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REPORT OF THE STAP SELECTIVE REVIEW OF "CHINA EFFICIENT INDUSTRIAL BOILER PROJECT"

(Prepared by the Scientific and Technical Advisory Panel)

Report of the
STAP Selective Review of
"China Efficient Industrial Boiler Project"

Prepared by

The Scientific and Technical Advisory Panel (STAP)
of the Global Environment Facility (GEF)

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Preface

It is a pleasure to present the final report of the STAP Selective Review on the "*China Efficient Industrial Boiler Project*". The Selective Review was undertaken as an integral part of the Programme Studies co-ordinated by the Monitoring and Evaluation Unit of the GEF Secretariat.

The STAP Review Team that visited the project sites would like to thank the staff of the project for their assistance in undertaking the review.

This report was prepared by Prof. Zhou Dadi, Member of STAP who led the STAP Review Team and Dr. Fuqiu Zhou, a Boiler expert from the Beijing Energy Efficiency Center.

Madhav Gadgil
STAP Chairman

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Executive Summary

This report summarizes findings of the selective review of the *"China Efficient Industrial Boilers Project (CEBP)"*. This review was undertaken as an integral part of the GEF Monitoring and Evaluation country review activities. The review was conducted by the STAP/GEF selective review group, according to the requirements specified in the Terms of Reference for the selective review. The review focused primarily on the selection of foreign boiler technologies, the technology transfer process and their implications.

The CEBP is a very complex project covering many sub-projects, with more than 30 implementing institutions (i.e. government agencies, boiler manufacturers and users, research institutes and other stakeholders), 9 different boilers and many additional auxiliary supplementary equipment. In addition, various associated boiler technologies will be designed as part of the project. The implementing institutions and the users of these new boilers are located in more than 10 cities from North to South and East to West of China. The distant city with the new boiler is more than 3,000 km away from Beijing. Many elements project are still under implementation, while others will proceed to its next phase. Given the time allocated for the selective review and resources made available, the group focused on specific dimensions of the project. Emphasis was therefore placed, on the Project Management Office (PMO), two implementing institutions in Beijing, and four other implementing institutions in three other cities in the East China, (hundreds km distance between each of the cities).

Though it is difficult to draw definitive conclusions about such a complex technology transfer project like the CEBP, which is still under implementation; overall, the general conclusion from the review of the project is very positive. The project was well prepared and structured and the technologies selected for the project are adequate, given the resources available. The implementation up to now, although delayed, has been successful, and the project is on track towards achieving its designed goals. Compared to other types of GEF interventions, projects such as the CEBP which focus on technology transfer may have more sustainable and longer effects on the energy efficiency and associated GHG reduction. Some preliminary findings from the review are highlighted which should be given consideration in the future design of technology transfer projects under OP5. These are summarised as follows:

- The domestic adoption capacity in the target country is crucial for technology selection and transfer. Country drivenness and local involvement are prerequisites for such projects.

- Capacity building should be emphasized in the technology transfer projects. Knowledge transfer is a key component of technology transfer. Success of technology transfer depends on the adoption by local manufacturers of the transferred knowledge, in addition to the hardware and software components of technology transfer.

- The technology transfer, in general, occurs between business entities. The technology procurement will follow the market rules even under GEF and government intervention. The project design and implementation schedule should avoid being too drawn out and complex, hindering the active involvement of the private sector.

- Market barrier removal for technology transfer is an important element to technology transfer projects. Without grant resources for the market barrier removal, otherwise the adoption and replication of new technology will be difficult.

Overall, the findings of the review, including the problems identified and lessons learnt from the project, provide very useful insights, which could be used as important reference points for the design of future potential technology transfer projects under OP5.

SECTION 1: INTRODUCTION AND BACKGROUND

1.1 Introduction

As part of the preparations for the Second GEF Overall Performance Study (OPS2), the Monitoring and Evaluation Unit of the GEF Secretariat co-ordinated a number of programme studies in climate change, biodiversity and international waters. STAP was requested to participate in these studies, especially for the review of selected features of projects which are oriented towards scientific and technical objectives. One such project selected by the Monitoring and Evaluation Unit for analysis by STAP was *the "China Efficient Industrial Boilers Project (CEBP)."*

1.2 Overview of CEBP: Main elements of the China Efficient Industrial Boilers (CEBP) and the Implementation Progress

The objective of the *"China Efficient Industrial Boilers Project (CETP)"* is to improve the energy efficiency of industrial boilers in China, and associated reductions in growth of carbon dioxide emissions and other pollutants. This objective will be achieved through: (a) introduction, development and design of efficient and clean industrial boiler products, (b) mass production and marketing of efficient industrial boilers, and (c) by means of capacity building of boiler research institutes, improvement of information exchange, and encouraging policy reform for energy efficiency and relevant environment protection as a means of promoting the use of efficient and clean industrial boiler technologies in China.

