GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET

Naoko Ishii
CEO and Chairperson

October 14, 2014

Dear Council Member:

UNIDO as the Implementing Agency for the project entitled: ***China: Promoting Energy Efficiency in Industrial Heat Systems and High Energy-consuming (HEC) Equipment***, has submitted the attached proposed project document for CEO endorsement prior to final approval of the project document in accordance with UNIDO procedures.

The Secretariat has reviewed the project document. It is consistent with the proposal approved by Council in June 2012 and the proposed project remains consistent with the Instrument and GEF policies and procedures. The attached explanation prepared by UNIDO satisfactorily details how Council's comments and those of the STAP have been addressed. I am, therefore, endorsing the project document.

We have today posted the proposed project document on the GEF website at www.TheGEF.org. If you do not have access to the Web, you may request the local field office of UNDP or the World Bank to download the document for you. Alternatively, you may request a copy of the document from the Secretariat. If you make such a request, please confirm for us your current mailing address.

Sincerely,

for Naoko Ishii

Attachment: GEFSEC Project Review Document
Copy to: Country Operational Focal Point, GEF Agencies, STAP, Trustee

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REQUEST FOR CEO ENDORSEMENT

PROJECT TYPE: Full-Sized Project

TYPE OF TRUST Fund: GEF Trust Fund

PART I: PROJECT INFORMATION

Project Title: Promoting energy efficiency in industrial heat systems and high energy-consuming (HEC) equipment			
Country(ies):	China	GEFSEC project- ID:	4866
GEF Agency/ies:	UNIDO	GEF Agency Project ID:	100283
Other executing parties	Special Equipment Safety Supervision Bureau (SESA) of the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ)	Submission date: Re-submission date: Re-submission date: Re-submission date:	10 April 2014 15 May 2014 27 August 2014 22 September 2014
GEF Focal Area (s):	Climate Change	Project Duration (Months)	48
Name of parent program (if applicable): ➢ For SFM/REDD+ ➢ For SGP	N/A	Agency fee ($):	537,500

A. FOCAL AREA STRATEGY FRAMEWORK

Focal Area Objectives	Expected FA Outcomes	Expected FA Outputs	Trust Fund	Grant Amount ($)	Co-financing ($)
CCM-1	Enabling policy environment and mechanisms created for technology transfer	Innovative low-carbon technologies demonstrated and deployed on the ground	GEFTF	525,000	1,000,000
CCM-2	Appropriate policy, legal and regulatory frameworks adopted and enforced	Energy efficiency policy and regulation in place	GEFTF	600,000	4,500,000
CCM-2	Sustainable financing and delivery mechanisms established and operational	Energy savings achieved	GEFTF	4,250,000	35,000,000
		Total project costs		5,375,000	40,500,000

B. PROJECT FRAMEWORK

Project objective: To promote energy efficiency in "high energy consuming" special equipment through the development of technical regulations; the establishment of national laboratories; the training of national experts; and the demonstration of new technologies at enterprise level.						
Project Component	**Grant Type**	**Expected Outcomes**	**Expected Outputs**	**Trust Fund**	**Grant Amount ($)**	**Confirmed Co-financing ($)**
1. Policy and market promotion	TA	Enhanced regulatory framework that will enable HEC user to adopt energy efficiency measures and government institutions to monitor compliance, including a knowledge management tool	1.1 National technical regulations on energy efficiency for HEC special equipment (boilers and heat exchangers) are revised and improved through the implementation of innovative systemic approaches 1.2 A reporting system is designed and implemented to allow inspection agencies to collect data from in-service boilers systematically 1.3 A national awareness raising and dissemination campaign is developed and implemented	GEFTF	525,000	1,000,000
2. Capacity Building activities (Government)	TA	The AQSIQ has the capacities required to enforce the technical regulations, and testing capabilities are enhanced to facilitate the implementation of a systems optimization approach and the use of energy efficient equipment	2.1 The capacities of the HEC Special Equipment Energy Efficiency Testing Centre are upgraded 2.2 National testing laboratories are established and have the competencies to verify and test against the new technical regulations	GEFTF	600,000	4,500,000

3. Capacity Building activities (enterprises)	TA	A cadre of highly specialized system optimization experts from public and private sectors are available as a long-term technical resource to industry and the country. Enterprises awareness on measures and new technologies and EE financing mechanisms is increased.	3.1 Awareness on the concept of energy efficiency focused on optimization of steam systems and heat recovery systems is raised amongst 1000 representatives of selected stakeholder groups (inspection agencies, equipment manufacturers, enterprises, consultants) 3.2 50 candidates are trained to become national energy practitioners on steam and heat recovery systems optimization 3.3 75 in-depth system assessments are completed in manufacturing facilities to identify energy savings 3.4 100 enterprises improve their capacities for the financial evaluation of industrial energy efficiency projects	GEFTF	1,700,000	7,000,000
4. Demonstration of energy efficient equipment implementation and operation	INV	New efficient technologies are demonstrated at national level to serve as case studies for future investments	1) Systems optimization: 50 of the companies trained adopt measures to reduce their energy consumption 2) New technologies: at least 5 of the companies trained adopt measures and replace equipment with more efficient technologies	GEFTF	2,200,000	26,000,000

5. Monitoring and Evaluation	TA	A robust mechanism for the monitoring and evaluation is put in place to ensure the attainment of project outcomes	5.1 The project monitoring plan is designed and executed 5.2.Mid-term and final project evaluations are conducted 5.3 As part of the terminal evaluation follow-up actions recommendation are determined for long term project sustainability	GEFTF	100,000	180,000
				Sub-Total	5,125,000	38,680,000
				Project Management Cost (PMCs)	250,000	1,820,000
				Total Project Costs	5,375,000	40,500,000

C. SOURCES OF CONFIRMED CO-FINANCING FOR THE PROJECT BY SOURCE AND BY NAME ($)

Sources of Cofinancing	Name of Cofinancier (source)	Type of Cofinancing	Cofinancing Amount ($)
National Government	Special Equipment Safety Supervision Bureau (SESA) of the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ)/ China Special Equipment Inspection and Research Institute (CSEI)	Cash	1,500,000
		In-kind	4,000,000
GEF Agency	UNIDO	Cash	100,000
		In-kind*	260,000
Private Sector / Academia	Resources Technology Co. of Xi'an Jiaotong University	Cash	3,200,000
		In-kind	800,000
Private sector	Lanpec Technologies	Cash	4,000,000
		In-kind	1,000,000
Private sector	Beijing GuanSha Huanneng Technology	Cash	2,600,000
		In-kind	650,000
Private sector	Beijing Huanyuayitong Heating Supply Technology Development	Cash	5,600,000
		In-kind	1,400,000
Private sector	Dalian Hight Tech - Guangyuan Heat Power Co.	Cash	4,130,000
		In-kind	1,140,000
Private sector	Shanxi Lantian Environmental Protection Equipment Co.	Cash	3,656,000
		In-kind	914,000
Private sector	Guangzhou Devotion Thermal Facility Co.	Cash	2,000,000
		In-kind	500,000
Private sector	Lang Fang Aolin Boiler Energy Savings and Emission Reduction Combustion Technology	Cash	840,000
		In-kind	210,000
Private sector	Taishan Group Co.	Cash	1,600,000
		In-kind	400,000
Total Cofinancing			40,500,000

*Details of UNIDO's in kind contribution are provided in Annex G

D. TRUST FUND RESOURCES REQUESTED BY AGENCY, FOCAL AREA AND COUNTRY

The project consists of a single focal area, single country, single GEF Agency project, and single trust fund project, so no information is provided information for this table.

E. CONSULTANTS WORKING FOR TECHNICAL ASSISTANCE COMPONENTS

Component	Grant amount ($)	Co-financing ($)	Project total ($)
International consultants*	490,000	0	490,000
Local/national consultants	446,700	1,000,000	1,446,700

*Details of consultancy work are provided in Annex F

F. DOES THE PROJECT INCLUDE A "NON-GRANT" INSTRUMENT?

No

PART II: PROJECT JUSTIFICATION

A. DESCRIBE ANY CHANGES IN ALIGNMENT WITH THE PROJECT DESIGN OF THE ORIGINAL PIF[1]:

A.1. National strategies and plans or reports and assessments under relevant conventions, if applicable, i.e. NAPAS, NAPs, NBSAPs, national communications, TNAs, NCSA, NIPs, PRSPs, NPFE, Biennial Update Reports, etc.:

The main policy framework for this intervention is in the context of the 12th Five-Year Plan (FYP) period (2011-2020) that the Chinese Government has put forward. The main policies[2] for industrial energy efficiency set by the 12th FYP include the "Energy Saving and Environmental Protection Industry Development Plan", which establishes specific targets for energy use and emission reductions:

- Reducing energy intensity by 16% within the industrial sector by 2015 from the level of 2005;
- Reducing energy intensity by 10% in the cement production sector, the oil refinery sector, and the chemicals sector by 2015 from their 2010 levels; and
- Cutting carbon dioxide (CO_2) emission intensity by 17% between 2010 and 2015.

The new legislation also establishes specific measures to address energy efficiency, including:

- Conducting energy efficiency assessments and showing proof of the deployment of Best Available Technologies (BAT), before the Government approves any greenfield investments in fixed assets;
- Scaling-up results of the successful "1,000 Enterprises" Program from the 11th FYP with a "10,000 Enterprises" Program;
- Endorsing market approaches like energy service companies (ESCOs) that help to finance energy efficiency investments; and
- Implementing of the following energy efficiency technologies: transformation of boiler and furnaces, energy conservation on electrical system, energy systems optimization, residual heat and pressure recovering utilization, petroleum saving and replacement, energy conservation in construction, and green lighting. These measures are based on the "Ten Energy Conservation Programs" from the 11th FYP period.

In addition to the central policies described in the PIF under the 12th FYP Framework, the Central Government has developed additional policies to emphasize the need to address energy efficiency issues. A State Council "Framework Policy on Accelerating the Development of Energy-saving and Environmental Protection Industry" was published on 10 August 2013.

The main goals of the new policy are centered on fostering the development of energy saving measures that promote energy conservation. The policy is detailed in selecting the policy measures as well as key energy conversation technologies. The key policy elements are in line with the proposed project and would provide the regulatory support required to ensure that the selected measurers will be adopted. The concept of energy systems optimization is detailed within this regulation.

[1] For questions A.1-A.7 in Part II, if there are no changes since PIF and if not specifically requested in the review sheet at PIF stage, then no need to respond, please enter "NA" after the respective questions.

[2] A more thorough description of national polices is presented in the PIF and also abridged in Annex K Background information.

The key aspects of the aforementioned State Council Framework Policy are as follows:

Policy measures

The policy states that regulatory-driven incentives will be promoted, such as energy saving regulations and standards, including the strengthening of Government Bodies supervision and management.

Technologies

The policy emphasizes the need to promote key energy saving technologies for boilers, motors, heat exchangers and cooling equipment, new energy vehicles and semiconductor technologies.

The policy also provides details on the specific technologies (hardware and knowledge). For those technologies relevant to the proposed project, the policy indicates that: (1) for boilers, energy efficiency may be achieved by expanding the manufacturing of high efficiency boilers but also by adopting a systems optimization based approach (including measures such as automatic control, optimization, improved use of fuels, flue gas waste heat recovery, etc.); and (2) for heat transfer and cooling technology, more efficient equipment as well as heat integration/recovery approaches shall be promoted.

A.2 <u>GEF</u> focal area and/or fund(s) strategies, eligibility criteria and priorities,

As described in the PIF document, and on the basis of the "GEF 5 Programming Document", dated 12 May 2010, the project is in compliance with the Climate Change Mitigation Results Framework Objective #2 "Promote market transformation for energy efficiency in industry and the building sector". The GEF recognizes UNIDO's comparative advantage as an implementing agency in the development of projects for the industrial sector in focusing on energy efficiency, as well as its knowledge of small and medium enterprises (SMEs) in both developing and transition economy countries.

A.3 The GEF Agency's comparative advantage:

UNIDO's co-financing is increased from the $ 160,000 stated in the PIF to $ 360,000. The additional cofinancing takes into account the licensing of the steams systems optimization package as well as technical inputs from UNIDO's Compliance Infrastructure Unit, proving guidance on national quality infrastructure and polices and from the Energy Efficiency Unit in the development of the heat recovery optimization package. The breakdown is provided in Annex F.

UNIDO's capacities within the country program have not changed in comparison with the PIF document[3].

A.4 The baseline project and the problem that it seeks to address:

The following section provides an abridged analysis of the issues presented at the PIF stage. For more details refer to Annex K Background Information.

<u>Background and problem analysis</u>

A very common measure adopted by industries seeking to reduce energy consumption is the replacement of existing inefficient equipment by new more efficient models. This happens to be the most prevalent approach for heat transfer equipment in China:

- Industrial boilers in China are the most significant equipment employed in terms of energy conversion, with the majority being coal-fired. In 2010, the total coal production in China reached 3.24 billion tones, with

[3] Please refer to the PIF document for details.

boilers representing 70% (about 2.24 billion tons) of the consumption. The average operational efficiency of industrial boilers in China is only 65%, which is 15-20% lower than that of boilers in more technologically developed countries. Several previous projects have addressed the performance issues related to industrial boilers in recent years, perhaps mostly importantly the GEF-WB China Efficient-Industrial Boilers Project (GEF ID 97). Nevertheless, considerable potential for energy saving still remains to be realized.

- For heat exchangers research by the Chinese Special Equipment Institute (CSEI) shows that the expenditure on heat exchangers comprises 30% of the total capital expenditure on new equipment in the chemical industry, and around 40% in oil refineries. Improved heat recovery efficiency and the optimization of heat exchanger networks (HENs) would significantly contribute towards higher overall plant energy efficiency. These technologies have benefited from a growing realization of the effects of climate change. The consequent tightening of environmental regulations has prompted greater demand for energy saving equipment, in particular heat exchangers, as economically optimized heat recovery typically offers a 15-40% improvement in energy efficiency. An additional benefit to industrial enterprises is that manufacturing costs are significantly reduced, at better rates of return than other alternatives. Equipment manufacturers have responded to the resulting market demand with many new types of specialized heat exchanger designs[4] for niche applications.

Experience has shown that energy savings realized from mere replacement of existing equipment with newer more efficient models are typically limited to 3-5% of the overall energy consumption. However, if a systems optimization approach is used, energy savings of 15–40% could be realized. To date, almost all efforts in Chinese industry have been focused on either replacing equipment or improving equipment performance through upgrades; only limited attention has been given to systems approaches such as optimized Heat Exchanger Network (HEN) design, heat exchanger cleaning strategies, and integration of the Combined Heat and Power (CHP) systems within the process (see Annex L for a technical glossary describing these measures in detail).

Until 2013, the energy conservation polices and tools have been centered on improvement in the performance of high energy consuming equipment. The technical solutions tend to ignore the use of systems based approaches in which energy use is analyzed from both the supply side as well as the demand side. Hence, all regulations have been centered in the improvement of equipment performance (boilers) rather than on the efficiency of energy consuming systems (steam systems). Also, no progress has been made on evaluating performance or efficiency of heat exchangers and their networks (heat recovery systems). Detailed definitions on the equipment and systems approach are laid out in detail in the technical glossary in Annex L.

In 2010, the total CO_2 emissions from the energy use in Chinese manufacturing [5] were equal to 4,473 million tons (Mt) CO_2 which accounted for 60% of China's total CO_2 emissions in that year. Assuming that around 30% of the total primary energy consumption in manufacturing is used by industrial boilers[6], the CO_2 emissions of industrial boilers is equal to 1,342 Mt CO_2 in 2010 (baseline). Under the business and usual, two scenarios can be projected as follows:

- Static scenario: The CO_2 intensity (CO_2 emissions per unit of GDP) does not change in the future and remains at the current value of 2013. In this case, the estimated CO2 emissions of industrial boilers in 2027

[4] Examples include tube inserts, self-supporting twisted-tube bundles, helical baffles, rod-baffles, plate and frame, spiral-plate, and "compabloc" heat exchangers.

[5] In Chinese statistics, the term "industry" refers to manufacturing as well as mining of coal and minerals, oil and gas extraction, power generation, and the production and distribution of water. These subsectors of industry (other than manufacturing) are not included in the present study.

6 There are no figures for the energy consumed by industrial boilers in manufacturing China, hence the value is derived from the 2010 Manufacturing Energy Consumption Survey (MECS) Survey Data in the United States.

(10 years after the completion of the proposed GEF intervention) is equal to 3,390 Mt CO_2, which is almost 2.5 times the level of industrial boilers emissions under the baseline.

- Copenhagen Target scenario: China has an official target of reducing the CO_2 intensity of its economy by 40% in 2020 compared to 2005 level[7]. Also, when estimating the CO_2 emissions of the industrial boilers in 2027, it is assumed that an additional 10% reduction in the CO_2 intensity in the period of 2020-2027 occurs. Under this scenario, the CO_2 emissions of industrial boilers in 2027 are equal to 2,500 Mt CO_2 which is around 1.9 times the level of industrial boilers emissions under the baseline.

To achieve the Copenhagen target, China has put in place a series of energy policies and programs during the 11th and 12th FYPs. The "Top-1,000 Enterprises Energy Saving Program" and the "10 Key Energy Saving Projects Program" implemented during the 11th FYP are examples of such efforts by the Chinese Government and have both been extended to the 12th FYP with the "Top 1,000 Program" being scaled up to the "Top-10,000 Enterprises Energy Saving Program".

