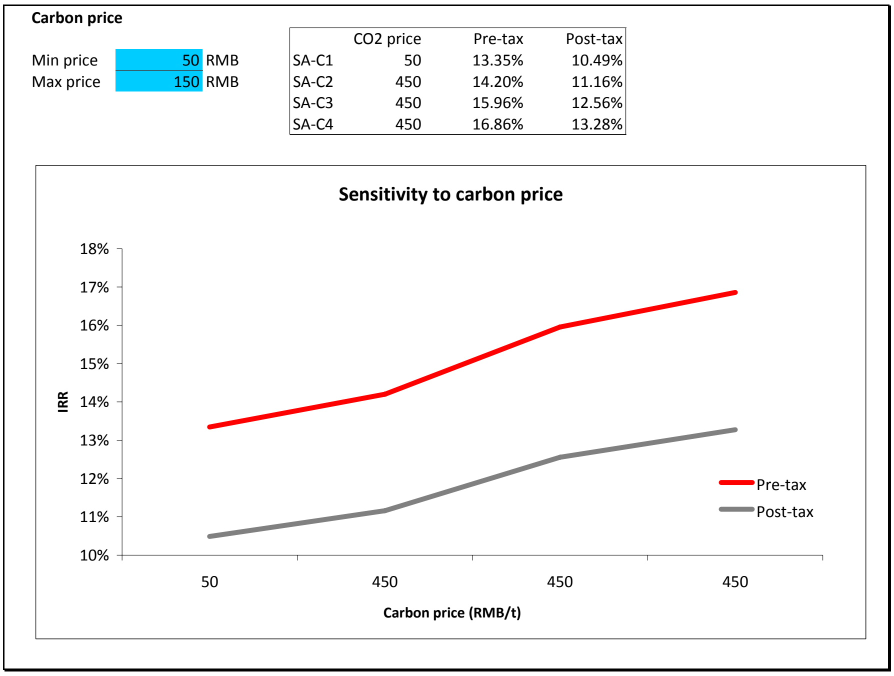
Net present value

The project NPV is calculated using the MS Excel NPV function. The payback time is shown in a cumulative earnings chart.

Sensitivity analysis

The main parameters influencing the project IRR and CERs are CAPEX, carbon price, electricity sell price and utilised HRPG steam turbine utilisation (and actual electricity generation). The effect of varying these parameters on project IRR is displayed on various charts in the *SA_summary* worksheet, as shown in Figure 9.

Figure 9 The sensitivity of carbon price and impact on project IRR (with CDM revenue)



Carbon price

Min price	50	RMB
Max price	150	RMB

	CO2 price	Pre-tax	Post-tax
SA-C1	50	13.35%	10.49%
SA-C2	450	14.20%	11.16%
SA-C3	450	15.96%	12.56%
SA-C4	450	16.86%	13.28%

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[4] Economic Evaluation Method and Criteria for Construction Project, NDRC and Ministry of Construction P.R. China, the 3rd version.

5.2.3 Outputs

The CDM component outputs are as follows:

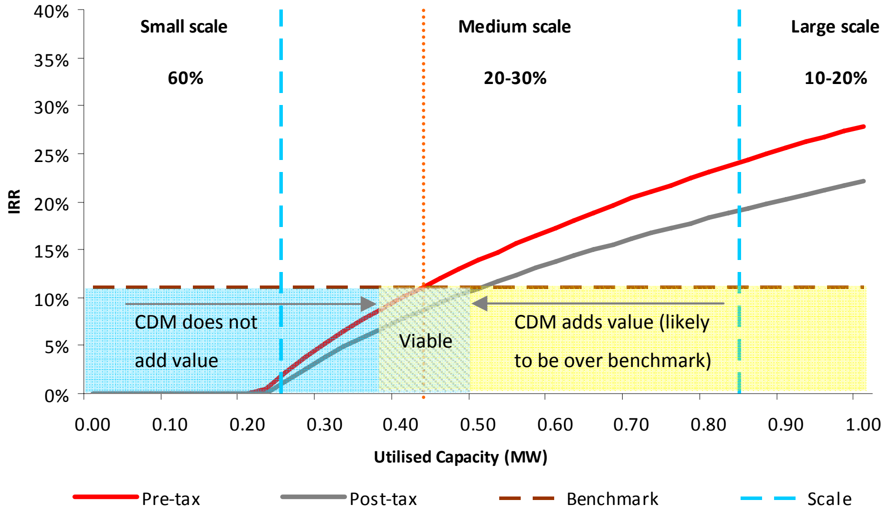
- Assessment of financial additionality for CDM (comparison of IRR with benchmark)
- Sensitivity analysis charts
- Sector-level curve plotting IRR against utilised capacity of HRPG steam turbine capacity (extrapolated from pilot site points)

