**RE-385**

# *Ex post evaluation of mitigation measures in the Samalayuca II and Monterrey III thermal power generation projects*

*Office of Evaluation and Oversight, OVE*

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## ACRONYMS

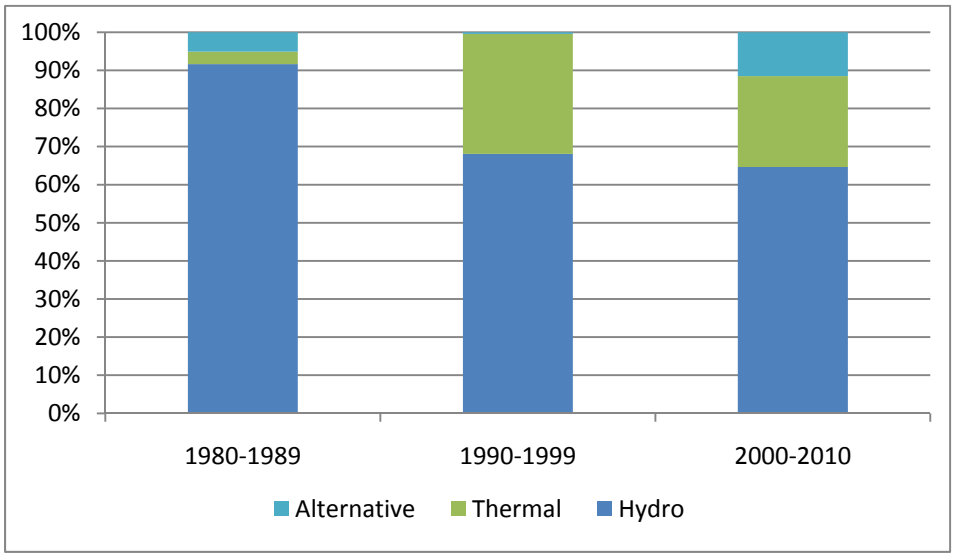
| | |
|---|---|
| CFE | Comisión Federal de Electricidad [Federal Electricity Commission] |
| EBRD | European Bank for Reconstruction and Development |
| EIA | Environmental impact assessment |
| EIM | Environmental impact manifest |
| ESIR | Environmental and social impact report |
| EIM | Environmental impact manifest |
| OVE | Office of Evaluation and Oversight (IDB) |
| PRI | Private Sector Department |
| SEMARNAP | Secretaría del Medio Ambiente, Recursos Naturales y Pesca [Ministry of the Environment, Natural Resources, and Fishing] |
| SEN | Sistema Eléctrico Nacional [National electricity system] |

# I. INTRODUCTION

## A. Scope and objectives of the study

1.1 Bank financing for **thermal power generation projects** grew steadily from 3% of total funding for power generation in the 1980s to 31% in the 1990s (US$535 million), and has accounted for 24% (US$1 billion) since 2000 (see Figure 1). As a counterpart, hydroelectric projects received relatively less support in the 1990s, and investment in this type of project has recovered only since 2005.

**Figure 1. Amount of power generation projects approved, 1980-2010**




*Source: OVE, 2008*

1.2 **The Bank has not performed any environmental impact assessments on approved power generation projects.**[1] As part of the 2007-2008 Work Plan, the IDB's Office of Evaluation and Oversight (OVE) decided to **evaluate the environmental quality control process in Bank operations with environmental**

[1] The Bank's Environment and Safeguards Compliance Policy (document GN-2208), approved in 2006, defines environmental protection as one of its four priority actions. In 2003 the Private Sector Department (PRI) systemized a number of internal guidelines for the supervision and environmental and social monitoring of projects, applied mainly in semiannual reviews (SARs) and in independent environmental social, health, and safety (ESHS) audits during the lifetime of the PRI loan or guarantee. Project completion reports (PCRs) also contain information on environmental and social performance.

**impacts**, starting with a pilot study in the energy sector.[2] With the aim of generating methodologies for the ex post evaluation of environmental mitigation measures in this type of project, OVE selected two thermal power generation projects for an in-depth evaluation of the Bank's environmental supervision and monitoring process: the thermoelectric power generation plants Samalayuca II (managed by the Federal Electricity Commission (CFE)) and Monterrey III (operated by Iberdrola Energía Monterrey), both in Mexico.[3]

1.3 In the case of Samalayuca II, the Bank only provided technical support to the CFE during the design stage until the loan was approved by the Board of Executive Directors (review of environmental impact assessment (EIA) documentation submitted by the borrower and preparation of the environmental and social impact report (ESIR)). In the Monterrey III project, in addition to providing support during the design stage, the Bank also continued to monitor environmental issues for two years (through semiannual status reports produced by external consultants and validated by the Bank's Private Sector Department staff).

