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IMPLEMENTATION COMPLETION AND RESULTS REPORT

TF018030

ON A

GRANT

FROM THE

GLOBAL ENVIRONMENT FACILITY TRUST FUND

IN THE AMOUNT OF

US$2,538,900 million

TO THE

Republic of Lebanon

FOR THE

PCB Management in the Power Sector Project

October 4, 2021

Environment, Natural Resources & The Blue Economy Global Practice
Middle East And North Africa Region

CURRENCY EQUIVALENTS

September 2021

Currency Unit	=	The Lebanese Pound
LBP 1,524.5	=	US$1
US$1.44	=	SDR1

FISCAL YEAR

January 1 – December 31

Regional Vice President:	
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ABBREVIATIONS AND ACRONYMS

CPF	Country Partnership Framework
CPS	Country Partnership Strategy
DO	Development Objective
EDL	Electricity of Lebanon (*Électricité du Liban*)
ERP	Emergency Response Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
FM	Financial Management
FY	Fiscal Year
GDP	Gross Domestic Product
GEF	Global Environment Facility
GoL	Government of Lebanon
ICR	Implementation Completion Report
IFR	Interim Financial Report
IP	Implementation Progress
ISR	Implementation Status and Results Report
LB	Lebanon
LBP	Lebanese Pound
LRA	Litani River Authority
M&E	Monitoring & Evaluation
MENA	Middle East and North Africa
MoF	Ministry of Finance
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water
MTR	Mid-Term Review
PCB	Polychlorinated Biphenyl
PDO	Project Development Objective
PMU	Project Management Unit
POP	Persistent Organic Pollutants
PpM	Parts per Million
ToC	Theory of Change
TF	Trust Fund
TTL	Task Team Leader
UNEP	United Nations Environment Programme
USD	United States Dollar
USJ	University of Saint Joseph Beirut

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DATA SHEET

BASIC INFORMATION

Product Information

Project ID	Project Name
P122540	LB: PCB Management in the Power Sector Project
Country	**Financing Instrument**
Lebanon	Investment Project Financing
Original EA Category	**Revised EA Category**
Full Assessment (A)	Full Assessment (A)

Organizations

Borrower	Implementing Agency
Government of Lebanon	Ministry of Environmenta

Project Development Objective (PDO)

Original PDO

The objective of the Project is to dispose of high risk PCBs and improve the inventory management of transformers in the power sector in an environmentally sound manner.

FINANCING

	Original Amount (US$)	Revised Amount (US$)	Actual Disbursed (US$)
World Bank Financing			
TF-18030	2,538,900	2,538,895	2,538,895
Total	**2,538,900**	**2,538,895**	**2,538,895**
Non-World Bank Financing			
Borrower/Recipient	0	0	0
Total	**0**	**0**	**0**
Total Project Cost	**2,538,900**	**2,538,895**	**2,538,895**

KEY DATES

Approval	Effectiveness	MTR Review	Original Closing	Actual Closing
21-Nov-2014	30-Mar-2015	26-Sep-2018	30-Jun-2020	31-Mar-2021

RESTRUCTURING AND/OR ADDITIONAL FINANCING

Date(s)	Amount Disbursed (US$M)	Key Revisions
10-Jun-2020	2.04	Change in Loan Closing Date(s)
16-Dec-2020	2.12	Change in Loan Closing Date(s)

KEY RATINGS

Outcome	Bank Performance	M&E Quality
Highly Satisfactory	Satisfactory	High

RATINGS OF PROJECT PERFORMANCE IN ISRs

No.	Date ISR Archived	DO Rating	IP Rating	Actual Disbursements (US$M)
01	24-Feb-2015	Satisfactory	Satisfactory	0

02	12-Sep-2015	Satisfactory	Satisfactory	.13
03	11-Nov-2015	Satisfactory	Satisfactory	.13
04	14-Apr-2016	Satisfactory	Moderately Satisfactory	.32
05	08-Oct-2016	Satisfactory	Satisfactory	.33
06	29-Jun-2017	Satisfactory	Satisfactory	.84
07	25-Jun-2018	Satisfactory	Satisfactory	1.47
08	09-May-2019	Satisfactory	Satisfactory	1.85
09	26-Jun-2020	Satisfactory	Satisfactory	2.05

SECTORS AND THEMES

Sectors

Major Sector/Sector	(%)
Public Administration	**26**
Central Government (Central Agencies)	26
Energy and Extractives	**74**
Other Energy and Extractives	74

Themes

Major Theme/ Theme (Level 2)/ Theme (Level 3)	(%)
Environment and Natural Resource Management	**0**
Environmental Health and Pollution Management	99
Air quality management	33
Water Pollution	33
Soil Pollution	33
Private Sector Development	**100**
Jobs	100

ADM STAFF		
Role	**At Approval**	**At ICR**
Vice President:	Inger Andersen	Ferid Belhaj
Country Director:	Ferid Belhaj	Saroj Kumar Jha
Director:	Bilal H. Rahill	Ayat Soliman
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I. PROJECT CONTEXT AND DEVELOPMENT OBJECTIVES

A. CONTEXT AT APPRAISAL

Context

1. Lebanon is a small country of about 10,000 km^2 and a population of about 6.8 million people with a large diaspora. At the time of appraisal, Lebanon was categorized as an upper-middle-income country with an average GDP per capita of around US$9,750 in 2013. With half of the population living in the capital, Beirut, the country is considered highly urbanized (85 percent).

2. **The political situation in Lebanon was - and remains - complex and often characterized by instability.** Frequent deadlocks and ineffective governance affected the performance of ministries and the quality of public institutions for policy making and services delivery. Over time, a lack of institutional capacity had developed due to inadequate resources and a shortage of skilled staff.

3. **Water, air pollution and lack of proper solid waste management were major environmental problems in the country and substantially caused by industrial activities.** The country ranked 90th among 163 countries on the Environmental Performance Index at the time of appraisal (EPI Yale University). The Cost of Environmental Degradation was estimated at US$800 million, or 3.7 percent of the country's GDP, in 2005[1], and its physical and natural assets had declined between 2005 and 2010.[2]

4. **The use of Persistent Organic Pollutants (POPs) in industry and agriculture grew over time in Lebanon and is still being used in the power sector.** POPs are chemical substances that persist in the environment and bio-accumulate through the food web. Among the POPs, Polychlorinated Biphenyls (PCBs) are a group of organic compounds that at high-concentration levels are proven to cause cancer in humans and animals. While the production of PCBs was globally banned in 2001 as part of the UN Stockholm Convention, stockpiles of PCBs were and remain being used in some industries, particularly in the power sector as dielectric fluids in older transformers. The Electricity of Lebanon (*Électricité du Liban*, EDL), which is an autonomous state-owned entity under the jurisdiction of the Ministry of Energy and Water (MOEW), owned most PCB-containing equipment in Lebanon.

5. **The Government of Lebanon (GOL) was committed to eliminating PCBs and became Party to the Stockholm Convention on January 3, 2003 (Law 432).** Lebanon banned imports and exports of PCBs (Decree 4461/2000), enacted laws to preserve the environment against pollution from hazardous waste and PCBs (Law 64/1988), and increased safety conditions for workers handling chemical products (Decree 11802/2004). After ratifying the Stockholm convention, Lebanon completed a National Implementation Plan (NIP) in 2006, which identified the following top priorities in POPs management: (i) awareness raising; (ii) institutional and regulatory strengthening; (iii) PCB management; and (iv) management of emissions of dioxins and furans.

6. **The Ministry of Environment (MOE), the main agency responsible for the management of POPs, had substantial capacity in planning and executing international projects, but little experience in PCB management.** While basic legislation to regulate hazardous chemicals was in place, a rapid assessment carried out in 2011 identified

[1] World Bank. 2011. Republic of Lebanon. Country Environmental Analysis. Report No. 62266-LB. Middle East and North Africa.
[2] The Adjusted Net Savings or Genuine Savings measures the net savings of a country at a macro-economic scale, taking into consideration the investments in human resources, depreciation of physical assets, and decrease in natural resources.

the following legal gaps: i) no explicit regulation for PCB management and the phase-out of PCB-containing equipment; ii) lack of classification and adequate packaging and labeling requirements for PCB and PCB containing equipment; iii) no formal protocols in place between government bodies to ban PCB imports and the movement of PCB material in-country; iv) gaps on basic aspects of waste management, such as the absence of key definitions and principles on PCB and other hazardous waste management, and licensing for environmentally sound disposal/destruction of PCB-containing equipment.

7. **The Project was aligned with Lebanon's strategic development objectives**, such as the GOL's Progress and Development Program established in November 2009 as the GOL's economic and social development platform, which sought, among other objectives, to improve the quality of Lebanese life through better safeguarding the environment. It contributed to the goals outlined in the NIP in support of the Stockholm Convention and the elimination of POPs. It supported the GEF Chemicals Strategy in promoting sound management of chemicals throughout their life cycle. Finally, it underpinned the Country Partnership Strategy (2011-2014) between Lebanon and the World Bank, which identified the environment as a priority area in which immediate reform and investment actions were needed.

8. **The World Bank was well-positioned to support Lebanon in dealing with the legacy of hazardous PCB waste.** The Project aligned with the overarching goals of the World Bank by reducing global and local environmental hazards thereby improving the general health condition and enhancing productivity and quality of life for the population living in proximity of contaminated sources. The World Bank was uniquely positioned to provide expert technical input based on the lessons learned from several years of operations in the chemicals area, particularly PCBs.[3]

Theory of Change (Results Chain)

9. The Project's theory of change was not formally developed at appraisal. The ICR team prepared the TOC based on the Project description in the PAD and developed the illustration below in Figure 1.

10. **The Project's theory of change was organized around each of the two intended development outcomes: to dispose of high-risk PCBs and to improve inventory management of PCB contaminated transformers. Both outcomes were focused on the power sector and on environmentally sound implementation. (Figure 1).** The first results chain sought to eliminate 300 tons of high-risk PCBs owned by EDL by: (i) draining, packaging, exporting, and disposing of contaminated equipment, both out-of-service (44 tons) and in-service (147 tons); and (ii) by eliminating 100 tons of contaminated oil stored at the Bauchrieh repair and storage facility, which would substantially reduce the risk of cross contamination. As part of the economic analysis completed at the appraisal stage, the environmentally safest option at the least cost was identified to be export of the wastes for destruction abroad. A critical assumption underpinning the achievement of the first results chain, was EDL's commitment to bear the cost of replacing in-service equipment during implementation and to purchase PCB-free oil.

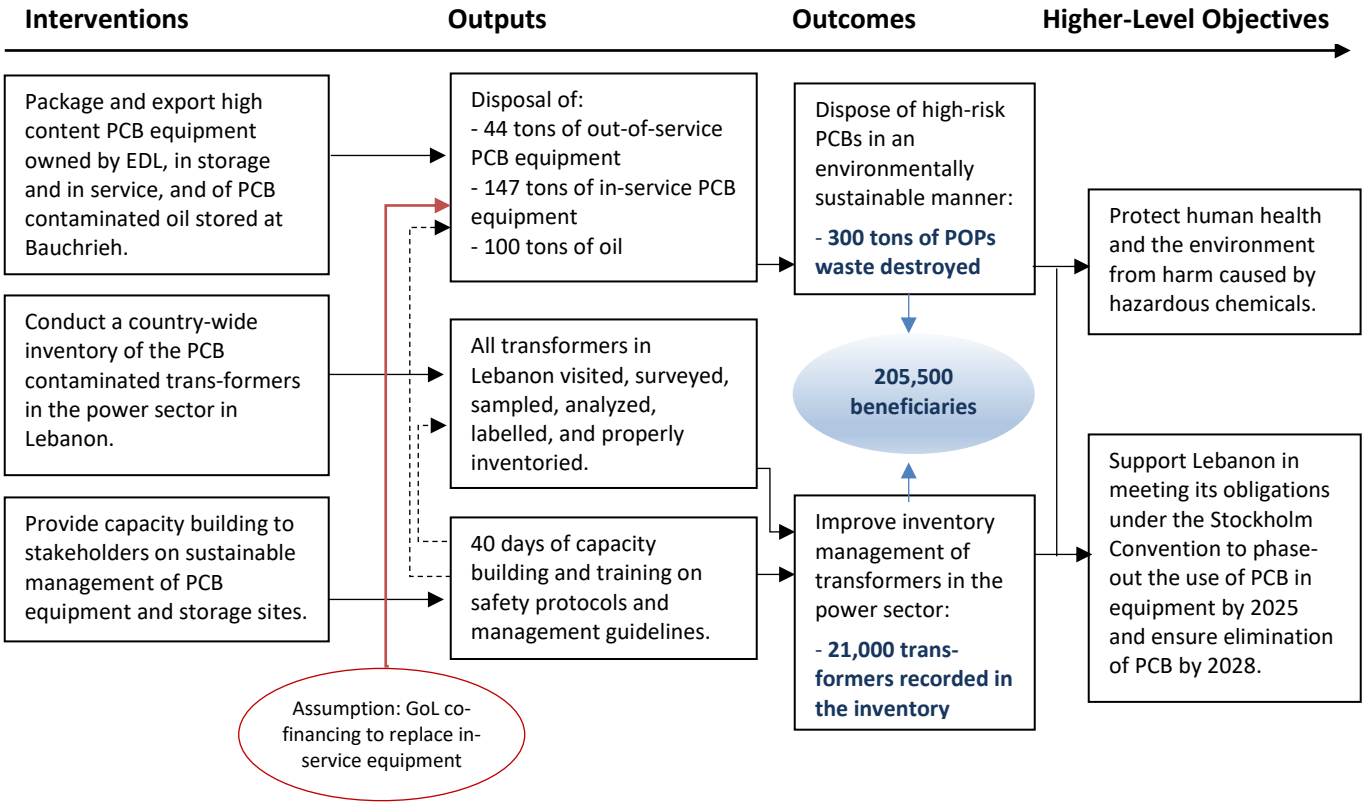
11. **The second results chain aimed at improving management of PCB contaminated transformers by building a national inventory of transformers**. This would be done by first getting a complete overview of all transformers in the country in addition to the 21,000 known transformers, then systematically visiting, surveying, and labelling every

[3] Examples include PCB management projects in Tunisia (P100478), Egypt (P116230), Vietnam (P099460), China (P082993), Moldova (P090037), Nigeria (P113173) and Kosovo. Based on this experience, the Bank team will ensure that the proposed activities are pragmatic and yield concrete results in terms of PCB elimination.

single transformer and recording its status in a central database. In parallel, institutional capacity would be strengthened through development of management guidelines, safety manuals, etc., and key staff and stakeholders would be trained in the safe handling and proper inventorying of equipment. Underlying the results chain is the critical assumption that key stakeholders in the power sector, including concessions with PCB equipment, will take active part in the process of inventorying and building capacity for improved PCB management.

12. **Beneficiaries and higher-level objectives:** Project outcomes would above all support Lebanon in protecting the environment and human health of the population from harm caused by hazardous chemicals. This includes the 205,500 drirect project beneficiaries living near the Project sites. Project outcomes would also help meet Lebanon's obligations under the Stockholm Convention by moving Lebanon closer to phasing-out the use of PCB in equipment by 2025 and ensuring elimination of all PCBs by 2028.

Figure 1: Theory of Change



The Project would be implemented in an **"environmentally sound manner"** in accordance with the requirements of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, which offers the following definition of environmentally sound management on PCBs relevant to both parts of the PDO: "Environmentally sound management of hazardous wastes or other wastes means taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects, which may result from such wastes." A set of technical guidelines developed by UNEP operationalizes this definition by defining "the practicable steps" related to the safe handling of PCBs in the document "PCB Transformers and Capacitors from Management to Reclassification and Disposal (2002)."

Project Development Objectives (PDOs)

13. The objective of the Project was to dispose of high-risk PCBs and improve the inventory management of transformers in the power sector in an environmentally sound manner.

