OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

China Climate Change Partnership Framework

Promoting Waste Heat Recovery for Power Generation within the Chinese Coal-Gangue Brick Sector

MDG ACHIEVEMENT FUND

China Climate Change Partnership Framework

Promoting Waste Heat Recovery for Power Generation within the Chinese Coal-Gangue Brick Sector

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna, 2011

Contents

As part of the "China Climate Change Partnership Framework (CCPF)" programme, which is funded under the UNDP-Spain Millennium Development Goals Achievement Fund (MDG-F), UNIDO in partnership with the Chinese Ministry of Agriculture (MoA) is implementing the project "*Promoting Waste Heat Recovery for Power Generation within the Chinese Coal-Gangue-Brick Sector*". This project aims to promote the application and deployment of waste heat recovery power generation (WHPRG) throughout the Chinese coal-gangue brick sector as firstly, a way to reduce the sector's greenhouse gas emissions and hence reduce its impact in terms of climate change, while at the same helping coal-gangue brick enterprises to reduce operational costs by reducing their energy bills, and hence increase their profits.

WHRPG is where waste heat from a high temperature industrial process, like brick kiln firing, is captured and used to produce high temperature and pressure steam which is then passed through a steam turbine set to generate electricity. This technology is quite mature internationally and is widely applied in China at the larger scale of 10-12 MW within sectors such as cement, iron and steel, coking and glass making. The project described in this document is seeking to expand the scope of WHRPG in China by developing and promoting WHRPG systems in coal-gangue brick factories using waste heat from the coal-gangue tunnel brick kilns to generate power in the range of 1.0 to 2.0 MW.

As this document describes, the project centres around a number of pillars of intervention. Firstly promoting and disseminating well-researched and developed technical support and self-assessment packages for use by brick factory operators/owners to determine the feasibility and benefits that WHRPG can yield in terms of their own operations. Secondly, the construction of two working WHRPG plants within two separate commercially operating tunnel kiln using coal-gangue brick factories. Thirdly, the development of a set of policies and regulations designed to promote replication and sustainability of the WHRPG application throughout the Chinese coal-gangue brick (and general brick) sector.

The project's WHRPG piloting component is proving that this technology is potentially a highly profitable investment for Chinese coal-gangue brick enterprises. The project has determined that WHRPG investments in the 1.0 to 1.5 MW range generally have attractive pay-back periods of four to five years and post-tax internal rates of return of 20 to 25 per cent. Depending on the size of the brick enterprise, a WHRPG system can meet anywhere up to 100 per cent of the factory's electricity needs. For the project's two pilot plants; Pilot One being a 1.5 MW installation and Pilot Two being a 1.0 MW installation, after factoring in the WHRPG plant operational and maintenance costs, this results in an estimated energy cost saving of RMB 2.5 million and RMB 2.01 million respectively in terms of avoided electricity bills per year.

In terms of environmental performance, these systems provide a meaningful way for coal-gangue brick enterprises to reduce their environmental and climate change impact. Based on the displaced national grid electricity, which is generated using coal, the two project pilots will be generating annual CO_2 emission reductions in the order of 6,328 and 5,796 tons respectively.

Climate change and the role of industry

Climate change is the defining issue facing the global community today. If unchecked it has the potential to present humanity with disastrous consequences in terms of negative social impacts, economic losses and extreme global environmental degradation. Of the six greenhouse gases (GHGs) (CO_2, CH_4, N_2O, CF_4, HFCs, PFCs, SF_6) that drive global atmospheric warming and hence climate change, the emission of CO_2 from the combustion of fossil fuels (natural gas, oil, and coal) is arguably the main cause of the effect that we are beginning to observe globally. Global atmospheric concentrations of CO_2 have increased from pre-industrial revolution levels of 280 ppm to 391 ppm today.[1]

The Intergovernmental Panel on Climate Change (IPCC), the international scientific authority on climate change, which is tasked with informing and advising the global community on climate change, stated in its 2007 Synthesis Report that using the best-estimate climate sensitivity data, stabilizing global warming at 2.0° C to 2.4° C requires stabilizing atmospheric carbon dioxide concentrations in the range of 350-400 ppm of CO_2, or 445-495ppm of CO_2-equivalent.[2] To reach this stabilized concentration, the IPCC determined that developed countries (annex I countries) need to reduce their GHG emissions by 25-40 per cent below 1990 levels by 2020, and 80-95 per cent below 1990 levels by 2050.[2] In addition to the role of the developed countries, developing countries, particularly the large developing countries such as China, India, South Africa and Brazil, are also becoming important in terms of global GHG emissions as their energy use is growing rapidly as their respective economies continue to industrialize and expand. Therefore, increasingly, a global climate change and GHG emission mitigation solution will be required if the world is to remain within the IPCC's atmospheric CO_2 target range of 350-400 ppm. The IPCC calculates that this stabilization pathway will provide a "reasonable chance" of averting warming beyond 2.0° C above pre-industrial temperatures and will therefore offer the world the chance to avoid the possible catastrophic consequences on human and ecological systems that temperature rises above 2.5° C will lead to.[2] At the present growth rate of atmospheric CO_2 concentrations (2 ppm per year), this point will be reached by 2042, if not sooner.

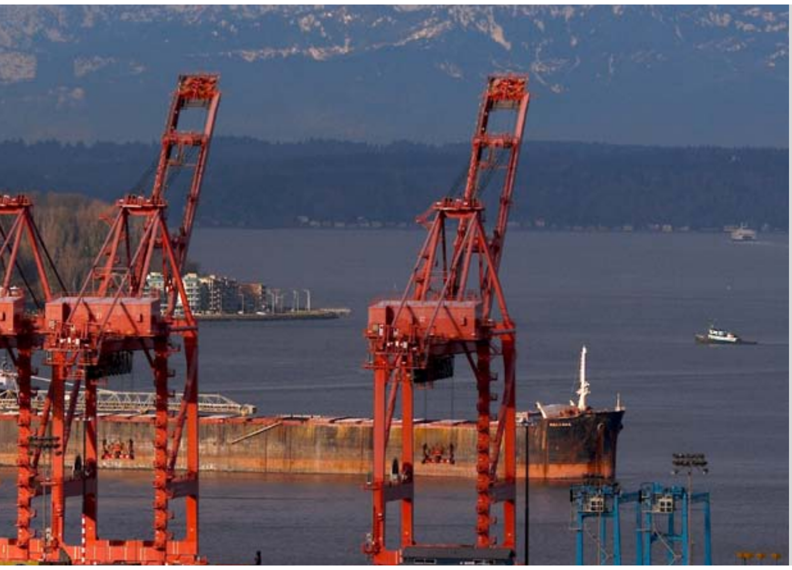
Industry is one of the most important sectors to consider with regard to climate change mitigation as it is directly responsible for approximately a third of global energy consumption and 36 per cent of global greenhouse gas emissions. Therefore, industry must be properly engaged, incentivized and assisted, where necessary, to adopt new energy efficient and low carbon technologies and production methods. Over the past few decades much of the industrial growth and hence growth in industrial energy demand over this time period has been in emerging economies. China alone accounts for about 80 per cent of the growth in global industrial energy usage in the past 25 years and China today is the world's largest producer of iron and steel, ammonia and cement.[3] This situation has added environmental implications as while globally industrial energy efficiency has improved substantially in the past 25 years, in emerging economies such as China, industrial energy efficiency is still lower on average than in OECD countries.