The above programs along with other policies and incentives can help to reduce the energy intensity of manufacturing in China but they are not a guarantee that China will achieve its Copenhagen target. This is primarily because of financial and non-financial barriers. The lack of expertise and capacity to implement energy assessments and energy efficiency projects, especially system optimization projects which go beyond simple energy saving measures, is one of the key barriers to improving the energy efficiency within Chinese industry. Finally, the lack of capacity within the Government entities tasked to enforce the current standards is another key barrier that China faces. This proposed GEF project aims to address some of these key barriers.

Baseline Project

The following section addresses the key drivers for the adoption of energy efficiency measures, including the current policy framework, the capacities at country level to adopt the necessary measures, and the availability of technologies.

Policy framework

Following the promulgation of the National Energy Conservation laws in 2007[8], regulations on Energy Conservation Supervision were issued for HEC equipment management. The regulations envisage that the supervision of energy conservation measures will be undertaken by the General Administration of Quality Supervision Inspection and Quarantine (AQSIQ) – an autonomous Government body[9]. AQSIQ is also responsible for ensuring safety aspects, hence the integration of energy efficiency measures allows for greater coherency in implementation and enforcement of the regulations.

The AQSIQ has produced new technical regulations to monitor the energy performance of heat transfer equipment. To date, a set of technical regulations have been issued including:

- "Supervision Administration Regulation on Energy Conservation Technology for Boilers" (TSG G0002-2010);
- "Energy Efficiency Test and Evaluation Regulation for Industrial Boilers" (TSG G0003-2010).

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[7] China's autonomous domestic mitigation actions as announced for information to the UNFCCC Parties under the Copenhagen Accords, dated 28 January 2010.

[8] Article 16 of the Energy Conservation Law stipulates that stipulates "special equipment, which consumes excessive quantities of energy shall be subject to examination and control for energy conservation".

[9] In 2009, AQSIQ issued Order No.116 "The Supervision Administration on Energy Conservation for High Energy Consuming Special Equipment" which defined the energy conservation supervision system and scope for high energy consuming special equipment, as well as specific energy saving requirements for special equipment manufacturing, servicing and other linkages.

- In 2011, a new standard has been drafted and its application is being piloted: "Boiler Design File for Energy Conservation Review Measures (Trial)".

Neither regulations nor technical standards have yet been drafted to assess energy efficiency of steam systems. There are no methods to determine efficiency parameters of either steam systems or heat recovery systems.

In the absence of a GEF intervention, the AQSIQ would undertake the drafting of technical standards, as well as the development of technical guidelines, but progress would be gradual and centered on equipment performance. The Energy Efficiency Promotion in Industry Project (GEF ID 4109), currently being implemented by the International Bank for Reconstruction and Development (IBRD), will support the development of national industrial energy efficiency policies, but it will not focus on technical standards or specific testing guidelines. The Technical Standards development progress has been limited due to technical constraints; however the new State Council Framework Policy from August 2013 requires accelerated implementation.

Capacities

The China Special Equipment Inspection and Research Institute (CSEI) has been instrumental in developing existing regulations through chairing the technical committees and making recommendations on draft regulations to the AQSIQ. The CSEI acknowledged that the understanding of system approaches for both steam and heat recovery systems is very limited.

In 2009-2010, AQSIQ undertook research to determine the existing capacities in autonomous regions, municipalities to inspect energy use in HEC. In 2011, they identified 82 inspection agencies that have the capacity to inspect boilers performance but not systems efficiency. In 2012, more agencies were identified to facilitate boiler efficiency testing.

The current capacities of CSEI include boilers and heat exchanger testing and evaluation. These facilities are mainly used for research, since the test center has a regulatory rather than a compliance role. It generates the data which is then used as the technical basis for the development of relevant regulations, standards and energy policies.

The implementation of Technical Standards TSG G0002-2010 and TSG G0003-2010 began in 2011. Since then, more than 10,000 boiler design files were reviewed and approximately 1,500 new boiler designs have been tested; however these inspections were not detailed enough to assess energy efficiency aspects.

To implement the existing standards, the inspection agencies such as CSEI should be able to test over 15,000 boilers yearly, by adopting a regular testing schedule of industrial equipment.

A new AQSIQ research and testing center is being built in the Shunyi District, Beijing area. The center will be opened in 2015 and new reference laboratories have been planned for performance testing of HEC in laboratory conditions. The design of monitoring and inspection for testing and evaluating the performance of steam and heats transfer equipment and energy systems will be required. Training on the adopted methods for inspectors, laboratory staff and enterprises will also be required.

Technologies

As of 2010, AQSIQ was mandated to be responsible for the inspection of HEC equipment. In 2010, there were 610,000 boilers and 768,000 heat exchangers in operation within China. The expected average annual growth rate for such equipment, based on economic growth is 8% in the period 2010-2015 and 6% for the period 2015-2020.

Preliminary CSEI research on more than 20 large Chinese petrochemical enterprises shows that they have gradually deployed new technologies. However, the uptake of more efficient heat exchangers was slow as companies selected models which met their manufacturing process requirements giving little consideration to their thermal efficiency. The most commonly used technologies were expansion bellow and plate heat exchanger types, while more efficient exchangers, such as "helix changer" were the least used.

In the absence of a GEF intervention and without technology transfer promotion or regulatory measures to address energy efficiency of heat equipment, the uptake of BAT by enterprises will remain limited. The Energy Efficiency

Promotion in Industry Project (GEF ID 4109), currently being implemented by IBRD, will support enterprises in adopting energy management systems. However, it will not address steam or heat recovery system optimization measures. Without the transfer of technical knowledge, the adoption of operational and maintenance measures to reduce energy consumption will remain limited.

The main barriers identified which prevent national stakeholders adopting energy efficiency measures are in line with those presented in the PIF. The list of barriers and how the project will address them is presented in the following Section A.5.

A.5 Incremental /Additional cost reasoning: describe the incremental (GEF Trust Fund/NPIF) or additional (LDCF/SCCF) activities requested for GEF/LDCF/SCCF/NPIF financing and the associated global environmental benefits (GEF Trust Fund) or associated adaptation benefits (LDCF/SCCF) to be delivered by the project:

The proposed objective is to promote energy efficiency in high energy consuming special equipment through a comprehensive approach, including: the development and revision of technical regulations; the provision of training to national experts; and the establishment of a National High Energy Consuming (HEC) Special Equipment Energy Efficiency Testing Centre. The proposed project has been structured around four main technical components which have specific outcomes that will address the barriers described in section A.4 by implementing the following measures:

Project Component - Outcomes	Barriers	How the proposed project addresses these barriers
Policy Implementation – testing standards and market promotion Enhanced regulatory framework that will enable HEC users to adopt energy efficiency measures and government institutions to monitor compliance, including a knowledge management tool	• Enforcement of energy efficiency targets has been piecemeal for HEC and limited in regard to macro-level energy reduction targets which lack the support of monitoring and enforcement mechanisms. • There are no energy efficiency indicators or energy efficiency evaluation methods on heat exchangers in China. • Benchmarking techniques, standards and technical regulations do not exist or are in need of revision. • Little macro-level data is available on energy performance of local manufactured heat exchangers. • Lack of capacities to develop the necessary regulations on systems to implement and enforce HEC special equipment regulations.	• Enhance policy and market promotion by drafting testing codes and regulations based on international and national standards that will allow Government agencies to establish regulations and methods for both steam and heat recovery systems. • Performance indicators for condensing and non-condensing boilers shall be introduced by revising the existing regulation. • A boiler database will be established to benchmark performance and set targets. • Supporting CSEI in the drafting of new regulations. • CSEI submits the regulations to AQSIQ for approval and issuance.
Capacity Building Activities (government) The AQSIQ has the capacities required to enforce the technical regulations. A	• The Government's ability to monitor energy performance is limited as it is unable to independently test equipment	• The CSEI have the capacities (equipment and staff) required to put in place the technical regulations and methods required to adopt steam and

Project Component - Outcomes	Barriers	How the proposed project addresses these barriers
knowledge management tool is available to users, which facilitates the implementation of systems optimization and efficient equipment by improving testing capabilities	available on the market to ensure that is both safe and energy efficient. • Testing facilities and inspectors have the abilities to enforce safety aspects of industrial equipment but have limited knowledge on heat transfer performance and international standards in the same field.	heat recovery systems assessment methods. • Six laboratories will be established and will have the capacities (protocols and staff) required to draft, test and enforce the regulations.
Capacity Building Activities (enterprises) A cadre of highly specialized system optimization experts from the public and private sectors are available as a long-term technical resource to industry and the country. Enterprises awareness on measures and new technologies and EE financing mechanisms has been increased	• Lack of familiarity with the range of energy efficiency technologies and processes. • Energy efficiency is not part of the core business for most companies, company strategies tend to focus on output growth rather than cost management. • A components based approach to energy efficiency is taken as opposed to a systemic one which would result in even greater energy savings.	• A cadre of highly specialized heat system optimization experts (40 on steam systems and 10 on heat recovery systems) from the public and private sectors will be developed as a long-term technical resource to industry and the country. • User and awareness raising training for enterprises on systems optimization measures. • Awareness raising programme to improve the understanding of energy efficiency professionals on financial evaluation of industrial energy efficiency projects to facilitate investment decisions.
Heat exchangers and technology transfer New efficient technologies are demonstrated at national level to serve as case studies for future investments	• There is a disconnect between the upfront capital investment costs of heat equipment and the life cycle energy cost of its operation. • Enterprises have limited information on the equipment available in the market and can only go by the information provided by equipment manufacturers	• A demonstration programme to show that energy savings are achievable is undertaken by the adoption of energy systems optimization and new technologies in enterprises. • Dissemination of best case studies and information collected in the national database.

The project scope has remained largely the same as initially planned at the PIF stage. Adjustments were proposed to each component to better suit the needs analysis performed during the PPG stage.

The main adjustments include:

- Defining concrete monitoring indicators for both equipment performance as well as systems efficiency to allow inspection agencies to verify that the equipment is operated in both a safe and energy efficient manner;
- Establishing a boiler performance database to allow CSEI to monitor performance, set benchmarks and targets instead of an online information platform. The CSEI acknowledged the need to design a robust system for the collection of data from inspections at a national level and decided to prioritize this aspect. Dissemination of best practices and experience will be made. However, the use of an online tool has been discarded;

- Undertaking steam systems optimization training at all levels (awareness raising, user and expert level) as well as heat recovery systems training in order to improve Government and enterprise technical skills. This decision was taken recognising that other relevant projects in energy efficiency have not addressed this matter and the necessary skills are still lacking;
- Providing training to on financing of energy efficiency measures to technical experts and enterprises rather than to banks. During the PPG phase it was assessed that there is sufficient capacity in the financial sector to evaluate energy efficiency projects. These capacities have been developed by other prior GEF interventions, such as the World Bank/International Finance Corporation (WB/IDC) China Utility-Based Energy Efficiency Finance (CHUEE) Program and WB Energy Efficiency Financing, for which more details in section A.7.
- For this additional capacity building activity, of financial training for technical experts, the target set is of 100 enterprises. The training shall focus on the financial valuation of energy efficiency projects and will enable each enterprise to create its own business plan. Further details are presented below in the description of component 3.
- A significant increase in cofinancing is defined but no increase in the planned deliverables. The national counterparts have chosen a conservative approach and cannot guarantee that investment project shall materialise and have emphasized the need to maintain the targets to at least five of the fifty enterprises conducting technological retrofits.

The proposed project has five components which have specific outputs.

The first component focuses on the improvement of the standards and national regulations that are required to enforce national policies. To achieve this goal three main outputs are set including: (i) the drafting of technical regulations on boilers; (ii) the establishment of a reporting system to systematically collect data from boilers in service; and (iii) the dissemination of regulations and technical practices though a national awareness campaign.
The detailed activities are outlined in the table below.

Expected Outputs	Detailed Activities
1.1 National technical regulations on energy efficiency for HEC special equipment (boilers and heat exchangers) are revised and improved through the implementation of innovative systemic approaches	1.1.1 An analytical study conducted to define an energy efficiency indicator (EEI) for steam systems. 1.1.2 A key performance indicator (BPI) for in-service boiler's thermal efficiency is established through numerical analysis. 1.1.3 A testing method standard is drafted for condensing boilers. 1.1.4 Technical regulations are revised to include the new appraisal methods for boiler thermal efficiency (BPI - 1.1.1 Condensing Boiler and 1.1.2 Non-condensing Boilers) and for steam systems (EEI - 1.1.3). 1.1.5 Technical committees are called by AQSIQ to review the necessary testing methods required to implement the regulations. 1.1.6 A national guideline to assess the energy conservation potential of heat recovery systems is formulated, based on the global best available experience.
1.2 A reporting system is designed and put in place for inspection agencies to collect data from in service boilers systematically	1.2.1 The regulatory reporting needs are assessed and a template reporting structure is designed. 1.2.2 An electronic based system is created for systematic data collection, leading to the creation of a heat equipment and system database. 1.2.3 The CSEI, jointly with the inspection agencies, shall collect data from enterprises, considering size, and type of boilers. 1.2.4 The database is used to conduct a detailed study to determine the steam systems energy efficiency supply curves.
1.3 A national awareness raising and dissemination campaign is developed and implemented	1.3.1 Design a national information campaign (seminars, road shows, multimedia, and promotional material/brochures) on equipment performance improvements, systems optimization and EE regulation for equipment targeted at different beneficiary groups (inspection agencies, equipment manufacturers, enterprises, consultants). 1.3.2 Disseminate the results of the best case studies from Component 4 .

The second component is centered on improving the capacities that the national institutions will need to establish the required new policies, monitoring their performance and enforcing regulations. The outputs include the establishment of the necessary laboratories to test new technical parameters as well as the training of staff to best evaluate these parameters. The laboratories will be based at the new CSEI National Reference Center being built in the Shunyi District, Beijing, planned for 2015. The laboratories in this National Center will focus on energy efficiency research. The national dissemination of the new regulations is planned through the training of staff (inspectors) of provincial and city level inspection agencies.

The detailed activities are outlined below.

Expected Outputs	**Detailed Activities**
2.1 The capacities of the HEC Special Equipment Energy Efficiency Testing Centre are upgraded	2.1.1 Improve the existing analytical capacities of the Center for testing the relevant parameters for Steam and Heat Recovery systems to implement the methods established in Outcome 1 by training key staff. 2.1.2 Train staff and 100 inspectors from provincial agencies in the analysis of data collected from the enterprises. 2.1.3 Procure necessary equipment for verification of the key parameters identified in the testing methods. 2.1.4 Adopt and localize the software tools required to assess heat recovery systems.
2.2 Six national testing laboratories are established and have the competencies to verify and test against the new technical regulations	2.2.1 Establish Boiler Energy Efficiency Test Research and Evaluation Laboratory. 2.2.2 Establish Exchanger Components Energy Efficiency Evaluation Laboratory. 2.2.3 Establish Heat Exchanger Product Energy Efficiency Evaluation Laboratory. 2.2.4 Establish Oil and Gaseous Fuel Burners (OGFB) Testing Laboratory. 2.2.5 Establish Boiler Energy Efficiency and Environmental Protection Evaluation Mobile Laboratory. 2.2.6 Establish Fuel Analysis Laboratory.

The third component shall improve the capacities of enterprises to adopt the technical measures that will allow them to comply with the new regulations, and undertake steam and/or heat recovery system optimization measures in their operations. The output aim to raise national capacities by providing a stakeholder focused approach to technical training. This approach will provide different training courses for enterprise managers, equipment vendors, and for technical staff of enterprises who aim to become national experts in a specific field. Specific training to improve the ability of project proponents to undertake financial assessment of energy efficiency projects will be conducted, which will enable trainees to distinguish that in EE project financial returns are obtained from savings in fuel and power.

The training shall be designed with the support of international experts. The training program materials will be localized to conditions within China and made available in the local language. Trainings will be conducted jointly by national and international trainers; a licensing fee to the training is included in the UNIDO co-financing contributions to the project (see Annex F).

The sustainability of training programs to be provided in this project shall be achieved by the following measures

- For users training in system optimization a national institution shall be sought to continue providing the training programmes. Participants of the experts training program shall have the capacities to impart the user training.
- For experts training in system optimization a personnel certification scheme may be devised, in order to formalize national experts who will be able to continue providing the expert level training.

Trainees for the expert level program shall be selected under criteria established in the Training Program Framework, which involves several step: the candidates are invited to apply; then a pool of candidates is preselected and invited to the user training. During the users training the candidates are assessed by the intentional trainers and sit for a written assessment. A weighted criterion assessment is then made to select the most suitable applicants.

The enterprises that will undertake activities in Component 4.6 will be selected during the development of the steam and heat recovery optimization period, by inviting interested enterprises to participate in both the trainings, with agreement that trainees can undertake the practical activities of their training within enterprises facilities. Enterprise selection will be made based on relevance within their industrial sub-sector (focusing on high energy consuming sectors); the potential to become cases studies; and willingness to invest in energy efficiency measures. Enterprises have expressed their interest during the preparatory phase, including those who have provided co-financing letters.

The detailed activities are outlined below.