Key Expected Outcomes and Outcome Indicators

14. Outcomes are focused on the power sector: i) disposal of high-risk PCBs; and ii) improved inventory management of transformers. Three related outcome indicators were defined, as stated in **Table** 1.

Table 1: PDO Outcome Indicators

#	Indicator	Unit	Target	Core Indicator
To dispose of high-risk PCBs				
1	POPs and POPs waste destroyed, disposed, or contained in environmentally sound manner	Metric Tons	300	Yes
To improve the inventory management of transformers				
2	EDL transformers recorded in the inventory	Number	21,000	
3	Direct project beneficiaries	Number	205,500	Yes
-	Female beneficiaries	Percentage	50	Yes

Components

Component 1: Inventory of PCB Contaminated Transformers

Estimated cost: US$0.79 million

Actual cost: US$1.0 million

15. Component 1 would support a countrywide inventory of PCB contaminated transformers in the power sector. It was based on a four-step approach involving a desk review of the EDL database to identify the number of transformers potentially contaminated, followed by sampling, on-site testing, and laboratory testing of PCB. Focus was on the entire stock of transformers stored in Bauchrieh (about 2,000) storage site and in EDL's distribution network (about 19,000).

Component 2: Disposal of High-Content PCB Equipment and Contaminated Oil

Estimated cost: US$1.1 million

Actual cost: US$0.75 million

16. Component 2 would support the disposal of high-content PCB equipment owned by EDL, both in-service and in storage, associated capacitors and contaminated oil, soil, and waste. Based on an efficiency analysis, the most cost-effective solution was to export the PCB material to licensed facilities abroad in accordance with the requirements of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal.

Component 3: Capacity Building and Project Management

Estimated cost: US$0.65 million

Actual cost: US$0.78 million

17. Component 3 would support Project management and coordination activities, including: (i) the establishment and staffing of a Project Management Unit within the Ministry of Environment to perform the functions of monitoring and evaluation, progress reporting, financial management, procurement, social and environmental safeguards; (ii) training staff at the MoE, EDL, and other relevant institutions on improved management of PCBs, working with databases, and other aspects of Project management; and (iii) building the capacity of relevant technical staff in reviewing, sampling, testing, draining and labeling of PCB contaminated oil for improved inventory management.

B. SIGNIFICANT CHANGES DURING IMPLEMENTATION

Revised PDOs and Outcome Targets

18. The project development objectives and key targets were not revised.

Revised PDO Indicators

19. The PDO indicators were not revised.

Revised Components

20. The components were not revised.

Other Changes

21. The project closing date was extended for a total of 9 months through two Level 2 restructurings: June 15, 2020 - the closing date was extended from June 30, 2020 to December 31, 2020; December 17, 2020 - the closing date was extended from December 31, 2020 to March 31, 2021.

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

22. The rationale for extending the Project closing date related to implementation delay caused by (i) the political crisis of October 2019; (ii) the COVID-19 pandemic; and (iii) the explosion in the Port of Beirut in 2020. A series of protests beginning in October of 2019 led to the resignation of former Prime Minister Saad Hariri, leaving the country in political vacuum for a prolonged period. The ensuing collapse of the government, the sharp restrictions on capital movement, and the default on public debt in March 2020 caused significant implementation delays. This was compounded by the onset of the COVID-19 pandemic, which further restricted movement of people and prevented international contractors from operating. Finally, a devastating blast in the Port of Beirut on August 4, 2020 destroyed EDL's Head Office and took a human toll among EDL staff members working on the Project. Project grant savings generated from the competitive procurement of contracts under Component 2 were applied towards maintaining PMU staff for the extension period. The extensions did not alter the PDO.

II. OUTCOME

A. RELEVANCE OF PDOs

Rating: High

Assessment of Relevance of PDOs and Rating

23. **The development objectives of the project have remained highly relevant to the current Country Partnership Framework (CPF) for the period FY2017 through FY2022.** Focus Area 1 of the strategic priorities for cooperation between Lebanon and the World Bank aims to expand access to and quality of service delivery, and specifically includes investments in the environment sector to reduce industrial, hazardous, and wastewater pollution. The safe removal and destruction of PCB material as well as improved management of remaining PCB material directly supports the achievement of these broader strategic goals. Furthermore, the CPF seeks to strengthen the relationship between the state and its citizens, a critical ingredient for peace and stability. The Project underpins this objective by removing

a potential risk factor that could impose significant damage on the population and the environment in case of an accident.

24. **The Project is aligned with Lebanon's National Economic Vision 2025 in which the GoL seeks to reform the power sector to spur economic growth.** The strategy seeks to make power generation more efficient and more sustainable, and specifically aims to reduce the reliance on liquid fuel for power generation. The Project supports these objectives by eliminating toxic PCBs and promoting improved management of PCBs in the power sector, which will help to reduce cost inefficiencies and increase environmental sustainability.

B. ACHIEVEMENT OF PDOs (EFFICACY)

Rating: High

Assessment of Achievement of Each Objective/Outcome

PDO 1: Dispose of high-risk PCBs in the power sector in an environmentally sound manner

25. **The project disposed of 389 tons of equipment, oil, soil, and waste contaminated with PCBs at levels above 50 parts per million, which poses a high risk to human health and the environment.** As shown in ***Table 2***, the project disposed of: i) 254 tons of EDL out-of-service transformers; ii) 35 tons of capacitors; iii) 86 tons of contaminated oil; and iv) 14 tons of contaminated soil and waste. *With a total of 389 tons of high-risk PCBs eliminated, outcome indicator #1 is 130 percent achieved*.

Table 2: Total disposal of high-risk PCB-contaminated equipment, oil, soil, and waste.

PCB-contaminated	First Export (2016)		Second Export (2020)		Overall Project	
	Unit	Weight (kg)	Unit	Weight (kg)	Unit	Weight (kg)
Transformers	17	18,750	265	235,270	282	254,020
Capacitors	606	34,845			606	34,845
Oil (Drums)	130	29,040	286	57,450	416	86,490
Soil		7,795		5,050		12,845
Waste		570		320		890
TOTAL	**753**	**91,000**	**551**	**298,090**	**1,304**	**389,090**

26. **The disposal involved the environmentally sound removal, draining, packaging, handling, transport, and export of contaminated out-of-service equipment and associated oil, soil, and waste located at EDL's various facilities in consistent with the Technical Guidelines issued by the Stockholm Convention.** The entire disposal process was handled by an international contractor with the expertise to safely manage PCBs. Taking "all practicable steps" to protect human health and the environment against the adverse effects from PCBs, the disposal process led by the PMU in collaboration with EDL and Project contractors occurred in an environmentally sound manner. Solid and comprehensive arrangements for controlling and monitoring compliance with planned safeguards measures in both procurement and implementation of Project activities coupled with extensive training and capacity building of local workers at the storage site and power plants ensured that the disposal occurred without any incidents. Additional photos of the disposal process are included in ***Annex 1***.

Figure 2: Draining

Figure 3: Storing

Figure 4: Loading

27. **The disposal occurred in two separate exports to Saint Vulbas in France, where the PCBs were securely destroyed in suitable incinerators for hazardous waste in accordance with the requirements of the Basel Convention.** The first export of 91 tons of PCB-contaminated material was shipped from the Port of Beirut on December 15, 2016 (***Table 7*** in Annex 1). It consisted of material identified in the previously conducted rapid assessment from 2010. The second export of 298 tons of PCB-contaminated material was realized in three different shipments in 2020 (***Table 8*** in Annex 1). It consisted of out-of-service transformers stored at EDL's storage and repair site in Bauchrieh. For an explanation of the change of disposal schedule, see para. 63.

28. ***Certificates of Eliminations*** were provided as proof of evidence of the environmentally sustainable elimination of 389 tons of PCBs (Annex 6).

PDO 2: Improve inventory management of transformers in the power sector in an environmentally sound manner

29. The project improved management of transformers in the power sector by inventorying 86 percent of all transformers in the power sector and strengthening Lebanon's institutional capacity for safer handling and management of remaining PCBs in the power sector.

(i) Building a national inventory of PCB contaminated transformers

30. **The project inventoried 22,983 transformers: equal to 86 percent of all transformers in the power sector.** *This corresponds to 109 percent of the original target for outcome indicator #2 (see Annex 1).* This was achieved by: (i) merging existing databases maintained by EDL, MoEW, and other concessions into a computerized system compliant with UNEP guidelines on inventory management of PCB-contaminated transformers; (ii) surveying equipment owners to report on the global stock of transformers and capacitors present in Lebanon, which revealed the existence of additional transformers; and (iii) surveying, sampling, screening, testing, analyzing, labelling, and inventorying assets accordingly. The process of inventorying transformers is described and illustrated in ***Annex 1***.

Table 3: Inventorying of transformers

Inventorying Transformers	#	%
Target number of transformers estimated in the power sector at Project Appraisal to be inventoried	21,000	
Additional number of transformers reported by equipment owners	5,860	
Overall number of transformers in the power sector	**26,860**	**100%**
Number of transformers inventoried at Project closing	**22,983**	**86%**
Number of transformers yet to be inventoried	**3,877**	**14%**

31. **The result is recorded in a national database of transformers in the power sector, which allows for tracking of PCB-contaminated equipment (*Table 10* in Annex 1).** The database, which built on an existing inventory housed in EDL, was significantly improved with additional entries critical for allowing proper tracking of transformers and PCBs. These included: i) weight of transformers; ii) amount of liquid; iii) type of liquid filling; and iv) presence of PCB. Importantly, the database also includes out-of-service transformers, which were never inventoried before, and which will help prevent contaminated transformers from being sold as scrap metal. The updated and centralized database housed with EDL is an excel spreadsheet containing data points and photos of all transformers visited during inventory, and it is compliant with the forms for PCB inventory established by UNEP in 2003**.** With the inventory, it is possible to track transformers contaminated with PCB levels above 50 ppm when they are moved, repaired, or decommissioned. This helps to ensure the proper handling of PCBs in accordance with guidelines for hazardous chemicals.

Figure 5: Sampling

Figure 6: Testing

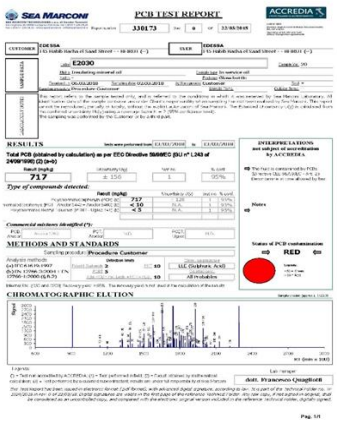


Figure 7: Labelling

32. **Status of the remaining disposal and inventory of PCBs in Lebanon.** Based on the inventory at Project closing, a total of 1,115 transformers with PCB-contaminated oil weighing 1,496 tons remain in the power sector in Lebanon. According to Table 12 in Annex 1, of the 1,380 contaminated transformers recorded in the inventory, 265 transformers weighing 235 tons were exported as part of the project in July 2020. That leaves 1,496 tons of PCB contaminated equipment and oil to be eliminated in the future. In addition, there remain another 3,877 reported transformers, or 14 percent of the total number of transformers across the Lebanese territories, yet to be sampled and inventoried according to their level of PCB contamination.

33. **At Project end, MoE and EDL have developed the institutional capacity to manage PCBs in the power sector in an environmentally sound manner and to keep the national inventory of transformers updated going forward.** This was achieved in a three-pronged approach. First, a ***Process and Procedure Manual*** was developed to outline proper procedures of inventory management. The manual is a set of guidelines on how to keep the inventory up-to-date and on how to properly handle contaminated transformers, both in storage depots and on the grid. The manual is being used daily by EDL in collaboration with other equipment owners. Second, **comprehensive training** was provided to local workers, administrative staff, and equipment owners in both classroom sessions and in the field to build the human and institutional capacity to ensure the proper application of the manual (***Table 12*** shows that the Project delivered 59 client days of training on the inventory of PCBs.) Importantly, training and capacity building went beyond the technical departments of production, transmission, distribution, and storage to also include staff members in departments of sales, procurement, property management, media, and public relations. Third, **MoE and EDL has acquired the technical skills and hardware** to identify contaminated equipment, which allow them to manage their assets in accordance with the environmentally sound management outlined in the technical guidelines prepared by UNEP Chemicals. Lastly, EDL has appointed a designated committee to serve as focal point for PCB and to coordinate among all related parties going forward.

(ii) Strengthening Lebanon's institutional capacity for safer handling of remaining PCBs in the power sector

34. **The Project effectuated observable improvements in daily management of PCB-contaminated equipment.** At the operational level, the Project changed the way EDL and other equipment owners in the Power sector manage their assets. At the Bauchrieh storage and repair site and at transmission stations, EDL now stores transformers based on their level of PCB-contamination, which reduces accidental occupational exposure and cross-contamination. Transformers are no longer sold for scrap metal without first being tested for PCBs. For operational safety, an ***Emergency Response Plan (ERP)*** *for the Bauchrieh site* was developed by MoE as part of the Project, which outlines actions to be taken in case of an observed or potential incident. The ERP, which is a living document to be updated continuously based on the situation at the facility, is critically important given the location of the Bauchrieh site in a highly urbanized residential and commercial area in Northern Beirut. The ERP is now used by the Manager of the Bauchrieh storage yard and other concerned employees as a basis for the management of the site. By adopting the ERP, the concept of environmental health and safety has been introduced to EDL and their on-site technicians.

35. **The Project built the pillars needed for safely eliminating the remaining PCBs in Lebanon.** At the policy level, the Project developed two key strategic management tools aimed at completely phasing out PCBs from the power sector in Lebanon. The ***PCB Management Action Plan*** is a detailed prioritization of actions to be done in the short, medium, and long term to develop and promote uniform requirements for the management of PCBs in Lebanon targeting the remaining 1,115 transformers in distribution, transmission, and production, which were confirmed with PCB contamination above 50 ppm. The Action Plan, which establishes a schedule for eliminating PCBs, depends on funding from international donors. At the time of Project closing, a commitment has been made by UNEP to dispose of about 50% of the remaining PCB-contaminated transformers/waste under Phase 1 of its MedProgram funded by GEF. The UNEP MedProgram may cover more PCB waste under its Phase 2 if possible per MoE's information. The Action Plan also indicates potential funding resources by 2028 in order to meet Lebanon's commitment to the Stockholm Convention in the elimination of PCBs (***Table 13***, ***Table 14***, and ***Table 15*** in Annex 1).

36. **The Project drafted a legal Decree to regulate environmentally sound and sustainable PCB management of contaminated equipment and waste.** At the legal level, the main elements of the Decree tackles use, maintenance, inventorying, disposal, and permitting of equipment and waste containing PCBs. With the Decree, maintaining the inventory database becomes a binding obligation. While the Decree has been cleared by the Ministry of Environment, the draft has yet to be submitted to the Council of Ministers for formal adoption. This Decree complements other decrees requested under the over-arching law on integrated solid waste management (Law 80 of 2018), and includes the development of a hazardous waste management system in Lebanon, and thereby supports the wider POPs agenda. Despite the GoL's strong commitment for the issuance of this Decree, the current political instability in Lebanon poses a risk to the adoption of the Decree which is beyond the project. Even if the adoption is significantly delayed, the Project worked to ensure sustainability of the technical aspects of PCB management and of the inventory to sustain Lebanon's progress towards the timely phase-out of PCBs.

37. **The Project set the stage for continued engagement and commitment of the GoL in wider POPs and waste issues in the country.** The Project became a vehicle for continued collaboration between the GoL and the Bank Team to address the challenges that Lebanon is facing on other POPs issues and in the broader hazardous and solid waste management agenda. Building on the milestones achieved during the Project, a concept of a new Project titled "Reduction of Unintentional POPs through Waste Management in a Circular Economy" was approved by GEF Council in June 2021. The new Project will finance improvements in hazardous and solid waste management in Lebanon and therefore would support sustainability of the current Project outcomes.

