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The World Bank

Report No: ICR00003966

IMPLEMENTATION COMPLETION AND RESULTS REPORT
(TF-12536)

ON A

GRANT

IN THE AMOUNT OF US$ 5.0 MILLION

TO THE

NATIONAL DEVELOPMENT AND REFORM COMMISSION, CHINA

FOR A

CHINA TECHNOLOGY NEEDS ASSESSMENT PROJECT

December 20, 2016

Energy and Extractives Global Practice
East Asia and Pacific Region

CURRENCY EQUIVALENTS
(Exchange Rate Effective December 1, 2016)

Currency Unit = Renminbi (RMB)
RMB 1.00 = US$0.145
US$1.00 = RMB 6.88

FISCAL YEAR
July 1 – June 30

ABBREVIATIONS AND ACRONYMS

AHP	Analytic Hierarchy Process
CQS	Selection Based on Consultants' Qualifications
ETS	Emissions Trading Scheme
FM	Financial Management
FYP	Five-Year Plan
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GoC	Government of China
NDRC	National Development and Reform Commission
M&E	Monitoring and Evaluation
MCDA	Multi Criteria Decision Analysis
MoF	Ministry of Finance
MTR	Mid-term Review
NCSC	National Strategic Research and International Cooperation Center for Climate Change
NDC	Nationally Determined Contribution
PAD	Project Appraisal Document
PDO	Project Development Objective
PMO	Project Management Office
TNA	Technology Needs Assessment
TOR	Terms of Reference
UNFCCC	United Nations Framework Convention on Climate Change

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PEOPLE'S REPUBLIC OF CHINA
CHINA TECHNOLOGY NEEDS ASSESSMENT PROJECT

CONTENTS

A. Basic Information

Country:	China	Project Name:	China Technology Needs Assessment (TNA)
Project ID:	P120932	L/C/TF Number(s):	TF-12536
ICR Date:	11/06/2016	ICR Type:	Core ICR
Lending Instrument:	SIL	Borrower:	PEOPLE'S REPUBLIC OF CHINA
Original Total Commitment:	US$5.00 Million	Disbursed Amount:	US$4.526 Million
Revised Amount:	US$5.00 Million		
Environmental Category: C		**Global Focal Area: C**	
Implementing Agencies: Department of Climate Change, NDRC			
Cofinanciers and Other External Partners:			

B. Key Dates

Process	Date	Process	Original Date	Revised / Actual Date(s)
Concept Review:	03/24/2010	Effectiveness:	07/31/2012	07/17/2012
Appraisal:	11/22/2011	Restructuring(s):		09/09/2015
Approval:	05/29/2012	Mid-term Review:	12/16/2014	12/17/2014
		Closing:	11/30/2015	06/30/2016

C. Ratings Summary

C.1 Performance Rating by ICR	
Outcomes:	Satisfactory
Risk to Global Environment Outcome	Moderate
Bank Performance:	Moderately Satisfactory
Borrower Performance:	Satisfactory

C.2 Detailed Ratings of Bank and Borrower Performance

Bank	Ratings	Borrower	Ratings
Quality at Entry:	Moderately Satisfactory	Government:	Satisfactory
Quality of Supervision:	Satisfactory	Implementing Agency/Agencies:	Moderately Satisfactory
Overall Bank Performance:	Moderately Satisfactory	**Overall Borrower Performance:**	Moderately Satisfactory

C.3 Quality at Entry and Implementation Performance Indicators			
Implementation Performance	**Indicators**	**QAG Assessments (if any)**	**Rating**
Potential Problem Project at any time (Yes/No):	No	Quality at Entry (QEA):	None
Problem Project at any time (Yes/No):	Yes	Quality of Supervision (QSA):	None
GEO rating before Closing/Inactive status	Moderately Satisfactory		N.A.

D. Sector and Theme Codes

	Original	Actual
Sector Code (as % of total Bank financing)		
Other Agriculture, Fishing and Forestry	15	15
Other Energy and Extractives	50	50
Other Transportation	15	15
Other industry	20	20
Theme Code (as % of total Bank financing)		
Climate change	100	100

E. Bank Staff

Positions	At ICR	At Approval
Vice President:	Laura Tuck	Pamela Cox
Country Director:	Bert Hofman	Klaus Rohland
Practice Manager/Manager:	Jie Tang	Paul Kriss
Project Team Leader:	Garo J. Batmanian	Carter J. Brandon
ICR Team Leader:	Dafei Huang	
ICR Primary Author:	Dafei Huang	

F. Results Framework Analysis

Global Environment Objectives (GEO) and Key Indicators(as approved)
To support China's efforts to assess climate mitigation and adaptation technology needs and adopt corresponding global best practices.

Revised Global Environment Objectives (as approved by original approving authority) and Key Indicators and reasons/justifications

Not applicable.

(a) GEO Indicator(s)
The Project Development Objective is the same as the GEO.

Indicator	Baseline Value	Original Target Values (from approval documents)	Formally Revised Target Values	Actual Value Achieved at Completion or Target Years
Indicator 1:	Technology assessments			
Value (quantitative or Qualitative)	0	20	NA[1]	20
Date achieved	11/01/2013	11/01/2015	06/01/2016	06/01/2016
Comments (incl. % achievement)	100% completed. 20 assessments completed (12 mitigation, 4 adaptation and 1 provincial assessment with four provinces). This was the first national TNA in China, forming the initial technical guidance and frameworks for the country. Provided strong analytical basis to inform policy making.			
Indicator 2 :	Capacity building support to climate technology assessment centers and networks			
Value (quantitative or Qualitative)	No capacity building support.	Capacity building support implemented; and stakeholder survey confirms demand for and evaluates the fulfillment of TNA related functions provided.	NA	Capacity building support implemented; and stakeholder survey confirms demand for and evaluates the fulfillment of TNA related functions provided.
Date achieved	11/01/2013	11/01/2015	06/01/2016	06/01/2016

[1] NA stands for 'not applicable'. And this applies throughout the table.

Comments (incl. % achievement)	100% completed. Initial network of capacity building centers, incl. a national center with 4 provincial centers in Guangdong, Liaoning, Jiangxi and Shaanxi; and 2 sectoral centers in the power and building sectors were established. 122 trainings and 1,983 stakeholders trained.			
Indicator 3 :	Measureable financial and economic benefits of accelerating technology transfer through small grant support to companies. Evaluation of impacts and lessons learned related to technology modification, deployments, transfer and/or diffusion.			
Value (quantitative or Qualitative)	0	1	NA	1
Date achieved	11/01/2013	11/01/2015	06/01/2016	06/01/2016
Comments (incl. % achievement)	100% completed. Evaluation report delivered in May 2016. Findings showed that the program delivered 4.3 million tCO_2e reduction. US$680,000 grant disbursed, leveraging US$3.5 million investment. Each tone of CO_2 saving at a cost of US$0.97.			
Indicator 4 :	Lifetime direct GHG emissions avoided			
Value (quantitative or Qualitative)	0	500000	NA	4366393
Date achieved	11/01/2013	11/01/2015	06/01/2016	06/01/2016
Comments (incl. % achievement)	600% completed. Compared with target, the program leveraged technologies considerably larger scale in terms of both investment and emission reductions. The design required minimum leverage ratio of 1:125. The implementation reached over 1:5.			

(b) Intermediate Outcome Indicator(s)

Indicator	Baseline Value	Original Target Values (from approval documents)	Formally Revised Target Values	Actual Value Achieved at Completion or Target Years
Indicator 1 :	Production of 3 synthesis reports (1 for mitigation, 1 for adaptation, and 1 for provinces), collating and disseminating the results from the individual sector technology assessments.			
Value (quantitative or Qualitative)	0	3	NA	3
Date achieved	11/01/2013	11/01/2015	06/01/2016	06/01/2016

Comments (incl. % achievement)	100% completed. 3 synthesis reports were shared for consultation and delivered by May 2016.			
Indicator 2 :	Development of a database which houses information on priority technologies collected at the sector and provincial level. The database will be a national virtual data hub for facilitating the transfer of and investment of climate technologies for China.			
Value (quantitative or Qualitative)	No database	Database established.	NA	Database established.
Date achieved	06/01/2013	06/01/2015	06/01/2016	06/01/2016
Comments (incl. % achievement)	100% completed. The database and information system was completed in May 2016, which can be accessed by public through http://data.tnachina.org/. Established a rich pool of technology transfer experience and case studies and data on the implementation.			
Indicator 3 :	Organization of workshops for dissemination and evaluation.			
Value (quantitative or Qualitative)	0	4	NA	7
Date achieved	06/01/2013	06/01/2015	06/01/2016	06/01/2016
Comments (incl. % achievement)	100% completed. 7 workshops were organized, including an overall kick-off workshop, 3 interim and 3 dissemination workshops respectively on mitigation, adaptation and provincial assessments and overall closing.			
Indicator 4 :	Competitively selected "Technology improvement grants" made.			
Value (quantitative or Qualitative)	0	8-12	NA	8
Date achieved	06/01/2013	06/01/2014	06/01/2016	06/01/2016
Comments (incl. % achievement)	100% completed. 8 grants have been fully executed, out of the total 9 grants that were competitively selected. 1 grant dropped due to administrative approval delay.			

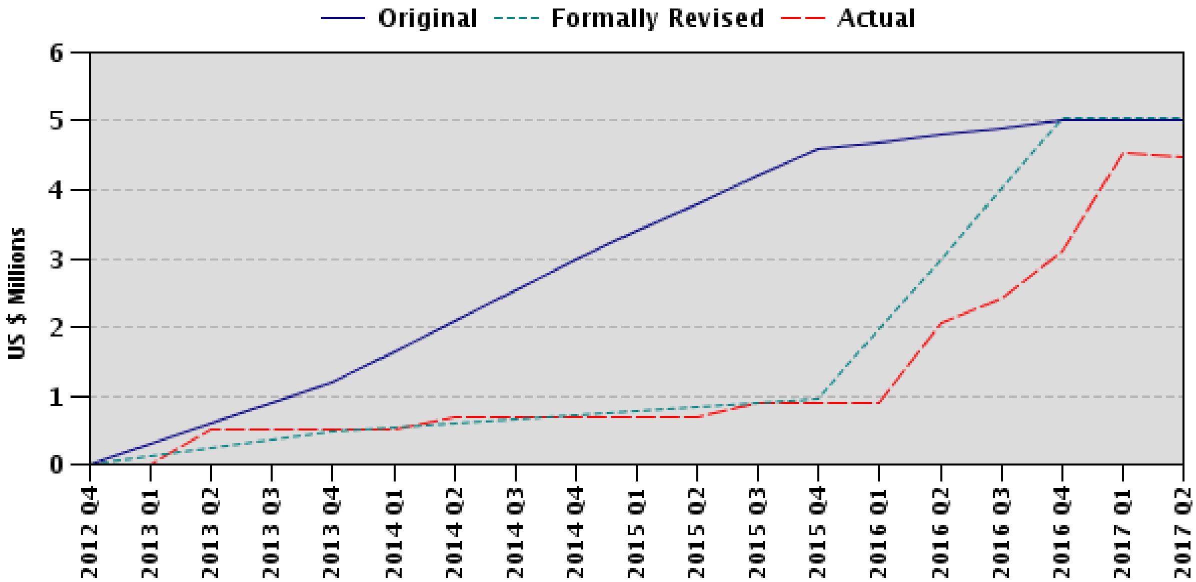
G. Ratings of Project Performance in ISRs

No.	Date ISR Archived	GEO	IP	Actual Disbursements (USD millions)
1	11/11/2012	Satisfactory	Satisfactory	0.00
2	06/07/2013	Moderately Satisfactory	Moderately Satisfactory	0.50
3	12/03/2013	Moderately Satisfactory	Moderately Satisfactory	0.50
4	06/15/2014	Moderately Satisfactory	Moderately Unsatisfactory	0.68
5	12/01/2014	Moderately Satisfactory	Moderately Unsatisfactory	0.68
6	02/20/2015	Moderately Unsatisfactory	Moderately Unsatisfactory	0.90
7	06/26/2015	Moderately Satisfactory	Moderately Satisfactory	0.90
8	12/09/2015	Moderately Satisfactory	Moderately Satisfactory	2.07
9	06/14/2016	Moderately Satisfactory	Moderately Satisfactory	3.10

H. Restructuring (if any)

Restructuring Date(s)	Board Approved GEO Change	ISR Ratings at Restructuring		Amount Disbursed at Restructuring in USD millions	Reason for Restructuring & Key Changes Made
		GEO	IP		
09/09/2015	N	MS	MS	0.90	A level-two restructuring was approved during implementation on September 9, 2015: 1) extension of the grant closing date by seven months from November 30, 2015 to June 30, 2016; 2). Re-allocation of US$40,000 from the sub-grants disbursement category to the ‘goods, consultant services, training, workshops, study tours, and incremental costs’ and corresponding changes to the disbursement estimates and implementation schedule.

I. Disbursement Profile



1. Project Context, Global Environment Objectives and Design

1.1 Context at Appraisal

1. **Country Context. At the time of appraisal, China had experienced more than two decades of rapid economic growth, although many imbalances remained.** In the decade prior to appraisal, gross domestic product (GDP) grew by 9.9 percent per annum with broadly effective macroeconomic management. Inflation was kept under control. While China's real economy was affected by the global financial crisis through its trade and foreign direct investment, a forceful fiscal and monetary stimulus helped keep China's growth rate from falling rapidly. Per capita income rose rapidly in urban and rural areas over the previous two decades, with hundreds of millions of people lifted out of poverty. At the same time, approximately 200 million people were still below the World Bank poverty line,[2] giving China the second-largest poor population among all countries (after India). In addition, some economic and social imbalances had emerged and were growing, in particular:

- Widening disparities in regional development and incomes, between urban and rural areas, and between coastal and inland provinces; and
- Growing local and global environmental challenges, and high vulnerability to the adverse impacts of climate change.

2. **Addressing climate change – both mitigation and adaptation – had grown in importance to China.** On the mitigation side, China's rapidly growing coal-dependent economy resulted in total CO_2 emissions becoming the largest in the world (although per capita emissions remained below the average developed country level). Projections under business-as-usual conditions showed continually growing emissions. On the adaptation side, with its long coastline and vast expanses of arid and semi-arid land, China was vulnerable to the adverse impacts of climate change, which could result in intensified water shortages in northern China, increases in the incidence of extreme temperature events and consequent flooding and droughts, and the reduction in the yields of major crops.

3. **A number of factors specific to China impeded its response to climate change.** The primary factor impeding China's climate change response was continued rapid economic growth. Economic development, if fueled primarily by fossil fuels, would continue to drive a growth in CO_2 emissions. Increasing energy demand also raised energy security concerns as the share of China's energy imports (mainly petroleum and natural gas) continued to rise. These concerns strengthened China's resolve to make use of domestic energy options, which had been dominated by coal, even as it had begun to diversify energy supply with renewables and nuclear power. While China had been purposely pursuing a full range of technologies, the majority of its existing energy infrastructure – generation, transmission, and use – was coal-dominated, and its overall energy use per unit of GDP was much higher than the average for middle and high income economies. At the time of appraisal, China had yet to meet the technological standards of Organisation for Economic Co-operation and Development countries in general. In addition, the country's large size and overall diversity made it vulnerable to a wide variety of climate change threats, as noted above.

[2] US$1.25 per person per day, used at the time of project approval.

The challenge for formulating climate change mitigation and adaptation strategies was and remains complex, interlinked, and dependent on both technological and policy innovations.

Sectoral and Institutional Context

4. **The United Nations Framework Convention on Climate Change (UNFCCC) negotiations has long highlighted the importance of technology transfer and development** in helping countries address climate change mitigation and adaptation. The UNFCCC's Expert Group on Technology Transfer has encouraged all non-Annex I Parties to the Convention, such as China, to identify their climate technology needs through "Technology Needs Assessments" (TNAs). A number of countries have either already undertaken or are now undertaking such assessments.

5. **The Government of China (GoC) had taken numerous steps to address climate change.** In November 2009, the State Council announced that by 2020, China would cut CO_2 emissions intensity per unit of GDP by 40 to 45 percent compared to 2005 levels. Numerous efforts were made during the 11th Five-Year Plan (FYP) (2006-2010) with the release of the "China's National Climate Change Program" (June 2007), and the passing of the "Actively Facing Climate Change Act" by the National People's Congress (August 2009). According to official data, implementation of the government targets is on track. On the adaptation side, the National Climate Change Program outlined a number of strategies, including improving agricultural infrastructure, breeding stress-resistant animal and crop varieties, addressing land degradation, strengthening protection of forests and other natural ecosystems, enhancing water resources and management, and improving capability in monitoring and early warning systems for coastal zones. The project has supported TNAs of these important areas and contributes to building the analytical basis to inform policy making.

6. **The GoC continually stressed the role of advanced technologies for both mitigation and adaptation** to meet its economic, social, and environmental goals at minimum cost. Making the most relevant and advanced technologies available for widespread deployment would involve both the transfer of best available global technologies to China (when not already available domestically) and enhancement of China's own science, technology, innovation capacity, and diffusion. Given China's vast size, its rapid economic growth, its growing greenhouse gas (GHG) emissions, and vulnerability to climate change, the climate technology needs of China are immense.

7. **At the time of appraisal, the GoC had issued several plans with significant implications for the development of climate change technologies.** The most prominent were:

(a) The Medium and Long-Term Development Plan for Renewable Energy;

(b) The 12th FYP (2011-2015) with a focus on the development of seven strategic emerging industries; and

(c) The Medium- to Long-Term Plan for the Development of Science and Technology.

8. **Gaps between China and international benchmarks in terms of technology level and production efficiency were still significant**. Due to disparities in internal management skills,

limited capacities for technology development and deployment, and uneven domestic incentives, there were still large needs for China to improve its technology levels and achieve further mitigation. For example, in 2009, each ton of steel, cement and, ethylene produced in China consumed 679 kg, 139 kg and 976 kg of standard coal equivalent, respectively, which were 11 percent, 18 percent, and 51 percent higher than levels in more advanced countries (source: China Energy Statistic Yearbook 2011).

1.2 Original Project Development Objectives /Global Environment Objectives (GEOs) and Key Indicators *(as approved)*

9. **The global environment objective (GEO) was to support China's efforts to assess climate mitigation and adaptation technology needs and to adopt corresponding global best practices.**

10. The GEO-level indicators were (a) technology assessments conducted; (b) capacity building support to climate technology assessment centers and networks; (c) measureable financial and economic benefits of accelerating technology transfer through small grant support to companies; and (d) lifetime direct GHG emissions avoided. The GEO is the same as the Project Development Objective (PDO), which was defined in the Project Appraisal Document (PAD).

1.3 Revised GEO and Key Indicators, and reasons/justification *(as approved by original approving authority)*

11. Neither the GEO nor the key indicators were revised during implementation.

1.4 Main Beneficiaries

12. Given the wide range of sectors that touch upon climate change mitigation and adaptation, the beneficiaries of this project identified at appraisal were extensive and included the following:

- The global environment, given that China is the world's largest emitter of CO_2.
- The overall Chinese population, through spillover effects in terms of: (a) local environmental co-benefits in the form of reduced air pollution from the reduced use of coal; and (b) national benefits in terms of adaptation to climate change. Chinese citizens most vulnerable to climate change, and those that would benefit from the application of global best-practice technologies for adaptation. Including those in the sectors most affected by climate change, such as agriculture, and people living in the most vulnerable areas, such as low-lying and coastal communities.

1.5 Original Components *(as approved)*

13. **The project consisted of the following five components**. Consistent with the overall objective, the project focused on the completion of TNA reports, the strengthening of national and provincial centers equipped to provide services to relevant stakeholders, and the piloting of a program to facilitate technology transfer, diffusion and scale-up.