Expected Outputs	**Detailed Activities**
3.1 Awareness on energy efficiency focused on optimization of steam (SSO) and heat recovery systems (HRSO) is raised amongst 1000 representatives of selected stakeholder groups (inspection agencies, equipment manufacturers, enterprises, consultants)	3.1.1 Awareness and promotion workshop for 1000 managers and technical personnel of enterprises (0.5 days). 3.1.2 Training of 100 national trainers who will train operators in the user training steam systems optimization (SSO) and heat recovery system optimization (HRSO). 3.1.3 Training for 10,000 boiler operators (user). 3.1.4 Dedicated training to 300 equipment manufacturers and vendors (0.5 days).
3.2 50 candidates are trained to become national energy practitioners on steam and heat recovery systems optimization	3.2.1 Internationally best available training program on steam systems optimization (SSO) training is adapted. 3.2.2 A web-based platform and other training methods for trainees are developed. 3.2.3 40 EE professionals receive expert level steam system optimization (SSO) training, domestically and abroad. 3.2.4 Heat recovery system optimization (HRSO) training is developed. 3.2.5 10 EE professionals receive expert level system optimization (HRSO) training domestically and abroad.
3.3 75 in-depth system assessments are completed in manufacturing facilities	3.3.1 Preparation of a list of candidate companies for in-depth assessment and selection 3.3.2 National trainees carry out in-depth energy systems assessments as part of their practical training process led by international trainers (60 steam systems and 15 for heat recovery systems).
3.4 Improve capacities for the financial evaluation of industrial energy efficiency projects in 100 enterprises	3.4.1 Preparation of training program for financial evaluation of industrial energy efficiency projects. 3.4.2 100 experts and industry personnel trained on the evaluation of EE projects financing and access to finance resources.

The fourth component aims to demonstrate best available technologies by undertaking demonstration of improved operations in enterprises; namely the adoption of the acquired systems optimization measures, and also replacing equipment with more efficient technologies.

Technologies have been screened during the preparatory phase, and the results are presented in Annex B. The typical measures have been selected based on the capital investment required and the period of time required for such interventions, including boiler optimization, boiler excess air control, increased condensate recovery, optimized cogeneration, heat recovery optimization, optimized heat exchanger cleaning technologies and integrated heat recovery (pinch analysis) measures.

The detailed activities are outlined in the table below.

Expected Outputs	Detailed Activities
4.1 Systems optimization: 50 of the companies which conduct in-depth assessments in Component 3 adopt low cost system optimization measures	4.1.1 50 industries implement the systems optimization measures identified during the in-depth systems assessments.
4.2 New technologies: 5 of the companies which conduct in-depth assessment in component 3 replace their equipment with more efficient technologies	4.2.1 Conceptual and/or basic engineering of selected technologies is completed 4.2.2 Bankable business plans are prepared 4.2.3 Technology retrofits are conducted

Finally, a fifth component that encompasses all project management activities is proposed. This component creates a robust mechanism for project monitoring and evaluation is operationalized to ensure the attainment of project outcomes.

Expected Outputs	Detailed Activities
5.1 The project monitoring plan is designed and executed	5.1.1 Inception workshop is conducted. 5.1.2 Design of monitoring plan and tools for data collection and recording. 5.1.3 Periodic progress reports and monitoring of project impact indicators (as per Log Frame). 5.1.4 Measurement GEF Tracking Tool specific indicators.
5.2.Mid-term and final project evaluations are conducted	5.2.1 Mid-term evaluation. 5.2.2 Independent terminal project evaluation.
5.3 As part of the terminal evaluation, follow-up actions are identified, that shall address project's long term sustainability	5.3.1 Follow-up actions are identified by the national counterparts to ensure long term project sustainability.

Global Environmental Benefits

The Global Environmental Benefits of the proposed project were calculated using the GEF manual and tool for "Calculating Greenhouse Gas Benefits of the Global Environment Facility Energy Efficiency Projects Version 1.0" (GEF 2013). Out of the four technical project components mentioned above (excluding project management), the detailed bottom-up analysis using the GEF tool could only be conducted for two components, i.e. policy and market promotion (under standards and labeling module category of the GEF guidelines) and demonstration of energy efficient equipment implementation and operation (under demonstration and diffusion module category of the GEF guidelines).

An estimate of the expected project energy savings and GHG emissions reductions are summarized in the table below. The detailed emission reduction calculations are presented in Annex E.

Savings for All Project Components	*2014-2017 (direct)*	*2018-2027 (direct post project)*	*2018-2027 (indirect bottom up)*	*2018-2027 (indirect top down)*
Electricity Savings (GWh)	125	0	975	N/A
Coal Bituminous Savings (PJ)	24	9,530	115	N/A
Total Energy Savings (PJ)	25	9,530	118	60,510
GHG Emission Savings ($ktCO_2$)	2,423	912,889	10,527	2,329,010

A.6 Risks, including climate change, potential social and environmental risks that might prevent the project objectives from being achieved, and measures that address these risks:

Risk	Rating*	Mitigation
Lack of effective coordination between various partners involved and with other EE programs	L	Proper coordination will be sought through the Project Steering Committee. Ad-hoc working groups per sector or theme can be set up as needed, bringing in other partners and beneficiaries.
Effectiveness of policy to promote the desired results	L	The technical standards will be drafted with the aim of ensuring that all new equipment complies with the targets of reducing energy consumption, in line with the latest State Council Policy.
Limited number of candidates interested in training	L	Awareness raising and stakeholder engagement during the preparatory phase has built a project "constituency" however continuous awareness and engagement needs to be addressed to maintain interest.
No immediate demand of services for trained experts	M	The integrated approach adopted by the project is expected to mitigate this risk by combining expert training with factory training designed to create interest in the services that the new national experts will provide.
Demonstration projects are delayed, limiting the opportunity to disseminate success stories and develop case studies	L	The enterprises selected as demonstration sites for the expert-level training will be carefully screened for management support and implementation of the resulting recommendations. These factories are anticipated to provide the initial case studies and thus serve as examples for other factories.
Incentives and financial support systems are insufficient, especially for technology transfer	L	Financial institutions will be encouraged to learn more about potential savings resulting from industrial energy efficiency; and companies will be made aware of financing opportunities.
Vulnerability to climate events	L	The type of interventions to be undertaken in this project (standards and demonstration and diffusion measures) has negligible vulnerability to climatic events.

* L = low risk; M = medium risk; H = high risk

A.7 Coordination with other relevant GEF financed initiatives:

The proposed project has taken into consideration during its design the exiting or completed projects in the China/GEF portfolio in order to avoid duplication and to identify potential synergies for collaboration. Those projects include:

Completed projects

China - Efficient Industrial Boilers Project

This GEF/ World Bank/ Ministry of Machinery Industry Project[10] (GEF ID97, 1996-2004) involved the upgrading of existing boiler models and adoption of new boiler models as well as technical assistance and training. In total, nine international boiler technology transfer packages were piloted by nine domestic boiler manufacturers and auxiliary equipment makers. The technology transfers were considered successful in themselves, with new designs giving energy savings of up to 5%. However, changes in government policy and the market itself prevented the project from having a broader impact.

This project has also supported the drafting of one national and four sectoral standards and the revising of two national standards and two sectoral standards. However, no technical regulations were formulated under the project framework. Therefore, the proposed project shall address issues which were not considered before by this project.

Efficiency Upgrade for Coal-burning Industrial Boilers and Kilns

As part of the Medium and Long-term Plan of Energy Conservation, in 2006, the NDRC announced three measures to reduce the nation's kiln and boiler consumption of coal by 70 million tons: selection of high-quality coal, lump coal, and sulphur-fixed coal; renovation of medium-sized and small boilers and kilns with advanced techniques such as circulating fluidized bed (CFB) and pulverized coal firing; and establishment of a scientific management and operation system.

The project has been successful at reducing fuel use, but it did not address systems optimization or operational performance of boilers. Also in this case the proposed project shall address issues which were not considered before.

On-going projects

China Utility-Based Energy Efficiency Finance (CHUEE) Program

This WB/IFC (GEFID 2624, 2008-2012) led project has assisted national banks in providing loans to energy efficiency projects, as well as organizing and providing marketing and financing services to large energy consumer in all economic sectors. This project does not provide technical support to enterprises nor assesses issues related to standards. This project is listed to avoid duplication of actions: based on discussions with the IFC project team, the awareness of national banks on the financing of energy efficiency issues is high as a consequence of this and other similar interventions.

Energy Efficiency Financing Project

This GEF/World Bank Project (GEF ID 2951, 2011-2015) focuses on the establishment of Energy Service Companies (ESCOs) but primarily on the fostering of large-scale energy efficiency loan programs in three Chinese National Banks that may provide loans for projects within heavy industries in the $5-10 million range. This project is listed to

[10] http://gefonline.org/projectDetailsSQL.cfm?projID=97

avoid duplication of actions: which indicates that national banks have acquired the capacity to finance large energy efficiency investment projects.

The Energy Efficiency Promotion in Industry Project

This ongoing GEF/World Bank Project (GEF ID 4109, 2011-2015) aims to improve the technical and managerial capacities required to promote a rational use of energy in the key industrial sectors and has four main components: supporting policy development (but not focused on technical standards); capacity building for energy managers (focuses on energy managers but not on system optimization); demonstration of energy management measures; and dissemination of knowledge.

Establishment of Measurement and Verification System for Energy Efficiency in China

This GEF/World Bank Project which is at PPG stage (GEF ID 4947, approved in June 2012), aims to establish MRV systems to control energy efficiency investment undertaken under the Ministry of Finance "Financial Reward Fund for Energy Saving Technologies". The project will be centered on the capacity building to establish the quality infrastructure for MRV, but will not address steam or heat recovery systems in depth.

The proposed project shall monitor the progress of these existing GEF projects, through the interaction with the national GEF focal point and the related implementing agencies to identify areas of collaboration.

B. ADDITIONAL INFORMATION NOT ADDRESSED AT PIF STAGE:

B.1 Describe how the stakeholders will be engaged in project implementation:

UNIDO is entrusted by the Government of China and by the GEF with the mandate to implement the project to achieve its objective, its outcomes and outputs and within its budget and time frame as approved in this project document. UNIDO is accountable to the GEF for the funds of this project and will in close consultation with AQSIQ; implement the project according to the established UNIDO's rules and regulations, the applicable GEF requirements, and the Ministry of Finance "GEF Grant Project Management Approach" Notice No. 45 from 26 June 2007. This means that UNIDO will maintain the oversight on the project implementation, including supervision of the execution of key activities, as well as organize planned evaluations.

Overall responsibility for project execution will lie with the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ). The China Special Equipment Inspection and Research Institute (CSEI) will have specific responsibility at national level for executing concrete tasks within the current UNIDO/GEF project.

The relationship between the AQSIQ, UNIDO and the Ministry of Finance in China as the supervisory national body for GEF projects will be outlined in a tripartite agreement that shall be concluded once the project approval cycle is completed. Coordination among Government agencies and the implementing agency will be achieved through a National Project Coordination Committee (NPCC) which will be chaired by AQSIQ and UNIDO. The NPCC will provide necessary guidance and oversight on the project's implementation, and will invite members and experts for specific meetings, as needed.

Meetings will be held once in every six months. NPCC is expected to deal with the coordination of various aspects of project activities, including all execution, its planning, and the monitoring and evaluation activities. The NPCC will function not only to coordinate the project execution, but will also act as a discussion forum for proposed activities, policies and initiatives. The NPCC can also serve to coordinate the activities of the demonstration and support programs so that they adequately incorporate energy efficiency potential and corresponding funding. The proposed members of the NPCC are

- Ministry of Finance of People's Republic of China as supervisor
- General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) as executing party，
- China Special Equipment Inspection and Research Institute (CSEI) as executing partner of AQSIQ; and
- UNIDO as implementing agency

The NPCC will be responsible for:

- Coordinating and managing the overall project activities at a macro level.
- Facilitating coordination of project activities across institutions.
- Reviewing project activities and their adherence to the work plan set forth in the project document, in line with the GEF regulations on major and minor amendments.
- Reviewing and commenting on each year's proposed work plan and budget.
- The NPCC will be responsible to request and review financial and progress reports.
- Taking decisions on the issues brought to its notice by UNIDO and other cooperating institutions and advice regarding efficient and timely execution of the project.
- Initiating remedial action to remove impediments in the progress of project activities that were not envisaged earlier.

UNIDO's role in the NPCC is to provide supervision and technical support. The UNIDO Project Manager (PM) will facilitate the work of the Project Management Office (PMO) in co-ordination and networking with other related initiatives and institutions in the country. UNIDO will fulfill this responsibility by appointing a Project Manager and mobilizing services of its other technical, administrative and financial branches at UNIDO Headquarters and at the UNIDO Regional Office in Beijing.

The PMO or a relevant government financial institution will maintain an accounting and financial transaction reporting mechanism for the project, and report to the Ministry of Finance and to the NPCC. The UNIDO Beijing Office will assist with this area of work. The Ministry of Finance will provide UNIDO with certified periodic financial statements, and with an annual audit of the financial statements relating to the status of UNIDO (including GEF) funds according to the procedures set out in the UNIDO Financial Manual. These audits will be conducted by the legally recognized auditor of the Government, according to the Chinese auditing procedures, or by a commercial auditor engaged by the Government.

It is expected that each set of activities to be implemented in the targeted country will be governed by the provisions of the Standard Basic Cooperation Agreement concluded between the Government of China and UNIDO, which was signed on 29 June 1979 and entered into force on 24 June 1985.

Project management

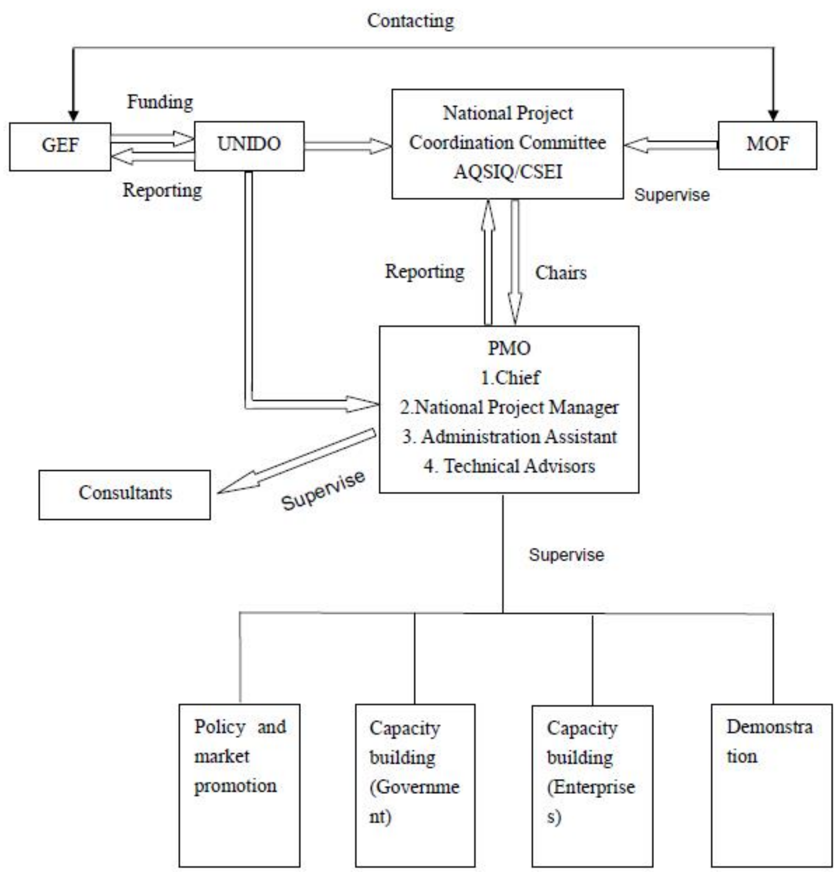
The Project Management Office (PMO) will be the project secretariat and will provide guidance/advice on the execution of each project component. The PMO will be composed of local energy experts whose combined expertise and experiences will cover all the technical and execution aspects of the project. The PMO shall be established during the PPG phase and will be located at CSEI. The PMO will be responsible for the day-to-day management and monitoring of project activities as agreed through the annual project work plan.

The PMO will consist of a PMO Chief, supported by a project assistant and by technical experts from the executing parties. The PMO will be located at CSEI offices in Beijing. During the whole implementation period of the project (2014-2017), the UNIDO Project Manager will provide the PMO with the necessary technical and monitoring support while the PMO will be responsible for the management of the project and coordination with the project stakeholders.

The PMO will comprise of:

- A PMO Chief
- Industry and energy experts (co-financing)
- An Administrative-financial officer (co-financing)

The roles and responsibilities of the stakeholders involved in the project depicted in the following figure**:**



The PMO Chief will report to the NPCC and will be responsible for:

- Coordinating the management and implementation activities of the project as set out in the project document.
- Providing assistance to the NPCC to ensure that project activities conform to the agreed project document.
- Coordinating with the other institutions/agencies involved in the project execution.
- Reviewing the Terms of References for consultants and contracting/subcontracting agencies.
- Organizing tripartite review meetings as per NPCC procedures.
- Preparing Annual Project Reports (APR) and other relevant reports for submission to UNIDO and GEF Secretariat.
- Chairing the PMO monthly meetings.

- Providing guidance to the NPCC for the execution and adhering to the planned milestones and to ensure that project activities conform to the agreed project document.
- Coordinating and supervising the work carried out by consultants/contractors (international & national) who will be involved in the project.
- Reviewing consultant's reports, project budget revisions and all other administrative arrangements required as per AQSIQ and UNIDO procedures.
- Preparing the annual work plan and budget of the project and its timely submission.
- Submitting regular progress reports to the AQSIQ and UNIDO.

Technical Advisors will include national and international research institutions, such as national research centers or universities. Each institution could have different roles based on the specific activity, but in general they will

- Provide technical guidance on specific relevant subject matters to the PMO.
- Undertake global studies and compare international best practices with national practices.
- Design training packages at different levels.
- Execute project activities as required.

