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Report No: ICR00004642

IMPLEMENTATION COMPLETION AND RESULTS REPORT

TF 011898

ON A

GRANT FROM THE GLOBAL ENVIRONMENT FACILITY

IN THE AMOUNT OF US$15 MILLION

TO THE

PEOPLE'S REPUBLIC OF CHINA

FOR THE

DIOXINS REDUCTION FROM THE PULP AND PAPER INDUSTRY PROJECT (P125528)

December 19, 2019

Environment, Natural Resources and Blue Economy Global Practice
East Asia and Pacific

CURRENCY EQUIVALENTS

(Exchange Rate Effective June 30, 2019)

Currency Unit =	Chinese Yuan (CNY)
CNY 6.8692 =	US$1

FISCAL YEAR

July 1 – June 30

ABBREVIATIONS AND ACRONYMS

ADt	Air Dry Ton
ASEAN	Association of Southeast Asian Nations
AOX	Absorbable Organic Halides
BAT	Best Available Techniques
BEP	Best Environmental Practices
BOD	Biological Oxygen Demand
BRICS	Brazil, Russia, India, China, and South Africa
CEH	Chlorination, Alkaline Extraction, and Hypochlorite
COD	Chemical Oxygen Demand
CPA	China Paper Association
ECF	Elemental Chlorine Free bleaching
EHS	Environment, Health, and Safety
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPB	Environmental Protection Bureau
ESMF	Environmental and Social Management Framework
FECO	Foreign Environmental Cooperation Center of MEE, formerly Foreign Economic Coop. Office
FYP	Five-year Plan
GEF	Global Environment Facility
GoC	Government of China
g TEQ	Grams Toxic Equivalent
HRGC	High Resolution Gas Chromatography
HRMS	High Resolution Mass Spectrometry
ICR	Implementation Completion and Results Report
IFC	International Finance Corporation
MEE	Ministry of Ecology and Environment, formerly Ministry of Environmental Protection
MOF	Ministry of Finance
NAP	National Action Plan
NH_3-N	Ammoniacal Nitrogen
NIP	National Implementation Plan for the Stockholm Convention
PAD	Project Appraisal Document
PBF	Performance-based Financing

PCDDs	Polychlorinated dibenzo-*p*-dioxins – a sub class of dioxins
PCDFs	Polychlorinated dibenzofurans – a sub class of furans
PDO	Project Development Objective
PIF	Project Identification Form
PMO	Project Management Office
POPs	Persistent Organic Pollutants
TCF	Total Chlorine Free bleaching
ToC	Theory of Change
TTL	Task Team Leader
UNEP	United Nations Environment Programme
UPOPs	Unintentionally Produced POPs

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DATA SHEET

BASIC INFORMATION

Product Information

Project ID	Project Name
P125528	Dioxins Reduction from the Pulp and Paper Industry
Country	**Financing Instrument**
China	Investment Project Financing
Original EA Category	**Revised EA Category**
Full Assessment (A)	Full Assessment (A)

Organizations

Borrower	Implementing Agency
People's Republic of China	Foreign Environmental Cooperation Center of Ministry of Ecology and Environment

Project Development Objective (PDO)

Original PDO

The project development objectives are to: (a) demonstrate the result of adoption of best available techniques and best environmental practices (BAT/BEP) in four selected non-wood pulp mills; and (b) support China in developing and adopting a long-term action plan to guide the promotion of a sector-wide BAT/BEP adoption.

PDO as stated in the legal agreement

Both the Grant Agreement and the PAD include the same PDO statement as follows: "the objectives of the project are: (a) to demonstrate the result of BAT/BEP adoption in four selected non-wood pulp mills; and (b) to support the Recipient to develop its long-term action plan to guide the promotion of sector-wide BAT/BEP adoption. The statement of "original PDO" above is found in the Operations Portal. Given there was no formal change to the PDO, the ICR refers to the PDO wording as found in the Grant Agreement and PAD (noting that the slightly different wording in the Portal is not material).

FINANCING

	Original Amount (US$)	Revised Amount (US$)	Actual Disbursed (US$)
World Bank Financing			
TF-11898	15,000,000	15,000,000	14,855,212
Total	**15,000,000**	**15,000,000**	**14,855,212**
Non-World Bank Financing			
Borrower/Recipient	66,000,000	57,160,000	61,690,000
Total	**66,000,000**	**57,160,000**	**61,690,000**
Total Project Cost	**81,000,000**	**72,160,000**	**76,545,212**

KEY DATES

Approval	Effectiveness	MTR Review	Original Closing	Actual Closing
29-Mar-2012	19-Jun-2012	01-Dec-2015	30-Jun-2017	30-Jun-2019

RESTRUCTURING AND/OR ADDITIONAL FINANCING

Date(s)	Amount Disbursed (US$M)	Key Revisions
15-Nov-2014	3.28	Change in Results Framework Change in Safeguard Policies Triggered Change in Institutional Arrangements Change in Implementation Schedule
28-Jun-2016	6.74	Change in Results Framework Change in Components and Cost Change in Loan Closing Date(s) Reallocation between Disbursement Categories Change in Disbursements Arrangements Change in Legal Covenants Change in Implementation Schedule
27-Jun-2018	13.43	Change in Loan Closing Date(s)
27-Sep-2018	13.70	Change in Results Framework Change in Loan Closing Date(s) Reallocation between Disbursement Categories Change in Disbursements Arrangements Change in Procurement Change in Implementation Schedule

KEY RATINGS

Outcome	Bank Performance	M&E Quality
Satisfactory	Satisfactory	Substantial

RATINGS OF PROJECT PERFORMANCE IN ISRs

No.	Date ISR Archived	DO Rating	IP Rating	Actual Disbursements (US$M)
01	16-Jun-2012	Satisfactory	Satisfactory	0
02	31-Mar-2013	Satisfactory	Moderately Satisfactory	2.00
03	24-Oct-2013	Moderately Satisfactory	Moderately Unsatisfactory	2.00
04	25-Mar-2014	Moderately Satisfactory	Moderately Unsatisfactory	3.28
05	19-Nov-2014	Moderately Satisfactory	Moderately Unsatisfactory	3.28
06	14-Apr-2015	Moderately Satisfactory	Moderately Unsatisfactory	3.63
07	19-Oct-2015	Moderately Unsatisfactory	Moderately Unsatisfactory	3.63
08	20-May-2016	Moderately Unsatisfactory	Moderately Unsatisfactory	6.74
09	21-Nov-2016	Moderately Satisfactory	Moderately Satisfactory	8.99
10	09-Mar-2017	Moderately Satisfactory	Moderately Satisfactory	10.91
11	04-Nov-2017	Moderately Satisfactory	Moderately Satisfactory	8.93
12	24-Apr-2018	Moderately Satisfactory	Moderately Satisfactory	12.76
13	14-Nov-2018	Moderately Satisfactory	Moderately Satisfactory	13.70
14	29-Jun-2019	Satisfactory	Moderately Satisfactory	14.81

SECTORS AND THEMES

Sectors

Major Sector/Sector	(%)
Water, Sanitation and Waste Management	**50**
Public Administration - Water, Sanitation and Waste Management	50
Industry, Trade and Services	**50**
Public Administration - Industry, Trade and Services	30
Other Industry, Trade and Services	20

Themes

Major Theme/ Theme (Level 2)/ Theme (Level 3)	(%)
Environment and Natural Resource Management	**101**
Environmental Health and Pollution Management	81
Air quality management	27
Water Pollution	27
Soil Pollution	27
Environmental policies and institutions	20

ADM STAFF

Role	At Approval	At ICR
Vice President:	Pamela Cox	Victoria Kwakwa
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I. PROJECT CONTEXT AND DEVELOPMENT OBJECTIVES

A. CONTEXT AT APPRAISAL

Context

Country Context

1. The rapid economic development in China since the late 1970s under a resource-intensive growth model led to significant environmental pollution and ecological degradation. Committed to reversing this downward environmental trend, the Government made environmental protection a national policy. Therefore, a pillar of the World Bank's Country Assistance Strategy[1] was 'Managing Resource Scarcity and Environmental Challenges.' Internationally, China ratified numerous conventions including the Stockholm Convention on Persistent Organic Pollutants for which China had prepared a National Implementation Plan (NIP) in April 2007, offering a blueprint for reduction of persistent organic pollutants (POPs) to 2025. POPs are a group of chemical substances that persist in the environment; can be transported far from their sources and bioaccumulated through the food web; and can lead to serious health effects, including certain cancers, birth defects, and dysfunctional immune and reproductive systems.[2] Under the Stockholm Convention, a total of 28 chemical substances are listed as POPs, including pesticides (such as Dichlorodiphenyltrichloroethane [DDT]), industrial chemicals (such as polychlorinated biphenyls) and unintentional byproducts of industrial processes (such as dioxins and furans). The last group of chemicals is often referred to as unintentionally produced POPs (UPOPs[3]).

2. According to the China NIP, the pulp and paper sector was one of the priority sectors for control and reduction of UPOPs releases given its listing in the Stockholm Convention[4] as a priority source category with potential for comparatively high formation and release to the environment. Moreover, the importance of the sector was highlighted as it was understood[5] to be (a) a major source of water pollution in 2006, accounting for about 15 percent of national industrial wastewater and about 33 percent of national industrial chemical oxygen demand (COD) discharge; (b) one of the industrial sectors with the highest energy consumption; and (c) a sector that was expected to experience high growth rates. Among all pulp and paper production processes, the NIP identified the elemental chlorine-based pulp bleaching process as the main source of UPOPs and proposed a series of reduction measures in line with the best available techniques/best environmental practices (BAT/BEP) mandated by the Stockholm Convention.[6] The Chinese Government requested a World Bank project financed by the Global Environment Facility (GEF), as the financial mechanism to the Stockholm Convention, to help implement the NIP in the pulp and paper sector.

[1] World Bank Group, Report No. 46896-CN, May 2006.
[2] *What Are POPs,* Stockholm Convention on POPs http://www.pops.int/TheConvention/ThePOPs/tabid/673/Default.aspx.
[3] In the context of the project, and of this ICR, the terms "dioxins" and "UPOPs" are used interchangeably.
[4] Stockholm Convention, Annex C, Part II.
[5] *Study on UPOPs Releases from Non-wood Pulp and Paper Mills*, prepared by the Research Center for Eco-Environmental Science of the Chinese Academy of Sciences with World Bank Canada POPs Trust Fund support, December 2009.
[6] *Guidelines on Best Available Techniques and Provisional Guidance on Best Environmental Practices Relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants*, United Nations Environment Programme, May 2007.

Sectoral and Institutional Context

3. The China Paper Association (CPA)[7] reported in 2009 that China had about 3,700 pulp and paper mills, including many of small capacity, with a total pulp production of 66.74 million tons. In contrast to other countries, China relied heavily on non-wood fiber materials to produce its virgin pulp, as the country had relatively limited production capacity for wood fiber materials. The country was promoting development of wood pulp production and increased import of wood and waste fiber, leading to a decrease in the share of non-wood pulp as a share of total pulp (including non-virgin pulp from recycled materials) from 40 percent in 2000 to about 15 percent in 2009. The share of non-wood fiber materials remained high, however, and was of continued strategic importance for China.

4. Traditionally, the pulp and paper sector produced and released UPOPs into the environment as a result of elemental chlorine-based pulp production processes widely used in the sector. To improve the environmental performance of this sector, China had initiated industry restructuring efforts from 1996 to encourage concentration of production capacity and support closure of inefficient small mills. In the context of the 11th Five-year Plan (FYP) (2006–2010), particularly its target on reduction of COD, China had issued a series of Cleaner Production Guidelines since 2007 and the revised Wastewater Discharge Standards for the Pulp and Paper Industry (GB3544-2008) in 2008. The 2008 standards,[8] require all new mills established after August 1, 2008, to meet stricter discharge standards, including a water consumption standard, and for the first time an effluent standard on dioxins. This new standard further required all existing mills to meet the discharge standards from July 1, 2011.

5. The pulp and paper sector, as a key source of water pollution in China, had been under strict environmental monitoring and enforcement by the municipal or provincial environmental protection bureaus (EPBs) since the mid-1990s. Data from online monitoring equipment (measuring COD concentration, volume of discharged wastewater, and, in some cases, SO_2 concentration and volume of discharged flue gas) at the mills were being transmitted directly to the EPBs and failure to meet standards would result in an onsite visit by EPB agents. Noncompliance with environment standards triggered significant penalties in addition to the mandatory discharge fee.

6. Because of these government initiatives, there was a significant improvement in the sector's environmental performance (for example, reducing COD discharge from about 3.1 million tons in 2000 to about 1.3 million tons in 2008). The positive results of these policy measures and active environmental monitoring and enforcement had provided a sound basis for the sector to eliminate elemental chlorine bleaching-based production to comply with the 2008 standards. Most large wood pulp mills had already adopted BAT/BEP based on elemental chlorine-free technologies. In contrast, few non-wood mills had followed the national policy and acted on their own to adopt BAT/BEP for their non-wood pulp production lines. Therefore, the BAT/BEP demonstration objective and corresponding activities in Component 1 specifically targeted non-wood pulp mills. Project activities in Components 2 and 3 were similarly largely focused on non-wood-based production, but the project's long-term action plan objective also included wood-based production.

[7] *China Paper Association Annual Report*, 2009.
[8] The GB3544-2008 standards have not been revised and are current at project completion.

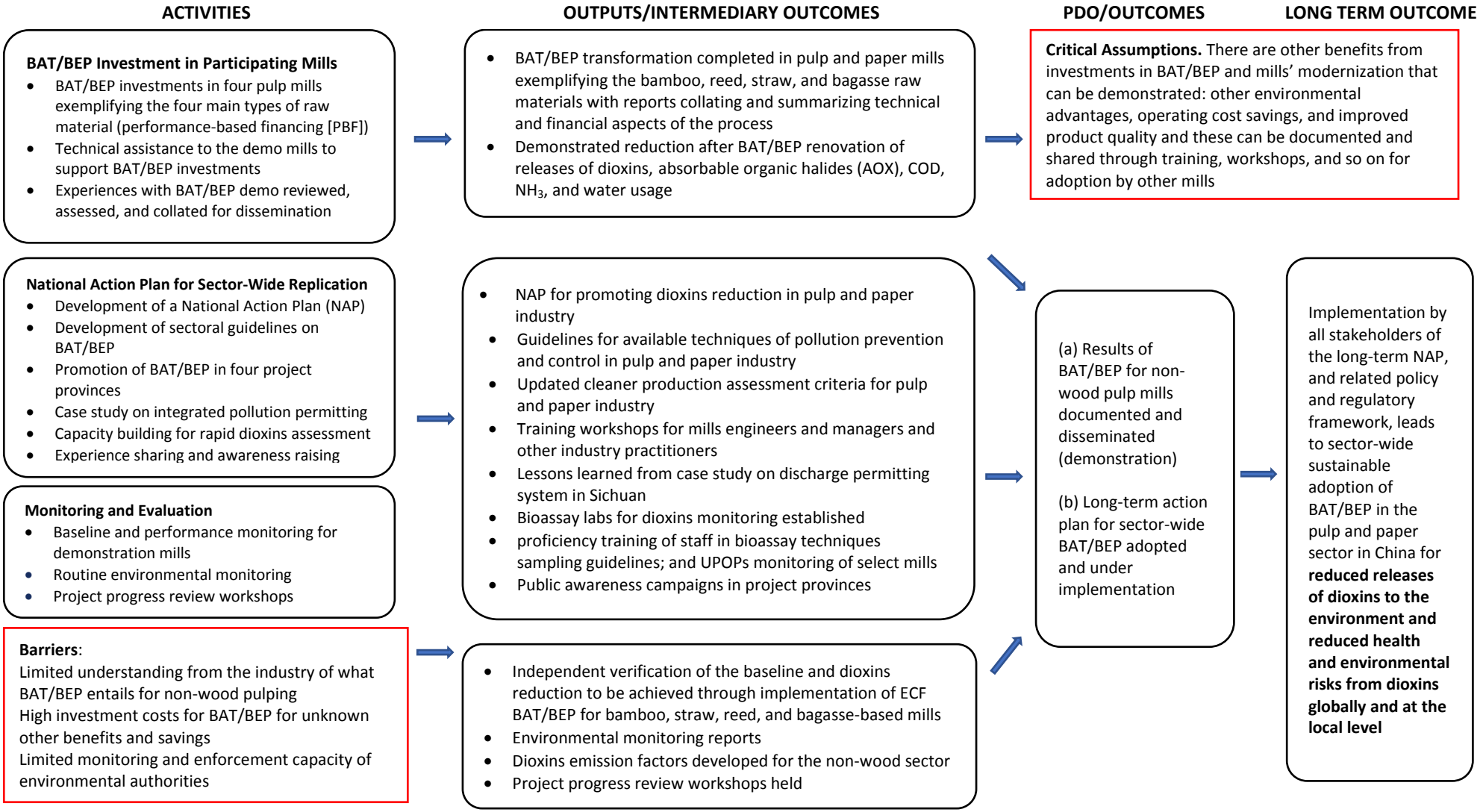
Theory of Change (Results Chain)

7. The Project Appraisal Document (PAD) at approval did not offer an explicit theory of change (ToC), but a ToC is embedded in the Results Framework and implicit in the last paragraph of the 'Sectoral and Institutional Context' section of the PAD that outlines the incremental reasoning and basis for GEF support. The wording in the PAD is as follows and is considered robust: "Two challenges face the Government in encouraging sector wide adoption of BAT/BEP: (a) high investment cost and yet-to be demonstrated benefits of BAT/BEP adoption in the non-wood sector; and (b) limited dioxin monitoring and enforcement capacity at the local level to ensure compliance of existing mills with the 2008 discharge standards. To respond to these challenges, this project is focused on (a) demonstrating BAT/BEP in four existing non-wood mills which typify the most commonly used non-wood fiber material in China: straw, reed, bamboo and bagasse; and (b) strengthen the government's capacity in monitoring and enforcement of the 2008 dioxin standard. Based on the results of the demonstration projects, the Ministry of Environmental Protection will develop a long-term national action plan to scale up BAT/BEP adoption and further control the formation and release of UPOPs from both the wood and non-wood pulp sectors."

8. The abovementioned high investment cost must be considered hand in hand with the "yet to be demonstrated benefits". The project was not designed to address the financing barrier as such (beyond direct support to a limited number of mills) but rather was to demonstrate what constitutes BAT/BEP and how these investments are to be carried out. Also, the project was to demonstrate that they can offer a good return on investment for the mills with operating cost savings and improved product quality as well as meet environmental and regulatory imperatives. The critical assumptions that underlie the ToC is that there will indeed be benefits to the mills that can be documented and disseminated to the industry through training and workshops and will be sufficiently appealing (coupled with regulatory and enforcement push) for the other mills in the sector to carry out BAT/BEP investments.

9. The ToC is presented graphically in figure 1, developed for this Implementation Completion and Results Report (ICR). The original ToC was fundamentally unaffected by the changes that occurred during implementation described further. (The late withdrawal of one of the participating mills led to technical assistance support to three mills and to additional support to Component 2, particularly expansion of the scope of the support to building capacity for bioassay monitoring.)

Figure 1. Theory of Change



Project Development Objective (PDO)

10. The PDO as stated in the PAD and the Grant Agreement is to: "(a) demonstrate the result of BAT/BEP adoption in four selected non-wood pulp mills; and (b) to support the Recipient to develop its long-term action plan to guide the promotion of sector-wide BAT/BEP adoption".

Key Expected Outcomes and Outcome Indicators

11. The PDO-level results indicators were

(a) Reduced UPOPs releases in the four non-wood fiber mills supported by the project;

(b) Adoption of a long-term action plan for the sector's UPOPs reduction.

Components

12. The project was designed with two main complementary components addressing the two key challenges identified during project preparation, with a third component specifically targeting monitoring and evaluation (M&E), and a fourth component for project management.

Component 1: BAT/BEP Investment in Participating Mills (Total cost estimated at appraisal: US$73.64 million, GEF grant: US$11.55 million; Actual cost: US$67.64 million, GEF grant: US$9.92 million)

13. This component was to support adoption of BAT/BEP in four selected non-wood pulp mills by replacing the existing elemental chlorine-based bleaching process with the elemental chlorine free (ECF) process to minimize releases of dioxins and furans. Construction, renovation, and rehabilitation of production processes and facilities were to be carried out in the participating mills to improve their overall environmental performance, including reducing pollution load in effluents and increasing water conservation. Technical assistance to the participating mills was to support review of technical proposals and design of BAT/BEP during trial operations after the completion of the technological upgrades. Four mills were selected in Guangxi, Hunan, Ningxia, and Sichuan Provinces. Each mill represented one of the four different main types of non-wood fiber used in pulp production (bagasse, reed, straw, and bamboo).

14. A Performance-based Financing (PBF) scheme was designed to incentivize the mills to carry out the agreed BAT/BEP investments, complete needed trial operations to adjust the system to the specific production conditions, operate the new facility for a one-year period, and achieve agreed performance targets.

15. In support of the demonstration objective of the project, an assessment of the results of the BAT/BEP investment was carried out to review and analyze experience gained in implementing the four demonstration investments, covering the full range of technical, operational, financial, and environmental issues experienced by the four demonstration mills.