6 Conclusions and recommendations

Coal-gangue HRPG projects that display financial additionality may not be profitable enough to create value from the CDM. This is an irony that is often encountered with small-scale CDM projects. An inverse relationship can be seen between scale and carbon price required to generate value from the CDM (larger capacity turbine will generate more electricity at the same operating hours therefore will generate more CERs, for example). At a carbon price of between 90 and 130 RMB, Camco estimates that the CDM could add value to the Yiwang and Juyi pilot projects (based upon the FSR data), however projects of this scale (0.45 MW and above) are not financially additional (above 11% IRR pre tax).

Figure 10 below is the output from the sector model described in deliverable one. The graph shows the 11% benchmark superimposed over the IRR curve of the HRPG technology at increasing scale. The blue and yellow areas represent the range of scales of which HRPG in the CGB sector would be ineligible for CDM. CDM for small scale projects (highlighted in blue) does not add sufficient value; larger scale projects (highlighted in yellow) are likely to generate financial returns that are above the 11% benchmark. It is possible that projects of a scale between these two constraints (located in the green area) may be viable for CDM, although it is not possible from the analysis to quantify the exact number of projects or range of scales.

Figure 10 Relationship between IRR and production output/HRPG steam turbine utilised capacity for a CGB factory.



Based upon the data contained in the FSRs and information gathered from the workshops, our analysis has shown that there are two primary barriers to CDM.

- The first applies to small scale coal-gangue brick HRPG projects below a certain utilisation level that do not create enough CERs to justify the project development costs.
- The second barrier applies to large scale projects that are not financially additional under the CDM guidelines set out by the UNFCCC Executive Board.

The key underlying assumptions in the analysis are that the D&T costs (applying a flat fee and single project approach) will be approximately RMB 1 million, and the carbon price will be between EUR 8 and 25. Little can be done to mitigate the risk posed by the carbon price, however D&T costs can be reduced through using the bundled or pCDM approaches.

Camco estimates that the PD costs would be reduced by 25% to RMB 750,000 per project by using the bundled approach (assuming 10 projects per bundle); and costs would be reduced to RMB 100,000 by using pCDM (this excludes the cost of an aggregator, which could be substantial).

As discussed, bundling increases elements of CDM delivery and registration risk, and although pCDM offers the potential to sufficiently reduce PD costs, it is so far unproven in China. To date, no pCDM projects have been registered in China thus presenting an inherent risk to any commercial entity setting out to qualify a programme in China. It is Camco’s view that attempting to qualify a pCDM project in China would involve a large element of learning by doing. Furthermore, measurement, reporting and verification (MRV) costs are uncertain and could consume up to 100% of returns from a pCDM project.

6.1.1 Reliability of data contained in the FSRs

It is important to note that there are a number of uncertainties in the FSR data that feed through to uncertainties in the analysis.

The FSRs assumes that the design of the HRPG system is substantially oversized, and it is unclear why the ‘utilised capacity’ is between 50% and 75% of name plate capacity. This impacts the IRR calculations by assuming low electricity generation and high capital expenditure.

Conversely, the capital expenditure seems to be underestimated and the revenues over estimated.

- A figure of RMB 6000/kW has been used to calculate the capital cost of the HRPG equipment, but this applies to large scale plants and would be expected to increase significantly for smaller scale installations.
- The RMB 550/MWh electricity tariff appears very high, considering that the CGB plant is unlikely to productively use all of the power produced and the average tariff being paid by grid providers is much lower.

6.1.2 Corrected analysis

It is not possible to accurately quantify or correct for the uncertainties discussed above, but a number of educated assumptions have been made to illustrate the sensitivity of the analysis to changes in the input data, shown in Figure 11 below.