Project execution

While a concrete work plan shall be established during the inception phase, it is anticipated that CSEI will be the provider of specific services, in particular those related to the following activities:

- Drafting the testing method standard for condensing boilers (1.1.3).
- Revising the technical regulations including the new appraisal methods for boiler thermal efficiency (1.1.4).
- Coordinating with AQSIQ to call the technical committees that shall review the necessary testing methods regulations required to implement the regulations (1.1.5).
- Formulating a national guideline to assess the energy conservation potential of heat recovery systems (1.1.6).
- Assessing the regulatory reporting needs and preparing a template reporting structure (1.2.1).
- Creating an electronic based system is created for systematic data collection (1.2.2).
- Engaging in the collection of data from enterprises, jointly with the inspection agencies (1.2.3).
- Designing a national information campaign (1.3.1).
- Disseminating the results of the best case studies (1.3.2).
- Adopting and localizing the software tools required to assess heat recovery systems (2.1.4).
- Preparing of list of candidate companies for in-depth assessment and selection (3.3.1).

The provision of such services shall be subcontracted to CSEI by the project.

B.2. Describe the socioeconomic benefits to be delivered by the Project at the national and local levels, including consideration of gender dimensions, and how these will support the achievement of global environment benefits (GEF Trust Fund/NPIF) or adaptation benefits (LDCF/SCCF)

The project focuses on improving energy conservation across industries by focusing on steam and heat transfer systems. This will achieve energy savings which will have a positive effect on profitability, competitiveness and energy resilience of Chinese industries, thus contributing to the national economy.

In terms of the economic aspects, the efficient use of energy enhances the competitiveness of industry by reducing energy bills and exposure to price volatility; and thus improves production costs resilience. At the same time, reduced energy use also diminishes production costs which increase industrial competitiveness. A direct benefit of system optimization measures are the improved operation of manufacturing lines which results in increased productivity. Finally, an associated benefit of energy efficiency is the creation of a culture of improved resources efficiency reinforcing competitiveness.

In terms of environmental benefits, the energy savings derived from this project are in the order of 143 PJ (4.89 Mtce), which will support global environment benefits by direct savings of 915 Million tons of CO_2 emissions over 10 years.

With regards to social benefits the project has a strong capacity building aspect which shall improve national skills on an industrial manufacturing as well as improving the design of national equipment. Furthermore, efforts will be made to mainstream gender issues by adopting two main measures:

- Direct action: efforts will be made to make the expert training program available to equally qualified female candidates. A budgetary provision of 5,000 USD will be made available in the first three years to address these issues, based on experience from prior projects. These funds may be used to cater for needs of female candidates, such as dedicated space for child care during full day training sessions.

- To sensitize relevant stakeholders on the importance of gender issues and their relationship with capacity building projects in the technical field. In addition, a basic gender analysis will be conducted in the inception phase to include additional relevant gender sensitive indicators in the project results framework (see KPIs in Annex A). It shall be noted that a macro level analysis was intended to be implemented during the project design; however, a desk based analysis of the gender data available showed very limited disaggregation of the available national data. A set of key indicators were pursued which are relevant to projects which have key objectives of improving female technical capacities, such as number of females graduating from science and technology degrees. Such information is not available from Chinese national statistics, or in the widely used international statistical databases, such as the World Bank Gender Equality Data and Statistics and the OECD Gender Equality Statistics.

Innovativeness, sustainability and scale up potential

The proposed project will address sustainability and the potential for scaling up in the following manner:

- Innovativeness: The proposed project strengthens technical capacities which will be available as a long-term technical resource to the country. The innovative concept to be promoted is the energy systems optimization approach. If an energy consuming system is not properly designed and operated, the presence of energy-efficient components in industrial systems provides no assurance that energy savings will be attained. Evidence from implemented national and international programs shows that, while efficient components may bring about gains in the range of 2 to 5%, systems optimization measures can attain average efficiency gains of 20 to 30% with a payback period of less than 2 years. The implementation of system optimization measures requires specific technical knowledge, consistent monitoring and remedy action by the industry.
- Sustainability: The sustainability of the project is backed up by a set of actions. The government and industrial stakeholders will receive training and capacity building for long-term implementation of the policies. The direct beneficiaries, industrial enterprises, will be able to reduce energy consumption in heating systems. The enterprises will gain the ability to adopt system optimization measures and become aware of new technologies. Energy conservation effect could be found through the introduction of new technologies' application and demonstration and which will be continuing role in the country after project for long time. Energy savings practices have direct linkages to cost reduction, increased productivity, environmental compliance and global competitiveness. The on-

going operation costs of the demonstration subproject will be covered by the savings of energy use in the industrial sector

- Potential for scaling up: This proposed project targets 50 Chinese private industrial companies, that will implement steam systems improvements. The government has listed 10,000 companies for industrial energy efficiency improvement with energy saving targets. As such, this project has a huge potential to scale up private investments.

B.3. Explain how cost-effectiveness is reflected in the project design:

The project takes a comprehensive approach to address many of the barriers that are preventing the Chinese manufacturing sector to achieve its full economic potential for energy efficiency improvements, in particular those related to awareness; compliance with technical regulations as well as the capacity of industry and relevant institutions to adopt system optimization measures.

Given its focus on addressing policy and technical capacity barriers, the project will generate the biggest share of GHG emission savings after the project implementation period (931 Mt CO_2), when the developed standards and regulations are adopted and start to affect operational practices at the enterprise level.

´Cost-effectiveness´ is defined as GEF contribution divided by direct and indirect emission reduction (USD/tCO_2). Cost effectiveness for this project may be calculated for both the standards and labelling and the demonstration and diffusion measures. However, since the adoption of standards and labels will require significant investment from heat equipment operators, the project will consider that the cost effectiveness, as real, measurable and verifiable emission reductions resulting from the project can only be attributed to the direct demonstration and diffusion activities.

A comparison with two alternative scenarios were considered, by assessing the most likely investment that an industrial enterprise could undertake to abate GHG emissions; provided they would chose not to invest in energy efficiency improvements in their steam systems. The two scenarios are:

Scenario One would be use of solid biomass cofiring technologies, which requires modest adjustment to coal fired boilers, for steam generation.

Scenario Two would be the use of solar thermal technologies to produce heat, with a limited the scale based on typical applications found in industry.

Also, similar interventions in the GEF portfolio, such as the use of solar or biomass for steam generation, were used for an additional comparison for GEF funded projects in China during the GEF 4 and GEF 5 cycles. Since these projects do not have direct industrial applications, comparison is also made to projects in which there was use of renewable energy for industrial applications. To have comparable projects, for all cases, the top-down indirect emissions were omitted.

Project name and number	Cumulative Emission reductions for saving achieved	GEF funding	Cofinancing	Cost-effectiveness (total funding)	Cost-effectiveness- (GEF funding)
	t CO_2	USD	USD	(US$/t$CO_2$)	(US$/t$CO_2$
Promoting energy efficiency in industrial heat systems and high energy-consuming (HEC) equipment - 4866	14,120,752	$3,900,000	$30,640,000	$2.45	$0.28
Scenario Analysis - Investing in Renewables					
Case 1.a - Cofiring of biomass for cogeneration (10% heat)	748,021	$3,900,000	$73,487,443	$103.46	$5.21
Case 1.b - Sensibility analysis with lowest possible CapEx	748,021	$3,900,000	$44,092,466	$64.16	$5.21
Case 1.c - Sensibility analysis with lowest possible CapEx and 50% heat	3,740,106	$3,900,000	$44,092,466	$12.83	$1.04
Case 2.a - Use of evacuated tube solar thermal to produce heat	13,105	$3,900,000	$5,916,667	$749.06	$297.59
Case 2.d - Sensibility analysis with collectors of sufficiently large size to produce 1% of heat requirements	23,937	$3,900,000	$10,806,697	$614.40	$162.93
GEF Projects Investing in RE in China and/or Investing in RE for Industrial Applications					
China Renewable Energy Scaling-Up Program (CRESP) Phase II - 4493	3,900,000	$27,280,000	$4,410,000	$8.13	$6.99
Integrated Renewable Biomass Energy Development Project -3744	940,000	$6,850,000	$141,410,000	$157.72	$7.29
Promoting Business Models for Increasing Penetration and Scaling up of Solar Energy - 4788	249,000	$2,875,000.00	$15,000,000	$71.79	$11.55
Improving Energy Efficiency and Promoting Renewable Energy in the Agro-food and other small and Medium enterprises (SMEs) in Ukraine -3917	2,200,000	$3,209,820	$30,930,568	$15.52	$1.46

The table shows that renewable energy (RE) technologies result in significantly more expensive costs of the GHG emissions abated than the proposed technologies. In addition, the RE measures also lead to smaller volumes of emission reductions. The results show that the proposed project achieves real, measurable and verifiable emission reductions in a more economic manner than the other GEF interventions.

The analysis for these case studies and a detailed results table are presented in Annex H.

C. DESCRIBE THE BUDGETED M&E PLAN:

Project Kick off

A Project Inception Workshop will be held within the first two months of the project's starting date. This activity will involve those stakeholders with assigned roles in the project organisation structure. The Inception Workshop is crucial to building ownership for the project results and to plan the first year's annual work plan. The Inception Workshop will:

- Assist all partners to fully understand and take ownership of the project objectives, outputs and activities. It includes detailing out the roles, the support services to be provided, and the complementary responsibilities of local stakeholders in relation to the PMO.
- Ensure that all stakeholders are aware of the roles, functions and responsibilities within the project's decision making structures, including reporting and communication lines, and conflict resolution mechanisms. The terms of reference for project staff will be reviewed again as needed;
- Based on the project results framework the first annual work plan will be finalised.
- Revise the results based framework indicators, targets and their means of verification and
- Recheck assumptions and risks;
- Elaborate the M&E work plan, following the proposed budget, that should include a detailed overview of reporting, monitoring and evaluation (M&E) requirements; including the gender analysis.
- Review financial reporting procedures, obligations, and arrangements for annual auditing;
- Plan and schedule National Project Coordination Committee (NPCC) meetings. Roles and responsibilities of all project organization structures will be clarified and meetings planned.

The first NPCC meeting should be held within the first 12 months following the project's Inception Workshop.
An Inception Workshop report is a key reference document and must be prepared and shared with participants to formalise various agreements and plans decided during the meeting.

KPIs

Monitoring and reporting shall be based against Key Performance Indicators (KPIs), under which the progress of the project implementation and impact will be measured under a quarterly, annual, mid-term and final reviews. These indicators are presented in Annex A, and are based on the Result Based Framework approach and the reporting requirements of the GEF Climate Change Tracking Tool (CC TT). The GEF CC TT will be submitted at design, mid-term and final reviews project phases.

During the inception phase, a gender analysis will be performed. Gender based monitoring and reporting will be undertaken against the following gender disaggregated indicators:

- The analytical capacities of the HEC Special Equipment Energy Efficiency Testing Centre that are upgraded
- Number of stakeholders with increased awareness of steam and heat recovery systems measures
- Trained local practitioners in System Optimization active in industry

National targets

The AQSIQ has identified four key guiding principles, to be achieved under the project and will be attained by adopting the relevant measures from all project components.

The four overarching targets that guide the project design are the following:

1) Setting an indicator to measure energy efficiency of steam systems;

2) Setting an indicator for in-service boiler thermal performance;

3) Setting an indicator and developing a testing method to measure energy efficiency of steam systems with condensing boilers; and

4) Setting an appraisal method for energy efficiency of heat recovery systems.

The target approach and its relation with the Results Based Framework are presented in Annex J as a double entry matrix.

Semi-Annual Review

For UNIDO a semi-annual project implementation report will be prepared in accordance with the guidelines and templates set out in UNIDO's 2006 Guidelines on Technical Cooperation Programs and Projects or as required in updated guidelines.

Annual Project Review/Project Implementation Reports (APR/PIR)

These key reports are prepared to monitor project progress achieved since the project's starting date and in particular for the previous reporting period. The APR/PIR Reports include, but are not limited to the following aspects:

- Progress made towards achieving project objectives and project outcomes – each with indicators, baseline data and end of project targets (cumulative).
- Project outputs delivered per project outcome (annual).
- Lessons learned/and good practice identified.
- Expenditure reporting.
- Risk and adaptive management.
- Portfolio level indicators (i.e. GEF tracking tools) are also used by most focal areas on an annual basis.

Mid-term of Project Cycle

The project will undergo an independent mid-term evaluation at the mid-point of the project's implementation. The mid-term evaluation will determine progress being made toward the achievement of outcomes and will identify course correction if needed. It will focus on the effectiveness, efficiency and timeliness of project implementation; it will highlight issues requiring decisions and actions; and will present initial lessons learned about project design, implementation and management. The findings of this review will be incorporated as recommendations for enhanced implementation during the final half of the project's implementation term. The organization, terms of reference (TOR) and timing of the mid-term evaluation will be decided after consultation between the relevant parties under the project document. The TOR for this mid-term evaluation will be prepared by the UNIDO Project Manager. The midterm review will also include the GEF CC TT submission. The management response and the evaluation will be uploaded to the UNIDO Evaluation Group website for public access.

End of Project

An independent Final Evaluation will take place three months prior to the final NPCC meeting and will be undertaken in accordance with UNIDO and GEF guidance. The final evaluation will focus on the delivery of the project's results as initially planned (and as corrected after the mid-term evaluation, if any such correction took place). The final evaluation will look at the impact and sustainability of project results, including the project contribution to capacity development and the achievement of global environmental benefits/goals. The TOR for this evaluation will be prepared by the UNIDO Project Manager based on guidance from UNIDO Evaluation Group. The final review will also include the GEF CC TT submission.

According to the Monitoring and Evaluation policy of the GEF and UNIDO, follow-up studies like Country Portfolio Evaluations and Thematic Evaluations can be initiated and conducted. All project partners and contractors are obliged to make relevant and appropriate studies, reports and other documentation related to the project. They will also be available for interviews with staff involved in the project activities.

The final evaluation should also provide recommendations for follow up activities and requires a management response. During the last three months the project team will prepare the Project Terminal Report. This comprehensive report will summarise the results achieved (objectives, outcomes, outputs), lessons learned, problems met and areas where results may not have been achieved. It will also lay out recommendations for any further steps that may need to be taken to ensure the sustainability and replicability of the project's results.

Learning and Knowledge Sharing

Results from the project will be disseminated within and beyond the project intervention zone through existing information sharing networks and forums in China.The project will identify and participate inrelevant and appropriate scientific policy based and/or any other networks which may be of benefit to project implementation through lessons learned. The project will identify, analyze and share lessons learned that may be beneficial in the design and implementation of similar future projects.

Legal Context

The Government of the People's Republic of China agrees to apply to the present project, mutatis mutandis, under the provisions of the Standard Basic Assistance Agreement between the United Nations Development Program and the Government of the People's Republic of China, which was signed on 29 June 1979 and entered into force on 24 June 1985.

Costs of M&E Activities:

Type of M&E activity	Responsible Parties	Budget USD				Time frame
		GEF	UNIDO cash	UNIDO In kind	Government in-kind	
Inception Workshop (IW) and inception report (including gender analysis)	UNIDO Project Manager (PM); Project Management Office (PMO); Gender Specialist	2500 *	0	10,000	25,000	Within first two months of project start up
Design of monitoring plan and tools for data collection and recording	UNIDO Project Manager (PM); Project Management Office (PMO); Monitoring and Evaluation specialist GEBs monitoring expert	10,000	0	5,000	15,000	Within first two months of project start up
Backstopping by M&E specialist	UNIDO Project Manager (PM); Project Management Office (PMO); Monitoring and Evaluation specialist	15,000	0	2,000	0	As needed
Review of project activities on gender-specific issues	UNIDO Project Manager (PM); Gender Specialist	2,500	0	2,000	0	Annually
Periodic progress reports and monitoring of project impact indicators (as per LogFrame)	UNIDO Project Manager (PM); Project Management Office (PMO); NPCC	0	0	10,000	60,000	Semi-annually
Measurement GEF Tracking Tool specific indicators	UNIDO Project Manager (PM); Project Management Unit (PMU); NPCC; GEBs monitoring expert	10,000	0	6,000	0	Mid-point of project implementation and at project completion
Mid-term evaluation	Independent evaluator for submission to UNIDO Project Manager (PM)	20,000	10,000	5,000	0	Mid-point of project
Independent terminal project evaluation	Independent evaluator for submission to UNIDO Project Manager (PM)	40,000	20,000	10,000	0	Project completion (at least one month prior to the end of the project and no later than six months after project completion)
Total Indicative cost		100,000	30,000	50,000	100,000	

*For gender analysis only

PART III: APPROVAL/ENDORSEMENT BY GEF OPERATIONAL FOCAL POINT(S) AND GEF AGENCY(IES)

A. **RECORD OF ENDORSEMENT OF GEF OPERATIONAL FOCAL POINT(S) ON BEHALF OF THE GOVERNMENT(S):** (Please attach the Operational Focal Point endorsement letter(s) with this template. For SGP, use this OFP endorsement letter).

NAME	**POSITION**	**MINISTRY**	**DATE**
Ms. Jiandi YE	Director of IFI Division III International Department	Ministry of Finance	02/21/2012

B. GEF AGENCY/IES CERTIFICATION

This request has been prepared in accordance with GEF/LDCF/SCCF policies and procedures and meets the GEF/LDCF/SCCF criteria for project identification and preparation.