China, industrial energy use and climate change

Industrial energy consumption in China

Total primary energy consumption in China has grown considerably over the three decades, together with the country's economic expansion, and is expected to continue to grow between 7.0-8.4 per cent per year over the next decade.[4] The increase in energy usage can be attributed to increased industrial production and increased demand for goods and services whose manufacture and provision require energy. China is now ranked within the top two in the world in terms of overall primary energy consumption with the United States. China's high energy demand and consumption, combined with the fact that most of its energy is derived from coal, has resulted in China becoming the world's largest national emitter of carbon dioxide, having overtaken the United States in 2007. However, in terms of per capita emissions, China ranks seventy-ninth in the world, with its per capita emissions amounting to 4.7 tons which equates to 25 per cent of those of the United States.[5]

The industrial sector in China accounts for approximately 65 per cent of all national primary energy consumption and while China's industrial sector has made significant improvements in energy efficiency, it is still generally inefficient and highly polluting by OECD standards. The Government of China increasingly views improving industrial energy efficiency as a high priority area as it relates to the wider key national interests of



climate change and national energy security. The eleventh Five-Year Plan announced in 2005, established the ambitious goal of reducing energy intensity by 20 per cent between 2005 and 2010 (an average reduction of 4 per cent per year). Numerous government policies, new regulations, incentive programmes and schemes have been designed, some in partnership with international development agencies, in order to realize this goal and considerable progress has been achieved. However, given the sizable scale of the problem much more remains to be achieved. It is envisaged that the Government is likely to continue, and most likely expand, the drive to achieve greater industrial energy efficiency in the coming twelfth Five-Year Plan.

The vulnerability of China to climate change and its potential impacts

China is a country which is at high risk in terms of future physical impacts that may potentially result from climate change. China's particular vulnerability to the impacts of climate change results from a number of environmental, social and economic factors, with the Government of China estimating that climate change will impact the country in a number of different ways based on specific national vulnerabilities. Firstly, climate change will impact the agricultural and livestock industry by increasing instability in agricultural production where the yields of wheat, rice and maize will be reduced and/or have their ideal geographical growing conditions changed. This will most likely have the effect of dramatically increasing the costs of sustaining agricultural production levels through investment, which will in turn lead to significant food price increases and potential shortages. Secondly, China's ecosystem will suffer through shrinking and changing patterns of forest cover as well as through reduced forest productivity and increased risks of forest fires and disease. China's grasslands could also suffer a similar fate with increased rates of desertification. China's glaciers will also decrease in terms of coverage and thickness over time with potentially serious consequences for downstream river systems. China's permafrost will reduce in size and volume and the pattern of snow fall across the country is also likely to change. Thirdly, climate change will significantly impact China's water resources through further reductions in water volumes passing through six of China's major river systems as well as increasing the potential for extreme hydrological events such as floods and droughts. The arid continental river basins are particularly vulnerable to climate change and are therefore likely to suffer pronounced impacts in the future. Fourthly, climate change will impact China's coastal regions through increases in sea-levels producing increases in erosion and saltwater intrusion within fresh ground water tables as well as increased mangrove and coral reef

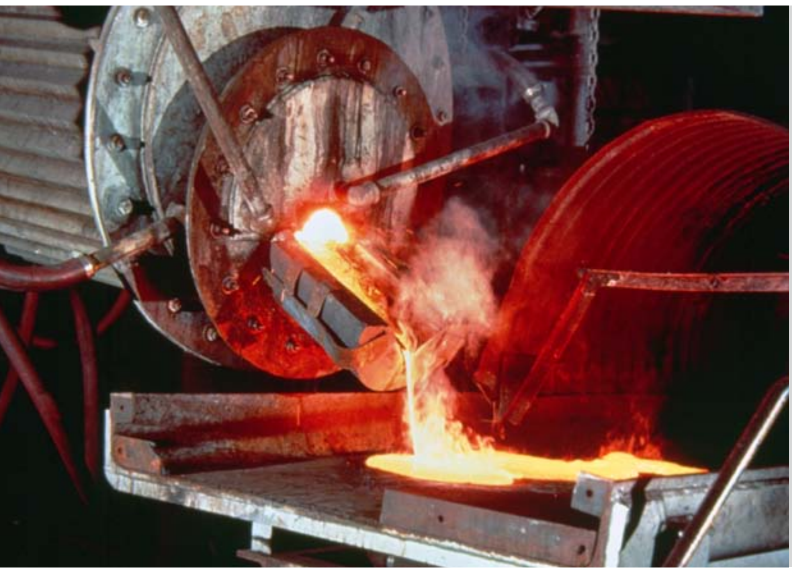

degradation. In addition, climate change will result in the increased frequency and severity of typhoons and storm surges. Lastly, climate change is likely to affect China by causing increased and prolonged heatwaves with their associated human health risks, and diseases such as malaria and dengue fever may also expand their geographical coverage and intensities. Beyond these foreseen possible impacts, climate change has the potential to negatively affect China in a number of ways which have yet to be determined or quantified.

The impact of climate change on business

Climate change and the international policies and regulations that are likely to form part of the eventual overall response to mitigate it, will have an impact on Chinese industry and business, both domestically and within the international market place.

At the domestic level, the cost of energy (electricity, coal, gas, oil and other petroleum products) can be expected to rise in the coming years and, while increases in the price of energy can occur in the absence of measures connected with climate change mitigation polices, energy usage and its associated emission of GHGs are central to climate change and therefore, energy pricing can be considered a major pillar of future climate change mitigation policies. This is because when energy becomes more expensive, industry generally invests capital to become more energy efficient in order to minimize production costs and maintain competitiveness. Energy in China, contrary to the view of many outsiders, is actually already relatively expensive in terms of industrial energy, with pricing being generally at or even above international levels.[6]

Beyond the expected reaction to energy price increases, industry and business in China needs to take into account the present and potential future energy and energy efficiency policies of the Government. Under the eleventh Five-Year Plan, the Government set the goal of reducing the energy intensity of the country's economy by 20 per cent per unit of GDP and presently China is on a course to meet approximately 60 per cent of this goal. In order to realize this impressive achievement, the Government undertook numerous initiatives which included the forced closure of many smaller, inefficient and highly polluting industrial installations and power stations. The Government is continuing with this policy drive towards greater industrial energy efficiency, and its enforcement, under the twelfth Five-Year Plan. While it is still at this point in time unlikely



that China will sign up to internationally binding carbon emission reduction targets, it is increasingly possible that China itself may put in place internal national carbon caps or carbon taxes, and therefore Chinese industry and business will need to consider maximizing future energy efficiency, minimizing production costs and remaining within the boundaries of the Government's energy efficiency and environmental policies.

When considering the international market place and the fact that approximately 30 per cent of China's economy and GDP is dependent on the export of manufactured goods to countries such as those in North America and the European Union, future carbon reduction policies, regulations and consumer spending habits in these countries will have the potential to negatively effect Chinese exporters if the exported products are deemed to have been produced under carbon intensive conditions. Carbon-related trade barriers are a distinct possibility in the future.

Climate change will also have the potential to present Chinese industry and business with direct challenges and impacts. For example, climate change may cause future restrictions in access to industrial and manufacturing resources, extreme weather events may disrupt distribution and production networks (as happened during the 2008 Chinese winter storm crisis), and increasing average mean temperatures across China may result in the deteriorating health and productivity of the national workforce.

Therefore, in view of all the above potential social, economic and environmental impacts that climate change presents to China, the Government of China as well as industry and business need to put in place a series of measures that will firstly, contribute to mitigating emissions of GHGs; and secondly, prepare the country for the potential impacts of climate change as well as the international and national policies that will be eventually put in place to address it.