Project Benefits and Beneficiaries

38. **The project generated important occupational, local, and global benefits.** At the local level, 513 workers at the power plants have benefitted from improved occupational safety and health, while 365,000 residents in nearby communities have benefitted from risk reduction of accidental environmental exposure to PCBs. At the global level, the environment has benefitted from risk reduction of accidental release of dioxins and furans through the destruction of PCBs that had the potential to cause atmospheric pollution.

39. **A Project blog and video were developed and can be accessed using the following links:** *https://blogs.worldbank.org/arabvoices/lebanon-389-tons-toxic-chemicals-removed-through-groundbreaking-work*

Justification of Overall Efficacy Rating

40.**Overall project efficacy is rated High.** This is justified by the full attainment of both project development objectives. The Project generated important local and global environmental benefits, particularly for nearby communities of the three Project sites, as well as occupational safety benefits for local workers in the power sector. The Project successfully disposed of 389 tons of PCB waste in accordance with the Basel Convention, inventoried 22,983 transformers to build a national database of 86 percent of all transformers in the power sector, strengthened the institutional capacity of equipment-owners and key stakeholders for safer handling of PCBs in accordance with the technical guidelines prepared by UNEP in support of the Stockholm Convention, and developed a detailed Action Plan for the complete elimination of all PCBs in the power sector. The overachievement of key targets for PDO indicators #1 (achieved at 130 percent) and PDO indicator #2 (achieved at 109 percent) reflects these outcomes.

C. EFFICIENCY

Rating: Substantial

Assessment of Efficiency and Rating

a. Economic efficiency

41. **A basic cost-benefit analysis illustrates the positive economic value of eliminating hazardous PCB material and improving management of remaining PCBs in the power sector.** The economic analysis shows that quantifying just a single dimension of the potential Project benefits, namely the productivity loss linked to the reduction in excess mortality in the local community and in workers in direct contact with PCBs, even under very conservative scenarios, yields exceptionally large net positive social benefits. Relaxing some of the conservative assumptions would yield even greater benefits.

42. **The Cost Benefit Analysis (CBA) shows that the present value of Project benefits in 2020 is US$19.3 million** (***Table 18*** in Annex 4). Considering the Project cost of US$2.54 million, the analysis confirms that even under conservative assumptions, and only examining a subset of the overall Project benefits, the benefits of the Project far exceed its costs. The Internal Rate of Return (IRR) of the project is positive ***(Table 17***). Applying a mortality rate of 0.07% per year the IRR is 20.9 percent, which is far more than either the 12 percent or the 6 percent required social return (discount rate).

43. **An ex-post cost-effectiveness analysis of PCB elimination shows that the Project was highly efficient compared with appraised cost estimates.** In ***Table 4***, it is demonstrated that for all categories the actual cost per type of PCB eliminated is lower than the appraised value. For transformers, the actual cost of US$1,780 per ton eliminated is 36% lower than the appraised estimate of US$2,800. For soil, capacitor, and waste, the actual cost and appraised estimate are closer as the US$2,586 per ton eliminated is 8% lower than the appraised US$2,800 estimate. Finally, for contaminated oil, the actual cost of US$2,009 per ton eliminated is 31% lower than the US$2,900 appraisal estimate.

Table 4: Cost-effectiveness analysis

PCB eliminated	Appraised unit cost	Actual (weighted) unit cost
	US$/ton	US$/ton
Transformers	2,800	1,780
Soil/Capacitors/Waste	2,800	2,586
Oil	2,900	2,009

44. **Project efficiency also compares favorably to other Bank projects.** This includes the Moldova POPs Stockpiles Management and Destruction Project in which the cost per ton of PCB eliminated was US$4,200, and to the China PCB Management and Disposal Demonstration Project, where each ton of eliminated PCB cost US$4,100.

b. Implementation efficiency

45. **The Project design itself facilitated efficiency through simply structured components with a high degree of internal complementarity that were based on solid analysis at the preparation stage.** The economic analysis in the PAD ensured an efficient allocation of resources by pointing to the least cost option of exporting PCB to be

destroyed abroad. Through a competitive bidding process, the Project was able to eliminate an additional 89 tons of PCB at an overall lower component cost than estimated. In parallel, other aspects of the implementation arrangements posed a significant challenge to Project efficiency. Specifically, the lengthy procedures to transfer funds from the Ministry of Finance (MoF) to the Ministry of Environment (MoE) constituted reputational risks to the GoL and to the World Bank caused by the extensive delays in accessing project funds (see Section III.B(a)).

46. **A comparison of actual expenditures to appraisal estimates by component shows that while there were some deviations, the PMU was able to offset the differences.** Component 1 was financed at 127 percent of the appraised value. The increased cost was due to the higher number of transformers to be included in the inventory as the PMU learned of the existence of more transformers. In contrast, component 2 cost only 68% of the appraised value due to efficiencies gained from economies of scale and from a beneficial development of the exchange rate. Actual expenditures under Component 3 reached 120% of the appraisal estimate. As discussed in Section III.B.(a), the Project was able to gap-fill certain activities, such as the development of a draft decree to improve regulation on PCB management. Overall, the dedicated PMU was able to overcome these inefficiencies to prevent any negative impact on Project outcomes.

47. **While the Project was extended twice, the overall extension period was less than a year and did not incur any cost overruns.** The nine-month extension of the Project closing date allowed for the realization of planned outcomes and the overachievement of original targets. This is remarkable given the country context: Projects in Lebanon often experience implementation delay due to political instability, frequent changes in leadership in government offices, and heavy bureaucratic procedures. These factors did affect the present Project as well, but due to the sustained commitment of the PMU and MoE, they did not impact the final Project outcomes.

D. JUSTIFICATION OF OVERALL OUTCOME RATING

48. **Overall project outcome is rated Highly Satisfactory.** This is justified by: (a) project development objectives that remain highly relevant at project closing; (b) a high attainment of project development objectives (the overachievement of key outcome targets) and generation of important local, national, and global benefits; and (c) a substantial level of efficiency.

E. OTHER OUTCOMES AND IMPACTS

Gender

49. The Project was not gender-tagged, but two core indicators tracked female beneficiary and participation rates.

50. **Women were a significant part of project beneficiaries.** Women make up 49.7 percent of the Lebanese population, according to World Bank data (2019). Community members living near the three main project sites, numbered 200,000 near Zouk power plant, 5,000 people near Jieh power plant, and 160,000 people near Bauchrieh repair and storage facility. Assuming that women account for half of those communities, it may be estimated that over 182,000 women benefitted from the removal of hazardous waste as a source of risk to their local environment and personal health. See also outcome indicator #3 and related sub-indicator in the results framework in Annex 1.

51. **The Project delivered 266 client days of training to 168 female participants.** As summarized in ***Table 5*** below, women accounted for 33 percent of all participants in training and capacity building activities over the life of the project. This compares favorably with the original ratio of a 20 percent female participation rate in the 40 planned

training days (see also intermediate indicator #3 and sub-indicator in the RF). A full overview of training and capacity building activities with a gender breakdown is provided in ***Table 12*** in Annex 1.

Table 5: Female participation in training and capacity building activities

Capacity Building	#	# female	% female
Planned training days	40	8	20
Actual training days	45		
Participants	507	168	33
Client days of training	815	266	33

Institutional Strengthening

52. Institutional strengthening and sustainability were key elements addressed in the Project, and Project achievements to this end are covered in Section II.B (ii) above.

53. **The Project disseminated numerous knowledge products to the public and developed ties between the research and practitioner community.** High Project visibility helped create both public and institutional awareness on PCB issues. Radio, video, and television material was developed and shared with the Public throughout Project implementation. Furthermore, the PMU/MoE attended important international scientific conferences to share lessons learned and bring back best practices to Lebanon (***Table 12***). In addition, the Project nurtured linkages between academia and practitioners. It supported a PhD dissertation study on modelling bioremediation at the Bauchrieh site. The Project also collaborated with the University of Saint Joseph Beirut on PCB-related research i.e. to test for the presence of PCBs in the hair and blood of EDL technicians (unpublished) and supported another published research study on the presence of PCBs in pregnant women[4].

Mobilizing Private Sector Financing

N/A

Poverty Reduction and Shared Prosperity

54. The Project contributes towards the achievement of the twin overarching goals of the World Bank by reducing the global and local environmental hazards that high-risk PCBs are to the general health of the population living in proximity of contaminated sources. Scholarly research has pointed to the detrimental effects of environmental hazards on poverty, such as strong evidence that urban environmental hazards are major contributors to urban poverty (Satterthwaite, 2003). By removing the risk of cross contamination from leaking equipment through elimination and safer management of PCBs, the Project has made significant indirect contributions to poverty reduction and shared prosperity.

Other Unintended Outcomes and Impacts

N/A

[4] Maternal and cord serum levels of polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) among Lebanese pregnant women and predictors of exposure. Published in Chemosphere 266 (2021).

III. KEY FACTORS THAT AFFECTED IMPLEMENTATION AND OUTCOME

A. KEY FACTORS DURING PREPARATION

55. Drawing on lessons learned in other PCB projects, the design was based on good diagnostics and kept simple with clear development objectives and sound implementation arrangements, which helped ensure a high level of readiness for implementation at the time of project approval.

56. **The Bank's considerable experience in working with countries on chemicals, in particular on PCBs, had revealed a number of lessons learned, which were carefully incorporated in the Project:** (i) maintaining a simple project design to minimize implementation delay, as evident in the design of just two main operations, namely inventory and disposal; (ii) conducting preliminary inventories and using a risk-based assessment approach to meet the country's highest priorities on the POPs agenda, as was done in the rapid inventory and project preparation study by COWI in 2011; (iii) assessing alternative technologies to select the most cost-effective solution that meets the site-specific requirements, as evident in the cost-effectiveness analysis prepared at the appraisal stage, which determined the option of exporting the PCBs to be destroyed abroad; and (iv) relying solely on licensed operators to dispose of PCBs in accordance with well-established regulations to avoid procurement and implementation delays, as was done during implementation of this Project through international bidding among competent firms.

57. **Project design and preparation was technically sound and realistically linked to the country context and the capacity of counterparts.** The objectives were clearly defined, and the targets were realistic and ambitious at the right level. The components were well-structured and enjoyed internal operational logic with tight sequencing of planned activities. The results framework was aligned with operational objectives and the indicators were relevant if somewhat output driven. Monitoring arrangements were appropriate, and proof and attribution of project outcomes for evaluation purposes were thought into the M&E design. Overall implementation arrangements were designed with adequate attention to the operational risk ratings due to the political and security situation in Lebanon with potentially direct implications on project implementation. Key mitigation measures included close oversight of project implementation by the World Bank.

B. KEY FACTORS DURING IMPLEMENTATION

(a) Factors subject to the control government and/or implementing entities

58. **Following Project approval, the Council of Ministers acted promptly to authorize the Ministry of Finance to sign the Grant Agreement.** The Project was declared effective 130 days after Board approval upon receiving a satisfactory legal opinion and selecting a Project Manager and Project Assistant for the PMU. In a Lebanese context, this may be considered prompt when compared with other Bank projects.

59. **The PMU performed at a highly satisfactory level with commitment and dedication throughout the implementation period.** Following Project start, the PMU was proactive in preparing tender documents for the first disposal of PCB equipment and for the PCB inventory, which together accounted for 40% of total project funds. However, several issues regarding financial management and procurement arose in the early implementation phase that challenged the PMU. In hindsight, though and as explained further below, the PMU's leadership proved indispensable to advance implementation progress.

60. **Initial delay in transfer of funds from MoF to MoE caused early procurement and implementation delay and placed the project at risk of not meeting its development objectives.** Several factors interacted in obstructing the transfer of funds. First, the annual budgets for FY2015 and FY2016 were not timely transferred to MoE's account due to heavy bureaucratic procedures. Second, there was lack of clarity over whether to apply national or World Bank standards, even though Article 8 of the "2005 Government Budget" states that proceeds from an international grant should follow donor procedures. Third, the Grant Approval Decree Nb. 1552 dated 13/12/2015 divided the first amount transferred to the designated account over more than 22 budget lines thereby restricting disbursement and leaving the project in shortage for money on main budget lines. The launch of the first procurement packages were delayed. Payments for committed work and equipment could not be timely honored. Consequently, the GOL and the World Bank were exposed to reputational risks.

61. **The PMU, together with the World Bank, team took decisive action to bring attention to the bottlenecks and resolve the issues concerning the smooth flow of funds.** Through high-level meetings with officials at the MoF and numerous communications, the issues were mostly resolved. The annual budgets for 2015 and 2016 were made available three to six months into the year. The Grant Decree was amended in 2016 to cancel the usage of several budget lines and to manage the remaining funds under a single category line from the budget. Coordination issues between ministries for the timely transfer of funds persisted to some degree throughout implementation, however the PMU effectively managed its cash needs and prevented negative impacts on project outcomes.

62. **Funds for parallel financing of complementary activities were not timely provided, however, MoE and EDL provided essential in-kind support.** Project outcomes were designed to be independent of parallel financed activities. Yet, the activities were important to the overall PCB agenda and some related specifically to the Project. *First, MoE had committed US$2.5 million* to: (i) update a laboratory in Lebanon; (ii) conduct an environmental assessment of the widely contaminated Bauchrieh storage site and well; (iii) strengthen the legal framework by drafting a PCB decree with management guidelines; and (iv) undertake awareness raising activities with stakeholders and the public. Apart from awareness raising, the MoE depended on funds to be transferred from the MoF to undertake planned activities. By early 2020, the MoE received US$1.75 million for the environmental site assessment, however, at Project end the contract is still pending clearance from the Court of Audit. Meanwhile, the Process and Procedure manual specified that EDL fence-off the well, which has been out of use since before the Project started (see Section D). The PMU was able to gap-fill a review of the legal framework and the drafting of a decree to govern PCB management towards full phase-out. *Second, EDL had committed US$2.2 million* to: (i) update their database with the results from the country-wide inventory; (ii) purchase new transformers for the replacement of 17 in-service Askarel transformers at the Jieh power plant; and (iii) purchase PCB-free oil to be used for transformers' maintenance and repair. When the GoL made the decision to fully demolish the Jieh plant, the second commitment was abandoned. EDL instead contributed by paying for already-contracted Service Providers to support the PMU team to carry out the inventory and to provide access to in-service transformers on the grid.

63. **The GoL's decision to decommission the Jieh power plant changed the PCB disposal schedule.** While it was planned that in-service PCB contaminated equipment at Jieh power plant be replaced and eliminated, this was cancelled when the GoL decided to decommission the Jieh power plant as per the Council of Ministers' decision No. 19 dated April 18, 2016. Therefore, no in-service contaminated equipment was replaced under the Project. The PMU reprioritized the disposal schedule based on the completed national inventory and in accordance with the short-term priorities outlined in the Action Plan. The Project instead disposed of contaminated transformers stored

at Bauchrieh as those transformers were: (i) already off the grid; (ii) would help clear the site for the environmental investigation of soil contamination; and (iii) would ensure that the stored contaminated transformers would not be put back in service nor be sold as scrap metals. The PMU's proactive leadership allowed the project to meet and exceed original targets.

64. **The PMU worked diligently to ensure compliance with all Bank policies.** Solid monitoring and evaluation arrangements were in place, which allowed the PMU to tackle issues on the ground quickly and ensure continued progress towards planned targets. Reporting on safeguards, procurement, and FM remained in compliance over the entire project lifecycle (see section IVA and IV.B for further details).

(b) Factors subject to the control of the World Bank

65. **The World Bank provided timely and adequate supervision of project implementation.** Task team leadership changed three times over the course of the Project, yet the team remained actively engaged with the client throughout implementation. Bi-annual implementation support missions provided the PMU with consistent supervision from the Bank's side. Issues for management attention were raised with candor in the ISRs on a regular basis. The Bank team acted proactively to resolve issues in collaboration with implementing agencies to identify corrective measures. The Bank team helped ensure appropriate transition arrangements by extending the project closing date another three months, thereby allowing EDL, especially, additional time to rebuild the organizational structures following the August 4, 2020 blast in the port of Beirut.