The project includes the following components:

- **Renovation of existing industrial boiler models in China**. This will be achieved by importing foreign advanced combustion systems and auxiliary equipment and, particularly, adopting simple automatic control apparatus. The industrial boiler models, which represent over 60% of current industrial boiler market demand in China, are identified for renovation objectives. These include the:

  - Packaged water-tube boiler;
  - Improved packaged fire-tube and water-tube boiler;
  - Modular water-tube boiler;
  - Modular water-tube high sulfur coal boiler;
  - Packaged and modular hot water boiler;
  - Packaged and modular extended water-tube furnace and fire-tube boiler.

- **Adoption of new efficient boiler models**. Modern manufacture techniques and boiler design adaptable to coal types in China are to be imported for the development of new boiler models. Three new boiler models are to be developed under the project, shares of which, as a percentage of the Chinese industrial boiler market, are expected to grow gradually. These models are:

  - Medium capacity steam boiler (for co-generation);
  - Medium capacity hot water boiler (for district heating);
  - Circulating Fluidized bed combustion (CFBC) steam boiler.

- **Technical assistance and training for domestic boiler manufacturers (DBMs) and customers.** This covers: (a) improvement of the quality of boiler operation through

advanced training approaches and the establishment of a boiler operator certification system, (b) assistance for DBMs in development of marketing plans of efficient boilers, (c) pilot programmes in two Chinese cities (Jinan, Shanghai), thereby promoting market penetration of efficient and clean industrial boiler products, (d) customer service improvement programmes of DBMs, (e) popularization of successful boiler technologies to other DBMs, (f) revision of relevant national standards for thermal efficiency, pollutant emission and coal quality of industrial boilers, (g) design renovation and spread of industrial boilers, and h) improvement in enforcement of standards of industrial boilers.

- **Monitoring, evaluation and project management**. Support will be provided for development of a monitoring and evaluation system, including provision of monitoring equipment and training of the staff of the Project Management Office (PMO).

1.3 Progress in the Project Implementation

The China Efficient Industrial Boilers Project (CEBP) includes 9 boiler sub-projects, 11 auxiliary equipment projects and 10 technical assistance components (see Annex 1 for details). The preparation of the project started in the early 1990s and continued for several years. The formal implementation of the project commenced on January 14, 1997, the date, the grant agreement for the project came into effect. The implementation of the project is divided into two phases. Elements of the first phase include the importation of technology, personnel training, new boiler design, manufacture, installation, commissioning, performance verification and evaluation, and acceptance examination of demonstrative boiler units. Elements of the second phase include production capacity renovation and procurement of the necessary production equipment to facilitate a production capacity of 3,000 steam tons annually, for each DBM of the 9 boiler sub-projects.

According to the original project implementation plan (PIP), implementation of the project should have been completed on December 31, 2000, and the special account for the project closed on June 30, 2001. However, due to some unexpected difficulties during implementation, the project completion date has been revised to June 30, 2002.

The implementation of the project is currently in its first phase. To date, the technology transfer contracts for the 9 boiler sub-projects have become effective. With the except of No. 1,6,7, & 8 boiler sub-projects, personnel training for the other boiler sub-projects has been completed. In addition, the installation of demonstrative boilers of No.3, 4, & 9 boiler sub-projects and the manufacture of demonstrative boilers of No.2, & 5 boiler sub-projects has been completed and their commissioning and installation are ongoing.

The technology transfer contracts for the 11 auxiliary equipment projects are already signed and are being executed. Two foundry production lines have been delivered, and the installation of the foundry production line in Yongning Machinery Plant has been completed, and its commissioning will soon be undertaken. The procurement of secondary fan equipment and two automatic control systems has also been completed, and will soon be matched with the related demonstrative boilers for performance verification. The installation of the fabric filters, pneumatic conveying system for ash/slag and ash coolers has already been completed in demonstrative boiler houses. These will be commissioned with the mainframe demonstrative boilers in the near future. Progress of the Multicyclone dust collector and the Pre-furnace Briquetting Machine projects is somewhat slower than other auxiliary equipment projects because of the late signing of contracts.

Of all 10 technical assistance components, 9 ones are being executed as planned except for the sub-license components.

1.4 Selective Review

The selective review, undertaken as part of the GEF Monitoring and Evaluation country review activity focused primarily on the selection of the foreign technologies and the technology transfer process.

Notwithstanding that, the project is still under implementation, indications are that the technologies selected for the project are adequate, given the resources available and good progress has been made with transfer technologies process.