China's policy response to climate change and energy security

Over the past few years the Government of China has released a series of laws, instructions and initiatives in order to begin to address climate change and to promote increased industrial energy efficiency and cleaner energy production and utilization. Some of the most notable actions taken by the Government are listed below:

20 per cent reduction in the energy intensity of national GDP (and the Top 1,000 Energy Consuming Enterprise Programme). In 2005, the Government announced the ambitious goal of reducing national energy intensity as a function of GDP by 20 per cent between 2005 and 2010. One of the main initiatives for realizing this goal is the "Top-1,000 Energy Consuming Enterprise Programme". The energy consumption of these 1,000 enterprises in 2004 accounted for approximately 33 per cent of total national energy utilization and 47 per cent of industrial energy utilization in China.[7]

China's National Climate Change Programme. In June 2007, the Government published its "National Climate Change Programme". In doing so, China became the first developing country to publish a national strategy to address climate change and its potential national impacts.

Energy White Paper. In December 2007, the Government issued an "Energy White Paper". The paper set forth a number of Government policy positions with regard to its redirected efforts to foster a more sustainable energy future for China. The white paper places emphasis on reducing the utilization of energy resources through education, optimization and development of new technologies.

China's Policies and Actions for Addressing Climate Change White Paper. In October 2008, the Government issued this white paper which further sets out China's strategies and objectives for addressing climate change. It included topics such as potential impacts, policies and actions to adapt to climate change, enhancing public awareness on climate change, enhancing international cooperation on climate change, and building institutions and mechanisms for coping with climate change mitigation and its impacts.

The energy and climate change role of the United Nations system within China

The different United Nations agencies present in China operate within the United Nations Development Assistance Framework (UNDAF) which outlines the common objectives and strategies of all United Nations entities providing development assistance to China. The current UNDAF period (2006-2010) coincides with that of the Government's eleventh Five-Year Plan. Of the five UNDAF outcome areas, Outcome III encompasses the United Nations objectives with regard to climate change in China:

> *"UNDAF Outcome III—more efficient management of natural resources and development of environmentally friendly behaviour in order to ensure environmental sustainability (with a special focus on energy, biodiversity and water resources)"*

To better coordinate the energy and climate change activities of the different relevant United Nations agencies operating in China, the United Nations Theme Group on Climate Change and Environment was established. The theme group's main task is to develop and coordinate initiatives that will aid the Government to more effectively track energy and natural resource utilization, increase energy efficiency, improve air quality, increase access to clean and safe forms of energy, reduce/reverse biodiversity loss and secure access to clean water resources.

UNIDO's energy and climate change activities in China

UNIDO has a long history of working in China having had an office in the country since 1979. Since then, UNIDO has implemented a wide range of programmes and projects whose focus has been continuously adjusted in order to better address China's changing needs and requirements as the country rapidly develops economically. In terms of energy and climate change directed initiatives, UNIDO has focused recently on two main areas; firstly, improving the energy efficiency of a number of different Town and Village Enterprise (TVE) sectors (cement, brick making, coking, and metal casting) and secondly, optimizing industrial motor systems in southern China.

The China Climate Change Partnership Framework (CCPF)

The project detailed in this document is an ongoing initiative which seeks to improve the energy efficiency of the Chinese coal-gangue brick sector by promoting the adoption of waste heat recovery for power generation for on-site usage and potential sale to local power grids. The project is part of the wider "China Climate Change Partnership Framework (CCPF)" programme. The CCPF is funded under the "United Nations-Spain Millennium Development Goal Achievement Fund (MDG-F)".

In December 2006, the United Nations and the Government of Spain signed an agreement to establish a EUR 528 Million fund to accelerate efforts to reach the United Nations Millennium Development Goals (MDGs) as well as to promote greater cooperation between the different United Nations agencies at the country-level. For more information on the MDGs, visit www.un.org/millenniumgoals. The MDG-F was further strengthened with an additional EUR 90 Million from Spain in September 2008. The MDG-F supports initiatives in a number of thematic areas including democratic governance, gender equality and women's empowerment, environmental sustainability, basic social services, economic and private sector development and finally, conflict prevention and peace building. More detailed information on the MDG-F is available at: www.undp.org/mdgf.

The CCPF was developed by the United Nations Theme Group on Climate Change and Environment in partnership with the Chinese Government and it brings together the work of nine United Nations agencies, eight government ministries and a number of NGOs, institutes and private sector entities. The programme consists of 16 individual but connected components under the implementation of the different participating United Nations agencies and their respective Government counterpart agencies. The CCPF began implementation in May 2008 and will run for three years in total. The CCPF addresses three main priority areas of climate change issues, these being, firstly, climate change policy; secondly, climate change mitigation; and thirdly, climate change vulnerability assessment and adaptation. The project described in this document falls under the second focus area of climate change mitigation.

CCPF outcome 2.1: Promoting Waste Heat Recovery for Power Generation within the Chinese Coal-Gangue Brick Sector

Overview of the project

This component project of the CCPF (hereafter termed the project) aims to promote the large-scale uptake of waste heat recovery power generation (WHRPG) technology within the Chinese coal-gangue brick sector through a series of initiatives that include demonstrating the system's technical and economic viability, governmental advice on developing supportive policies/regulations/incentives, and awareness building and advocacy within the industrial brick-making sector. Of all the 16 individual project components that make up the CCPF, this component project is the largest in terms of component funding with a total allocation of approximately US$ 1.5 million. The project began on-the-ground implementation along with the other CCPF component projects in May 2008.

Partners

UNIDO's counterpart for this project is the Ministry of Agriculture. The Ministry of Agriculture is the responsible government agency for the private brick-making sector and many other industrial sectors in China under the umbrella of "Town and Village Enterprises" and while this term might indicate small enterprises, it in fact actually encompasses large industrial facilities across many sectors. UNIDO has had a long-term working relationship with the Ministry of Agriculture, implementing a wide range of industrial energy efficiency projects in sectors such brickmaking, pig-iron casting, cement and coking under previous projects.

Project background

While the project focuses on promoting WHRPG within the coal-gangue brick sector, WHRPG technology would also be applicable to the tunnel kiln using standard clay brick sector even though coal-gangue brick production has a number of distinct differences to that of standard clay brick production. This section seeks to describe the coal-gangue brick making process by firstly explaining what coal-gangue is, the environmental issues surrounding its production and stockpiling and government efforts to address coal-gangue issues and promote the utilization of this potential industrial resource. The section then goes on to describe the development of the coal-gangue brick sector in China, the step-wise process of coal-gangue brick making, and finally the nature of waste heat recovery power generation systems and their application.

Coal-gangue

Coal-gangue is a solid waste product leftover from the coal-mining process and is generally made up from a variety of rock type materials—including coal particles. The volume of coal-gangue production is related to the volume of coal produced, with the production of one ton of coal resulting in the production of 0.1-0.15 tons of coal-gangue.

Coal-gangue is often dumped indiscriminately into huge hill-like mounds during surface and underground mining processes (see pictures below). It cannot be considered a harmless mining by-product, because when coal-gangue begins to weather, which it does rapidly, it produces acid drainage, in which sulphur-bearing compounds combine with oxygen in water vapour to form sulphuric acid. In addition, the weathering of coal-gangue can also produce alkaline compounds, heavy metals and other sediments, which, along with acid drainage, can leach from coal-gangue waste mounds into groundwater or are washed away by rainwater and go on to pollute streams, rivers and lakes. Coal-gangue also presents environmental hazards in terms of air

Coal-gangue tips in Zibo, Shandong Province, China

1966 collapse of a coal-gangue tip in Aberfan, Wales, U.K., which killed 144 people, including 116 children pollution as coal-gangue mounds are susceptible to spontaneous combustion releasing gases such as SO_2, CO, CO_2, NO_X as well as particulate aerosols. In addition, as the coal-gangue mounds weather they release large volumes of dust into the atmosphere which can damage the health of the local population. Beyond the environmental hazard presented by coal-gangue mounds, they also present physical safety hazards to coal-mine workers and their surrounding communities. Coal-gangue mounds can collapse catastrophically when they become saturated with rainwater. The collapsing material is able to travel considerable distances down slope inundating and burying everything in its path, often with fatal consequences (see previous page, bottom right). As a result of the range of potential hazards presented by coal-gangue mounds, Governments in many countries now require coal-mining enterprises to adhere to a number of new more stringent regulations regarding the disposal of coal-gangue and other coal-mining wastes.