Component 2: National Action Plan for Sector-Wide Replication (Total cost estimated at appraisal: US$2.56 million, GEF grant: US$1.8 million; Actual cost: US$5.23 million, GEF grant US$3.34 million)

16. This component was to establish an enabling environment for promotion of BAT/BEP techniques and practices tested under Component 1, including the development of a NIP to guide sector-wide adoption of BAT/BEP. Based on the experiences learned in the four demonstration projects, the component was to support (a) development, dissemination, and implementation of general sectoral technical guidelines on BAT/BEP and specific guidelines for the non-wood pulp sector of China; (b) development of a National Action Plan (NAP) setting out a detailed approach for the pulp and paper sector in China to progressively eliminate elemental chlorine-based bleaching production process; (c) measures to encourage sector-wide BAT/BEP adoption, including promotion of good practices for wood-based mills, with training of governmental officials and representatives of industrial institutions on BAT/BEP adoption in the pulp and paper sector; (d) provision of capacity-building support and training to local EPBs to conduct sampling and monitoring of dioxin release from the operation of paper and pulp mills using rapid assessment methods; and (e) awareness raising on good production practices for both the non-wood and wood-based pulp and paper sectors.

Component 3: Monitoring and Evaluation (Total Cost: US$1.2 million, GEF grant: US$0.87 million; Actual cost: US$1.32 million, GEF grant US$0.87 million)

17. Due to the pilot nature of the project, emphasis was to be placed on monitoring and evaluating the results of the investments supported by the project. This component was to support independent verification of baseline and sample results at the four mills to quantify reduction of dioxins releases as well as water quality parameters and water savings achieved. In addition, dioxin monitoring activities were to be performed at selected wood mills that had adopted BAT/BEP to evaluate BAT/BEP options for the wood pulp sector. In the four project provinces, the project was also to support the efforts of the four provincial EPBs to promote UPOP monitoring and enforcement based on the 2008 standards, which in the longer term would incentivize both non-wood and wood mills to adopt BAT/BEP. Other traditional project M&E activities were to be carried out during the course of project implementation.

Component 4: Project Management (Total cost estimated at appraisal: US$3.6 million, GEF grant US$0.78 million; Actual cost: US$2.32 million, GEF grant US$0.78 million)

18. This component was to support provision of technical assistance to improve the capacity of the Foreign Environmental Cooperation Center[9] (FECO) of the Ministry of Ecology and Environment (MEE) and the four provincial EPBs to manage the implementation of the project. Project management consultants were to be recruited to support routine project management tasks, and technical consultants to provide technical inputs/comments on technical issues of contracts and technical reports. In addition, this component was to support incremental operating costs of FECO and the provincial EPBs associated with project implementation.

[9] Formerly, Foreign Economic Cooperation Office of the Ministry of Environmental Protection.

B. SIGNIFICANT CHANGES DURING IMPLEMENTATION

Revised PDO and Outcome Targets

19. The PDO was not revised.[10]

20. The outcome targets were only revised insofar as specific targets for dioxin reduction at participating demonstration mills were added. At appraisal, these targets were 'to be decided' because the baselines required to set the targets had not been determined. Specific baselines and targets, consistent with Chinese standards and project technical objectives, were added during implementation (see annex 1A).

Revised PDO Indicators

21. The PDO indicators were not revised.[11]

22. Targets were added where previously missing (see annex 1A). In particular, targets were specified for the dioxins reduction indicator for the demonstration mills because the reference baselines were not available at appraisal.

23. Regarding the indicator on adoption of a long-term action plan for sectoral UPOPs reduction, the indicator and target themselves were not revised, but the intermediate target dates for steps in the development of the plan were revised to reflect a more realistic preparation timetable.

Revised Components

24. Component one was revised through the second project restructuring, in June 2016, to reflect new support to selected mills in the form of technical assistance for BAT/BEP planning, in response to the withdrawal from the project of the bagasse-based mill and non-replacement for BAT/BEP investment demonstration.

Other Changes

25. The project underwent four Level 2 restructurings: in November 2014, June 2016, June 2018, and September 2018:

November 2014

- Replacement of two of the originally selected demonstration mills[12] that withdrew from the project for business reasons linked to the conditions of the market: Ningxia Zhongye Meili

[10] The quality enhancement review meeting for the midterm review for the project discussed whether to amend the statement PDO that refers to BAT/BEP adoption in 'four' selected non-wood mills to 'three' following the withdrawal and non-replacement of the bagasse-based mill but decided against this as it would have brought no substantive benefit, with no implication on the implementation or outcomes of the project. (November 16, 2015, meeting minutes on file).
[11] The statement of outcome indicator referring to number of mills (four) was not changed for the reasons discussed above in the context of the PDO.
[12] In the case of Ningxia Zhongye, the company made poor investments to increase its share of wood pulp that could not be

(straw) and Hunan Yueyang (reed) replaced by Henan Baiyun (straw) and Hunan Linyuan (reed)[13]; intermediate indicators revised accordingly to set baselines and targets for the two new mills for COD, ammonia (NH_3), and water consumption.

- Implementation schedule adjusted to reflect implementation delays due to time needed to select and appraise the new mills.

- Relabeling of the intermediary indicator 'UPOPs monitoring guideline for the pulp and paper sector developed' to 'UPOPs sampling guideline for the pulp and paper sector developed', to better reflect the needs identified.

June 2016

26. In response to the late decision of the Guangxi Pumiao[14] bagasse-based mill to pull out of the project and close down for business reasons, the following changes were made:

- Component costs adjusted accordingly, including to reflect a drop in co-financing due to Pumiao mill investments no longer being counted toward the total.

- Additional technical assistance activity to support BAT/BEP investment planning; introduction of related intermediary indicator 'Numbers of selected mills to develop BAT/BEP investment plans' (four).

- Support to bioassay dioxins monitoring expanded from four to eight laboratories/provinces; increased intermediary indicators targets for 'Training in rapid dioxins monitoring' (from three to four) and for 'Increased UPOPs monitoring'.

- Intermediate indicator targets for 'Workshops on BAT/BEP knowledge dissemination' and 'Training for design institutes' adjusted downward (from six to three and from four to one, respectively) to adapt to changing circumstances, namely, the consolidation of the industry with many small pulp and paper mills having closed down in the years since appraisal.

- Implementation schedule adjusted to reflect implementation delays and project closing date extended by one year, to June 30, 2018.

June 2018

- Extension of the project closing date by three months to allow time to finalize the restructuring request of the Government of China (GoC).

sustained and at the time of ICR had pulled out of the pulp making business altogether. Hunan Yueyang decided to shift its production to non-bleached pulp only.

[13] An Environmental Impact Assessment and Environmental Management Plan were prepared by each mill and disclosed prior to restructuring.

[14] A leading reason was the additional cost of air pollution control faced by the mill which led Pumiao's parent company to shut down the mill.

September 2018

- Adjusted implementation modality for the technical assistance support to BAT/BEP planning to allow for a subproject implementation modality, given that the modality originally envisaged for FECO to recruit consultants directly was not attractive to the enterprises and none had confirmed their interest.

- Target under intermediary results indicator for 'Numbers of selected mills to develop BAT/BEP investment plans' decreased from four to two to better reflect costs and available budget (eventually, three bagasse mills participated).

- Implementation schedule adjusted to reflect implementation delays and the project closing date extended by nine months, to June 30, 2019, to allow for issuance of the NAP and completion of project activities to support long-term sustainability of project outcomes.

Rationale for Changes and Their Implication on the Original Theory of Change

27. The most significant changes resulted from the withdrawal of three of the four originally appraised demonstration mills. Two mills based on reed and straw in Hunan and Ningxia were replaced by equivalent mills in Hunan and Henan with no other implication on project design. The bagasse-based mill in Guangxi withdrew late in the project. By that time, it was decided not to seek replacement with an equivalent mill, given that this would likely lead to greater delays in implementation. Rather, the decision was taken to rely on the early experiences the project had been able to establish with bagasse already before the withdrawal of Pumiao and further support the bagasse-based pulp and paper industry in Guangxi through technical assistance for BAT/BEP planning (this is further discussed under section IIIB).

28. These changes had only limited impact on the ToC because the mills exemplifying reed- and straw-based pulping were replaced by equivalent mills, while experiences from the bagasse-based mill could be drawn from a combination of the original mill before it closed down and the mills supported through technical assistance.

29. The additional support allocated to the bioassay laboratories, by increasing the number of laboratories supported and the support to each of them, strengthens the prospects for long-term sustainability by increasing the critical mass of stakeholders aware of the potential of bioassay-based techniques, and therefore the likelihood that they would become acceptable alternatives to costly chemical analysis in certain conditions.

II. OUTCOME

A. RELEVANCE OF PDOs

Rating: High

Assessment of Relevance of PDOs and Rating

30. There are no shortcomings in the relevance of the project to the Country Partnership Strategy at project closing,[15] and the project is fully aligned with the focus and objectives of previous iterations of the World Bank's partnership with China:

- Prepared during the 2006–2010 Country Partnership Strategy[16] in line with that strategy's 3rd pillar on 'Managing Resource Scarcity and Environmental Challenges' and Country Assistance Strategy's goals of 'Improved natural resource management to reduce degradation and depletion' and 'International environmental commitments met'.

- Implemented during the 2013–2016 Country Partnership Strategy[17] and listed against Strategic Theme I on 'Supporting Greener Growth', Outcome 1.6 on 'Demonstrating Pollution Management Measures'.

- At project closure, the project is fully aligned with the priorities highlighted under the Systematic Country Diagnostic[18] in sections on 'Greening Energy and Industry' and 'Water and Soil Pollution' under Chapter IV on 'Green Growth for Sustainability'. Moreover, with its focus on global environmental public goods and institutions building, the project is well aligned with the World Bank's comparative advantage and with the directions for the partnership between the World Bank and China following the 2018 capital increase, particularly the focus on leading and delivering on the global public goods agenda.[19] The project consequently continues to be relevant to the objectives of the new Country Partnership Framework[20] for China adopted shortly after project closing, specifically its Objective 2.2 of 'Reducing Air, Soil, Water, and Marine Plastic Pollution'.

31. The project is also fully aligned with the successive FYPs of China that see increasing attention to environmental pollution and with China's emphasis on creating an ecological civilization:

- At preparation, with the 11th FYP (2006–2010) goal for creating a less polluting society.

[15] The 2013–2016 Country Partnership Strategy was still current at project closing; a new Country Partnership Framework was approved by the World Bank Board, December 5, 2019.
[16] World Bank Group, Report No. 46896-CN, May 2006.
[17] World Bank Group, Report No. 67566-CN, October 2012.
[18] World Bank Group, Report No. 113092-CN, 2017.
[19] World Bank Group. 2018. *Sustainable Financing for Sustainable Development: World Bank Group Capital Package Proposal*, Report to Governors at 2018 Spring Meetings, April 2018.
[20] World Bank Group, Report No. 117875-CN, November 2019.

- Implemented in parallel with the 12th FYP (2011–2015) with its focus on 'intensifying environmental protection' and specifically on controlling the discharge of pollutants and major contaminants.

- At closure, the project is directly supporting the objective of the 13th FYP (2016–2020) to control emissions from key industrial pollution sectors, which explicitly refers to papermaking. Moreover, the importance of non-wood in papermaking is very specific to China: while globally non-wood represents 6.5 percent of the yearly production of virgin pulp, in China non-wood pulp constitutes 44 percent of virgin pulp (table 1).

32. This alignment with China's development priorities is the key factor that has enabled the project's catalytic effect, allowing the project to influence several important and broader policies and regulations and to contribute to accelerate the transformation to BAT/BEP of a large segment of the market.

33. Finally, the project is aligned with China's plans to implement the Stockholm Convention on Persistent Organic Pollutants, with the convention's work program, and with the priorities of the GEF:

- The NIP for the Stockholm Convention submitted by China to the Conference of the Parties to the Convention in 2007 lists the pulp and paper sector as a key industrial sector to be controlled for dioxins reduction. This is retained through the updated NIP[21] submitted in December 2018 by the GoC.

- The project was directly relevant to the Stockholm Convention and to Stockholm Convention guidance to the GEF as its financial mechanism at the time of approval and continues to be relevant at project closing, for example, the program of work around unintentional POPs adopted at the recent Conference of the Parties in May 2019.[22.]

- This work continues to be relevant to the GEF—it was fully aligned with the GEF-5 chemicals strategy under which the project was approved and continues to be aligned with the GEF-7 (2018–2022) strategy[23] for Chemicals and Waste Program 1 on Industrial Chemicals that seeks the 'introduction and use of best available techniques and best environmental practices to minimize and ultimately eliminate releases of unintentionally produced POPs'.

[21] *The People's Republic of China National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants*, http://www.pops.int/Implementation/NationalImplementationPlans/NIPTransmission/tabid/253/Default.aspx.
[22] Decision SC-9/7, http://www.pops.int/TheConvention/ConferenceoftheParties/ReportsandDecisions/tabid/208/Default.aspx.
[23] GEF7 Programming Directions, Chemicals and Waste Focal Area Strategy, GEF/R.7/19, April 2018.

Table 1. World Pulp Production Data

Virgin pulp production, million tons (2014)			
Wood		**Non-wood**	
World	176	World	12.3
United States	49.4	China	6.8
Brazil	17.8	India	2.0
Canada	17.6	Spain	0.8
Sweden	11.6	Pakistan	0.4
Finland	10.5	USA	0.3
Non-wood pulp share of total virgin pulp, %			
World	6.5	China	44

Note: FAO data cited in Biermann's Handbook of Pulp and Paper 2018.

B. ACHIEVEMENT OF PDOs (EFFICACY)

Rating: Substantial

Assessment of Achievement of Each Objective/Outcome

34. The objectives of the project are '(a) to demonstrate the result of BAT/BEP adoption in four selected non-wood pulp mills; and (b) to support the Recipient to develop its long-term action plan to guide the promotion of sector-wide BAT/BEP adoption'. The PDOs have been substantially achieved. The PDO and intermediate results indicators have been met as described under the Results Framework section (annex 1A). The PDO can be unpacked into two outcomes, and indicators/results measuring this and achievements under these outcomes are presented in the following paragraphs.

Outcome 1: To demonstrate the result of BAT/BEP adoption in four selected non-wood pulp mills

35. **Pilot investment mills.** Results of the adoption of BAT/BEP were measured by the first PDO indicator 'Reduced UPOPs releases in the four non-wood fiber mills supported by the project'. This outcome was met with the successful demonstration of BAT/BEP investments at three selected non-wood mills recorded and disseminated, which exemplify the pulp-making process for three main types of non-wood fibers, that is, bamboo, reed, and straw-based pulping.

36. The BAT/BEP renovations that were conducted at the three mills consisted of a number of process improvements tailored to the specific conditions and requirements of each mill (figures 2–4). This included raw material preparation, improved cooking, oxygen delignification, and improved knot removal. All three mills introduced chlorine dioxide bleaching in place of elemental chlorine bleaching. The benefits for the mills from the renovations were assessed to include the following (annex 10 for details):

- Reduced dioxins and AOX formation and release
- Reduced releases of convention pollutants, including COD, biological oxygen demand (BOD), and ammoniacal nitrogen (NH_3-N)
- Water usage savings
- Reduced energy consumption
- Reduced amount of chemicals use
- Improved pulp yield

- Improved product quality: pulp strength and whiteness
- Operating costs savings and increased profit margin.

37. Specifically, with regard to the dioxins reduction outcome of the project, the BAT/BEP transformation was confirmed to significantly reduce releases of dioxins from the bleaching workshop effluents. Concentrations of dioxins at various sampling points at the mills were assessed independently through an accredited laboratory. The dioxins reductions ranged from 77 percent to 98 percent, exceeding the 70 percent reduction target of the project (see annex 1A) and leading to levels well below the Chinese[24] standards GB3544-2008 on Water Pollutant Discharge for Pulping and Paper Industry (see table 2).

38. Moreover, bioassay monitoring continued to take place at the three mills in 2017, 2018, and 2019, the three years following BAT/BEP renovation and dioxins reduction verification. The results show continued low levels of dioxins generated from the bleaching process (see annex 10). While these results are more of a qualitative[25] nature, they point to a positive trend in a continued low level of emissions at the mills.

39. The full technical and financial details of the renovation process, including expected reduction of other conventional pollutants and operating costs savings, were assessed, synthesized and published, and form the basis for the 'Technical Opinion' that accompanies the NAP developed and adopted to meet PDO 2. These demonstration results were also summarized in the "BAT/BEP Design Technical Manual for Non-wood Pulp" that was published as a book and disseminated within the industry and used in training of mills operators under Component 2 in support of PDO 2, as well as to serve as a guide for the design of pulp mills in the future.

Table 2. Component 1 Summary Results

	Dioxins Concentration in Bleaching Workshop Effluent pg/L	**Dioxin Release Reduction from Bleaching Effluent after BAT/BEP (ECF) Implementation (%)**
Sichuan Jinfu (bamboo pulp)	0.52	98
Henan Baiyun (straw pulp)	1.35	77
Hunan Linyuan (reed pulp)	0.92	98
GB3544-2008 Standards on Water Pollutant Discharge for Pulping and Paper Industry	30	–
Baseline (2008) total sector releases of dioxins from bleaching effluents of non-wood mills: 30 g		
Project direct dioxins reduction from bleaching effluents of six participating mills: 0.5 g		
Sector-wide (project indirect, 2018) dioxins reduction from bleaching effluents of non-wood mills: 25.5 g		

[24] Concentrations are also lower than limits set by other jurisdictions, for example, Canada (15 pg/L) or United States (10 pg/L for tetra-chlorinated dibenzo-para dioxin [TCDD]).
[25] There is no recognized standard method for bioassays in China, and the GB3544-2008 standards require high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS) determination of dioxins. Moreover, the relationship between the results obtained with both methods is not established for pulp milling effluents. The results presented therefore were obtained for the purposes of research and development under the project and have no regulatory standing or implication.

40. Through this effort, the project was also able to generate new emission factors for dioxins releases from non-wood pulp making reflecting the current level of technology, which were the basis for assessment of sector-wide impact. These results were published in a peer-reviewed international scientific publication.[26] The project-specific and sector-wide dioxin release reduction can be found in the GEF tracking tool prepared to meet GEF reporting requirements, in annex 7, with the basis for calculations presented in annex 8.

41. **Technical assistance support to bagasse-based mills.** Due to the withdrawal of the Pumiao bagasse-based mill, the project did not fully demonstrate BAT/BEP for the bagasse-based process through investment. While the project was able to document the renovation process, the renovated mill did not go into operation and therefore the project was not able to document operating cost savings. However, the project was able to document dioxins releases following BAT/BEP for bagasse-based mills through information collected on actual reductions from a similar bagasse-based mill, Guangxi Nanhua that was assessed by the project's independent verification consultant, and BAT/BEP adoption was facilitated through technical assistance in three other bagasse-based mills implemented after the September 2018 restructuring. Therefore, the outcome of 'demonstrating the result of adoption' in the fourth mill was essentially achieved as well.

42. As noted earlier, following restructurings in 2016 and 2018, funds available with the withdrawal of the Pumiao mill were in part allocated to support the process of BAT/BEP planning in three bagasse-based mills in the Guangxi Province, to facilitate and speed up adoption of BAT/BEP at these mills, with a view to catalyzing adoption of BAT/BEP throughout the province. As outlined in annex 10, the mills received support for the development of a number of investment planning tools including feasibility study, construction safety assessment, and construction drawing review. This also included Environmental and Social Management Plans to develop mitigation measures and improve environmental and social risk management at the mills in the future after project closure. At time of writing this ICR, two of the mills had completed BAT/BEP renovations, Tianyuang in March 2019 and Dongtang in October 2019, while the third one was expected to complete its investments by the end of 2019.

43. With this outcome almost fully achieved, achievement of this first outcome is therefore rated Substantial.

Outcome 2: To support the Recipient to develop its long-term action plan to guide the promotion of sector-wide BAT/BEP adoption

44. **NAP.** The second outcome can be understood to encompass the suite of capacity-building and institutional strengthening outcomes that were supported by the project to provide the framework to guide the whole sector toward sustainable ECF techniques and practices after closure of the project, including policy and regulatory improvements, capacity building for monitoring and enforcement, and training for the industry.

45. This was captured by the PDO indicator 'Adoption of a long-term action plan for the sector's UPOPs reduction' which was fully achieved. The National Action Plan for Dioxins Reduction in the Pulp

[26] Xiao et al. (2017) "A primary estimation of PCDD/Fs release reduction from non-wood pulp and paper industry in China based on the investigation of pulp bleaching with chlorine converting to chlorine dioxide", *Chemosphere*, 185:329-335. Project results were also disseminated in Chinese through two books and four other research articles; see annex 6 for references.

and Paper Industry was issued by the CPA on November 23, 2018; it mandates that the pulp and paper sector be fully free of elemental chlorine-based bleaching by 2025. The NAP provided the framework for the project to deliver its catalytic impact, with transformation of most of the industry during the project lifetime. Although the action plan was only formally issued toward the end of the project implementation period, the project had in fact been supporting the actions envisaged under the NAP much earlier, including numerous capacity-building activities, methodology development, training, and engagement with stakeholders that directly supported early implementation of the action plan, leading to the majority of the sector having converted to ECF bleaching by closure of the project.[27] With the strengthening of environmental institutions and regulatory oversight following the 2018 reform[28] of environmental governance in China and with the goals of the project inscribed in powerful policy documents as described in the following paragraphs, it is expected that the sector will be fully ECF by 2025 as required by the NAP.