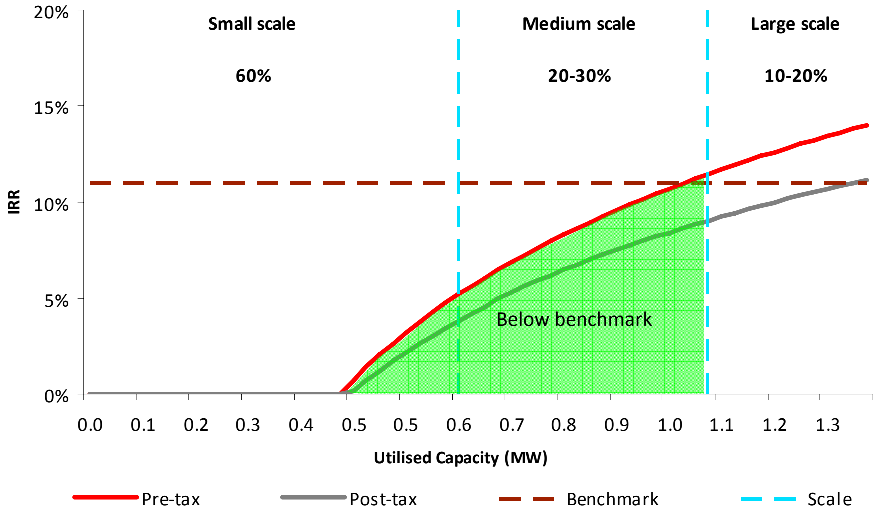
The sector model described in Deliverable One has been run using the FSR data and the following corrections:

- 25% increase in CAPEX to compensate for RMB 6000 per kW assumption that looks very low.
- Electricity price has been changed to RMB 350 per MWh, which is considered realistic in Camco’s experience. However, CDM guidelines dictate that the electricity price used in the

financial analysis needs to be the approved government purchase price. In China this is higher than what a PD would realistically expect to receive.

By changing two of the input variables for CAPEX and electricity price, the model indicates that all of the small and medium scale projects are financially additional.

Figure 11 Corrected illustration of expected returns on HRPG projects in the CGB sector



6.2 Recommendations

Further research into the Chinese brick making sector and economic parameters – Further work is required to gain a deeper understanding of the HRPG technology and economic parameters at different sizes to provide a more accurate assessment of capital costs and revenue. This could help remove uncertainty and perceived risk in order to attract further attention from investors or CDM developers. This could involve identification of further potential projects and the development of further FSRs. More accurate market information on the CGB and standard brick making sector is required to better assess the CDM HRPG potential across the sector (e.g. survey CGB factory owners in parallel with the workshops planned by UNIDO to be held in 2010). Furthermore, it would be useful to further research the potential impacts of the Chinese government's strong targets for increased utilisation of coal gangue. If this leads to a marked increase in new coal-gangue brick factories, the opportunities for CDM might also multiply.

CDM project development – There is nothing preventing project developers or project owners from attempting to qualify an HRPG investment as a CDM project. However, based upon the financial parameters given in the FSRs, no project developer would be willing to develop this under a revenue shared agreement and the fixed fee would negate any value as we have shown. Alternatively, a succinct manual and relevant guideline could be offered to project owners to help them develop the CDM project themselves, thus removing the PD costs from the equation.

Unlock the potential of Programmatic CDM – No programmes have yet been registered in China. Six are in various stages of development none of which are related to energy efficiency, HRPG or building materials. Further work and research is required to remove the policy barriers facing pCDM in China and to reduce the uncertainties and associated programmed development costs. A project could be funded to to create a PoA and implement several CPAs under the programme (e.g. several HRPG projects). Further research is required into the coal gangue and standard brick making sector to gather more accurate market intelligence on the number of eligible factories with tunnel kilns (or future plans to construct tunnel kilns) where HRPG could be applied. Action would be required to identify those factories who could meet the criteria for inclusion into any CDM programme.

Investing in high returns at the medium to large scale – Medium to large coal gangue brick companies should invest in HRPG technology themselves (due to the evident high economic returns) in all new brick factories. It is possible, that tunnel kilns could become mandatory within new builds over the next 3 to 5 years in China throughout CGB and standard brick sector. This could reduce the costs for this technology further and thus impact CDM additionality. UNIDO could perhaps focus effort on an alternative sector and alternative technology which has high emissions reduction potential but little or no financial return.