In order to facilitate the selective review, a number of steps were taken, namely, a comprehensive review of the documentation on the project with an emphasis on foreign technologies and the technology transfer process, extensive consultation with a cross-section of project stakeholders (i.e. PMO, Ministry of Machinery Industry, boiler manufacturers and users, research institutes, etc.) and specific site visits where boilers have been installed. Annex II provides an overview of the primary activities undertaken in the selective review.

SECTION 2: EVALUATION OF THE BOILER TECHNOLOGY SELECTION AND TECHNOLOGY TRANSFER

2.1 Technology Level of Chinese Industrial Boiler Products

Currently, there are 706 industrial boiler manufacturers with grade E and higher production licenses in China. Most of them are of relatively small scale. In addition to these licensed manufacturers, there are hundreds of smaller plants producing small hot water boilers without pressure, which in general, are not in the category of industrial boilers. Models of industrial boilers produced in China are diverse, and can be classified into 8 categories, 38 series, 85 types and more than 300 specifications by terms of fuel types and combustion approaches (Table 2.1). While there are diverse types and specifications with regard to Chinese industrial boiler products, their design and manufacture is still based upon the design principles and production process in the 1950s, which results in poor product performance. This is characterized by:

(a) Small capacity per boiler unit, with an average of less than 4t/h;
(b) Of all industrial boiler products, those with small capacity are dominant. In recent years, production of boilers with capacity less than 1t/h accounts for some 5% of total industrial boiler production in China, that with capacity of 2~10t/h accounts for 75%, and that with capacity more than 10t/h is less than 20%;
(c) Coal-fired boilers are dominant, most of which are chain grate boilers with poor adaptability to different coal types. Advanced boilers with coal casting device and vibrating grate boilers are rare;
(d) Low automatic control level. There is generally no automatic regulation for combustion conditions of industrial boilers;
(e) Defect in optimization of auxiliary equipment;
(f) Low operation efficiency. The operation efficiency of industrial boilers in China is typically 60~65%. However, in developed nations, the net efficiency of industrial boilers with same capacity and application is generally over 80%. In addition to the boiler technology gap, fuel type (oil, gas or coal), coal quality, operation conditions, operation labor skill, are also the reason for the significant low efficiency.

Table 2.1 Classification of Industrial Boiler Products in China

Category	Manual Operation Boiler	Chain Grate Boiler	To-and-fro Movement Grate Boiler	Boiler with Coal Casting Device	Boiling Combustion Boiler	Pulverized Fuel Boiler	Oil/Gas Boiler	Hot Water Boiler
Series	9	5	4	2	5	5	5	12
Type	16	17	15	2	12	7	6	16
Specification	30	110	41	7	33	11	26	44
Capacity (t/h)	0.2~1	0.5~20	0.5~10	10~20	2~35	4~20	0.5~20	0.35~29MW

2.2 Related Technical Studies in Support and Preparation of the Project

During the preparation process of the project, a number of technical studies were carried out, including:

(a) Preliminary Feasibility Study of Efficient Industrial Boilers in 1994. This was a collaborative study between the World Bank and the Chinese government. The primary conclusion of the study is that improvement of energy efficiency of Chinese industrial boilers can only be achieved, by a system engineering approach covering importation and demonstration of advanced foreign boiler design and manufacturing technologies as well as the elimination of barriers impeding their popularization in China, instead of,

by simply retrofitting existing industrial boilers. As a part of the study, the former Chinese Ministry of Machinery Industry with the assistance of foreign boiler experts and the World Bank, conducted a detailed evaluation of domestic industrial boiler manufacturers and their customers. The future trend of industrial boiler demand in China were analyzed and the most desired industrial boiler technologies identified, were of steam and hot water boilers.

(b) Surveys of the Chinese Industrial Boiler market. Three such surveys were carried out by the Second Institute of Project Planning & Research under the former Ministry of Machinery Industry in 1988, 1991 and 1994, respectively. The findings of these surveys were used to identify demand for the boiler models to be supported by the GEF project and the costs of improved boilers.

2.3 Selection Process of the Technologies Imported

During the preparation stage of the project, and in accordance with the project administration procedures of the World Bank, the PMO issued bulletins for the project in different newspapers and publications, both at home and abroad. A number of well-known foreign firms were also contacted through the Chinese foreign embassies, to inform them of the scope, requirements, and application procedures for the project. After receipt of the applications of foreign firms, screening was undertaken by the PMO. This was followed by the establishment of a review group for the purpose of investigating these firms. Based on the investigations of the Review Group, 18 foreign firms and the boiler technologies they produced (including Foster Wheeler Company (F.W), Detroit Stoker Company, ABB-CE Company, Maxitherm Australia Pty Ltd., CRE, etc.) were short-listed and confirmed by the World Bank to be technology sources for the project, as well as options for the domestic bid winner enterprises of the 9 boiler sub-projects.