According to China's National Coal Association (CNCA), China produced a total of 2.52 billion tons of raw coal in 2007. Therefore, the amount of corresponding coal-gangue waste produced in the same year reached somewhere between 250-330 million tons. It is estimated that by the end of 2007 China had piled up an estimated 5 billion tons of coal-gangue, covering an estimated area of 15,000-16,000 hectares of land. Given the vast amount of coal-gangue produced each year in China and its associated hazards, the Government has long viewed coal-gangue production as an issue that needs addressing.

Legislative efforts to address coal-gangue first began back in 1985 with the Government issuing "Provisional Regulations of the State Economic and Trade Commission on Certain Issues Concerning the Comprehensive Utilization of Resources (No.117)" which includes a focus on coal-gangue utilization. Since this first proclamation, the Government has followed up with a series of further measures intended to encourage greater utilization of coal-gauge. In 1999, the Government formulated its "Policy Points of Comprehensive Utilization on the Coal-Gangue Technology (The State Economic and Trade Commission, Resource [1999], No. 1005)—Provisional Regulations on the Construction and Management of Power Generation Projects, Heat and Power Cogeneration and Comprehensive Utilization of Coal-Gangue". In 2007, the National Development and Reform Commission (NDRC) together with the then State Environmental Protection Administration (SEPA) issued the "Notice on Printing and Distributing Suggestions on Energy Conservation and Emission Reduction". Under this notice, the long-term piling of coal-gangue was to be banned with the intention it should be instead comprehensively utilized. This was followed in early 2008, by a notice issued by NDRC entitled "The Notice of Concerned Matters on the Approval of Power Plant Projects for Coal-Gangue Comprehensive Utilization".

The Government is actively promoting the use of coal-gangue for power generation through the use of favourable taxing and power dispatching conditions. Under the eleventh Five-Year Plan, it was planned that an additional 20 GW of coal-gangue generating capacity would be established. While burning coal-gangue waste to generate power does reduce the volume of the final waste product (by approximately 15 per cent), there are considerable environmental drawbacks to this method of utilization/disposal. For instance, coal-gangue has a considerably smaller calorific content than normal coal (approximately half) and therefore twice as much coal-gangue must be burned to produce the same amount of electricity as would be produced by half as much coal. This has environmental implications as coal-gangue typically contains a much higher concentration of mercury than normal coal and therefore the production of electricity from coal-gangue results in the generation of large amounts of mercury relative to the electricity generated by normal coal. Furthermore, as the combustion of coal-gangue only reduces the amount of waste by approximately 15 per cent, this method of coal-gangue utilization still results in the need for large volumes of waste to be disposed of. The combustion product, coal-gangue ash, is itself potentially environmentally hazardous due the presence of harmful compounds contained within it, such as mercury.

Fortunately, coal-gangue can be utilized in a number of different ways beyond combustion for power generation. For example, it can be used as an ingredient material in cement production as well as coal-gangue concrete production. It can also be used in the production of high-quality vitrified tiles and as a feed stock for the production of certain chemical products. Coal-gangue is often used for back-filling and it can also be used in land-reclamation. One of the main ways in which coal-gangue is increasingly being utilized in China is in the production of coal-gangue bricks.

The coal-gangue brick sector in China

The brick sector in China is of a considerable size both in terms of the volume of bricks it produces and the resources it consumes. In 2008, China's total brick production reached 1.0 trillion bricks, of which 660 billion were clay-based bricks with 400 billion being solid clay bricks or standard bricks and 220 billion being hollow or non-solid clay bricks (an increase of more than 11 times from the 20 billion production level of hollowed clay bricks in 2000). This clay brick total accounted for 66 per cent of the total amount of all brick-type wall materials produced in 2008, with the remaining 340 billion bricks consisting of firstly 100 billion concrete and steam autoclaved silicate bricks; and secondly, 240 billion "new material" bricks including bricks made of such materials as coal-gangue and fly ash. The production of clay-based bricks in 2008 consumed an estimated one billion tons of clay and approximately 50 million tons of coal equivalent as fuel to fire the bricks.

Having seen rapid development in recent years, bricks produced from new materials such as various industrial wastes (coal-gangue, fly ash and other residues) as well as more environmentally friendly materials, increasingly command a significant and growing proportion of the entire brick market. In 2008, bricks made using coal-gangue as the base material constituted approximately 2 per cent of the total output for the entire brick sector, with 20 billion bricks being produced. While as an overall percentage this figure does not seem so large, it is increasing very rapidly due in part to stronger restrictions on the use of clay in brick production being put in place by the Government in an effort to preserve the country's arable land resources for future food production.

Finished coal-gangue bricks ready for delivery

Brick source materials—coal-gangue (at the rear) and shale

While coal-gangue brick making in China has been taking place under different forms for decades, it is generally considered that the sector has gone through four distinct stages. The first stage can be considered to be that which took place before 1965 where research and testing facilities in Sichuan and Liaoning Provinces began experimenting with production techniques. The second stage lasted from 1965 to 1985, and consisted of a small number of factories using relatively simple equipment and production processes. The third stage, which began in 1969 and lasted until 2000, was characterized by a considerable transformation of the sector with rapid expansion and improvement in technology and production techniques, with many factories importing state-of-the-art brick-making equipment from Europe and the United States as well as developing their own equipment under focused research and development efforts. The forth stage began in 2000 and brings the sector up to the present day. This latest stage of the sector's development has been characterized by further rapid technological and production improvements with increasing attention being paid to energy efficiency and product quality improvement.

Coal-gangue brick factories are now located all across China, particularly in regions which have large established coal-mining industries. According to the "China Coal Industry Yearbook", most of the operating coal-gangue brick factories (approximately 90 per cent) are located near to key state-owned coal mines and can presently be found in Sichuan, Shandong, Henan, Beijing, Liaoning, Jiangxi, Hebei and Jilin provinces.

Table 1. Regional distribution of coal-gangue brick production in China

Region	Coal-gangue brick production (billions)	Proportion of total national production (per cent)
Sichuan	3.3	21.6
Shandong	1.8	20.6
Henan	2.6	13.6
Liaoning	0.8	8.4
Beijing	0.3	8.3
Jiangxi	1.1	7.9
Hebei	1.4	4.3
Jilin	0.9	4.1
Heilongjiang	1.9	9.5
Inner Mongolia	1.5	7.5
Other	4.4	22.0
Total national production	**20**	**100**

Source: The China Bricks and Tiles Industrial Association (CBTIA)

By the end of 2005, there were over 5,000 coal-gangue brick plants operating across China, of which 400 can be classed as being within the formal state-owned coal-mining structure with the remaining 4,600 or so enterprises being classed as independent operators of varying sizes. New coal-gangue brick factories, built within recent years, are generally characterized by increasing degrees of mechanization and automation as well as by the increased focus on the production of load-bearing and non-load-bearing hollow bricks.