Annex

Clean Development Mechanism

7 Clean Development Mechanism

7.1 Introduction

The Clean Development Mechanism (CDM) allows emission reduction (or emission removal) projects in developing countries to earn certified emissions reductions (CER) credits, each equivalent to one tonne of CO_2. These CERs can be traded and sold, and used by industrialised countries to a meet a part of their emissions reductions targets under the Kyoto Protocol. In Europe, CERs can be purchased directly by companies that have legal emissions reduction obligations under the EU Emissions Trading Scheme.

The mechanism stimulates sustainable development and emissions reductions, while giving industrialised countries some flexibility in how they meet their emissions reductions limitation targets.

The projects must qualify through a rigorous and public registration and issuance process designed to ensure real, measurable and verifiable emissions reductions that are additional to what would have occurred without the project. The mechanism is overseen by the CDM Executive Board, answerable ultimately to the countries that have ratified the Kyoto Protocol.

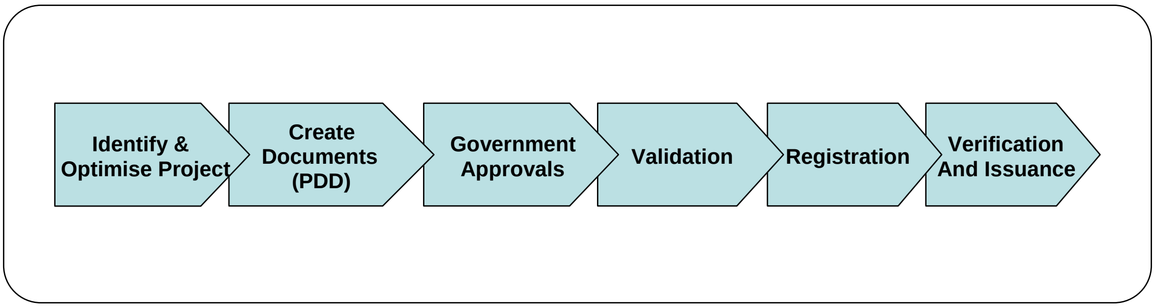
In order to be considered for registration, a project must first be approved by the Designated National Authority (DNA) of the host country.

Operational since 2003, the mechanism has already registered more than 1,000 projects and is anticipated to produce CERs amounting to around 1 billion tonnes of CO_2 equivalent in the first commitment period of the Kyoto Protocol, 2008–2012.

7.2 Project development process

The key steps of CDM application process in China are shown in Figure 12 and are described below.

Figure 12 Typical CDM project development



Identify and optimise project – The first step in the CDM project cycle is the identification and formulation of potential CDM projects. The emissions reductions from a CDM project must be real, measurable and additional.

Create documents – The Project Design Document (PDD) is a key document for a CDM project application. It should be written in line with the requirements of an applicable methodology that has been approved by the CDM Executive Board and should contain the project description, baseline identification, additionality demonstration, emission reduction calculation and other key elements.

Government approvals – These should be obtained from both the government of the project owner (i.e. China) and the government of the buyer of the credits. In China, the CDM Designated National Authority (DNA) is the National Climate Change Co-ordination Committee (NC4) of the National Development and Reform Commission.

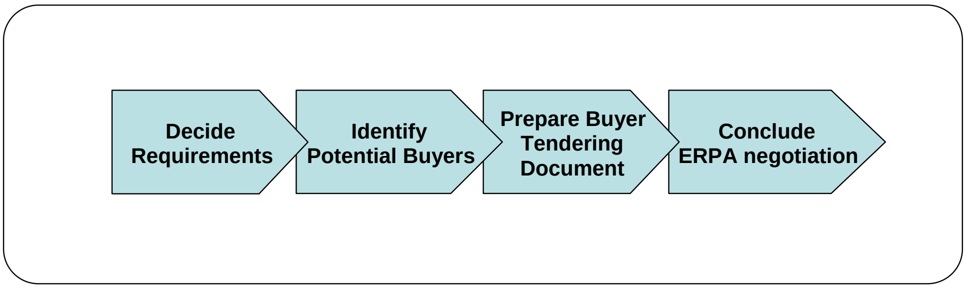
Validation and Registration – Each potential CDM project has to have independent third party validation from an accredited certification company known as a Designation Operational Entity, to ensure that the project meets the requirements of the CDM.