14. **Component 1: Methodology Development, Technical Oversight, Synthesis and Dissemination.** This component supported the development of methodologies of the needs assessment and provided technical oversight through the governmental Project Steering Committee, the Project Technical Committee, and the network of technical peer reviewers. This component also provided a results synthesis, and an outlet for dissemination through a series of workshops coordinating the steering committee and other stakeholders. It adopted a consistent approach in application of the methodologies while still accounting for the differences in specific sectors. There were two specific subcomponents, as follows:

- Methodology development, technical oversight, peer review and synthesis of technology methodologies and assessments;
- Workshops and consultations.

15. **Component 2: Technology Assessments at the Sector and Provincial Levels.** This component supported the technology assessments of identified mitigation and adaptation sectors, as well as of several provinces. There were 20 planned assessments in total, divided into 12 mitigation sectors, 4 adaptation sectors, and 4 provincial assessments (see table 1).

Table 1. Component 2 - Mitigation and Adaption Sectors

Sub-component 2.1 Mitigation	Sub-component 2.2 Adaptation	Sub-component 2.3 Provincial-Level Assessments
1. Coal mining and oil & gas exploration[3] 2. Thermal Power 3. Renewable energy 4. Iron & Steel 5. Building materials manufacturing 6. Chemical industry 7. Nonferrous metallurgy 8. Transportation 9. Residential &commercial buildings 10. Agriculture, forestry, and land use 11. Carbon capture and sequestration (CCS) 12. Waste management	1. Agriculture, forests and ecosystems 2. Water resources 3. Urban 4. Disaster forecast and weather monitoring	1. Guangdong 2. Liaoning 3. Jiangxi 4. Shaanxi

16. For each assessment, two or more peer reviewers – both local and international -- were assigned to review and comment at each stage, that is, concept review, working draft, and final draft. These reviewers were selected and hired under the project for expertise specific to the prioritized technologies within each assessment.

17. **Component 3: Capacity Building to Support Climate Technology Networks.** This component included capacity building activities to support one national center, two sectoral centers, and four provincial networks with their own climate technology databases and personnel to serve as knowledge centers or networks. The capacity building counterparts were to be selected from existing centers of excellence in government institutions, universities, or industry associations.

[3] The World Bank Operational Guidance on Coal Screening Criteria does not apply to this case, because the scope of activities of the proposed project falls outside the scope covered by the Operational Guidance.

This component also intended to create a series of technology databases available to all project stakeholders; disseminated indicators based on data and trends in the database; and supported capacity building activities of relevant stakeholders to understand technology transfer mechanisms and the barriers to timely and widespread deployment of global best practice options.

18. **Component 4: Pilot Program to Accelerate Technology Transfer**. "Technology Improvement Grants" were to be awarded on a competitive and cost-sharing basis to small and medium sized companies for the purpose of supporting enterprise-level efforts to accelerate the process of technology modification, deployment, transfer, and/or diffusion.

19. The pilot program was designed to be completed in the first two years of the TNA, allowing adequate time for evaluating results. By combining the evaluation of the pilot competitive grants scheme with overall TNA findings – particularly the barriers to technology transfer identified in the assessments -- this component would also design one or more follow-up technology transfer mechanisms that would accelerate the ultimate deployment of prioritized technologies in both climate mitigation and adaptation after the project's completion. Furthermore, the capacity building elements of the project (Component 3) was designed to support not only technology assessments, but also the implementation of these follow-up actions.

20. **Component 5: Project Management Office.** This component supported the establishment and operation of the Project Management Office (PMO) for purposes of Project implementation, management, reporting, monitoring, coordination, and dissemination of Project results.

1.6 Revised Components

21. The project components were not revised.

1.7 Other Significant Changes

22. Extension and reallocation of funds: A restructuring was requested based on the findings in the midterm review (MTR) (December 17-19, 2014), it was approved on September 9, 2015. The PDO/GEO and the safeguards category remained the same. The changes proposed in this restructuring were requested through a letter from the Ministry of Finance (MoF) dated August 10, 2015. The restructuring encompassed:

(a) Extension of the grant closing date by seven months from November 30, 2015 to June 30, 2016;

(b) Reallocation of US$40,000 from the sub-grants disbursement category to the "goods, consultant services, training, workshops, study tours, and incremental costs" and corresponding changes to the disbursement estimate and implementation schedule.

2. Key Factors Affecting Implementation and Outcomes

2.1 Project Preparation, Design and Quality at Entry

Soundness of the Background Analysis

23. **Background analysis was technically sound.** The project design took into account of international practices and technical guidelines available at the time, as well as the latest UNFCCC negotiation progress as broader background. The project design addressed China's specific complexity and conditions through interviews and engagement with stakeholders. The key sectors with the most significant contribution to the country's emissions profile were rightfully identified.

24. **The Bank was in a unique position to support China on this project.** Based on global experiences with undertaking TNAs, international knowledge and lessons from multiple sectors was needed to support this initiative. For a large and diverse country such as China, the Bank needed to draw upon its extensive pool of global expertise across multiple business lines and sectors. Climate Change has been mainstreamed into the World Bank Group program in China, which has one of the IBRD's largest and most innovative climate change mitigation and adaptation investment programs with 40 percent of the IBRD's active portfolio of 112 projects supporting climate change. Most of the interventions are at the cutting edge of technology and institutional and financial reform, providing demonstrations that are then replicated at a significant scale through subsequent investment from China's own resources. Each year one to three climate-related projects enter the China-IBRD loan pipeline. This project on the TNA helps to guide the selection and preparation of the IBRD pipeline development. This mainstreaming in the lending portfolio has been supported with innovative pilots financed by the Global Environment Facility (GEF) and trust funds. China has one of the IBRD's largest GEF climate change portfolios with about 67 percent of its 21 GEF projects and total GEF commitments of about US$187 million currently. GEF grants, especially when blended with IBRD financing, have provided a successful platform to develop laws, policies and regulations, and to test and scale-up innovations at national and local levels on energy, transport, water resources and agriculture, helping to promote innovation, policy dialogue, and capacity building. On the other hand, through financial investment, the Bank is an important partner in supporting the adoption of new, cutting-edge technologies that might not be favored by commercial banks. Furthermore, the Bank had also been an important partner of China with a large portfolio of Clean Development Mechanism projects with carbon finance. This earlier collaboration in carbon finance has demonstrated successful examples in facilitating technology transfer in the clean energy, waste management and forestry sectors. The GoC had requested the Bank's support for the project.

Assessment of the Project Design

25. **PDO/GEOs**. The project objectives were clearly stated and reflected the achievable impacts within the project's resource and duration.

26. The project outcome can be fairly evaluated with the GEO level indicators. However, the project would have benefitted from indicators that could monitor and assess progress of implementation towards the achievement of the GEO. This shortcoming was later raised in Implementation Support Reports (ISR). Implementation tracking tools were utilized during implementation.

27. **Components**. Overall, the project design was innovative and comprehensive, however, the detailed activities designed created complexity.

28. **Innovative design of the project components.** Compared with other TNA projects, the project incorporated additional components, namely Component 3 of capacity building and Component 4 of a pilot program. Component 3 was to assist China to establish a technology transfer network for sustaining the institutional framework post-project. Component 4 of the Pilot Program to Accelerate Technology Transfer is the other highlight, which intended to facilitate and 'test drive' technology transfer on the ground. The pilot program would effectively support the client to identify challenges in the implementation process and accumulate lessons learned for informing policy making. With this design, the project was well positioned to advance the technology transfer agenda from assessment to adoption.

29. **Over-complex design for a small grant.** The project benefited from technical guidance provided under the international framework and from international experience at the time of its design. However, because the global process had only just begun, no other developing country as large as China or as diverse in terms of sectoral coverage had yet done a TNA. The project design had to take into consideration such challenges, through the sequencing of activities. The project design included methodology guidelines for mitigation and adaption under Component 1 to provide country level guidance to the large number of assessments across sectors and geographic coverage under Component 2. To address the specific needs of technical expertise and qualifications of each sectors, Component 2 consisted of 20 assessments, each one requiring the procurement of sector-specific consultants. Peer reviewers were also hired to support quality control of the assessments. In total, the project had 94 contracts, among which 73 were small individual consultant contracts.

30. While the technology assessment activities were designed to focus on specific sectors and geographic areas, additional considerations on the practicality of downstream implementation could have been taken. The US$5 million grant with dozens of small consultancy contracts entailed a high administrative burden and the detailed planning and sequencing of implementation activities was excessively rigid. This was particularly challenging for a PMO new to the World Bank's procurement and financial management (FM) policies. The nature of TNAs also imposed timing pressure, with sufficient time needed to collect stakeholder feedback. In addition, the outputs from the assessments were expected to provide technical guidance and inputs for capacity building in Component 3 and for the Pilot Program to Accelerate Technology Transfer in Component 4. Because both of these required lead time for evaluation and the design of follow-up actions, in the end these subsequent activities were rushed. Consideration could have been made for the design of contracting arrangements on the research assignments, as well as a reduction in the number of individual contracts for peer reviewers by better leveraging of each consultants' technical expertise and/or better utilization of the project technical committee.

31. **Institutional arrangements.** The risks related to institutional arrangements were not fully assessed or appreciated during preparation. The location of the PMO at a think-tank center that informs policies for the National Development and Reform Commission (NDRC) was an excellent idea, allowing the direct sharing of knowledge on China's climate change programs and international cooperation in the area of technology transfer. However, the risk of project implementation delays due to the frequent traveling of the PMO head and project director who needed to sign off on all contracts (but were instead involved in international climate change negotiations) was not anticipated.

32. **Adequacy of government commitment**. Overall, the government showed great commitment to the project and the policy agenda, including the decision to establish an institutional framework for technology transfer. The project involved considerable stakeholder participation.

33. **Significant government commitment at entry.** The Director General of the Department of Climate Change established and chaired a project steering committee for the project, consisting of director-level representatives from six ministries (including the MoF, Ministry of Industry and Information Technology, Ministry of Science and Technology, Ministry of Housing and Urban Development, Ministry of Agriculture and Ministry of Environmental Protection) to ensure close coordination and cross-sectoral engagement and inputs. This was the first grant of US$5 million or above that had been received by the department. A senior official at Deputy Director General level was subsequently appointed as the National Project Director, and a competent PMO was established with qualified and technically-relevant staff.

34. **Participatory process in preparation.** Project design and preparation was carried out with widespread engagement of both domestic and international stakeholders, including relevant Chinese ministries and United Nations Environment Programme and United Nations Development Programme.

35. **Project risks**. The overall risk of the project was assessed to be substantial at appraisal. The PAD raised the risk of uncertainty in international climate change negotiation with respect to technology transfer, and the Bank's ability to support technology development for a single country without it appearing to be preferential. These were valid concerns at the time of project preparation after COP 15 in Copenhagen in 2009. The inability of negotiation outcomes to meet the high public expectations created considerable tension among countries, and therefore the risk of perceived political pressure by the World Bank was tenable. Another risk was China's unwillingness to disclose and share project outputs, which was also affected by the timing of the negotiation process. Nevertheless, none of these risks materialized during implementation. China subsequently has taken a pro-active position on climate change negotiations post-Copenhagen. For example, China established a national carbon intensity reduction target in 2009, began a pilot emissions trading scheme (ETS) in 2011, the high-profile presidential announcement in Paris of a national ETS launched by 2017, and at the same time the submission of China's Nationally Determined Contributions (NDCs). As the political landscape evolved, the measures put into place to address the originally anticipated risks –the large number of individual consultants for peer-reviewing and quality assurance – turned out to be a significant administrative burden for the PMO. This became one of the key reasons for the delay in implementation progress.

2.2 Implementation

36. All activities were completed by project closure, despite the fact that the project faced implementation challenges from the beginning. Following the MTR, implementation progress saw a steady improvement.

37. **A dedicated project management team for implementation of complex project**. As discussed earlier, the comprehensive project design included a large number of small contracts (94 contracts including 73 individual consultant contracts). To address the significant workload, the

project had a PMO that was larger than the typical size for a technical assistance project. To support the national project director and the PMO manager, the PMO hired a full-time administrative manager, a full-time project officer, a procurement officer, and an FM officer. Without the two full-time PMO staff and the procurement officer dedicated to day-to-day management, the implementation of such a large number of contracts would not have been possible.

38. **Out-sourcing the pilot program management to leverage external capacity**. Implementation of the pilot program was led by an external advisory firm that was technically competent with highly qualified staff. This arrangement was incorporated into the project design based on agreements between the Bank and the PMO. Given the large administrative burden of the PMO, this approach was critical in completing the implementation of the pilot program within the project period. The technical advisory firm, contracted since May 2013, had access to sectoral knowledge and market information which put it in a strong position to facilitate the call for proposals and technical evaluations. Another advantage was that the contractor was in a position to provide professional evaluation of the pilots, as well as propose recommendations on the design of future follow-up actions.

39. **Strong policy leadership, but overly complex administrative procedures**. In order to provide direct support to the policy agenda and build technical capacity, the project was overseen at the departmental director general level while the PMO was led by managers involved in the front lines of the UNFCCC negotiations. This arrangement ensured an effective policy dialogue: technical inputs from the project level were available for national policy making and international knowledge sharing. However, active engagement on UNFCCC negotiations required a significant amount of international travel. The PMO managers were also key technical researchers at a government-affiliated think tank. Respecting the government's rules and procedures, the project's institution arrangement required Director General-level sign-off for the approval of contracts regardless of size or amount. Because both the national project director and the PMO manager were generally engaged with other responsibilities as well as extensive travel, implementation delays were a persistent issue until most of the contracts were committed. Notwithstanding the strong implementation capacity of the PMO, they were not empowered to make decisions, and thus could not provide a full solution to the implementation challenges mentioned above.

40. **Changes at the MTR.** Due to the implementation delays, the MTR was postponed from March 2014 to September 2014, and later on, to December 2014, given that the majority of the technology assessment contracts were still being procured in September. All assessments were contracted by the MTR, which therefore focused on evaluating implementation progress and the likeliness of achieving the GEO, as well as discussions on the resources needed for implementation. The MTR concluded that the most challenging implementation tasks had been completed, and that the project could achieve its objectives if the implementation were extended. As a result, the MTR proposed a level II restructuring to extend the project closing date by 7 months from November 30, 2015 to June 30, 2016. In addition, US$40,000 from the sub-grants disbursement category was reallocated to the "goods, consultant services, training, workshops, study tours, and incremental costs," and corresponding changes were made to the disbursement estimates and implementation schedule.

2.3 Monitoring and Evaluation (M&E) Design, Implementation and Utilization

41. **Design**. The design of the results framework was sound and was intended to allow the evaluation of impacts of both technology assessments and the capacity building activities by tracking the cumulative number of outputs delivered. A schedule of deliverables were arranged throughout the three years of implementation under the assumption that the activities could be launched and carried out in a sequenced and gradual process. For example, it was expected that in the first year, two technology assessments would be completed, by year two a total of 10 assessments would be completed, and by year three all 20 assessments would be completed. The information and data required for tracking would be accessible and credible for the design.

42. **Implementation**. Additional measures were adopted during implementation to supplement the results framework for implementation tracking. In practice, the implementation of activities did not exactly follow the original schedule. Because the 20 assessments covered a wide spectrum of sectors, sequencing was not achieved. In practice, the technical assessments took place in parallel during the implementation period because each required a similar budget and more or less the same amount of time to complete. The design thus created challenges for the PMO and for the Bank’s supervision team to track implementation progress. In the end, the project was completed with many of the outputs delivered only towards to end of the project. Implementation was initially carried out following the original design framework, however, an additional monitoring tool was developed during implementation to allow the PMO and the Bank to better track the procurement progress and the interim disbursement status. The PMO implemented the M&E protocol in a timely manner.

43. **Utilization**. As a result of the implementation delays, additional work was required to track resource allocation. The results framework became less relevant for tracking implementation. Nevertheless, the PMO and the Bank’s team relied on the additional monitoring tool developed during implementation. The Bank also used its internal operational system and trust fund portal to track resource data to support the PMO’s decision making on the use of the remaining fund balance. The results framework was then used for evaluating the project outcomes at the end of implementation.

2.4 Safeguard and Fiduciary Compliance

44. **Environmental safeguards**. The project was identified as a category C project since no adverse environmental impacts were foreseen from project activities. Although OP 4.01 (Environmental Assessment) applied as per Bank practice, no further environmental safeguard action was required.

45. **Social safeguards**. The project did not trigger social policies.

46. **FM**. The project had an adequate project FM system that provided, with reasonable assurance, accurate and timely information that the grant was used for the intended purposes. The project accounting and financial reporting were in line with the regulations issued by the MoF, with the requirements specified in the grant agreement. No significant FM issues were noted throughout the project implementation and the FM-related weaknesses raised during supervision and by auditor were resolved on a timely basis. The project audit reports all had unqualified audit

opinions. In addition, the withdrawal procedure and funds flow arrangements were appropriate. The grant proceeds were disbursed for the project in a timely manner.

47. **Procurement**. A procurement officer experienced in Bank's policies and procurement was on board from the project start, and remained engaged throughout the implementation period. No domestic or World Bank non-compliance issues were reported or identified against domestic and Bank review procedures. A key challenge was managing the selection process for a large number of small-value consulting contracts, as well as contract monitoring and supervision to ensure that the deliverables were of high quality. The key measure to address this was by hiring individual technical consultants in addition to the procurement officer, the project's administration manager, and the project official to support preparation of the terms of reference (TOR) of contracts and management of the technical elements during the procurement process.

2.5 Post-completion Operation/Next Phase

48. All key outputs have been delivered. The project has delivered an initial set of technical guidance assessments, and established national, provincial and sectoral training center networks and information databases. In addition, the pilot program has produced case studies, proposals for business models, and collected valuable lessons learned. These outputs have laid a solid foundation for the next phase of promoting and rolling out additional climate change technology programs. Options for future technology transfer mechanisms or platforms were proposed in an analytical study based on the lessons learned from the business cases of the pilot program.

49. **The national capacity building center has been established in the National Strategic Research and International Cooperation Center for Climate Change (NCSC),** which is a research and think tank affiliated with the NDRC. The team led the set-up and day-to-day management of the center and the online platform, and are the core team of experts engaged in supporting the development of China's NDC. The data collected throughout project implementation has made a large contribution to the country's climate-related technology research and the development of China's FYP for climate change targets and actions which will play an increasing role in China's NDC implementation. Nevertheless, it is noted that upon project completion, the PMO was closed due to budget constraints. Technical staff remain in the research teams of the NCSC, and the NCSC continues to serve as the national level think tank supporting the NDRC on the climate technology agenda.

50. Under the UNFCCC framework, China is considering initiating the preparation of a Technology Action Plan based on the results of the project. As the work progresses, the GoC may seek further international technical assistance in the development of the plan.

3. Assessment of Outcomes

3.1 Relevance of Objectives, Design and Implementation

Rating: High

51. **The objective of the project was and still remains highly relevant to the country's development and climate change strategies.** Since the initial design of the project, China has taken further actions to advance its commitment to combatting global climate change. China's NDC was submitted to the UNFCCC in 2015, and in September 2016, China ratified the Paris

Agreement. The NDC lays out China's commitment for 2030 to achieve peak CO_2 emissions, lower CO_2 emissions per unit of GDP by 60-65 percent from 2005 levels, increase the share of non-fossil fuels in primary energy consumption to around 20 percent, and increase the forest stock volume by around 4.5 billion cubic meters compared to 2005 levels. These commitments build on strong near-term national actions on climate change. The 13th FYP (2016-2020) includes targets for 2020 to reduce the CO_2 intensity of GDP by 18 percent, increase the share of non-fossil fuel in primary energy to 15 percent, and increase the forest stock to 16.5 billion cubic meters.