In the implementation stage of the project, the domestic bid winner enterprises of the 9 boiler sub-projects, together with China Machine-Building International Corporation, (as an open window of the project to the outside), issued the bidding documents to these 18 foreign firms, in accordance with the Procurement Guidelines of the World Bank. However, for a variety of reasons, most of the 18 foreign firms announced their withdrawal. This resulted in the failure of the first round of bidding.

As a consequence of the failure of the first round bidding, the PMO organized all domestic bid winner enterprises to look for new foreign technology sources. After the new shortlist of foreign technology source enterprises had been identified and re-confirmed by the World Bank, the second round bidding was carried out. The first technology transfer sub-contracts of the boiler sub-projects were signed at the end of 1998, and the last one came into effect in April 2000. The technical consulting sub-contracts for the coal pre-treatment and briquetting machine sub-project were signed, but have not become effective. As a consequence, the overall project schedule was delayed. However, to ensure the realization of the project objectives, the planned project completion time was extended by 18 months.

2.4 Technology Transfer Approach

Technology transfer is the primary component of the CEBP project. The technology transfer approach adopted by the project is designed as follows: the Chinese domestic boiler manufacturers procure production licenses for advanced foreign industrial boiler technologies and production equipment with the GEF grant. Open and competitive procedures are applied for the selection and identification of advanced foreign boiler technology suppliers, so as to make it possible for domestic boiler manufacturers to obtain the most advanced and effective industrial boiler technologies at the lowest prices.

The technology transfer procedure is divided into two stages. In the first stage, the domestic

boiler manufacturers procure advanced industrial boiler technologies and production licenses for the production of demonstrative boiler units from foreign technology suppliers. In the second stage, the domestic boiler manufacturers, who successfully satisfy the performance indicators of their boiler sub-projects, are allowed to procure production equipment necessary for mass production of improved boilers. The technologies imported under each boiler sub-project may be conditionally re-transferred, according to the specific agreement of the license procurement, to another 2~3 domestic boiler manufacturers.

2.5 Adequacy of the Selected Technologies and Their Adaptation to Local Situations

Generally, the technologies selected for the project are adequate, and adaptable to Chinese situations. They are advanced boiler technologies, in terms of their utilization requirement and fuel types and comparable to similar technologies available on the world market. In addition, the boiler technologies met the first goal of the project which is to improve the technology level in the design and manufacture of existing industrial boiler product series in China (especially chain grate boilers accounting for some 60% of the annual capacity of industrial boilers produced in China), thereby improving their thermal efficiency and reducing related CO2 emissions. Technologies in this area included those imported as part of No.1, 2, 3, 4, 5 and 6 boiler sub-projects and their related auxiliary equipment projects. The advantages of these technologies include improvement in design and manufacture of combustion devices, grate manufacture, air-tightness of air boxes, and optimization of auxiliary equipment and assembly.

The second goal is aimed at supplementing and improving the inadequacy of Chinese industrial boiler product series, thereby improving their economic performance and adaptability to the Chinese industrial boiler market as well as reducing CO2 emissions. Technologies related to this goal included those imported in No.7, 8 and 9 boiler sub-projects and related auxiliary equipment projects (e.g. overall design technology of large capacity, movement grate hot water boilers covering hydrodynamics design and calculation methods, CAD software, thermodynamics and air dynamics calculation methods of FBC boilers, etc.)

As far as the 9 boiler sub-projects are concerned, the sources of the technologies imported came from leading global companies (e.g. Babcock of Germany, Ansaldo Volund A/S Denmark, John Thompson Africa, and Combustion Power Company (CPC) of USA) with advanced design and manufacture technologies of small and medium capacity coal-fired boilers. For example, the introduction of the chain grate stoker technology of John Thompson Africa is new to China, whereas the hot water boiler technology of Ansaldo Volund A/S Denmark can help to remedy and eliminate some of the shortcomings and inadequacies in the Chinese industrial boiler manufacturing process. The CFBC boiler technology of CPC, developed specially for commercialization of 35~220 t/h boilers, fits China requirement.

With respect to the 11 auxiliary equipments, three foundry production lines of grate bars are imported from two well-known companies in the foundry field, namely, Stokogio Ltd. of Japan and Hunter Corp. of USA, respectively. The importation of the three foundry production lines of grate bars will contribute to upgrading the level of foundry production line of grate bar in China. That is very important for a country like China where coal is a dominant fuel for industrial boilers. Before the project, there was no suitable production line of grate bar in China. The design technology for two automatic control systems is imported from Siemens of Germany. In addition, the importation of technologies for fabric filters, ash coolers and pneumatic conveying system for ash/slag, which have never been matched with industrial boilers in China before, will fill important gaps and the importation of secondary fans and multi-cyclone dust collector technologies will greatly improve the overall level of Chinese industrial boilers.