The use of coal-gangue waste as a replacement for clay in brick making presents a number of environmental, social and agricultural benefits. Firstly, it reduces the amount of coal-gangue that is presently being piled up as a result of coal mining and reduces the associated health and environmental hazards of coal-gangue storage/piling. Secondly, substituting clay for coal-gangue helps to reduce the pressure on agricultural land by reducing the demand for clay, thereby contributing to greater long-term national food supply security. Coal-gangue brick production also has the additional environmental benefit that no additional coal or any other combustion fuel is required for the brick-firing process as the coal-gangue pre-firing bricks, or "green bricks" as they are termed, themselves contain enough coal particles to drive the firing process, and this is the fundamental process difference that distinguishes the production of coal-gangue bricks from the production of standard clay-based bricks.

The coal-gangue brick manufacturing process generally consists of the following five main steps:

- The coal-gangue is crushed/pulverized along with another rock (shale for example) at a specific ratio. The mixture is then stirred and mixed.
- The powdered mixture is then blended with water after which the resulting plastic-like material is placed in an ageing pool via a belt conveyer where it is aged for at least three days.
- After the ageing process, the coal-gangue paste mixture is removed from the ageing pool by a stirring extruder and mixed with more water in a massing machine. When this treatment is complete, the material is then formed into long wet "green" brick strips by a vacuum moulding brick extruder. The resulting strips are then cut into "green bricks" according to the standard brick dimensions by an automatic wire cutting machine.
- The cut wet green bricks are then sent to be dried in a special drying room, a process that takes 24 to 36 hours.
- Finally, the dried green bricks are placed into the brick-firing kiln where they are ignited and the coal particles contained within the bricks begin to burn and drive the firing process. The firing process generally takes 32 to 60 hours after which the fired bricks are allowed to cool before they packed ready for storage and shipping.

Freshly cut green bricks

Green bricks prior to drying

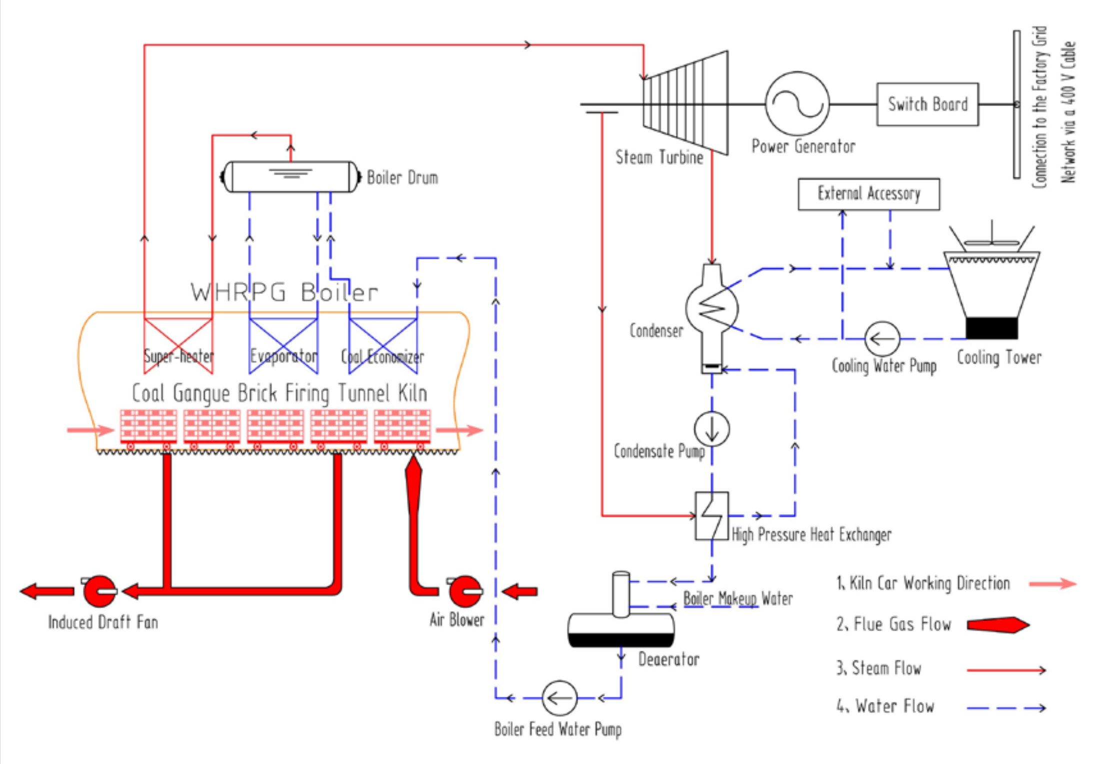


Figure 1. Schematic diagram of a coal-gangue brick waste heat recovery power generation plant

Heat recovery power generation systems

Waste heat is heat energy that is produced in an industrial process where fuels such as coal, oil or gas are burned to drive the process, with the resulting heat energy being "dumped" or "vented" into the atmosphere. Waste heat recovery is where a portion of this heat energy is captured and used to do some form of useful work. Large volumes of waste heat are produced at various temperatures in many industrial processes; for example, high temperature waste heat (in the range of 650-1,650° C) is produced by, for example, dry-process cement kilns, iron and steel furnaces, waste incinerators, glass furnaces, and the process of coking. Medium temperature waste heat (in the range of 230-650° C) is produced by, for example, steam boiler exhausts, gas turbine exhausts, heat treating furnaces and drying and baking ovens—including brick-firing ovens/kilns.

By recovering some of the heat that would be wasted by venting, considerable amounts of primary fuel and money can be saved if the recovered waste heat can be re-injected into the process somewhere to, for example, pre-heat input materials and furnace combustion air or if it is used to drive some other process displacing a portion the fuel that would have been used otherwise. The strategy of how to recover waste heat depends in part on the temperature of the waste gases and the economics involved, but generally, the higher the temperature of the waste heat, the higher the quality will be and the more economically attractive heat recovery will be. In any proposed heat recovery application, there should always be some useful purpose for the heat that is recovered.

One of the potential uses of recovered waste heat is to generate electricity where the waste heat from a high temperature industrial process, such as cement clinker firing for example, is captured and used to produce high temperature and pressure steam through a system of heat exchangers and boilers. The high temperature/pressure steam is then passed through a steam turbine set to generate electricity. This technology is quite mature internationally and is widely applied in China within sectors such as cement, iron and steel, coking and glass making. Many of the present examples of WHRPG in China are a result of carbon emission reduction Clean Development Mechanism (CDM) projects where the electricity generated is used to displace electricity generated by the coal power stations supplying the surrounding local electrical distribution grid. WHRPG installations within such enterprises have typically been quite large with installed capacity ranges of 10 to 12 MW. The project described in this document is seeking to expand the scope of WHRPG in China by developing and promoting WHRPG systems in coal-gangue brick factories which will use medium to high temperature waste heat for power generation within the 1.0 to 2.0 MW range. Figure 1 shows a schematic diagram of a WHRPG system for a coal-gangue (and/or clay) brick plant indicating the main components of the system.

Project objective, outcomes and outputs

The objective of the project (where objective means the long-term development/environmental goal of the project) is to lower the greenhouse gas emissions of the Chinese coal-gangue brick sector, through the introduction and large-scale adoption of heat recovery power generation.

The project seeks to promote the mitigation of greenhouse gas (GHG) emissions from the coal-gangue brick-making subsector in China by constructing two WHRPG pilots and replicating their best practices throughout the whole subsector countrywide. The type of WHRGP technology/system that the project is developing and promoting is applicable to tunnel brick kilns and has been proved to work well at the first experimental pilot site facility. The project will essentially further prove and promote the economic and technical viability of this WHRPG system for the coal-gangue brick sector in China and prepare the way for sectoral dissemination.