52. **The objective of the project continues to be highly relevant to the World Bank and its client strategy**. The Country Partnership Strategy FY13-FY16 for China has as its first pillar to "Support Greener Growth." This project supports the strengthening of institutional and financial mechanisms for addressing climate change, and for promoting access to new technologies to address both mitigation and adaptation challenges.

53. **The project design and implementation arrangements were highly relevant to the objectives of the project**, encompassing the provision of technical guidelines and analytical processes for climate technology development, capacity building that would remain within China's institutional framework after the project, and a pilot program to facilitate initial climate technology development initiatives. For the pilot program, initial stakeholder reactions and feedback were collected and support the adoption of further pro-active policies in the field. At the launch of the pilot program, over 20 enterprises submitted expressions of interest. A total of nine candidates were awarded sub-grants totaling US$760,000.[4] The pilot program leveraged an additional US$3.5 million in investment and resulted in a lifecycle direct emission reductions of over 4.3 million tCO_2e.

54. All the project activities have been completed within the implementation period. Details of outputs are provided in Annex 2.

3.2 Achievement of Global Environmental Objectives

Rating: Satisfactory

55. The project's GEO is 'to support China's efforts to assess climate mitigation and adaptation technology needs and adopt corresponding global best practices'.

I. Achievement of the first objective of supporting China to assess climate mitigation and adaptation technology needs: Satisfactory

56. **All 20 comprehensive assessments were completed.** Component 1 and 2 were designed to provide technical oversight and delivery of the TNAs. Although delayed from the original schedule, the technical guidelines and all assessments were completed within the implementation period. This was the first national TNA for climate change in China. With the support of the project a comprehensive and systematic review of the status quo of key climate change technologies in China has been done through the implementation of 20 climate TNAs. Overall, the project has identified 12 mitigation sectors, 4 adaptation sectors and 4 provincial areas to analyze specific technology needs to address climate change. Compared with TNAs that have been done in other

[4] During implementation one of the sub-grant pilots dropped out during to administrative approval delay with the local authorities. 8 pilots have been implemented and the actual disbursement of sub-grant was US$680,000.

countries, which have looked at only one to three sectors, this project is the first and only comprehensive TNA that covers 16 sectors on both mitigation and adaptation. The project, due to China's large geographic and sectoral coverage, analyzed a wide range of technologies and identified a list of priority technologies in need by China to tackle climate change. This list, putting into the global TNA context, is comprehensive. Tables 2 and 3 are the priority technologies that have been assessed and analyzed in details.

Table 2. A Short List of Priority Technologies for Mitigation

No.	Sector	Name of technologies
1	Coal mining	Abandoned Coal-bed methane (gas) extraction technology
2		The Extremely low concentration coal-bed gas power generation technology (the technology of flow reactor)
3	Oil and gas exploration and development	surface engineering
4		Improvement of water drive
5		Surface engineering
6		Emission reduction and improving efficiency
7	Thermal power industry	High parameter and large capacity, and the generation of ultra-supercritical power
8		natural gas combined cycle power-generation
9		Distributed cold, hot and electricity tri-generation (CCHP)
10		Retrofitting of the steam turbine system
11		The deep use of flue gas waste heat and latent heat
12	Renewable energ y industry	Offshore wind power technology
13		Hull cell photovoltaic power generation technology)
14		Aviation bio-fuel technologies
15		Solar thermal power generation technology
16	Iron and steel ind ustry	Gas steam combined cycle power generation technology (150MW grade)
17		The flue gas conditioning technology
18		Smelting reduction iron-making technology (including COREX, FINEX Technology)
19		Recycling technology of sintering flue gas
20	Building Materials Industry	Cement kiln co-processing of municipal solid waste (RDF disposal)
21		Cement production information system
22		Cement kilns intelligent optimization control system
23		New dry milling technology of building ceramics
24	Chemical Industry	Hydraulic turbine energy-saving technology
25		No CO_2 emission pulverized coal pressurized delivery technology
26		Opening Heat Pump Technology
27		Hydro step-less compressor air conditioning systems
28		High CO_2 natural gas making methanol technology

No.	Sector	Name of technologies
29		The ion-exchange membrane technology
30	Non-ferrous metal industry	Enriched flash smelting technology
31		Liquid oxygen bottom blowing smelting reduction of high lead slag bottom blowing lead smelting technology)
32		Gas firing automatic temperature Control of aluminum reduction cell technology)
33	Transportation	Pure electric vehicles
34		LNG ships
35		Energy saving transformation of aviation engine
36		Aircraft engine cleaning
37		Fuel cell technology
38	Residential housing and commercial building	Insulation: graphite modified expandable polystyrene
39		Insulation: outer thermal insulation and expansion fire retardant coating for foamed material and cellulose material
40		Insulation: roof waterproof insulation film, self-adhesive, acid alkali, special metal surface layer, glass fiber, base membrane
41		Door and window curtain wall technology: ultra-low energy consumption building door
42		Door and window curtain wall technology: self-expanding sealing belt for energy saving windows and door
43		Door and window curtain wall technology: waterproof sealing cloth system
44		Heating and air conditioning system: fresh air and exhaust heat recovery, heat and moisture exchange membrane
45	Agriculture, forest and land utilization	High efficiency utilization of nitrogen fertilizer
46		Breeding technology of rice varieties
47		Afforestation increase remit technology
48		Forest management increase remit emission reduction technology
49		Comprehensive management technology of land utilization
50	CCS	Separation of CO_2 by chemical absorption method
51		Oxygen-enriched combustion technology
52		Hydrogen-enriched combustion gas turbine technology
53		Underground materials and equipment with long life and corrosion resistance
54		Safety monitoring, evaluation and risk management techniques
55	Waste disposal	Landfill gas collection and utilization technology
56		Waste-to-energy gas turbine process combination
57		High solid anaerobic biogas technology

Table 3. A Short List of Priority Technologies for Adaptation

No.	Sector	Sub-sector	Technology	Technology Type
1	Agriculture and Forest Ecosystem	Agricultural Water-saving Technology	Degradable Mulch	Hardware
2		Agricultural Water-saving Technology	Pipeline Water Delivery Technology	Hard/software
3		Precision Agriculture Technology	Precision Water and Fertilizer Management Technology	Software
4		Precision Agriculture Technology	Intelligent Agricultural Machinery	Hardware
5		Stress-tolerant Varietal Breeding Technology	Insect-resistant Cotton, Anti-rice Blast Breeding in Rice, Drought Resistance Breeding in Wheat, Drought Resistance Breeding in Wheat and Corn and other Breeding Technologies	Hardware
6		Forest Ecosystem	Boreal Coniferous Forest Timber Felling Management Technology that can adapt to climate change	Software and Orgware[5] Technology
7		Forest Ecosystem	Adaptive Forest Management Technology to manage trade-offs between forest products and service supply capacity	Software and Orgware Technology
8	Water Resources	Unconventional Water Resource Utilization	Rainwater Accumulation Utilization Technology	Hardware
9		Agriculture Water saving	Drip Irrigation Technology	Hardware
10		Unconventional Water Resource Utilization	Water Developing and Integrated Utilization Technology in Water Poor Layer	Hardware
11		Water Source Project Construction	Pumping Irrigation and Water Saving Technology by Solar Photovoltaic	Hardware
12		Water Source Project Construction	Water Supply Technology by Rubber Dam	Hardware
13	Urban	Infrastructure	Sponge City Planning and Operative Technology	Hard/software Technology
14		City Planning	Climate Change Adaptive Planning System Building Technology	Hardware and Orgware Technology
15		City Planning	Urban Green Space Layout Optimization Technology	Hardware
16		Infrastructure	Key Technology of Long Distance, High Lift and Large Flow in Water Diversion Project	Hardware
17		Infrastructure	Roof Greening Technology	Hard/software Technology

[5] Authors of the report refer to 'orgware technology' as the capacity building of different institutional actors involved in the adaptation process of a new technology.

18		Infrastructure	Permeable Pavement Application Technology	Hardware
19	Disaster Forecast and Weather Monitoring	Impact Assessment and Adaptation	Climate & Climate Change Impact Assessment	Software
20		Impact Assessment and Adaptation	Environment related Weather Numerical Modeling Technology	Software
21		Weather Forecast	Regional NWP Technique	Software
22		Data Analysis	Meteorological Data Reanalysis Technique, Global and Regional Products	Software
23		Weather Monitoring	Weather Radar Monitoring	Hard/software Technology

57. **A systematic analytical methodology and guideline has been developed.** At the initial stage of the project, national TNA guidelines for climate change mitigation and adaptation were developed as the first sets of outputs. These general guidelines were applied by all the TNAs of the project at the sectoral level. Following these guidelines, key sectors and sub-sectors are identified based on national macro-level strategies and policies. Within each sector, multiple technologies are listed. Based on an index system, the long list of technologies are analyzed, through the scoring of multiple indicators, for example, emission reduction potential and costs. A short list of priority technologies have been formulated as a result of this analytical step. The project has assessed 476 technologies in China, and has analyzed in detail 120 priority technologies. A summary of the number of technologies analyzed in the process are presented in table 4 below.

Table 4. Summary of Long-listed and Shortlisted Technologies

No.	Sectors / Provinces	Long-listed Technologies	Short-listed Technology
Mitigation			
M001	Coal Mining and Oil and Gas Exploration	18	6
M002	Thermal Power	10	5
M003	Renewable Energy	19	4
M004	Iron and Steel	18	4
M005	Building Materials Manufacture	28	4
M006	Chemical Industry	30	6
M007	Nonferrous Metallurgy	95	3
M008	Transportation	21	5
M009	Residential and Commercial Buildings	20	7
M010	Agriculture, Forest and Land use	18	5
M011	CCS	30	5
M012	Waste Management	30	3
Adaptation			
A001	Agriculture, Forest and Ecosystem	24	7
A002	Water Resources	16	5
A003	Urban	16	6
A004	Disaster Forecast and Weather Monitoring	18	5
Provincial			
P001	Guangdong	18	5
P002	Liaoning	15	5
P003	Jiangxi	15	5
P004	Shaanxi	17	5
	Total	476	120

58. Each sector and their priority technologies are further analyzed with a systematic process to identify gaps and barriers in technology transfer. Each assessment generated a set of policy recommendations relevant to each sector. The technical guidelines and the assessments have lied a strong foundation for China to roll out and update TNA across the country. Box 1 is a summary of the technical process and considerations of the TNA.

Box 1. Summary of the Technology Assessment Process

Specifically on mitigation, the assessments started with the identification of sectors based on emissions profile and mitigation potential. The process also took into consideration national strategies and statistics. The next step was compilation of most of the available mitigation technologies under each sector, based on literature review and feedback collected from seminars, expert consultation, and field visits. This broad list of general technologies was further screened and evaluated by a set of key indicators to generate a long list of technologies. The long list was sorted and filtered based on two main methodologies. The first one is based on emission reduction potential and cost of emission reduction of the specific technology. Where information is sufficient, abatement cost curve modeling is applied to identify the technology choice at the minimum cost. The other selection method was through the application of multi criteria decision analysis (MCDA) and analytic hierarchy process (AHP) method. This is an index scoring system. Through applying score and weights to a set of technical indicators and the qualitative evaluations, the priority scores are calculated for ranking the technologies. Based on the identified priority technologies, further detailed information was collected to determine the development stage of the core technologies. Technologies in different development stages require support of different means. This step was particularly important to identifying gaps and penetration barriers. Finally, through the literature research and consultations, analysis of gaps and obstacles are done in more details respecting development stage of specific technologies and generate recommendations for next steps of technology transfer.

Coal industry, non-ferrous metal industry, agriculture, forestry and land use industry used MCDA and the method of AHP. Thermal power, renewable energy industry, iron and steel, building materials, transportation, and waste treatment industry applied a combination of abatement cost curve, MCDA and AHP qualitative and quantitative methodologies. A qualitative evaluation method was applied in the chemical industry. Residential and commercial building industry also uses MCDA and AHP methods, but different from other sectors, residential and commercial building energy savings and emissions reduction is mainly reflected on a combination of technologies as an overall solution. CCS sector was assessed on two aspects, that is, technology development stage and needs. The evaluation index includes four indicators, that is, technology sustainability, feasibility, economic model and replication potential. For the geological utilization and storage of CO_2, multiple factors were assessed including emission reduction potential, economic costs, law and regulation, safety risks and development potential and other indicators.

Similarly, on adaptation, based on the national assessment guideline, each sector developed sectoral specific methodology for climate adaptation TNAs, taking into account sectoral-specific characteristics, technology attributes, as well as available data and information. Due to lack of data and information, as well as the difficulty in quantifying some key indicators such as vulnerability and adaptation costs, the assessments used both qualitative and quantitative analyses based on the above methodological framework. The assessments also used stakeholder interviews and expert ratings to determine the final list of technologies.

59. **A rich pool of analytical data has been collected and will continue to contribute to informing China's climate technology and broader policies.** The project's national capacity building center has been established at the NCSC, the key research institute supporting the NDRC on the climate policies. These analytical tools and initial set of systematically organized data at the national capacity building center has contributed to the formulation of climate technology policies, specifically to the annual publication of China's Low Carbon Technology Catalogue by the NDRC. The Low Carbon Technology Catalogue is an important guidance document for promoting investment in climate friendly technologies throughout the country. Project data on mitigation potential, climate risk costs and technology investment costs provides a solid analytical basis to inform climate policy development at both domestic level and international level where China

participates in negotiations and cooperation dialogues. For example, the analytical research works for China's NDCs have been led by a team of national experts, many of them are either experts at the NCSC or experts that have been advising the TNA project. The project database served the NDC research work and informed the policy making. With the considerations above, achievement of the first objective of the GEO is rated as satisfactory.

II. Achievement of the second objective of supporting China to adopt corresponding global best practices: Satisfactory

60. **The institutional arrangements for the project was established to support future technology transfer**. Component 3 supported the establishment of a network of technology transfer capacity building centers. The national level center was established at the NCSC. Two sectoral centers have also been established, that is, the power sector center at the State Grid Energy Research Institute and the building sector center at the Center of Science and Technology of Construction under Ministry of Housing and Urban-Rural Development (MOHURD). The provincial centers have been housed inside institutions at respective provinces, namely Guangdong Climate Center, Liaoning International Engineering Consulting Center, Institute of Energy of Jiangxi Academy of Sciences and Shaanxi Industrial Technology Research Institute. Centers at each level has dedicated staff, and led by division chief/director level officials. Table 5 summarize the assigned staff responsible for technology transfer agenda within the centers. The network mechanism is supported by an information technology infrastructure, which consists of an online database and website for data sharing within the network and dissemination of information to broader stakeholders.[6]

Table 5. Technology Transfer Capacity Building Centers

Center	**Organization**	**Responsible person**
National Center	NCSC	Director
Power sector	State Grid Energy Research Institute	Deputy Director
Building sector	Center of Science and Technology of Construction, MOHURD	Division chief
Liaoning Province	Liaoning International Engineering Consulting Center	Deputy Director
Guangdong Province	Guangdong Climate Center	Lead Specialist
Jiangxi Province	Institute of Energy of Jiangxi Academy of Sciences	Deputy Director
Shaanxi Province	Shaanxi Industrial Technology Research Institute	Director

61. The national center has delivered a general operational manual for the network and the centers, as well as the national level database and online platform for data storage and management. Training has been provided by the national center to the network members on the operational manual and the use of database. The provincial and sectoral centers have completed data collection, stakeholder identification and engagement activities on the ground. The national center has aggregated the data and input to the national database. These formed a strong institutional foundation to support future technology transfer. After the project period, supervisor and technical

[6] http://www.tnachina.org/cn/index.aspx

staff remain in their organizations, while technology transfer function has been mainstreamed into their day-to-day responsibilities.

62. **All out-reach and training activities were conducted, despite delays in the TNAs.** Most of data and business case studies information were uploaded to the online platform towards the end of the implementation. The network has collectively provided 20 trainings and 6 workshops to 1,281 participants. Most of these trainings and workshop focused on the top-down operational manual training, general methodology, local data collection, and stakeholder feedback solicitation. One of the key activities on dissemination of assessment results, and consultation with stakeholders on operationalizing the deployment process had to be done on a limited scale and timeframe. The project reached and surpassed the outcome indicators for this aspect, but on hindsight, if the project had more time it could have benefited from a deeper and wider engagement with stakeholders, that could have been carried out to facilitate solid rounds of user feedback and inputs on the next steps for the adoption of technologies if Further stakeholder feedback and technology adoption is expected to be advanced after the project using the existing network that was established.

Box 2: Stakeholder Out-reach and Training Examples

Shaanxi experience sharing workshop

An experience workshop was hosted by the Shaanxi Provincial Center in Xi'an on March 25, 2016. To facilitate public sector, business and leading enterprises exchange on policy updates and experience sharing, the workshop invited representatives from the Provincial Information and Technology Bureau, Hydrological Resource Bureau, academia and business representatives. Over 80 stakeholders participated in the one-day workshop. After the Shaanxi Provincial Center presented the policy updates, representatives of the business sector shared their experience in technology transfer business case studies on 7 different technologies. Different business models were discussed, lessons learned on failure and success cases were shared with participants.

Power sector capacity building workshop

The Power Sector Capacity Building Center, State Grid Energy Research Institute, hosted a capacity building workshop on December 16, 2015 in Beijing. 50 participants from research institutes, power sector state-owned enterprises, industrial associations, international companies joined the workshop. The dissemination of the sectoral TNA interim findings were shared for stakeholder comments and inputs. Representatives from the private sector, that is, Siemens and Whirlpool, shared business case studies on emission reduction technology transfer to China, and the policy trends and updates was presented by leading researchers in this field.

63. **The Pilot Program (Component 4) has supported the deployment of 8 technology transfer projects which overcame obstacles in implementation**. The sub-grants have leveraged US$3.5 million investment from the private sector at a 1 to 5 ratio, and delivered over 4.3 million

tCO_2e of emissions reduction in the projects' life cycle. Table 6 is a summary of the pilot projects. Another table of the pilot projects with further information can be found in Annex 12. Options of future technology transfer mechanism or platform were proposed in an analytical study based on the lessons learned from the business cases of the pilot program. This also provides important contributions to accelerating deployment of priority technologies in both climate mitigation and adaptation after the project's completion. A short-coming, with the implementation delay, little time was left to leverage further impacts from the pilot program within the project period. The pilot program was designed to be completed by the second year of the project, to allow sufficient time for post-evaluation and potentially a downstream operation to support the actual scaling up/implementation of technology could have been designed.

Table 6. A List of the Pilot Projects

No.	Pilot Projects	Grants from TNA Project (US$)	Own financial contribution (US$)	Lifetime direct GHG emissions avoided (tCO_2 eq)
1	Large-scaled Data Center Energy Efficiency Optimization System Pilot Program	80,000	140,000	169,521
2	Design and Demonstration of Effective PV/Diesel/Storage Power System based on Energy Management System	80,000	200,000	706
3	Improving Energy Efficiency of Large Wind Turbines Pilot Program	100,000	132,000	178,398
4	Fiber Membrane Decarbonization and Purification of Landfill Gas for NGV Pilot Program	100,000	1,400,000	231,548
5	Inlet Air Cooling System of Gas Turbine Front End and Waste Heat's Deep Utilization of After End Program	60,000	170,000	393,007
6	Qinhuangdao Centrifuge Heat Pump Project	80,000	331,900	65,273
7	The Pilot-Testing of FS12 On-Fire Side Energy Efficiency Promotion Technology in China's Energy Sector	100,000	231,908	3,299,973
8	Pilot Program of Regeneration of Lead-acid Batteries by Solar Energy	80,000	894,000	27,967
	Total	**680,000**	**3,499,808**	**4,366,393**

3.3 Efficiency

64. **The project's efficiency is rated as substantial**. The project implemented all the planned activities and achieved all targets within the allocated resources, as planned.