46. **Policy and regulatory strengthening.** Embedded in this outcome are a large number of normative and guidance documents for the sector that were either directly supported by the project or toward which the project provided input (see annex 1B Key Outputs). The key guidelines tracked by the Results Framework are the 'General Guidelines on BAT/BEP for Pollution Prevention and Control of Paper Making Industry' that include dioxin-specific elements developed under the project and were issued by the Ministry of Ecology and Environment (MEE) in January 2018. Another important policy document that was developed with input from the project team is the 'Action Plan for Prevention and Control of Water Pollution' issued by the State Council in 2015 and featuring the pulp and paper sector as 1 of the 10 key industrial sectors targeted for technological upgrade. It includes the provision that "papermaking industry should strive to achieve elemental chlorine free (ECF) bleaching of paper pulp or adopt other low-pollution pulping technologies". Support was also extended to Guangxi and Hunan Provinces to develop their own policy documents and guidelines as needed.

47. **Bioassay monitoring.** In support of this outcome of sector-wide BAT/BEP adoption and to build long-term capacity for monitoring, the project under Component 2 also established eight bioassay[29] laboratories and achieved staff proficiency as measured by laboratory comparison exercises, introducing the bioassay technique as a possible alternative for regulatory and screening purposes (see figures 8–9). This entailed the purchase of equipment, standards, and consumables; the construction of a dedicated laboratory space in the participating laboratories; and the training of staff. The project is the first to have piloted the bioassay technique for environmental screening and monitoring of provincial environment

[27] The combination of the project's catalytic impact and regulatory and enforcement push has also led to continued consolidation of the industry. In Sichuan, for example, while the capacity for bamboo-based pulp increased 50 percent between 2012 and 2018, the number of mills decreased from 20 to 13, while the number of mills producing unbleached pulp increased from 3 to 5.

[28] The new MEE was created in March 2018, consolidating pollution enforcement and environmental powers from a number of agencies.

[29] A biological assay or bioassay is an analytical method to determine the concentration of a substance by its effect on living cells or tissues. The method promoted by the project is the Chemical Activated LUciferase gene eXpression (CALUX) technique developed in the United States which is a quantitative bioassay. While it is not precise enough to fully replace traditional analytical chemistry (HRGC/HRMS), it is cheaper to use and therefore very useful for screening purposes. Moreover, the result is by definition directly related to the biological activity of a sample and therefore can be a better indicator of its toxic potency. See, for example, Eichbaum et al. (2014) "In vitro bioassays for detecting dioxin-like activity— Application Potentials and Limits of Detection, a Review." *Sci Total Environment*.

departments in China. This work was published in a Chinese scientific journal.[30] The laboratories performed UPOPs analysis on pulp and paper mills' effluents in the years following their establishment, meeting the intermediary indicator for 'Increased UPOPs monitoring for pulp and paper mills in the participating provinces', as reported in the Results Framework section (annex 1B). Other media were also analyzed such as contaminated sites and soils in the vicinity of waste incinerators, and the staff of the first four laboratories to have been established also participated in the development of the draft standard for screening of dioxins in solid waste samples, which is expected to be issued by the MEE.

48. **Awareness raising.** Finally, NAP promotion and dissemination activities were conducted targeting the industry as well as aimed at raising awareness of the general public to increase demand for ECF and unbleached products. Several workshops and training events were held for technical staff and managers from pulp and paper mills across the country as well as design institutes and other specialized research and consulting institutions. Public awareness campaigns were also conducted to disseminate knowledge about POPs and the formation of dioxins in the pulp and paper industry. These activities were conducted through dissemination by TV, Internet, newspaper, and on-site promotion with students and residents in communities (see figures 5-7). Public awareness materials such as brochures, ECF-based notebooks, and ECF-based as well as unbleached household paper products, were distributed.

49. With this outcome fully achieved, achievement of this second outcome is therefore rated High.

Justification of Overall Efficacy Rating

50. With achievement of the first outcome rated Substantial and achievement of the second outcome rated High, overall efficacy is Substantial.

C. EFFICIENCY

Rating: Substantial.

Assessment of Efficiency and Rating

51. Project efficiency is Substantial, despite the delays in implementation. Project efficiency gains can be estimated from several angles in the absence of a reliable method to estimate the cost-benefit of dioxins reduction. Assessment of efficiency is detailed in annex 4.

(a) The project has largely achieved what it set out to achieve within budget. However, the project could not anticipate[31] that it would start implementation at a time of restructuring of the industry, leading to the withdrawal from the project of three of the four mills that had been appraised originally, which resulted in most[32] of the two-year implementation delay.

[30] Ma, Hui, Boyu Song, Songyan Zhang, Qunhui Xie, Li Xu, Zhengyu Cao, and Bin Zhao. 2018. "Development and Application of Luciferase Reporter Gene-based Bioassay System for Dioxin Determination." *Scienta Sinica Chimica*, 48.

[31] As an indicator of turmoil in market conditions hitting after the project start, non-wood pulp production stood at 12.4 million tons in 2011 when the project was prepared and had been stable around that level since 2002; it was down to 8.3 million tons by 2013, stabilizing around 6 million tons by 2016 (table 2).

[32] There were also some administrative delays following the relocation of the project's Designated Account from FECO to the MOF, and back to FECO.

(b) As described in the PAD, the project followed a least-cost approach to meeting China's obligations under the Stockholm Convention to reduce the release of dioxins from the pulp and paper sector by comparing and benchmarking the effectiveness of ECF and total chlorine free (TCF) bleaching, and ultimately selecting ECF with its lower investment and operating costs.

(c) The project leveraged significant private sector investments in BAT/BEP through co-financing from the participating mills, with US$57.7 million for a GEF contribution of US$9.1 million under Component 1. This is not counting the investments towards BAT/BEP and sector-wide ECF from the other enterprises not directly supported by the project.

(d) From the mills' perspective, the investment not only was meeting a mandatory regulatory regime, but also proved to be a good return on investment, with savings on energy use, water treatment, and other operating costs, and improved product quality. The payback on investment[33] was estimated at 3.9 years for Sichuan Jinfu (bamboo), 4.3 years for Hunan Linyuan (reed), and 5.2 years for Zhumadian Baiyun (straw). This confirms the hypothesis that cleaner production methods pursued in parallel (and as part of) with BAT/BEP would lead to savings.

(e) Under Component 2 on National Action Plan for Sector-Wide Replication, the project worked with Provincial Ecology and Environment Departments, environmental monitoring centers, provincial research academies and other research institutes, and the CPA and six participating mills, to produce thirteen policies and standards, research reports and technical manuals, training materials, two books and five published scientific and technical papers. While difficult to benchmark, this is an impressive number that was made possible by relying on national experts, consultants, and researchers, rather than relying on international expertise; this was also appropriate given the limited international experience on the matter.

(f) Under Component 2, the project also established eight bioassay laboratories and achieved staff proficiency as measured by inter-laboratory comparison exercises,[34] introducing the bioassay technique as a possible alternative for regulatory and screening purposes. This is a cost-effective alternative to costly analytical techniques for screening of dioxins and the project has contributed to the development of a standard which would codify, recognize, and allow the use of that method.

(g) **Implementation efficiency.** There was strong institutional stability with the project teams both from FECO and from the World Bank's side, and cost of preparation and supervision were within cost norms despite the implementation delay of two years. The main efficiency impact of the delay was on the additional cost of project management on the side of FECO and implementation support cost on the side of the World Bank, as well as the costs of

[33] Financial analysis data from Client Completion Report, September 2019, based on Environmental Protection Research Institute of Light Industry report on each mill's renovation process.
[34] Where the same sample is analyzed by a reference laboratory and the participating labs.

preparing and appraising the originally planned investments at the three mills. Overall, given that this allowed the project to reach its objectives, the additional[35] effort was justified.

Incremental cost reasoning

52. The approach to incremental reasoning underlying the rationale for GEF support to the project is outlined in the efficiency analysis (annex 4). The project addressed global pollutants, a subject of the Stockholm Convention on POPs, and a priority under China's NIP for the convention, with the GEF providing support as the financial mechanism to assist China in meeting its obligations. The analysis mirrors the ToC for the project discussed in section 1.A. Under business as usual, China would have continued to close small mills and mandated improved water treatment for the larger ones, but BAT/BEP for dioxins reduction in the non-wood sector would have been largely ignored due to technology and financial barriers and inadequate enforcement. The GEF alternative (the project) helped China effectively restructure its pulp and paper sector, improve the sector's economic and environmental performance, and minimize UPOPs.

D. JUSTIFICATION OF OVERALL OUTCOME RATING

53. **The overall outcome of the project is assessed to be Satisfactory: relevance of the PDO is High; efficacy is Substantial and efficiency is Substantial.** There are only minor shortcomings in achievement of objectives with the first PDO (demonstrate the result of BAT/BEP adoption) almost fully achieved and the second PDO (support the recipient to develop its long-term action plan to guide the promotion of sector-wide BAT/BEP adoption) fully achieved; there is only minor shortcoming in efficiency due to the two-year extension.

Figure 2. Sichuan Jinfu Paper Mill Bleaching Line before Project Renovation

Figure 3. Sichuan Jinfu Bleaching Line after BAT/BEP Renovation

[35] The project's management costs assessed at closing were lower than estimated at the time of approval.

Figure 4. Sichuan Jinfu after Project-Supported Renovation

Figure 5. Middle School Students in Laibin City Learn about the Project and ECF Paper

Figure 6. Distribution of Awareness-raising Material in Renmin Park, Laibin, Guangxi

Figure 7. Distribution of ECF and Unbleached Household Paper at Chengdu University, Sichuan

Figure 8. Bioassay Laboratory at Guangxi Environmental Monitoring Center

Figure 9. Bioassay Equipment at Sichuan Institute of Environmental Protection Science

E. OTHER OUTCOMES AND IMPACTS

Gender

54. The project had no direct gender impact or implications and was not designed to directly address gender gaps.[36] The project had positive social benefits because it improved environment protection through the reduction of UPOPs emissions, thus minimizing potential health impacts associated with such pollutants, including potential for prenatal exposure of children of women exposed to POPs, which is of particular concern.

55. There were no jobs lost at the mills from the conversion to the new technology, and there was no land acquisition or involuntary resettlement associated with project activities; therefore, no negative impact on women and girls.

Institutional Strengthening

56. The project had considerable institutional strengthening impact, which was the focus of the second of its two main components. The project directly developed or provided support to the development of several policy and regulatory documents at the central and provincial government levels (see Key Outputs, annex 1B) and established capacities for environmental monitoring with novel methods in eight provinces, setting the stage for the long-term transformation and sustainability of the non-wood pulp making sector in China.

Mobilizing Private Sector Financing

57. The project mobilized considerable private sector financing during its implementation, and further private sector financing is expected as the whole sector shifts to ECF. The project mobilized US$57.7 million from the participating mills' investments in BAT/BEP for a GEF contribution under project Component 1 on BAT/BEP investment of US$9.1 million. These investments were incentivized through a PBF scheme where disbursements to pilot participating mills were linked to completion of an agreed milestone. Final payment was contingent on stable operation of the new facility and achieving agreed dioxins reduction performance targets verified by an independent verification consultant.

Poverty Reduction and Shared Prosperity

58. The main impact of the project is in delivering global public goods. The project led to environmental improvement, both of the global commons and of the local and regional environment by addressing global contaminants—POPs—in one of the most polluting industrial sectors. There is a wealth of information[37]—not specific to China—that shows that the poor are disproportionately affected by pollution and therefore the project, by reducing the pollution load, is very likely having a positive impact on the poor in China in the provinces most affected by pulp making.

[36] Workforce at the mills is composed mostly of men.

[37] See, for example, World Bank Group. 2017. *Toward a Clean World for All: An Evaluation of the World Bank Group's Support to Pollution Management*, IEG.

Other Unintended Outcomes and Impacts

59. While not wholly unintended, it was the first time, through this project support, that the bioassay technique was introduced in China as a possible alternative for regulatory and screening purposes. This is a cost-effective alternative to costly analytical techniques for screening of dioxins, and the project has contributed to the development of a standard which would codify, recognize, and allow, the use of that method. This could be a very important long-lasting impact of the project in China.

III. KEY FACTORS THAT AFFECTED IMPLEMENTATION AND OUTCOME

A. KEY FACTORS DURING PREPARATION

60. The following are key factors that affected project preparation:

- China was (and still is) an active participant in the negotiation of the Stockholm Convention and its early implementation[38] and had a coherent strategy to implement the Convention through a series of projects targeting priority POPs chemicals/sectors. This was the eighth project supported by the GEF as the financial mechanism of the Stockholm Convention and the third managed by the World Bank.

- Project preparation benefitted from having been preceded by analytical work supported by the Canada POPs Trust Fund[39] which was also implemented with FECO and the CPA and provided sector data and information, as well as contributing to forging partnership with stakeholders.

- Project design was straightforward, with clearly defined realistic objectives addressing identified barriers to improved environmental management in the non-wood pulp and paper sector and operationalized through the two main project components.

- Moreover, the FECO team had experience of working with the World Bank and was familiar with meeting World Bank fiduciary requirements. On the World Bank side, the team assembled had the appropriate mix of technical, policy, and environmental skills needed to prepare this technical project.

- Because of all the above points, the project was prepared in less than a year from concept approval to Board approval, despite being classified as a Category A (full assessment) project from an environmental risk perspective, requiring a number of safeguards instruments to be prepared and disclosed.

- To deal with a situation where the majority of funding required for the renovations was expected to be put forward by the participating enterprises, the World Bank team proposed the use of innovative PBF sub-grants under which the enterprises were allowed to follow

[38] China, for example, was the first of the Brazil, Russia, India, China, and South Africa (BRICS) to submit its NIP to the Convention, a full four years before the next BRICS country to do so.
[39] 'China: Study on POPs releases from non-wood fiber mills' (P115613), approved 2009.

'commercial practices acceptable to the World Bank', ensuring value for money while meeting the mill's business requirements and in line with their own significantly larger baseline investments. Payments under the sub-grant agreements were based on milestones[40] verified by an independent entity.

- **Risk assessment and management.** Risks and mitigation measures were appropriately identified, although the sector risks that materialized following abrupt change in the conditions of the market as described below were not anticipated, leading to some of the mills pulling out of the project. The stakeholder risk related to the mills' commitment to participate had been rated as moderate but was exacerbated by these unfavorable market conditions. At approval, the technical risks related to BAT/BEP had been rated as substantial for technical design which was justified given the lack of experience with implementation of BET/BEP in the non-wood pulp sector. This risk was adequately mitigated during project implementation by working with the 'design institutes' and the CPA to offer technical support to the participating enterprises. The World Bank team also benefitted from the participation of a highly specialized environmental engineer consultant with direct expertise in non-wood pulp and papermaking process.

B. KEY FACTORS DURING IMPLEMENTATION

61. **The following are key factors that affected project implementation:**

- The description of Components 2 and 3 refers to some limited activities targeting the wood sector, specifically promotion of good practices under Component 2 and monitoring under Component 3. While the policy support work was extended to the wood sector as envisaged (in particular, the NAP developed under the project), no other activities focused on the wood subsector: given that when the project started nearly all wood-based pulp mills had already adopted BAT/BEP, it was felt there was no need to promote it further, and the project should focus its efforts on the non-wood based mills.

- **Stakeholder engagement**. As the project addressed one industrial subsector, there was a finite number of stakeholders that had to be engaged, both from the Government and from the industry side. The project benefitted from close collaboration with the industry through the CPA as most of the pulp and paper mills are members of the Association which was able to facilitate mills' selection, outreach to the industry, training of staff, and so on. Moreover, the project was very inclusive in that subsector, and can be described as a partnership with central, provincial, and local environmental authorities; industry association; individual

[40] The sub-grant agreements cover the whole renovation workplan as approved by FECO following the no-objection of the World Bank. The first payment of 20 percent was released following completion of design documents and environmental acceptance as well as submission of the baseline verification report, with evidence of eligible expenditures of at least 20 percent of the sub-grant amount; the second payment for 70 percent was after trial operation, following completion of all civil work and equipment installation, with evidence of eligible expenditures of at least 90 percent of the sub-grant amount; and the third and final payment for 10 percent was after stable operation of at least three months and independent verification confirming release of dioxins meeting project target of 70 percent reduction, with evidence of eligible expenditures of at least 100 percent of the sub-grant amount.

enterprises and their experts; and provincial environmental centers and academia (see list of stakeholders – annex 9).

- Project implementation benefitted from strong institutional stability from the World Bank and FECO. In FECO, the key project officers and manager were unchanged for the last five years of implementation of the project, with the same national technical adviser in place from the start of the project. On the World Bank side, the team was similarly stable, with two task team leaders (TTLs) for most of the project implementation period, the second TTL having been co-TTL since project preparation. Moreover, the World Bank's environmental engineer consultant supported the team and the client from preparation to completion.

- The project undoubtedly benefitted from its timing, which was aligned with overall strengthening of environmental management governance in China and allowed the project to tag on and influence major larger environmental policies/regulations (in particular the Action Plan for Prevention and Control of Water Pollution, State Council, 2015 and 13th Five-Year Plan for Eco-environmental protection, State Council, 2016). This 'opportunistic' approach is what allowed the project to have outsize influence and successfully catalyze sector-transformation, while contributing to mainstreaming of dioxins control in China.

- On the negative side, the start of project implementation saw abrupt changes in market conditions, with a strong decline in yearly production, due in part to the import of cheaper wood pulp which reduced the market share of bleached non-wood pulp. This directly affected the mills' capacity to engage in the project given the significant investments that they had to finance independently, even if receiving project support. Other reasons for the decline of non-wood pulp production are that reed-based pulping is competing with the priority for wetlands conservation and straw-based pulping is the process where it is most difficult to control quality. Table 3 shows the share of virgin pulp production in China, which had been stable around 12 million tons per year for years before the project started, including the year of project preparation, but had dropped to 8.3 million tons by 2013, to stabilize around 6 million tons per year by 2016. Overall, looking forward, the CPA expects bagasse-based pulping to stay stable, while bamboo-based pulping is expected to grow further.[41] The 2017 China ban on import of wastepaper is also having a positive effect on the market for virgin pulp.

- This led to the withdrawal from the project of three of the four originally selected mills. For two of the mills, this was due to decisions to redirect investments rather than supporting BAT/BEP under the project as planned, while the third mill closed down altogether due to the parent company's decision. In all cases, this can be linked to business decisions related to changing and difficult market conditions at that time that would have been hard to predict during project preparation. The impact of this abrupt change of the industry was mediated by a flexible and adaptive approach to project management. The World Bank team worked

[41] As discussed in the January 2019 implementation support/ICR mission aide-memoire and in the MTR. At the same time, the industry continued to consolidate. The MTR notes that by 2015 less than 60 non-wood mills were still in operation, while the January 2019 mission reported that, in Sichuan, the number of mills had decreased from 20 to 13 while overall capacity had increased 50%, between 2012 and 2018.

with FECO and the CPA rapidly to select and appraise new demonstration mills in replacement of the ones that had withdrawn and had the support of World Bank management to restructure the project as needed.

- In 2015, bagasse represented 14 percent of non-wood pulp production in China. As such, it was important for the project to seek to capture experiences in the subsector. This was achieved through a variety of means, such that it can be said that the demonstration element of the project in the bagasse subsector is largely achieved: technical assistance was extended to three bagasse-based mills in Guangxi further to the September 2018 restructuring; some of the experiences with BAT/BEP renovations at the Pumiao mill before it closed down could be captured and documented; the independent verification consultant was able to measure baseline releases and derive emission factors for dioxins for bagasse-based mills; and active promotion of BAT/BEP took place with the bagasse-based industry in Guangxi with the support of the project.

- **Midterm review**. A midterm review was completed in December 2015. The review was to assess the continued strategic relevance of the project and risk of withdrawal of further participating mills and discuss with FECO and stakeholders options to improve implementation performance and contribute to PDO achievement. The midterm review mission confirmed that the sector was stabilizing and that demand for non-wood pulp was expected to continue for the foreseeable future albeit at a level lower than at time of preparation. Specifically, it was confirmed that the three demonstration mills were confident in their capacity to complete their BAT/BEP renovations successfully. Agreements reached between the World Bank and FECO during the midterm review led to the June 2016 restructuring that reallocated project resources following the late withdrawal of the one bagasse-based mill.

- The World Bank held regular six-monthly implementation support missions (14 over the duration of the project), reporting through quality Aide Memoires. Close communication was maintained with FECO in between formal implementation support missions and the World Bank worked with FECO to develop and implement a detailed and strict action plan which helped ensure that the project stayed on track after the initial delay and helped ensure that all project activities could be completed by project closing (albeit with a two-year delay from the closing date).

- Finally, the World Bank was candid with its assessment of progress, downgrading ratings for Implementation Progress and Development Objective rapidly when implementation suffered from withdrawal of demonstration mills and upgrading them when implementation improved.