The project centres around four main pillars of intervention, firstly promoting and disseminating well-researched and developed technical support and self-assessment packages for use by brick factory operators/owners to determine the feasibility of WHRPG and the benefits that it could yield in terms of their own operations. Secondly, the construction of two working WHRPG plants within two separate commercially operating industrial coal-gangue brick factories. Thirdly, the development of a set of policies and regulations designed to promote replication and sustainability of the WHRPG application throughout the Chinese coal-gangue brick sector. In addition to these three objectives, the project is also pursuing the objective of evaluating the potential role of WHRPG within the Chinese brick sector in terms of the Clean Development Mechanism (CDM). As mentioned previously, the CDM in China to date has focused on very large cement, coke and iron and steel factories for the development of industrial energy efficiency CDM projects (usually WHRPG projects) and while this proved highly successful, there is a strong need to diversify and expand the possible role of the CDM to other industrial sectors in China, and this project aims to assist that goal.

These interventions and the outputs that the project activities will produce should ideally lead to the project realizing its intended outcomes (where outcomes refer to the changes in behaviour or changes in the business-as-usual scenario within the sector that result as a consequence of the project), these outcomes being:

1. The awareness of brick factory owners/operators throughout the Chinese coal-gangue brick sector has been raised in regard to the need to increase the energy efficiency of their operations and the economic opportunities presented by WHRPG systems.
2. A package of policy/regulation/incentives, put in place by the Government as a result of targeted policy advice developed by the project, promotes replication of the WHRPG pilot plants established by the project throughout the coal-gangue brick sector.
3. If the coal-gangue brick sector is determined and proved to be viable in terms of the Clean Development Mechanism (CDM) under different CDM project scenarios, private CDM project development companies will expand their present industrial energy efficiency CDM project activities to include WHRPG within the Chinese coal-gangue brick sector.
4. Numerous coal-gangue brick factories across China adopt WHRPG systems and use the power generated either on-site to fulfil their own power requirements and/or they export power to local power grids. It is the intention of the project that an additional ten replication WHRPG plants be established within the evaluation period of the project.

In order to try and achieve these four outcomes, the project is producing a number of targeted outputs. Outputs are the physical products of the project, e.g. pilot plants established, best practice guides published, personnel trained, policy reports/papers published, studies conducted, etc. The outputs of this project over its three-year implementation are as follows:

1. *Coal-Gangue Brick Sectoral Study and Heat Recovery Power Generation Assessment.* The first part of this assessment focused on determining and analysing the present status and extent of the coal-gangue brick sector in China. The second part of the assessment examined the development of heat recovery power generation within China and the different applications of this technology as well as the variations of technologies that are typically deployed and what options are available on the market.

2. *Evaluation Study on the Potential of the Clean Development Mechanism (CDM) within the Coal-Gangue Brick Sector.* The CDM has been a major driving force in regard to improving industrial energy efficiency within China and for the expansion of waste heat recovery power generation, most notably within the cement, coking, and iron and steel sectors. However, as industrial installations within these sectors are effectively used-up by having CDM projects established within them, the CDM must diversify and expand its focus to include new and previously unexploited industrial sectors—brick manufacturing could possibly be one such worthwhile area for expansion. However, establishing a CDM project is generally quite costly,

Manufacturing of one the brick kiln roof heat exchanger components

Installation of WHRPG components at the Xinrong New Type Buildings Co. Ltd. pilot plant the volume of potential Certified Emission Reduction (CER) credits must be substantial. Therefore, to determine the potential of the coal-gangue brick sector in regard to the CDM, the project carried out an assessment study that considered the three CDM project scenarios in order to determine the sector's viability in terms of the CDM: single coal-gangue brick factory CDM projects, bundled CDM projects (projects containing a given number of individual coal-gangue brick factories covered by a single CDM project document/agreement) and programmatic CDM coal-gangue brick projects.

3. *Two Fully Operational Coal-Gangue Brick Factory WHRPG Pilot Plant.* The process of selecting the two pilot plants for the construction of the WHRPG plants was an exhaustive process consisting of the evaluation of a number of different parameters including kiln type (the WHRPG systems are based on tunnel kilns), company size and brick production output, the company's energy consumption and financial capitalization. Below is a brief description of each of the two companies selected for the project's pilot programme and the WHRPG plant that has been established in each brick factory.

Pilot One: Xinrong New Type Building Materials Co. Ltd. under the Juyi Industrial Group, Lingshi County, Shanxi Province.

Xinrong New Type Building Materials Co. Ltd. was established in 2002 with a registered capital of RMB 190 million (US$ 28.0 million*). The company has 1,200 employees and present assets totalling RMB 520 million (US$ 76.5 million). The company possesses an existing coal-gangue brick plant with output of 60 million bricks in 2008. The company is now investing in a second coal-gangue brick plant that will have a production capacity of 120 million bricks per year, and it is on this new brick production line that the project will establish the WHRPG pilot plant.

The new brick production line will be connected to the local public power grid at a voltage of 10kVA through a transformer with a capacity of 2,000 kVA. The capacity of the electrical equipment installed within the factory is 1,600 kW. The future operational power consumption of the new coal-gangue brick factory is estimated to be in the order of approximately 500 kWh per 10,000 bricks or 6.0 million kWh (6.0×10^3 MWh) for the factory's intended total annual output of 120 million bricks. The price the factory pays for its electricity is RMB 0.58 (US$ 0.09) per kWh peak and RMB 0.4 (US$ 0.06) per kWh off-peak. The waste heat temperature from the tunnel brick kilns has been designed to be in the range of 300-950° C with an energy rating (subtracting the waste heat volume used for pre-firing brick drying) of 33.9×10^6 kJ/h to be made available for recovery and possible power generation. The WHRPG plant that has been installed has an installed maximum capacity of 1.5 MW and will generate an expected 6.66×10^3 MWh of electricity per annum for usage within the factory, totally fulfilling the brick factory's power requirement, saving the company an estimated RMB 2.5 million (US$ 367,647) (taking into account O&M costs) in avoided electricity bills per year. The WHRPG plant will cost RMB 10.2 million (US$ 1.5 million) to build and will thus have a pay-back period of four years with a post-tax internal rate of return (IRR) of 25.4 per cent. The avoided CO_2 emissions generated as a result of the WHRPG plant, based on displaced grid electricity will be approximately 6,328 tons per year, with this figure being based on the carbon emissions factor of the Northern China Electricity Grid (0.9502 tCO_2/MWh).

Pilot Two: Hebei Guoneng New Materials Co. Ltd., Luquan City, Hebei Province

Hebei Guoneng New Materials CO. Ltd. was established in 2005 with a registered capital of RMB 59 million (US$ 8.7 million). The company has 500 employees and present assets totalling RMB 162 million (US$ 23.8 million). The company possesses an existing coal-gangue brick plant with annual output of

* The financial calculations in this section are based on an US$/RMB exchange rate of: 1.0 US$ to 6.8 RMB

205 million bricks in 2009. In contrast to the first pilot at Xinrong New Type Building Materials Co. Ltd, the WHRPG plant at Hebei Guoneng New Materials CO. Ltd. will built by retrofitting the company's existing coal-gangue brick production line kilns to incorporate the new WHRPG pilot plant.