Verification and Issuance – Once a registered project is operational, participants should prepare a monitoring report, including an estimate of CERs generated, and submit it for verification by a DOE. The DOE must make sure that the CERs have resulted according to the guidelines and conditions agreed upon in the initial validation of the project before any CERs can be issued.

7.3 Commercial arrangements

Carbon credits are typically contracted under long-term contracts. A variety of models exist but typically a project owner will enter into a legal agreement with a buyer of CERs to supply CERs in return for a fixed payment for each CER.

Figure 13 Typical steps for commercialising carbon credits



7.4 Methodologies for waste heat recovery projects

There are two approved CDM methodologies relevant to industrial HRPG projects, large scale and small scale (UNFCCC/CCNUCC 2007).

ACM0012 "Consolidated baseline methodology for GHG emission reductions from waste energy recovery projects" This is a large scale methodology, meaning it is normally only applied to projects achieving emissions reductions of more than 60,000 tonnes CO_2e per year. There are 12 ACM0012 projects registered under the CDM with a total of 1.3 $MtCO_2$e emission reductions per annum. Figure 14 shows that nine projects are located in China. Details of all projects are listed in Table 7.

Figure 14 Registered ACM0012 CDM project by region

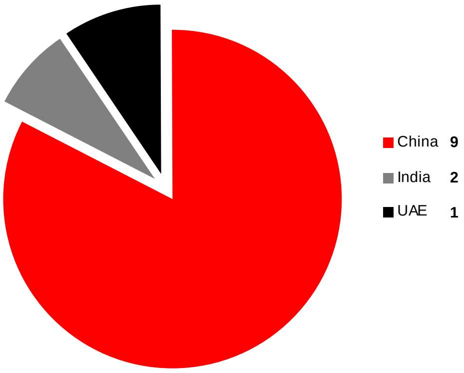


Table 7 Registered ACM0012 CDM projects under the CDM

Project code	Sector	Host Country	Estimated CERs	DOE	Project Developer
1878	Cement	China	97711	DNV	Deutsche Bank AG London
1905	Carbon black manufacturing	India	87305	TÜV SÜD	Hi – Tech Carbon (HTC)
2686	Power and water desalination	United Arab Emirates	119069	DNV	Emirates CMS Power ; Abu Dhabi Future Energy
2701	Cement	China	67054	TÜV SÜD	Climate Change Capital Carbon Managed Account Limited ; Climate Change Capital Carbon Fund II s.à r.l.
2095	Cement	China	95546	Energy Systems International B.V.	China United Cement Corporation Nanyang Branch
2516	Coking	China	108740	TÜV SÜD	Nippon Steel Corporation (NSC)Zibo
2515	Iron and Steel	China	135992	TÜV NORD	Carbon Asset Management Sweden AB
2506	Iron and Steel	China	271355	TÜV SÜD	Deutsche Bank AG London
2504	Metal	India	18082	TÜV NORD	Sterlite Industries (India) Limited
2416	Chemical	China	62676	TÜV SÜD	China Carbon N.V.
2469	Iron and Steel	China	105681	JQA	International Bank for Reconstruction and Development as Trustee of the Italian Carbon Fund
2521	Cement	China	110124	TÜV SÜD	Holcim Environment Services S.A.

AMS-III.Q – "Waste energy recovery (gas/heat/pressure) projects" is a small scale methodology, meaning it is only applied to projects that achieve less than 60,000 tonnes of emissions reduction per year. There are only three AMS-III.Q projects registered under the CDM. These are detailed in Table 8.

Table 8 AMS-III.Q projects registered under the CDM

Project code	Sector	Host Country	Estimated CERs	DOE	Project Developer
2379	Cement	Cambodia	17,107	SGS	Carbon Bridge pte ltd
1727	Chemicals	India	866	DNV	Cantor CO2e India
2675	Cement	China	46,813	TUV-SUD	KOE Japan

Small-scale CDM projects require:

- 15 MW maximum output capacity for RE projects;
- 60 GWh maximum energy saving for EE projects; and
- Annual emission reductions equal to or less than 60,000 tonnes of CO_2e for other project activities.