65. This is the first comprehensive TNA in a large country covering sixteen sectors with pilot sub-grants, hence, it is hard to compare the project with TNAs from other countries. Although TNAs have been done in many countries, each one has followed a country-driven approach that suits its specific needs. Since 2009, the GEF has provided funding to three phases of global TNA development, totaling about US$19.4 million including the on-going and most recent Phase III. This support has been implemented at the global level by the United Nations Environment Programme, covering 64 countries' TNA. The average funding of each country is about US$300,000, focusing on one or two sectors, and thus far smaller than this US$5 million grant.

66. The China TNA Project also follows the general TNA technical guidelines, however, it is a country project that covers most sectors, and with an additional dimension that looks at provincial-specific needs. National level guidelines were developed to provide more detailed and standardized guidance to the sectors. The China TNA has also included capacity building components that involve establishment of capacity building networks, databases, and knowledge platform. The technology transfer pilot program is not only additional to a standard TNA technical analysis, it also demonstrates success in leveraging investment from businesses. Given the differences in width, depth and scale, it is not possible to judge the efficiency of this grant compared with other TNAs.

67. **Fund utilization**. A total of 90.52 percent of the grant was disbursed. Funding was well utilized. The sub-grants disbursed US$760,000, leveraged US$3.5 million investment from the private sector. The key factor that contributed to the savings was the devaluation of the RMB by 9.2 percent relative to the U.S. dollar during implementation.

68. **Economic and financial analysis**. No formal, analytical economic analysis was made at this GEF-funded project at appraisal. An economic analysis was done based on the quantifiable economic benefits delivered by the Pilot Program. According to the PMO's economic analysis, verified by the Bank team, the project has achieved direct lifetime emissions reduction through the sub-grants projects estimated at 4,366,393 tCO_2e. Based on the total project grant of US$5 million and the leveraged private sector investment of US$3.5 million by the pilot program, the project overall has delivered each ton of CO_2 emission reduction at a cost of US$1.95. This is below the current international carbon price of US$5.3/ton (EU ETS unit of allowance as of November 28, 2016), and significantly below the Bank's shadow price of carbon which is in the range of US$20/ton. Annex 3 provides further details on the economic analysis.

3.4 Justification of Overall Outcome Rating

Rating: Satisfactory

69. Based on the high relevance of project objectives and relevance of design and implementation, satisfactory achievement of project objectives and substantial efficiency, the overall outcome is rated satisfactory. The project has delivered solid analytical grounds to TNAs, set-up of an institutional structure, and delivered capacity building activities that contribute to technology adoption.

3.5 Overarching Themes, Other Outcomes and Impacts

(a) Poverty Impacts, Gender Aspects, and Social Development

70. The project's social benefits include assisting industries in identifying low carbon technology solutions and ultimately promote cleaner industries and GHG reductions, which benefit the Chinese and the World population. Equally important, on the adaptation side, in a country like China of large size and diversity, a large population is vulnerable to a wide variety of climate change threats, especially the ones do not have economic advantages. Stakeholders will benefit from better technologies and capacity in forecasting and protection from the increased incidence of extreme weather events such as flooding and droughts, and yields of crops in the agriculture sector.

(b) Institutional Change/Strengthening

71. **The project has specifically targeted institutional strengthening**. Under component 3, support was provided to establish a national technology center with provincial and sectoral center-networks and supplemented with the database and information network. It is expected China will benefit from the continuous operation of the network after the project completion.

72. **The national center**. China Climate Technology Networks National Center was established within the NCSC. The NCSC is also China's National Designated Entity (NDE) under the UNFCCC's Climate Technology Center and Networks. A standardized operational manual for the network has been developed by the NCSC.

73. **Sectoral centers**. With the support of the project, two sectoral centers were established, namely the power sector center housed in the National Power Grid Energy Research Institute and the building sector center housed in the Ministry of Housing, Urban and Rural Development Technology Promotion Center.

74. **Provincial centers and networks**. Four provincial centers have been set up in Guangdong, Liaoning, Jiangxi and Shaanxi. Each of the centers is staffed with at least two full-time employees and supported with technical guidance and operation manuals. The centers have started their initial tasks of information collection that feeds into the climate technology database and network platform. The centers have collected local and sectoral technology transfer business cases and conducted analysis on the lessons learned. The selection of the centers was based on the technical relevance, access to stakeholders, and capacity to carry out the required roles and responsibilities. All existing centers have received training on the networks. The network provides a foundation for replication of provincial and sectoral centers with standard technical guidance. This potentially creates a significant impact for the rolling out of a technology transfer network nationwide.

(c) Other Unintended Outcomes and Impacts *(positive or negative, if any)*

75. The project has delivered positive contributions to the preparation of China's NDC. The data collection and assessments of technologies across the sectors have built up a solid data foundation that was required by the analytical process for the definition of the NDC. The same data foundation has also contributed to the feasibility analysis of the energy and climate change

targets of China's 13th national FYP. The NDRC, being the central agency responsible for China's economic planning, was able to directly benefit from the rich information pool.

3.6 Summary of Findings of Beneficiary Survey and/or Stakeholder Workshops

76. Stakeholder mapping has been conducted which covers governmental agencies, private sector businesses and industrial associations, financial institutions and service providers. According to the stakeholder consultation summary report,[7] among 202 targeted stakeholders, 88 valid feedbacks were received responding to the questionnaire on the usefulness of the project's climate technology network. About 94 percent of the respondents agreed the climate technology network is useful to their work and 83 percent indicated interest in collaboration with the network.

4. Assessment of Risk to Development Outcome

Rating: Moderate

77. The project is fully in line with China's climate change policy agenda. Technology transfer has also been one of the key topics in the international climate change negotiation process. Kick-starting the technology transfer mechanism and sustaining the operation of technology transfer networks relies on multiple factors, including an enabling policy environment domestically and a sound and robust international agreement and action plan. Domestically, the government will need to continue enhancing actions to put in place fiscal and taxation incentives, funding supports, capacity building and awareness building, and the government's commitment in addressing intellectual property rights. Commitment from the international community is as important as domestic efforts for international climate technology transfer. Financing gaps, political support and commercial interests will need to find common ground through international conventions and cooperation. The GoC has taken a proactive role in international negotiations and climate change efforts. This has created a favorable environment for the next step of technology transfer to China following the project. While multiple factors will need to come together for successful transfer of climate technologies globally, the project provides important outputs for China to play a positive role.

5. Assessment of Bank and Borrower Performance

5.1 Bank

(a) Bank Performance in Ensuring Quality at Entry

Rating: Moderately Satisfactory.

78. Global experiences and lessons for preparing and implementing TNAs were appropriately assessed and incorporated by the Bank in project design and formulation. Building upon the experience of other TNA projects, the task team added components for capacity building and the pilot program which were useful to China in translating assessments into concrete actions. A short-coming of the preparation was that it took 25 months, which is longer than usual for preparing a small grant. This also impacted the timeliness of the provision of support. Moreover, the main short-coming was that the project design resulted in complex procurement arrangements due to the large number of small contracts. At "quality of entry," the Bank team did not anticipate the lengthy

[7] Shanghai Environment and Energy Exchange and South-South Technology Exchange, May 2016.

approval process the PMO had to follow in order to sign each contract. Either the design could have been different, for example, to have larger but fewer contracts, or the task team could have planned for additional measures to address this challenge. The additional measures could have included a strategic dialogue at a higher level.

(b) Quality of Supervision
Rating: Satisfactory.

79. A strong Bank task team was involved throughout the entire project. The Bank team closely supervised and monitored implementation progress and timely identified problems by (a) carrying out biannual supervision missions; (b) carrying out monthly visits to the PMO to provide guidance on pending issues; (c) providing training and conducting workshops on various issues related to Bank policies and procedures; (d) reviewing semiannual project progress reports and annual audit financial reports; and (e) monitoring the GEO result indicators provided annually. With the procurement challenge recognized since the early stage of the project in 2013, the Bank team supported the PMO to develop and agree on annual action plans, and provided support on an ad-hoc basis throughout the implementation period through close connections by telephone and technical meetings on a monthly basis. Procurement and FM specialists met with the PMO whenever guidance was needed from the team. Additional reporting formats were created by the Bank with the PMO to track progress of the assessments and activities, as the results framework had originally been designed to primarily monitor final outputs. To facilitate international dissemination and exchange, the team also coordinated with the UNFCCC's Climate Technology Center and Network for the PMO's participations in the events of under the international framework.

80. To address the delay, the Bank approved a project restructuring at the MTR. The Bank's task team assisted with communications with the MoF on financial reporting and adjustment in direct payment ceilings in order to address the challenge that a large share of the fund would be disbursed near the end of the project.

81. One short-coming of supervision was that the Bank could have intervened more intensely not only with day-to-day communications but on the strategic dialogues, especially during the first year of the project when implementation weaknesses were recognized

(c) Justification of Rating for Overall Bank Performance
Rating: Moderately Satisfactory.

82. The overall rating of Bank performance has been rated moderately satisfactory for the moderately satisfactory project preparation and satisfactory implementation for reasons stated above.

5.2 Borrower

(a) Government Performance
Rating: Satisfactory.

83. The GoC attached high importance to the project for its support in facilitating technology measures addressing climate change, as well as the important role of technology transfer in the on-

going climate negotiations. To ensure strategic and technical alignment, the NDRC appointed key experts supporting the climate change negotiation process as project managers. The draw back was that the workload and travel demands of such key personnel resulted in delays in project implementation, however, this was resolved after the first year of delay. This signals the need for further capacity and institutional building of professionals in the field of climate technology. Under the commitment of the central government, the climate technology network, consisting of a national level center and provincial centers with database and information system, was established through the project's support. This demonstrates the GoC's willingness to take on adoption actions on technology transfer. More empowerment to the implementation level could be considered for future development.

(b) Implementing Agency or Agencies Performance
Rating: Moderately Satisfactory.

84. The PMO delivered and implemented all the activities and established effective coordination and communications with stakeholders during implementation that were set as deliverables in the project. As discussed earlier, the project faced persistent implementation delays during the first year of implementation, mainly due to the PMO team which included highly competent technical personnel, but who had other obligations including intensive engagement in international climate change negotiations. Soon after, it also became clear that the institutional approval process was a key issue impeding the implementation process. The PMO made its best efforts to address the administrative tasks. Execution and monitoring, results reporting, coordination and organizations of stakeholder consultations were all conducted in a timely manner. However, a shortcoming that was external to the PMO's control was that without sufficient empowerment and regular technical leadership (that is, at the PMO manager level leadership), the PMO at times struggled to improve implementation.

85. The PMO was dissolved after the project completed. As the administrative team was no longer in the office, this resulted in challenges in retrieving historic details and records for the immediate term of the ICR preparation. In the medium to long term, the technical staff remains in the NCSC leading climate technology research activities. NCSC as an institution continues to coordinate with the provincial and sectoral centers on the technology agenda.

(c) Justification of Rating for Overall Borrower Performance
Rating: Moderately Satisfactory.

86. Commitment from the counterpart has been high. The PMO assembled a dedicated team to administrate project implementation following the Bank's rules and policies. However, while the decision making and approval process could have been streamlined, in the end the project met or exceeded all of its goals by the close of the project and within the budget.

6. Lessons Learned

87. **Technology transfer requires the close collaboration of stakeholders, from both public and private sectors**. **The public sector plays a particularly important role in guiding climate technologies that provide 'public goods'.** Compared to private technologies such as telecommunications and consumer electronics, the "public goods" nature of climate change

technology requires investment from the public sector. Innovation and development of climate technologies provides significant economic benefits (such as greenhouse gases reduction and more resilient habitats), however, many of these benefits are not ones that the private sector will automatically recognize or invest in. Therefore, government actions are needed to initiate the development process for public goods. Technical guidance and sectoral assessments are essential parts of initial public actions. In addition, policies and public funding provide incentives and policies to promote technology transfer, and capacity and awareness building are critical in creating an enabling environment. Through the project and the pilot program, it has been demonstrated that technical guidance and "pump-priming" funding from the public sector can leverage significant private sector investment. The leverage ratio reached 1:4.76 in the pilot program. There are different models for technology development and transfer, broadly including public-led investment, public-private partnerships, and private investment. As the policy and market environment matures, the role of the government should evolve over time, with the private sector involved to spur innovation and lower costs. Standards and guidelines on how to define and measure climate friendly are critical to guide private sector investment.

88. **Project design needs to find a good balance between technical depth and implementation practicality**. To achieve project objectives successfully requires both sound technical design and smooth implementation. A small grant implemented by a central government agency could benefit from bundling small activities under a larger consultancy contract. This results in a longer procurement process up-front, however, once the larger contract is in place, the administrative burden of procurement by the PMO is reduced significantly, allowing the PMO to focus on technical guidance and engagement with stakeholders. Larger contracts attract larger consultancy firms and institutions who are experienced in forming a consortium of technical and project management experts. Technical leadership and engagement in policy dialogue is also critical for the success of a project such as this, however, if the project cannot be properly managed and executed, project success is also difficult. A dedicated and experienced administrative team, or at least a team led by an experienced administrative manager, would make a difference in the implementation process.

89. **Administrative approval process is another key factor affecting implementation.** The project's initial delays were partially due to the lengthy approval process of each contract procured. Differentiated evaluation process, for example, risk-based approach according to contract value or sensitivity, and delegation of authority could effectively address the issue when there are a large number of small contracts. Alternatively, assigning an alternative or acting decision maker/signature could also address the waiting time when the designated person is away from the office.

90. **The Bank also benefits from engagement in this important project, and should be prepared for any uptake of technology adoption**. The Bank benefits from the outputs, including the assessments findings, rich pool of data, and the exposure to the potential project pipeline. Understanding China's needs on climate technology informs for formulation of the China-IBRD project pipeline for the next few years. This rich source of information on technology and on China specifically also informs the Bank's preparation of the next Country Strategic Partnership, the Bank's commitment to support China implementing its NDC on climate change as well as other strategic studies such as New Drivers for Growth. Internally within the Bank, with coordination with the NDRC, a dissemination channel of project outputs should be established. As discussed

earlier of the Bank's unique position to support this project, one of the comparative advantages is that with the existing business lines of investment lending, the Bank is well positioned to uptake the outputs and support China to deliver a demonstrative case of technology transfer. Continuing regular dialogues with ministries across sectors, keeping communications channels open and actively coordinating with internal teams, with these the Bank may be further prepared to explore with China in developing its Technology Transfer Action Plan under the UNFCCC.

91. **The Bank has the convening power to share TNA experience and knowledge from China to other developing countries in the global technology transfer agenda**. The detailed methodological guidelines have been developed and applied in China. For client countries, either involved or not in the current UNFCCC TNA process, the knowledge and the experience could be convened through the Bank's operation cross countries. Technology as identified as one of the key four pillars in the international negotiations to address climate change, countries with lower capacity requires support from the initial needs assessment to adoption. As the Bank is actively involved in supporting countries with NDCs implementation, the approach of systematically identifying needs, evaluation of costs and benefits, determining gaps and barriers and recommendations of policy measures, can be replicated in project preparation and design when assisting client countries to focus on the most urgent issues with the most cost effective technologies.

92. **A national level project could serve as a capacity building and stakeholder engagement platform to maximize promotion of the sustainability agenda**, for example, climate change. The TNA project established technical committee to engage ministries across sectors in the technology dialogues. The project also engaged a large number of organizations and experts, and provided trainings to even larger group of stakeholders. These mechanisms and activities contributed to the promotion of publicity and building capacity of addressing climate change at both central government level as well as practitioner level.

7. Comments on Issues Raised by Borrower/Implementing Agencies/Partners

(a) Borrower/implementing agencies

From the PMO:

93. The project contributed to the formulation of China's climate technology policy. China issues its Low-Carbon Technology Catalogue every year. TNA project regularly engaged and communicated with the team in charge of the Catalogue so that they are well aware of the methodology and outcomes of the TNA. This could change the way they conduct their work.

94. The project made available the analytical tools and sound data for the formulation of China's climate change strategies and plans. The latest information of climate technologies, such as mitigation potential and cost of investment and operation, provide a good foundation for future relevant modeling exercises that help with the strategy making.

95. The TNA project contributed to the promotion of publicity and building capacity of addressing climate change. The project engaged a large number of organizations and experts, and its training activities covered even larger group of stakeholders. It led some of China's top

academia and experts think and act on China’s TNA and enable practitioners on the ground to be aware of and act on addressing climate change through their own perspectives.

96. It well served China’s participation in the UNFCCC negotiation on technology issue. China is the coordinator of G77+China in the negotiation, meaning that it has to take the lead with the new ideas and concept that represent developing countries’ needs. Given the geographic and sectorial diversification, China’s technology needs explored by the project have a strong representativeness and has been a good basis for generating the ideas and concept in the negotiation.

(b) Cofinanciers

Feedback from sub-grant pilot project owners:

97. Beijing PROTECHT Environmental Technology Ltd.: Since participating in the pilot project, the sub-grant project’s American partner company (the technology supplier) has been more confident in the cooperation of technology transfer, which made the negotiation of transferring the technology (namely, magnetic levitation centrifuge) much smoother. In addition, the pilot project has provided additional financial resources to conduct capacity building activities for staff and clients, and has also allowed them to share their experience and communicate with other project owners in similar fields. The project owner also expressed concerns that other similar projects without support of government and international resources might not be able to make it through so efficiently. Huadian (Xiamen) Distributed Energy Co.,Ltd.: the technology involved in the sub-grant project is gas turbine generating set’s front inlet cooling and waste heat depth by using technical scheme. The pilot project facilitates their communication with their partner, Stallar Energy, and enabled them to train more technicians.