4. Technology Transfer under the CEBP

4.1 CEBP is a pilot project of technology transfer in the OP5 projects

Technology transfer is the key element of the CEBP. However, because the project is still under implementation, it is too early to come to a definitive conclusion on the results relating to technology transfer aspects of the project. Nevertheless, based on the review team's observations, on-site surveys an analysis positive results are already being seen.

The design and realization of the project objectives with respect to the introduction of technology, included a combination of software, blueprint, calculating formula, processes and material requirements. Another important element of the project is capacity building. This involved training both domestically and abroad, in all the sub-contracts. The technology transfer process was not designed to simply copy the manufacturing of products but to practice the entire process of design, production, testing and utilization of the transferred new technology and associated products. This process helped the various stakeholders (e.g. PMO, participating institutions, manufacturers, etc.) to broaden their field of vision and improve their skills and knowledge. Some subcontractors such as Changzhou Boiler Works built up their own blueprint bases and databases, and went through the process of design, development, and manufacturing of the new technology through the process of technology transfer. Such a practice will help domestic designers and manufacturers to improve their future technological capacity and innovation.

Another important component of the CEBP is technology transfer diffusion, a process whereby the technologies imported during the first phase of the project are spread to at least two other similar manufacturers, after the practice is certified as being successful for the first round technology receivers. This process helps to test the technology transfer process as well as to enhance the knowledge transferred. One of the technical assistance sub-projects has the objective of improving the boiler design level in China, through standardized design guidelines. These guidelines play a very important role for many of the smaller boiler producers who have less capacity to design the boilers by themselves but who instead copy the standard designs.

The significance of this kind of technology transfer for the industrial boiler sector of China is obvious. The current stock of industrial boilers in China is about 500,000, and thousands of new boilers are sold each year. If the project is successfully implemented, it is estimated that the average level of industrial boiler technology in China could be broadly improved, as outlined in the project document, with an up to ten percent improvement of average thermal efficiency of Industrial boilers. The total volume of energy conserved and emissions avoided would also be very significant.

There are however uncertainties related to the expected results of the project. It is too early to conclude whether all the planned outputs will be achieved, since the project is still under implementation. Even if the project finishes as scheduled, the market penetration of the new technology as well as the capacity building in the updating of new boiler design and manufacturing will need more time to take effect than the duration of the project. To some extent, the replication of the new boilers will depend on external conditions, such as environmental protection regulation, the enforcement of which has an important impact on the competition of the new boilers in the market. Furthermore, coal quality will have an important impact on the realization of the higher efficiency of the new boilers, as well as on the current boilers. Nevertheless, the technology transferred provides better alternatives and more reliable capability to meet stricter environmental protection standards and higher efficiency requirements.

4.2 Difficulties and lessons in technology transfer process of CEBP

The time period of the preparation and implementation of the project is too long. More

than 8 years have already passed since the beginning of the preparation stage of the China Efficient Industrial Boilers Project. During this period, the Chinese parties involved in the project, including the units undertaking sub-projects, the PMO, and the former Ministry of Machinery Industry, have undergone significant changes. With the exception of a few persons, almost all the officials, managers, and professional who were involved in the project from the beginning, have either left or retired. Relevant market situations, policies, and regulations have also undergone significant changes. Two more years will be required to complete the planned activities of the project. In addition, the time needed for further relevant activities, such as the wide-spread marketing and spreading of the new technologies are not included in the planned activities. Overall, the project preparation and implementation process is too long a period for any government or business institution. This was highlighted by the stakeholders, who indicated that from their viewpoint, the time spent on the project became a big burden to them. This has had a negative impact on the project.

The complexity of the project and its implementing procedure influences efficiency and the effectiveness of the project. There are two reasons for the complicated nature of the project. First, when the project was planned and designed, the complexity of the technology transfer was not fully recognized. The Chinese parties had the best intentions of using the GEF grant resources as effectively and efficiently as possible, thereby facilitating the transfer of as many technologies as needed to improve the industrial boiler industry of China. The number of sub-projects under the CEBP was 30, with more than 20 Chinese agencies, institutes, and companies being direct parties of the technology transfer process. On the other hand, the strict and complex approaches and rules of contracting, procurement, and project management under which the project operated, exacerbated the difficulties and complexity of the implementation of the project. Difficulties were experienced with the procurement of the technology as well as with project disbursement procedures. Many stakeholders identified the difficulties associated with this process as an impediment for timely implementation. Many stakeholders complained that the support from their manufacturer's leadership for the project became weaker due to the long time required for the input of resources and the subsequent delayed outputs.