The existing brick production line is connected to the local public power grid at a voltage of 10 kVA through a transformer with a capacity of 2,000 kVA. The installed capacity of the electrical equipment within the factory is 3,800 kW. The operational power consumption of the coal-gangue brick factory is 500 kWh per 10,000 bricks or 14 million kWh (14,000 MWh) for the factory's total annual output of 205 million bricks. The price the factory pays for its electricity is RMB 0.65 (US$ 0.10) per kWh peak and RMB 0.45 (US$ 0.07) off-peak. The waste heat temperature from the tunnel brick kilns is in the range of 300 to 900^{o} C with an energy rating (subtracting for the waste heat volume used for pre-firing brick drying) of 29.4 x 10^6 kJ/h to be made available for recovery and possible power generation. The WHRPG plant that is being installed has an installed maximum capacity of 1.1 MW and will generate an expected 6.10 x 10^3 MWh of electricity per annum for usage within the factory, fulfilling 43 per cent of the brick factory's power requirement, saving the company an estimated RMB 2.01 million (US$ 295,588) (taking into account O&M costs) in avoided electricity bills per year. The WHRPG plant will cost RMB 10.02 million (US$ 1.474 million) to build and will thus have a pay-back period of approximately five years with a post-tax internal rate of return (IRR) of 20.4 per cent. The avoided CO_2 emissions generated as a result of the WHRPG plant, based on displaced grid electricity will be approximately 5,796 tons per year, with this figure being based on the carbon emissions factor of the Northern China Electricity Grid (0.9502 tCO_2/MWh).

4. *Full Technical, Operational and Economic WHRPG Pilot Evaluation Assessment.* After the commissioning of the pilot WHRPG installations at Xinrong New Type Building Materials Co. Ltd. and Hebei Guoneng New Materials CO. Ltd., a full evaluation of the two WHRPG systems will be conducted jointly between the hosting coal-gangue brick factory companies, UNIDO, the WHRPG and boiler installation companies, and an external engineering evaluation team. The evaluations will examine both of the pilot WHRPG systems in terms of their operational performance, their economic and financial performance, and their environmental performance in terms of electricity generated and grid electricity displaced (with the corresponding CO_2 emissions displacement). Other factors such as operational and maintenance issues, improved worker conditions, and factory's contribution to local air pollution will also be evaluated. Key findings and

Installed WHRPG boiler components at the Xinrong New Type Buildings Co. Ltd. pilot plant

Tunnel brick kiln roof with WHRPG heat exchangers built-in at the Xinrong New Type Buildings Co. Ltd. pilot plant outputs of the pilot evaluation assessments will be consolidated and used in the finalization of *(1)* "Coal-Gangue Brick WHRPG Sectoral Support and Self-Assessment Package" and *(2)* a "Coal-Gangue Brick WHRPG Best-Practice Guide".

5. *Coal-Gangue Brick WHRPG Sectoral Support and Self-Assessment Package.* Essentially, the "Coal-Gangue Brick WHRPG Sectoral Support and Self-Assessment Package" is intended to be a PC-based application with supporting documentation which will be firstly distributed at project awareness and capacity building workshops and at other sectoral association events (in the form of a folder containing an auto-run CD-ROM and supporting documentation). Secondly, it will be adapted for uploading onto the Internet for enterprises to download. The package will target coal-gangue brick enterprise owners and operators, both private and state-owned. The package aims to:

   - Introduce WHRPG to coal-gangue brick sector enterprises and give an account of the project's WHRPG pilot experiences.
   - Present the coal-gangue brick WHRPG self-assessment feasibility model (with full user instructional documentation), which is intended to facilitate a given enterprise owner/operator to fully assess their existing (or future) coal-gangue brick making operation technically and economically in regard to the option of investing in a WHRPG system for their factory. The model will be easy to use but detailed enough to give a coal-gangue brick enterprise owner/operator accurate and informative predictions relating to project cost and potential business revenue savings through energy savings, etc. The model should give the enterprise owner/operator enough information and confidence to decide on whether a WHRPG system is a good potential investment for their operation and whether or not to go ahead with investing in a full WHRPG technical and economic feasibility study.
   - Give coal-gangue brick enterprise owners/operators the "where to go next steps" if they are interested in further examining the option of establishing a WHRPG plant in their factory based on the results of the model included within the package. This will include advice on planning and approval procedures, possible government assistance measures and a list of engineering consultancies who are experienced in conducting full WHRPG feasibility and project planning studies as well as potential equipment suppliers.

6. *Coal-Gangue Brick WHRPG Best Practice Guide.* As part of the Coal-Gangue Brick WHRPG Sectoral Support and Self-Assessment Package, the project will develop a "Coal-Gangue Brick WHRPG Sectoral Best-Practice Guidelines" based on the experiences and information gathered from the WHRPG pilot plants and from expert experience and opinions from the different WHRPG equipment suppliers and project experts. The best practice guide will aim to, firstly further inform coal-gangue brick enterprises on the potential benefits of WHRPG technology within their sector, and secondly, form part of the mechanism with which the project will approach central Government to petition for a policy/regulatory/financial incentive programme to better promote the large-scale application of WHRPG throughout the coal-gangue brick sector.

7. *Policy/Regulatory/Financial Incentive Advice for Central Government for the Promotion of WHRPG in the Coal-Gangue Brick Sector.* In order to promote a greater degree of replication and WHRPG diffusion throughout the Chinese coal-gangue brick sector, the project is seeking to examine and present a number of the issues identified during the course of the project to the central government of China in order to foster the development of suitable policy/regulatory/financial or tax incentive support for WHRPG within the coal-gangue brick sector. During early 2011, a series of Government Focus Groups will be convened in order to discuss the options and possible ways forward for developing suitable support options for WHRPG within the coal-gangue brick sector.

As part of this process, the project is examining all relevant existing policies, regulations and financial incentive schemes that are intended to promote industrial energy efficiency and energy saving through investment in cleaner self-generation. With a view to smaller-scale WHRPG applications, the analysis focuses on the strengths, weaknesses, opportunities and threats of the present energy efficiency and saving policy/regulation/incentive situation in relation to promoting WHRPG within the coal-gangue brick sector through identifying relevant barriers (including financial barriers such as access to capital) and the factors that determine the degree to which existing measures are proving to be successful in terms of promoting greater energy efficiency and cleaner on-site generation.

Based on this analysis and the nature and scale of the WHRPG systems that the project is promoting throughout the Chinese coal-gangue brick sector, the project will develop a series of policy suggestions that will be used to approach central Government to lobby for an appropriate form of policy, regulatory and/or financial incentive scheme under which the long-term promotion of the WHRPG technology could be strengthened across the coal-gangue brick sector.

8. *Coal-Gangue Brick WHRPG Sectoral Awareness Programme.* As mentioned, one of the main intended outcomes of the project is that the pilot WHRPG experience should be replicated in numerous other coal-gangue brick enterprises, but in order for this process to begin to take effect across the sector, enterprise owners/operators need to be exposed to the potential benefits of WHRPG through a series of awareness-raising activities.