(c) Other partners and stakeholders

(e.g. NGOs/private sector/civil society)

Annex 1. Project Costs and Financing

(a) Project Cost by Component (in USD Million equivalent)

Components	Appraisal Estimate (USD millions)	Actual/Latest Estimate (USD millions)	Percentage of Appraisal
Technology oversight, synthesis and dissemination	0.593	0.394	66%
Technology assessment at the sector and provincial level	2.332	2.108	90%
Capacity building to support climate technology networks transfer	0.975	0.864	89%
Pilot program to accelerate technology transfer	0.850	0.910	107%
Project management office	0.250	0.250	100%
Total Project Cost	5.000	4.526	90.5%

(b) Financing

Source of Funds	Type of Cofinancing	Appraisal Estimate (USD millions)	Actual/Latest Estimate (USD millions)	Percentage of Appraisal
Borrower	Investment	1.70	3.500	205%
GEF	Grant	5.00	4.526	90.5%

Annex 2. Outputs by Component

#	Project outputs	Plan at Appraisal	Actual Completed
Component 1: Methodology development, technical oversight, synthesis and dissemination			
1.	Design and summary report for mitigation	Develop and publish at the initial implementation stage of China's guidebook for mitigation TNA; consolidate the mitigation assessments and prepare a synthesis report on the topic.	In March 2014, the mitigation guidebook was finalized in Chinese and English and presentation was made to the Steering Committee and contractors of the sectoral assessments. The synthesis report was finalized in Chinese and English June 2016. A list of 276 mitigation priority technologies was selected from 12 sectors, among which 57 key technologies were shortlisted after in-depth assessment. A stakeholder survey to evaluate the use of the comprehensive mitigation technology assessments was conducted in May 2016. 80 questionnaires were sent out to targeted stakeholders and institutions. Among the 60 returned qualified questionnaires, 95% stakeholders agreed with the selection of the key technologies and 98% stakeholders agreed the methodology developed is helpful to their work.
2.	Design and summary report for adaptation	Develop and publish at the initial implementation stage of China's guidebook for adaptation TNA; consolidate the mitigation assessments and prepare a synthesis report on the topic.	In March 2014, the adaptation guidebook was finalized and presentation was made to the Steering Committee and contractors of the sectoral assessments. The synthesis report was finalized in Chinese and English June 2016. A list of 86 mitigation priority technologies was selected from 4 sectors, among which 23 key technologies were shortlisted after in-depth assessment. A stakeholder survey to evaluate the applicability of the comprehensive adaptation technology assessment was conducted in May 2016. 32 questionnaires were sent out to targeted stakeholders and institutions. Out of the 23 returned qualified questionnaires, 98% stakeholders agreed with the selection of the key technologies and 99% stakeholders agreed the methodology developed is helpful to their work.
3.	Design and summary report for provincial	Preparation of a synthesis report on provincial assessments based on the four provincial assessment reports.	The provincial assessments started in December 2014, after a prolonged procurement process. The provinces covered are Guangdong, Liaoning, Jiangxi and Shaanxi, consistent as planned in the project design. The preparation of the TOR started after the completion of the mitigation and adaptation guidebooks to ensure that the provincial level assessments would benefit from the results of the national level sector assessments and that the respective provincial authorities would be consulted at precise stages during the preparation process. In March 2015 the provincial guidebook was finalized and presentation was made to the Steering Committee. The expert consultation was held in January 2016, after

			the submission of interim report of four provinces. The synthesis report was finalized in Chinese and English in June 2016. A list of 65 priority technologies was selected from 4 provinces, among which 20 key technologies were shortlisted after in-depth assessment. A stakeholder survey to evaluate the use of the completed provincial technology assessment was conducted in May 2016. 32 questionnaires were sent out. Out of the 23 returned qualified questionnaires, 81% stakeholders agreed that the selected key technologies were in line with the relevant local policies; 99% stakeholders agreed the key technologies analysis was sufficient and helpful for their work.
4.	Information system	To design, collect information, create, and maintain a national-level database on priority technologies. The database will serve as a national virtual data hub accessible to the public, and in support of other technology centers within China and beyond.	As a part of "Capacity Building to Support Climate Technology Networks" of the TNA project, the information system has been developed to support the establishment of a National Climate Technology Network by providing provincial and sectoral development trend, key policy and regulations, identified stakeholders in each province and sector, technology catalogs, technology transfer case studies, training materials and workshop outcomes. The information system was completed in May 2016, which can be accessed by public through http://data.tnachina.org/
4.	Seven workshops for stakeholder input, evaluation, and dissemination	One kick-off, three interim workshops, and three project concluding workshops (mitigation, adaptation, and provincial networks). These workshops intended to provide a venue for the larger stakeholder community (including national agencies, industry associations, and international / national experts) to interact with the project. In particular, the first workshop would gather input from the different stakeholders to finalize the project approach and guide project execution.	1. The project's kick-off workshop was held on December 13, 2012 in Beijing for stakeholder inputs, key experts to disseminate technical principles and work plan on the guidebook development and take stock of the status quo in the provinces. 2. One general methodology development consultation workshop has been held by PMO from May 23 to 24, 2013 for all the sector TNA consultants, specialists from Project Technical Committee explained the methodology guidelines for consultants. Given the differentiation of progress between sectors, instead of large workshops, sixteen individual mitigation and adaptation interim workshops were held during 2014-2015, and the provincial assessment interim workshop were held in March 2016, where each consultant firm presented their progressive outcomes to PMO, peer-reviewers and other external specialist for opinion advice. 3. Three project concluding workshops were held one by one on the same day on 14th June 2016, where presentations were made to PMO, Project Steering Committee and Project Technical Committee by consulting firms and synthesis report authors. In the concluding workshops, both project steering committee and

			project technical committee deemed that a series of TNA project outcomes meet the requirements in their TOR.
	Project Steering Committee and stakeholder consultations	To provide overall leadership, guidance, and institutional coordination for project implementation, a Project Steering Committee will be established by the NDRC and chaired by the Director General of the NDRC Climate Change Department. It will consist of representatives from concerned government agencies (MoF, MIIT, MOST, MEP, MOA, and so on) and national industry associations and will meet at least once a year in Beijing and more often, upon request of the PMO, when important issues arise.	Steering committee meetings: • The first meeting took place jointly with the project's kick-off workshop on December 13, 2012. • The second meeting was held on February 19, 2014 to discuss the progress of the project. 5 members of Project Steering Committee, 5 members of PMO, 2 NDRC Climate Change Department staff, all together 12 participants attended the meeting. The PMO introduced overall design, implementation status of TNA project. Each Project Steering Committee made comments on the progress of TNA projects, and provided suggestions to address the challenges. • The third meeting took place jointly with the MTR December 2014. The Bank team, PMO and 3 representatives from Project Steering Committee have participated in the MTR. It is decided to extend TNA project to 30 June 2016. • The fourth meeting was conducted jointly with the interim progress workshop on 18-19 August, 2015. Over 80 representatives from consulting firms and experts from Project Steering Committee and Project Technical Committee have participated in the workshop. In the workshop, Steering Committee urged a timely implementation of project and call for intensifying efforts from all stakeholders to meet the project deadline. Project Technical Committee: In addition to the Steering Committee, the PMO invited ten experts to sit on the Project Technical Committee, and held the first meeting of the Project Technical Committee before the kick-off meeting in Beijing on December 13, 2012. The Project Technical Committee supervised the application of the technology assessment methodologies in each of the sectors and provinces selected, ensuring that the methodologies are properly applied to the specifics of each sector and province. The Technical Committee also participated in the interim progress workshop from 18-19 August, 2015.
Component 2: Technology assessments at the sector and provincial levels			
	Mitigation: coal mining and oil and gas exploration	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report	The assessment methodology was proposed in May 2014, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in March 2016. A list of 18 priority technologies was developed by the consulting firm, including 6 shortlisted key technologies for in-depth assessment.

		Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	PMO signed the contract with China Petroleum and Chemical Industry Federation on14 March 2014 through the selection method of Selection Based on Consultants' Qualifications (CQS). Yang Yong and Zhang Aling, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.
	Mitigation: thermal power	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	The assessment methodology was proposed in December 2014, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in March 2016. A list of 10 priority technologies was developed by the consulting firm, including 5 shortlisted key technologies for in-depth assessment. PMO signed the contract with KOE Environmental Consultancy, Inc. (Leading Partner) & Branch Association of Energy Conservation & Environmental Protection, China Electricity Council on 9 June 2014 through the selection method of CQS. Wang Zhuokun and Zhao Xiusheng, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.
	Mitigation: renewable energy	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	The assessment methodology was proposed in January 2015, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in May 2016. A list of 19 priority technologies was developed by the consulting firm, including 4 shortlisted key technologies for in-depth assessment. PMO signed the contract with Tsinghua University on 17 Octorber2014 through the selection method of CQS. Qin Haiyan, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.
	Mitigation: iron and steel	PMO will award contracts competitively	The assessment methodology was proposed in January 2015, and the final sectoral report including technology identification, technology gaps analysis, barriers to

		Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	technology transfer and deployment, case studies was submitted to PMO in May 2016. A list of 18 priority technologies was developed by the consulting firm, including 5 shortlisted key technologies for in-depth assessment. PMO signed the contract with China Metallurgical Industry Planning and Research Institute on 29 May 2014 through the selection method of CQS. Huang Dao and Wang Yanjia, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.
	Mitigation: building materials manufacture	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	The assessment methodology was proposed in April 2014, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in March 2016. A list of 28 priority technologies was developed by the consulting firm, including 5 shortlisted key technologies for in-depth assessment. PMO signed the contract with China Building Materials Academy on 20 January 2014 through the selection method of CQS. Kong Xiangzhong and Zhang Aling, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.
	Mitigation: chemical industry	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology	The assessment methodology was proposed in March 2014, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in December 2015. A list of 30 priority technologies was developed by the consulting firm, including 6 shortlisted key technologies for in-depth assessment. PMO signed the contract with China Industrial Energy Conservation and Cleaner Production Association on 14 March 2014 through the selection method of CQS.Yu Lean and Li Wenjun, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.

		development, to report preparation, to final review	
	Mitigation: nonferrous metallurgy	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	The assessment methodology was proposed in March 2014, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in April 2016. A list of 95 priority technologies was developed by the consulting firm, including 9 shortlisted key technologies for in-depth assessment. PMO signed the contract with Kunming University of Science and Technology on 20 January 2014 through the selection method of CQS. Xie Gang and Meng Jie, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.
	Mitigation: transportation	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	The assessment methodology was proposed in March 2014, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in March 2016. A list of 21 priority technologies was developed by the consulting firm, including 6 shortlisted key technologies for in-depth assessment. PMO signed the contract with China Academy of Transportation Sciences (Leading Partner) & China Academy of Civil Aviation Science and Technology on 28 February 2014 through the selection method of CQS. Wang Hewu and Zhao Fengcai, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.
	Mitigation: residential and commercial buildings	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report	The assessment methodology was proposed in August 2014, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in March 2016. A list of 20 priority technologies was developed by the consulting firm, including 15 shortlisted key technologies for in-depth assessment. PMO signed the contract with Center of Science and

		Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	Technology of Construction on10 February 2014 through the selection method of CQS. Zhou Nan and Ye Yaoxian, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.
	Mitigation: agriculture, forest and land use	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	The assessment methodology was proposed in March 2014, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in May 2016. A list of 18 priority technologies was developed by the consulting firm, including 5 shortlisted key technologies for in-depth assessment. PMO signed the contract with Institute of Forest Ecology, Environment & Protection, Chinese Academy of Forestry on 10 February 2014 through the selection method of CQS. Yan Xiaodong and Xie Gaodi, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.
	Mitigation: CCS	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology	The assessment methodology was proposed in January 2015, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in May 2016. A list of 30 priority technologies was developed by the consulting firm, including 13 shortlisted key technologies for in-depth assessment. PMO signed the contract with Institute of Engineering Thermophysics, Chinese Academy of Sciences on 14 March 2014 through the selection method of CQS. Zhang Jiutian and Xu Ruina, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.

		development, to report preparation, to final review	
	Mitigation: waste management	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	The assessment methodology was proposed in April 2014, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in April 2016. A list of 30 priority technologies was developed by the consulting firm, including 6 shortlisted key technologies for in-depth assessment. PMO signed the contract with China Urban Construction Design and Research Institute Co., Ltd. On 14 March 2014 through the selection method of CQS. Cai Bofeng and Chen Shaohua, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.
	Adaptation: agriculture, forest and ecosystem	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	The assessment methodology was proposed in May 2014, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in April 2016. A list of 24 priority technologies was developed by the consulting firm, including 6 shortlisted key technologies for in-depth assessment. PMO signed the contract with Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences on 10 February 2014 through the selection method of CQS. He Zhonghu and Xie Gaodi, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.
	Adaptation: water resources	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report	The assessment methodology was proposed in April 2015, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in June 2016. A list of 16 priority technologies was developed by the consulting firm, including 5 shortlisted key technologies for in-depth assessment.

		Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	PMO signed the contract with China Institute of Water Resources and Hydropower Research on 15 October 2014 through the selection method of CQS. Jiang Dong and Xia Jun, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.
	Adaptation: urban	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	The assessment methodology was proposed in August 2015, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in April 2016. A list of 16 priority technologies was developed by the consulting firm, including 6 shortlisted key technologies for in-depth assessment. PMO signed the contract with China Urban Construction Design and Research Institute Co., Ltd on 21 August 2014 through the selection method of CQS. Zheng Dawei and Tian Yongying, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.
	Adaptation: disaster forecast and weather monitoring	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology	The assessment methodology was proposed in August 2015, and the final sectoral report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in May 2016. A list of 18 priority technologies was developed by the consulting firm, including 5 shortlisted key technologies for in-depth assessment. Given the confidentiality of data and information required for this sectoral assessment, National Climate Center of State Meteorological Administration is the most suitable institute with access to data and excellent research capability. According to their core research team's schedule, PMO decided wait until 13 April 2015 to sign the contract with National Climate Center, through the selection method of CQS. Luo Yong and Zhu Changhan, hired through the selection method of IC by PMO, were the peer-reviewers to ensure the technical quality and objectivity of the assessments.

		development, to report preparation, to final review	
	Provincial level assessment	PMO will award contracts competitively Selected consultants will propose assessment methodology, and conduct a sectoral TNA with a final report Develop a list of priority technologies for China The peer review function will span the full sectoral TNA process, from methodology development, to report preparation, to final review	The assessment methodology was proposed in June 2015, and an interim expert consulting workshop was held in February 2016. The provincial synthesis report including technology identification, technology gaps analysis, barriers to technology transfer and deployment, case studies was submitted to PMO in May 2016. A list of 18 priority technologies was developed by the consulting firm, including 5 shortlisted key technologies for Guangdong Province; a list of 15 priority technologies was developed by the consulting firm, including 5 shortlisted key technologies respectively for Liaoning and Jiangxi Provinces; a list of 17 priority technologies was developed by the consulting firm, including 5 shortlisted key technologies for Shaanxi Province. PMO signed the contract with Beijing Energy and Environment Development Research Center on 5 January 2015 through the selection method of QCBS. The center is hired as a consulting firm to conduct all four provincial level assessments, which are Guangdong, Liaoning, Shaanxi, and Jiangxi. Liu Qiang, hired through the selection method of IC by PMO, was the provincial assessment expert to ensure the technical quality and objectivity of the assessments.
Component 3: Capacity building to support climate technology networks			
	National capacity building	Information collection: Design and management of a national climate technology database and network platform, Information collection, analysis, and dissemination Collection and analysis of technology transfer business cases: identification and collection of both successful and unsuccessful experiences (business cases)	The national climate technology database was completed and publicly accessible from December 2015. Information on methodologies, technology needs lists, firms, experts, TNA cases, technology transfer cases from the TNA's "sector and provincial technology needs assessment" component outputs was collected and populated into database in March 2016. A training on database and network platform was held in December 2015 for all capacity building workstations. 6 dissemination workshops were held during 2015-2016 by 6 workstations. Shanghai Environment and Energy Exchange Co. Ltd. was hired as the consulting firm to lead the business case study. They identified seven technology transfer networks world widely for business model and operational experience analysis.

		of domestic enterprises with technology transfer Organization of workshops on technology transfer mechanisms, organization of overseas investigations.	Eight workshops on technology transfer mechanisms were held by six workstations during 2015-2016, with a total participation of 168 person-time from 97 institutions.
	Provincial capacity building: Guangdong	Information collection: design and management of provincial climate technology database and network platform; Information collection, analysis, and dissemination Collection and analysis of technology transfer business cases: identification and collection of both successful and unsuccessful experiences (business cases) of provincial enterprises with technology transfer Organization and communication: participation of provincial companies in domestic and international technology transfer and training activities; organization of a provincial technology transfer workshop on climate technologies.; coordination and assistance to relevant provincial institutes in technology development and transfer.	Guangdong Climate Center was hired as the consulting firm for provincial capacity building as the Guangdong workstation. A report covering the design of provincial climate technology database and information including climate technology status and needs, international best practices, stakeholders in Guangdong Province was submitted in November 2015. All the data and information collected were uploaded to online platform in May 2016. Eleven international technology transfer cases were studied in the final report submitted in May 2016. Case studies cover both successful and unsuccessful experience from various mitigation and adaptation sectors including renewable energy, ceramic, power, oil & gas, weather forecast, wetland recovery in Guangdong Province. Thirty-seven key stakeholders were identified in Guangdong Province, including 10 government departments, 10 industrial associations, 9 research institutions, 6 enterprises, 2 financial institutes. One workshop on TNA information system and online platform training was held in January 2016, in which 27 representatives from 14 stakeholders in Guangdong Province participated. One workshop on technology transfer was held in April 2016 with 24 participant from 14 institutions in Guangdong Province.
	Provincial capacity building: Liaoning	Information collection: design and management of provincial climate technology database and network platform; Information collection, analysis, and dissemination	Liaoning International Engineering Consulting Center was hired as the consulting firm for provincial capacity building as the Liaoning workstation. A report covering the design of provincial climate technology database and information including climate technology status and needs, international best practices, stakeholders in Liaoning Province was submitted in December 2015. All the data and information collected were uploaded to online platform in May 2016.

		Collection and analysis of technology transfer business cases: identification and collection of both successful and unsuccessful experiences (business cases) of provincial enterprises with technology transfer Organization and communication: participation of provincial companies in domestic and international technology transfer and training activities; organization of a provincial technology transfer workshop on climate technologies.; coordination and assistance to relevant provincial institutes in technology development and transfer.	Three international technology transfer cases were studied in the final report submitted in May 2016. Case studies cover both successful and unsuccessful experience from various mitigation and adaptation sectors including power plant, chemical industry, steel & iron industry in Liaoning Province. Thirty four key stakeholders were identified in Liaoning Province, including 9 government departments, 9 industrial associations, 10 research institutions, 6 enterprises. One workshop for all stakeholders on TNA information system and online platform training was held in April 2016, in which 47 representatives from 29 stakeholders in Liaoning Province participated. One workshop on technology transfer was held in March 2016 with 15 participant from 5 institutions in Liaoning Province.
	Provincial capacity building: Jiangxi	Information collection: design and management of provincial climate technology database and network platform; Information collection, analysis, and dissemination Collection and analysis of technology transfer business cases: identification and collection of both successful and unsuccessful experiences (business cases) of provincial enterprises with technology transfer Organization and communication: participation of provincial companies in domestic and international technology transfer and training activities; organization of a provincial technology transfer workshop on climate technologies.; coordination and assistance	Institute of Energy, Jiangxi Academy of Sciences was hired as the consulting firm for provincial capacity building as the Jiangxi workstation. A report covering the design of provincial climate technology database and information including climate technology status and needs, international best practices, stakeholders in Jiangxi Province was submitted in December 2015. All the data and information collected were uploaded to online platform in May 2016. Three international technology transfer cases were studied in the final report submitted in May 2016. Case studies cover both successful and unsuccessful experience from various mitigation sectors including machinery, waste management, and construction material in Jiangxi Province. Twenty-one key stakeholders were identified in Jiangxi Province, including 7 government departments, 4 enterprises, 5industrial associations, 4 research institutions, and 1 property right exchange. One workshop for all stakeholders on TNA information system and online platform training was held in December 2015, in which around 100 representatives from 52 institutions in Jiangxi Province participated. One workshop on technology transfer was held in March 2016 with 16 participant from 13 institutions in Jiangxi Province. Two workshops on TNA were held respectively in December 2015 and January 2016.

		to relevant provincial institutes in technology development and transfer.	
	Provincial capacity building: Shaanxi	Information collection: design and management of provincial climate technology database and network platform; Information collection, analysis, and dissemination Collection and analysis of technology transfer business cases: identification and collection of both successful and unsuccessful experiences (business cases) of provincial enterprises with technology transfer Organization and communication: participation of provincial companies in domestic and international technology transfer and training activities; organization of a provincial technology transfer workshop on climate technologies.; coordination and assistance to relevant provincial institutes in technology development and transfer.	Shaanxi Industrial Technology Research Institute was hired as the consulting firm for provincial capacity building as the Shaanxi workstation. A report covering the design of provincial climate technology database and information including climate technology status and needs, international best practices, stakeholders in Shaanxi Province was submitted in December 2015. All the data and information collected were uploaded to online platform in May 2016. Six international technology transfer cases were studied in the final report submitted in May 2016. Case studies cover both successful and unsuccessful experience from various mitigation and adaptation sectors including renewable energy, power, waste management, machinery, oil and gas in Shaanxi Province. Forty-five key stakeholders were identified in Shananxi Province, including 2 government departments, 7 industrial associations, 10 research institutions, 24 enterprises, and 2 financial institutions. One workshop for all stakeholders on TNA information system and online platform training was held in April 2016, in which 82 representatives from 74 institutions in Shaanxi Province participated. Three workshops on technology transfer were held in July, September, and November 2015 with a total participant number of 78 from 48 institutions and companies in Shaanxi Province.
	Sectoral capacity building: Power Sector	Information collection :Review of technology status and needs for each sector; foreign technology scanning to find state-of-the-art meeting needs; design and management of sector climate technology database and network platform; information collection, analysis, and dissemination Collection and analysis of technology transfer business cases: Identification and collection of both successful and	State Grid Energy Research Institute, State Grid Corporation of China (leading partner) & Beijing Jiao Tong University were hired as the consulting firms for power sector. A report covering climate technology status and needs, international best practices, stakeholders in power sector was submitted in January 2016. Relevant data and information were uploaded to online database in May 2016. Three international technology transfer cases in power sector were studied (1. Off-shore wind power 2. Blast Furnace Top Gas Recovery Turbine Unit 3. Direct-drive Permanent Magnetic Technology) in the final report submitted in May 2016.