Agency Coordinator, Agency Name	**Signature**	**Date**	**Project Contact Person**	**Telephone**	**Email Address**
Mr. Philippe R. Scholtès Managing Director, Programme Development and Technical Cooperation Division UNIDO GEF Focal Point		22 September 2014	Ms. Bettina Schreck, Industrial Energy Efficiency Unit	+43 126026-3032	**b.schreck@unido.org**

ANNEX A: PROJECT RESULTS FRAMEWORK

	Indicator	Baseline	Target at end of Project	Source of verification	Risk & Assumptions
Project Objective: To promote energy efficiency in high energy consuming special equipment through a comprehensive approach, developing and revising technical regulations, providing training to national experts and establish a national HEC Special Equipment Energy Efficiency Testing Centre	A) Incremental direct CO_2eq emission reductions (tons of CO_2eq)	The emissions of industrial boilers are equal to 1,342,000 kt CO_2 in 2010	Cumulative Direct emission reductions of 2,423 ktCO_2 Cumulative post project direct emission reduction of 912,889 ktCO_2	Validated energy savings from project reports	A1. Sustained and solid Government support to the project. A2. Industry drive for energy costs reduction and enhanced energy efficiency grows progressively stronger and widens. A3. Various international IEE technical cooperation programs achieve good synergy and leverage of respective complementarities
	B) Incremental indirect CO_2eq emission reductions (tons of CO_2eq)		Indirect emission reduction of up to 2,339,723 ktCO_2 (as a result of the wide implementation of the equipment standards)	Calculated emission reductions using the data from validated project reports and GEF GHG estimation tool for EE projects	
	C) Specific energy consumption of selected enterprises	The annual energy consumption of heat and steam systems in 50 selected enterprises is of 207 PJ of fuel and 4,199 GWh power (see assumptions and distribution of enterprises in Annex E)	Implementation of systems optimization and operational improvements in 50 enterprises (including equipment replacement in 5 of them) lead to annual fuel savings of 139 PJ and power savings of 1100 GWh	Validated energy savings from project reports	
Outcome 1: Enhanced regulatory framework that will enable HEC user to adopt energy efficiency measures and government institutions to monitor compliance, including a knowledge management tool	1)National technical regulations on energy efficiency for HEC special equipment are adopted	Existing regulations do not include Key Performance Indicators (KPIs), and do not consider a systemic approach to steam or heat recovery systems as methods to improve performance	KPI have been identified for both equipment performance as well as systems efficiency; and the regulations have been revised to reflect these methods	AQSIQ records of revised/new regulations	Government-level support for incentives and other supporting measures for industrial EE
	2) A reporting system from in service boilers is available	Inspection data is not centralized, only collected at inspection agency level, and not systematically	A reporting system is created and database is populated	Reports on the database and system supply curves technical paper	Inspection agencies complete a sufficient number of inspections to populate the database
	3) A dissemination campaign is conducted	Inspection agencies and enterprises have limited knowledge of measures to improve equipment performance and energy efficiency	Awareness has been raised amongst selected stakeholders	Workshop reports, website for project dissemination, flyers and other dissemination materials	Willingness of companies to share info

Outcome 2: The AQSIQ has the capacities required to enforce the technical regulations a knowledge management tool is available to users and facilitating the implementation of systems optimization and efficient equipment by improving testing capabilities	4) The analytical capacities of the HEC Special Equipment Energy Efficiency Testing Centre are upgraded	Inspection agencies and CSEI staff have limited analytical capacities to collect and analyze data on steam and heat recovery systems	100 CSEI staff and regional inspectors are trained in the analysis of data collected from the enterprises (gender disaggregated)	Training reports from CSEI and inspection offices	Local personnel available for training Sufficient number of qualified females are available in the select technical area
	5) 6 national testing laboratories have the competencies to verify and test against the new technical regulations	The 6 national testing laboratories are to be established in 2015. Currently testing is conducted mostly on performance and safety parameters and there is need for testing/verification capacities to be established for the new technical regulations.	The 6 laboratories are equipped, staffed and trained for testing the relevant parameters for Steam and Heat Recovery systems to implement the methods established in outcome 1	Laboratory reports, testing certificates	Availability of financial and human resources
Outcome 3: A cadre of highly specialized system optimization experts from the public and private sectors are available as a long-term technical resource to industry and the country. Enterprises awareness on measures and new technologies and EE financing mechanisms has been increased	6) Number of stakeholders with increased awareness of steam and heat recovery systems measures	Only a few large industries have energy management personnel; some industries have replaced or refurbished inefficient equipment yet there is limited awareness on energy efficiency and/or systems optimization measures	1000 representatives of selected stakeholder groups have improved awareness 200 enterprises technical staff receive user training (gender disaggregated)	Training evaluation reports	Availability and willingness of experts to receive training Commitment of trained experts to impart training Sufficient number of qualified females are available in the select technical area
	7) Trained local practitioners in System Optimization active in industry	ESCOs are operating in the market, yet their focus is on replacing or refurbishing inefficient equipment	50 practitioners are trained (gender disaggregated)	Training evaluation reports	Availability and willingness of experts to receive training Commitment of trained experts to impart training efficient number of qualified females are available in the select technical area
	8) Training material available for SSO and HRSO	SSO training package only available in English HRSO training package not developed	Training material are available in Chinese and localized web based platform has assisted them in the training	Published training packages	Localization is adequate and reflects on the usual practice in Chinese industry
	9) Appropriate and active financial mechanisms to support industrial EE projects	Number of enterprises which have improved abilities to conduct financial evaluation of EE projects	100 enterprises to be trained	training evaluation reports	Availability and willingness of experts to receive training

	10) In-depth system assessments of SSO and HRSO conducted	1500 facility inspections have been conducted by national inspection agencies to assess equipment performance yet none of them has assessed systems efficiency	75 enterprises	Plant verification and assessment reports	Willingness of enterprises involved in project to invest in SO improvements
Outcome 4: New efficient technologies are demonstrated at national level to serve as case studies for future investments	11) Systems optimization measures are implemented	Limited number of companies have implemented systems optimization measures	50 of the companies adopt measures	Plant verification and assessment reports	Willingness of enterprises involved in project to invest in SO improvements
	12) Replaced equipment	xx companies have replaced or refurbished their equipment under GEF project (number)	5 companies	Bankable business studies and verification of measures adopted	Willingness of enterprises involved in project to invest in SO improvements

ANNEX B: RESPONSES TO PROJECT REVIEWS (from GEF Secretariat and GEF Agencies, and Responses to Comments from Council at work program inclusion and the Convention Secretariat and STAP at PIF).

STAP Comment dated 29 April 2012	UNIDO Response at GEF CEO Endorsement stage
1. Systems optimization: STAP commends China for aiming at systems optimization to reduce energy consumption, since national and international experience widely agree that while improving the efficiency of components might yield minor gains in industry, but a systemic optimization can result in more significant gains (20-30%) with pay back periods, in some cases less than 2 years. However, there is a need for a systematic assessment of what systems optimization involves; technology packages, capacity requirements, investment cost, O&M costs, etc.? Systems optimization may involve in some cases large investments for HEC equipment. Thus it is very important to assess theinvestment cost as well as cost-benefit analysis of new designs for efficient HEC equipment.	The project assessed a variety of system optimization measures which can be implemented with low payback period. In the proposed project, we plan to implement 50 low cost system optimization measures for steam systems and heat recovery systems. These measures are the low hanging fruits and mostly focus on improvement in operational practices without any major technological retrofits. In addition to this, we will have another 5 technology demonstration projects which will involve investment in technologies with higher capital cost. The cost-effectiveness of the proposed project is presented in section B.3.
2. Barrier analysis: STAP commends the detailed listing of barriers for different technologies. However during the next phase, it is important to conduct a systematic assessment of the barriers and rank them according to technologies and stakeholders.	Barriers for typical technology measures to be adopted for both steam and heat systems have been assessed. A summary of the finding is presented in a separate table in this same Annex. It is worth noting that power generation technologies (except for cogeneration) are not considered, as they do not fall within the scope of this project.
3. Promotion of efficient HEC equipment: The project seems to focus largely on issues such as establishing testing centers, building capacity, conducting training programs, creating awareness, preparation of business plans and plant assessments. These are of course necessary and an integral part but, the access to robust technologies, maintenance and service guarantees, and financial viability are equally critical and need to be considered.	All of the suggested aspects have been considered in the design with equivalent level of importance. With regards to the specific aspects identified by the STAP the assessment is that: - The selection of technologies has resulted in the identification of readily available, robust technologies that may easily be transferred to China (see question 2) - Maintenance and service aspects shall be integrated into the operational process as a result of a systems optimization approach. Systems optimization measures are accompanied of changes in routine inspection, operation and monitoring which are integrated into the system. - Financial viability the energy conservation technologies have short payback periods and are documented to have high rates of return, and it is a criterion for technology selection. - Access to finance and loan guarantees for energy efficiency has been extensively covered by multiple domestic and international development programs for EE promotion in China, including the Ministry of Finance incentives scheme, known as the "Financial Reward Fund for the Energy-saving Technology Transformation or the China Utility-Based Energy Efficiency Finance Program (CHUEE) of the IFC. Furthermore, industries have shown willingness in undertaken their own investment as proven by the additional cofinancing raised.

STAP Comment dated 29 April 2012	UNIDO Response at GEF CEO Endorsement stage
4. Learning lessons from similar projects in China: Several energy efficiency improvement projects funded by national and multilateral agencies including GEF have been implemented in China. It is necessary to learn from the past and ongoing projects for successful implementation of this initiative.	Prior projects reports have been revised carefully to avoid duplication as well as meeting and discussion with technical experts who participated in the GEF 97 project and financial institutions developing the current projects

GEF sec outstanding comments, following PIF review dated 20 March 2012	UNIDO Response at PIF stage	UNIDO Response at GEF CEO Endorsement stage
Question 14. b) Please explain how the GEF funding will be allocated to the 50 companies adopting energy saving measures and equipment.	A detailed budget was presented to the GEF Sec which required further investigation of costs during PPG phase.	The section of enterprises and other beneficiaries is described in section A.5. The 50 enterprise that will undertake measures included soft measures identified during the detailed assessment, equal amounts of funds shall be provided to all enterprise to either undertake less capital investment measures, or serve as partial financing for engineering design that may lead to a larger capital investment, to be covered by cofinancing The costs investigation for the larger capital investment projects has been completed (as presented in the following table).
Question 15. Are the applied methodology and assumptions for the description of the incremental/ additional benefits sound and appropriate?	The desktop review of data did not provide consistent information for the period 2007-2011. UNIDO considers that the 2005-2006 data available is not relevant to describe the current of project energy savings, since energy consumption has increased 50% in the 11 FYP period. This is the reason for undertaking the detailed GEBs calculation during the PPG phase.	The incremental/additional benefits from both bottom-up and top-down methods have been calculated following the methodology explained in GEF manual and tool. To prepare the data to be used in the calculation, the latest available data from Chinese statistics was collected. Where Chinese datasets were not available, the proxy data from U.S. DOE's MECS 2010 were used. Also, the assumptions made relied on international experts input for the potential energy savings by the implementation of system optimization as well as the technology demonstration projects. The results of the analysis were also double checked with previous analysis done by IEA and LBNL.
Question 20. Is the project implementation/execution arrangement adequate?	The precise execution arrangements to be used for this project will be elaborated during the PPG phase,	The detailed execution arrangements are described in section B.1.
Question 25 At PIF: comment on the indicated cofinancing; At CEO endorsement: indicate if confirmed co-financing is provided	While it is possible that the investment component could reach a co-financing level of 1:10, there is need to discuss the support and involvement of national banks during the PPG phase. The increase co-financing could fund one additional demonstration pilot. The	The continuous engagement with the private sector counterparts (during awareness raising and technical workshops) has shown that reaching the anticipated level of co-financing was challenging. It is important to note that the enterprises that committed cofinancing have indicated that they would only participate provided that

	overall co-financing rate would be of 1:8	the project is financed by the GEF. It is worth noting that national counterparts have chosen to have a conservative position regarding cofinancing and guarantee that the original deliverable targets (5 enterprises do investment) should be maintained

Assessment of barriers to the adoption of the proposed technologies

During the PPG phase the typical measures to be deployed adopted have been selected based on the typical capital investment required and the period of time required for such interventions, which are presented in the following table:

Capital intensive technologies*	Typical capital investment and operational investment, in USD	Average timeline for implementation of the measures (years)			
		Project identification and planning	Project approval and fundraising	Engineering, procurement construction	Total duration
Boiler optimization					
Boiler excess air control	30,000 per boiler	0.2	0.5	0.3	1
Increased condensate recovery	75,000 per site	0.2	0.3	0.5	1
Optimized cogeneration**	500-1200 per KW of power generation on site	0.5	1	2.5	4
Heat recovery optimization					
Optimized HX cleaning technologies***	100,000 per process unit	0.25	0.25	0.25	0.75
Integrated heat recovery (pinch analysis)	25-30 per MMBtu fuel saved at plan site	1	1	2	4

* For modeling purposes the most typical technologies have been selected, yet the technologies adopted in component 4 by national enterprises may not be limited to technology scope listed in the above table.
** If significant boiler retrofits are required the capital costs will be higher
*** Can vary considerably, depending on fouling rate. Not applicable to non-fouling fluids.

For the selected technologies the typical barriers can be attributed to four key aspects as described in section A.5

1) Awareness on energy conservation: energy conservation measures are not part of the core business of enterprise, decision makers tend to show apathy toward such investments. There is disconnection between the upfront capital investment costs of heat equipment with the life cycle energy cost of its operation.
2) Knowledge: advance technological measure such as pinch analysis tend to be unknown to plant engineers
3) Availability of financing: costly measures are normally
4) Government support to adopt measures both in terms of enabling polices and financing

ANNEX C: STATUS OF IMPLEMENTATION OF PROJECT PREPARATION ACTIVITIES AND THE USE OF FUNDS

A. DESCRIBE IF ANY FINDINGS THAT MIGHT AFFECT THE PROJECT DESIGN OR ANY CONCERNS ON PROJECT IMPLEMENTATION, IF ANY

N/A

B. PROVIDE DETAILED FUNDING AMOUNT OF THE PPG ACTIVITIES IN THE TABLE BELOW:

PPG Grant Approved at PIF: 75,000 USD			
Project Preparation Activities Implementeded	***GEF/LDCF/SCCF/NPIF Amount ($)***		
	Budgeted Amount	***Amount Spent Todate***	***Amount Committed***
1. Baseline assessment	20,000	20,000	
2. Counterparts and stakeholder selection	0	0	
3. Detailed project design	35,000	30,000	5,000
4. Determination of BaU scenarios	10,000	10,000	
5. Determination of GEBs/GHG emissions	10,000	10,000	
6. Consultation and commitment confirmation	0	0	
Total	75,000	70,000	5,000

ANNEX D: CALENDAR OF EXPECTED REFLOWS (if non-grant instrument is used)

Provide a calendar of expected reflows to the GEF/LDCF/SCCF/NPIF Trust Fund or to your Agency (and/or revolving fund that will be set up)

N/A

ANNEX E: ESTIMATED CO_2 AND ENERGY SAVINGS

Out of the 4 project components proposed, the detailed bottom-up analysis using the GEF tool could only be conducted for two components, i.e. policy and market promotion (under the standards and labeling module in the GEF guideline) and demonstration of energy efficient equipment implementation and operation (under the demonstration and diffusion module in the GEF guideline).

Each of the aforementioned project components also was divided into several activities for the analysis as follows:

Demonstration of energy efficient equipment implementation and operation (under demonstration and diffusion module):

- Steam systems optimization demonstration projects
- Heat recovery systems optimization demonstration projects
- New technologies demonstration – Combined Heat and Power (CHP)
- New technologies demonstration – non-CHP

Policy and market promotion (under standards and labeling module):

- New/revised boilers standards- Industrial steam boilers
- New/revised boilers standards- Industrial hot water boilers

The following method and assumptions are used in the calculation of annual energy savings for each of the aforementioned activities which are then used as an input into the respective sheet in the GEF calculation tool.

Demonstration of energy efficient equipment implementation and operation:

This component of the project will include 50 steam and heat recovery systems optimization demonstration projects and 5 new technology demonstrations. The difference between system optimization projects and technology demonstration projects is that the system optimization projects are easier to implement in shorter amount of time and they are less capital intensive. On the contrary, the technology demonstration projects are more capital intensive and take longer time to implement.

The project team chose several industrial sub-sectors which are highly steam-intensive for the demonstration projects. These subsectors are chemical and petrochemical, oil refinery, pulp and paper, and food industry. These four sub-sectors accounted for over 25% of the total primary energy use in the Chinese manufacturing in 2010. The table below shows the assumption on the distribution of the demonstration projects in each subsector. Since the food industry is not as fuel (steam)-intensive as the other three subsectors, it is excluded from the new technology demonstration projects.

	Number of the demonstration projects				
Industry sector	Chemical and petrochemical	Oil refinery	Pulp and Paper	Food	**Total**
Steam systems optimization demonstration projects	10	10	10	3	**33**
Heat recovery systems optimization demonstration projects	5	5	5	2	**17**
New technologies demonstration – Combined Heat and Power (CHP)		1			**1**
New technologies demonstration – non-CHP	2	1	1	0	**4**

Then, it an average plant energy use for each of the subsectors mentioned above based on data from various Chinese and U.S. studies and the percentage reduction of energy use by implementing each of the aforementioned project activities, which was based on data from the International Energy Agency, and was validated thorough international experts' consultation. In addition, a survey of industries was conducted and was consistent with the typical values used. The table below details these assumptions.

Typical energy savings from proposed measures					
	Unit	**Chemical and petrochemical**	**Oil refinery**	**Pulp and Paper**	**Food**
Typical average plant annual electricity use	MWh/yr/plant	15,612	124,443	111,709	6,183
Typical average plant annual fuel use	TJ/yr/plant	298	10,965	926	79
Energy Saving					
Steam systems optimization demonstration projects					
Electricity saving	% of electricity use in a typical plant	1%	1%	1%	1%
Fuel saving	% of fuel use in a typical plant	8%	8%	8%	8%
Heat recovery systems optimization demonstration projects					
Electricity saving	% of electricity use in a typical plant	0	0	0	0
Fuel saving	% of fuel use in a typical plant	2.4%	2.2%	1.1%	0.9%
New technologies demonstration – non-CHP					
Electricity saving	% of electricity use in a typical plant	-	-	-	-
Fuel saving	% of fuel use in a typical plant	16.8%	15.2%	7.9%	6.6%

Using the information from tables above, the annual electricity and fuel saving by each project activity for each subsector can be calculated. The results are presented in the table below. However, in the GEF's GHG calculation tool, only one number can be used for electricity and fuel saving for each project activity (i.e. Steam systems optimization, Heat recovery systems optimization, and new technologies demonstration – non-CHP). This number is then multiplied by the number of projects. Thus, the weighted average annual electricity and fuel savings for each project activity was calculate and used as an input in the GEF's GHG calculation tool.