The grant available for each of the technology procurement is not sufficient. Since the project is divided into many sub-projects, covering 9 types of boilers and more auxiliary equipment, the amount of GEF grant allocated for each sub-project is relatively low (US$ 2 million). Such resources are relatively low which is rather low for the kind of technology procurement associated with the CEBP Project. As a result, many potential technology sources withdrew especially the larger companies, thus narrowing the technology choices. Given the limited resources, the GEF grants were used primarily for the purchase of the new technologies, leaving less room for capacity building elements in the specific technology transfer such as the personal exchange and training in each of the sub-projects. Another aspect of the limited budget was the rather strict constraint placed on the replication of the technologies transferred. The technology purchases were of a one time buy/sell nature, and did not make adequate allowances for further improvement and upgrading of the transferred technology. In addition, the technological diffusion process was also limited by strict terms. For example, in some sub-contracts, only two or three manufacturers shared the licenses while in other sub-contracts, some users were required to pay for the royalties.

The difficulty and high cost of adopting the technology should be taken into consideration. Many domestic boiler manufacturers have been involved in the project from the early stages of project planning and preparation. Therefore, hundreds of hours of senior managers, engineers, and other skilled workers time have been invested in the project. Such investments were made by manufacturers to benefit from the manufacturing of and marketing of the new boilers. The new boilers are, however, at least in the demonstration period, more expensive than the current products. Furthermore, the advantages of the new products have not been proved, nor have they been recognized by the users. Uncertainty exists for the newly designed products, and it is not easy to persuade the users to take the risk, even if it is small. At the same time, the

manufacturers involved in the project face strong competition from other manufacturers in the boiler sector, who are selling the old products with lower production cost. All the project members indicated that they have not seen a return on their investment. In addition, uncertainties exist on how long it will take before the investment will generate profit. It is suggested that such kind of market barrier should be fully considered in the design of technology transfer project under OP5.

5. General Conclusion

The team recognises that it is difficult to draw definitive conclusions about a complex, technology transfer project like the CEBP that is still under implementation. According to our observations, and the discussions with the project members, the general conclusion from the review of the project is very positive. The project was well prepared and structured and the technologies selected for the project are adequate, given the resources available. The implementation up to now, although delayed, has been successful, and the project is on track towards achieving its designed goals. Compared to other types of GEF interventions, projects such as the CEBP that focus on technology transfer, may have more sustainable and longer-term effects on energy efficiency and associated GHG reduction. Some preliminary findings from the review are highlighted which should be given consideration in the future design of technology transfer projects under OP5. These are summarised as follows:

- The design and preparation of the project is very important. The domestic adoption capacity in the target country is crucial for technology selection and transfer. Country drivennes and local involvement are prerequisites for such projects.

- Capacity building should be emphasized in technology transfer projects. Knowledge transfer is a key component of technology transfer. The success of technology transfer depends on the adoption of local people of the transferred knowledge, in addition to the hardware and software components of the technology transfer.

- Technology transfer, in general, occurs between business entities. The technology procurement will follow the market rules even under the GEF and government intervention. Therefore, the project design and implementation schedule should avoid being too complex and drawn out, hindering the active involvement of the private sector.

- Market barrier removal for technology transfer is an important element of technology transfer projects. Without grant resources for the market barrier removal, the adoption and replication of new technologies may be difficult.

Annex 1

Inventory of sub-projects of China Efficient Boiler Project

1. 9 boiler sub-projects are:

(a) **1-6t/h Packaged Water-tube Boiler**. The domestic bid winner is Xinjiang Tianshan Boiler Works. The foreign technology supplier is Babcock Borsig Power Service GmbH. Characteristics of the imported technology include louver type grate bar with good air tightness and cooling performance, good adaptability to interior bituminous coal, high boiler efficiency, and low dust emission density.

(b) **1-6t/h Improved Packaged Fire-tube and Water-tube Boiler**. The domestic bid winner is Yingkou Boiler Works. The foreign technology supplier is John Thompson Africa (Pty) Ltd. South Africa. Characteristics of the imported technology include a light type chain grate structure and frame with superb side tightness, advanced and adjustable air distribution system, high combustion efficiency and low dust emission density.

(c) **6-20t/h Module Water-tube Boiler**. The domestic bid winner is Shanghai Sifang Boiler Works. The foreign technology supplier is Ansaldo Volund A/S Denmark. Characteristics of the imported technology include unique corner tube boiler technology, adaptability to class III bituminous coal, and much lower dust emission density than traditional boilers.

(d) **6-20t/h Module Water-tube High Sulfur Boiler**. The domestic bid winner is Jiangxi Boiler Works. The foreign technology supplier is Friedrich u Kari Bay GmbH & Co. KG Germany. Characteristics of the imported technology include the patented Bio-fluid FBC combustion technology, good sulfur removal effect, low Nox creation and high combustion efficiency.