		unsuccessful experiences (business cases) of domestic enterprises with technology transfer Organization and communication: organization of workshops on technology transfer mechanisms; organization of overseas investigations.	 Two workshops on technology transfer mechanism were held respectively in December 2015 and May 2016, with 50 participants from 34 institutions. One workshop on investigations was held in March 2016 with 10 participant from 7 institutions.
	Sectoral capacity building: Building Sector	Information collection :Review of technology status and needs for each sector; foreign technology scanning to find state-of-the-art meeting needs; design and management of sector climate technology database and network platform; information collection, analysis, and dissemination Collection and analysis of technology transfer business cases: Identification and collection of both successful and unsuccessful experiences (business cases) of domestic enterprises with technology transfer Organization and communication: organization of workshops on technology transfer mechanisms; organization of overseas investigations.	Center of Science and Technology of Construction, Ministry of Housing and Urban-Rural was hired as the consulting firm for building sector. A report covering climate technology status and needs, international best practices, stakeholders in building sector was submitted in January 2016. Relevant data and information were uploaded to online database in May 2016. Three international technology transfer cases in building sector were studied, that is, aluminum clad wooden door, integrated heating system, and IEA-SHC IA, in the final report submitted in May 2016. One workshop on technology transfer mechanism were held in January 2016, with 31 participants from 8 institutions. One workshop on overseas investigations was held in March 2016 with 38 participant from 6 institutions.
Component 4: Pilot program to accelerate technology transfer			
	Technology improvement grants	Original plan to launch within 4 provinces. "Technology Improvement Grants" will be awarded on a competitive and cost-sharing	Given a lack of pilot project company applicants from the four selected provinces, the Bank's team and PMO reached consensus during implementation that the pilot projects selection process should cover the whole country. The call-for-proposals for TNA technology transfer pilot program was carried out in two batches—in May 2014 and January 2015—and the total number of eligible programs exceeded 20. After two rounds of expert consultation with the steering committee, technical committee and external experts, 9 programs were selected for financial support under the TNA technology transfer pilot program. All of the pilot programs were completed by June 2016, except the Golmud Sterling Solar-thermal

		basis to small and medium sized companies The maximum grant size would be US$100,000, and the average would be about US$80,000 or RMB 500,000. It is estimated that the pilot demonstration program would make 8-12 such grants over 1-2 years. The findings will help determine whether or not this model of Technology Improvement Grants merit scale-up in order to better implement the final recommendations of the TNA.	Power Generation program in Qinhai Province, which ceased (with advanced payment transferred) during the implementation phase due to changes in the provincial development planning. Eight pilot programs are widely distributed across China, including Hebei, Shandong, Liaoning, Shaanxi, Gansu, Xinjiang, Guangdong and Fujian Provinces; technologies of these pilot programs are introduced from the United States, Germany, Britain, Denmark, Sweden, Australia, South Korea, and so on. For the 8 completed pilot programs, the amount of the GEF grant is between US$60,000 and US$100,000, the grant leveraging ratio ranges between 1.3 and 14, which is higher than the requirement of the CFP document. The total amount of the GEF grant is US$760,000 and the leveraged enterprises' own funds is US$3,620,000, which means an average leverage ratio of 4.76. According to the final report submitted by the 8 enterprises, the annual profit of these pilot programs ranges from RMB 0.5 to RMB 8 million, which indicates that the introduced technology is commercially available. Besides, after running the GEF GHG emission reduction model (CC Mitigation Tracking Tool), the pilot programs report a total lifetime direct GHG emission avoided of 7,643,636 tonnes CO_2 eq. With the support of TNA grant, all pilot program implementing companies carried out capacity building activities including 33 technical training sessions and 46 workshops, which helped the technical personnel to gain a deeper understanding of the introduced advance technology and know-how.
	Management of pilot program and design of future technology transfer program	This sub-component will implement the pilot competitive grants scheme during the first two years. By combining the evaluation of the pilot program with overall TNA findings – particularly the barriers to technology transfer identified in the assessments	CECEP Consulting Co., Ltd was hired as the consulting firm for the contract of *Management of Pilot Program* and *Design of future technology transfer program.* With the support of CECEP and across two rounds, PMO successfully selected the appropriate pilot programs, with variety in terms of both sector and geography. Throughout the TNA project implementation, CECEP trained pilot program sub-grantees on GEF GHG emission reduction model. CECEP submitted a *TNA Pilot Program Assessment Report* in May 2016 to the PMO for an in-depth understanding of the successful experience, barriers and restrictions among these 8 technology transfer cases.

		This component will also design one or more technology transfer mechanisms that would accelerate the ultimate deployment of prioritized technologies in both climate mitigation and adaptation.	CECEP submitted a report on future technology transfer program design in May, 2016. In the report, various international technology transfer modes were thoroughly analyzed, including applied situation, benefits, restrictions and corresponding case studies. For accelerating the ultimate deployment of prioritized technologies relevant to climate change, several business model and policy suggestions were provided in the end of this report. Professor Wang Yanjia from Tsinghua University was the review expert to ensure the technical quality and objectivity of the report.

Annex 3. Economic and Financial Analysis

1. There was no economic analysis conducted for the PAD. However, the PAD identified the project economic benefits as (a) potential greenhouse gases (GHG) emissions reduction (local and global environmental benefits) in the case of mitigation technologies; and (b) developmental benefits to be identified by the sectoral assessments in the case of adaptation technologies.

2. As a part of the criteria, priority mitigation technologies will result in considerable GHG emission reduction. At the same time, climate friendly technology promotion and development brings in benefits on the environment, economy, and society, including, conservation of natural resources and energy, promotion of industry, creation of employment, poverty alleviation, as well as contributing to achieving China's strategic climate change objectives. For instance, technologies reducing emission of CO_2, some not all, also reduces SO_2 and NOx emissions, improving management of wastewater and wastes contributes to low carbon development. As technologies help optimizing China's energy structure, this also reduces dependence fossil fuels, and accelerate development and integration of renewable energy. Advanced technology also reduces costs on production, management and processing, at the same time, it helps attract further investment. Finally, technologies enhance competitiveness, as well as creating resource for attracting and building of human resources. Overall, economic benefits of technology transfer is broad and difficult to quantify. Especially for each of the priority technology analyzed in the project, its deployment and scale of roll-up depends upon multiple factors, including government policies and incentives, successful removal of the barriers identified in the assessments.

3. For adaptation technologies is even more challenging due to traditionally lack of data and information. In many cases, adaptation technologies could be more investment intensive, though bring in social benefits and avoid significant downstream economic costs due to increased extreme climate incidents. For example, urban areas may be perceived to offer residents better welfares in China. Though the urban poor, informal settlements, and other disadvantaged groups are especially vulnerable. The impact of climate change is location specific with large regional variations. The climate change risks that Chinese cities are exposed to include heat waves, urban flooding, drought, water shortage, sea level rise, windstorms, and ice and snow disasters. Technologies for urban city planning, infrastructure and weather monitoring and forecasting are all a part of a complex solution that address complex issues. As mentioned, deployment depends upon multiple factors external to the project. Overall, economic analysis of the project is very hard in to be done in a quantitative approach; while the above provides a qualitative justification on the benefits.

4. In order to provide some level of quantitative evaluation, this completion review refers to the economic analysis at a project scope that narrows down to the direct lifetime emissions reduction created by the pilot program. Through small grants made to enterprises, facilitated individual cases of technology transfer and implementation, the pilot program generated direct financial and economic benefits within the project time frame. Based on the PMO’s application on the tracking tool that the direct lifetime emissions reduction is estimated at 4,366,393 tCO_2e. Based on the total project grant of US$5 million and the leveraged private sector investment of US$3.5 million by the pilot program, the project overall has delivered each tone of CO_2 emission reduction at a cost of US$1.95. This is significantly below the current carbon price.

Annex 4. Bank Lending and Implementation Support/Supervision Processes

(a) Task Team members

Names	Title	Unit	Responsibility/ Specialty
Lending			
Lourdes L. Anducta	Program Assistant	GSU02	
Frederic Asseline	Senior Energy Specialist	EASCS - HIS	
Carter J. Brandon	Lead Economist	GENGE	
Jonathan d'Entremont Coony	Senior Private Sector Specialist	GTCID	
Christophe Crepin	Sector Leader	GEN2B	
Gailius J. Draugelis	Lead Energy Specialist	GEE02	
Yi Geng	Sr FM Specialist	GGO20	
Minhnguyet Le Khorami	Program Assistant	GFA04	
Emmanuel Py	Infrastructure Specialist	GEE05	
Jean-Louis Charles Racine	Senior Private Sector Specialist	GTCID	
Yanqin Song	Senior Energy Specialist	GEE09	
Guoping Yu	Senior Procurement Specialist	GGO08	
Lijun Zhang	Program Assistant	EACCF	
Supervision/ICR			
Garo Batmanian	Lead Environmental Specialist	GEN2A	
Todd Johnson	Lead Energy Specialist	GEE09	
Dafei Huang	Environmental Specialist	GEN2A	
Guoping Yu	Sr Procurement Specialist	GGO08	
Emmanuel Py	Sr Energy Specialist	GEE05	
Fang Zhang	FM Specialist	GGO20	
Fowzia Hassan	Sr Energy Operations Officer	GEE02	
Juliana Victor	Sr M&E Specialist	GEESO	
Jieli Bai	Program Assistant	EACCF	

(b) Staff Time and Cost

Stage of Project Cycle	Staff Time and Cost (Bank Budget Only)	
	No. of staff weeks	USD Thousands (including travel and consultant costs)
Lending		
FY 10	18.6	85,705.34
FY 11	27.23	160,287.18
FY 12	14.04	92,733.67
FY 13	0	-439.13
Total:	**59.87**	**338,287.06**
Supervision/ICR		
FY 13	11.26	54,605.49
FY 14	14.7	63,453.24
FY 15	11.69	68941.73
FY 16	11.61	58,878.87
FY 17	4.4	16,876.58
Total:	**53.66**	**262,755.91**

Annex 5. Beneficiary Survey Results

(if any)

Annex 6. Stakeholder Workshop Report and Results

(if any)

Please refer to details in Annex 2.

Annex 7. Summary of Borrower's ICR and/or Comments on Draft ICR

1. INTRODUCTION

This report evaluates China Climate Technology Needs Assessment Project (hereafter the TNA Project) against PDOs, as well as the project implementation and FM and disbursement.

2. PROJECT BACKGROUNDS

The TNA Project, funded by the GEF, is to support the Chinese Government efforts to assess climate change mitigation and adaptation technology needs and to adopt corresponding global best practices. The responsible agency of the Project is Climate Change Department of the NDRC, the People's Republic of China (PRC). The findings of the Project will support the Chinese Government in the international climate change negotiation.

3. PROJECT IMPLEMENTATION

The implementation period of the TNA Project was 29 May 2012 to 30 June 2016. The TNA project is implemented as five components, namely Component 1: Methodology Development, Technical Oversight, Synthesis and Dissemination; Component 2: Technology Assessments at the Sector and Provincial Levels; Component 3: Capacity Building to Support Climate Technology Networks; Component 4: Pilot Program to Accelerate Technology Transfer; and□Component 5: Project Management Office. All project components have been completed.

4. EVALUATION OF THE PROJECT IMPLEMENTATION

The PDO is to support China's efforts to assess climate mitigation and adaptation technology needs and adopt corresponding global best practices. There are four GEO level results indicators, namely 1) technology assessments; 2) capacity-building support to climate technology assessment centers and networks; 3) Measurable financial and economic benefits of accelerating technology transfer through small grant support to companies. Evaluation of impacts and lessons learned related to technology transfer, diffusion, and scale-up; and 4) lifetime direct GHG emissions avoided. The evaluation confirmed all indicators were achieved 100 percent.

- Impacts and Lessons Learned Related to Technology Transfer, Diffusion, and Scale-up

  The technologies introduced by the 8 companies are from different enterprises and institutions of 7 countries, resulting in different characteristics of the transfer mode. Among them, 2 companies adopt the joint R&D mode to realize the technology transfer. In this way, technology development achievements and intellectual property are owned by the both sides, which achieved the introduction and absorption of the technology; Only 1 enterprise realized the technology transfer by the way of license purchase, which achieved the localization of the technology through the digestion and improvements (according to the characteristics of China market); 4 companies using the way of equipment purchase or technology agency to realize the technology transfer. During the purchase, installation and commissioning process, they can prepare for technology localization through the communication and learning of the foreign experts; 2 enterprises realize the technology transfer through the establishment of the joint venture. This way helps the partners to find common interests and localize the technologies through the establishment of manufacturing plants in China.

- LIFETIME DIRECT GHG EMISSION AVOIDED

  TNA technology transfer pilot programs provided grants[8] to support technology transfer and realize direct GHG emission avoided. Indicator four requires at least 500,000 tonnes GHG emission to be avoided. The amount of GHG emission avoided is calculated using the GEF climate change monitoring tool (CC Mitigation Tracking Tool GEF, EE Tool v1.0 GEF).

The lifetime direct GHG emissions avoided is 4,366,393 tCO_2 eq in total, higher than the requirements of 500,000 tCO_2 eq.

5. CONCLUSIONS

The TNA project successfully supported the Chinese Government in assessing climate change mitigation and adaptation technology needs and provided a good foundation for key mitigation and adaptation sectors to adopt corresponding global best practices.

All of the four GEO indicator targets of the TNA Project have been successfully met, with the total amount of lifetime direct GHG emissions avoided (4,366,393 tCO_2 eq) largely more than the target (500,000 tCO_2 eq).

[8] The total amount of grant used for technology transfer pilot program is US$680,000, ranged from US$60,000 to US$100,000 for each pilot project.

Annex 8. Comments of Cofinanciers and Other Partners/Stakeholders

N/A

Annex 9. List of Supporting Documents

By the Borrower:

- ICR Report by Project Management Office
- Synthesis Report: Mitigation Technology Needs Assessment
- Synthesis Report: Adaptation Technology Needs Assessment
- Synthesis Report: Provincial Technology Needs Assessment
- Technology Transfer Pilot Program Assessment Report

Annex 10. Example of the Technology Assessment

Technology Needs Assessment on Renewable Energy

Extracted from the TNA report on Renewable Energy Sector Conclusion Chapter, Tsinghua University, May 2016

Based on comprehensive analysis and studies on the renewable energy sector, this research establishes a long list, through expert analysis, literature review, and so on. The long list covers 46 renewable energy technologies with regard to small hydropower, wind energy, solar energy, biomass energy, heat pump, tidal energy, and so on. Each technology's indicators and performance in employment, poverty relief, environment, economy and safety are collected by virtue of databases, academic articles, institutions' reports, expert consultation and field investigations and its economic cost per unit of emission reduction is calculated and comprehensive assessment in society and environment is presented, and suggestions and opinions from experts are considered. Finally, **intelligent offshore wind power technology, thin-film PV power technology, aviation biofuel technology and CSP technology** are selected for priority development.

Advanced intelligent offshore wind power technology is possessed by UK, Denmark, Germany and other European and American countries. The gap between China and them lies in the inadequate exploration of offshore wind energy resources, the backward construction technology and equipment and the backward equipment manufacturing technology. In relation to offshore wind power generation units, the core component is gearbox. Reliable high-power gearboxes are important guarantee for the reliable and safe operation of generation units. Meanwhile, direct-drive wind turbines (without gearbox) are also an important gap between China and advanced countries. According to IEA China Wind Energy Development Roadmap 2050, installed capacity of offshore wind power of China will amount to 30,000MW by 2020, 65,000MW by 2030 and 200,000MW by 2050 and its emission reduction will be 4.78×10^7 tons of GHG/year, 1.04×10^8 tons of GHG/year and 3.19×10^8 tons of GHG/year respectively in 2020, 2030 and 2050.

Japanese and U.S. enterprises have advanced thin-film PV power technology. Gaps exist mainly in the conversion efficiency, performance stability and manufacturing advancement of the cells. The gap in core technology lies in the sputtering technology during manufacturing. According to the Outline of the 12^{th} FYP for the Development of Renewable Energy in China, the country's installed capacity of distributed PV power systems will reach 27 million KW by 2020. Both of them, especially distributed PV power system, are all covered by the thin-film PV power sector, of which the annual emission reduction will get to 2.58×10^7 tons of GHG/year.

U.S. and European enterprises are among the best in terms of aviation biofuel development. China is capable merely of simple early treatment of raw materials, rather than deep processing in the later stage; in the meantime, there are great gaps in the security of raw material supply and the construction of supporting facilities and systems. According to the IATA aviation biofuel substitution plan, China put 280,000 tons of aviation biofuel into use in 2015 while the actual production capacity for the year was fewer than 50,000 tons and the actual use is extremely low. Relevant literature[9] indicates the heat value of aviation biofuel is 44.14MJ/kg, and the TCE

[9] Qi Panlun, He Hao, Hu Xuteng, et al. Overview for the Characteristics and Specifications of Aviation Biofuel [J]. Chemical Industry and Engineering Progress, 2013, (1).

conversion coefficient is 1.506. On this basis, it's figured out that annual emission reduction is 4.34×10^4 tons of GHG/year.

Advanced CSP technology is possessed by Spain and the United States. Main technology gaps are that China has yet established a complete industrial chain, is faced with a lack of power station operation experience and has insufficient accumulation of technology. Core subcomponent gap lies in the design and manufacturing of collector pipes. According to the 12th FYP for the Development of Solar Power Generation, installed solar power capacity of China will amount to 3 million KW by 2020 and the Inner Mongolia 50MW slot-shaped solar thermal power project will be utilized for 2,400 hours a year. So, by 2020, China's solar thermal power generation will be 7.2 billion KWh. Emission factor calculation, for which 600MW ultra-supercritical thermal power generator sets are taken as the benchmark, indicates that CSP technology can achieve an emission reduction of 5.74×10^6 tons by 2020 for China.

Policy Suggestions

8.2.1 Suggestions for Removing Barriers and Promoting Technology Development and Transfer

The transfer of renewable energy technologies has propelled the domestic manufacturing of renewable energy equipment and also promoted the utilization of renewable energy resources in China. However, it's confronted with such restrictions as **high cost, repeated technology introduction, inadequate capacity for technology absorption and digestion of enterprises, and so on.** To improve the technology transfer mechanism further and promote the healthy and rapid development of the renewable energy sector in China, this research presents relevant suggestions as follows:

(I) Macroscopic policies

- Environmental policies: Formulate environmental protection-related rules, regulations or policies, taken into consideration the maximum benefit principle, and shift enterprise investment to expensive renewable energy technologies; strengthen the orientation of top policy design because policies in environmental protection and energy conservation are less coherent, notification, implementation and supervision are to be enhanced and the social awareness of environmental protection is weak.
- Technology policies: Transfer of renewable energy technologies requests sound technology policies and effect assessment policies. As China starts late in the development of renewable energy resources, its environmental policies and standards related are to be improved and relevant technology policies are to be formulated.
- Financial and tax policies: Establish a specific generic technology development fund for the renewable energy industry, organize relevant institutions to develop technologies that are highly common and inseparable, may play an important role in renewable energy development, have great future economic benefits, can improve the technological level of the industry, are comprehensive and need cross-industry and trans-national efforts, and finally share the achieves within the renewable energy sector.