Table 3. Virgin Pulp Production in China 2006–2018

Million tons\year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Wood pulp	5.26	6.05	6.79	5.60	7.16	8.23	8.10	8.82	9.62	9.66	10.05	10.50	11.47
Non-wood pulp	**12.90**	**13.02**	**12.98**	**11.76**	**12.97**	**12.40**	**10.74**	**8.29**	**7.55**	**6.80**	**5.91**	**5.97**	**6.10**
Reed	1.44	1.44	1.50	1.44	1.56	1.58	1.43	1.26	1.13	1.00	0.68	0.69	0.49
Bagasse	0.74	0.90	0.97	0.98	1.17	1.21	0.90	0.97	1.11	0.96	0.90	0.86	0.90
Bamboo	0.95	1.20	1.46	1.61	1.94	1.92	1.75	1.37	1.54	1.43	1.57	1.65	1.91
Straw	9.08	8.49	8.08	6.76	7.19	6.60	5.92	4.01	3.36	3.03	2.44	2.46	2.50
Others	0.69	0.99	0.97	0.97	1.11	1.09	0.74	0.68	0.41	0.38	0.32	0.31	0.30

IV. BANK PERFORMANCE, COMPLIANCE ISSUES, AND RISK TO DEVELOPMENT OUTCOME

A. QUALITY OF MONITORING AND EVALUATION (M&E)

Rating: High

M&E Design

62. M&E design was sound. While a ToC was not explicitly defined, the PAD outlined an implicit ToC, with two main barriers to sector-wide adoption of BAT/BEP which were addressed by the two objectives of the PDO through the two main project components. The project selected a relatively limited number of PDO indicators and intermediate results indicators, which were however sufficient to track progress toward meeting its two objectives.

63. Given the demonstration nature of the project, a strong emphasis was placed on M&E and on collation and dissemination of lessons learned. The project also designed a PBF scheme to support the participating enterprises, with an independent consultant accredited for dioxins monitoring tasked with establishing the baseline and verifying dioxins reduction after BAT/BEP renovation at the participating mills.

M&E Implementation

64. M&E was implemented thoroughly and as planned and reported regularly as part of the six-monthly project progress reports. The project relied both on its own tools for M&E and on higher-level institutional arrangements: while an independent laboratory/consulting firm was retained to establish the dioxins baseline and verify reduction post BAT/BEP renovation, the project relied on the regular monitoring results from the local EPBs to verify reduction of release of conventional pollution parameters such as COD and NH_3 and compliance with national water effluent standards.

M&E Utilization

65. The results of M&E at the participating mills underpinned the project in being the basis for release of the last tranche of payment to the participating mills under the PBF system. The project was also able to generate new and much improved data on dioxins releases from pulp and paper mills in China, and these were published[42] in the academic literature and will serve to update the United Nations Environment Programme (UNEP)/Stockholm Convention toolkit for dioxins inventory.

Justification of Overall Rating of Quality of M&E

66. **Overall, M&E quality is rated High**. The project relied on a solid, if implicit, ToC, with clear indicators to cover the PDO and intermediate results. High quality data generated by an independent consultant was at the heart of project design and implementation and served to verify dioxins reduction outcome.

[42] Xiao et al. (2017) *Op. Cit.*

B. ENVIRONMENTAL, SOCIAL, AND FIDUCIARY COMPLIANCE

Environmental

67. The project implementation has brought significant environmental benefits by supporting selected non-wood pulp and paper mills to adopt ECF-based technical upgrading to minimize UPOPs (dioxins and furans) releases and reduce water consumption and pollutant load in effluent (that is, COD, BOD, and total suspended solids), which also meets the requirements of more stringent environmental standards in China. The project implementation also supported the strengthening of UPOPs monitoring and enforcement in eight participating provinces, including the four provinces where the mills are located.

68. The project triggered OP/BP (4.01) on Environmental Assessment and was categorized as Category A (full assessment) due to the scale and risk level of potential environmental impact from the operation of pulp and paper mills. During project preparation, a Framework Environmental Assessment was prepared and disclosed on June 20, 2011, and site-specific Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) were developed for each participating mill. The EIAs and EMPs for the original project mills were disclosed locally on October 17, 2011 and disclosed through InfoShop on November 28, 2011. For the two new project mills that joined after the 2014 restructuring, the EMPs were disclosed locally on April 22, 2014, and through InfoShop on May 16, 2014.

69. The Framework Environmental Assessment provided an analysis of the pertinent laws and regulations, benchmarking Chinese standards with Bank Environmental, Health, and Safety (EHS) guidelines and other standards, and included guidelines and TORs for the conduct of environmental assessment and template for EMP. The mills' EIAs and EMPs also covered site specific environmental baseline and detailed description of existing process and renovations to be implemented, with identification of risks and specific mitigation measures to be followed during construction. In addition, under the May 2016 restructuring, an Environmental and Social Management Framework (ESMF) was developed as a supplementary environmental assessment document for the project with enhanced attention to social aspects, and disclosed on June 27, 2016, to guide the design and implementation of newly introduced activities on technical assistance support to BAT/BEP planning.

70. During implementation, the project's environmental performance was closely monitored and reviewed by both FECO and the World Bank's Task Team based on regular field visits and semiannual environmental monitoring data. The mills' operations and environmental management were conducted under regular monitoring and inspection of local EPBs with online monitoring systems. Environmental training was regularly provided to staff of the participating mills by the World Bank team's environmental safeguards specialist. Following the EMP requirements, the monitoring data for wastewater discharge and exhaust emissions were sent by participating mills to the World Bank for review on a semiannual basis. No noncompliance was found. However, FECO and the World Bank were informed that a wastewater spill incident occurred at the Hunan Lingyuan Paper Mill during the renovation of its wastewater treatment facilities on December 4, 2016. Lingyuan had taken immediate and effective corrective actions to resolve the issue and, with the authorization of the local EPB, managed to resume its normal production after two weeks. Nevertheless, a detailed investigation was conducted by the mill to understand the root cause of the problem and propose actions to capture the lessons learned from the incident in its future operation. Following the mill's self-investigation, a special field mission was conducted jointly by FECO and the World

Bank in November 2017, which confirmed the strengthening of EHS management at the mill and consistent environmental compliance after the incident.

71. The ESMF implementation was also satisfactory under the project, particularly concerning its application to the sub-grants added through restructuring to support technical assistance activities of additional mills in planning for BAT/BEP investments. Three mills were selected in line with the criteria outlined in the ESMF. Environmental and Social Due Diligence Reports and Environmental and Social Management Plans were developed for all of them as part of the supported technical activities and were reviewed and cleared by the World Bank before project closure, for future implementation.

72. The risks of working in a highly polluting industry were thus mitigated by the satisfactory implementation of the Environmental and Social Management Plans and other safeguards instruments developed for the project and by the growing and strengthened oversight by environmental authorities, for example, through the inclusion of the pulp and paper sector as one of the 10 industries covered in the Action Plan for Water Pollution Prevention and Control under the 13th FYP.

Social

73. OP/BP (4.12) on Involuntary Resettlement was triggered due to one of the mills having acquired land prior to the project. The report on "Review of Land Acquisition and Compensation" was disclosed on January 19, 2012, and concluded that the land acquisition and distribution of compensation was conducted satisfactorily in accordance with legislation. No other issue arose during implementation. The project had positive social benefits as it improved environmental protection through the reduction of UPOPs emissions, thus minimizing potential health impacts associated with such pollutants. The project was considered to have low social risks and minor negative impacts. The participating mills carried out BAT/BEP activities within their existing facilities and did not undertake further land acquisition or physical resettlement for the project. Workers working on the original elemental chlorine-based pulp production lines did not lose their jobs. All mills provided them with training on the new production facilities and production processes and offered livelihood maintenance throughout project implementation. Monitoring of these potential issues or any other unexpected social risks was integrated in the regular project supervision and no noncompliance or new social issue/risk was reported and identified.

74. When considering technical assistance support to additional bagasse-based mills, a social screening process was followed by FECO as outlined in the ESMF to identify if any land acquisition, resettlement, or other social risks were present; no additional social safeguard document was prepared as the proposed investments for new mills were to be carried out within existing facilities to upgrade existing old production lines. Following this initial social screening, the mills were required to prepare a more detailed Social Due Diligence Report and Social Management Plan (as part of Environmental and Social Management Plan) to develop mitigation measures for any potential social impacts and risks and further improve social risk management at the mills, such as establishing a grievance mechanism and improving the information disclosure system. These documents were reviewed and cleared by the World Bank before project closing for further implementation by the mills.

Financial Management

75. The project had adequate project financial management systems that provided, with reasonable assurance, accurate and timely information that the grant was being used for the intended purposes. The project accounting and financial reporting were in line with the regulations issued by the Ministry of Finance (MOF) and the requirements specified in the Grant Agreement. No significant financial management issues were noted throughout the project implementation and any financial management-related weaknesses raised during financial management supervision were resolved on time. The project audit reports were all with unqualified audit opinions. Moreover, the withdrawal procedure and funds flow arrangement were fit for purpose and the grant proceeds could be disbursed on time.

Procurement

76. Procurement under the project was carried out in accordance with the World Bank procurement policies, procedures, and requirements. The Project Management Office (PMO) housed in FECO had a designated procurement officer and project management staff. The PMO staff had World Bank project experience including procurement and attended procurement and contract management training provided by the World Bank and other institutions throughout the project preparation and implementation. Overall procurement under the project was implemented smoothly and on time without any complaint having been received or any misprocurement. The Procurement Plan was regularly updated, at least every year or as needed, and there are few undisbursed grant funds by closing of the grant.

77. Procurement under the PBF sub-grants followed commercial practices acceptable to the World Bank, ensuring value for money in the process that met the mill's business requirements and was in line with their baseline investments. The project procurement performance has been rated as Satisfactory throughout the project cycle.

C. BANK PERFORMANCE

Quality at Entry

78. **World Bank performance at entry was Satisfactory**. The project was prepared efficiently, with 19 months from concept approval to first disbursement, including oversight and advice for timely preparation and disclosure of environmental and social safeguards documents for this Category A project. The World Bank team that was assembled had an appropriate composition, including a mix of technical, policy, and safeguards expertise, to conduct the needed assessments and appraisal of the project from the social, environmental, and fiduciary aspects and assess risks.

79. A performance-based mechanism was developed that was an appropriate and efficient tool to underlie the contracting arrangements between FECO and the pilot enterprises, together with a strong M&E system with an independent consultant to verify key achievements that were the basis for payment under the performance-based framework.

80. The one shortcoming is related to three of the four originally selected mills having withdrawn from the project early on. While the efficiency analysis (annex 4) notes that the turmoil in market

conditions at the start of the project would have been difficult to predict, with hindsight, the stakeholder risk related to the mills' participation should have been assessed as Substantial rather than Moderate.

Quality of Supervision

81. **Quality of supervision was Satisfactory.** The World Bank team conducted regular six-monthly implementation support missions that were recorded in comprehensive Aide Memoires. The World Bank also offered day-to-day support to the FECO project team through maintaining a field-based co-TTL during most of the implementation of the project. The World Bank team included the relevant skills mix, with financial, procurement, social, environment, technical, and policy, and was complemented throughout project implementation by a senior consultant with expertise in environmental engineering, and specifically, non-wood pulp making, who was able to share highly specialized and relevant knowledge and experience with the FECO project team and industry partners.

82. The project was in Moderately Unsatisfactory status for overall implementation progress for a long period of time from October 2013 to November 2016. This was due to the withdrawal of two mills from the project in early 2013, followed by the late withdrawal of a third mill in 2015 (which also led to downgrading the progress towards achievement of PDO rating to Moderately Unsatisfactory, for a one-year period). Nevertheless, the team was able to respond proactively to the challenges posed by mill owner's business decisions in response to the unpredictable market and adapted the project design through a number of timely restructurings along the way. The project rating was returned to Moderately Satisfactory only after the three remaining mills physically completed their renovations.

83. The team also supported implementation through the development and close monitoring with FECO of a detailed action plan to ensure that project implementation was on track after the initial delays and helped facilitate the project closing having disbursed 99 percent of the grant.

Justification of Overall Rating of Bank Performance

84. With satisfactory quality at entry and quality of supervision, World Bank performance is rated as Satisfactory.

D. RISK TO DEVELOPMENT OUTCOME

85. **The risk to development outcome is Low.**

86. For the mills that have completed their BAT/BEP investments with project support, there is no returning to elemental chlorine-based bleaching as it would not be cost-effective to do so.

87. For the sector as a whole, the adoption by the CPA of the NAP developed with project support and adoption of other related policy/regulatory documents, including the MEE Guidelines on BAT/BEP for the pulp and paper industry supported by the project, ensures that no new pulp and paper mill is established in China that would rely on elemental chlorine for bleaching, and sets a target for 2025 for the whole sector being ECF. Nevertheless, while many but not all non-wood pulp and paper mills have now adopted BAT/BEP, continued monitoring and enforcement are required so that the sector is fully ECF by 2025 as expected by the NAP. Training of industry practitioners and exchange of experiences and lessons

learned should also continue to be promoted by the CPA for ongoing environmental improvement of the sector.

88. At the global level, non-wood pulp is a relatively important source of virgin pulp in other developing countries in the Association of Southeast Asian Nations (ASEAN) region and South Asia, and China should continue to share experiences with these countries to facilitate their modernization efforts.

89. The project introduced the bioassay technique for environmental monitoring of dioxins and established eight laboratories in environmental monitoring centers across the country. This is a significant effort, but the laboratories will need continuous support and funding or else the capacities that were developed will disappear. Part of the answer lies with recognizing in regulation and allowing the bioassay technique to occupy its niche among a panoply of tools for environmental monitoring. The standard for solid waste that was developed with the technical support of the project-supported labs and is undergoing review is a good step in that direction.

V. LESSONS AND RECOMMENDATIONS

90. This section seeks to highlight some of the features of this project that helped ensure its success and could translate to other operations in China or elsewhere.

- **Upstream analytical work is particularly important when addressing new sectors.** The project was prepared based on an upstream study conducted with the support of the Canada POPs Trust Fund. This proved invaluable in allowing the World Bank team and FECO to gain knowledge of the sector and build networks with industry partners. The project would not have been prepared as rapidly without this preliminary analytical work.

- **Technical skills mix and team continuity are crucial to the success of novel and technical projects.** The project benefitted from the excellent technical skills, professionality, quality of relevant experience, and skills mix within the team, and continuity. The quality of technical advice provided, the proficiency level in the technical dialogue between the World Bank and counterparts, and the detailed knowledge of the science and engineering underpinning the project were important enabling factors for achieving good outcomes. The continuity in the teams both on FECO and the World Bank side was also a significant factor, allowing for continuous, uninterrupted, and upward learning curve.

- **A combination of pilot demonstration and enabling environment can lead to catalytic sector-wide transformation.** The project relied on a relatively straightforward project design, addressing the two key barriers that were identified through two complementary components, one focused on technical demonstration and one focused on sector policy and regulatory framework. This proved very successful and FECO was able to use the project and build on the technical demonstrations to successfully influence policy and regulations to facilitate sector-wide promotion and adoption of BAT/BEP. This validates the approach of combining demonstration with policy interventions which was followed by China in a comparable manner to address other sectors to meet its obligations under the Stockholm convention.

- **PBF sub-grants following commercial practices for procurement is an efficient way to engage enterprises.** Procurement under the PBF sub-grants followed commercial practices acceptable to the World Bank, ensuring value for money in the process that met the mill's business requirements and was in line with their baseline investments. The PBF modality was a relatively novel instrument introduced by the World Bank that proved very apt as basis to transfer grant resources to enterprises that were investing their own (significantly larger) resources. Credible and independent verification helped ensure the integrity of the process.

- **Partnerships with industry and other stakeholders can enhance the impact of pollution control interventions.** The project relied on a strong partnership between the CPA, FECO, and the World Bank. All relevant stakeholders were involved, with local environment departments, monitoring centers, academia, and industrial organizations and industry experts. The involvement of the CPA facilitated the selection of participating enterprises and the buy-in needed for adoption of the NAP, while the participation of various actors facilitated the project's influence on broader policies and regulations.

- **Aligning global benefits with local development priorities can maximize impact.** This relatively modest GEF grant had a significant impact on policy and regulatory developments in the pulp making and papermaking sector in China, one of the most polluting industrial sectors with regard to water quality. This was in part in response to good timing that provided a window for the project to influence important pieces of environmental regulations that were being developed, thereby contributing to mainstreaming dioxins control in the broader framework for environmental protection that was being strengthened during the period of project implementation.

- **Modernizing production processes for pollution control can be financially beneficial.** From the mills' perspective, the investment not only was meeting a mandatory regulatory regime, but also proved to be a good return on investment, with savings on energy use, water treatment, and other operating costs, and improved product quality. Payback on investment varied between 3.9 and 5.2 years for the three mills that participated in the project's investment demonstration component. This confirms the hypothesis that cleaner production methods pursued in parallel (and as part of) BAT/BEP would lead to savings.

ANNEX 1. RESULTS FRAMEWORK AND KEY OUTPUTS

A. RESULTS INDICATORS

A.1 PDO Indicators

Objective/Outcome: Demonstrate the results of BAT/BEP adoption in four selected non-wood pulp mills

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Reduced UPOPs releases in the four non-wood fiber mills supported by the Project	Text	Sichuan Jinfu: 0.078; Hunan Linyuan: 0.113; Henan Baiyun: 0.067 03-Aug-2017	Sichuan Jinfu: 0.023; Hunan Linyuan: 0.034; Henan Baiyun: 0.020 03-Aug-2017		Sichuan Jinfu: 0.001; Hunan Linyuan: 0.002; Henan Baiyun: 0.015 03-Aug-2017

Comments (achievements against targets):

Target 75% Achieved

Target met at project closing in the three remaining participating mill s. The first PDO indicator supports the objective to demonstrate the results of BAT/BEP adoption in four different types of non-wood pulp mills. The indicator is partially achieved through investment support in three non-wood mills (demonstrating BAT/BEP for bamboo, reed and straw). The fourth mill, originally chosen to exemplify the bagasse-based process, closed down due to business decision and was not replaced. The demonstration objective for bagasse, however, is addressed in part through the technical assistance offered to three bagasse-based mills in Guangxi further to the September 2018 restructuring (with a new intermediate results indicator - see below).

Unit of Measure: g TEQ/a UPOPs released. This measures the toxic equivalent (TEQ) of the UPOPs released by each mill annually. TEQ is the internationally agreed method to report on the concentration of the family of dioxins.

Testing of dioxins (i.e., UPOPs) baselines and final emissions (verification) were conducted by an accredited independent monitoring consultant, after stable operation following BAT/BEP investments. The three demonstration mills completed BAT/BEP investments during 2015-2016, with BAT/BEP verification completed in 2017, and this is the value for "Actual achieved at completion" that is reported here.

The end target was set as 70% reduction of the baselines as discussed in the June 2016 implementation support mission aide-memoire, and confirmed through the June 2016 restructuring. This meets Chinese and international standards and is in line with the BAT/BEP guidelines adopted by the Stockholm Convention. The baseline calculation methodology, and therefore values for the baselines, was reconfirmed by the August 2017 mission aide-memoire. Dioxins release reduction from the baseline for the three mills was verified and calculated at 98% for bamboo (Sichuan) and reed (Hunan) and 77% for straw (Henan), by the independent verification consultant (*Report on Dioxins monitoring at the three demonstrations mills*, Aug 2017). 88% Dioxins release reduction was also estimated for bagasse-based mills using verified reductions from a similar mill, Guangxi Nanhua, judged to represent a good model for bagasse-based mills. (The project was however unable to review and document the full technical and financial aspects of the renovation).

Objective/Outcome: Develop a long-term action plan to guide the promotion of sector-wide BAT/BEP adoption

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Adoption of a long-term action plan for the sector's UPOPs reduction	Text	0 29-Mar-2012	Issued 30-Jun-2017		NAP issued by Chinese Paper Association 23-Nov-2018

Comments (achievements against targets):

Target 100% Achieved The second PDO indicator relates to the adoption of the *National Action Plan for Dioxins Reduction in the Pulp and Paper Industry (NAP)* by the China Paper Association, and addresses the objective of developing a long-term action plan to guide the promotion of sector-wide BAT/BEP adoption. The Action Plan that was adopted meets this objective and mandates that the pulp and paper sector be free of elemental chlorine bleaching by 2025. The NAP was issued by the CPA on 23 November, 2018. The NAP consists of the "*China Paper Association's Guiding Opinions on Promoting Dioxin Emissions Reduction in Pulp and Paper Industry*", together with a detailed "*Compilation Manual*". It is supported by MEE guidelines for BAT/BEP and other policy and regulatory documents (see intermediate results indicator below).

A.2 Intermediate Results Indicators

Component: 1. BAT/BEP Investment in Participating Mills and Promotion of BAT/BEP Investment in Selected Mills

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Completion of BAT/BEP investment	Number	0.00 29-Mar-2012	4.00 30-Jun-2015	4.00 30-Jun-2016	3.00 31-Jul-2016

Comments (achievements against targets):

Target 75% Achieved

Three demonstration mills completed BAT/BEP investments during 2015-2016, with& nbsp;final independent verification completed in December 2017 for the last one (Linyuan) after stable operation. The fourth, Pumiao mill, withdrew from the project and was not replaced. This indicator is 75% achieved (3 out of 4) at project closing. As reported in the Jan 2017 aide-memoire, all investments were completed by July 2016.