	Unit	Chemical and petrochemical	Oil refinery	Pulp and Paper	Food	Weighted average
Annual electricity and fuel savings						
Steam systems optimization demonstration project						
Annual Electricity saving	MWh/yr/project	156	1,244	1,117	62	769
Annual Fuel saving	TJ/yr/project	24	877	74	6	296
Total Annual Electricity saving of all projects	MWh/yr	1,561	12,444	11,171	186	
Total Annual fuel saving of all projects	TJ/yr	239	8,772	741	19	
Heat recovery systems optimization demonstration project						
Annual Electricity saving	MWh/yr/project	-	-	-	-	-
Annual Fuel saving	TJ/yr/project	7	238	10	1	75
Total Annual Electricity saving of all projects	MWh/yr	-	-	-	-	
Total Annual fuel saving of all projects	TJ/yr	36	1,192	52	1	
New technologies demonstration – non-CHP						
Annual Electricity saving	MWh/yr/project	-	-	-	-	-
Annual Fuel saving	TJ/yr/project	50	1,669	73		461
Total Annual Electricity saving of all projects	MWh/yr	-	-	-	-	-
Total Annual fuel saving of all projects	TJ/yr	100	1,669	73		

For the CHP demonstration project the analysis is done differently, since the system results in more onsite fuel use, while it increases the overall efficiency of heat plus power generation which saves the overall energy. However, part of the energy saving happens outside of plant's boundary (in the power sector). For this analysis, the energy calculation is done for a 10MW CHP system using US EPA's CHP calculation tool[11]. The details of the analysis can be found in the table below.

	Value	Unit
Annual electricity generation by CHP	74,460	MWh/yr
Useful CHP Thermal Output	388	TJ/yr
Fuel use by Displaced Thermal Production	555	TJ/yr
CHP Fuel Consumption	921	TJ/yr
Additional fuel use by CHP at the plant site	366	TJ/yr

Additional assumption used in the calculation of annual energy savings of demonstration projects are as follows:

- Useful lifetime of 15 years for system optimization measures and 20 years for energy efficient technology demonstration.
- Percent of Activities Implemented in the Baseline was assumed to be 10% for the system optimization measures and zero for energy efficient technology demonstration since these technologies are very capital

[11] http://www.epa.gov/chp/basic/calculator.html

intensive and without the proposed GEF it is less likely that the companies will implement them within the studied period.

- Replications factor for Post-project as Spillover was assumed to be one across all demonstration projects.

Having the aforementioned data and assumption as the input to the Demonstration/Diffusion Module of the GEF GHG calculation tool, the direct energy and GHG avoided during the project period (2014-2017) and post project period (2018-2027) as well as the indirect bottom-up saving during 2018-2027 can be calculated for each of the component under this module. The results for the GHG avoided are presented in the table below.

Figures in tones of CO_2	**Steam systems optimization**	**Heat recovery systems optimization**	**New technologies demonstration - non CHP**	**New technologies demonstration - CHP**	**Total**
Direct GHG Avoided, 2014-2017	1,891,525	241,230	261,664	29,074	2,423,493
Direct Post Project GHG Avoided, 2018-2027	8,597,841	1,064,250	1,744,424	290,743	11,697,259
Indirect bottom-up Savings, 2018-2027	7,738,057	957,825	1,569,982	261,669	10,527,533

Policy and market promotion (standards and labeling module):

This component of the project analyzed here includes new or refined standards for industrial boilers. Both steam and hot water industrial boilers are included in the analysis. However, since the efficiency of steam and hot water boilers are calculated using different methods, they are analyzed separately in the GEF GHG tool and at the end the calculated energy saving for each type of boiler was added together. For this analysis, all steam and hot water industrial boilers were included and no specific industrial subsector was chosen. This is because once the standard is in place; it will affect the new boilers sold in all industries.

In the GEF GHG calculation tool, it is required to input the annual energy use of a "conventional boiler" (before new or refined standards are in place) and "energy-efficient boiler" (after new or refined standards are in place). Since the energy use of the boiler varies by the size, the energy use of boilers for different boiler size category was calculated and using the boiler size distribution data in China, a weighted average energy use by the conventional and energy-efficient boiler for both steam boiler and hot water boiler types was determined. Table below shows the data and assumptions used for these calculations.

Calculation of typical annual fuel use for industrial **steam** boiler

Unit capacity (t/hr)	Assumed Representative size (t/hr)	% of boiler in this size range (by number)	Typical Conventional boiler efficiency (before GEF intervention)	Typical Energy-efficient boiler efficiency (after GEF intervention)	Typical pressure (bar)	Typical operation hours per year (hr/yr)	Annual fuel use by Conventional steam boiler (GJ/yr)	Annual fuel use by Energy-efficient steam boiler (GJ/yr)
D<1	1	35.5%	64%	70%	0.5	2150	8,847	8,092
1≤D≤2	1.5	31.1%	68%	74%	0.6	2150	12,622	11,596
2<D≤8	5	23.7%	70%	76%	0.7	2150	41,074	37,825
8<D≤20	14	7.5%	70%	76%	0.8	2150	114,139	105,163
D>20	20	2.3%	72%	78%	1.1	2150	160,926	148,484
						Weighted average	**29,019**	**26,706**

Calculation of typical annual fuel use for industrial **hot water** boiler

Unit capacity (t/hr)	Assumed Representative size (t/hr)	% of boiler in this size range (by number)	Typical Conventional boiler efficiency (before GEF intervention)	Typical Energy-efficient boiler efficiency (after GEF intervention)	Temperature difference between inlet and outlet of the boiler (°C)	Typical operation hours per year (hr/yr)	Annual fuel use by Conventional hot water boiler (GJ/yr)	Annual fuel use by Energy-efficient hot water boiler (GJ/yr)
D<1	1	35.5%	64%	70%	20	2150	280	256
1≤D≤2	1.5	31.1%	68%	74%	20	2150	398	366
2<D≤8	5	23.7%	70%	76%	25	2150	1,616	1,488
8<D≤20	14	7.5%	70%	76%	30	2150	5,378	4,955
D>20	20	2.3%	72%	78%	40	2150	10,058	9,280
						Weighted average	**1,239**	**1,141**

Additional assumption used in the calculation of annual energy savings in standard and labeling module are as follows:

- Useful lifetime of 15 years for both types of boilers
- Annual boiler sales in 2014 (the start year of the proposed GEF project) are 50,470 units for industrial steam boilers and 13,940 for industrial hot water boilers. It is also assumed that this annual sales will remain constant up to 2027. In other words, a zero percentage growth rate in annual sales.
- Boiler size distribution will remain constant during the study period.
- 10% market share of energy efficient boilers in 2014 and a 2% annual increase in market share of energy efficient boilers during 2014-2027 without GEF intervention.
- The new or refined standard which will result from the proposed project will be in place in 2018 and 70% of the new industrial boilers sold shall comply with the new standards.

Having the aforementioned data and assumptions as the input to the standard and labeling module of the GEF GHG calculation tool, the direct energy and GHG avoided during the project period (2014-2017) and post project period (2018-2027) can be calculated for each of the components under this module. The results for the GHG avoided are presented in the table below. The direct GHG avoided is equal to zero because the new standards will come in place after the project completion, i.e. in 2018.

Figures in tones of CO_2	**New/revised standards for industrial steam boilers**	**New/revised standards for industrial hot water boilers**	**Total**
Direct GHG Avoided, 2014-2017	0	0	0
Direct Post Project GHG Avoided, 2018-2027	898,136,477	3,065,294	901,201,771

Calculation of the Indirect Top-Down Impacts

Emission reductions from the implementation of the proposed project will occur during the project implementation and post-project influence period (10 years; 2018-2027). These post project reductions may be estimated using a top-down approach by comparing the baseline scenario with an energy efficiency alternative scenario. The advantage of the top-down approach is that it will capture part of the saving that could not be covered with bottom-up approach mentioned above. For example, the impact of Government capacity building and enterprises capacity building measures which are two or the four major component of the proposed project could not be quantified using the GEF GHG calculation tool because the tool does not include module to deal with capacity building activities (trainings, energy assessments, etc.). Below the methodology and assumptions for indirect top-down impacts estimate is explained.

First, two scenarios were developed:

1. Static scenario: The CO_2 intensity (CO_2 emissions per unit of GDP) does not change in the future and remains at the current 2013.
2. Copenhagen Target scenario: China has an official target of reducing the CO_2 intensity of its economy by 40% in 2020 compared to 2005 level. Also, we assumed an additional 10% reduction in the CO_2 intensity in the period of 2020-2027 in order to estimate the CO_2 emissions of the industrial boilers in 2027.

Other key assumptions used in the top-down analysis are listed in the table below:

Key Assumptions	**Value**
GDP Growth Rate (2011-2015)	7.5%
GDP Growth Rate (2016-2020)	7.0%
GDP Growth Rate (2020-2027)	6.0%
Industry Share of Total GDP in 2010	42.6%
Industry Share of Total GDP in 2015	42.0%
Industry Share of Total GDP in 2020	41.4%
Industry Share of Total GDP in 2027	39.0%
Share of manufacturing from industry[12] GDP, 2010-2020	85%
Share of manufacturing from industry GDP, 2020-2027	84%
Share of steam systems from total manufacturing energy-related GHG emissions	30%

Using these assumptions and data, the top-down estimate for CO_2 emission reduction potential in industrial steam systems (boilers as well as steam distribution) in China can be calculated for the period of 2018-2027. Table below shows the results for each year as well as for the entire period.

[12] In Chinese statistics, the term "industry" refers to manufacturing as well as mining of coal and minerals, oil and gas extraction, power generation, and production and distribution of water. These subsectors of industry (other than manufacturing) are not included in the present study.

Figures in Mt CO_2	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**Total**
CO_2 emissions of industrial steam systems-static scenario (1)	2,127	2,270	2,422	2,515	2,643	2,778	2,920	3,069	3,225	3,390	27,359
CO_2 emissions of industrial steam systems -Copenhagen scenario (2)	1,828	1,904	1,984	2,031	2,104	2,179	2,256	2,335	2,416	2,500	21,537
CO_2 emissions reduction potential in industrial steam systems = (1)-(2)	300	365	437	484	539	599	664	734	809	890	**5,823**
40% attributed as a modest contribution of GEF project											**2,329**

The values shown in the above table, however, are the total estimated market potential for CO_2 emission reduction through industrial steam system efficiency improvement. To calculate the impact of the proposed GEF project, the GEF's modest Causality Factor of 40% was used. This results in CO_2 emissions reduction of 2,329 Mt CO_2 as a top-down estimate for the overall impact of the proposed project during 2018-2027.

Results

Savings for All Project Components in tones of CO_2	**Demonstration and Diffusion**	**Standards and Labeling**	**All Components**
Direct GHG Emission (2014-2017)	2,423,493		
Direct Post-project GHG Emission Savings (2018-2027)	11,697,259	901,201,771	
Indirect Bottom-up Emission Savings (2018-2027)	10,527,533		
Indirect Top-down Emission Savings (2018-2027)			2,329,010,000

Annex F: Detailed budget Breakdown for consultancy services

Project Management Unit

Position	$ / person week	Estimated person weeks	Total ($)	Tasks
Project Management Office (PMO) Chief	700	250	175,000	Under the supervision of the UNIDO Project Manager, the NPC will be responsible for the day-to- day management of the implementation of the project including all program and administrative matters, and also the Project Management Unit (PMO), to ensure that the project is effectively and smoothly implemented as described in the project document, and that proper and effective communication with all the stakeholders is carried out.
Administration Assistant	300	250	75,000	Under the supervision of the National Project Manager, the Administrative and Finance Project Assistant will be responsible for the provision of the administrative, financial and clerical assistance to the Project Management Unit.
Total			**250,000**	

National Consultants

Position	$ / person week	Estimated person weeks	Total ($)	Tasks
Standards experts	600	20	12,000	Conduct scientific research and provide support to technical drafting of documents
Laboratory experts	600	25	15,000	Provide support to the organization and delivery of training for inspectors and laboratory staff
SO Practitioners/ trainers	1,000	22	22,000	Provide support to the design of SO demo projects and provide training on SO (steam, heat recovery); monitor, report and organize training and guidance to the local stakeholders on SO; capture lessons learned and best practices for dissemination; organize and conduct workshops on SO including for suppliers
Finance Practitioners	800	20	16,000	Advise on innovative finance mechanisms to support EE; assist with financial evaluation of EE and SO projects; provide corresponding training
Trainee Practitioners	325	500	162,500	Assist in design and project management for SO projects
Information and PR	600	40	24,000	Organize information and awareness stimulation activities; capture lessons learned and best practices and assist in their dissemination; support the development of awards scheme
Engineering consultancies	1,200	160	192,000	Basic and conceptual engineering, estimated 5 projects,
Gender Specialist	800	4	3,200	Gender analysis at the inception and review of gender activities
Total			**446,700**	

International Consultants

Position	$ / person week	Estimated person weeks	Total ($)	Tasks
Standards experts	2,500	8	20,000	Advise on international standards and best practices relevant to EE in HEC, especially on SO and HNE; provide support to technical drafting of documents
Policy experts	2,500	8	20,000	Advise on international technical regulations, policies and best practices relevant to EE in HEC; provide support to technical drafting of documents
Laboratory experts	3,000	40	120,000	Advise on TORs, prepare training material, organize and conduct training for inspectors and laboratory staff
SO Expert trainers /Practitioners	3,000	100	300,000	Design of SO demo projects; provide training on SO (steam, heat); Monitor, report and organize training and guidance to the local stakeholders on SO; capture lessons learned and best practices for dissemination; organize and conduct workshops on SO including for suppliers.
Monitoring an Evaluation specialist	3,000	6	18,000	Design the monitoring plan and the tools for data collection and recording; as well as backstopping the data collection processes
GEBs monitoring expert	3,000	4	12,000	Yearly assessment of emission reduction based on GEF tracking Tool and calculation manual
Total			**490,000**	

Other Expenses

Task	Amounts*
Translation of documentation and as required throughout project including training	100,000
Travel costs of experts to & from and within China	525,000
Engineering services / contractors for component 4	2,000,000
SO Training and Laboratory Equipment	725,000
Logistics for meetings	340,000
Publishing	50,000
Website design & maintenance	29,000
Other overheads	420,000
Total	**4,189,000**

***These amounts are tentative at this stage, and will be firmed up by the PMO during the start-up phase in close consultations with AQSIQ and key stakeholders.**

UNIDO in kind contribution

UNIDO's in-kind contribution is estimated as follows:

	Description	unit	number	cost ($/ unit)	Total $
License costs for UNIDO Systems Optimization training material (1 package: steam)					
1	Awareness raising	license fee	1,000	100	100,000
2	Vendors	license fee	500	150	75,000
3	User	license fee	200	150	30,000
4	Experts	license fee	50	500	25,000
5	Staff time from Compliance Infrastructure Unit (PTC/TCB/CIU) on accreditation/certification of professionals in systems optimization	week	5	3,000	15,000
6	Staff time Industrial Energy Efficiency (PTC/ECC/IEE) on design of the heat recovery package	week	5	3,000	15,000
	Total				**260,000**

ANNEX G: COFINANCING LETTERS "see letters in separate annex"

ANNEX H: COST EFFECTIVENESS ANALYSIS

The cost effectiveness analysis is made by analyzing the most likely investment that enterprises would make to abate their greenhouse gas emissions, if they would not choose to invest in the proposed energy efficiency measures

The identified renewable energy sources[13] are

1) Biomass: which has the largest substitution potential in the manufacturing industry
2) Solar thermal systems: that have a large technical and economic potential in small scale plants and less energy-intensive industries.

The selection of sources is consistent with the targets set for China under the 12th FYP, which advocates for 100 million tce of fossil energy (2.93 EJ) will be replaced by renewable energies to satisfy heating and fuel demand by 2015.

The technologies for industrial applications considered are direct cofiring for biomass, as with only a relatively modest incremental investment is needed to retrofit existing boilers; and for solar thermal, evacuated tube collectors since they are the most disseminated technology in China, with 86% of all newly installed collectors market in 2012.