(e) **0.7-14MW Packaged & Module Hot Water Boiler**. The domestic bid winner is Changzhou Boiler Works. The foreign technology supplier is Ansaldo Volund A/S Denmark. Characteristics of the imported technology mainly include a ECO grate, a adjustable ignition furnace arch and a forced circulating system, good combustion control, good adaptability to interior coal types produced in China, and high boiler efficiency.

(f) **4-20t/h Packaged & Module Extended Water-tube Furnace & Fire-tube Boiler**. The domestic bid winner is Zhengzhou Boiler Works. The foreign technology suppliers are Friedrich u Kari Bay GmbH & Co. KG Germany and Babcock Company Germany. A joint design approach is adopted. Characteristics of the imported technology include advanced grate structure, even air distribution, stable combustion, high boiler efficiency and low dust emission.

(g) **35-100t/h Heat Power Steam Boiler**. The domestic bid winner is Jinan Boiler Works. The foreign technology supplier is John Thompson Africa (Pty) Ltd. South Africa. The technology imported fills in the gaps in China in such fields as grate structure, removal of dust inside the furnace, coal feeders, mainframe of boilers, and grate air tightness.

(h) **7-70MW Hot Water Boiler**. The domestic bid winner is Hangzhou Boiler Works. The foreign technology supplier is Danstoker A/S Denmark. Characteristics of the imported technology include corner tube boiler with full film wall structure, flag-like heat

transfer surface disposed in the tail convection zone, the secondary air arranged at both the front and back of the furnace so as to prolong time of flying ash staying in the furnace, adjustable air supply, and simple grate installation requirement.

(i) **35-100t/h Circulating Fluidized Bed Combustion (CFBC) Steam Boiler**. The domestic bid winner is Harbin Boiler Works Industrial Boiler Company. The foreign technology supplier is Combustion Power Company (CPC) in USA. Characteristics of the imported technology include the advanced fine particle CFBC technology, good adaptability to low volatile contents/difficult burning fuels, high combustion efficiency and good sulfur removal effect.

2. 11 auxiliary equipment sub-projects are:

(a) **Foundry Equipment**. China's Liaoning Wafangdian Yongning Machinery Plant will procure a foundry production line from Sitokogio Ltd. in Japan to produce grate for the demonstrative boiler of No.2 boiler sub-project.

(b) **Foundry Equipment**. China's Tianjin Ninghe Grate Plant will procure a foundry production line from Hunter Automated Machinery Corp. in USA to produce grate for the demonstrative boiler of No.7 boiler sub-project.

(c) **Foundry Equipment**. China's Jiangsu Wuxi Huguang Combustion Equipment Factory will procure a foundry production line from Hunter Automated Machinery Corp. in USA to produce grate for the demonstrative boiler of No.5 boiler sub-project.

(d) **Secondary Fan**. China's Nantong Fan Works will procure a horizontal hard-bearing balance machine from Schenck Rotec GmbH in Germany to produce secondary fans for No.8 boiler sub-project.

(e) **Fabric Filter**. China's Jiangsu Wujiang Dust Collector Factory will import the technology from Environmental Elements Technology Corp. In USA to produce fabric filters for No.9 boiler sub-project.

(f) **Multicyclone Dust Collector**. China's Complete Sets of Equipment Co. Under Shanxi Taiyuan Boiler Factory will import the technology from Environmental Elements Technology Corp. In USA to produce multicyclone dust collectors for No.6 boiler sub-project.

(g) **Coal Pre-treatment and Briquetting Machine**. Zemag Co. in Germany is contracted to provide relevant consulting service for No.2 boiler sub-project.

(h) **Handling Equipment for Ash/Slag**. China's Complete Sets of Equipment Co. Under Shanxi Taiyuan Boiler Factory will procure a handling equipment for ash/slag from Ducon Fluid Transport Division, which will be matched with No.9 boiler sub-project.

(i) **Ash Cooler**. China's Hubei Boiler Auxiliary Works will import the technology from Christian Engineering in USA to produce ash coolers for No.9 boiler sub-project.

(j) **Automatic Control System**. China's Shanghai Power Station Engineering Company will import the technology from Siemens AG Power Generation KWU in Germany to produce an automatic control system for No.7 boiler sub-project.

(k) **Automatic Control System**. China's Beijing Yilai Engineering Corp. will import the technology from Siemens AG Power Generation KWU in Germany to produce an automatic control system for No.9 boiler sub-project.

3. 10 technical assistance components are:

(a) **Boiler Operator Training and Certification Program**. Undertaken by Harbin Power System Engineering and Research Institute.

(b) **Marketing and Dissemination Program**. Undertaken by Beijing Electrical Research Institute for Technique and Economy.

(c) **Revision of Industrial Boiler Standards**. Undertaken by Beijing Electrical Research Institute for Technique and Economy.

(d) **Boiler Design Improvement Program**. Undertaken by Beijing Clean Combustion Engineering Co., Ltd..