(c) Factors outside the control of government and/or implementing entities

66. **Lebanon was marked by a series of compounded crises leaving the country without a stable government in the last year and half of implementation.** The 2019–2020 mass protests, also known locally as the October Revolution, led former Prime Minister Hariri to tender his resignation. In October 2019, the economy plunged into a financial crisis brought about by a sudden stop in capital inflows, which precipitated systemic failures across the banking sector and debt sector, as well as effecting the exchange rate. Subsequently, on March 7, 2020, the Government defaulted on the repayment of a US$1.2 billion Eurobond, marking Lebanon's first-ever sovereign default. On March 18, the Government declared a State of General Mobilization, imposing a lockdown to counter the COVID-19 pandemic, which included the closure of borders (air, sea, and land) and of public and private institutions. Lastly, on August 4, 2020, a massive explosion rocked the Port of Beirut, destroying much of the port, including the headquarters of EDL, and severely damaging dense residential and commercial areas within a 2-mile radius, including MoE's offices and that of the PMU.

67. **The COVID-19 pandemic contributed to implementation delay at the final stages of the project and the need to extend the project closing date.** Lockdown measures and the closure of the airport delayed the second shipment of PCB waste, as the international team of contractors had to pause their work and return later to finalize packing and loading of the shipment. The lockdown also affected access to the Bauchrieh site, which delayed the last contract to inventory scrap transformers stored at the site. With only a care-taker government in place, the prepared Decree was not issued and remains a draft. The Borrower was proactive in requesting an extension of the closing date (section I.B).

68. **It is worth highlighting that the PMU and MoE overcame the obstacles presented by a challenging political environment to achieve the original development outcomes in the manner that the project was envisioned at the preparation stage.** Due to the dedicated actions of the PMU and the commitment of the MoE to the overall

objectives of the project, the events did not impact negatively on the outcome of the PDOs. This is a testament to the commitment, motivation, and competence of the overall Project team.

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

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

Rating: High

M&E Design

69. **Monitoring and evaluation were designed to be integral parts of the project.** The Project enjoyed a high degree of internal logic between planned activities, outputs, and outcomes. The Results Framework (RF) was adequate in tracking project progress with specific, measurable, achievable, relevant, and time-bound indicators. Meanwhile the outcome indicators were somewhat output-based because the ultimate project outcome and impact lies in eliminating a risk factor that in and of itself cannot be assessed. The RF together with the effective implementation of M&E arrangements (described under M&E Implementation) was designed to allow for the attribution of project outcomes to planned activities. Responsibility to carry out ongoing M&E activities was placed within the PMU.

M&E Implementation

70. **The methodology underlying the data collection and analysis was robust.** The PMU ensured, that embedded within each contract were guidelines for tracking progress on the ground and requirements for reporting to the PMU with daily, weekly, and monthly progress reports on environmental, safety, and data management. Throughout implementation, reports were timely submitted to the PMU providing optimal conditions to continuously assess and reassess implementation progress towards planned outputs and outcomes. M&E was rated Satisfactory throughout project implementation.

71. **The PMU utilized a combination of M&E instruments to assess and control data gathered on implementation progress, leading to increased Project efficiency.** The PMU exercised comprehensive quality assurance and control of M&E data points collected from contractors undertaking Project activities. First, a Field Supervisor was recruited by the PMU to monitor the compliance of Contractors against contractual commitments and international and national rules and regulations. Second, the PMU assessed and verified daily, weekly, and monthly reports submitted by contractors and the field supervisor, requiring timely submission of proofs, photos, certificates, movement documents, and laboratory reports. Third, spot visits and site investigations were used to confirm M&E data points. Fourth, cross checking the reported quantities of equipment surveyed and screened and of laboratory results ensured that inventory data was routinely verified. Fifth, feedback loops and progress meetings with both contractors and equipment owners ensured that all stakeholders were included in the M&E process. The solid implementation of M&E arrangements helped in promptly identifying and solving problems as they arose. They also ensured Project efficiency by closely monitoring the actions of contractors, such as proper weighting of PCB material which is directly related to Project expenditures. Furthermore, it should be noted that the training of Field Supervisors supported overall national capacity building on management of hazardous waste.

M&E Utilization

72. **Data obtained through monitoring and evaluation was routinely used to inform project management and decision-making by the PMU.** Monitoring data tracking progress towards key outcome indicators were the driving factor for extending the project closing date and enabling the second export of contaminated PCB. Data collected on each transformer was included in a national inventory and to make a list of PCB contaminated equipment. This data was utilized by the project to track progress towards outcome indicator #2.

73. **M&E data was used to actively prevent PCB contamination in real time, setting an example for the wider solid waste sector.** M&E data was used to alert the MoE of an emergency unfolding at a sub-station outside of the Project sites, where an in-service PCB contaminated transmission transformer was leaking and causing soil contamination. The MoE responded by purchasing UN drums from a local supplier along with personal protective equipment, requesting the Litani River Authority (LRA) responsible for the substation to allocate local workers, and requesting EDL as the owner of the leaking transmission transformer to purchase trays to be placed underneath. The event highlighted how a functioning M&E system tracking PCB contaminated transformers strengthened the institutional capacity of MoE to respond proactively in close collaboration with LRA and EDL and prevent further soil pollution. As such, M&E becomes a tool for policy improvement that applies to the entire solid waste sector.

74. **Collected data was used to course-correct implementation to fulfill project objectives and increase efficiency.** For example, the inventory contract was amended when the data showed that the initial number of 21,000 transformers was underestimated. The data set was again consulted when in-service transformers were not being replaced, and the PMU adjusted disposal activities to concentrate on the Bauchrieh site. Through continuous quality assurance and control, monitoring data was used to identify and rectify errors in the screening results and to ensure that only the samples that needed further analysis were sent to the lab, thereby increasing project efficiency, and allowing for testing and inventorying of additional transformers. Finally, the data set will be utilized in future project designs and serve Lebanon to meet its obligation for phasing-out PCBs.

Justification of Overall Rating of Quality of M&E

75. **The overall quality of the M&E system is rated High.** The justification is that there were no, or only minor shortcomings in the M&E system's design, implementation, or utilization. The RF and M&E arrangements together permitted a proper assessment of the results chain and the attainment of project outcomes. Furthermore, M&E was actively used as a project management tool and will help inform the preparation of future projects.

B. ENVIRONMENTAL, SOCIAL, AND FIDUCIARY COMPLIANCE

76. **The project was rated 'Category A' (full environmental and social impact assessment) with expected significant positive environmental impacts and long-term public health benefits.** The project triggered safeguards policy OP/BP 4.01 Environmental Assessment reflecting the potential for negative environmental and health impacts mainly associated with Component 2 with regards to handling PCB contaminated material.

77. **The project complied with all applicable safeguards and risk mitigation measures.** During preparation, extensive efforts were made to identify and mitigate operational, institutional, governance, and safeguards risks. The project safeguards instruments were prepared by the GoL and cleared by the World Bank regional safeguards adviser. The ESMP was comprehensive and went beyond the scope of the Project for MOE and EDL to manage PCBs in the future. Drafts were timely disclosed and shared with stakeholders, and the final ESIA was disclosed on

October 19, 2015. The capacity of the implementing agencies, MOE and EDL, to correctly implement the safeguards policies and instruments were strengthened to ensure compliance with the technical, procurement, safeguards, and financial management aspects of the project. The World Bank provided safeguards training and capacity building to staff members of the implementing agencies in the proper implementation of World Bank policies. On the procurement side, to meet the ESIA/ESMP requirements related to inventory and disposal of PCBs, bidding documents required Contractors to have in place an Environmental Management System and a training module for local staff on occupational health and safety measures. A grievance redress mechanism was established at the project level and communicated to project stakeholders, though no complaints were received. Safeguard ratings were consistently rated in the Satisfactory range.

78. **The PMU diligently managed all FM aspects of the Project including accounting, recording, and reporting based on acceptable internal controls and disbursement procedures.** The PMU submitted satisfactory quarterly Interim Financial Reports (IFRs) to the WB on a timely basis. Annual audit reports in accordance with international standards were duly submitted with unqualified clean opinions. The FM rating was downgraded to Moderately Unsatisfactory in Spring of 2016 (ISR #4) due in part to challenges obtaining committed counterpart funds and in part to delays caused by the GoL's restrictive FM procedures, which were being applied in parallel with Bank procedures. This affected project implementation in various ways as discussed in Section III.B(a). The issues were resolved jointly by the World Bank, PMU, and senior MOF officials, and the rating was upgraded subsequently.

79. **Procurement plans were updated regularly to develop the budget and submitted on time to the WB.** Activities were executed according to the different processes and procedures as defined in the procurement plans. Bi-annual post procurement reviews were carried out by the Bank. No issues regarding compliance with procurement policies arose during implementation.

C. BANK PERFORMANCE

Rating: Satisfactory

Quality at Entry

80. **The project benefitted from satisfactory quality at entry.** The project was based on a solid diagnostic of Lebanon's development challenges, and it supported the World Bank's engagement strategy with the country as well as its global agenda to eliminate hazardous PCBs. The project team adopted a relatively simple project design consisting of two main components with complementary sequencing. This approach built on lessons learned from the Bank's deep experience with similar projects and was appropriate given the high-risk country context due to political complexity. Particular attention was paid to environmental risks associated with handling toxic PCBs through preparation of a comprehensive ESMP, which went beyond the scope of the Project for MOE and EDL to manage PCBs on their own in the future, and by requiring Contractors to have in place an Environmental Management System, including a training module for local staff on occupational health and safety measures. Project readiness was in an advanced stage with all necessary analyses performed, i.e., cost-effectiveness analysis and rapid inventory. In hindsight, arrangement for financial management could have considered alternative options of transferring grant funds to the GoL (see section III.B.a, and Lessons Learned). The Bank team did well to structure complementary activities as parallel financing, rather than co-financing, enabling the PMU to successfully achieve the grant-funded part. Provisions for procurement and safeguards were adequate at the design stage.

Quality of Supervision

81. **The Bank Team showed timely and dedicated attention to the project, addressing technical, safeguards and fiduciary issues efficiently.** The World Bank task team conducted an average of two supervision missions a year. The Project was managed by four different Task Team Leaders, the teams should be commended for their high level of commitment to the project and for expediently supporting the PMU to overcome obstacles as they arose. Through candid reporting and direct engagement with the client, implementation challenges were quickly identified and addressed with management support. When needed, Bank teams leveraged its impact in adding pressure on the GoL, i.e. to resolve FM issues related to the flow of funds between ministries. Despite a challenging a country context, the Project was fully disbursed and has fully achieved and, in some cases, overachieved, its targets. Overall, the Bank's supervision underpinned the high performance of the PMU, provided strong support to FM and procurement, and ensured adequate transition arrangements for sustainability of attained development outcomes.

82. **The Bank Team proactively engaged MoE to continue its efforts in addressing POPs and broader hazardous and solid waste management agenda in Lebanon.** The Bank team engaged the MoE and the PMU in 2019 for a follow-up GEF project building on the milestones achieved by the PCB project and the challenges that the country is facing on other POPs issues and waste management. Through two years of joint and persistent efforts of the Bank team and the PMU, the concept for the follow-up project was cleared by the GEF Chief Executive Officer and a project preparation grant was approved in May 2021. The new Project titled "Reduction of Unintentional POPs through Waste Management in a Circular Economy" (GEF Grant of US$ 8,858,447 for the country) will contribute to improving hazardous and solid waste management in Lebanon. The new Project can serve as a mitigating factor

to help ensure sustainability of Project outcomes as it will further improve hazardous waste management including POPs in Lebanon.

Justification of Overall Rating of Bank Performance

83. **Overall Bank performance is rated Satisfactory.** This is justified by the satisfactory preparation and supervision of the project. Through challenging country circumstances, the World Bank team's sustained stewardship led the Project to its high achievement of original development objectives.

D. RISK TO DEVELOPMENT OUTCOME

84. **There are no risks to the sustainability of the first project development outcome.** With evidence of the safe destruction of 389 tons of high-risk PCBs from the power sector, there are no risks that might change or impact that result.

85. **There are moderate risks to the sustainability of the second project development outcome.** Improving PCB management in the power sector in an environmentally sound manner is a continuous process, rather than an end. Potential risks, their likelihood of materializing, and their possible impact on project outcomes are considered below:

- **The inventory may not be kept up to date through timely reporting when transformers change status.** Having a reliable inventory of transformers and contaminated PCB equipment is essential for the safe and proper management of the PCBs that remain in the power sector and await elimination. Continuous updating of the inventory relies on multiple factors and stakeholder acting in a concerted manner. However, there is a risk that the capacity or resources to fulfill this responsibility are eroded over time, and that labelled assets are not managed according to the procedure manual developed by the Project. The August 4, 2020 explosion is a stark reminder that institutional capacity can be lost and relies on the commitment of the leadership to retain its value.

- **High-level commitment to implement the Action Plan and phase out remaining PCBs could dwindle.** With 1,435 tons of PCBs remaining in the power sector, the agenda to eliminate those PCBs in accordance with the approved Action Plan depends on the GoL's sustained commitment to fulfill its obligations under the Stockholm Convention. While the GoL has shown dedicated attention to this objective, the political instability in the country could jeopardize this.

- **The process to get the Draft Decree approved may be delayed.** The Decree will provide the legal basis for regulating management of PCBs including maintenance of the PCB database established under the project. However, issuance of the decree is still pending. To advance the status of the decree and submit it for approval, the opinion of the State Consultative Council in the Ministry of Justice is needed. The MoE must continue to follow-up on this point once the new government is formed and work to ensure that the Decree be approved as soon as possible. The Decree is an important legal instrument to meet Lebanon's obligations under the Stockholm Convention, to which it remains committed.

- **The project supported disposal of PCBs transformers from the Bauchrieh storage site, yet assessment and remediation of the site including an on-location well did not form part of project activities.** The well in Bauchrieh site was already abandoned prior to Project start and has not been used by EDL personnel. The well is not accessible to the population as it is located with the Bauchrieh site. The Process and

Procedure manual, prepared by the Project, specified that EDL fence-off the well to prevent accidents. The bidding process for an environment assessment of Bauchrieh site (including the well) had been completed before the project closing but it was cancelled due to the unexpected crises in the country. This environment assessment, to be supported by the MoE's parallel financing, will include the well and all relevant remedies actions if deemed needed to depollute the site, therefore preventing impacts on occupational and community health and safety.

V. LESSONS AND RECOMMENDATIONS

86. **Small grants can be catalytic in bringing about change in policy, institutional, and investment responses even when set within a fragility context.** With an investment of only US$2.5 million dollars, the Project achieved far beyond its weight. Despite the small size of the Project, the outcomes are fundamental to eliminating all PCBs in Lebanon. The demonstration-effect of disposing PCBs, the national inventory of transformers, and the legal, policy, and operational documents developed have set Lebanon on a path to fulfilling its obligations under the Stockholm Convention. Furthermore, the Project built the capacity of individuals and institutions to organize small groups of peers and colleagues into high-functioning collaborative efforts. Going forward, it will be critical to maintain Lebanon's engagement and build on the successes achieved thus far to eliminate all remaining PCBs. While discussions with other donors have revealed a funding gap to cover the disposal of remaining PCBs, the new World Bank project backed by GEF-7 funding will help sustain Lebanon's commitment to the overall POPs agenda.