Small-scale CDM uses simplified baseline and monitoring methodologies which do not require common practice analysis.

7.5 Key parameters and calculations for AMS-III.Q

In order to assess the financial additionality and financial viability of a CDM project, a number of key parameters and data points must be known. Approved methodology AMS-III.Q clearly defines the parameters needed for the additionality argument and CER calculation. The parameters needed to assess financial viability to the PD are the same revenue and cost items that are used in the financial additionality calculation, merely interpreted differently.

The key parameters can be split into *technical* and *financial* and are listed in the tables below.

Table 9 The parameters describing the technical specification of the CGB plant and the HRPG technology, in accordance with AMS-III.Q.

Parameter*	Unit	Description
Production output	bricks/day	The production volume is determined by the size of the factory and kilns. This affects the amount of waste heat
Quantity of the waste heat	kJ/kg	The amount of waste thermal energy emitted as heat from the kilns influences the size of HRPG boiler and steam turbine
Temperature	°C	The "quality" of the waste heat medium is determined by its temperature, pressure and flow rate
Pressure	bar	
Flow rate	Q tonnes/hour	
Capacity of steam turbine	MW	The bigger the turbine capacity, the higher the CAPEX and, normally, the greater the electricity output
Operating hours	hours/year	The total operational time affects the amount of electricity generated
Auxiliary consumption	%	The higher the auxiliary consumption of the factory plant, the less electricity generated can be sold to the grid.
Grid emissions factor	tCO2e/MWh	Ranges from 0.6 to 1.2 for China depending on location

Table 10 Financial parameters

Parameter*	Unit	Description
Investment (CAPEX)	Money	All parameters affect the rate of financial return of the investment.
Payment schedule	% of CAPEX / year	
Operating expenditure (OPEX)	Money	
Tax rate(s)	%	
Salvage value of equipment	Money	
Grid electricity price (buy)	Money / kWh	
Carbon price	Money	

7.6 Single project, bundled and programmatic CDM approaches

CDM projects can be developed using one of three different approaches according to the size of the project and potential emissions reduction. These have various differences differ in terms of number of projects, development costs, registration risk, registration procedure and DOE requirement.

7.6.1 Single project site approach

This is the normal application scenario, and the application is proposed based on a specific individual project. Compared to a large scale CDM project, a small scale CDM follows a simpler and more flexible registration procedure.

Table 11 Single small-scale CDM under validation

Project Title*	Technology	Methodology	Reductions**	DOE/AE	Registered
Xiangfan Huaxin Cement 7.5 MW Waste Heat Recovery as Power Project	Waste gas based energy systems	AMS-III.Q. ver. 1	42,198	TÜV SÜD	Corrections (following review)
Chibi Huaxin Cement 7.5 MW Waste Heat Recovery as Power Project	Waste Energy Recovery (gas/heat/pressure) Projects	AMS-III.Q. ver. 1	42,198	TÜV SÜD	Review Requested

7.6.2 Bundled approach

This refers to the bringing together of several smaller scale CDM project activities, with the CDM project application based on the whole bundle. This is a good method to simplify the registration process and lower the transaction cost. Table 12 shows all bundled projects under validation in China, all of which are power generation from hydro. There are currently no EE or WHR bundled projects registered in China.