1.4 **The aim of this ex-post evaluation is to compare the results of measures to prevent, mitigate, or offset the environmental and social impacts caused by the Samalayuca II and Monterrey III thermal power generation projects**, based on the environmental and social management indicators and programs contained in the operations' design documents (EIA and the Bank's validation documents) and in the monitoring reports produced by the power generation firms.

## B. Description of the Samalayuca II and Monterrey III thermoelectric power plants

### 1. Monterrey III thermoelectric power plant

1.5 The project undertaken by Iberdrola Energía Monterrey consists of a power plant with four generating units of 285 MW each, using **gas-fired combined-cycle technology**. Half of the electricity generated is sold to the CFE, while the other half is used to supply the needs of industry located in Monterrey.

1.6 The Monterrey III thermoelectric plant is located in the municipio of Pesquería in the state of Nuevo León, 2 km east of the Monterrey metropolitan area, adjacent to the community of Dulces Nombres (see Figure 2). The project began in May 2000, and commercial operations came on line in April 2002.

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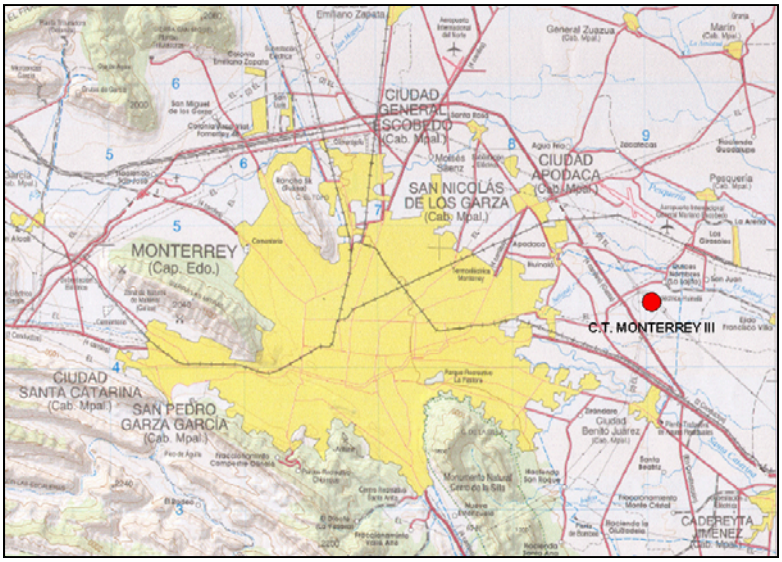
[2] See OVE, 2008. *OVE's Environmental Performance Review applied to the Energy Sector*. Inter-American Development Bank. Washington, D.C. This pilot study takes a sample of 22 infrastructure projects in the electricity sector, for which a desk review is undertaken of the quality of ex ante documentation available to the Bank to verify the environmental viability of the bank-financed operations using a qualitative checklist.

[3] Among the sample of 22 infrastructure projects, a hydroelectric power generation project was also analyzed in the energy sector pilot study. See OVE, 2008. Evaluación ex-post del impacto de las medidas de mitigación ambiental en el proyecto hidroeléctrico Porce II [Ex post impact evaluation of environmental mitigation measures in the Porce II hydroelectric project]. Inter-American Development Bank.

**Figure 2. Location of the Monterrey III thermoelectric power plant**




*Source: OVE, 2008*

1.7 The industrial boom in the state of Nuevo León spawned a surge in the number of industries located in Monterrey and nearby municipios. **The electricity rates policy contributed to high-consumption plant designs**, while **low gasoline prices** drove rapid, unrestricted growth in the vehicle fleet. These two factors are responsible for the current state of air pollution in the basin of the Monterrey metropolitan area. To alleviate the area's air pollution problems, the Monterrey Metropolitan Air Quality Management Program of 1997-2000 was developed (published by the Ministry of the Environment, Natural Resources, and Fishing (SEMARNAP) and the Government of the State of Nuevo León, 1997) to take preventive and corrective measures to mitigate air pollution. The municipio of Pesquería, where the Monterrey III project is located, adjoins the metropolitan area, specifically the municipios of Apodaca, Guadalupe, and Juárez.