87. **Careful consideration should be given to the complexity of the financial governmental procedures during project preparation to avoid implementation delay.** The PMU faced several challenges because the grant proceeds were integrated into the national purse and the MoF required that the MoE access the grant money through an "Emergency Advance Decision". This meant that the applicable procurement and settlement procedures were different from the Bank's procedures, thereby restricting disbursement and adding layers of bureaucracy. The following recommendations are proposed to prevent this from happening in future projects:

- Consider alternative options of transferring grant proceeds to the government;
- Consider doing all eligible payments as Direct Payments and not transferring any grant proceeds to the national Treasury's account;
- Explore possibilities to simplify MoF's financial system concerning grant proceeds;
- Build awareness around the challenges related to the 2020 Budget Law, which stipulates the need for the Court of Audit to approve contracts for international projects;
- Train the Ministry's financial department further on the specifics of governmental financial management and flow of funds systems in Lebanon; and
- Involve financial staff from the MoE, in addition to the technical experts, in project negotiations so that financial issues can be better planned from the beginning.

88. **The signing of a Memorandum of Understanding between MoE and EDL helped to lessen the bureaucratic procedures and noticeably strengthen the level of commitment of EDL staff.** The MOU was signed on March 15, 2016 and clarified the responsibilities of each party and allowed delegation of authority to the EDL Technical

committee on most implementation matters related to the Project. The result was a stronger institutional commitment from both parties to the benefit of the PMU and the Project.

89. **The highly dedicated and professional PMU is critical for successful project implementation in a complex country like Lebanon.** The PMU for the PCB project is small, but with highly qualified and dedicated staff in charge of daily project implementation. They paid close attention to effectively coordinate with the stakeholders outside MoE by regularly briefing project progress, providing training on PCB management, and seeking collaboration. The PMU also efficiently ensures liaison with MoE to get its full support to the project. The PMU staff also selectively requested and participated in international knowledge events on PCB and POPs management, which further built its technical and managerial capacity for successful project implementation and transferring knowledge to concerned stakeholders.

90. **Keeping sustainability in mind throughout project implementation allows necessary and timely adjustment of project activities.** The project originally included development of an inventory of the PCB equipment and waste in the country with a database, which is important to inform the PCB management actions beyond the project. Additional activities were considered during project implementation to strengthen sustainability of the project outcomes. These additional activities were either identified and agreed through the MTR or at a later stage of project implementation. Both MoE and PMU were engaged to implement these activities using the project grant saved from the competitive bidding processes for PCB waste disposals. These activities include: i) preparation of a draft Decree for management of PCBs in closed applications; ii) development of a PCB Management Plan by 2028 – a deadline for Parties to the Stockholm Convention to eliminate all PCB wastes in the country; iii) preparation of an Operation Manual on PCB Management and Maintenance, policy review and recommendations for PCB management; iv) preparation of an emergency response plan for the Bauchrieh storage site of transformers; v) inventory for scrap transformers empty of oil at the Bauchrieh site; vi) a preliminary assessment of usage of PCBs in open applications which would be a baseline for any future projects in the country; and vii) procurement of PCB screening analyzer to be used by the Ministry of Environment and equipment owners for continued sampling and testing unlabeled transformers after the project upon receipt at storage or maintenance sites. The results and outputs of these activities will guide EDL and other PCB owners to continue environmentally sound management of PCBs and associated waste after the project life to enable Lebanon to meet the obligations under the Stockholm Convention.

ANNEX 1. RESULTS FRAMEWORK AND KEY OUTPUTS

A. RESULTS INDICATORS

A.1 PDO Indicators

Objective/Outcome: EDL transformer recorded in the inventory

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
EDL transformers recorded in the inventory	Number	0.00 01-Jan-2015	21000.00 30-Jun-2020		22,983.00 31-Mar-2021

Comments (achievements against targets):

Target 109% achieved. The indicator was defined based on the number of transformers in the electrical network, most of them located in EDL's distribution network (18,800), others used in power plants (300), and some in storage at Bauchrieh for repair or to be sold as scrap material (1,900). EDL's database of transformers in the distribution and transmission network already included basic information such as location, serial number, capacity (kVA), make and year of manufacture. However, the database lacked specific information that would enable proper management of PCB contaminated transformers, such as the i) weight of transformers, ii) amount of liquid, iii) type of liquid filling, and iv) presence of PCB. At project end, a total of 22,983 transformers had been recorded in a national inventory. This was achieved by first merging existing databases maintained by EDL, by MoEW, and by other concessions into a computerized system in compliance with the forms for PCB inventory established by UNEP (2003). Following, the entire stock of transformers, capacitors, and oil drums was surveyed, sampled, screened, tested, analyzed, labelled, and inventoried accordingly. A "Practice and Procedure Manual; Inventory of PCB contaminated Equipment" was developed in Arabic and English to properly update the inventory on a continuous basis (2018).

Objective/Outcome: POPs and POPs waste destroyed, disposed or contained in environmentally sound manner

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
POPs&pops waste destroyed,disposed or contained in environmentally sound manner	Metric ton	0.00 01-Jan-2015	300.00 30-Jun-2020		389.00 31-Mar-2020

Comments (achievements against targets):

Target 130% achieved. The indicator was defined the number of tons of PCB material sustainably eliminated in accordance with the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. The target value of 300 tons was based on i) 44 tons of EDL out-of-service, high-content PCB equipment and 10 tons of highly contaminated soil and concrete from leakages from the power plant in Zouk, ii) 147 tons of EDL in-service, high-content PCB equipment from the power plant in Jieh, iii) an estimated 100 tons of contaminated oil from the Bauchrieh repair and storage site, and iv) possibly 5 tons of PCB equipment from willing participants in the private sector. This adds up to a total of 306 tons of contaminated PCB equipment, oil, and waste. At project end, a total of 389,090 tons of PCB waste had been exported to Saint Vulbas, France and securely destroyed at the TREDI facility in suitable incinerators for hazardous waste in accordance with the requirements of the Basel Convention for environmentally sustainable elimination of PCB material.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Direct project beneficiaries	Number	0.00 26-Jun-2014	205500.00 30-Jun-2020		36,500.00 31-Mar-2021
Female beneficiaries	Percentage	0.00	50.00		50.00

Comments (achievements against targets):

Target achieved. The indicator relates to both parts of the PDO. The indicator target value was defined as i) 500 EDL employees, including workers and technicians at respectively Jieh power plant (228), Zouk power plant (256), and Bauchrieh storage and repair workshop (5); and ii) the population living in the areas surrounding Zouk power plant (200,000 people) and Jieh power plant (5,000 people). The PAD recognized that the population of 150,000 people living in the highly urban area surrounding the Bauchrieh storage and repair workshop would also benefit from the project but chose not to include them as project beneficiaries because site contamination from a well would remain in Bauchrieh. At project end, all direct project beneficiaries of 365,000 individuals were counted, including the employees working at and the populations living near the Zouk and Jieh power plant and the Bauchrieh repair and storage site. Urban growth near the Bauchrieh site located in Beirut accounts for an additional 10,000 beneficiaries. However, general site contamination at the Bauchrieh repair and storage facility has yet to be dealt, beginning with an environmental assessment to develop depth profiles and areas with high contamination levels throughout the site, including the area around the well.

A.2 Intermediate Results Indicators

Component: Component 1: Inventory of PCB contaminated transformers

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Contract for Inventory signed	Number	0.00 01-Jan-2015	1.00 30-Jun-2020		2.00 31-Mar-2021

Comments (achievements against targets):

Target 200% achieved. The indicator was defined as an intermediate output to mark the beginning of developing a national inventory of PCB contaminated transformers. The target was achieved on October 19, 2016 when the good and works contract PW001 for “Inventory of PCB Contaminated Equipment” wa
The contract covered visitation, surveying, sampling, screening, testing, analyzing, labelling, and inventorying the entire stock of transformers in the power s

Lebanon, as appropriate. At the end of the contract a PCB Action Plan, a National PCB Inventory Database (spreadsheets of transformers with photos), a Practice and Procedure Manual (in Arabic and English), and a National List of PCB contaminated transformers had been produced. Towards the end of the project, a second contract was signed to inventory 424 irreparable transformers stored at Bauchrieh intended to be sold as scrap metal. The PMU/MoE informed EDL that sampling and testing had to be carried prior to any sale of the assets could be initiated, since if the transformers turned out to be PCB contaminated, they would be considered as hazardous waste and thus needed to be safeguarded properly. The results showed that 251 of the 424 transformers were PCB contaminated.

Component: Component 2: Disposal of high content PCB equipment and contaminated oil

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Contract for First Shipment and Disposal of PCB signed	Number	0.00 01-Jan-2015	1.00 30-Jun-2020		1.00 31-Mar-2021

Comments (achievements against targets):

Target achieved. The indicator was defined as an intermediate output to mark the first contract to ship and dispose of PCB material. The target was achieve 31, 2016 when the good and works contract PW002 for "Disposal of PCB Equipment and Waste" was signed. The contract covered: i) Drainage, labeling, pac shipping of high-risk PCB equipment, oil, and waste from Lebanon, ii) export of the hazardous waste as per Basel Convention rules, and iii) disposal of the ha waste in a licensed facility. At the end of the contract, 91 tons of PCB material had been successfully destroyed at the TREDI facility in Saint Vulbas, France. A video of the first disposal of PCBs was developed:

http://www.worldbank.org/en/news/feature/2017/05/12/lebanon-starts-to-get-rid-of-persistent-organicpollutants-that-endanger-environment-and-health

Component: Component 3: Capacity building and project management

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Client days of training	Number	0.00	40.00		815.00

provided (number)		01-Jan-2015	30-Jun-2020		31-Mar-2021
Client days of training provided - Female (number)	Number	0.00 01-Jan-2015	8.00 30-Jun-2020		266.00 31-Mar-2021

Comments (achievements against targets):

Target achieved. The indicator was likely defined as the number of days of training provided to various project stakeholders. However, as a core indicator, the actual definition of the “Client days of training provided” is “the number of clients who completed training multiplied by the duration of training expressed in days". While not formally revised, the PMU estimated that in applying the core definition the end target would be 700 client days of training. At project end, and based on data from the PMU, who tracked the number of training days provided and the number of participants at each event, the project provided a total of 45 days of training to 507 participants of which 339 were male (67%) and 168 were female (33%). The number of client days per event is calculated in ***Table 14*** below (Annex 1) and it shows that a total of 815 client days of training was provided over the life of the project (116 percent of adjusted target). Against the original indicator, the target could be estimated to be 113 percent achieved as the project provided 45 days of training compared to the intended 40 days of training.

Table 6: Output by Component

Outcome (i): Dispose of high-risk PCBs in an environmentally sustainable manner	
Outcome Indicators	1. POPs and POPs waste destroyed, disposed, or contained in environmentally sound manner (Metric tons) - CORE
Intermediate Results Indicators	*Component 2: Disposal of high-content PCB equipment and contaminated oil* 2. Contract for first shipment and disposal of PCB signed (Number) *Component 3: Capacity building and project management* 3. Client days of training provided (Number) - CORE - Client days of training provided - female (Number) - CORE
Key Outputs by Component (linked to the achievement of the Objective / Outcome 1)	**COMPONENT 2: Disposal of high-content PCB equipment and contaminated oil** - First export of 91 tons of PCB was shipped on 15/12/2016 in 5 containers. See ***Table 7*** below. As proof of destruction, TREDI submitted a "Certification of Elimination for Notification LB 2016/2987/B" dated July 31, 2017 for the five achieved movement forms (total of 91.670 tons). Certificate enclosed in ***Annex 6***. The weight of received PCB material as recorded by TREDI is higher than the weight recorded in Lebanon prior to shipment by 1.39 tons. - Second export of 298,090 tons of PCB was shipped in three different shipments: The first shipment of 84.36 tons in four containers occurred on 18/02/2020; the second shipment of 105.96 tons in five containers occurred on 19/03/2020; and the third and final shipment of 107.78 tons in five containers occurred on 28/07/2020. See ***Table 8*** below. As proof of destruction, TREDI submitted a "Certification of Elimination for Notification LB 2019/4171/B" dated December 1, 2020 for the fourteen achieved movement forms (total of 289.300 tons). Certificate enclosed in ***Annex 6***. The weight of received PCB material as recorded by TREDI is higher than the weight recorded in Lebanon prior to shipment by 0.2 tons. **COMPONENT 3: Capacity building and project management** - Training events, workshops, and conferences were provided to the PMU, MOE, EDL, Concessions (i.e. other owners and operators of transformers), academic sectors, Government institutions, consultancy firms, technical officers and laboratories on a range of topics, including PCB inventory management, hazardous waste management, and environmental safeguard activities related to disposal of PCB equipment and waste. A complete overview is provided in ***Table 12*** below.

Outcome (ii): Improve inventory management of transformers in the power sector	
Outcome Indicators	3. EDL transformers recorded in the inventory (Number) 4. Direct project beneficiaries (Number) - CORE - Female beneficiaries (Percentage) - CORE
Intermediate Results Indicators	*Component 1: Inventory of PCB contaminated transformers* 1. Contract for inventory signed (Number) *Component 3: Capacity building and project management* 3. Client days of training provided (Number) - CORE - Client days of training provided - female (Number) - CORE
Key Outputs by Component (linked to the achievement of the Objective / Outcome 1)	**COMPONENT 1: Inventory of PCB contaminated transformers** Campaign to develop a national inventory of PCB contaminated transformers as captured in **Error! Reference source not found.** and

The process of inventorying transformers in the power sector

Field visits to 22,983 transformers were undertaken, and of those, 13,560 were surveyed on-site, while 9,383 were white-labelled due to their low-risk of containing high levels of PCBs. Samples were collected from 12,011 transformers, while 1,549 transformers were inaccessible due to various reasons such as the inability to disconnect the unit from electricity, the presence of major obstacles (trees, generators cables, etc.), or because of a defunct faucet. Following screening and additional lab testing of 3,408 transformers, the transformers were confirmed to be either PCB-free (green label) or PCB-contaminated above 50 ppm (orange label with level of contamination clearly indicated). The process is illustrated in Figure 3 above. As part of the inventorying process, the Project also surveyed 28 capacitors and sampled 33 drums of oil for a total 23,044 assets inventoried.

Figure 14 below:

- Visited 22,983 transformers nationally distributed on and off the grid
- White-labelled 9,383 transformers and surveyed 13,560 transformers
- Sampled and screened 12,011 transformers
- Lab tested 3,408 transformers
- Registered 1,380 transformers as PCB contaminated (***Table 10***).
- Developed a spreadsheet (full database) including all information related to the 13,560 surveyed transformers
- Analysis of inventory results and development of disposal / replacement action plan with prioritization and costing

List of publications:

- National List of PCB contaminated transformers
- PCB National Inventory Report and Action Plan (2018) – *including spreadsheets of transformers with photos*

	- Practice and Procedure Manual; Inventory of PCB contaminated Equipment (2018) – *available in Arabic and English* - Emergency Response Plan – *available in Arabic and English* **COMPONENT 3: Capacity building and project management** - Training events, workshops, and conferences were provided to the PMU, MOE, EDL, Concessions (i.e. other owners and operators of transformers), academic sectors, Government institutions, consultancy firms, technical officers and laboratories on a range of topics, including PCB inventory management, hazardous waste management, and environmental safeguard activities related to disposal of PCB equipment and waste. A complete overview is provided in ***Table 12*** below.