   The project team, working in partnership with the China Bricks and Tiles Industrial Association (CBTIA), will seek to raise the WHRPG awareness of coal-gangue brick enterprise owners/operators through a number of different activities,. Firstly, the project is developing a series of WHRPG and project promotion materials that will be disseminated to the coal-gangue brick enterprise membership base of CBTIA. Secondly, the project will convene three coal-gangue brick WHRPG workshops in the three main coal-gangue brick producing regions of China. These workshops will introduce the concept of WHRPG for the coal-gangue brick sector, describe the WHRPG systems, highlight the project's pilot results, and begin the process of building the capacity of the enterprise owners/operators in terms of being able to assess whether the introduction of a WHRPG plant makes technical and economic sense for their own operation. Thirdly, the project will also hold a small number of study tours for coal-gangue brick

WHRPG boiler stages at the Xinrong New Type Buildings Co. Ltd pilot plant

Main WHRPG boiler at the Xinrong New Type Buildings Co. Ltd. pilot plant owners/operators to the project's pilot WHRPG installations at Xinrong New Type Building Materials Co. and Hebei Guoneng New Materials CO. Ltd. in order to demonstrate the on-the-ground application of WHRPG systems within operating coal-gangue brick plants. Fourthly, the "Coal-Gangue Brick WHRPG Sectoral Support and Self-Assessment Package" will also be disseminated through the CBTIA membership network in order to provide coal-gangue brick enterprise owners/operators with the means to conduct a WHRPG pre-feasibility style study/assessment on their own operation in terms of WHRPG viability. Lastly, the project has commissioned the filming of a documentary film by a Chinese film studio to be shown on China Central Television (CCTV). Once completed, the film will introduce the WHRPG concept, catalogue the project's experiences, and in particular, present the project's pilot experiences. As CCTV reaches hundreds of millions of viewers right across China, this is one of the best means to disseminate the project's message and highlight the different opportunities that WHRPG systems can present to as wide an audience as possible.

9. *Coal-Gangue Health and Safety Guidelines.* The final main component of the project looks at assessing and assisting the Government in strengthening the occupational health and safety (OHS) functions of the Chinese coal-gangue brick sector and determining the potential health and safety implications resulting from the introduction of WHRPG throughout the sector. For this component of the project UNIDO and the Ministry of Agriculture, are partnering with the World Health Organization, the International Labour Organization, and the National Institute for Occupational Health and Poisoning Control under the Ministry of Health.

   Specifically the project will contribute to the following objectives: firstly, to determine the OHS implications and aspects of the WHRPG systems in regard to their application within the Chinese coal-gangue brick sector. Secondly, to assist relevant Government agencies to further improve and strengthen coal-gangue brick (and general brick) production OHS functions throughout the sector through the application of appropriate policy and regulatory provisions—including a focus on the OHS ramifications of introducing WHRPG systems within coal-gangue brick factories.

A Coal-gangue brick plant employee in Zibo, Shandong Province

A Coal-gangue brick plant employee in Zibo, Shandong Province

This project activity seeks to produce the following outputs in order to contribute to realizing the above objectives:

- An assessment of the current operational OHS environment within coal-gangue brick factories and categorizations of OHS risks.
- An assessment of the adequacy of existing WHRPG OHS operational guidelines and their application in other industrial sectors as well as any current OHS regulatory frameworks governing WHRPG utilization in China.
- A set of recommendations on how to foster improvement in the current coal-gangue brick sector management of OHS, including risk assessment, control, training and communication.
- A set of policy/regulatory recommendations in regard to the adaption of existing WHRPG rules, standards, laws, regulations to the smaller scale that would be employed within the brick sector, resulting in the development of WHRPG OHS guidelines for central Government in the form of policy and regulatory advice.

The results of these OHS activities will be presented to central government in a series of recommendation reports for consideration and action. The results will also be repackaged and presented at the project's three planned Coal-Gangue Brick WHRPG regional workshops as well as in an OHS section within the "Coal-Gangue Brick WHRPG Sectoral Best-Practice Guidelines".

Project progress (as of December 2010)

The implementation of the project has been running for approximately two and a half years now and during this time the following steps have been completed:

- Full sectoral scoping and analysis of the Chinese coal-gangue brick sector and the state of development of WHRPG and its application in China.
- Pilot site assessments and selection.
- Development of an initial version of the "Coal-Gangue Brick WHRPG Sectoral Support and Self-Assessment Package".
- WHRPG plant feasibility studies on a number of coal-gangue brick factories intended for short-listing with regard to the project's pilot programme, which was followed by the selection of the two project pilots.
- Full engineering designs for the WHRPG plants at the two pilot brick factories.
- Construction and completion of the first WHRPG pilot plant at Xinrong New Type Building Materials Co. Ltd., Lingshi County, Shanxi Province.
- Commencement of the construction of the second WHRPG pilot plant at Hebei Guoneng New Building Material Co. Ltd., Luquan City, Hebei Province.
- Initiation of analysis and discussion groups for the development of supportive policy and regulatory conditions to encourage the wide-spread adoption of WHRPG throughout the tunnel kiln using coal-gangue brick sector.
- The OHS component has reached approximately 70 per cent completion with the project team having assessed a number of different coal-gangue brick factories in terms of OHS with initial policy recommendations and possible sectoral best-practice procedures being developed.

WHRPG support and project contact details

After studying the WHRPG information presented in this brochure on *Promoting Waste Heat Recovery for Power Generation within the Chinese Coal-Gangue Brick Sector*, if you feel that your enterprise/company would like to further investigate the possibility of establishing a WHRGP plant in order to reduce your enterprise's energy consumption, operational costs and contribution to climate change, you should contact the following institutions. These institutions can arrange direct access to teams of qualified energy, WHRPG, and environmental protection experts who can assist you in assessing whether WHRPG makes good technical and economic sense for your company. They can assist you in developing the necessary full feasibility and engineering studies, as well as sourcing WHRPG equipment and implementing best practices.

Mr. Song Dongfeng
Project Coordinator
Project Management Office,
Ministry of Agriculture,
Room 9001, Tongguang Building,
No.12 Nongzhanguan Nan Lu,
Chaoyang District,
Beijing, 100125,
China
Tel.: +86 (0)10 871 9632
Email: gefpmo2004@yahoo.com.cn

Mr. Wang Wenjun
Manager
Sichuan Guoli Energy Science and Technology Co. Ltd.
Room 407, Taifeng Building, East Huidong Road,
Zigong City, 643100,
Sichuan Province,
China
Tel.: +86 (0)813 6203722
Email: scglkj@163.com
Website: www.zgglkj.cn

Mr. Zhou Xuan
Director
Xi'an Research and Design Institute of Wall and Roof Materials,
No. 6, Chang'an South Road,
Xi'an, 710061,
Shaanxi Province,
China
Tel.: +86 (0)29 822 4662
Email: zhouxuan240762@yahoo.com.cn
Website: www.brick-tile.com

Mr. Edward Clarence-Smith
Representative and Head of UNIDO's Regional Office China
United Nations Industrial Development Organization
2-141, Tayuan Diplomatic Office Building,
No. 14 Liang Ma He Nan Lu,
Chaoyang District,
Beijing, 100600,
China
Tel.: +86 (0)10 65323440
Email: e.clarence-smith@unido.org
Website: www.unido.org

References

1. Dr. Pieter Tans, 2010-08-12, NOAA/ESRL(www.noaa.gov/gmd/ccgg/trends/).

2. IPCC, 2007, "2007 Synthesis Report".

3. IEA, 2007, "Tracking Industrial Energy Efficiency and CO_2 Emissions".

4. Louis Kuijs, World Bank China Office, June 2009, Research Working Paper No. 9, "China through 2020—A Macroeconomic Scenario".

5. U.S. Department of Energy's Carbon Dioxide Information Analysis Center (CDIAC), 2007.

6. Mark D. Levine, 2008 "Myths and Realities about Energy and Energy Related CO_2 Emissions in China".

7. Lynn Price, Lawrence Berkeley National Laboratory, Xuejun Wang, Peking University, Jiang Yun, China Energy Conservation Association, 2008, "China's Top-1000 Energy-Consuming Enterprises Program: Reducing Energy Consumption of the 1000 Largest Industrial Enterprises in China".

Printed in Austria
V.10-58654–April 2011

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Telephone: (+43-1) 26026-0, Fax: (+43-1) 26926-69
E-mail: unido@unido.org, Internet: www.unido.org