To summarize this effort, a "Non-wood pulp BAT/BEP design manual" was compiled and published that is the first technical manual for non-wood pulping in China and expected to serve as guide for new construction or renovation of non-wood production lines.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Numbers of selected mills to develop BAT/BEP investment plans	Number	0.00 28-Jun-2016	4.00 30-Jun-2018	2.00 30-Jun-2019	3.00 30-Jun-2019

Comments (achievements against targets):

Target 100% Achieved
Technical Assistance Sub-Grant agreements were signed with three bagasse-based mills in Guangxi to support development of investment plans. This indicator was added by the June 2016 restructuring following the withdrawal from the project of the Guangxi Pumiao mill.
The end target was revised from four to two ;following the September 2018 restructuring, as a result of further appraisal of activity cost and budget.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
COD discharge per unit of non-wood pulp production from the four mills	Text	Sichuan Jinfu: 10.2; Hunan Linyuan 5.28; Henan Baiyun: 4.73 29-Mar-2012	Sichuan Jinfu: 4.83 30-Jun-2015	Sichuan Jinfu: 4.83; Hunan Linyuan:4.65; Henan Baiyun: 3.33 30-Jun-2016	Sichuan Jinfu: 1.94; Hunan Linyuan: 1.42; Henan Baiyun: 1.67 30-Jun-2019

Comments (achievements against targets):
Target 100% Achieved. Effluents of the three participating mills meet national standards.
The results of COD regular monitoring by the local environmental protection bureaus were reported through the project 6-monthly progress reports. Following the completion of BAT/BEP investments at the demonstration mills, these monitoring results have consistently complied with the national standards. The last reported data are shown here as "Actual achieved at completion".
The end targets were set based on the national "discharge standard of water pollutants for pulp and paper industry" (GB3544-2008), expressed as "intensity" as a measure of COD discharge per unit dry pulp produced, to allow for better comparison between mills. The baseline and target for Sichuan Jinfu (bamboo) were set at appraisal. The baseline and target for the replacement mills Henan Baiyun (straw) and Hunan Linyuan (reed) were set by the first restructuring, in November 2014. Baselines and targets were also established for the original mills for straw, reed and bagasse, and can be found in the PAD.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
NH3-N discharge per unit of non-wood pulp production from the four mills	Text	Sichuan Jinfu: 0.72; Hunan Linyuan: 0.45; Henan Baiyun: 0.21 29-Mar-2012	Sichuan Jinfu: 0.43 30-Jun-2015	Sichuan Jinfu: 0.43; Hunan Linyuan: 0.41; Henan Baiyun: 0.15 30-Jun-2016	Sichuan Jinfu: 0.079; Hunan Linyuan: 0.10; Henan Baiyun: 0.128 30-Jun-2019

Comments (achievements against targets):

Target 100% Achieved. Effluents of the three participating mills meet national standards.
The results of NH3-N regular monitoring by the local environmental protection bureaus were reported through the project 6-monthly progress reports. Following the completion of BAT/BEP investments at the demonstration mills, these monitoring results have consistently complied with the national standards. The last reported data are shown here as "Actual achieved at completion".
The end targets were set based on the national "discharge standard of water pollutants for pulp and paper industry" (GB3544-2008), expressed as "intensity" as a measure of NH3-N discharge per unit dry pulp produced, to allow for better comparison between mills. The baseline and target for Sichuan Jinfu (bamboo) were set at appraisal. The baseline and target for the replacement mills Henan Baiyun (straw) and Hunan Linyuan (reed) were set by the first restructuring, in November 2014. Baselines and targets were also established for the original mills for straw, reed and bagasse, and can be found in the PAD.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Water consumption per unit of non-wood pulp production from the mills	Text	Sichuan Jinfu: 72.0 29-Mar-2012	Sichuan Jinfu: 53.6 30-Jun-2015	Sichuan Jinfu: 53.6; Hunan Linyuan: 52.2; Henan Baiyun: 49.2 30-Jun-2016	Sichuan Jinfu: 25.3; Hunan Linyuan: 42.3; Henan Baiyun: 45 30-Jun-2019

Comments (achievements against targets):

Target 100% Achieved. Water consumption of the three participating mills is reduced.

The resul ts of water consumption regular monitoring by the local environmental protection bureaus were reported through the Project 6-monthly progress reports. Following the completion of BAT/BEP investments at the demonstration mills, these monitoring results have consistently shown reduced water consumption.

The baseline and targets are expressed as intensity, as a measure of water consumption per unit dry pulp produced, to allow for better comparison between mills. The baseline and target for Sichuan Jinfu (bamboo) were set at appraisal. The baseline and target for the replacement mills Henan Baiyun (straw) and Hunan Linyuan (reed) were set by the first restructuring, in November 2014. Baselines and targets were also established for the original mills for straw, reed and bagasse, and can be found in the PAD.

Component: 2. National Action Plan for Sector-Wide Replication

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Sectorwide BAT/BEP Guideline developed	Text	0 29-Mar-2012	Issued 30-Jun-2016		Issued 31-Jan-2018

Comments (achievements against targets):

Target 100% Achieved. Activity completed and end-target fully achieved. With the support of the Project, the "*Guideline for Available Techniques of Pollution Prevention and Control for Pulp and Paper Industry*" were issued by MEE in January 2018.

In addition, a large number of other documents were produced through th e project in support of the long-term sustainable sector-wide adoption of BAT/BEP, including a BAT/BEP Design Technical Manual for Non-wood Pulp; Technical Guidelines for Pollution Discharge Licensing in Pulp and Paper Industry in Guangxi; Technical Manual of Pollution Prevention in Pulp and Paper Industry in Guangxi; Technical Specification for Issuance of Discharge Permit in Paper Industry (under review and to be issued by MEE); development of a standard for Bioassay-based Solid Waste-screening of PCDD/Fs; National guidance document issued by MEE on Technical Policy of Dioxin Pollution Prevention and Control in Key industries; inclusion of dioxin reduction

measures in the Action Plan for Water Pollution Prevention and Control issued by the State Council in 2015; and the Evaluation Index System of Cleaner Production in Pulp and Paper Industry.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
UPOPs monitoring guideline for the pulp and paper sector developed	Text	0 29-Mar-2012	Issued and Implemented 30-Jun-2017		Issued and implemented. 30-Jun-2017

Comments (achievements against targets):

Target 100% Achieved. Activity completed and end-target fully achieved. Guidelines for sampling for bioassay dioxins determination were issued in June 2017 and implemented by the eight bioassay laboratories supported by the project.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
National workshops on BAT/BEP knowledge dissemination to mills	Number	0.00 29-Mar-2012	6.00 30-Jun-2017	3.00 30-Jun-2018	3.00 31-Jul-2017

Comments (achievements against targets):

(Revised) Target 100% Achieved. Activities completed and end-target fully achieved. Two workshops were held in 2017 with 56 participants and one workshop was held in 2018 with 20.
Target was reduced from 6 workshops with 100 participating mills to 3 workshops with 50 participating mills by the June 2016 restructuring, to reflect the closure of many small pulp and paper mills due to market conditions in the years since project appraisal.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
National training on BAT/BEP for design institutes	Number	0.00 29-Mar-2012	2.00 30-Jun-2017	1.00 30-Jun-2017	1.00 31-Aug-2018

Comments (achievements against targets):
(Revised) Target 100% Achieved. Activity completed and end-target fully achieved. One training workshop was delivered for design institutes.
Target was reduced from two workshops with 40 participating ;design institutes to one workshop with 20 design institutes by the June 2016 restructuring, to reflect the closure of many small pulp and paper mills due to market conditions in the years since project appraisal.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Training on rapid method dioxins monitoring for provincial and municipal EPBs	Number	0.00 29-Mar-2012	3.00 30-Jun-2017	4.00 30-Jun-2018	5.00 31-Jul-2018

Comments (achievements against targets):

Target 125% Achieved. Activities completed and end target fully achieved. In 2014, 1 training course was attended by 4 EPBs; in 2016, 2 courses were attended by 8 EPBs; in 2018, 1 course was attended by 4 EPBs; and in 2019, one training course took place with 4 EPBs.

Component: 3. Monitoring and Evaluation

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Increased UPOPs monitoring for pulp and paper mills in the participating provinces.	Text	0 30-Jun-2012	10 30-Jun-2017	16 30-Jun-2019	16 30-Jun-2019

Comments (achievements against targets):

Target 100% Achieved. The laboratories supported by the project conducted bioassay-based monitoring of 16 mills during the last year of implementation of the project. The target is for the number of mills to be monitored during the year (not a cumulative target). The end-target which is the target for 2019 is 16: each of the 8 laboratories supported in 8 provinces were tasked to monitor 2 mills each.

B. KEY OUTPUTS

Objective/Outcome 1 - Demonstrate the result of BAT/BEP adoption in four selected non-wood pulp mills	
Outcome Indicators	Reduced UPOPs releases in the four non-wood fiber mills supported by the Project
Intermediate Results Indicators	1. Completion of BAT/BEP investment 2. Number of selected mills to develop BAT/BEP investment plans 3. COD discharge per unit of non-wood pulp production from the four mills 4. NH3-N discharge per unit of non-wood pulp production from the four mills 5. Water consumption per unit of non-wood pulp production from the mills
Key Outputs by Component (linked to the achievement of the Objective/Outcome 1)	Under Component 1 1. Review of demonstrations technical proposals and engineering designs. 2. BAT/BEP transformation completed in three pulp and paper mills exemplifying the bamboo, reed and straw raw materials; with reports collating and summarizing technical and financial aspects of the process. 3. Demonstrated reduction after BAT/BEP renovation of releases of dioxins, AOX, COD and NH3, and reduced water usage. 4. *Prevention and Control Technology of Dioxin Pollution in Pulp and Paper Industry* and *Non-wood Pulp BAT/BEP Design Technical Manual*, prepared on the basis of the above demonstration reports; published by the Chemical Industry Press in 2018 and 2019, respectively. 5. Environmental and Social Management Plans and other feasibility studies for three bagasse-based mills.

	Under Component 3 6. Independent verification of the baseline and dioxins reduction to be achieved through implementation of ECF BAT/BEP for bamboo, straw, reed and bagasse-based mills. 7. Dioxins emission factors developed for the non-wood sector, and published in the peer-reviewed international literature.
Objective/Outcome 2 -Support the Recipient to develop its long-term action plan to guide the promotion of sector-wide BAT/BEP adoption	
Outcome Indicators	Adoption of a long-term action plan for the sector's UPOPs reduction
Intermediate Results Indicators	1. Sector-wide BAT/BEP guidelines developed 2. UPOPs monitoring guideline for the pulp and paper sector developed 3. National workshops on BAT/BEP knowledge dissemination to mills 4. National training on BAT/BEP for design institutes 5. Training on rapid method dioxins monitoring for provincial and municipal EPBs 6. Increased UPOPs monitoring for pulp and paper mills in the participating provinces
Key Outputs by Component (linked to the achievement of the Objective/Outcome 2)	Under Component 2 <u>Policy documents</u> 1. *National Action Plan* for promoting dioxins reduction in pulp and paper industry, issued by the CPA. 2. Support to *Technical Policy on Dioxin Pollution Prevention and Control in Key Industries*, MEE, Dec 2015. 3. Support to formulation of the *Action Plan for Water Pollution Prevention and Control* and the *13th Five-Year Plan for Eco-environmental Protection*, issued by the State Council, April 2015 and November 2016, respectively.

	4. *Special Governance Plan for Pulp and Paper in Guangxi*, issued by Guangxi Ecology and Environment Dept, June 2019. <u>Guidelines and regulations</u> 5. Support to *Guidelines for available techniques of pollution prevention and control in pulp and paper industry* (HJ 2302-2018), issued by MEE, January 2018. 6. Support to development of the *Technical Specification for Application and Issuance of Discharge Permit in Paper Industry*. 7. Facilitated updating of the *Evaluation Index System of Cleaner Production in Pulp and Paper Industry* (GoC co-financing). 8. Support to development of *Bioassay-based standard for solid waste screening of PCDD/Fs* provided by the first four labs supported by the project; standard to be issued by MEE. 9. *Technical Guidelines for Sample Collection and Preparation of Dioxins Monitoring in Pulp and Paper Industry*, in use by the labs supported by the project. 10. Guangxi *Technical Guidelines for Pollution Discharge Licensing and Standardized Management in Pulp and Paper Industry*, to be issued; and *Technical Manual of Pollution Prevention and Control and Environmental Management in Pulp and Paper Industry*. 11. Hunan *Pulp and Paper Cleaner Production Upgrading Program based on Dioxin Discharge Reduction*. <u>Training</u> 12. Development of training material and training of industry practitioners, three workshops with participants from 56 non-wood pulp and paper mills, May, June and July 2017; training estimated by FECO to affect more than 10,000 industry workers, indirectly. 13. Training of participants from 20 design institutes and other related institutions, one workshop Jul 2017.

	Capacity building for monitoring 14. Establishment of bioassay labs for dioxins monitoring in eight provincial or municipal environment monitoring departments, including the four provinces hosting demonstration mills: first in Sichuan, Guangxi, Henan and Hunan; and, after restructuring, Hubei, Guangzhou, Ningbo and Shannxi. 15. Proficiency training of 95 laboratory staff in bioassay techniques; a total of 5 training workshops were delivered, with each lab receiving three rounds of training. Experience sharing and exchange 16. Information exchange workshop with 20 participants from ASEAN in June 2016; discussions during China-ASEAN forum in 2017; presentation to Persistent Toxic Substances symposium, Basel, Nov 2018. 17. Case study on discharge permitting system in Sichuan (supported by SIDA). 18. Five research articles published in academic journals, including one in English in international peer-reviewed journal (see annex 6 for references). 19. Public awareness campaigns conducted in the demonstration provinces (Guangxi, Henan, Hunan and Sichuan), as well as at annual meetings of the paper industry. Under Component 3 20. UPOPs monitoring of pulp and paper mills by the various labs, a total of 16 enterprises were monitored the last year of implementation (2 in each of the Provinces where bioassay labs were established).

ANNEX 2. BANK LENDING AND IMPLEMENTATION SUPPORT/SUPERVISION

A. TASK TEAM MEMBERS

Name	Role
Preparation	
Jiang Ru	Task Team Leader
Guoping Yu	Procurement Specialist
Fang Zhang	Financial Management Specialist
Bernardita Ledesma	Operations analyst
Ning Yang	Environmental Specialist, co-TTL
Meixiang Zhou	Social Specialist
Qinghua Tian	Consultant, Sr Environmental Engineer
Supervision/ICR	
Laurent Granier	Task Team Leader from Sep 2018 and ICR author
Anis Wan	Co-TTL since 2015
Ning Yang	Co-TTL, Task Team Leader from 2015 to Sep 2018
Jiang Ru	Task Team Leader to 2015
Guoping Yu	Procurement Specialist
Fang Zhang	Financial Management Specialist
Qinghua Tian	Consultant, Sr Environmental Engineer
Xiaodan Huang	Environmental Specialist
Shuang Zhou	Social Specialist
Xieli Bai	Program Associate
Mingjie Li	Program Associate
Lisha Wang	Program Associate
Zijing Niu	Program Associate

B. STAFF TIME AND COST

Stage of Project Cycle	Staff Time and Cost	
	No. of staff weeks	US$ (including travel and consultant costs)
Preparation		
FY11	32.754	163,839.54
FY12	16.477	82,695.22
Total	**49.23**	**246,534.76**
Supervision/ICR		
FY11	0	23.00
FY12	0	8,669.19
FY13	6.895	49,444.53
FY14	5.875	40,158.35
FY15	7.425	57,595.86
FY16	8.593	51,929.96
FY17	9.346	54,434.30
FY18	9.025	75,337.65
FY19	9.261	91,606.58
FY20	1.950	17,069.78
Total	**58.37**	**446,269.20**

ANNEX 3. PROJECT COST BY COMPONENT

1. The project costs at approval and at project closure are presented in Table 3.2 below. At project closing, the GEF grant was nearly 99 percent disbursed.

Table 3.1. Project Cost by Component

Components	Total at Approval (US$, millions)	Total Actual at Closing (US$, millions)	Total Actual as % Approval	GEF Grant at Approval (US$, millions)	GEF Grant Actual at Closing (US$, millions)	GEF Actual as % Approval
BAT/BEP Investment in Participating Mills	73.64	67.64	92	11.55	9.92	86
National Action Plan for Sector-Wide Replication	2.56	5.23	204	1.80	3.34	186
Monitoring and Evaluation	1.20	1.32	110	0.87	1.01	116
Project Management	3.60	2.32	64	0.78	0.55	71
Total	**81.00**	**76.51**	**94**	**15.00**	**14.82**	**99**

Note: the GEF total "actual at closing" is US$31,560.06 lower than in the financing table of the data sheet due to that amount still pending return from the project designated account at time of writing this ICR, and therefore showing in the World Bank financial accounting system as "disbursed" until it is returned.

2. Co-financing 'realization' shown in table 3.2 was submitted to the GEF as part of completion reporting.

Table 3.2. Co-financing Realization

Source of Co-financing	Amount Confirmed at CEO Endorsement/Approval	Actual Amount Materialized at Closing	Actual as % of Approval
MEE and environment protection authorities in participating provinces	3.5	3.7	106
Participating enterprises	62	57.7	93
Bilateral agency (SIDA)	0.5	0.3	60
Total	**66**	**61.7**	**93.5**

Note: CEO = Chief Executive Officer; SIDA = Swedish International Development Cooperation Authority.

3. The slight drop in co-financing at closing (93 percent of the amount confirmed at CEO endorsement/Board approval) was due to the withdrawal of the Pumiao mill, which was only partially compensated by the co-financing from the mills receiving technical assistance support. The co-financing disbursed at project closure is in fact higher than the amount that was estimated at restructuring and formally revised to reflect the loss of Pumiao co-financing (US$57.16 million according to the financing table in the data sheet). This is due to the higher than originally anticipated co-financing from the three mills that received technical assistance support.

ANNEX 4. EFFICIENCY ANALYSIS

1. Project efficiency is assessed as Substantial, in spite of delays in implementation. As discussed in this annex, the project achieved what it had promised and took a least-cost approach to achieving global environmental benefits through demonstration of dioxins reduction from non-wood paper mills and establishing a framework for sustainable sector-wide conversion.

Economic and Financial Analysis at Appraisal

2. At appraisal, the PAD presented an economic analysis and a financial analysis. The economic analysis focused on demonstrating that ECF offered the least-cost option to meeting the goals of BAT/BEP for dioxins reduction in the sector. This is further confirmed at the ICR stage as discussed in the following paragraphs.

3. The financial analysis was used to show that the mills could sustain the BAT/BEP investments and concluded that the four selected pilot mills showed good financial viability, which bode well for the project's future sustainability. This analysis proved to be of limited usefulness, however, because three of these four originally selected mills eventually decided to withdraw from the project due to business decisions in part reflecting difficult market conditions and unrelated to their financial strength on paper. (This point is further elaborated under section IIIB) The summary of this analysis at appraisal[43] pointed out that it was 'very sensitive to increase in operating costs and decrease in pulp prices'. Moreover, the World Bank had identified the risk of one or more mills not following through with their commitment to participate in the project, at concept review and at the time of appraisal.[44] Indeed, the FECO project team, the CPA, and the World Bank team worked closely to identify candidate replacement mills fairly rapidly once it was confirmed that mills would not participate, but the process of withdrawal, appraisal, environmental permitting, and contractual arrangements inevitably lead to delays. In hindsight, the World Bank and FECO could have undertaken a more thorough assessment of the sector and how the transformation that it was experiencing might affect project implementation. It should be noted however that the main turmoil only hit the industry around the time the project started, with dramatic change during the first two years of project implementation due in part to the import[45] of cheap wood pulp that reduced market shares of bleached non-wood pulp. It is not certain that the signs could have been better understood[46] at the time of project preparation.

Incremental Cost Reasoning

4. As part of the GEF Council work program approval documentation, the GEF Project Identification Form (PIF) articulated the incremental reasoning underlying the request for GEF support and outlining the

[43] PAD, P.9.

[44] Project Concept Review Decision Note, May 2011, and minutes of Technical Review Meeting, October 2011, on file; the risk related to the commitment of the selected mills to participate was flagged as 'Moderate' in the project's Operational Risk Assessment Framework.

[45] Conversely, the ban on wastepaper import imposed by China in 2017 would serve to strengthen the demand for virgin including non-wood pulp.

[46] Non-wood pulp production in 2011, the year the project was prepared, was over 12 million tons, roughly unchanged since 2002; in 2013, it dropped to just over 8 million tons. By 2016, it was hovering around 6 million tons and had stayed unchanged since (see Table 3).

baseline/business-as-usual scenario and value added of GEF intervention.[47] The analysis mirrored the implicit ToC discussed in section 1A. and noted that under business as usual, China would continue to close small mills and mandate improved water treatment for the larger ones, but BAT/BEP for dioxins reduction in the non-wood sector would be largely ignored due to technology and financial barriers and inadequate enforcement. On the other hand, the GEF alternative (the project) would 'help China effectively restructure its pulp and paper sector, improve the sector's economic and environmental performance, and minimize UPOPs'. The project was also noted to be expected to generate multiple benefits for the global environment as it would not only lead to a reduction in UPOPs releases from the sector but would also reduce the sector's water consumption and conventional pollutants discharge (particularly COD), which would benefit the East Asia large marine ecosystem as the majority of pulp and paper mills were located in East China and discharged their wastewater into rivers flowing into East Asia's seas. Broad GEF eligibility was established by the project addressing a class of chemicals specifically covered by the Stockholm Convention and addressing a priority under the country's NIP[48] for the convention.