Table 12 Bundled CDM project under validation

Project Title[5]	Technology	Methodology	Reductions[6]	DOE/AE	Registered
12.8 MW Bundled Small Hydropower Project in Nasha and Nabin	Grid connected renewable electricity generation	AMS-I.D. ver. 10	39090	DNV	10 Dec 07
Changpinghe Yiji and Erji 10.4 MW Bundled Small Hydropower Project	Grid connected renewable electricity generation	AMS-I.D. ver. 10	29640	DNV	31 Mar 08
14 MW Bundled Small Hydropower Project in Xiping and Puhe	Grid connected renewable electricity generation	AMS-I.D. ver. 10	40189	DNV	12 Sep 08
Xinning County Dalong Small-scale Hydropower Bundled Project	Grid connected renewable electricity generation	AMS-I.D. ver. 12	28568	TÜV SÜD	09 Mar 09
Shuangqiao, Banqiao and Longtoushan Bundled Small Hydropower Project in Heilongjiang Province	Grid connected renewable electricity generation	AMS-I.D. ver. 13	46306	DNV	31 Jul 09
7.5 MW Bundled Small Hydropower Project in Qiandongnan Autonomous Region, Guizhou Province, P.R. China	Grid connected renewable electricity generation	AMS-I.D. ver. 13	19828	JACO CDM	21 Aug 09
Hunan Yongzhou Hydro Bundled Project	Grid connected renewable electricity generation	AMS-I.D. ver. 13	29335	Korea GHG Certification Office, Korea Energy Management Corporation	Review Requested
Xile and Huangqing 6.15MW Bundled Hydropower Project in Jiangxi Province	Grid connected renewable electricity generation	AMS-I.D. ver. 13	16325	TÜV SÜD	21 Dec 09
Hubei Wufeng Tangjia River Hydropower Bundled Project	Grid connected renewable electricity generation	AMS-I.D. ver. 13	35684	TÜV NORD	08 Jan 10
Xincun and Wenzhu Bundled Small Hydropower Project in Zhaoping County, Guangxi Zhuang Autonomous Region, China	Grid connected renewable electricity generation	AMS-I.D. ver. 13	28770	Deloitte	Review Requested

7.6.3 Programmatic approach

pCDM involves registering the project concept (referred to as the Programme of Activities document – PoA) and then, once approved, applying the concept to any number of eligible projects (CDM Programme Activity – CPA). This approach brings down the transaction costs per project and shortens project development time scales for CPAs once the PoA has been approved.

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[5] *AM - Large scale, ACM - Consolidated Methodologies, AMS - Small scale*
[6] *Estimated emission reductions in metric tonnes of CO_2 equivalent per annum (as stated by the project participants)*

Guidance for the development of pCDM has been provided by the UNFCCC, but the approach is yet to be put in to wide scale practice. There are currently only two registered pCDM projects in the world (both in Latin America) and nine more projects in validation. Six of these projects are in China but it is unclear whether they have been granted LoA approval by the NDRC.

This approach brings together several CDM project activities in a programmed structure, and there is no limitation on project scale. In this approach, a program contains many similar projects to be registered with the United Nations Executive Board, and each project involved would be subsequently added to the program. The approach requires registration and ongoing management at both the program level and for each individual project level, and a coordination entity is required to manage the program at both levels. In theory, the approach offers greater flexibility for CDM development within a sector and provides benefits to smaller scale projects; however in practice there are many barriers to overcome. Table 13 shows that there are no pCDM projects under development in China related to energy efficiency, HRPG or building materials.

Table 13 Programmatic CDM project under validation in China

Project Title	Technology	Methodology	Reductions[7]	DOE/AE	Period for Comments
Hydraulic rams for irrigation and domestic water supply in Zhejiang, China	Mechanical Energy for the user	AMS-I.B. ver. 10	1,000	TÜV NORD	09 Jun 09 - 08 Jul 09
Hunan Household Biogas Digester Programme	Thermal Energy for the user	AMS-I.C. ver. 15	400,000	Det Norske Veritas Certification AS	24 Nov 09 - 23 Dec 09
SGCC In-advance Distribution Transformer Replacement CDM Programme	Supply side energy efficiency improvements – transmission and distribution	AMS-II.A. ver. 10	3,933	TÜV NORD	24 Nov 09 - 23 Dec 09
Henan Province Shangqiu City Rural Household Biogas Development Programme (2008-2012)	Thermal Energy for the user	AMS-I.C. ver. 16	4,135	TUEV SUED	30 Dec 09 - 28 Jan 10
Henan Province Zhoukou City Rural Household Biogas Development Programme (2007-2010)	Thermal Energy for the user	AMS-I.C. ver. 16	1,925	TUEV SUED	30 Dec 09 - 28 Jan 10
Hydraulic rams for irrigation and domestic water supply in Zhejiang, China	Mechanical Energy for the user	AMS-I.B. ver. 10	1,000	TÜV NORD	09 Jun 09 - 08 Jul 09

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[7] *Emission reductions in metric tonnes of CO_2 equivalent per annum that are based on the estimates provided by the project participants in non-validated PDDs*

7.7 Project development and transaction costs

All CDM projects incur a number of development and transaction costs. CDM project developers are in the business of identifying and developing CDM projects. Costs are incurred at each stage of the development process shown in Figure 12 and Figure 13 above. These costs can be split into project development and transaction (D&T) costs as detailed in Table 14.