Table 7: First export of contaminated PCB equipment and waste

Producer / Owner	Shipper	Transboundary Shipment No.	Shipment	Shipment	Net Quantity weighted in Lebanon	Quantity weighted by TREDI	Date of receiving the load	Date of final disposal	Disposal operation
			No.	Date	Tons	Tons			
MOE -Lebanon	POLYECO SA	LB 2016/ 2987/B	1/30	15/12/2016	18.334	18.93	17/1/2017	13/7/2017	D10/R4
MOE -Lebanon	POLYECO SA	LB 2016/ 2987/B	2/30	15/12/2016	20.654	20.63	16/1/2017	13/7/2017	D10/R4
MOE -Lebanon	POLYECO SA	LB 2016/ 2987/B	3/30	15/12/2016	19.521	19.93	17/1/2017	13/7/2017	D10/R4
MOE -Lebanon	POLYECO SA	LB 2016/ 2987/B	4/30	15/12/2016	18.017	18	16/1/2017	13/7/2017	D10/R4
MOE -Lebanon	POLYECO SA	LB 2016/ 2987/B	5/30	15/12/2016	13.75	14.18	13/1/2017	20/4/2017	D10
TOTAL weight					90.276	91.670			

Table 8: Second export of contaminated PCB equipment and waste

Producer	Shipper	Transboundary Shipment No.	Shipment	Shipment	Net Quantity weighted in Lebanon	Quantity weighted by TREDI	Date of receiving the load	Date of final disposal	Disposal operation
			No.	Date	Tons	Tons			
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	3/35	18/2/2020	20.79	20.79	20/3/2020	24/11/2020	D10
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	4/35	18/2/2020	20.84	20.84	19/3/2020	26/11/2020	D10
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	5/35	18/2/2020	21.41	21.41	23/3/2020	28/11/2020	D10
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	6/35	18/2/2020	21.32	21.32	24/3/2020	27/11/2020	D10
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	7/35	19/3/2020	21.25	21.25	14/4/2020	30/07/2020	D10
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	8/35	19/3/2020	21.15	21.15	15/4/2020	28/11/2020	D10
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	9/35	19/3/2020	21.10	21.10	10/4/2020	28/11/2020	D10
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	10/35	19/3/2020	21.32	21.32	10/4/2020	26/11/2020	D10
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	11/35	19/3/2020	21.14	21.14	14/4/2020	28/11/2020	D10
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	12/35	28/7/2020	21.85	21.85	20/8/2020	28/11/2020	D10
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	13/35	28/7/2020	21.41	21.41	20/8/2020	27/11/2020	D10
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	14/35	28/7/2020	22.06	22.26	21/8/2020	28/11/2020	D10
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	15/35	28/7/2020	21.36	21.36	21/8/2020	28/11/2020	D10
MOE -Lebanon	POLYECO SA	LB 2019/4171/B	16/35	28/7/2020	21.10	21.10	24/8/2020	27/11/2020	D10
Total weight					298.10	298.30			

Project photos

Figure 8: Site visits at equipment owners using proper PPE.

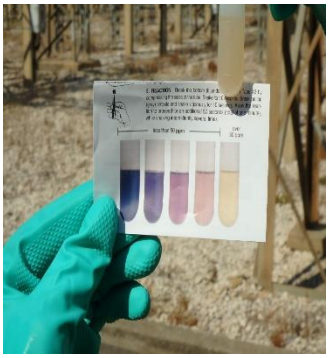
Figure 9: Draining and wrapping contaminated

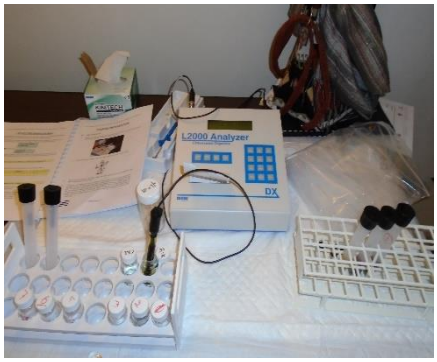
Figure 10: Transformers and oil drums stored at Bauchrieh and being loaded on containers to be exported.

Figure 11: Oily mud and soil with possible PCB contamination

Figure 12: Sampling of soil and transformers

Figure 13: On-site testing and lab testing

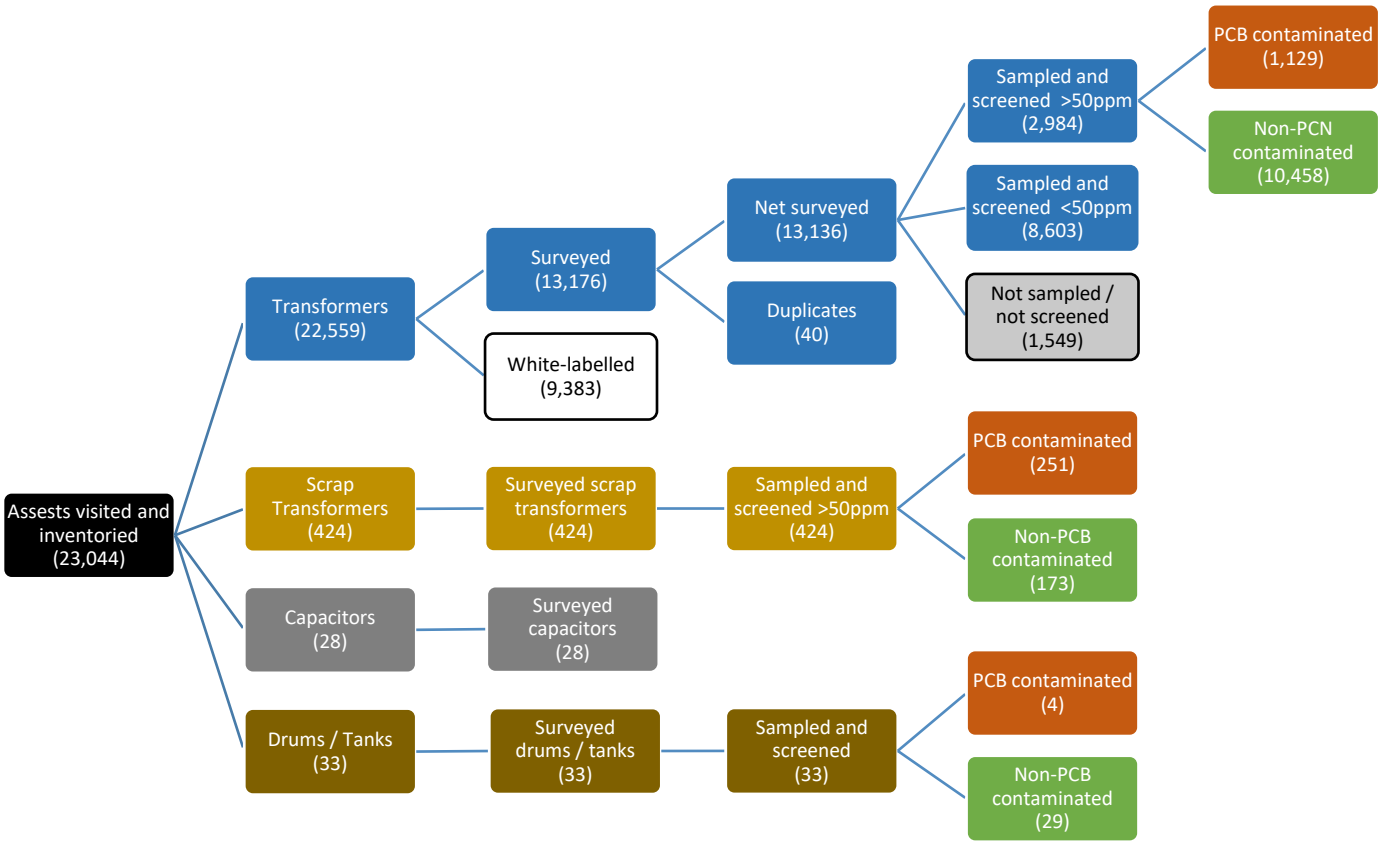




The process of inventorying transformers in the power sector

Field visits to 22,983 transformers were undertaken, and of those, 13,560 were surveyed on-site, while 9,383 were white-labelled due to their low-risk of containing high levels of PCBs. Samples were collected from 12,011 transformers, while 1,549 transformers were inaccessible due to various reasons such as the inability to disconnect the unit from electricity, the presence of major obstacles (trees, generators cables, etc.), or because of a defunct faucet. Following screening and additional lab testing of 3,408 transformers, the transformers were confirmed to be either PCB-free (green label) or PCB-contaminated above 50 ppm (orange label with level of contamination clearly indicated). The process is illustrated in Figure 3 above. As part of the inventorying process, the Project also surveyed 28 capacitors and sampled 33 drums of oil for a total 23,044 assets inventoried.

Figure 14: National Inventory - Field visits and sampling activities

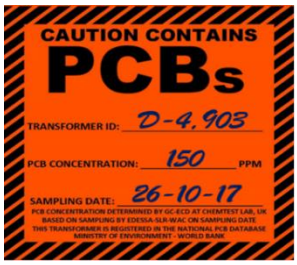


The total PCB content was determined by calculation as per EEC Directive 59/96/EC (GU n° L243 of 24/09/1996) (Art-2). The ***Clor-N-Oil technique*** was used to test electrical insulating fluids for the presence of PCB. The analysis takes less than 5 minutes per sample and results in either 'below 50 ppm' or 'above 50 ppm'. If the result is 'below 50 ppm', the transformer is labeled PCB-free with a green label. If the result obtained is 'above 50 ppm', the sample is sent to be tested in a lab using ***Gas Chromatography (GC) analysis***. If the result is 'below 50 ppm', the transformer is labeled PCB-free with a green label. If the result

obtained is 'above 50 ppm', the transformer is labeled with an orange label indicating the level of contamination.

The transformers that were visited were typically labelled with one of four types of labels, namely:

- Green Label: Indicates the absence of PCBs in the transformers.
- White Label: Indicates low risk of PCB contamination based on analysis of existing database entries.
- Orange Label: Indicates the presence of PCBs at the concentration indicated on the label based on results from laboratory testing.
- Written Note: Indicates that the transformer was inaccessible or could not be sampled. In some cases, the transformer could not be accessed because on the inability to disconnect it from electricity or because of the presence of major obstacles (trees, generators cables, etc.). In other cases, oil samples could not be collected from the transformer because of a defunct faucet or because no oil was found in the transformer.



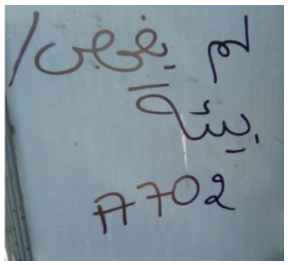


Table 9: Status of inventorying transformers in the power sector in Lebanon

Owner/Provider	Theoretical numbers			Actual numbers			
	# of trans-formers reported	# to be surveyed	# to be white labelled	Visited	Percent completed	Surveyed	White labelled
Aley Concession	199	90	109	213	Done	76	137
Bared Concession	10	10		10	Done	10	
Bhamdoun Concession	90	33	57	66	Done	22	44
Jbeil Concession	478	175	303	503	Done	164	339
Nahr Ibrahim Concession	18	16	2	19	Done	17	2
Qadisha Concession	2,048	2,046	2	2,299	Done	1,568	731
Qadisha Transmission				58	Done	58	
Qadisha Transmission-Aux				12	Done	12	
Zahleh Concession	850	311	539	872	Done	330	542
Concessions	3,693	2,681	1,012	4,052	Done	2,257	1,795
Beddawi Refinery	7	7		7	Done	7	
Litani River Authority	38	38		30	Done	30	
Military	99	99		22	22%	18	4
Private Companies	20	20			0%		
Zahrani Oil Installations	62	62		81	Done	81	
Public/Private Institutions	226	226		140		136	4
EDL Transmission	180	180		275	Done	275	
EDL Trans. Auxiliary				33	Done	31	2
Baouchrieh Depot	2,500	2,500		3,839	Done	2,899	940
Qartaba Depot				62	Done	62	
EDL Transmission/Depots	2,680	2,680		4,209	Done	3,267	942
BUS – Lot 1	7,196	4,579	2,617	5,937	82%	2,784	3,153
KVA – Lot 2	5,078	2,585	2,493	2,085	41%	844	1,241
NEUC – Lot 3	7,987	6,272	1,715	6,096	76%	3,848	2,248
EDL Distribution	20,261	13,436	6,825	14,118	70%	7,476	6,642
Total	26,860	19,023	7,837	22,519*	84%	13,136*	9,383

* The number does not include the 424 scrap transformers that were visited and surveyed towards the end of the project. During inventorying there were 40 duplicate transformers surveyed, hence the number of 22,559 in

The process of inventorying transformers in the power sector

Field visits to 22,983 transformers were undertaken, and of those, 13,560 were surveyed on-site, while 9,383 were white-labelled due to their low-risk of containing high levels of PCBs. Samples were collected from 12,011 transformers, while 1,549 transformers were inaccessible due to various reasons such as the inability to disconnect the unit from electricity, the presence of major obstacles (trees, generators cables, etc.), or because of a defunct faucet. Following screening and additional lab testing of 3,408 transformers, the transformers were confirmed to be either PCB-free (green label) or PCB-contaminated above 50 ppm (orange label with level of contamination clearly indicated). The process is illustrated in Figure 3 above.

As part of the inventorying process, the Project also surveyed 28 capacitors and sampled 33 drums of oil for a total 23,044 assets inventoried.

Figure 14 above.
**

Table 10: PCB-contaminated transformers recorded in the National Inventory – by owner

	Number of PCB Transformers	Total Weight (kg)
	Contamination >50 ppm	Oil and metal
EDL	921	1,164,048
Storage	264	290,578
Distribution Network	390	527,749
Transmission	16	131,350
Scrap Transformers	251	214,371
CONCESSIONS	459	567,531
Qadisha Concession	328	417,461
Storage	151	179,279
Distribution	171	211,439
Transmission	6	26,743
Zahleh Concession	86	104,235
Storage	8	9,333
Distribution	78	94,902
Jbeil Concession	25	29,085
Storage	2	2,113
Distribution	23	26,972
Aley Concession	5	5,545
Storage	4	3,495
Distribution	1	2,050
Nahr Ibrahim Concession	2	180
Distribution	2	180
Zahrani Refinery	6	1,880
Storage	2	620
Distribution	4	1,260
Litani Authority	2	1,315
Storage	2	1,315
Lebanese Army	5	7,830
Storage	5	7,830
EDL and Concessions (number and tons)	1,380	1,731,579

***Note*:** The actual inventory also includes 4 drums / tanks of PCB-contaminated oil with a total weight of 2,208 kg.

Table 11: Direct Project Beneficiaries

Site Name	Location	Site Type	Owner	Disposed PCB Material		Beneficiaries	
				Capacitors	Transformers	EDL Workers	Residents
Bauchrieh	Mount Lebanon	Storage Site	EDL	205	267	5	(160,000)
Ras Beirut	Beirut	Substation	EDL	93	0	3	
Adma	Mount Lebanon	Substation	EDL	35	0	4	
Deir Nbouh	North	Substation	EDL	12	0	4	
Gaz	Beirut	Substation	EDL	172	0	2	
Hazmieh	Mount Lebanon	Substation	EDL	11	0	3	
Jamhour	Mount Lebanon	Substation	EDL	78	4	5	
Jieh	South	Power Plant	EDL	0	1	228	5,000
Zouk	Mount Lebanon	Power Plant	EDL	0	10	256	200,000
Pins	Beirut	Substation	EDL	0	0	3	
TOTAL				606	282	513	205,000

Table 12: Overview of capacity building and actual client days of training

Capacity Building				Dates	# of Days	# of Partici-pants	# of females	Actual client days of training*	Actual female days	Agency	Type of Intervention from PMU
Meeting	Conference	Workshop	Training								
		Development of Project Action Plan		9/7/2015	1	7	3	7	3	PCB PMU	
	Launching Event of the PCB Project			1/9/2015	1	77	40	77	40	PCB PMU	
		Updating Inventory of Initial and New POPs		26/1/2016	1	21	10	21	10	MoE	Presentation on project
			Environmentally Sound Management of PCBs	1-3/3/2016	3	60	28	180	84	PCB PMU	
		Regional workshop on Hazardous Waste Management in the light of the experience of the Lebanese and Arab countries		6/4/2016	1	30	15	30	15	BCRC / MoE	Presentation on project