5. This qualitative analysis was confirmed at the time of GEF CEO endorsement/World Bank appraisal, and slightly expanded to include a more precise description of the barriers to BAT/BEP adoption and the 'alternative' project to be supported by the GEF. There was no quantitative analysis at appraisal as the GEF was moving from a strict incremental costs analysis approach to an approach emphasizing incremental reasoning and value added of the GEF intervention. It should be noted that this approach is well suited for GEF financing of POPs projects, where there is no Stockholm Convention or other guidance to define incremental costs, beyond the general principle[49] that 'agreed full incremental costs' are to be supported.[50]

6. The analysis remains valid at completion. The project has addressed the key barriers to adoption of BAT/BEP through demonstrations, documenting the technical aspects of the process for the various non-wood pulp raw materials and the environmental benefits and operating costs savings that would derive from the technical transformation, as well as building capacities in industry and the government at national and local levels to manage the sector, and adopting a targeted NAP to guide sector-wide adoption of BAT/BEP.

Appropriateness of Public Sector Provision and Private Sector Leveraging

7. This was not explicitly discussed at appraisal and was only required following issuance of the IPF Economic Analysis Guidance Note by the World Bank in October 2014. The project directly mobilized significant private sector investments in BAT/BEP through co-financing from the participating mills, with US$57.7 million investment from the participating mills for a GEF contribution of US$9.1 million under Component 1. This is being complemented by further industry investments to achieve sector-wide ECF

[47] GEF Project Identification Form, January 15, 2011, on file.
[48] *The People's Republic of China National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants,* April 2007, http://www.pops.int/Implementation/NationalImplementationPlans/NIPTransmission/tabid/253/Default.aspx
[49] Stockholm Convention, Article 13.
[50] It is understood that reduction of POPs releases to the environment leads to global and local benefits— however, there is no guidance from the GEF or the Stockholm Convention as to how this is to be operationalized and whether local benefits should be discounted, for example—which in any event would be technically extremely challenging if at all possible—and the practice therefore has been based on cost sharing between the GEF and project recipients.

transformation by 2025 according to the NAP developed under the project. The project itself has two complementary aspects: the investments and demonstration of BAT/BEP, and strengthening of the framework for regulatory oversight to support long-term sector wide transformation. The latter is supported by Component 2 on National Action Plan for Sector-Wide Replication which is wholly concerned with strengthening public sector policy, regulatory, and enforcement capacities. Component 1 on BAT/BEP Investment in Participating Mills included a public subsidy to facilitate the private investments and represents the majority of project grant funds. This is justified by the need to (a) use the demonstration projects as open books to record and disseminate the full experience from the technological BAT/BEP upgrade, including investment costs and operational savings, and (b) accelerate sector transformation. In all instances, the subsidy was significantly lower than the mills' own investments. (The fact that three mills had to withdraw from the project also indirectly suggests that the subsidies were not disproportionately high.) The project team had discussions with the International Finance Corporation (IFC) at the time of project preparation to explore whether alternative implementation modalities would be possible, but it was estimated that these would not lead to the requisite demonstration objective, in the right time frame.

Value Added of World Bank Support

8. This also was not explicitly discussed at appraisal (and was also only required after issuance of the IPF Economic Analysis Guidance Note by the World Bank in October 2014), but was articulated in the PIF for the GEF Council approval under the heading of 'comparative advantage'. The GEF describes[51] the World Bank as "a leading international financial institution at the global scale in a number of sectors […] with strong experience in investment lending focusing on institution building, infrastructure development and policy reform, across all the focal areas of the GEF." The PIF makes reference to past experience of the World Bank Group with the IFC and with energy efficiency investments in a few pulp and papermaking facilities through domestic financial intermediaries. The PIF further notes the ongoing support that the World Bank had been extending to China, and continues to extend as part of a strong pollution management portfolio. Noting that with regard to POPs, "the Bank has supported China through its trust fund resources to build up its capacity in developing its NIP and preparing GEF POPs projects since 2002. The World Bank has helped China prepare and implement three out of the country's nine active POPs projects […]. The project's BAT/BEP demonstration component, which will require significant investment, is in line with the World Bank's comparative advantage on investment interventions and its long-term engagement with China's pulp and paper sector". Indeed, this ICR finds that the World Bank was uniquely placed among all GEF agencies to offer the mix of investment, policy making, and capacity-building support that was necessary for the project's achieving its development objectives and for its sustainability.

Revisiting the Economic Analysis at ICR

(a) ECF as the Least Cost Technology

9. As described in the PAD, the project followed a least-cost approach to meeting China's obligations under the Stockholm Convention to reduce releases of dioxins from the pulp and paper sector, by comparing and benchmarking the effectiveness of ECF bleaching and TCF bleaching and ultimately

[51] Comparative Advantage of the GEF Agencies, GEF/C.31/5, May 2007.

selecting ECF with its lower investment and operating costs. This decision was appropriate including for the following reasons:

- It was not for the project to attempt a cost-benefit analysis of dioxins release reduction from pulp making and papermaking when this has already been prioritized at the global level through the adoption of the Stockholm Convention and the BAT/BEP guidance adopted by the parties. Moreover, the scientific basis to do so is weak in line of the still misunderstood dose-response relationship between dioxins exposure and adverse health effects. By way of example, the U.S. EPA in 1993 gave a widely varying estimate[52] for water-related benefits from dioxins water release reduction in the industry, with annual water-related benefits ranging between US$71 to US$430 million.
- The choice of ECF is in line with the international BAT/BEP Guidelines[53] adopted by the parties to the Stockholm Convention, which describe ECF bleaching as the key BAT for bleaching and further notes that TCF constitutes an alternative for kraft pulp that 'has lost its attraction because of weakness in fiber characteristics, lower pulp yield and higher energy consumption' and that 'the operating costs of TCF pulping are usually higher than those of ECF pulping'. Moreover, the guidelines list additional technical reasons why 'TCF bleaching is not viable in traditional alkaline non-wood processes'.
- Selecting ECF is also in line with the World Bank Group EHS guidelines[54] that provide that "recommended wastewater prevention and control methods for kraft and sulfite mills include […] decreasing or eliminating the formation of 2,3,7,8-TCDD and 2,3,7,8-TCDF in wood and non-wood bleaching processes by replacement of elemental chlorine bleaching with elemental chlorine free (ECF) bleaching or total chlorine free (TCF) bleaching; [and] both ECF and TCF bleaching are used at kraft mills, although ECF is the more common[…]. When Elemental Chlorine Free (ECF) or Total Chlorine Free (TCF) bleaching technologies are used, the concentrations of dioxins and furans in the effluents are below the detection limits."
- This is further confirmed by the latest revision to the comprehensive Biermann's Handbook of Pulp and Paper[55] which states that "ECF pulp, bleached with chlorine dioxide, continues to grow and is now dominating the market. […] Field studies, research and chemical analysis over the last two decades have shown that treated wastewater from well-managed pulp and paper mills using ECF bleaching is virtually fee of dioxin and persistent bioaccumulative substances. […] Studies comparing ECF and TCF effluents confirmed the absence of significant differences in biological effects in the aquatic environment." The handbook further notes that capital costs of conversion are significantly higher with TCF, and so are operating costs with increased incremental operating costs of US$20–US$75 per ton from ECF to TCF in the United States and a comparable estimate of US$60 per ton in Austria.

[52] *Regulatory Impact Assessment of Proposed Effluent Guidelines and NESHAP for the Pulp, Paper and Paperboard Industry*, EPA-821-R-93-020, Nov 1993.
[53] *Guidelines on Best Available Techniques and Provisional Guidance on Best Environmental Practices Relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants*, United National Environment Program, May 2007.
[54] *Environmental, Health, and Safety Guidelines Pulp and Paper Mills*, World Bank Group, December 2007.
[55] *Biermann's Handbook of Pulp and Paper: Raw Material and Pulp Making*, 3rd Ed., 647pp, P. Bajpai, Elsevier, 2018.

- Finally, a recent review[56] in the peer-reviewed literature states that "the effect of the transition from elemental chlorine bleaching to chlorine dioxide bleaching in the pulp and paper industry on the formation of PCDD/Fs confirms that there is clear indication that 100 percent chlorine dioxide bleaching does not produce 2,3,7,8-TCDD and 2,3,7,8-TCDF (the most toxic forms of dioxins)."

10. A complementary approach could have been to analyze the cost-effectiveness of the project from the point of view of cost norms for dioxins abatement. This is, however, largely impossible to do in a meaningful way, for the following reasons:

- There are no readily available comparisons to be made. This project, for example, is the only GEF-supported project addressing dioxins release reduction from the pulp and paper sector, let alone the non-wood sector.
- There is no other World Bank Group project specifically addressing dioxins releases from pulp and papermaking.
- While there are some projects in the GEF portfolio that address the reduction of dioxins emissions to air, there are none that address dioxins release to water. This makes it impossible to compare as releases and emissions to different media have very different environmental and health impacts. Releases to water bodies have a singular importance because a key source of human exposure to dioxins is the ingestion of contaminated biota that has bioaccumulated dioxins from surrounding water and sediment. A second aspect specific to papermaking is related to food packaging, with residual amount of dioxins that will be transferred to the paper in the case of elemental chlorine bleaching and from there can cause intake and accumulation by infants and others.
- The objective of the project is demonstration to address barriers to sector-wide transformation, not the actual reduction achieved by the select few mills participating in the project. By way of comparison, the US EPA estimated[57] the annual cost of compliance with its 1993 'Cluster Rule' for the pulp and paper industry at US$600 million for the entire industry.

11. Finally, to bring some perspective for the approximately 30 g TEQ reduction for the sector that is expected to be achieved by 2025 with implementation of the NAP developed under the project and adopted (see annex 8): this is in the order of magnitude of the total emissions from industrial and non-industrial sources for a small industrialized country such as Denmark[58] (20–49 g TEQ), while the U.S. EPA estimates[59] total releases from the pulp and paper industry in the United States at 1.2 g TEQ.

[56] Axegard, Chemosphere, 236 (2019) – the paper also notes that while most wood pulp mills worldwide now rely on ECF, there are still a number of non-wood mills in developing countries in particular China that use elemental chlorine – emphasizing the timeliness and strategic importance of this project.
[57] *Regulatory Impact Assessment of Proposed Effluent Guidelines*, op. cit. (The capitol costs to the industry were later found to have been overestimated by EPA by 30 - 100 percent - Morgan et al., *Ex ante* and *ex post* cost estimates of the cluster rule and MACT II rule, J. Benefit Cost Anal. 2014; 5(2): 195-224.)
[58] European Commission, DG Environment. 2000. *European Dioxin Emission Inventory Stage II*, *Volume 3.*
[59] U.S. EPA. 2013. A*n Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000*. External Review Draft.

(b) Affordability from the Mills' Perspective

12. As suggested above, investing in BAT/BEP for dioxins release reduction in the pulp and paper sector should not necessarily need to yield a positive financial return on investment from the mills. Rather, it is to meet a mandatory regulatory regime stemming in part from China's commitment under the global Stockholm Convention on POPs. It is part of the cost of doing business and, implicitly, one of the reasons that the smaller mills have been closing is they are too small to sustain the investment needed to modernize. For this reason, there is no attempt here to reproduce the analysis at project appraisal of the financial viability of the candidate participating mills, given how that analysis has proven to be of limited value. Rather, we highlight here that the project also demonstrated that the investments in BAT/BEP and related cleaner technologies could be a good return on investment, with savings on energy use, water treatment, and other operating costs, as well as improved product quality, for all of the participating mills: the demonstration reports[60] that were published for each of the participating mills show that the payback on investment was estimated at 3.9 years for Sichuan Jinfu (bamboo), 4.3 years for Hunan Linyuan (reed), and 5.2 years for Zhumadian Baiyun (straw). This confirms the hypothesis that cleaner production methods pursued in parallel (and as part of) BAT/BEP would lead to savings.

(c) Promoting a Least Cost Approach to Monitoring

13. Under Component 2, the project also established eight bioassay laboratories and achieved staff proficiency –as measured by laboratory comparison exercise—introducing the bioassay technique as a possible alternative for regulatory and screening purposes. This is a cost-effective alternative to costly analytical techniques for screening of dioxins, and the project has contributed to the development of a standard which would allow and codify the use of that method. A recent review,[61] for example, confirms that both chemical analysis and bioassays are useful and complementary and notes that while chemical investigations can give a more detailed view regarding specific quantities of different compounds present in complex environmental mixtures: "bioassays are better suited to pre-screen those mixtures and hence to identify the most dioxin-like active samples. In this context, bioassays have the distinct advantage that they can detect the overall dioxin-like potential of a sample including chemicals that cannot be analyzed by chemical analytical techniques." The project is the first time that the technique is promoted in provincial environmental departments in China, and this could pave the way for the adoption of cost-effective monitoring approaches in the future.

(d) Efficiency of the Technical Assistance Interventions

14. Under Component 2 on National Action Plan for Sector-Wide Replication, the project worked with Provincial Ecology and Environment Departments, environmental monitoring centers, provincial research academies and other research institutes, and the CPA and participating mills, to produce or contribute to thirteen policies and standards, research reports and technical manuals, training materials, two books and

[60] Sichuan Jinfu Paper Co., Ltd, Demonstration Report of Dioxin Emission Reduction from the Bamboo Pulp Production; Henan Zhumadian City Baiyun Paper Co., Ltd, Demonstration Report of Dioxin Emission Reduction from the Straw Pulp; and Hunan Linyuan Co., Ltd. Pumiao Paper Mill Branch, Demonstration Report of Dioxin Emission Reduction in Reed Pulp Production, Light Industry Environmental Protection Institute, December 2017.

[61] Eichbaum et al. 2014. "In vitro Bioassays for Detecting Dioxin-like Activity - Application Potentials and Limits of Detection, a Review." *Science of the Total Environment* 487 (2014): 37–48.

five published scientific and technical papers.[62] While difficult to benchmark, this is an impressive number that was made possible by relying on national experts, consultants, and researchers, rather than relying on international expertise; this was also appropriate given the limited international experience on the matter.

(e) Counterfactual

15. Would the sector-wide transformation to BAT/BEP for dioxins reduction have happened at a comparable pace? There are several elements that point to the project having accelerated BAT/BEP implementation in the non-wood sector, even as the sector was being transformed:

- Before the project, the wood-based pulp and paper industry had largely aligned itself with world trends and had adopted ECF in most of its production lines. The non-wood-based mills, however, had not, due to financial barriers and lack of understanding of the benefits that could result from implementing BAT/BEP. Around the time of project approval, there was significant realignment in the industry with the closure of many smaller mills. In Sichuan for example, there were 20 mills in 2012 but only 13 left in 2018, with an overall 50 percent increase in capacity. The signs are that any transformation would have happened much more slowly. In 2012, for example, Wang[63] et al. noted that "it has been estimated that China produces approximately 80 percent of the world's non-wood pulp. However, most non-wood pulp and paper mills in P.R. China still adopt the conventional chlorine bleaching technology." In Guangxi Province, for example, one of the mills supported with technical assistance had its EIA approved in 2012 but had not been able to proceed with investments until supported by the project in 2018.
- The project was timely in providing input to, and ensuring that the guidelines for Available Techniques of Pollution Prevention and Control for the Pulp and Paper industry, issued by the MEE, included consideration of BAT/BEP for dioxins release reduction. This seamless alignment of national regulatory rule-making with the needs of the global Stockholm Convention on POPs would not have happened without the project.
- Regarding the use of bioassay techniques for dioxins monitoring, before this project there was very limited reference to the use of such techniques, and to our knowledge this is the first systematic effort to promote the technique with the monitoring laboratories of the provincial environment departments. It is unlikely that this would have happened without the push from the project.

[62] See list of Outputs, annex 3 and references annex 6.
[63] Wang et al. 2012. "Formation and Emission of PCDD/Fs in Chinese Non-Wood Pulp and Paper Mills" *Environ. Sci. Technol.* 2012, 46: 12234−12240.

Main Efficiency Failing

16. Three of the four originally selected mills withdrew from the project (two were replaced). For two of the mills, this was due to decisions to redirect investments[64] rather than supporting BAT/BEP under the project as planned, while the third mill closed down due to parent company decision. In all cases, this can be linked to business decisions related to changing and difficult market conditions at that time that would have been difficult to predict during project preparation. While, as discussed under section IIB, this did not prevent the project from meeting its development objectives, it led to implementation delay of 2 years and accompanying additional project management and opportunity costs on the side of FECO and implementation support costs on the side of the World Bank, as well as the costs of preparing and appraising the originally planned investments at the three mills.

17. Beyond these shortcomings, there were no other negative impacts on efficiency from the point of view of project design and implementation:

- There was strong institutional stability with the project teams both from the World Bank and the client's side. In FECO, the key project officers and the manager were unchanged for the last five years of implementation of the project (since the fourth implementation support mission), with the same national technical advisor in place from the start of the project. On the World Bank side, the team was similarly stable, with two TTLs for most of the project implementation period, the second TTL having been co-TTL since project preparation. The World Bank's key expert consultant supported the team from preparation to completion.
- In spite of the two-year extension of the project closing date, cost of preparation, and supervision for the World Bank were within cost-norms, and overall, did not exceed the agency fee made available by the GEF.
- There were no significant differences in component costs between appraisal and completion, as can be seen in the annex 3 table 3.1, except due to Component 1 supporting BAT/BEP investments in three rather than four mills as originally envisaged. Consequently, the unspent funds were made available chiefly for (a) technical assistance support to additional mills and (b) support to four additional bioassay labs—thereby increasing the outlook for sustainability of that subcomponent.

Conclusion

18. The project achieved value for money by following a least-cost approach to the delivery of global environmental benefits and setting up a framework for longer-term sustainable sector-wide transformation. While the withdrawal of three of the four originally identified mills represents a shortcoming that led to approximately two years of implementation delay and therefore prevents a rating of 'High, the project outcomes were achieved, and the overall efficiency can be assessed as Substantial based on the above analysis.

[64] In the case of Ningxia Zhongye, the company made poor investments to increase its share of wood pulp that could not be sustained and at the time of ICR had pulled out of the pulp making business altogether. Hunan Yueyang decided to shift its production to non-bleached pulp only and Guangxi Pumiao's parent company decided to shut down the mill when faced with the additional cost of air pollution control.

ANNEX 5. BORROWER, CO-FINANCIER AND OTHER PARTNER/STAKEHOLDER COMMENTS

The ICR was shared with FECO for review and incorporates comments received. FECO has prepared and submitted to the World Bank a completion report. The “abstract” and “lessons and recommendations” are appended here verbatim.

Abstract

Dioxins are some of the first controlled persistent pollutants in the Stockholm Convention, which can be generated through the elemental chlorine bleaching process used in pulping and papermaking and occur in water, sludge, and the products, posing high risks to the environment and human health. Research shows that the BAT/BEP, represented by ECF bleaching, can effectively reduce dioxin generation. By 2009, most paper mills using wood pulp in China had adopted BAT/BEP based on the ECF bleaching process. In contrast, few paper mills using non-wood pulp were applying BAT/BEP. These mills had become the main source of dioxins in the industry and could not meet the dioxins and AOX control requirements specified in the Discharge Standard of Water Pollutants for Pulp and Paper Industry (GB3544-2008).

To solve the problems of dioxins and environmental pollution in the pulp and paper industry, support the implementation of GB3544, and promote sustainable development of the industry, the FECO of the MEE joined forces with the World Bank to launch the GEF ‘Dioxins Reduction from the Pulp and Paper Industry Project for China’ in June 2012, which promoted dioxin discharge reduction and green development in the pulp and paper industry through a series of activities, including demonstrating BAT/BEP with four typical non-wood pulp types, namely, bagasse, straw, bamboo, and reed, and formulating and implementing a BAT/BEP transformation action plan for the entire industry.

After nearly seven years of joint efforts, the project was successfully completed in June 2019. The main outcomes of the project are detailed in the following paragraphs.

Outcome 1: Completed technical transformation of typical non-wood pulp mills, providing demonstration for BAT/BEP application in the non-wood pulp sector

BAT/BEP transformation based on ECF bleaching were conducted in three mills using typical non-wood pulp types, including bamboo, wheat straw, and reed. The economic and technical feasibility of BAT/BEP adoption in the non-wood pulp sector was verified and lessons and experience were summarized. Results show that after transformation, dioxin generation in the three typical non-wood pulp mills has decreased from 78 mg TEQ per year, 67 mg TEQ per year, and 113 mg TEQ per year to 1.48 mg TEQ per year, 15 mg TEQ per year, and 2 mg TEQ per year, respectively, with a reduction efficiency of 98.1 percent, 77.2 percent, and 98.2 percent, respectively. In addition, technical assistance was provided to bagasse pulp mills, leading to 88.2 percent reduction in dioxin discharge and substantial decreases in the discharge of COD, NH3-N, and other pollutants. These achievements added to the accumulated data and experience of BAT/BEP transformation and provided references as to the promotion of BAT/BEP for the entire industry.