Table 14 Breakdown of typical project development costs per project[8]

Development stage	Overview	Single project cost	Bundled cost (10 projects)	pCDM cost (500 projects
Project development costs per project				
Upfront costs				
Business development (BD)	Work undertaken at the BD stage includes identifying projects and agreeing commercial terms with project owner(s) (PO). BD costs are only recovered from successful projects.	RMB 50,000	RMB 25,000	Negligible
Qualification	Work undertaken by PD's qualification experts – includes writing the Project Design Document (PDD) and preparing associated technical and regulatory documentation for the validation and registration processes.	RMB 250,000	RMB 200,000	RMB 25,000
Annual costs				
Annual monitoring and delivery support	The PD needs to provide ongoing assistance to the project owner to ensure monitoring procedures are followed, and data is collected for third party verification.	RMB 20,000	RMB 10,000	Negligible, excluding the cost of an Aggregator[9]
Transaction costs per project				
Upfront costs				
Validation	Fee payable to Designated Operational Entity (DOE) for auditing and validation work.	RMB 200,000	RMB 150,000	RMB 25,000
Annual costs				
Annual verification cost	Fee payable to the DOE for ongoing auditing and verification of emission reductions.	RMB 180,000	RMB 90,000	RMB 50,000
Sundries				
Registration fee	Fee payable to the UN on submission for registration.	US¢ 10/CER for the first 15 ktCO2e, then US¢ 20/CER	US¢ 10/CER for first 15 ktCO2e, then US¢ 20/CER spread over all projects in bundle	Dependant on number of projects in the programme
Issuance fee	Fee payable to the UN on request for issuance of CERs. A tax is also placed on project owners by the Chinese Government.	US¢ 20/CER (minus the registration fee) plus a tax of 2% in China.	US¢ 20/CER (minus registration fee) plus a tax of 2% in China.	US¢ 20/CER (minus the registration fee) plus a tax of 2% in China.
Total upfront costs		RMB 500,000	RMB 375,000	RMB 50,000
Total annual costs		RMB 200,000	RMB 100,000	RMB 50,000

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[8] The D&T costs have been estimated by Camco based upon our experience and are deemed to be representative of the lower end of the CDM project developer market. The single project costs are considered to be conservative, in particular.

[9] The local Aggregator would receive a fee and be responsible for gathering and coordinating all eligible projects.

References

Song Lingling, Ding, Dongwei, Liu Xin. 2009. *The current status and trend of the coal-gangue brick sector in China*. *Tile.*

Energy and Environmental Development (EED) Consulting Ltd. 2009. *UNDP/Spanish MDG Achievements Funds: Sector Study and Project Pilot Identification on Promoting the Adoption of Heat Recovery Power Generation in Coal Gangue Brick Making Sector.*

UNFCCC/CCNUCC. 2007. *ACM0012 – Consolidated baseline methodology for GHG emission reductions from waste energy recovery projects. Version 03.2.* [pdf] Available at http://cdm.unfccc.int/UserManagement/FileStorage/0M4N9567GH1J7UAJ89YNQ299K1MYSI [Accessed 12 December 2009].

UNFCCC/CCNUCC. 2007. *AMS-III.Q – Waste energy recovery (gas/heat/pressure) projects. Version 03.* [pdf] Available at
http://cdm.unfccc.int/UserManagement/FileStorage/E6CV5BF043DMQ2HGY8I1AWZTNUJS9R

[Accessed 12 December 2009].

Chinese Government. 2008. *2009-2011 Plan for the Adjustment and Revival of Iron and Steel Sector in China*, [Online] Available at: http://www.gov.cn/zwgk/2009-03/20/content_1264318.htm [Accessed 12 December 2009].

Zhou Xuan. Xi’an Research & Design Institute of Wall & Roof Materials. 2009. *CDM Model Component Workshop organised by MOA/UNIDO/Camco.* (Personal communication, November 2009).

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