The variables considered for each technology are

	Biomass cofiring	Solar Thermal
Heat generation efficiency	36 -44%	29-36%
Cost per kW (in US dollars)	300-700 $/kW	7100 $/kW
Solar irradiation in North Eastern provinces of China		4 kWh/m^2/day
Data sources	Biomass Co-fi ring - Technology Brief IEA-ETSAP, IRENA, 2013	Solar Heat Worldwide, Markets and Contribution to the Energy Supply 2012 IEA Solar Heating & Cooling Program, June 2014 Solar Resources of China, NREL 2012

The summary of results is presented below

[13] Renewable Energies for Industry, IRENA 2014 and conversation with the lead authors

Project name and number	Country	Agency	Technology	Application	Cumulative Emission reductions for saving achieved	GEF funding	Cofinancing	Cost-effectiveness (total funding)	Cost-effectiveness- (GEF funding)
					t CO_2	US$	US$	US$/t$CO_2$	US$/t$CO_2$
Investing in Renewable Energy									
Case 1.a - cofiring of biomass for cogeneration	China	theoretical	cofiring of coal and 10% biomass	Industrial use	748,021	3,900,000	$73,487,443	$103.46	$5.21
Case 1.b - sensibility analysis with lower Capex of cofiring of biomass for cogeneration	China	theoretical	cofiring of coal and 10% biomass	Industrial use	748,021	3,900,000	$44,092,466	$64.16	$5.21
Case 1.c - sensibility analysis with lower Capex of and higher share of biomass	China	theoretical	cofiring of coal and 50% biomass	Industrial use	3,740,106	3,900,000	$44,092,466	$12.83	$1.04
Case 2.a - use of evacuated tube solar thermal to produce heat	China	theoretical	solar thermal for replacing 0.5% of heat needed	Industrial use	13,105	3,900,000	$5,916,667	$749.06	$297.59
Case 2.b - sensibility analysis with collectors of sufficnet large size to produce 10% of heat	China	theoretical	solar thermal for replacing 1% of heat needed	Industrial use	23,937	3,900,000	$10,806,697	$614.40	$162.93
GEF Projects									
China Renewable Energy Scaling-Up Program (CRESP) Phase II - 4493	China	World Bank	Offshore wind and tidal	power generation	3,900,000	$27,280,000	$4,410,000	$8.13	$6.99
Integrated Renewable Biomass Energy Development Project - 3744	China	ADB	anaerobic digestion from agricultural waste	biogas supply for domestic uses, power generation and agribusinesses	940,000	$6,850,000	$141,410,000	$157.72	$7.29

Project name and number	Country	Agency	Technology	Application	Cumulative Emission reductions for saving achieved	GEF funding	Cofinancing	Cost-effectiveness (total funding)	Cost-effectiveness-(GEF funding)
Promoting business models for increasing penetration and scaling up of solar energy - 4788	India	UNIDO	solar energy	Industrial use - heating to temperatures up to 120 C	249,000	$2,875,000.00	$15,000,000	$71.79	$11.55
Improving energy efficiency and promoting renewable energy in the agro-food and other small and medium enterprises (SMEs) in Ukraine -3917	Ukraine	UNIDO	biomass for SMEs and energy efficiency	Industrial use - range of applications	2,200,000	$3,209,820	$30,930,568	$15.52	$1.46
Promoting energy efficiency in industrial heat systems and high energy-consuming (HEC) equipment - 4866	China	UNIDO	steam systems optimization	Industrial use	14,120,752	$3,900,000	$30,640,000	$2.45	$0.28

ANNEX I: TIMELINE

Components	2014				2015				2016				2017			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Component 1 Policy and market promotion -																
1.1 National technical regulations																
1.2 Reporting system is designed																
1.3 National awareness raising and dissemination campaign																
Component 2 Capacity building (government)																
2.1 The capacities of the HEC Testing Centre are upgraded																
2.2 6 national testing laboratories established																
Component 3 Capacity building (enterprises)																
3.1 Awareness on SSO and HRSO is raised																
3.2 50 candidates are trained																
3.3 75 in-depth system assessments																
3.4 Improved capacities for the financial evaluation																
Component 4 Demonstration of energy efficient equipment																
4.1 Systems optimization: 50 of the companies																
4.2 New technologies: 5 equipment replacements																
Component 5 - Project management																
5.1 Project management																
5.2 Project monitoring and evaluation																

ANNEX J: TARGET BASED APPROACH

Targets	An indicator to measures energy efficiency of a steam system indicator	An indicator for the in-service boiler thermal performance	An indicator and a testing method to measures energy efficiency of a steam system indicator with condensing boilers	An appraisal method for energy efficiency of heat recovery systems
Component 1 Policy and market promotion - Develop the policy tools required for adopting energy efficiency measures in large heat transfer equipment	1.1.1 An analytical study is conducted to define an energy efficiency indicator (EEI) for steam systems analysis 1.1.4 Technical regulations are revised to include the new appraisal methods for boiler thermal efficiency (BPI - 1.1.1 Condensing boiler and 1.1.2 non condensing boilers) and for steam systems (EEI - 1.1.3) 1.1.5 Technical committees are called by AQSIQ to review the necessary testing methods regulations required to implement the regulations 1.3.1 Design a national information campaign (seminars, road shows, multimedia, and promotional material/brochures) on equipment performance improvements, systems optimization and EE regulation for equipment targeted at different beneficiary groups (inspection agencies, equipment manufacturers, enterprises, consultants) 1.3.2 Disseminate the results of the best case studies from Component 4	1.1.2 A key performance indicator (BPI) for in-service boiler's thermal efficiency is established through numerical analysis 1.1.4 Technical regulations are revised to include the new appraisal methods for boiler thermal efficiency (BPI - 1.1.1 condensing boiler and 1.1.2 non condensing boilers) and for steam systems (EEI - 1.1.3) 1.2.1 The regulatory reporting needs are assessed and a template reporting structure is designed 1.2.2 An electronic based system is created for systematic data collection, leading to the creation of a heat equipment and system database 1.2.3 The CSEI, jointly with the inspection agencies, shall collect data from enterprises, considering size, and type of boilers 1.2.4 The database is used to conduct a detailed study to determine the steam systems energy efficiency supply curves	1.1.3 A testing method standard is drafted for condensing boilers 1.1.4 Technical regulations are revised to include the new appraisal methods for boiler thermal efficiency (BPI - 1.1.1 condensing boiler and 1.1.2 non condensing boilers) and for steam systems (EEI - 1.1.3)	1.1.6 A national guideline to assess the energy conservation potential of heat recovery systems is formulated, based on global best available experience

Component 2 Capacity building (government)	2.2.5 Establish Boiler Energy Efficiency and Environmental Protection Evaluation Mobile Laboratory 2.1.1 Improve the existing analytical capacities of the Center for testing the relevant parameters for Steam and Heat Recovery systems to implement the methods established in outcome 1 by training key staff 2.1.3 Procure necessary equipment for verification of the key parameters identified in the testing methods	2.2.1 Establish Boiler Energy Efficiency Test Research and Evaluation Laboratory 2.2.4 Establish Oil and Gaseous Fuel Burners (OGFB) Testing Laboratory 2.2.6 Establish Fuel Analysis Laboratory 2.1.2 Train staff and 100 inspectors from provincial agencies in the analysis of data collected from the enterprises 2.1.3 Procure necessary equipment for verification of the key parameters identified in the testing methods	2.1.2 Train staff and 100 inspectors from provincial agencies in the analysis of data collected from the enterprises 2.1.3 Procure necessary equipment for verification of the key parameters identified in the testing methods	2.2.2 Establish Exchanger Components Energy Efficiency Evaluation Laboratory 2.2.3 Establish Heat Exchanger Product Energy Efficiency Evaluation Laboratory 2.1.2 Train staff and 100 inspectors from provincial agencies in the analysis of data collected from the enterprises 2.1.4 Adopt and localize the software tools required to assess heat recovery systems
Component 3 Capacity building (enterprises)	3.1.1 Awareness and promotion workshop for 1000 managers and technical personnel of enterprises (0.5 days) 3.1.2 Training of 100 national trainers who will train operators in the user training steam systems optimization (SSO) and heat recovery system optimization (HRSO) 3.1.3 Training for 10,000 boiler operators (user) 3.2.1 Internationally best available training program on steam systems optimization (SSO) training is adapted 3.2.2 a web-based platform and other training methods for trainees are developed; 3.2.3 40 EE professionals receive expert level steam system optimization (SSO) training, domestically and abroad 3.2.5 10 EE professionals receive expert level system optimization (HRSO) training domestically and abroad 3.3.1 Preparation of list of candidate companies for in-depth assessment and selection 3.3.2 National trainees carry out in-depth energy systems assessments as part of their practical training process	3.1.1 Awareness and promotion workshop for 1000 managers and technical personnel of enterprises (0.5 days) 3.1.2 Training of 100 national trainers who will train operators in the user training steam systems optimization (SSO) and heat recovery system optimization (HRSO) 3.1.3 Training for 10,000 boiler operators (user) 3.2.1 Internationally best available training program on steam systems optimization (SSO) training is adapted 3.2.2 A web-based platform and other training methods for trainees are developed; 3.2.3 40 EE professionals receive expert level steam system optimization (SSO) training, domestically and abroad 3.2.5 10 EE professionals receive expert level system optimization (HRSO) training domestically and abroad 3.3.1 Preparation of list of candidate companies for in-depth assessment and selection 3.3.2 National trainees carry out in-depth energy systems assessments as part of their practical training process	3.1.1 Awareness and promotion workshop for 1000 managers and technical personnel of enterprises (0.5 days) 3.1.2 Training of 100 national trainers who will train operators in the user training steam systems optimization (SSO) and heat recovery system optimization (HRSO) 3.1.3 Training for 10,000 boiler operators (user) 3.2.1 Internationally best available training program on steam systems optimization (SSO) training is adapted 3.2.2 A web-based platform and other training methods for trainees are developed; 3.2.3 40 EE professionals receive expert level steam system optimization (SSO) training, domestically and abroad 3.2.5 10 EE professionals receive expert level system optimization (HRSO) training domestically and abroad 3.3.1 Preparation of list of candidate companies for in-depth assessment and selection 3.3.2 National trainees carry out	3.1.1 Awareness and promotion workshop for 1000 managers and technical personnel of enterprises (0.5 days) 3.1.2 Training of 100 national trainers who will train operators in the user training steam systems optimization (SSO) and heat recovery system optimization (HRSO) 3.1.3 Training for 10,000 boiler operators (user) 3.2.1 Internationally best available training program on steam systems optimization (SSO) training is adapted 3.2.2 A web-based platform and other training methods for trainees are developed; 3.2.3 40 EE professionals receive expert level steam system optimization (SSO) training, domestically and abroad 3.2.5 10 EE professionals receive expert level system optimization (HRSO) training domestically and abroad 3.3.1 Preparation of list of candidate companies for in-depth assessment and selection 3.3.2 National trainees carry out

	led by international trainers (60 steam systems and 15 for heat recovery systems) 3.4.1 Preparation of training program for financial evaluation of industrial energy efficiency projects 3.4.2 Experts and industry personnel trained on the evaluation of EE projects financing and access to finance resources	led by international trainers (60 steam systems and 15 for heat recovery systems) 3.4.1 Preparation of training program for financial evaluation of industrial energy efficiency projects 3.4.2 Experts and industry personnel trained on the evaluation of EE projects financing and access to finance resources	in-depth energy systems assessments as part of their practical training process led by international trainers (60 steam systems and 15 for heat recovery systems) 3.4.1 Preparation of training program for financial evaluation of industrial energy efficiency projects 3.4.2 Experts and industry personnel trained on the evaluation of EE projects financing and access to finance resources	in-depth energy systems assessments as part of their practical training process led by international trainers (60 steam systems and 15 for heat recovery systems) 3.4.1 Preparation of training program for financial evaluation of industrial energy efficiency projects 3.4.2 Experts and industry personnel trained on the evaluation of EE projects financing and access to finance resources
Component 4 Demonstration of energy efficient equipment implementation and operation	4.1.1 50 industrial implement the systems optimization projects identified during the in-depth systems assessments 4.2.1 Conceptual and/or basic engineering of selected technologies is completed 4.2.2 Bankable business plans are prepared 4.2.3 Technology retrofits are conducted	4.1.1 50 industrial implement the systems optimization projects identified during the in-depth systems assessments 4.2.1 Conceptual and/or basic engineering of selected technologies is completed 4.2.2 Bankable business plans are prepared 4.2.3 Technology retrofits are conducted	4.1.1 50 industrial implement the systems optimization projects identified during the in-depth systems assessments 4.2.1 Conceptual and/or basic engineering of selected technologies is completed 4.2.2 Bankable business plans are prepared 4.2.3 Technology retrofits are conducted	4.1.1 50 industrial implement the systems optimization projects identified during the in-depth systems assessments 4.2.1 Conceptual and/or basic engineering of selected technologies is completed 4.2.2 Bankable business plans are prepared 4.2.3 technology retrofits are conducted

ANNEX K: BACKGROUND INFORMATION

Policy and programs in China 11th Five-Year Plan (FYP) period (2006-2010),

During the 11th Five-Year Plan (FYP) period (2006-2010), China had ambitious energy efficiency targets for industry. On one hand, it has successfully implemented the 1000 enterprises program. As part of this program an efficiency benchmarking system has been developed for energy intensive large enterprises such as power generation, iron and steel, cement and chemicals. On the other hand, China struggled to meet its energy intensity reduction target of 20 per cent. It reached 19.1 per cent by closing down as many as 2,000 small power plants, steelmakers, cement factories and paper mills at the end of 2010 following Premier Wen Jiabao's address months earlier on the tackling of energy efficiency with "iron hand". Several provinces across China had to take further direction action to meet targets by cutting power to industry, residential buildings, traffic lights, and in some instances, even hospitals.

The main relevant policies issued during this period included:

- Medium and Long-term Plan of Energy Conservation and its 10 Energy Conservation Programs (2004), which for energy efficiency included: upgrading coal-burning industrial boiler and kilns; upgrading of electric motor systems, undertaking fuel switching and conservation activities; conversion of exhaust heat and pressure; optimizing energy systems in major industries, primarily metallurgical, petrochemicals and chemicals; monitoring and Technical Services at sub-sectors and provincial levels; and green lighting.
- Energy Conservation Law (2007) - which for industrial equipment defined that if consumes excessive quantities of energy shall be subject to examination and control for energy conservation as required by the State Council (article 16 provision). Certain types of industrial equipment were classified as high energy-consuming (HEC) special equipment and were characterized by their safety aspects, consuming significant amounts of energy and having high potential for energy savings to be made. Three categories of HEC special equipment were defined including boilers, heat exchangers and elevators.

In the 11th FYP, Chinese policy for industrial energy efficiency was based on three tools:

- 1,000-enterprise program for large industry
- Stringent energy intensity targets
- Forced closure of plants based on scale or technology criteria

While significant progress has been accomplished in industrial energy efficiency during the 11th Five Year Plan Period, China still faces challenges to the achievement of sustained energy efficiency measures.

The main industrial energy efficiency challenges include:

- maintaining the sustained growth in energy-intensive industries while addressing climate change and realizing commitments with the international community where additional efforts are needed;
- meeting the national energy conservation targets, and
- promoting low carbon industrial development and energy conservation..

Policy and programs in China 12th Five-Year Plan (FYP) period (2011-2020),

The 12th FYP (2011-2015) goes further than previous Plan on energy saving measures. It considers a policy to place an actual cap on total energy consumption to approximately 4 billion tons of coal equivalent (tce) per year by 2015. For the medium term (2011-2015) the FYP sets development plans for seven strategic emerging industries. These "pillar industries" were identified to promote economic growth while decarbonizing the economy, and include: ICT (including smart grids); biotechnology industry; new and renewable energy; electric vehicles; energy-saving and environmental protection equipment/industry; new materials.

In terms of the national climate change communications, China has undertaken the following national exercises:

Reports and assessments under relevant conventions

The Initial National communication on Climate Change to the UNFCCC (2004) in the communication the government emphasized its efforts to mitigate climate change by adopting energy efficiency measures (as stated in the 10th Five Year Plan) amongst other initiatives. Full account of the undertaken and planed measures are provided. The description includes a list of GEF funded projects implemented by the World Bank, namely such as "China End-Use Energy Efficiency Program" and the "Energy Conservation Promotion Project

The Technology Needs Assessment is currently being conducted with GEF financing (GEF ID 4188). The project will closely monitor the exercise undertaken by the central government to identify its Technology Needs Assessment as defined by the international climate change agenda (UNFCCC), to complete a detailed assessment of the current situation of the technology development and potential technology needs in mitigation and adaptation, including implementation options (technical, institutional, policy, regulatory and capacity dimensions). The project is at early preparatory phase currently being undertaken by the World Bank.

Finally, China pledged in its communications under the Copenhagen Accords to reduce emissions intensity by 40-45% by 2020 compared to 2005 levels and increase the share of non-fossil fuels in primary energy consumption to 15% by 2020.

The baseline project

The following section describe the current status of the different elements that the project seeks to address, including testing of energy consumption, policy compliance and technical standards, energy saving measures in boiler and heat exchanger and technology transfer.

Policy implementation – testing standards

Following the promulgation of the Energy Conservation laws in 2007, regulations on Energy Conservation Supervision were issued for HEC equipment management. The regulations envisage that the supervision of energy conservation measures will be undertaken by the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) – an autonomous government body. AQSIQ is in charge of national quality, metrology, entry-exit commodity inspection, entry-exit health quarantine, entry-exit animal and plant quarantine, import-export food safety, certification and accreditation, standardization (China National Institute of Standardization directly under AQSIQ), as well as administrative law-enforcement. It also administrates the Certification and Accreditation Administration of the P.R. China (CNCA)[14] and the Standardization Administration of the P.R. China (SAC).

AQSIQ is also responsible for ensuring safety aspects, hence the integration of energy efficiency issues allows for greater coherency in implementation and enforcement of the regulations. As of 2010, AQSIQ is responsible for 3.03 million units of HEC special equipment and in this regard has set the target of a total of 70 million tons of coal equivalent (tce) reduction in energy consumption by 2015.

While there are certain existing national codes and standards for the testing of industrial and domestic boilers[15], there is need to define a system for technical testing using advanced testing technology standards. Under these new systems, the current specifications and regulations need revision.