			Training for PMU Project Assistant on PCB Environmental Sound Management	20-24/6/2016	5	1	1	5	5	PCB PMU	
		Development of First Disposal Field Action Plan		18/7/2016	1	11	2	11	2	PCB PMU	
Introduction of PCB Project to National Higher Council of Environment				25/7/2016	1	17	5	17	5	MoE	Presentation on project
			Training for PW002 National Technical Supervisor on PCB Environmental Sound Management	26-27/9/2016	2	1	0	2	0	PCB PMU	
	9th International PCB Workshop			9-13/10/2016	5	2	2	10	10	PCB conference	Poster on project
			Technical training on environmental safeguard activities related	20/10/2016	1	23	3	23	3	Polyeco / PMU	

			to Disposal of PCB equipment and waste								
			Introduction to PCBs in open applications	29/11/2016	1	20	9	20	9	PCB PMU	
		Inventory of PCB Contaminated Equipment		23/2/2017	1	38	12	38	12	EDESSA / PMU	
Luncheon meeting on PCB Project for MoE employees				24/5/2017	1	40	20	40	20	MoE	Presentation on project
Hazardous Waste Storage Facilities and EDL Storage site of transformers				12/10/2017	1	12	4	12	4	PCB PMU / EDL	
			HAZWOPER Standard	27-29/11/2017	3	30	9	90	27	Polyeco / PMU	Presentation on project
			Works Procurement Management Course-A9010378	4-8/12/2017	5	1	1	5	5	International Training Center, ILO	
	10th PCB International Conference and 38th International			26-31/8/2018	6	1	1	6	6	PCB conference	

	Symposium on Halogenated Persistent Organic Pollutants (POPs) - Dioxin 2018										
	Persistent Organic Pollutants in Lebanon Conference			9-10/5/2019	2	100	2	200	4	USJ	Presentation on project
			Technical training on environmental safeguard activities related to Disposal of PCB equipment and waste	9/1/2020	1	9	0	9	0	Polyeco / PMU	
			Technical training on environmental safeguards related to inventory of scrap transformers	3-4/3/2020	2	6	1	12	2	ERI / PMU	
TOTAL					45	507	168	815	266		

SUMMARY OF PCB MANAGEMENT ACTION PLAN

Table 13: Short Term Strategy

Outcome	Activities	Timeframe	Tentative budget	Status at Project end
Prepare the storage sites	Ensure suitable concrete pad is available to store the contaminated transformers in Baouchrieh and Hraiche	2018 - 2019	$100,000	No funds made available yet
Treatment / destruction of the decommissioned PCB contaminated transformers	Prepare and launch the tender for the treatment / destruction of 226 tons of decommissioned PCB contaminated transformers stored in the Baouchrieh depot based on the available World Bank budget.	2018 - 2019	$800,000	Completed as part of the Project
	Prepare and launch the tender for the treatment/destruction of the 275 remaining tons decommissioned contaminated transformers stored in Baouchrieh/Behsas/Hraiche	2020	$952,000	Proposed in Phase 1 of new UNEP Project

Table 14: Medium Term Strategy

Outcome	Activities	Timeframe	Tentative budget	Status at Project end
Treatment of transmission transformers	Continuous dechlorination of transmission transformers. Each transformer would require a short treatment cycle of maximum week, due to the low contamination level, plus one week mobilization with a verification testing after two months	2020	$840,000	Considered in Phase 2 of UNEP MEDProgramme
Decommissioning of old PCB contaminated transformers	Dedicate temporary storage facilities suitable to receive old PCB contaminated equipment that were on the grid and more recent PCB contaminated that are in congested areas.	2020 - 2022		Not yet completed, but in progress
Treatment / destruction of the decommissioned PCB contaminated transformers	Prepare and launch the tender for the treatment/destruction of the old 462 transformers still on the grid	2020 - 2022	$2,100,000	Considered in Phase 2 of UNEP MEDProgramme

Table 15: Long Term Strategy

Outcome	Activities	Timeframe	Tentative budget
Decommissioning of all remaining PCB contaminated transformers	Decommission and place in a temporary storage facility all remaining 204 PCB contaminated equipment that were on the grid including newly identified transformers	2022 - 2024	
Treatment/destruction of the decommissioned PCB contaminated transformers	Launch the tender for the treatment/destruction of the 204 PCB contaminated transformers placed in the temporary storage facility	2025	$890,000

ANNEX 2. BANK LENDING AND IMPLEMENTATION SUPPORT/SUPERVISION

A. TASK TEAM MEMBERS

Name	Role
Preparation	
Maria Sarraf	Task Team Leader(s)
Lina Fares	Procurement Specialist(s)
Chaogang Wang	Social Specialist
Ruma Tavorath	Social Specialist
Suiko Yoshijima	Social Specialist
Supervision/ICR	
Qing Wang	Task Team Leader(s)
Lina Fares, Jocelyne Jabbour	Procurement Specialist(s)
Rock Jabbour	Financial Management Specialist
Marie A. F. How Yew Kin	Procurement Team
Chaogang Wang	Social Specialist
Katelijn Van den Berg	Team Member
Mohamed Adnene Bezzaouia	Environmental Specialist
Noushig Chahe Kaloustian	Social Specialist
Sanne Agnete Tikjoeb	ICR Lead Author

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	8.355	52,339.07
FY12	6.712	56,631.01
FY13	3.208	15,536.72
FY14	6.630	33,749.43
FY15	6.497	37,220.54
Total	**31.40**	**195,476.77**
Supervision/ICR		
FY15	.038	1,020.66
FY16	6.132	36,681.63
FY17	14.630	67,333.09
FY18	7.600	55,184.32
FY19	8.525	52,377.71
FY20	10.625	66,490.40
Total	**47.55**	**279,087.81**

ANNEX 3. PROJECT COST BY COMPONENT

Components	Amount at Approval (US$M)	Actual at Project Closing (US$M)	Percentage of Approval (US$M)
Component 1: Inventory of PCB contaminated transformers	0.79	1.0	127
Component 2: Disposal of high content PCB equipment and contaminated oil	1.10	0.75	0.68
Component 3: Capacity building and project management	0.65	0.79	120
Total	**2.54**	2.54	**100**

Parallel Financing: The counterparts were to provide parallel financing in the amount of US$4.7 million, provided by MoE (US$2.5 million) and EDL (US$2.2 million), respectively. At project end, US$745,000 was provided as in-kind support and US$1.75 was transferred from MoF to MoE in two successive transfers at the end of 2019 and beginning of 2020 for the site assessment of Bauchrieh. While the bidding process was completed in June 2020, the contract is pending clearance from the Court of Audit, as per the new 2020 government budget, and has therefore not yet been signed. The replacement of in-service transformers for the Jieh power plant was cancelled since a decision was made by the GoL to fully demolish the plant. Instead, the contribution by EDL paid for Service Providers (contracted by them already on previous contracts) to support the PMU team to carry out the inventory and provided access to in-service transformers (on the grid).

ANNEX 4. EFFICIENCY ANALYSIS

The efficiency analysis is divided in two parts: (a) economic analysis; and (b) implementation efficiency.

a. Economic efficiency

At the time of Project Preparation, a cost-effectiveness analysis was carried out for the disposal of PCB equipment, both in-service and out-of-service, and of contaminated oil. The lack of sufficient baseline data and the difficulty to identify the dose-response effect between exposure to PCBs and health outcomes prevented a cost-benefit analysis of the project. In this ex-post economic analysis, however, the ICR attempts to make a basic calculation of Project cost-benefits and conducts a CEA for out-of-service equipment and contaminated oil only since no in-service equipment was disposed of.

(i) Cost-benefits analysis

The project generated important occupational, local, and global benefits. Those benefits are best understood by looking at how local workers at the power plants have benefitted from improved occupational safety and health, how nearby communities have benefitted from reduced environmental exposure through their local water flow and food chains, and how the global environment has benefitted by reducing accidental exposure with the potential to release dioxins and furans in the atmosphere. In a counterfactual (but-for) scenario, where the Project was not realized, the following benefits might not have accrued:

- **Occupational safety and health:** The Project contributed to workers' occupational health and safety when working at the power plants and when directly handling PCB contaminated equipment and oil. Improved safeguards measures and availability of personal protective gear puts workers at lower risk of PCB exposure when handling contaminated equipment. Furthermore, the disposal of stored out-of-service equipment no longer pose a risk of leakage. Estimating the benefits to workers at the power plant is tangible yet challenging as research has shown that it is difficult to demonstrate a clear dose-response relationship with estimated cumulative PCB exposure. To assist in the economic analysis, the ICR looked at various research investigating the mortality among workers, who confer additional occupational exposure to PCBs on top of environmental exposure to PCBs.
    - Research is inconclusive about whether occupational PCB exposure leads to increased mortality or disability rates. A meta-study reviewing research on the correlation between occupational PCB exposure and mortality conclude that the evidence is inconsistent. The study looked at research on cancer mortality among workers exposed in three US and two European plants up to the ban of PCBs in the late 1970'es (EB et al., 2013). While the airborne exposure levels to PCB exceed current occupational threshold limits values by several orders of magnitude, research consistently find that overall cancer mortality rates were below national averages. Therefore, given the lack of clarity, and for the sake of this CBA, it is conservatively assumed that, at the very least, workers at the power plants and at the storage facility have the same environmental exposure to PCB as the local community.
- **Local community:** The Project contributed to local public goods by averting potential illnesses such as cancer and other detrimental health impacts arising from environmental exposure around the contaminated sites.

Local communities may be exposed by breathing air near sites where hazardous waste is stored and drinking contaminated ground water. PCB liquid leaking from transformers can enter the water flows and the food chain, which induces various adverse health effects in humans and animals. Environmental exposures to PCBs have been associated with liver, kidney, endocrine, and neurodevelopmental adverse effects. Furthermore, PCB exposures of vulnerable populations, such as pregnant women, infants, and children are of particular concern because of heightened sensitivity during this period of brain development. Project benefits, delivered through averted exposure, are difficult to quantify. To aid in the economic analysis, the ICR leans on a study from Sweden that investigates the mortality risk of community members with elevated levels of PCB in the blood.

  - A study in Sweden found that persistent organic pollutants were associated with an increased mortality risk (Lind et al., 2019). In a population-based cohort study of 992 individuals, 18 persistent organic pollutants were measured in plasma at two occasions. Elevated levels of highly chlorinated polychlorinated biphenyls (PCBs) were associated with increased mortality risk, mainly from cardiovascular diseases, during 10 years of follow-up. The study showed that the individuals with the highest PCB levels with many chlorine atoms in the blood had 50% excess mortality, especially from cardiovascular disease, compared with the other groups. Overall, elevated levels of PCB in the blood corresponded to 7 excess deaths during the 10-year follow-up period.

- **Global environment:** The project has provided global public goods by reducing the risk of accidental exposure to PCBs with the potential of forming dioxins and furans in the atmosphere. Lebanon faces the additional risk of accidents and air strikes, such as it was witnessed in the August 4th blast in 2020 and the targeted air strikes on the Jieh power plant in 2006. Such events as well as fire-related incidents involving electrical equipment can cause the PCB material to burn and to form and release dioxins and furans in the atmosphere, with serious impacts on the global population and environment. Quantifying the benefits in terms of saved clean-up costs is difficult, but research related to previous accidents show that the cost is exorbitant. To aid in the economic analysis, the ICR makes note of the following study.

  - A meta-analysis of two highly exposed cohorts in Japan and in Taiwan, China show that all-cause mortality, all cancers, lung cancer, and heart disease were elevated in the two populations following accidental exposure to PCBs through contaminated food sources (Li et al., 2015). Only two major events of food contamination by PCBs and PCDFs have occurred around the world: the Yusho event in Japan in 1968 and the Yucheng event in Taiwan, China in 1979.

Were the Project not to have taken place, it can be conservatively assumed that a similar project would be implemented sometime before 2028 to fulfill Lebanon's commitment to the Stockholm Agreement of eliminating all PCBs by that date. Were Lebanon to delay compliance beyond 2028 the Project benefits would be even greater.

Scope of Analysis

The primary quantifiable benefits of the project are assumed to be the prevention of the loss of productivity engendered by the excess mortality in the Lebanese workforce. Other lost productivity costs related to occupational exposure, such as disability-adjusted life years, other health-care costs related to environmental exposure, as well as clean-up related to accidental exposure, are not included in the analysis.

It can conservatively be assumed that there will be a period of approximately 10 years before the benefits of the project start to be felt as a 10-year longitudinal study was linked to levels of PCB stocks at the beginning of the period (Lind et al. 2019). Using 2020 as the baseline year to conduct the analysis, the benefits of the project would begin to accrue in 2030 (which approximately corresponds to the time by which Lebanon would eliminate all PCBs on its own) and end in 2040 (which approximately corresponds to the time by which the benefits of Lebanon eliminating PCBs on its own would be felt). A death in 2030 will result in the loss of annual GDP per capita in each year from 2030 to 2040; whereas a death in 2040 will result in the loss of annual GDP per capita for only 2040, the end of the horizon.

Real GDP per capita is estimated at US$7,584 in 2019. According to the World Bank economic prospects Lebanon will experience a sharp recession with a 20.3 percent drop in GDP in 2020 and a 9.5 percent drop in GDP in 2021. Forecasts for 2022 and beyond are not available given the high degree of uncertainty present in Lebanon. However, conservatively, it is assumed that starting in 2022, Lebanon returns to its pre-COVID-19 pandemic long-run real GDP growth rate of 2.5 percent., which was the average between 2005 and 2018. This conservatively assumes that Lebanon will not experience a so-called V-shape recovery and GDP losses resulting from the pandemic and other circumstances are permanent.

The estimated production losses are discounted to 2020 at the real rate of return of 6 percent. As an alternative, a real rate of return of 12 percent is applied as well.

Summary of Assumptions:

- GDP per capita in 2019: US$7,584 (World Bank data).
- Real GDP growth forecasts (-20.3% in 2020, -9.5% in 2021, and 2.5% in 2022 and beyond).
- The local community population is forecasted for each year from 2020 onwards (United Nations population forecast for Lebanon).
- Mortality rate of 0.7 percent among all Project beneficiaries:
    - 500 workers at EDL power plants;
    - 205,000 community members living near the Zouk and Jieh power plants.
- Benefits accruing from reductions in excess mortality begin 10 years after Project closure.
- A discount rate of 6 percent and 12 percent per annum.

Table 16: Cost-benefit analysis

Discount Rate	6%
Real GDP Growth Rate World Bank (Average 2(	2.50%
Annual Mortality Rate Workers	0.07%
Annual Mortality Rate Community	0.07%

Calendar Year	2020	2021	2022	(...)	2031	2032	2033	2034	2035	2036	2037	2038	2038	2038
Population of Lebanon (Thousands)	6,825	6,769	6,685	(...)	6,187	6,190	6,202	6,220	6,242	6,266	6,294	6,323	6,323	6,323
Population Growth Rate (UN Estimates)		-0.82%	-1.25%	(...)	-0.12%	0.05%	0.19%	0.29%	0.35%	0.40%	0.44%	0.45%	0.00%	0.00%
Beneficiaries														
Workers	500	500	500	(...)	500	500	500	500	500	500	500	500	500	500
Community	205,000	203,309	200,777	(...)	185,835	185,925	186,276	186,810	187,462	188,208	189,035	189,895	189,895	189,895
Real GDP Growth Rate	-20.30%	-9.5%	2.50%	(...)	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
Real GDP	$ 6,044.45	$ 5,470.23	$ 5,606.98	(...)	$ 7,002.35	$ 7,177.41	$ 7,356.85	$ 7,540.77	$ 7,729.29	$ 7,922.52	$ 8,120.58	$ 8,323.59	$ 8,531.68	$ 8,744.98
Number of Affected Workers					0	0	0	0	0	0	0	0	0	0
Number of Affected Community Members					130	130	130	131	131	132	132	133	133	133
Total					130	130	131	131	132	132	133	133	133	133
Cumulative Mortality in Workers					0	1	1	1	2	2	2	3	3	4
Cumulative Mortality in Community					130	260	391	521	653	784	917	1,050	1,183	1,315
					130	261	392	523	654	786	919	1,052	1,186	1,319
Social Cost					$ 913,346	$ 1,872,815	$ 2,881,495	$ 3,942,255	$ 5,057,779	$ 6,230,755	$ 7,463,919	$ 8,759,854	$ 10,115,921	$ 11,534,316
Discount Factor	1.00	0.94	0.89	(...)	0.53	0.50	0.47	0.44	0.42	0.39	0.37	0.35	0.33	0.31
Present Value of Social Cost					$ 481,139	$ 930,732	$ 1,350,957	$ 1,743,663	$ 2,110,434	$ 2,452,714	$ 2,771,834	$ 3,068,961	$ 3,343,443	$ 3,596,454

Total PV of Social Cost	$ 21,850,332
Total Cost of Project	$ 2,538,000
Net Present Value (NPV)	$ 19,312,332

Results

The analysis shows that the present value of Project benefits in 2020 is US$19.3 million (***Table 16***). The economic analysis shows that even using conservative assumptions, and only examining a subset of the overall Project benefits, the benefits of the Project far exceed its costs of US$2.54 million.