(e) **The Implementation Plan of Revising the Code for Design of Boiler House**. Undertaken by Institute of Project Planning and Research.

(f) **Plan for Verification Testing and Long Term Monitoring for Thermal Efficiency and Emissions**. Undertaken by Shanghai Industrial Boiler Research Institute.

(g) **Boiler Design Safety Evaluation**. Undertaken by Beijing Clean Combustion Engineering Co., Ltd.

(h) **Engaging International Consultant on Boiler Design Safety Evaluation**. An American expert, Mr. Carl Horlitz will be contracted for this TA component.

(i) **Plan for Sub-project Evaluation**. Undertaken by the Second Institute of Project Planning & Research under former Ministry of Machinery Industry.

(j) **Sub-license**. Undertaken by Beijing GEF Efficient Industrial Boiler Technology Development Center.

Annex II

Primary Activities of the Selective Review

The selective review of the "*China Efficient Boiler Project*" was initiated on November 27, 2000, and finished on January12, 2001. The primary activities of the Selective Review included:

(a) A formal consultation with the management and staff of the Project Management Office (PMO) for the project on November 27, 2000. The review group provided an overview of aims and objectives and the purpose of the review. The modalities for undertaking the selective review were discussed and agreed to by all parties.

(b) The group including Mr. Eric Martinot, from the GEF Secretariat, and Ms. Nandita Mongia, UNDP, visited the PMO on November 31, 2000. Six staff members from the Project Management Office (PMO) attended the meeting. The PMO officials gave an overview of the implementation progress of the project, as well as highlighted the problems experienced in project implementation and the lessons learnt.

(c) The review group had a formal meeting with the PMO and other project participants on December 28, 2000 in Beijing. Attendees of the meeting included staff of the PMO (Mr. Wang Dunen, Mr. Jian Jingwen, Mr. Chen Songlin, Madam Yao Xiafen, etc.), Mr. Fan Beiyan from the Beijing Clean Combustion Engineering Co., Ltd., sub-contract of No.4 &7 technical assistance (TA) components of the project, and Ms. Tan Meijian, from the Beijing Electrical Research Institute for Technique and Economy, sub-contractor of No.2 & 3 TA components.

- Introduction of the Project, including a report on the progress and problems encountered in the project implementation;
- Report of the progress in implementation of No. 2,3,4 & 7 TA components;
- Detailed discussion focusing on the main subjects of the review, i.e., the selection of the foreign boiler technologies and the technology transfer process and results.

(d) A visit was made by the Review team to the Second Institute of Project Planning & Research under former Ministry of Machinery Industry located in Hangzhou on January 2, 2001. The Institute has been involved in preparation and design of the project and is partly responsible for No.9 TA component. The review group, accompanied by Mr. Wan Dun'en from the PMO, had a meeting with Mr. Zhang Sugang and Mr. Hu Jainlin from the visited institution. Subjects discussed included:

- Related technical studies in support and preparation of the project;
- Selection process of the foreign boiler technologies transferred under the project;
- Adequacy of the selected foreign technologies and their adaptation to local situations;
- Relevant lessons from the project.

(e) Visits were made to three domestic bid winner enterprises of the nine boiler sub-projects under the project during January 3-6, 2001, which are located in Houzhou, Shanghai and Changzhou, respectively. They are Hangzhou Boiler Works (the bid winner of No.8 boiler sub-project), Shanghai Sifang Boiler Works (the bid winner of No.3 boiler sub-project), and Changzhou Boiler Works (the bid winner of No.5 boiler sub-project). During the visits, three meetings were held with Mr. Xu Jinxuan and Mr. Zhang Minqiang from Hangzhou Boiler Works, Mr. Li Yongjin, Mr. Ding Wenbo and Mr. Den Xiangguan from Shanghai Sifang Boiler Works, and Mr. Wang Lizhi, Mr.

Zhang Huangqing and Mr. Lu Huanliang from Changzhou Boiler Works, respectively. Discussions were held on the following:

- Progress in implementation of the three boiler sub-projects.
- Difficulties and problems encountered in their implementation.
- Adequacy of the selected foreign technologies and adaptation to local situations.
- Lessons from the three boiler sub-projects.

In addition, the review group visited the plants of the three bid winning enterprises to see the imported foreign technologies (graph papers, design software, etc.) and production process and capacity of their demonstrative boilers. Information and materials relevant to the three sub-projects were collected.

(f) During January 8-12, 2001, the review group visited the PMO once again, and kept contact with PMO for further collection of information, clarification of questions, and discussion on their opinions of the findings during the review.

In general, the review activity received full support from the PMO and all the institutions visited. During all the meetings and on-site surveys, the discussions were very active, sincere and open-hearted. The PMO made efficient logistic arrangements for this site visit, including facilitating site review visits in the three cities.