(II) Micro channels for technology introduction

- Accelerate the establishment of a complete technology introduction information sharing system. The technology trade market is incomplete, where information of transferor and transferee is asymmetric so that the transferee can hardly acquire complete information in the complicated market environment. Repeated introduction takes place easily when an enterprise has poor knowledge about the technology introduction of another enterprise in the same industry. Introduction of critical core technologies should be planned and coordinated uniformly.

- Strengthen the digestion and absorption of introduced technologies, and establish an enterprises-oriented technical support system based on industry-university-research combination. Enterprises should invite colleges, universities and research institutions to participate in the introduction of major equipment, track jointly the development of international advanced technologies and carry out independent innovation activities on the basis of absorption.
- Introduce technologies through diversified approaches by virtue of technological globalization. As economic globalization speeds up its advancement, science and technology get spread more rapidly across the world and the trends to accelerated internationalization are enhanced constantly. China should make best use of technological globalization, strive to diversify the ways and accelerate the improvement of the technology innovation. It should also compete for advanced renewable energy technology talents on the international market, and provide support for renewable energy technology breakthroughs through various approaches such as personnel transfer and information exchange.

8.2.2 Suggestions for Independent Innovation, Based on Strategic Development Objectives and Long-term Technology Development

Quality gaps between introduced technologies and independently developed technologies, compatibility between products, charging ratios of international technology suppliers and overflow of technology introduction will all affect the preferences and technological innovation behaviors of market participators. Besides, the stronger the externality of product network is, the higher the technology preference will be. When the quality gap between introduced technology and independently developed technology falls into a sensitive interval, in particular, the Chinese government should balance seriously all special types of technologies introduced, give comprehensive assessments and refrain from laying blind emphasis on introducing high-quality technologies as many as possible so as to improve social benefits and competitiveness of industrial development most efficiently.

Though the high-tech products of most renewable energy enterprises of China are lagged behind that of developed countries in terms of quality, Chinese enterprises can make best use of the localization advantage, stress the development of auxiliary technologies, strengthen quality control of equipment and delicacy development, and develop high-quality and cost-efficient products according to its actual conditions. Though inferior to advanced enterprises when judged by core technologies, Chinese enterprises can rely fully on their good understanding about Chinese consumers to develop local demand-oriented products in multi-standard competitive industries in order to defeat foreign advanced enterprises and win a large share on the international market.

Development of independently developed technologies should be assured in a reasonable scope. In the adoption of technology introduction route, a space should be left for the development of independently developed technologies. Besides making Chinese enterprises better capable of having negotiations with international advanced enterprises, the development of independently developed technologies expands the thinking of re-innovation and helps to accumulate re-innovation experience. The absence of independently developed core technologies is quite harmful to industrial development. Though adopting technology introduction route, China shouldn't waive independently developed technologies, with the aim to improve Chinese enterprises' negotiation capacity in the course of technology introduction and impose pressure on technology transfer against international advanced enterprises.

Annex 11. Summary of the Sectors and the Priority Technologies

Table 11.1. A Short List of Priority Technologies for Mitigation

No.	Industry	Name of Technologies	Core Sub-technologies	Description of Technologies
1	Coal mining	Abandoned Coal-bed methane (gas) extraction technology	The key and the core technologies include: (1) the gas monitoring of the abandoned coal mine and the technology of the reserves evaluation; (2) the closure technology of the abandoned coal mine; (3) the gas extraction technology of the abandoned coal mine.)	This technology is mainly aimed at working face (or mine) after picking closed overburden movement stability mined-out area that within the old mined-out area of coal, coal pillar and adjacent coal strata released constantly desorption gas extraction technology to the ground.
2		The Extremely low concentration coal-bed gas power generation technology (the technology of flow reactor))	Hot reflux reaction technology （TFRR）	Electric heating element first exchange bed preheating to CH_4 oxidation temperature, ambient temperature ventilation air from the exchange bed side (lower temperature side) flow into and through the reactor, spent air temperature increased, in close proximity to exchange rapid oxidation of the bed in the middle of the high temperature zone of CH_4, generating heat. Heat production logistics to exchange bed the other side of the exchange of heat release, exchange bed temperature is getting higher and higher, into the high temperature side. At this time, oxidation reactor will automatically reverse ventilation air flow direction, the ambient temperature ventilation air flowing in from the high temperature side exchange bed, endothermic warming, close to the central area of the reactor, CH_4 is oxidation, produce the heat, heat energy is transferred to heat energy released in exchange for the of the low temperature side of the bed, so the cycle alternation operation.
3	Oil and gas exploration and development	surface engineering	Green completion well	In addition to reducing methane emissions, green Completion well can produce more natural gas and liquefied petroleum gas, and less solid waste discharge, less water pollution, more secure operating environment that can produce immediate economic benefits.

No.	Industry	Name of Technologies	Core Sub-technologies	Description of Technologies
4		Improvement of water drive	Single injection and production well(including DOWS and reinjection technology and Underground injection and production wells which are not separated	Downhole oil-water separation separates oil from water in the bottom of preliminary separation, and then makes a reinjection of the separated water so as to reduce the ground water production and improve the efficiency of oil well production and reduce consumption; Characteristics of injection-production well without separation underground：To converse the high aquifer of some oil wells and remaining wells are still used for oil extraction; to perforate the wells without injection for oil recovery, while the original injection continues injection.
5		Surface engineering	Enhanced oil/gas recovery	Casing gas gathers in the oil jacket of the oil well forming casing annulus. When the wellhead pressure is lower than the natural gas pipeline pressure, usually to discharge the casing gas into the atmosphere. If collecting these gases for sales rather than discharge, it is economic and environmental. It can install a compressor to collect the natural gas and pump it into the sales pipeline.
6		Emission reduction and improvin g efficiency	Capture and storage of carbon dioxide	In addition to reducing methane emissions, green Completion well can produce more natural gas and liquefied petroleum gas, and less solid waste discharge, less water pollution, more secure operating environment that can produce immediate economic benefits.
7	Thermal power industry	High parameter and large capacity, and the generation of ultra-supercritical power	Boiler and steam tu rbine	The main technical equipment is the high parameter large capacity Ultra Supercritical Boiler and the steam turbine. Boiler can provide steam pressure is greater than 26MPa, the temperature is greater than 600.
8		natural gas combined cy cle power-generation	Gas turbines	Gas - steam combined cycle with the high temperature exhaust gas turbine in the waste heat boiler to generate steam, and then sent to the acting in a steam turbine, the gas cycle (cycle Beltown) and steam cycle (Rankine cycle) combined with circulation.
9		Distributed cold, hot and electricity tri-generation （CCHP）	Micro gas turbine	Using natural gas as the main fuel driven gas-fired power generation equipment operation of gas turbine (micro gas turbines or diesel generators to produce electricity supply user demand for electricity, the power system, the discharge of waste heat through the waste heat recovery utilization equipment (steam turbine waste heat boiler or heat direct fired machine and so on) to user power supply, heating and cooling.
10		Retrofitting of the steam turbine system	Steam turbine design	By using the advanced turbine design (including linear blade and series) to improve the turbine structure, to improve the cylinder closure of the steam turbine, and to improve the efficiency of steam turbine.

No.	Industry	Name of Technologies	Core Sub-technologies	Description of Technologies
11		The deep use of flue gas waste heat and latent heat	Heat exchanging anticorrosion material	By adding heat pipe heat exchanger, flue gas cooler, low temperature economizer and other heat exchangers, or with the addition of waste heat tower and utilization of intermediate water to spray directly and contact for heat transfer, through the use of flue gas condensation latent heat to lower exhaust gas temperature, we can recycle flue gas and waste heat for heating the water, providing heat for heat users, et., so that it can improve the generation dispatch to reduce power supply coal consumption, improve the economic benefit of unit operation and save energy.
12	Renewable energy industry	Offshore wind power technology	Direct drive motor, doubly-fed motor flexible gear box, sea fan base, submarine cables design and laying technology, fan against typhoon, and so on	Since sea wind condition is better than the land and there is less restriction by noise, birds, land requisition, and so on, so this technology has brought the attention of several countries. At the same height, the shore wind speed off 10km will be 25% higher than that of the road. Sea wind turbulence intensity is small so as to there have a stable dominant wind direction and the fatigue load beard by the unit is low, making the fan longer life; wind shear becomes small so that it can lower the tower. Meanwhile, because China's coastal areas generally belong to the economically developed areas, offshore wind power is close to the load center.
13		Hull cell photovoltaic power generation technology)	Hull cell using the hull cell industrialization manufacturing technology (the sputtering technology) with TCO glass substrate and more than 10% efficiency and son on	The technology needs only a little silicon so that it can be more likely to reduce the cost, at the same time, it not only is a kind of highly efficient energy products, but also a type of new building material, easier to make a perfect combination with the building. Hull cell has a unique advantage that is affected by the shadow of small power loss.
14		Aviation bio-fuel technologies	Refined oil hydrogenation technology, pentose fermentation technology, cellulose, semi-finished products and finished products storage and transportation technology	The first generation of aviation bio-fuels is mainly extracted from corn, soybeans, sugar cane, and so on, existing the problems of affecting food security and so on, without high performance, safety, and quality of the jet fuel. The second generation of aviation fuel supplying mainly from jatropha, camelina, algae and halophytes. At present the main key affecting the aviation bio-fuels technology advance is in the raw material supply, high cost, the production process needs to be improved, and so on.

No.	Industry	Name of Technologies	Core Sub-technologies	Description of Technologies
15		solar thermal power generation technology	The lack of system integration technology, heat pipe, condenser.	Concentrated solar power generation technology is to gather solar energy at one point, the technology of steam turbine power generation by heating water or liquid. CSP technology in addition to the application of power production, but also can be applied to heat and power, hydrogen and salt from the plant and so on.
16	Iron and steel indu stry	Gas steam combined cycle power generation technology (150MW grade)	The core components of gas turbine production, such as high temperature parts, control system, rotor, and so on.	Low calorific value coal gas CCPP power generating system is to blast furnace iron and steel company by-product gas from steel pipe conveyor to the dust catcher, after purification, compress the gas, then put the gas into the gas turbine combustion chamber with a mixture with the air that is purified by air filter and pressurized air for mixture combustion; the flue gas of high temperature and high pressure in the gas turbine directly expanding power and drives the air compressor and generator to finish the combustion of single cycle power generation.
17		The flue gas conditioning technology	Fixed fluidized bed drier	Coal moisture control is short for furnace coal moisture control technology (CMC), mainly using the coke oven flue gas as heat source, through fluidized bed dryer or rotary kiln and other all kinds of ways to directly heating and dry the wet coal coking, removing part of the water before the furnace charging and keeping the boiling coal moisture stabilized at around 6.5%.
18		Smelting reduction iron-making technology (including COREX, FINEX Technology)	The core technology of COREX c-3000: the improvement of burden structure, furnace operation and the adjustment of airflow distribution, equipment improvement and maintenance, the longevity of COREX, the optimization of the furnace operation and so on. The core technology of Finex: (1) iron ore fluidized bed reduction process; (2) fluidized bed out part of the reduced iron pressing block into the molten gasifier;	The process of FINEX is a large improvement of COREX process and continuous technology innovation, especially development and application of the pulverized coal utilization technology and gas recycling technology, greatly enhancing the technical competitiveness of this process. The existing COREX process must solve the problem of the design of the shaft furnace after large-scale and the shaft furnace with anterograde gasifier connection link problem, and make a big improvement and innovation in coal resources development, utilization of pulverized coal, fuel quality, the structural optimization of fuel, and gas with high quality, and so on, greatly reducing the cost of crude fuel and melted iron so as to improve its competiveness.

No.	Industry	Name of Technologies	Core Sub-technologies	Description of Technologies
			(3) coal adding method by all loaded into the molten gasifier instead of part of the ground into a pulverized coal injection into the melt oxidation furnace, the rest of the coal, after crushing and binder pressed into briquettes briquette loaded into the molten gasifier; (4) melting gasifier is loaded in solid form become massive HCI and briquettes and sprayed into the pulverized coal; (5) gas processing system increased removal in coal gas by pressure swing adsorption of CO_2 removal device.	
19		Recycling technology of sintering flue gas	Sintering waste gas circulation and reduction process, deep purification process, new sintering system for energy saving and emission reduction, recycling process, circulation and coupling control emissions reduction,, dioxins removal technology, sintering experiment platform and numerical simulation.	By collecting part of the bellows of sintering flue gas circulation return to sintering material layer, there is a process that the contaminant such as SO_2, NOx and dust in the flue gas, etc. can be resolved, transformed, absorbed in sintered layer. Sintering flue gas recycling technology not only can reduce the amount of sintering waste gas emission and pollutant emission, but also can recover the low temperature and waste heat of flue gas and reduce the energy consumption of sintering process.

No.	Industry	Name of Technologies	Core Sub-technologies	Description of Technologies
20	Building Materials Industry	Cement kiln co-processing of municipal solid waste (RDF disposal)	Garbage sieved, homogenized, drying and other steps after the garbage into the kiln before pretreatment thermal equipment.	It belongs to cement kiln co-processing waste class technology, refers to after household waste pretreatment (including screening, drying, fermentation, and so on) ,it be feed inside the kiln or its subsidiaries after thermal equipment, and calcinated to take the effective use of domestic waste heat and ash, which make the disposal so harmless.
21		Cement production information system	The informational software systems of meeting the actual needs of enterprise	It belongs to the field of information technology, refers to the informational management system covering production management, equipment operation and maintenance, quality management, energy management and other content, which can enable automatic report generation, intelligent data logging and online maintenance equipment, power status and real-time statistical analysis and other functions.
22		Cement kilns intelligent optimization control system	The associated control systems and advanced sensors to meet the complex processes of kiln (such as flame temperature on-line monitoring sensors, flow sensors powder, and so on)	Make use of fuzzy logic, neural networks, and other advanced genetic optimization algorithm to establish the firing correlation model of cement kiln, which can lower the calcinating heat consumption based on the original fuel properties and production conditions, intelligent commissioning production control parameters, stable production conditions.
23		New dry milling technology of building ceramics	How to ensure the quality of products and traditional wet process can be fairly, including particle size distribution of the powder of dry process and conventional spray drying method are similar, whether raw material dry grinding equipment bring iron into during grinding or not etc. In addition, the main machinery equipment is also key, including electronic scales ingredients, large vertical mill, and	Process Description: raw materials according to the recipe ingredients, into the crushing fine grinding equipment for dry grinding and dry grinding process requirements to achieve the fineness of powder material into the granulator water granulated powder particles formed after press-forming stereotypes applied. Granulation, the amount of water can be 5% to 7%, the amount of pressure required to type powder; may also be too wet granulation process, add water to l0% ~ 12% granulated, and then dried to a fluidized bed moisture content of 5% to 7%, and the banal applied to press forming.

No.	Industry	Name of Technologies	Core Sub-technologies	Description of Technologies
			granulator and so on.	
24	Chemical Industry	Hydraulic turbine energy-saving technology		Hydraulic turbine using HSB single suction structure, binoculars body design, the casing is horizontal split double volute structure, the housing body only has import and export and balanced pipeline pump, feed pump inlet portion of the housing body except export outside are under pressure, and subjected to a smaller differential pressure within the housing.
25		No CO_2 emission pulverized coal pressurized delivery technology	High pressure dynamic sealing technology in the environments of containing solid particles and sealing materials and high-density transport technology.	Conventional pulverized coal pressurized delivery technology and system using pressurized lock hopper, pneumatic conveying method. This process needs to consume a large amount of CO_2 and vented, and there is a large energy consumption, slow, equipped with ultra-size and other issues, the use of new pulverized coal pressurized delivery system, which can effectively avoid CO_2 emissions.
26		Opening Heat Pump Technology		The refrigerant compressed by the compressor, refrigerant compressed at high temperature at which condensation heat and condensate were constant enthalpy throttling temperature is reduced and the formation of vapor-liquid mixed phase, vapor-liquid mixed phase after absorb heat from low-temperature heat and vaporization overheating, after entering the compressor, thus completing a cycle.
27		Hydrocom stepless compressor air conditioning systems		The technology uses digital computer technology and control technology, hydraulic actuator of the compressor during the compression process, the intake valve is held open controllable some time, that delayed closing of the intake valve of the way, so that part of the gas in the cylinder return the intake chamber.
28		High CO_2 natural gas making methanol technology	LURGI company is the professional top burned reformer and most of its proprietary LURGI typical water-cooled tubular	High containing CO2, N2 gas as raw materials, in which CO_2 / N2 in each of more than 20%, less than 60% methane. Using the company's proprietary LURGI top LURGI fired reformer; using proprietary LURGI its most representative water-cooled tube-type methanol reactor systems, heat recovery efficiency is the highest, the most uniform temperature distribution

No.	Industry	Name of Technologies	Core Sub-technologies	Description of Technologies
			methanol reactor column system.	in the bed, byproducts least, handling The catalyst easiest, most simple operation control, the same type of single reactor largest production capacity.
29		The ion-exchange membrane technology	Cell design and manufacturing technology, an electrode manufacturing technology	Secondary brine purification step; electrolysis process (electrolysis and electrolyte circulation); dilute brine dechlorination step.
30	Non-ferrous metal industry	Enriched flash smelting technology		Including the introduction of digestion and innovation of flash smelting method, Noranda, Isa law and Ausmelt house developed bottom blown oxygen furnace continuous copper smelting, and so on, for copper, lead, zinc, tin, nickel and other nonferrous pyro-metallurgical.
31		Liquid oxygen bottom blowing smelting reduction of high lead slag bottom blowing lead smelting technology)	High pressure dynamic sealing technology in the environments of containing solid particles and sealing materials and high-density transport technology	
32		Gas firing automatic temperature Control of aluminum reduction cell technology)		
33	the transportation industry)	Pure electric vehicles	Battery group technology	Pure electric vehicles refer to the vehicles which use battery as the power output, using motor drive wheels, and are in accordance with the requirements of road traffic, safety regulations and national standards for passenger vehicles.
34		LNG ships	Natural gas engine	Liquefied natural gas as the fuel for ships.
35		Energy saving transformation of aviation engine	Energy saving transformation of aviation engine	The energy saving modification of aircraft engine can significantly improve the engine life; reduce the maintenance cost of aircraft and the aviation kerosene fuel consumption.
36		Aircraft engine cleaning)	Aircraft engine washing equipment	The regular cleaning of the aircraft engine can reduce the surface attachments, improve the combustion efficiency of the engine to a certain extent, extend the engine life, and reduce the fuel consumption of the aircraft.