Outcome 2: Developed a number of policy documents and technical guides, improving the environmental management technology and the policy system of China's pulp and paper industry

The project supported in releasing ‘Opinions on Promoting Dioxins Reduction in Pulp and Paper Industry’ (China Paper Association, No. 22, 2018) and other industry policies. It also supported the development of 'Technical Policy for Dioxins Pollution Prevention and Control in Key Industries, Practical Technical Guidelines for Pollution Prevention, and Control in Pulp and Paper Industry’ and several other technical documents, and helped the demonstration provinces to formulate special management plans for the paper industry. The achievements of the project have been directly reflected or applied in national or provincial policies and standards, such as ‘Action Plan for Water Pollution Prevention and Control, 13th Five-Year Plan for Eco-environmental Protection, Technical Specification for Application and Issuance of Discharge Permits - Paper Making, and Evaluation Index System for Cleaner Production in Pulp and Paper Industry.’ These achievements have improved the environmental management system of the pulp and paper industry from various perspectives, such as national and local policy guidance and constraints, as well as technical guidance support, and have effectively facilitated the use of science and refinement of the environmental management of China’s pulp and paper industry.

Outcome 3: Promoted BAT/BEP adoption across the industry, further improving the industry’s environmental performance related to dioxins and other major pollutants

BAT/BEP was promoted in the pulp and paper industry nationwide and satisfactory results were achieved. As of June 2019, almost all bamboo pulp mills, most of the bagasse and reed pulp mills and some of the straw pulp mills have completed BAT/BEP transformation, reducing dioxin discharge by about 26.036 g TEQ per year. Meanwhile, the application of BAT/BEP has promoted synergistic discharge reduction of COD, NH_3-N and other pollutants, as well as water conservation, further improving the environmental performance across the industry.

Outcome 4: Established eight dioxin bioassay laboratories nationwide, laying a strong foundation for improving and developing China’s dioxin detecting and testing system.

Eight provincial or municipal environmental monitoring departments, such as Hubei Environmental Monitoring Center, were supported in the construction of experiment facilities for dioxin screening based on the reporter gene method and key managing staff and laboratory technicians, 95 people in total, were trained in relevant theories and practices of rapid detection of dioxins. The efforts increased the number of dioxin screening methods available in the eight environmental monitoring departments; enhanced their capabilities in dioxin detecting, testing, and screening; and built a team of talents with practical skills as well as theoretical knowledge. The laboratory construction and people training in turn facilitated the formulation of ‘Solid waste—Screening of PCDD/Fs—Chemical Activated Luciferase Expression’, the standardization of dioxin bioassays (reporter gene method), and further applications of the biological screening techniques for dioxins in media such as water, soil, and fly ash. The achievements promoted the application and development of biological screening techniques for dioxins in China, laying a strong foundation for a detection and testing system based on HRGC/HRMS, and supplemented by dioxin bioassays and a comprehensive dioxin management system as well.

Outcome 5: Conducted training in BAT/BEP and dioxin prevention and control, comprehensively upgrading the knowledge system of supervising officials and practitioners in the pulp and paper industry

Through systematically introducing the knowledge of dioxin pollution prevention and control in the pulp and paper industry and relevant experience in transformation, operation, and management, several training sessions in BAT/BEP and dioxin prevention and control were carried out for supervising officials, technical and managing personnel of pulp and paper mills, and staff of relevant technical consulting institutions. A total of 54 non-wood pulp and paper mills, covering more than 80 percent of the sector, and a total of 40 institutions offering consultancy and other services regarding design and equipment have been trained. The training activities have comprehensively improved the level of theoretical knowledge and practical skills of the industry practitioners and managing officials and facilitated the updating of the knowledge system and skills of relevant personnel.

Outcome 6: Systematically mastered laws of dioxins' discharge concentration and its migration and transformation in the pulp and paper industry, providing strong technical support for the implementation of the Stockholm Convention and dioxin pollution prevention and control.

The laws of dioxins' generation, migration, and transformation were systematically studied in different bleaching processes (chlorination, alkaline extraction, and hypochlorite [CEH] and ECF) for wheat straw, bamboo, reed, and bagasse. Dioxins' occurrence level in bleaching wastewater, total discharge wastewater, sludge, pulp, and air. The laws of dioxin's discharge concentration, migration, and transformation in non-wood pulp production were determined systematically for the first time, which provided an effective supplement to UNEP toolkit and a strong scientific and technical support for the implementation of China's obligations under the Stockholm Convention and the prevention and control of dioxin pollution in the country.

Outcome 7: Raised public awareness and comprehensively increased public knowledge about dioxin control in the pulp and paper industry

Environmental protection education bases were established in demonstration enterprises and relevant training, publicity, and implementation was organized. In the four demonstration provinces, a variety of publicity activities were held in the Government, communities, universities, schools, and other public places. Traditional and new media were extensively used to publicize dioxin knowledge, project results, and experience. According to the statistics, various publicity activities in demonstration provinces and cities covered more than 11,000 people and related conferences and forums covered more than 500 people. The above activities enhanced the public's scientific knowledge and understanding of dioxins in the pulp and paper industry, raised public awareness, encouraged participation in the prevention and control of POPs, urged relevant management departments to take guidance and control measures, and thus forced transformation and upgrading of the pulp and paper industry.

Through the implementation of the project, advancement of dioxin pollution prevention and control techniques was promoted in non-wood pulp production, the POPs problem in the pulp and paper industry was rendered mainstream, the pollution control and supervision capability in the pulp and paper industry was enhanced, and China's dioxin pollution control policy and standard system for the pulp and paper industry was improved. Satisfactory environmental, economic, and social benefits have been achieved and the project played an important role in promoting the sustainable development of China's pulp and paper

industry.

5. Summary and Recommendations

5.1 Summary

5.1.1 Clear Project Design

In the early stage of the project, a large number of basic investigations were carried out, and the current situation and existing problems of dioxin discharge in China's pulp and paper industry were analyzed in depth. Two objectives were determined including demonstration of BAT/BEP transformation and promotion of BAT/BEP adoption across the industry, around which detailed task indicators were formulated. Specific, feasible, and easy-to-operate activities were designed to facilitate the project, which laid a solid foundation for smooth implementation of the project and realization of the objectives.

5.1.2 Extensive Participation of Relevant Parties and Attention From Leaders

The wide participation of relevant parties and the support of leaders were important reasons for the successful completion of this project. At the national level, the MEE and MOF attached great importance to the project, fully mobilized various resources and actively promoted the project. At the local level, the ecology and environment departments, academies of environmental sciences and monitoring centers of the demonstration provinces and cities actively cooperated with the implementation of the projects. The leaders in charge directly took part in the project, and the responsibility and division of labor were clear, which ensured that the project advanced in an orderly manner. These provided technical support and material guarantee for the demonstration projects. At the industry level, the project fully mobilized industry resources such as CPA, relevant universities, scientific research institutions, consulting institutions, and so on, which provided adequate technical support for the smooth progress of the project.

5.1.3 Systematic Organization and Coordination

Effective organization and coordination played an important role in ensuring the smooth implementation of the project, as over 30 institutions were involved, including national and local government departments, industry associations, scientific research institutes, enterprises, and so on. As the specific implementation organization of the project, FECO has established a good communication and consultation mechanism through organizing kickoff meetings, annual coordination meetings, midterm seminars, and project summary meetings, and has handled major matters with the principles of pre-notification, audit and joint consultation, thus ensuring the consistency of project management and improving the efficiency of project implementation.

5.1.4 Standardized Project Management

The project has established a rigorous assessment and evaluation mechanism, with specific indicators to evaluate each link of iconic events as well as the entire implementation process. FECO managed and supervised the progress of the project through annual implementation planning, annual implementation reporting, annual implementation evaluation, annual financial audit and on-site inspection, and so on. The problems found in the process of project implementation were solved through in time communication and

negotiation to ensure the effectiveness of the project. The financial management, M&E plan of the project clarified the assessment indicators, methods, schedules, and responsibility subjects of each key activity implemented in the demonstration areas, which provided a basis for evaluating the expected output of each stage.

5.2 Recommendations

5.2.1 Continuous Promotion of BAT/BEP Application and Technological Innovation in Non-wood Pulp Sector

The project supported the demonstration enterprises in BAT/BEP transformation through international grants, which achieved good results. By 2019, most non-wood pulp manufacturers in China have adopted the ECF or TCF bleaching technique, while a few are still using elemental chlorine bleaching. After the project, it is recommended that the results achieved are further disseminated to promote BAT/BEP application in all enterprises in the sector. Besides, universities, scientific research institutions, and enterprises should be encouraged to develop and apply more advanced clean production technologies according to the characteristics of non-wood pulp production through the combination of production, teaching, and research, to further break through the technical bottleneck of non-wood pulp production and reduce the cost of BAT/BEP transformation. Moreover, training of managers and technicians of non-wood pulp production enterprises should be continued, and the operating procedures of non-wood pulp production processes should be constantly improved, to elevate the operation and maintenance management of production and environmental protection facilities to the next level.

5.2.2 Continuous Update and Improvement of Law, Regulation, and Standard System

The implementation effectiveness of existing management regulations, policies, and standards should be regularly evaluated. The existing management system should be constantly updated and improved. And the existing policy and standard system should be continuously updated and supplemented. Through developing the system of laws, regulations, and standards, a green and sustainable pulp and paper industry is further promoted.

5.2.3 Strengthening Exchanges with Other Non-wood Pulp Producing Countries

The pulp and paper industry is an important one in many Southeast Asian countries. For example, it makes the ninth largest economic contribution to Indonesia and is developing fast in Thailand, Vietnam, Malaysia, and so on. Although wood pulp production still dominates in Southeast Asian countries at present, with the shortage of wood resources becoming increasingly prominent, non-wood fibers as raw materials for pulp making and papermaking are continuously more valued in those countries. Indonesia, Philippines, Thailand, Malaysia, and other Southeast Asian countries have seen the emergence of non-wood pulp produced from bamboo, bagasse, and other raw materials. It is known that some Southeast Asian countries still lack relevant experience in non-wood pulp production. It is recommended that China enhance its communication with Southeast Asian countries regarding BAT/BEP application, promote the industry’s advancement in relevant countries, and reduce dioxin discharge in the global pulp and paper industry.

ANNEX 6. SUPPORTING DOCUMENTS

Project and Financing Documents

- Project Appraisal Document (Report No: 67044)
- Grant Agreement (and three amendments)
- Restructuring Paper (1st Restructuring – 11/13/2014)
- Amendment to Grant Agreement (1st Restructuring – 11/13/2014)
- Restructuring Paper (2nd Restructuring – 06/28/2016)
- Amendment to Grant Agreement (2nd Restructuring – 06/30/2016)
- Closing Date Extension (3rd Restructuring – 06/29/2018)
- Restructuring Paper (4th Restructuring – 09/2018)
- Amendment to Grant Agreement (4th Restructuring – 09/28/2018)
- GEF Project Identification Form and CEO Endorsement Request
- GEF Scientific and Technical Advisory Panel Screening of PIF
- GEF POPs Tracking Tool
- Model FECO-Mills Performance-based Financing Agreement (English Final)
- Baiyun Paper: PBF Agreement (in Chinese)
- Linyuan Paper: PBF Agreement (in Chinese)
- Jinfu Paper: PBF Agreement (in Chinese)

WBG Engagement Strategy Documents

- China Country Partnership Strategy FY06-10 (Report No. 35435)
- China Country Partnership Strategy FY 13-16 (Report No. 67566-CN)
- China Systematic Country Diagnostic 2017 (Report No. 113092-CN)
- China Country Partnership Framework FY2020-2025 (Report No. 117875-CN)

Environmental and Social Safeguards Documents

- ISDS Appraisal Stage (Report No.: ISDSA496; 2012)
- ISDS Restructuring Stage (Report No.: ISDSR18799; 2016)
- Framework Environmental Assessment for BAT/BEP Adoption Towards Reduction of UPOPs Releasing from Non-wood Pulp and Paper Sector in China (E2813)
- Environmental and Social Management Framework (SFG2286; 2016 Update)

- Environmental Assessment Executive Summary for China Dioxins Reduction from the Pulp and Paper Industry Project (66604)
- Amendment to the Environmental Assessment Executive Summary of China Dioxin Reduction from the Pulp and Paper Industry Project (93327)
- EIA for Pumiao Paper (E2813 v2); and EMP for Pumiao Paper (E2813 v12)
- Report on Review of Land Acquisition and Compensation, Pumiao Paper Mill, May 2011 (RP1235)
- EIA for Jinfu Paper (E2813 v15); and EMP for Jinfu Paper (E2813 v16)
- EIA for Linyuan Paper (E2813 v20); and EMP for Linyuan Paper (E2813 v18)
- EIA for Baiyun Paper (E2813 v19); EMP for Baiyun Paper (E2813 v17)
- Environmental & Social Due Diligence Report for Guangxi Laibin (May 2019, 155 pp); Fengtang Luzhai (April 2019, 129 pp); and Tianyang Nanhua (May 2019, 240 pp)
- Environmental & Social Management Plan for Guangxi Laibin (May 2019, 139 pp); Fengtang Luzhai (April 2019, 72 pp); and Tianyang Nanhua (May 2019, 47 pp)

Aide Memoires

- Identification Mission (03/21/2011 – 04/1/2011)
- Pre-Appraisal Mission (06/07/2011 – 06/07/2011)
- 1st Implementation Support Mission (12/10/2012 – 12/18/2012)
- 2nd Implementation Support Mission (6/2/2013 – 6/7/2013)
- 3rd Implementation Support Mission (12/9/2013 – 12/13/2013)
- 4th Implementation Support Mission (7/1/2014 – 7/10/2014)
- 5th Implementation Support Mission (12/2/2014 – 12/11/2014)
- 6th Implementation Support and Mid-term Review Mission (7/15/2015 – 7/19/2015)
- 7th Implementation Support and Mid-term Review Mission (12/1/2015 – 12/10/2015)
- 8th Implementation Support Mission (7/11/2016 – 7/15/2016)
- 9th Implementation Support Mission (1/11/2017 – 1/13/2017)
- 10th Implementation Support Mission (7/17/2017 – 8/3/2017)
- 11th Implementation Support Mission (1/25/2018 – 1/31/2018)
- 12th Implementation Support Mission (9/10/2018 – 9/17/2018)
- 13th Implementation Support Mission (1/14/2019 – 1/25/2019)
- 14th Implementation Support Mission (6/17/2019 – 6/20/2019)

Implementation Status Report

- ISR sequence: 1-14 (6/16/2012 – 6/29/2019)

Project Contributions

- The Dioxins Reduction from the Pulp and Paper Industry Project for China - Completion Report, FECO, August 2019
- Dioxin Monitoring at the Four Demonstration Mills Post-BAT/BEP Report, CSD IDEA Environmental Test and Analysis, Beijing, August 2017
- Compilation Manual of National Action Plan on Promoting Dioxin Emission Reduction in Pulp and Paper Industry for China, China Paper Association, November 2018
- National Action Plan on Promoting Dioxin Emission Reduction in Pulp and Paper Industry for China, China Paper Association, November 2018
- Guangxi Nanning Sugar Industry Co. Ltd. Pumiao Paper Mill Branch – Demonstration Report of Dioxin Emission Reduction and Technical Transformation Project, Environmental Protection Research Institute of Light Industry, December 2017
- Sichuan Jinfu Paper Co., Ltd – Demonstration Report of Dioxin Emission Reduction from the Bamboo Pulp Production, Environmental Protection Research Institute of Light Industry, December 2017
- Henan Zhumadian City Baiyun Paper Co., Ltd - Demonstration Report of Dioxin Emission Reduction from the Straw Pulp, Environmental Protection Research Institute of Light Industry, December 2017
- Hunan Linyuan Co., Ltd. Pumiao Paper Mill Branch – Demonstration Report of Dioxin Emission Reduction in Reed Pulp Production, Light Industry Environmental Protection Institute, December 2017
- Guidelines for Available Techniques of Pollution Prevention and Control in Pulp and Paper Industry (HJ 2302-2018), MEE, 2018
- A preliminary estimation of PCDD/Fs release reduction from non-wood pulp and paper industry in China based on the investigation of pulp bleaching with chlorine converting to chlorine dioxide, Chemosphere, 2017
- Case study on best available technology/best environmental practice renovation in bamboo-based pulping mills and related suggestions, China Pulp & Paper, Vol. 37, 2018
- A comparative Study on the Sources and Emissions of Dioxins in China's Pulp and Paper Industry, China Pulp & Paper
- Development and application of luciferase reporter gene-based bioassay system for dioxin determination, Scienta Sinica Chimica, Vol. 48, 2018
- Determination of Dioxins in the Fly Ash and the Surrounding Soil of Two Municipal Solid Waste Incinerators in Sichuan by Chemical-Activated Luciferase Gene Expression (CALUX), Sichuan

Environment

- Prevention and Control Technology of Dioxin Pollution in Pulp and Paper Industry, China Chemical Industry Press, 2018
- BAT/BEP Design Technical Manual for Non-wood Pulp, China Chemical Industry Press, 2019

Other Reference Documents

- Discharge Standard of Water Pollutants for Pulp and Paper Industry (GB3544-2008)
- Study on UPOPs Releases from Non-wood Pulp and Paper Mills (Project Preparation Output prepared with Canada POPs Trust Fund support)
- Guidelines on Best Available Techniques and Provisional Guidance on Best Environmental Practices Relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants, United Nations Environment Programme, May 2007
- China Paper Association Annual Report, 2009
- The People's Republic of China National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants, 2007/2018
- Eichbaum et al., In vitro bioassays for detecting dioxin-like activity— Application Potentials and Limits of Detection, a Review, *Sci Total Environment*, 2014
- Biermann's Handbook of Pulp and Paper: Raw Material and Pulp Making, 3rd Ed., 647pp, P. Bajpai, Elsevier, 2018

ANNEX 7. GEF TRACKING TOOL

Project title	Dioxins Reductions from the Pulp and Paper Industry in China
Country	China
GEF Agency	World Bank
GEF PMIS #	4441

Indicators	Number
Number[a] of countries receiving GEF support for dioxins/furans reduction	1
Number[a] of countries with Action Plans for UPOPs under development and implementation	1

Note. a. indicate '1' if this is a single-country project.

Indicators	Quantity g TEQ	Qualitative Comments[b,c] from Project Team or GEF Agency
UPOPs sector (pulp and paper mills) baseline (2008) inventory[4]	30.203	Estimate from FECO completion report based on 12.01 million tons pulping capacity relying on CEH elemental chlorine-based bleaching in 2008. The sector baseline is set at 2008 when the preparations for the project started. The tracking tool at CEO endorsement indicates '161 g TEQ/a in 2004'; this was NIP data based on the Stockholm Convention tool kit and limited domestic monitoring results. In fact, by 2008, most mills had either closed, or implemented a three-stage (CEH) bleaching process emitting much less dioxins than reported as the baseline initially.
UPOPs sector inventory at completion (2019)	4.167	Estimate from FECO completion report based on 500,000 tons capacity still relying on CEH elemental chlorine-based bleaching in 2019. The data for the updated dioxins inventory is not currently released by the MEE. The sector is expected to be fully ECF by 2025.

Note: b. If the project addresses more than one country, please specify in the comments column and also provide disaggregated data per country, if available.
c. Include information on basis for the inventory (for example, Stockholm Convention tool kit), and on coverage and precision.
d. This is the total baseline inventory in the country before the start of the project. It might be a preliminary inventory such as possibly at concept stage or a more detailed inventory such as is typically prepared during project development or as an early activity during project implementation. More updated accurate information should replace the first estimates as it becomes available—in that case, please indicate that the information has been updated relative to a previous entry in the 'comments' column.

Indicators	Implementation Status		Qualitative Comments[e] from Project Team or GEF Agency
Regulatory measures[e] in place	0 = Not applicable: not an objective of the project 1 = Regulatory measures drafted or revised 2 = Regulatory measures adopted but not enforced 3 = Regulatory measures implemented/enforced with corresponding budget	3	The Project directly supported or contributed to a number of policy and regulatory documents, including: • National Action Plan for Dioxins Reduction in the Pulp and Paper Industry developed and adopted by the China Paper Association; • Guideline for Available Techniques of Pollution Prevention and Control for Pulp and Paper Industry, issued by the MEE in January 2018; • BAT/BEP Design Technical Manual for Non-wood Pulp; • Technical Guidelines for Pollution Discharge Licensing in Pulp and Paper Industry in Guangxi; • Technical Manual of Pollution Prevention in Pulp and Paper Industry in Guangxi; • Technical Specification for Issuance of Discharge Permit in Paper Industry (under review and to be issued by the MEE); • Development of a standard for Bioassay-based Solid Waste Screening of PCDD/Fs (under way); • National Guidance Document issued by the MEE on Technical Policy of Dioxin Pollution Prevention and Control in Key industries; and • Evaluation Index System of Cleaner Production in Pulp and Paper Industry.

Note: e. Describe the type of regulatory measures, which can include laws, decrees, bylaws, standards, guidelines, and so on, in the 'comments' column.

Indicators	Quantity g TEQ Per Year		Cost (US$ per g TEQ)	Qualitative Comments[b,h] from Project Team or GEF Agency
	Project Target	Achieved to Date		
UPOPs reduced or avoided as a result of BAT/BEP applied[f] in industrial sectors and average cost - project direct	0.387	0.5	18,200,000	The project target was set at 70% of baseline for each of the participating mills. The baseline and reduction achieved is for the three BAT/BEP investment demonstration enterprises and for the three technical assistance BAT/BEP promotion enterprises. The Cost effectiveness is for the GEF grant directed to the six mills (US$9.1 million).