The Internal Rate of Return (IRR) of the project is positive. Applying a mortality rate of 0.07% per year the IRR is 20,9 percent, which is far more than either the 12 percent or the 6 percent required social return. ***Table 17*** summarizes the IRR under different assumptions for the mortality rate of workers and community beneficiaries.

Table 17: Internal rate of return

Mortality Rate	0.05%	0.06%	0.07%	0.08%	0.09%
IRR	18.4%	19.7%	20.9%	21.9%	22.8%

Conclusion

The economic analysis shows that quantifying only one dimension of the potential benefits previously discussed, namely the productivity loss linked to the reduction in excess mortality in the local community and in workers in direct contact with PCBs, even under very conservative scenarios, yields exceptionally large net positive social benefits. Relaxing some of the conservative assumptions would yield even greater benefits, such as: i) Some of the excess mortality could be reduced starting sooner than 2030; ii) extending the horizon window to a period greater than 10 years; iii) including permanent disability resulting from mental health disorders and other illnesses following occupational PCB exposure as having the same economic effects as excess mortality, and may even be a financial drain on households; iv) including the reduction in the probability of an accidental disaster that impacts the community beneficiaries as well as a wider regional population; v) if including the environmental clean-up cost linked to an accident; vi) deferring the cost of PCB elimination to a later date in compliance with the Stockholm Agreement; and vii) GDP growth is faster than assumed.

(ii) Cost-effectiveness analysis

CEA at Project preparation for out-of-service equipment: In the PAD, three options were considered as part of the cost-effectiveness analysis for disposal of out-of-service equipment: (i) building a stationary facility for treating hazardous waste; (ii) building a mobile waste incinerator and pretreatment facility, and; (iii) exporting and destroying the equipment in licensed facilities. The first two options were deemed not feasible for Lebanon, because of high costs and timing issues. For example, a stationary facility in Europe was estimated to cost about US$100 million and a mobile unit at least US$10 million. Furthermore, international experience showed that the expected time it would take to establish such a facility and begin operation was six to eight years.

The third option involved exporting and destroying the high-content PCB equipment by licensed facilities abroad according to the requirements of Basel Convention. The calculation for this option was based on the total cost of transformer preparation, drainage, packaging, transport, and destruction divided by the total by the weight of the equipment. Implementation of this option was calculated to be US$2,800/ton eliminated. This compared well to estimates for other countries, including US$4,200/ton in Moldova's POPs Stockpiles Management and Destruction Project and US$4,100/ton in China's PCB Management and Disposal Demonstration Project. Hence, the third option was chosen for the Project.

CEA at Project preparation for contaminated oil: In the PAD, two options were considered as part of the cost-effectiveness analysis for disposal of contaminated oil: (i) buying a dechlorination unit, or (ii) exporting and disposing in licensed facilities abroad. The first option involved purchasing a dechlorination unit, which would eliminate PCBs from oil based on sodium reduction technology. The CEA was based on the following estimates: dechlorination facility (US$700,000 if bought and US$1,400/day if rented), draining and packaging (US$100/ton), treatment (US$400/ton), storage tanks (US$11,000/tank), and possibly a storage site (US$200,000). The treated oil could then be sold as fuel with a market value of US$500/ton. Thus, the option of buying the dechlorination unit to decontaminate 100 tons of PCB oil would cost about US$7,300/ton of oil (with no storage site) or US$9,200/ton (with storage site if needed).

The second option involved draining PCB transformers and shipping and destroying the contaminated oil abroad. The estimated cost of US$2,900/ton eliminated was obtained by dividing the total disposal cost (drums, pumps, pellets, drainage, shipment, and disposal) by the weight of contaminated oil. A comparison among the two estimates showed that exporting and disposing of the contaminated oil abroad was the most cost-effective option. A similar conclusion was reached in the COWI 2011 study, which suggested that buying a dechlorination unit would only be cost-effective for quantities larger than 300 tons.

CEA at Project completion: An ex-post cost-effectiveness analysis of PCB elimination by type was undertaken at Project completion for the first and second export separately. ***Table 18*** summarizes the cost of eliminating different types of PCB under Component 2. In the first export, a total of 18,750 kilos of PCB-contaminated transformers were destroyed at a unit cost of US$2.46 per kilo. The unit cost of elimination for soil, capacitors, and waste was US$2.57 per kilo for the 29,040 kilos exported. Finally, 43,210 kilos of contaminated oil was eliminated for an overall cost of US$116,235 at US$2.57 per kilo.

In the second export, the unit cost per kilo was significantly lower. For transformers, the 235,270 kilos cost US$ 452,201 to eliminate at a unit of US$1.726 per kilo. Contaminated soil, capacitators, and waste also cost US$1.726 to eliminate, and contaminated oil was eliminated at a cost of US$ 1.752 per kilo. The higher efficiency is explained in part by the fact that the larger quantity offered economies of scale, in part by savings related to the elimination of out-of-service equipment only without the need to move in-service equipment off-grid and transported to Bauchrieh, and in part by the fact that the winning bid for the second contract was from the same operator that had carried out the first export and who made a competitive offer building on the previous experience and know-how obtained.

Table 18: Cost of PCB eliminated (Component 2)

PCB eliminated	First Export			Second export			Combined (weighted average)		
	Weight	US$/Kg	Cost	Weight	US$/Kg	Cost	Weight	US$/Kg	Cost
Transformers	18,750	2.46	46,125	235,270	1.726	406,076	254,020	1.780	452,201
Soil/Capacitors/Waste	29,040	2.57	74,633	57,450	1.726	99,159	48,580	2.586	125,643
Oil	43,210	2.69	116,235	5,370	1.752	9,408	86,490	2.009	173,792
Total Cost (US$)			**236,993**			**514,643**			**751,636**

To assess the cost-effectiveness, a weighted calculation of the combined cost per kilo per type of PCB eliminated is compared with the appraised estimate as well with other Bank projects of a similar nature. For the sake of the analysis, it is assumed that the appraisal estimate for out-of-service transformers of US$2,800/ton eliminated is

inclusive of or the same as for soil, capacitors, and waste since the PAD does not make a distinction between those categories.

The analysis shows that the Project was highly efficient compared with the appraised cost estimates. In ***Table 19,*** it is demonstrated that for all categories the actual cost per type of PCB eliminated is lower than the appraised value. For transformers, the actual cost of US$1,780 per ton eliminated is 36% lower than the appraised estimate of US$2,800. For soil, capacitor, and waste, the actual cost and appraised estimate are closer as the US$2,586 per ton eliminated is 8% lower than the appraised US$2,800 estimate. Finally, for contaminated oil, the actual cost of US$2,009 per ton eliminated is 31% lower than the US$2,900 appraisal estimate.

Table 19: Cost-effectiveness of actual to appraised cost per tons of PCB eliminated

PCB eliminated	Appraised unit cost	Actual (weighted) unit cost
	US$/ton	US$/ton
Transformers	2,800	1,780
Soil/Capacitors/Waste	2,800	2,586
Oil	2,900	2,009

As a reminder, Project efficiency also compares favorably to other Bank projects. This includes the Moldova POPs Stockpiles Management and Destruction Project in which the cost per ton of PCB eliminated was US$4,200, and to the China PCB Management and Disposal Demonstration Project, where each ton of eliminated PCB cost US$4,100.

b. Implementation efficiency:

- **Project design and implementation arrangements:** The Project design itself facilitated efficiency through simply structured components with a high degree of internal complementarity that were based on solid analysis at the preparation stage. The economic analysis in the PAD ensured an efficient allocation of resources by pointing to the least cost option of exporting PCB to be destroyed abroad. Through a competitive bidding process, the Project was able to eliminate an additional 89 tons of PCB at an overall lower component cost than estimated. Meanwhile, other parts of the implementation arrangements obstructed efficiency. Specifically, the lengthy procedures to transfer funds from the MoF to the MoE and the reputational risks to the GoL and the World Bank caused by the delay in accessing project funds (see Section III.B(a)).

- **Comparison of actual and appraised component costs:** Annex 3 compares actual cost to appraisal estimates by component. It shows that Component 1 was financed at 127 percent of the appraised value. The increased cost was due to the higher number of transformers to be included in the inventory as the PMU learned of the existence of more transformers. In contrast, component 2 cost only 68% of the appraised value due to efficiencies gained from economies of scale and from a beneficial development of the exchange rate. Actual expenditures under Component 3 reached 120% of the appraisal estimate. As discussed in Section III.B.(a), the Project was able to gap-fill certain activities, such as the development of a draft decree to improve regulation on PCB management. Overall, the dedicated PMU was able to overcome these inefficiencies to prevent any negative impact on Project outcomes.

- **Time and cost overruns:** While the Project were extended twice, the overall extension period was less than a year and did not incur any cost overruns. The nine-month extension of the Project closing date allowed for the realization of planned outcomes and the overachievement of original targets.
- **TTL turn-over**: The high turnover of task team leadership does not appear to have reduced efficiency.

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

The PMU was involved in the preparation of the ICR and its comments and suggestions have been fully considered. MoE also highly appreciated the Bank's full support and dedicated technical assistance to the country for successful implementation of the Project and preparation of the ICR. The draft ICR was shared with the MoE on August 3, 2021 and MoE confirmed that it had no further comments.

ANNEX 6. SUPPORTING DOCUMENTS

Project Documents:

- Project Appraisal Document dated October 29, 2014 (Report No. PAD149)
- GEF Grant Agreement dated February 16, 2015 (GEF Grant No. TF018030)
- Environmental and Social Impact Assessment. Prepared by the Ministry of Environment, Lebanese Republic. Revised September 2015 (Report No. SFG1432)
- Implementation Status and Results Reports, sequence 1-9.
- Mission aide memoires and management letters
- Mid-Term Review
- Restructuring Paper dated December 2020 (Report No. RES44925)
- Restructuring Paper approved June 15, 2020 (Report No. RES42051)
- Emergency Response Procedures Bauchrieh Maintenance and Storage Site. Prepared by MOE.

Other Documents:

- Country Partnership Framework for the Lebanese Republic FY17-22 (Report No. 75814-LB)
- Country Partnership Strategy for the Lebanese Republic FY11-14 (Report No. 54690-LB)
- New Follow-up GEF-7 POPs and Hazardous Waste Management

Video Material:

- *Lebanon Starts to Get Rid of Persistent Organic Pollutants that Endanger Environment and Health.* World Bank (2017). Link: *https://www.worldbank.org/en/news/feature/2017/05/12/lebanon-starts-to-get-rid-of-persistent-organic-pollutants-that-endanger-environment-and-health*

Scholarly Articles:

- Satterthwaite, David. "*The Links between Poverty and the Environment in Urban Areas of Africa, Asia, and Latin America*." The Annals of the American Academy of Political and Social Science 590 (2003): 73-92. Link: *http://www.jstor.org/stable/3658546*.
- Lind PM, Salihovic S, Stubleski J, Kärrman A, Lind L. *Association of Exposure to Persistent Organic Pollutants With Mortality Risk: An Analysis of Data From the Prospective Investigation of Vasculature in Uppsala Seniors (PIVUS) Study*. JAMA Netw Open. 2019;2(4):e193070. doi:10.1001/jamanetworkopen.2019.3070
- Li, Ming-Chieh, et al. "*Mortality after exposure to polychlorinated biphenyls and polychlorinated dibenzofurans: A meta‐analysis of two highly exposed cohorts.*" International journal of cancer 137.6 (2015): 1427-1432.
- EB, Pedersen & Jensen, Allan & P, Jacobsen & Brauer, Charlotte & Gunnarsen, Lars & Meyer, Harald & Ebbehøj, Niels & Bonde, Jens Peter. (2013). *Risk of disease following occupational exposure to Polychlorinated Biphenyls (PCBs)*.

Certificate of Elimination from TREDI Saint Vulbas dated July 31, 2017

CERTIFICATE OF ELIMINATION FOR NOTIFICATION: LB 2016/2987/B

ISSUED BY : TREDI
Parc Industriel de la Plaine de l'Ain
BP 55, 01150 SAINT-VULBAS – France
Laurent CARMONA
Phone: +33 4 74 46 22 10, Fax: +33 4 74 61 57 27

Waste Generator: Ministry of Environment of Lebanon
EWC Codes: 17 09 02*, 13 03 01*, 16 02 09*
Transformers, capacitors, solids and liquid wastes contaminated with PCB
Waste Treatment Code: D10
Total Weight: 91.670 tons
Movement Forms : 1, 2, 3, 4 and 5 **with Notification:** LB2016/2987B

29,29 tons - oily liquids contaminated with PCBs
18,91 tons - transformers contaminated with PCBS
35,44 tons - capacitors contaminated with PCBs
8,03 tons - solids contaminated with PCBs

Treatment Date:

Transport 1:	13.07.2017
Transport 2:	13.07.2017
Transport 3:	13.07.2017
Transport 4:	13.07.2017
Transport 5:	20.04.2017

This Certificate confirms that the waste specified above has been disposed in an environmentally sound manner at the TREDI Saint Vulbas site, in accordance with the Base Convention and all statutory permits and regulations in force at the facility.

Issued at TREDI

July 31, 2017

Manager of the Plant

Laurent CARMONA

Certificate of Elimination from TREDI Saint Vulbas dated December 1, 2020

Trédi
Séché global solutions

CERTIFICATE OF ELIMINATION FOR NOTIFICATION: LB 2019/4171/B

ISSUED BY:	TREDI Parc Industriel de la Plaine de l'Ain BP 55, 01150 SAINT-VULBAS - FRANCE Tel. : +33 4 74 46 22 10 Fax : +33 4 74 61 57 27

Waste Generator: Ministry of Environment of Lebanon
EWC Codes: 15 02 02*, 16 02 09*, 16 02 10*, 13 03 01*, 17 09 02*
Transformers, capacitors, solids and liquid wastes contaminated with PCB
Waste Treatment Code: D10
Total Weight: 298,300 tons
Movement Forms: 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 with
Notification : LB 2019/4171/B

57,460 tons – oily liquids contaminated with PCBs
235,470 tons – transformers contaminated with PCBs
5,370 tons – solids contaminated with PCBs

Treatment date:

Transport 3 : 24/11/2020	Transport 9 : 28/11/2020	Transport 15 : 27/11/2020
Transport 4 : 26/11/2020	Transport 10 : 26/11/2020	Transport 16 : 27/11/2020
Transport 5 : 28/11/2020	Transport 11 : 28/11/2020	
Transport 6 : 27/11/2020	Transport 12 : 28/11/2020	
Transport 7 : 31/07/2020	Transport 13 : 27/11/2020	
Transport 8 : 28/11/2020	Transport 14 : 28/11/2020	

This certificate confirms that the Waste specified above has been disposed in an environmentally sound manner at the TREDI Saint Vulbas site, in accordance with the Basel Convention and all statutory permits and regulations in force at the facility.

Issued at TREDI, date : 01/12/20

Manager of the Plant

Frédéric HUMMEL

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SA au capital de 20.000.000 Euros - R.C.S. Bourg en Bresse B 338 185 762