No.	Industry	Name of Technologies	Core Sub-technologies	Description of Technologies
37		Fuel cell technology	Fuel cell stack technology, high pressure hydrogen storage system	The use of the vehicle fuel cell device for high purity hydrogen fuel or fuel containing hydrogen by reforming the high hydrogen containing gas reforming.
38	the civil housing and commercial construction industry	Thermal insulation and fire protection technology of building envelope	Graphite modified expandable polystyrene	Graphite modified polystyrene is the raw material of graphite polyphenyl, which was first invented by German chemical company BASF, with two processes of suspension polymerization and extrusion polymerization production. Because of adding the infrared absorbent, the graphite modified polystyrene will have better absorption and thermal radiation reflection, so that greatly improve the heat preservation and heat insulation performance of materials.
39		Thermal insulation and fire protection technology of building envelope	Outer thermal insulation and expansion fire retardant coating for foamed material and cellulose material	Coating thickness: 2-3 mm; milky white transparent coating. After the curing and couplet macromolecules, there will have stable performance. The flame retardant will not migrate, not pulverize, and not crack. In case of fire, it can generate strong and dense carbon layer, with good insulation of carbon layer. After coating in the fire expansion, surface temperature of coating and substrate is less than 60℃. The protected foam and fiber material will not be affected by the surface coating, keeping the original physic and chemical properties and having good fire protection features.
40		thermal insulation and fire protection technology of building envelope	Roofing waterproof vapor membrane-since special metal surface viscous acid and alkali resistant fiberglass tire vapor membrane	A self-adhesive product is a cold vapor-proof elastomer modified asphalt coiled material. Fiberglass or fiberglass metal base, upper surface is a layer of acid, corrosion-resistant aluminum membranes or asphalt. Excellent vapor-proof effect, construction convenient cold adhesive, + 5 ℃ and above, install the products in accordance with EN ISO9001 quality control of production and products comply with European standard EN 13970 requires.
41		High efficiency and energy-saving door and window curtain wall technology	Ultra-low energy consumption building door	Has gas key, and water key, and anti-wind pressure, and across sound, and insulation, and fire, and anti-theft, variety performance, door of overall thickness in 100mm above, makes whole door has good of insulation performance, whole door of k value can up 0.6W/(M2.k); three road rubber article sealed, guarantee has households door of gas key sex; waterproof, fire; using European standard of more points lock, anti-theft grade can up WK4; tie special of fill material, across sound performance can up 45 DB.
42		High efficiency and energy-saving door and window curtain wall technology	High efficiency and self-expanding sealing belt for energy saving window and door	They are used for door and window and wall seams sealed, sill plates and external wall thermal insulation system of sealing and penetrate the component and the seal between the insulation layer. A windproof, waterproof, airtight, sound effects.

No.	Industry	Name of Technologies	Core Sub-technologies	Description of Technologies
			and window opening	
43		High efficiency and energy-saving door and window curtain wall technology	High efficiency and waterproof sealing cloth system of energy saving window	This technology is used for the joints between windows, doors and walls, with malleable, waterproof and penetrating properties. With self-adhesive and special adhesive, it realizes the effective bonding: effective bonding on window frame (or vice frame), and on the other by strong compatibility of special adhesive on the wall for real waterproofing and sealing.
44		Energy saving technology of high efficiency heating and air conditioning system	Heat recovery efficiency of heat and moisture exchange membrane with fresh air and exhaust air	The technical material to achieve its high efficiency between air flow on both sides (above 75%) of heat and moisture Exchange and mix two air leakage does not occur, the pollution situation and has bacteriostatic antimicrobial function. The material can be used in residential and commercial air conditioning systems of outdoor air and indoor ventilation heat recovery process, recovery of exhaust heat and humidity, to preheat the fresh air humidification (winter) or pre-cooling dehumidification (summer), reduce air-conditioning system load, improving system efficiency.
45	Agriculture, forest and land utilization	High efficiency utilization of nitrogen fertilizer	Efficient utilization technology of blue crystal with slow controlled release urea fertilizer to increase production and emission reduction	Nitrapyrin, N-Sever, as a kind of nitrification inhibitors, can effectively prevent the conversion of ammonium to nitrate in ordinary urea, promote the utilization of nitrogen, increase the utilization rate of nitrogen, ensure the crop production, and achieve a win-win economic and environmental benefits.
46		Breeding technology of rice varieties	Selection and breeding of rice varieties with high yield and low emission)	GHG emissions differences of different rice varieties in 1-5 times. High-yielding rice varieties with low emissions the following characteristics: seed biomass, high protein, high harvest index, less effective tillers, stem and leaf photosynthetic intensity is high, root, root oxidation ability. Field cultivation technology of strict application of the "three controls" technology to achieve the control seedlings (15,000-20,000 stump/MU), control fertilizer (total nitrogen, 180kg/HA) and disease-control (pest) coherent, efficient use of water and fertilizer, and fully tap the potential of high-yielding in rice.
47		Afforestation increase remit technology	Construction technology of agro-forestry system	On agricultural land and marginal land afforestation, agro-forestry system is formed. Carbon sequestration in agro-forestry systems on agricultural land is a very attractive option, because it remained in while huge swathes of land used for agricultural production, and also fixed a lot of carbon.

No.	Industry	Name of Technologies	Core Sub-technologies	Description of Technologies
48		Forest management increase remit emission reduction technology	Determination technology of optimal forest management plan	To analyze the effects of carbon sequestration in forests under different forest management strategies based on the forest ecosystem processes and the carbon storage and utilization of bio-energy technologies of wood-based products, to determine the best forest management plan. Common analysis models include FORECAST, CO2FIX, FORCARB-ON, FSFVS, and so on.
49		Comprehensive management technology of land utilization	comprehensive management technology of land utilization	To design and to compare the potential and effects of mitigating climate change in different land utilization scenarios, and to maintain environmental, social and economic benefits with the introduction of a sustainable way. Technical means is PRO-COMAP model and so on.
50	Carbon capture and storage industry	Separation of CO_2 by chemical absorption method	Efficient utilization technology of blue crystal with slow controlled release urea fertilizer to increase production and emission reduction	The chemical absorption method refers to the absorption of CO_2 in the flue gas by chemical reaction with the use of alkaline chemical absorbent so as to form unstable salt which can break down reversely to release CO_2 under certain conditions of temperature and pressure to remove the CO_2 from flue gas.
51		Oxygen-enriched combustion technology		The CO_2 concentration in the flue gas is only 13%~16% with the fuel combustion in the air, and at the moment the CO_2 capture will consume large amounts of energy, so oxygen-enriched combustion technology which is a new combustion mode from the point of burning is developed in order to get more separation of high concentrations of CO_2 with lower energy consumption and costs.
52		Hydrogen-enriched combustion gas turbine technology		Typical applications are for IGCC(Integrated gasification combined cycle), namely to obtain the synthesis gas containing carbon monoxide and hydrogen through the gas, and to obtain hydrogen rich syngas through the water-gas shift, purification and removal of carbon dioxide, and then put the gas into the gas turbine combined cycle system to combustion.
53		Underground materials and equipment with long life and corrosion resistance		The underground materials and equipment with long life and corrosion resistance mainly refer to underground corrosion protection methods and materials of the oil field. The anticorrosion technologies used in oil field mainly include: cathodic protection, chemical anti-corrosion, anti-corrosion coating and the anti-corrosion materials, such as the use of low density full back cement, the use of drilling fluid with high pH value and the reduction of the contact between the corrosive medium and so on.

No.	Industry	Name of Technologies	Core Sub-technologies	Description of Technologies
54		Safety monitoring, evaluation and risk management techniques		The main risk of CCS projects are CO_2 leakage, including CO_2 transport pipeline leak, injection leak, sealed formation escape, near the well leak, fault leakage and so on.
55	Waste disposal industry	Landfill gas collection and utilization technology	Internal combustion engines, steam turbines and micro turbines	The micro turbine technology has the highest emission reduction potential and the minimum cost of emission reduction. The first priority of the AHP is the internal combustion engine and turbine technology. Above all, we can know that the three technologies have their own advantages and disadvantages, and we should choose the appropriate power generation technology in terms of different situations.
56		WtE-GT process combination		The combined operation of the garbage incineration power plant and the gas plant (referred to as WtE-GT),and the further improvement the output steam temperature of the waste heat boiler with the use of the tail gas discharged from the gas turbine, are to improve the thermal efficiency of the waste incineration plant.
57		High solid anaerobic biogas technology	Valorga technology	Valorga technology should be given the priority to develop, and its technology has been applied in Dong Village garbage disposal plant of Beijing and Putuo garbage disposal plant of Shanghai, so it has taken the first step in terms of localization.

Table 11.2. A Short List of Priority Technologies for Adaptation

No.	Industry	Rank	Sub-sector	Technology	Technology Type (1)	Technology Maturity (2)	Technology Gap (3)
1	Agriculture and Forest Ecosystem	1	Agricultural Water-saving Technology	Degradable Mulch	Hardware Technology	Modern Technology	International Technology Transfer
2	Agriculture and Forest Ecosystem	2	Agricultural Water-saving Technology	Pipeline Water Delivery Technology	Hardware/software Technology	Conventional Technology	Promotion and application
3	Agriculture and Forest Ecosystem	3	Precision Agriculture Technology	Precision Water and Fertilizer Management Technology	Software Technology	Technology Development & Innovation	International Technology Transfer
4	Agriculture and Forest Ecosystem	4	Precision Agriculture Technology	Intelligent Agricultural Machinery	Hardware Technology	Technology Development & Innovation	International Technology Transfer
5	Agriculture	5	Stress-tolerant	Insect-resistant	Hardware	High-tech	International

	and Forest Ecosystem		Varietal Breeding Technology	Cotton, Anti-rice Blast Breeding in Rice, Drought Resistance Breeding in Wheat, Drought Resistance Breeding in Wheat and Corn and other Breeding Technologies	Technology		Technology Transfer
6	Agriculture and Forest Ecosystem	6	Forest Ecosystem	Boreal Coniferous Forest Timber Felling Management Technology that can adapt to climate change	Software Technology and Orgware Technology	Conventional Technology/ Modern Technology	International Technology Transfer
7	Agriculture and Forest Ecosystem	7	Forest Ecosystem	Adaptive Forest Management Technology to manage trade-offs between forest products and service supply capacity	Software Technology and Orgware Technology	Conventional Technology/ Modern Technology	International Technology Transfer
8	Water Resources	1	Unconventional Water Resource Utilization	Rainwater Accumulation Utilization Technology	Hardware Technology	Conventional Technology/ Modern Technology	Promotion and application
9	Water Resources	2	Agriculture Water saving	Drip Irrigation Technology	Hardware Technology	Conventional Technology	International Technology Transfer
10	Water Resources	3	Unconventional Water Resource Utilization	Water Developing and Integrated Utilization Technology in Water Poor Layer	Hardware Technology	Conventional Technology	Promotion and application
11	Water Resources	4	Water Source Project Construction	Pumping Irrigation and Water Saving Technology by Solar Photovoltaic	Hardware Technology	Modern Technology	International Technology Transfer
12	Water Resources	5	Water Source Project Construction	Water Supply Technology by Rubber Dam	Hardware Technology	Conventional Technology/ Modern Technology	Promotion and application
13	Urban	1	Infrastructure	Sponge City Planning and Operative Technology	Hardware/software Technology	Modern Technology	International Technology Transfer
14	Urban	2	City Planning	Climate Change Adaptive Planning System Building	Hardware Technology and Orgware	Modern Technology	Promotion and application/Technology

				Technology	Technology		Development & Innovation
15	Urban	3	City Planning	Urban Green Space Layout Optimization Technology	Hardware Technology	High-tech	International Technology Transfer
16	Urban	4	Infrastructure	Key Technology of Long Distance, High Lift and Large Flow in Water Diversion Project	Hardware Technology	Modern Technolog y	International Technology Transfer
17	Urban	5	Infrastructure	Roof Greening Technology	Hardware/so ftware Technology	Modern Technolog y	International Technology Transfer
18	Urban	6	Infrastructure	Permeable Pavement Application Technology	Hardware Technology	Modern Technolog y	International Technology Transfer
19	Disaster Forecast and Weather Monitoring	1	Impact Assessment and Adaptation	Climate & Climate Change Impact Assessment	Software Technology	Modern Technolog y	International Technology Transfer
20	Disaster Forecast and Weather Monitoring	2	Impact Assessment and Adaptation	Environment related Weather Numerical Modeling Technology	Software Technology	High-tech	Technology Development & Innovation
21	Disaster Forecast and Weather Monitoring	3	Weather Forecast	Regional NWP Technique	Software Technology	High-tech	Technology Development & Innovation
22	Disaster Forecast and Weather Monitoring	4	Data Analysis	Meteorological Data Reanalysis Technique, Global and Regional Products	Software Technology	Future Technolog y	International Technology Transfer
23	Disaster Forecast and Weather Monitoring	5	Weather Monitoring	Weather Radar Monitoring	Hardware/so ftware Technology	Modern Technolog y	Technology Development & Innovation

Annex 12. Pilot Projects

Table 12.1. List of Pilot Projects

No.	Pilot Projects	Description of Technologies	Project Location	Grants from TNA Project (US$)	Own financial contribution (US$)	Lifetime direct GHG emissions avoided (tCO_2 eq)
1	Large-scaled Data Center Energy Efficiency Optimization System Pilot Program	Introduce advanced Internet of Things Technology and efficiency assessment and energy conservation control system from Australian National University, acquire energy consumption of data center by wireless and IP network, effectively analyze equipment operation situations, draw 3D temperature-humidity nephogram, find out hotspots of temperature-humidity nephogram, and establish energy conservation assessment system for green data center to provide efficiency optimization strategy and realize accurate control of IT microenvironment (specifically rack and IT equipment) consumption reduction. Carry out technology promotion, drive efficiency optimization, energy conservation and emission reduction of data center by demonstration to lower the PUE value of domestic data center below 1.8, and realize energy conservation effect of over 10%.	Ji'nan, Shandong; Shenyang, Liaoning	80,000	140,000	169,521
2	Design and Demonstration of Effective PV/Diesel/Storage Power System based on EMS	Different from the single integration mode of multi-energy complementary power generation system in market, this program studies multi-energy supplementary management control technology to develop energy management platform, and applies energy management system to photovoltaic power generation, diesel power generation and energy storage system to realize energy optimization and coordination use of photovoltaic power generation, diesel power generation and energy storage system so as to realize the efficient, safe and reliable operation of the system. The program will push development of new energy technology and industry so as to gradually replace fossil energy, save	Yulin, Shanxi	80,000	200,000	706

No.	Pilot Projects	Description of Technologies	Project Location	Grants from TNA Project (US$)	Own financial contribution (US$)	Lifetime direct GHG emissions avoided (tCO_2 eq)
		energy, reduce energy consumption, and reduce carbon dioxide emission.				
3	Improving Energy Efficiency of Large Wind Turbines Pilot Program	The company jointly develops large wind turbines blade lengthening technology with foreign experts by introducing blade design technology from Germany and wind power load analysis software from UK. This technology is used to upgrade and reconstruct large wind turbines units. By lengthening the blade, the power generation volume can increase by over 6%. After technology transfer, the technology level can compete with that of leading enterprises in European and American.	Yumen, Gansu	100,000	132,000	178,398
4	Fiber Membrane Decarbonization and Purification of Landfill Gas for NGV Pilot Program	The perm-selective membrane is taken as separation medium for membrane filtering separation technology. When applying certain impetus to both sides, the components on raw material side will penetrate the membrane selectively so as to reach the purpose of separation and purification. The characteristics of membrane separation technology are shown in: (1) During the purification, methane loss is lower than 1%, and recovery rate of methane reaches up to 99%. The maximum utilization of raw methane can be reached. (2) Compared with other methods, the gas separation rate is high, and backflow is low and only 20% of total gas volume so that the power consumption during gas transmission is the lowest. (3) Other auxiliary materials, such as water and adsorbents are unnecessary so as to avoid pollution. (4) The device is simple, highly integrated, and convenient for carry and installation (5) It is simple to control. Normal operation can be finished by one person. The entire decarburization process is realized by full-automatic	Yantai, Shandong	100,000	1,400,000	231,548

No.	Pilot Projects	Description of Technologies	Project Location	Grants from TNA Project (US$)	Own financial contribu tion (US$)	Lifetime direct GHG emissions avoided (tCO_2 eq)
		process control and management system at normal temperature.				
5	Inlet Air Cooling System of Gas Turbine Front End and Waste Heat's Deep Utilization of After End Program	The performance of gas turbine is closely related to its ambient environment. The front-end air inlet cooling technology refrigerates and cools combustion air by exhaust waste heat when gas turbine generates power or by power generation volume increased to keep the gas turbine operating under ISO standard conditions so as to realize maximum output of gas turbine. It can improve energy conservation and comprehensive utilization efficiency of energy, and increase emission reduction volume. The end waste heat full utilization technology can supply energy to cascade refrigerating system of lithium bromide absorption unit by heat generated by the last step, that is, heat entering hot water circulation system from heat recovery boiler. The cooling unit can provide cooling capacity required by refrigerator for medium to low temperature environment. The waste heat cascade cooling can reduce above 50% of average energy consumption.	Xiamen, Fujian	60,000	170,000	393,007
6	Qinhuangdao Centrifuge Heat Pump Project	In order to realize resource recycling and reduce energy consumption and GHG emission by extracting "renewable energy" from "wasted energy" by advanced technology, Shugu Xiangyuan, the core office area covering 120,000 square meters in Data Industrial Park of Qinhuangdao Economic and Technological Development Zone, is the first program in China extracting cooling and heating energy from reclaimed water source by U.S. new generation efficient magnetic levitation Centrifuge Heat Pump technology. Due to the improvement of efficiency, this technology solves the problem that insufficient reclaimed	Qinhuangda o, Hebei	80,000	331,900	65,273

No.	Pilot Projects	Description of Technologies	Project Location	Grants from TNA Project (US$)	Own financial contribu tion (US$)	Lifetime direct GHG emissions avoided (tCO_2 eq)
		water sources failed to provide cooling and heating to the entire park, and realizes reduction of carbon dioxide emission. This technology is propagable and replicable in reclaimed energy programs.				
8	The Pilot-Testing of FS12 On-Fire Side Energy Efficiency Promotion Technology in China's Energy Sector	When heat exchange equipment such as boiler is operating, it will spray special chemical agent to heat exchange equipment via control device; the chemical agent is foggy in furnace, and spreads with the flue gas; the special chemical components of agent generate chemical reaction with coking elements in fuels to make coking ash loose and easy to exhaust with flue gas so as to realize efficient coking removal, thermal transmission improvement, heat exchange efficiency improvement and fuel consumption reduction; meanwhile it can reduce emission of CO_2, SO_2, NOx, dusts, and so on and help clients such as power plants to realize great economic, environmental and social benefits.	Changji, Xinjiang	100,000	231,908	3,299,973
9	Pilot Program of Regeneration of Lead-acid Batteries by Solar Energy	Extend the service life of lead-acid battery by introducing solar photovoltaic power generation technology and lead-acid battery repair and regeneration technology; set up a low carbon operation process of battery, that is, solar photovoltaic power – battery energy storage – power consumption of mobile electric equipment (such as electric forklift truck, electric vehicles) - battery numbering – battery maintenance – battery service life extension – battery scrapping. The major cause of lead-acid battery performance declining is that the sulfoacid aluminum generated during charging /discharging process increases internal impedance of battery, reduces proportion of electrolyte and lowers charging efficiency; during discharging process, sulfoacid aluminum generated	Guangzhou, Guangdong	80,000	894,000	27,967

No.	Pilot Projects	Description of Technologies	Project Location	Grants from TNA Project (US$)	Own financial contribution (US$)	Lifetime direct GHG emissions avoided (tCO_2 eq)
		on surface of plate electrode blocks the flowing space on plate electrode, blocks current channel, and increases impedance, leading to scrapping due to failing to discharge. The battery repair technology uses low-frequency motor to break down sulfoacid aluminum. No chemical products and powers are used during battery repair, and the environmental-friendly repair technology is used completely. After repair, the internal impedance reduces and electrolyte proportion increases. By improvement of charging efficiency, the discharging effect is recovered and increased to 90-95% of new battery standard. The repaired battery can be automatically detected and evaluated.				
			Total	680,000	3,499,808	4,366,393