Indicators	Quantity g TEQ Per Year		Cost (US$ per g TEQ)	Qualitative Comments[b,h] from Project Team or GEF Agency
	Project Target	Achieved to Date		
UPOPs reduced or avoided as a result of BAT/BEP applied[g] in industrial sectors and average cost expected through replication	n.a.	26	660,000	The sector baseline is set at 2008 when preparations for the project were made. Based on FECO completion report estimate, the total dioxins reduction from 2008 to current (2019) is 26.036 g, corresponding to a reduction in elemental chlorine-based bleaching from 12.01 million tons in 2008 to around 500,000 tons in 2019.

Note: f. Should capture upstream, in-plant, and downstream measures taken.
g. Should capture upstream, in-plant, and downstream measures replicated.
h. Provide information on input alternatives, recycling, process changes, end of pipe measures, and/or preventive waste management systems implemented.

Indicators[k]	Tons Per Year		Cost (US$ per ton)	Qualitative Comments[b,j] from Project Team or GEF Agency
	Project Target	Achieved to Date		
CO_2 reduction co-benefits - project direct	n.a.	n.a	n.a	Due to the nature of the project and its emphasis on releases to water, other co-pollutants were tracked, including COD and ammonia.
CO_2 reduction co-benefits - expected through replication	n.a.	n.a	n.a	

Note:
i. These indicators are optional for GEF-5.
j. Describe basis for estimate of co-benefits.

ANNEX 8. PROJECT DIOXINS REDUCTION ANALYSIS

1. The estimate of dioxins release reduction brought by the project is a key indicator from a GEF and global perspective. This annex provides the basis for the estimate listed in the GEF Tracking Tool (annex 7).

2. Dioxins release reduction has two elements:

- Direct release reduction from the participating mills
- Sector-wide reduction

Direct Dioxins Release Reduction from Participating Mills

3. The participating mills' BAT/BEP investments were subject to an intense verification process that was at the heart of the project and included pre-transformation monitoring to establish the baseline and post transformation verification of dioxins reduction by an accredited independent monitoring consultant. This independent verification was the basis for payment to the mills under the project's performance-based payment mechanism and undertaken by. The final monitoring report[65] was reviewed and discussed with the project team before being issued. It shows the following reduction at the three participating mills:

Table 8.1. Dioxins Release Reduction at Participating Investment Mills

Mill	Capacity (ADt)	Baseline (CEH)		BAT/BEP (ECF)		Reduction Rate After BAT/BEP (ECF) Implementation
		Dioxins per Unit Pulp (ng/ADt)	Dioxins Per Year (mg)	Dioxins Per Unit Pulp (ng/ADt)	Dioxins Per Year (mg)	
Sichuan Jinfu (bamboo pulp)	52,000	1,498.60	78	28.49	1	98
Henan Baiyun (straw pulp)	37,000	1,808.40	67	412.63	15	77
Hunan Linyuan (reed pulp)	51,000	2,206.25	113	33.98	2	98

Note: ADt: Air dry ton—industry standard for pulp weight, 10 percent moisture.

4. The overall dioxins reduction from the three mills is estimated at 240 mg, based on the mills' yearly outputs. Each year, the three mills reject an estimated residual 18 mg of dioxins to the wastewater treatment plant (where it is expected to partition mostly with the sewage sludge).

5. Another 260 mg reduction is achieved from the three bagasse-based mills in Guangxi supported through technical assistance sub-grants. This is estimated on the basis of one bagasse-based mill (Guangxi

[65] Xiao et al. 2017. "Report on Dioxin Monitoring at the Four Demonstration Mills post-BAT/BEP", CSD IDEA Environmental Test and Analysis, Beijing, August 2017. Key results were also published in the open literature, in "A Primary Estimation of PCDD/Fs Release Reduction from Non-wood Pulp and Paper Industry in China Based on the Investigation of Pulp Bleaching with Chlorine Converting to Chlorine Dioxide." *Chemosphere* 185, 329–335.

Nanhua) that was evaluated for baseline and post BAT/BEP dioxins releases by the independent verification team, although it did not otherwise directly benefit from the project:

Table 8.2. Dioxins Release Reduction in Bagasse-based Mills

Mill	Capacity (ADt)	Baseline (CEH)		BAT/BEP (ECF)		Reduction Rate After BAT/BEP (ECF) Implementation
		Dioxins Per Unit Pulp (ng/ADt)	Dioxins Per Year (mg)	Dioxins Per Unit Pulp (ng/ADt)	Dioxins Per Year (g)	
Guangxi Nanhua (bagasse pulp)	98,000	1,212.78	119	142.56	14	88%

6. In total, therefore, the project is estimated to have led to the direct reduction of 500 mg of dioxins from the bleaching effluents of the six participating mills receiving sub-grants under Component 1, three with investment support and three with technical assistance support.

Sector-wide Reduction

7. 2018 is selected as the reference year for reduction estimates as it is the final full year of implementation for the project and the year the NAP was adopted. 2008 is chosen as the baseline reference year for the following reasons:

- 2008 is the year when the GB2544-2008 standard for effluents for pulp and paper was enacted.
- The yearly non-wood pulp production capacity in 2008 is representative of the period 2002–2011.
- 2008 is the year when the World Bank engaged with MEE/FECO on this topic, with support from the Canada POPs Trust Fund.
- In 2008, no non-wood-based paper mill was yet put into production and stable operation using ECF.
- However, by 2008, most small mills using ‘backward’ technologies had closed down, and most remaining mills had switched to the less polluting three-stage bleaching to implement the GB3544-2001 standard, as discussed in the following paragraphs.

8. With this in mind, the sector-wide reduction estimate is calculated based on applying the project-derived emission factors at baseline to the actual amount of production in 2008, and the emission factors after BAT/BEP implementation to the amount of pulp produced in 2018, for different raw materials:

Table 8.3. Sector-wide Dioxins Release Reduction (g TEQ emitted)

Non-wood Pulp and Paper Sector Dioxins Reduction	2008 Baseline Reference	2018 ECF Project Indirect	2018 Remaining CEH	2025 Sector-wide Adoption of BAT/BEP as per NAP
Straw	19.20	1.83	0.71	Assuming total non-wood pulp production around 6 million tons
Reed	6.59	0.47	0.00	
Bagasse	1.84	0.29	0.38	
Bamboo	2.60	0.48	0.00	
Total releases	**30.20**	4.17		Approximately 3
Total reduction	—	**26**		**27**

Table 8.4. Basis for Calculations

Production (million tons)	2008 Baseline CEH	2008 ECF	2018 CEH	2018 BAT/BEP ECF
Straw	8.08	0	0.30	2.20
Reed	1.50	0	0.00	0.49
Bagasse	0.97	0	0.20	0.70
Bamboo	1.46	0	0.00	1.91
Total	**12.01**	**0**	**0.50**	**5.30**

9. The total non-wood production in 2018 was 6.1 million tons, including 5.8 million tons using the four main raw materials as described above. The remaining 300,000 tons (5 percent) using other raw materials include small mills with limited production and is not considered in this analysis.

10. Based on these results and other available data, the project experts calculate overall emission factors as shown in table 8.5 (see FECO completion report). These lead to higher total releases than the above as they include emissions to air and pulp product.

Table 8.5. Emission Factors from Pulp and Paper Mills

Estimated Overall Emission Factors (µg TEQ/ADt) Wastewater Effluent + Sewage Sludge + Produced Pulp + Alkali Recovery Boiler	Baseline Reference (CEH)	BAT/BEP (ECF)
Straw	2.373	0.833
Reed	4.393	0.963
Bagasse	1.893	0.413
Bamboo	1.783	0.253

Comparison with Estimate at Time of Appraisal

11. Annex 2 of the PAD provides an estimate for yearly reduction from pulp production at the four participating mills on the order of 6 g TEQ, 'based on UNEP emission factors'. This is roughly a factor 20 more than the 240 mg estimated through this analysis. This is due to the old and limited data on which the UNEP emission factor was based for non-wood pulp. (The project has led to update of these emission factors and publication in the peer-reviewed literature as noted above). The original UNEP Standard Toolkit for Identification and Quantification of Dioxin and Furan Emissions was released in December

2005. The data for non-wood-based pulp making is based on one study report.[66] The data is from 2000, before the issuance of standard GB3544-2001 and therefore reflects technologies that needed only to meet the 1992 standard, with a large number of mills as small as 5000 tons in yearly capacity. From that period to the project's baseline monitoring at the demonstration mills, the capacity of mills had increased to an average of 100,000 tons per year, with three-stage bleaching and already significant drop in the use of chlorine use per ton of product. It is not surprising therefore that the reduction achieved against a baseline of already much cleaner production techniques should have been much less than compared to the situation of over 20 years ago.

[66] Zheng et al. 2001. Polychlorinated Dibenzo-p-dioxins and Dibenzofurans in Paper Making from a Pulp Mill in China, Chemosphere 44 (6): 1335–37.

ANNEX 9. PROJECT STAKEHOLDERS

- Ministry of Ecology and Environment
- Ministry of Finance
- Foreign Environmental Cooperation Center
- Sichuan Jinfu Paper Co., Ltd.
- Hunan Linyuan Paper Co., Ltd.
- Henan Province Zhumadian City Baiyun Paper Co., Ltd.
- Nanning Sugar Industry Co., Ltd. Pumiao Paper Mill Branch
- Tianyang Nanhua Paper Co., Ltd.
- Guangxi Laibin Dongtang Paper Co., Ltd.
- Guangxi Fengtan Luzhai Paper Co., Ltd.
- Hunan Ecological Environment Bureau
- Sichuan Ecological Environment Bureau
- Henan Ecological Environment Bureau
- Guangxi Ecological Environment Bureau
- Ecological Environment Bureau in Ningxia Hui Autonomous Region
- Scientific Research Academy of Guangxi Environmental Protection
- Scientific Research Academy of Sichuan Environmental Protection
- Scientific Research Academy of Hunan Environmental Protection
- Environment Monitoring Center of Guangxi
- Environment Monitoring Center of Hunan
- Environment Monitoring Center of Henan
- Environment Monitoring Center of Ningbo
- Environment Monitoring Center of Shaanxi
- Environment Monitoring Center of Hubei
- Environment Monitoring Center of Guangdong
- Sichuan Environmental Protection Service Center for Foreign Economic Cooperation
- Henan Environmental Protection Publicity and Education Center
- China Paper Association

- National Research Center for Environmental Analysis and Measurement
- Research Center for Eco-Environmental Sciences, Chinese Academy of Science
- Dalian Institute of Chemical Physics, Chinese Academy of Science
- Environmental Protection Research Institute of Light Industry
- China Cleaner Production Center of Light Industry
- CSD IDEA (Beijing) Environmental Test & Analysis
- Beijing Boyitian Cultural Media Co., Ltd.

ANNEX 10. BAT/BEP RENOVATIONS AT PARTICIPATING MILLS AND ENVIRONMENTAL BENEFITS

Table 10.1. BAT/BEP Renovations in Three Pilot Investment Demonstration Mills

Mill Description	Situation before Renovation	Key Technical Transformations	Main Benefits
Sichuan Jinfu Paper Products Bamboo raw material 52,000 tons bleached pulp per year	• Elemental chlorine bleaching • High consumption of pulping chemicals • Poor pulp quality • High energy consumption • Large water consumption • High pollution load of bleaching, wastewater, and high production of dioxins	• Wet preparation • Low-energy cooking system • Improved pulp washing • New oxygen delignification system • Improved knot removal system • Bleaching with chlorine dioxide instead of elemental chlorine • Total cost approximately CNY 118 million, of which US$2.795 million is the project grant	• Less impurities leading to less use of alkali chemicals and improved pulp quality • Improved cooking efficiency leading to less steam use and reduced energy consumption • Reduced amount of chemical needed for bleaching • Reduced water consumption • Reduced dioxins and AOX production
Hunan Linyuan Paper Co. Reed raw material 51,000 tons bleached pulp per year	• Elemental chlorine bleaching • Old equipment • High energy consumption • High material consumption	• New oxygen delignification system • Bleaching with chlorine dioxide instead of elemental chlorine • Total cost approximately CNY 60 million, of which US$2.795million is the project grant	• Reduced amount of chemicals needed for bleaching • Reduced dioxins and AOX production • Improved pulp strength
Henan Baiyun Paper Co. Wheat straw raw material 37,000 tons bleached pulp per year	• Elemental chlorine bleaching • Old equipment	• New continuous cooking • New oxygen delignification • Improved knot removal system • Bleaching with chlorine dioxide instead of elemental chlorine • Total cost is approximately CNY 35 million, of which US$2.795 million is the project grant	• Improved cooking efficiency and pulp quality • Reduced amount of chemical needed for bleaching • Reduced water consumption • Reduced dioxins and AOX production • Improved pulp yield and quality

Table 10.2. Environmental Benefits: Key Parameters after BAT/BEP Renovation at Pilot Investment Mills, per Ton Produced Pulp

In Unit per Ton of Produced Pulp	Sichuan Jinfu (bamboo)		Hunan Linyuan (reed)		Henan Baiyun (straw)	
	Before	After	Before	After	Before	After
Total wastewater discharge (m^3)	72	50	59	45	45	33
COD (kg)	10.15	2.6	5.3	2.1	3.1	1.4
BOD (kg)	2.16	0.72	0.99	0.57	0.85	0.22
NH3-N (kg)	0.72	0.19	0.45	0.17	0.13	0.11
AOX in bleaching wastewater (kg)	0.42	0.006	3.44	0.006	0.37	0.11

Table 10.3. Bioassay Monitoring[a] at BAT/BEP Investment Mills after BAT/BEP Renovation Verification

Mill	Date	Concentration[b] pg BEQ/L[c]	Date	Concentration[b] pg BEQ/L	Date	Concentration[b] pg BEQ/L
Sichuan Jinfu	April 2017	5.03	n.a.	n.a.	February 2019	1.28
Hunan Linyuan	June 2017	0.96	May 2018	0.82	n.a.	n.a.
Henan Baiyun	April 2017	2.04	April 2018	2.03	May 2019	2.1

Note: a. There is no recognized standard method for bioassays in China, and the GB3544-2008 standard requires HRGC/HRMS determination of dioxins. Moreover, the relationship between the results obtained with both methods is not established for pulp milling effluents. The results presented here therefore were obtained for research and development under the project and have no regulatory standing or implication. Nevertheless, they point to a good trend in continued low level of emissions at the mills a number of years after BAT/BEP renovation and verification of dioxins reduction.
b. Dioxins concentrations measured in bleaching wastewater at the bleaching workshop outlet, according to GB3544-2008 standards
c. BEQ: biological toxicity equivalent quotients, used to express the results of bioassay determination. There is normally a correlation between TEQ and BEQ, with BEQ being higher than TEQ as other chemicals can elicit a positive response from the bioassay, and therefore bioassays are considered best used for screening purposes; see, for example, Eichbaum et al. 2016. “Bioanalytical and Instrumental Screening of the Uptake of Sediment-Borne, Dioxin-like Compounds in Roach.” *Environ Sci Pollut Res* (2016) 23:12060–12074.

Table 10.4. Technical Assistance Support to Bagasse-based Mills

Mill Description	Renovation Plans	Key Project Support	Current Situation
Guangxi Dongtang Paper Co. Bagasse raw material 98,000 tons bleached pulp per year	• The focus of this mill was on replacing the elemental chlorine-based CEH process by ECF bleaching. • The company committed to never again using elemental chlorine.	• Feasibility study • EIA report compilation • Designing project plan • Construction drawing review • Environmental and social due diligence • Environmental and social management plans	• Renovation was completed on October 15, 2019, following trial operation. • Regular monitoring by the local EPB shows the mill meets the GB-2008 standard for conventional pollutants.
Guangxi Tianyuang Paper Co. Bagasse raw material 95,000 tons bleached pulp per year	• The focus of this mill was on replacing the elemental chlorine based CEH process by ECF bleaching. • The company committed to never again using elemental chlorine.	• Feasibility study • EIA report compilation • Construction safety assessment report • Occupational hazard preassessment • Designing project plan • Construction drawing • Environmental and social due diligence • Environmental and social management plans	• Renovation was completed on March 16, 2019, following trial operation. • Regular monitoring by the local EPB shows the mill meets the GB-2008 standard for conventional pollutants.
Guangxi Fengtang Paper Co. Bagasse raw material 50,000 tons bleached pulp per year	• The focus of this mill was on replacing the elemental chlorine based CEH process by ECF bleaching, and upgrading the alkali recovery unit. • The company committed to never again using elemental chlorine.	• Feasibility study • EIA report compilation and review • Construction safety assessment report • Designing project plan • Construction drawing review • Environmental and social due diligence • Environmental and social management plans	• Renovation is to be completed by end 2019.

Table 10.5. Compliance[a] with GB3544-2008 Standard on Water Pollutant Discharge for Pulping and Paper Industry: Demonstration Mills after BAT/BEP Renovation, per Unit Pulp Produced[b]

	GB3544-2008 Non-wood	Sichuan Jinfu	Hunan Linyuan	Henan Baiyun
Water discharge m^3/ADt	54	50.3	45	33.14
COD[a] kg/ADt	4.86	2.60	2.07	1.4
BOD kg/ADt	1.08	0.72	0.57	0.22
NH_3-N kg/ADt	0.43	0.19	0.17	0.11
AOX kg/ADt	0.65	0.006	0.006	0.11
Dioxins ng TEQ/ADt[c]	1620	28.49	33.98	42.6

Note: a. Based on FECO completion report from the independent verification reports and as reported in the Results Framework, based on Environmental Protection Research Institute of Light Industry summary reports of the demonstrations at the three mills.
b. Amount/ADt is the main unit used for reporting under the project's Results Framework. This is with the exception of the PDO indicator for reduced UPOPs releases which is expressed in g TEQ emitted per year, reflecting the global environmental benefit/Stockholm Convention goal of dioxins release reduction to the environment.
c. At bleaching workshop effluent as per Chinese GB3544-2008 standard.
Both GB3544-2008 and EHS guidelines also include pH, suspended solids, total P and total N.

Table 10.6. Compliance with GB3544-2008 Standard on Water Pollutant Discharge for Pulping and Paper Industry: Demonstration Mills after BAT/BEP Renovation, by Concentration

	GB3544-2008	Sichuan Jinfu[b]	Hunan Linyuan[c]	Henan Baiyun[d]
BOD mg/L	20	14.3	4.5	6.7
COD mg/L	100	51.7	20	42.3
NH_3-N mg/L	12	3.84	0.5	3.45
AOX mg/L	12	0.12	0.01	1.53
Dioxins* pgTEQ/L	30	0.52 (0.48-0.53)	0.92 (0.60-1.20)	1.35 (1.1-1.9)

Note: a. Dioxins measured at bleaching workshop wastewater outlet as per GB3544-2008.
b. Environmental Protection Research Institute of Light Industry, Jinfu; Dioxins measured at effluent of the wastewater treatment plant: 0.21 pg TEQ/L (0.16-0.29).
c. Environmental Protection Research Institute of Light Industry, Linyuan; Dioxins measured at effluent of the wastewater treatment plant: 0.28 pg TEQ/L (0.22-0.44).
d. Environmental Protection Research Institute of Light Industry, Baiyun; Dioxins measured at effluent of the wastewater treatment plant: 0.70 pg TEQ/L (0.59-0.80).

ANNEX 11. PROJECT MAP AND LOCATION OF ACTIVITIES

Bioassay Laboratories

1. Sichuan Institute of Environmental Protection Science： No. 375 Wuke xisan Road, Wuhou district, Chengdu, Sichuan Province
2. Henan Environmental Monitoring Center：No.1, Shunhe Road, Jinshui District, Zhengzhou，Henan Province
3. Henan Environmental Monitoring Center: No.118, Wanjiali Middle Road, Changsha, Hunan Province
4. Guangxi Environmental Monitoring Center: No.16 Fuziling Road, Nanning City, Guangxi Zhuang autonomous region
5. Guangdong Environmental Monitoring Center: No. 28, Modisha Street, Donggang East Road, Guangdong Province
6. Hubei Environmental Monitoring Center: No. 338, Bayi Road, Hongshan District, Wuhan, Hubei Province
7. Shaanxi Environmental Monitoring Center: No. 106, Xiying Road, Yanta District, xi 'an, Shaanxi Province
8. Ningbo Environmental Monitoring Center: No. 105, Baoshan Road, Haishu District, Ningbo, Zhejiang Province

Participating BAT/BEP Performance-based Financing Mills

1. Sichuan Jinfu Paper Mill: Group 8, Shawan Village, Fulu Town, Shawan District, Leshan City, Sichuan Province
2. Hunan Linyaun Paper Mill: Luhu Reed Field, Yuanjiang city, Hunan Province
3. Zhumadian Baiyun Paper Mill：No.14 Gongren Road, Suiping County, Zhumadian City, Henan Province

Participating Technical Assistance Mills

1. Tianyang Nanhua Paper Mill: No. 106 Minle Street, Tianzhou Town, Tianyang County, Baise City, Guangxi Zhuang autonomous region
2. Fengtang Luzhai Paper Mill: No.88, Jianzhongxi Road, Luzhai County, Liuzhou City, Guangxi Zhuang autonomous region
3. Laibin Dongtang Paper Mill: Hexi Industrial Park, Laibin Industrial Zone, Laibin City, Guangxi Zhuang autonomous region