[14] CNCA is a vice-ministerial-level department, exercising the administrative responsibilities by undertaking unified management, supervision and overall coordination of certification and accreditation activities across the country, and SAC, which is also a vice-ministerial-level department, performs nationwide administrative responsibilities and carries out unified management for standardization across the country

[15] Standards include the domestic boiler testing codes and standards are TSG G0003-2010 (energy efficiency test and evaluation regulation for domestic boilers), GB/T 10180-2003 (industrial boiler thermal performance test procedures) and GB/T 10184-1988 (boiler thermal performance test procedure).

Policy implementation – laboratory capacities

In 2009-2010 AQSIQ undertook research to determine the existing abilities in autonomous regions and municipalities and defined conditions for boiler testing. In 2011 they identified 82 boiler efficiency testing agencies. In 2012 more agencies will be identified to facilitate boiler efficiency testing.

Six national laboratories will be required for boiler and heat exchanger testing and a comprehensive national laboratory: the National Special Equipment Safety and Energy Technology Center which will be associated to the China Special Equipment Inspection and Research Institute (CSEI). Further selection of the laboratories and an assessment of their capacities shall be undertaken during the project preparatory phase.

The current capacities of CSEI include boilers and heat exchanger testing and evaluation. These facilities are mainly used for research, since this test center has a regulatory rather than compliance role. It generates the data which is then used as the technical basis for the development of relevant regulations, standards and energy policies.

Industrial boilers – systems optimization

Industrial boilers in China's represent the most significant energy conversion equipment, and are mainly coal-fired. In 2010, the total coal yield in China reached 3.24 billion ton, with boilers represented 70 per cent (about 2.24 billion ton). The average operational efficiency of an industrial boiler in China is only 65 per cent, which is 15-20 per cent less than that of boilers in developed countries. Energy savings generated by using more efficient equipment could represent 70 million tce. Moreover, in addition to the energy efficiency savings in individual system components which markets and policymakers tend to focus on, if a systems optimization approach was used energy savings of 15–30 per cent could be realized.

Various projects have addressed the efficiency issues related to industrial boilers in recent years, perhaps mostly importantly the GEF-WB China Efficient-Industrial Boilers Project (GEF ID 97). However, a considerable potential for energy savings remains to be realized.

Heat exchangers – systems optimization and technology transfer

Research by the Chinese Special Equipment Institute (CSEI) shows that in the chemicals industry, expenditure on heat exchangers can comprise 30% of the total capital expenditure on new equipment and in oil refineries, approximately 40%. Improved heat transfer efficiency and the optimization of heat networks would significantly contribute to plants' overall energy efficiency.

The latest heat exchangers can achieve greater levels of thermal efficiency, can deal with larger loads and are also smaller in size. On average energy efficient heat exchangers comprised only 2-5 per cent of their heat exchange equipment needs and at the most only 10 per cent. Preliminary CSEI research on more than 20 large Chinese petrochemical enterprises16 shows that they have gradually deployed new technologies. However, the uptake of more efficient heat exchangers was slow as companies selected models which met their manufacturing process requirements giving little consideration to the thermal efficiency. The most commonly used technologies were expansion bellow and plate heat types, while more efficient exchangers, such as helix changer were the least used.

[16] including Sinopec, Petro China and China National Offshore Oil Corporation (CNOOC) etc.

ANNEX L: DEFINITION OF KEY TECHNICAL CONCEPTS - GLOSSARY

Boiler: heat transfer equipment which c uses input energy from a variety of possible sources to generate steam from water. The term *boiler* is sometimes used loosely to refer to devices which merely raise the temperature of a cold liquid such as water or oil, without vaporization (e.g. building hot water heating systems).. For the purpose of this project, we will limit the term *boiler* to mean applications which involve generating steam from water, regardless of the energy source. These energy sources may include radiant heat from combustion of fuels (natural gas, oil, coal, hydrogen, etc.), convective heat from hot fluids, and conductive heat from hot solids. By this definition, a boiler would include the following equipment types:

- Conventional Boilers, including burners, stack & controls
- Heat recovery steam generators (using hot flue gases from power generation devices such as gas turbines and internal combustion engines), which may or may not have supplementary fuel firing, and
- Process heat recovery steam regenerators (historically called "Waste" Heat Boilers), which are essentially unfired heat exchangers.

Steam system: is the integrated system composed of multiple boilers and essential sub-systems without which the boilers cannot effectively or efficiently perform their primary function of steam generation in accordance with the process demand. The main supporting subsystems are listed in Table 1

Boiler efficiency: Boiler efficiency has been variously defined. The most commonly used definition is that by the American Society of Mechanical Engineers (ASME): The general equation is expressed as

$$\eta = \frac{Useful\ Output}{Total\ Input},$$

where the Numerator = Total <u>useful</u> energy output, generally the heat added to convert boiler feedwater (BFW) into steam, and the Denominator = Total fuel + power required to produce the useful output.

Differences in the application of this equation lie in what is considered useful output and what energy usage is included in the energy inputs.

Steam system energy efficiency: The <u>function</u> of boilers is to generate steam, but their <u>purpose</u> is to deliver steam to the manufacturing process. This distinction is important. Therefore the correct measure for effectiveness of a steam <u>system</u> is its delivery efficiency, not its generation efficiency. Accordingly, we define steam system efficiency as follows:

$$Steam\ System\ Efficiency = \frac{Useful\ steam\ delivered\ to\ process}{Total\ Energy(Fuel + Power)\ Input}$$

It is equally acceptable to use the inverse of efficiency, as under:

$$Index = \frac{Total\ Energy(Fuel + Power)\ Input}{Useful\ steam\ delivered\ to\ process}$$

Energy Performance: This is the term used for any measure of effectiveness. The generic term is Key Performance Indicator, or KPI. It can be applied to energy, capacity, capital or other performance measure. Some illustrative examples of such KPIs are given below.

For a <u>Heat exchanger</u>: Overall heat transfer coefficient U, defined as heat flux (q/A) divided by the corrected mean temperature difference (CMTD) for that service, expressed in units of Btu/ft2-h-F or watts/m2-h-C.

For a <u>Heat Exchanger Network</u> (HEN): Capital cost of HEN per unit of total heat transfer surface area (frequently used but not a good measure) or per total heat transfer duty accomplished (a better measure). Possible units of measure would be $/ft2 of total surface area, or $/KW of heat transferred under a defined set of process operating temperatures – usually the design conditions.

For a fired heater (furnace): Energy efficiency, usually defined as absorbed duty by the cold process fluids (there could be more than one) divided by the total energy in the fuel fired. However, a better definition of furnace efficiency would be to include the energy consumed by auxiliary systems such as pumps, fans, flue gas scrubbers, etc., in the denominator.

Energy Efficiency: This commonly used term can apply to a variety of situations, e.g.:

- equipment
- process unit
- product
- business unit or organization

It is important to precisely define which efficiency one is talking about, and formulate the measure according to the purpose for which it is intended to be used. Energy Efficiency is merely one type of Energy Performance Index, or EPI. EPIs can have several different applications:

- Report card, for information only
- Benchmarking (historical, competitive, or absolute)
- Economic Dispatch
- Process Improvement, including troubleshooting
- Operations optimization

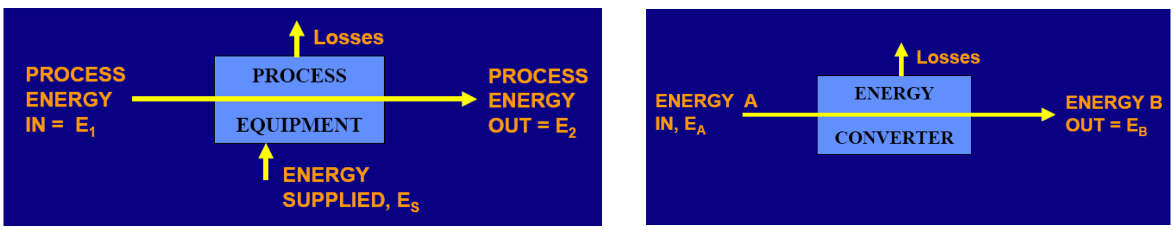
Each application requires a different formulation.

Of the various types of EPIs, Equipment EPIs are the simplest and easiest to formulate. The proper measure of energy efficiency for energy consumers (e.g. process heaters, dryers), is:

$$\text{Efficiency} = \frac{\text{Useful Energy Absorbed}}{\text{Utility Energy Supplied}} = \frac{E_2 - E_1}{E_S}$$

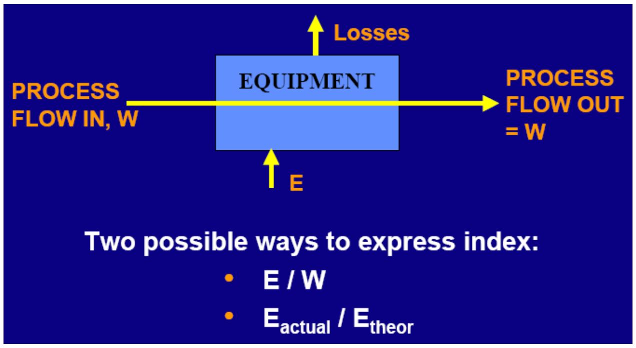
The proper measure of energy efficiency for energy converters (e.g. boilers, heat engines) is:

$$\text{Efficiency} = \frac{\text{Energy Output}}{\text{Energy Input}} = \frac{E_B}{E_A}$$

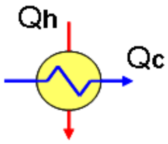


Energy Flows through (a) Consumers and (b) Converters

Energy Intensity: This is the amount of energy use per unit or output or service. The intensity can be expressed as an absolute value, or as a relative value (e.g. compared against some benchmark).



Heat Exchangers: A Heat Exchanger (HX) is a heat transfer device that transfers heat between two fluid streams across a partition (usually metallic) without physical mixing. Many different mechanical designs exist – the most common being Shell and Tube, because they are the cheapest. Fin fans are used when ambient air is the cooling medium. Other designs that have advantages such as lower fouling rate, ease of cleaning, lower space requirements, etc are often used when those features are important.



Schematic representation of an indirect contact heat exchanger

There is also a class of direct-contact heat exchangers that are used for "quenching" extremely viscous or reactive process fluids, and for transferring heat between fluids and solids. Examples of the latter include lime and cement kilns, dryers, catalyst beds, and molecular sieve beds.

The focus of the present project is the former type of HX only, viz. indirect heat transfer.

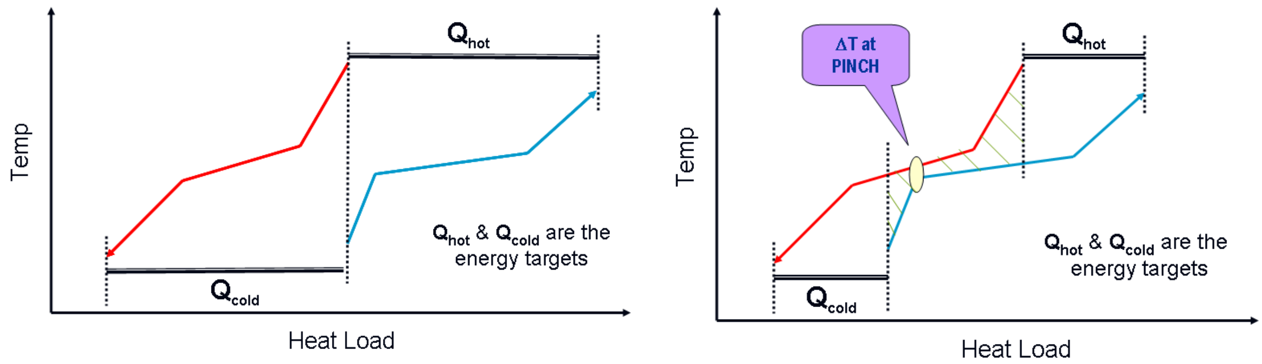
It is important to recognize that heat exchangers neither consume nor convert energy; they merely transfer it. In theory, as well as in practice for well-insulated equipment, the energy absorbed by the colder fluid is almost exactly equal (within 1%) of the energy given up by the hot fluid. Therefore conventional measures of energy efficiency are not only useless, but also meaningless.

Heat recovery systems: This term refers to a network of heat exchangers whose principal purpose is to reduce operating costs by reducing the amount of energy utilities (such as steam, fuel, electricity) consumed. A corollary but critically important benefit is that heat recovery reduces the production and emission of greenhouse gases that are known to cause adverse disruption of the global climate.

A Heat Exchanger Network is an example of a heat recovery system. The heat recovery efficiency of a HEN can be understood in terms of the composite heat demand and heat availability profiles of the process:

When both curves are plotted on the same T-H (temperature-Enthalpy) diagram, as in Figure 4, they show the opportunity for heat recovery as well as the minimum net heating and cooling requirements. The point of closest approach, where available temperature driving forces between hot and cold streams are at a minimum, is called the "Process Pinch". It separates the overall process into two distinct thermodynamic domains: (a) a net heat sink above the pinch temperature, meaning that hot utility must be supplied, and (b) a net heat source below the pinch temperature, meaning that cooling utilities must be provided (= heat must be removed).

The temperature difference between hot and cold streams at the pinch is called the Minimum Approach Temperature (MAT). For each value of MAT, there are corresponding values of minimum heating and cooling requirements $(Q_h)_{min}$ and $(Q_c)_{min}$. These are the theoretical energy targets.



Composite Curves (a) without heat recovery (b) with heat recovery

The energy (heat recovery) efficiency of the HEN can then be expressed as:

$$\eta = (E_{\max} - E_{actual}) / (E_{\max} - E_{opt})$$

Steam generation system: This refers purely to the generation of steam, and does not include the distribution of steam to the process and recovery of condensate for return to the deaerator.

Steam distribution system: This refers purely to the distribution of steam and recovery of condensate. Usually, there is significant potential for overall system energy efficiency improvement through optimizing steam header pressures, level of superheat, leak prevention, minimizing heat losses due to poor insulation, use of indirect heat transfer versus direct steam injection, and minimizing condensate losses due to inadequate trap performance and to poor condensate recovery system design.

Steam end-uses: These are the process users that require steam. Experience has shown that the steam pressure being used in any given service is often one or two pressure levels higher than what would be adequate to perform the process heating function. In such situations, significant energy efficiency improvements can be achieved by changing the steam supply source to the lowest pressure levels that is necessary for the process to function satisfactorily.

Boiler optimization: Is the efficient operation of boilers, which includes making sure that leaks in/out have been minimized, and the auxiliary systems for the boiler such as burners, and fuel/air ratio, and blowdown rate are operating at optimum conditions.

Steam system optimization: Is the optimization of the overall operation of the entire steam generation and distribution system

Energy Efficiency Benchmarking: Benchmarking is the procedure wherein the key performance parameters (KPIs) of the subject facility are compared relative to that of its competitors or its own performance in the past, usually with the goal of identifying areas of opportunity for improvement.

Equipment or Sub-System	Steam System	Combined Heat and Power System	Heat Recovery System
Boiler Feed Water (BFW) softening + Demineralization	no	✓	no
BFW makeup preheating	✓	✓	no
BFW Deaeration	✓	✓	no
BFW supply pumps	✓	✓	no
Economizer	✓	✓	no
Air supply fan (forced draft)	✓	✓	no
Air preheater	✓	✓	no
Boiler, including burners, stack & controls	✓	✓	no
Blowdown flash drum	✓	✓	no
Blowdown heat recovery HX	✓	✓	✓
Fuel gas supply system (eg. flare gas)	optional	✓	optional
Fuel oil supply system (eg. desulfurization)	optional	✓	no
Coal supply system (cleaning, conveying)	optional	✓	no
Ash disposal system a	optional	✓	no
Flue gas scrubbing (for SO2, NOx, etc)	optional	✓	optional
Baghouse or Electrostatic Precipitator ESP (particulate removal)	optional	✓	no
Steam distribution headers (heat loss)	✓	✓	no
Steam traps	✓	✓	no
Condensate recovery	✓	✓	✓
Steam turbines (back-press. + condensing)	✓	✓	optional
Internal combustion engines	no	✓	optional
Gas turbines	no	✓	optional
Electric power generators	no	✓	no
Heat recovery steam generators (on GT)	✓	✓	no
Process heat recovery steam generators (Waste Heat Boilers)	✓	✓	✓
Facility electricity import/distribution	no	✓	no
Process fuel-fired heaters (furnaces)	no	✓	✓
Process heat exchangers	no	no	✓
Process steam heaters	✓	✓	✓
Process utility coolers (air, CW, etc)	no	✓	✓
Process pumps and compressors motors	no	✓	✓

Table 1: equipment commonly found in Steam and Heat recovery systems

ANNEX **M:** COMMON ABBREVIATIONS USED IN THE PROJECT DOCUMENT

AQSIQ: General Administration of Quality Supervision, Inspection and Quarantine
SESA: Special Equipment Safety Supervision Bureau
BAT: Best available technologies
CCM: Climate change mitigation
CEO EF: Chief Executive Officer Endorsement form
CHP: Combined Heat and Power
CO_2: Carbon dioxide
CSEI: China Special Equipment Inspection and Research Institute
EE: Energy Efficiency
EEI: Energy efficiency indicator
ESCOs: Energy service companies
FYP: Five-year plan
GEF: Global Environment Facility
GHG: Greenhouse gases
GWh: Gigawatt hours
HEC: High energy consuming
HEN: heat exchanger networks
HRSO: Heat recovery systems optimization
IFC: International Finance Corporation
KPI: Key performance indicator
NPCC: National Project Coordination Committee
PIF: Project information form
PJ: Petajoules
PM: Project manager
PMCs: Project management cost
PMO: Project management office
PPG: Project preparation grant
SMEs: Small and medium enterprises
SSO: Steams systems optimization
TCE: Tons of coal equivalent
TOR: Terms of reference
UNIDO: United Nations Industrial Development Organization
WB: World Bank