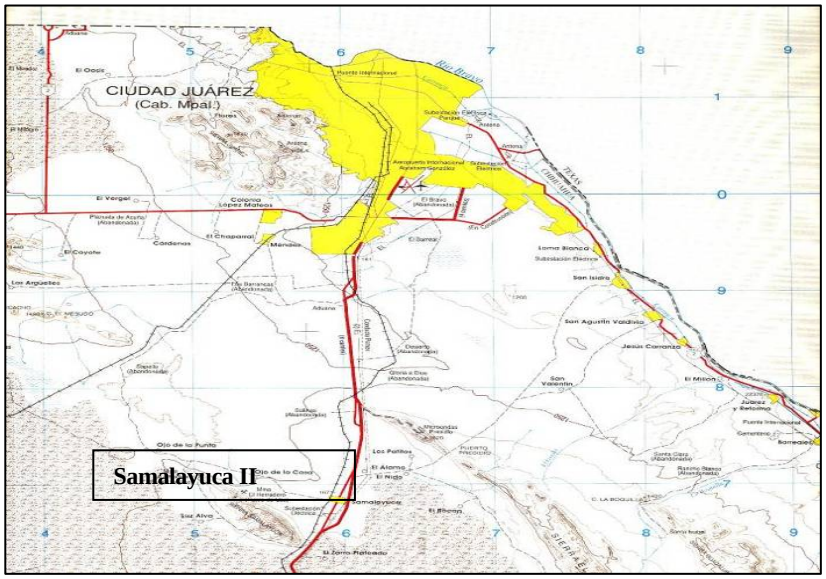
1.8 The environmental impact manifest (EIM) for Monterrey III was submitted to the authorities and approved by the Directorate General of Ecological Management and Environmental Impact of the National Ecology Institute (INE) in December 1999. The EIM and the project certificate specify a number of measures to mitigate and control the adverse environmental impacts identified for the various stages of its execution.

1.9 In the first half of 2000, the Bank requested several additional requirements from Iberdrola in order to ensure the project's environmental feasibility; and this resulted in supplementary studies and new mitigation measures being developed, as described in the project's ESIR.

## 2. Samalayuca II thermoelectric power plant

1.10 The Samalayuca II CFE-operated power plant came on line on 9 January 1999, with an installed capacity of 505.8 MW, three generating units of 168.6 MW each, for a total generating capacity of 4,393.62 GWh/year (figure for 2005). The Samalayuca II combined-cycle thermoelectric plant is located 800 m from the community of Samalayuca and roughly 43 km to the south of Ciudad Juárez, Chihuahua (Figure 3). The land owned by the CFE also contains the Chihuahua III power plant (a gas-fired combined-cycle thermoelectric plant operated by the independent energy producer Transalta) and the Samalayuca I plant (an oil-fired thermoelectric plant also operated by CFE, which shares resources with Samalayuca II).

**Figure 3. Location of Samalayuca II**




*Source: OVE, 2008*

1.11 Ciudad Juárez has an air quality management program, known as PROAIRE. According to the emission inventory for 2002, the main air pollution sources in the city are the transportation sector (58% of the total), industry (21%), vegetation and soils (11%), and commerce and services (10%). The main types of pollutants generated include 10 µm particulates ($PM_{10}$), nitrogen oxides ($NO_x$), total organic compounds and carbon monoxide (CO), caused mainly by the transportation sector; followed by sulfur dioxide ($SO_2$) caused mainly by electric power generation, although the sector also generates a quarter of all $NO_x$.

1.12 In the case of Samalayuca II, a community is less than 1 km away, with 804 inhabitants who earn their living from subsistence farming. The power plant was constructed on the same site as Samalayuca I, in the rural area of the state of Chihuahua. The vegetation of this zone is considered fragile (desert scrub and

grasslands with a high tolerance for high salt concentrations); but no threatened fauna or flora species have been reported.

### 3. Comparability criteria

1.13 Monterrey III and Samalayuca II have a number of similarities, including:

a. Electric power generation technology (combined-cycle),

b. Type of fuel used (natural gas),

c. Proximity to critical areas for air pollution (Samalayuca II close to Ciudad Juárez and Monterrey III just outside the Monterrey metropolitan area),

d. Semiarid climate in the surrounding areas,

e. Shortage of natural water supply sources,

f. The two power plants are virtually contemporary (Samalayuca II began operations in early 1999; Monterrey III in 2002).

1.14 The main features and differences between the two power plants are summarized in the following table:

**Table 1. Features and differences of the Monterrey III and Samalayuca II power plants**

| Feature | Monterrey III | Samalayuca II |
|---|---|---|
| Power generating capacity | 1,140 MW | 505.8 MW |
| Plant operation | Iberdrola (Spanish-owned independent energy producer) | Federal Electricity Commission (CFE) (decentralized federal public agency) |
| Supply of process water | Treated water (SADMON treatment plant) | Natural groundwater (deep wells authorized by CONAGUA) |
| Fuel used | Natural gas | Natural gas (and diesel for ignition) |
| Environmental compliance guidelines | Mexican legislation, CFE requirements, augmented by Bank requirements and monitoring (first two years of operation only) | Mexican legislation and CFE requirements, plus Bank requirements during the design phase only [4] |
| Environmental management system | System abides by the ISO-14001 model for all Iberdrola plants. | CFE's own system, with incentives operating through competition between plants to obtain budgets for improvement if they display good performance on certain environmental and industrial safety indicators. |

[4] Summarized and validated by the Bank in the ESIR and by the environmental clauses in the loan document.

| Feature | Monterrey III | Samalayuca II |
|---|---|---|
| Documents verifying environmental compliance | Clean industry certificate issued by PROFEPA (since 5 October 2004) and ISO-9001 certificates (awarded by IQNet & AENOR from 17 November 2005 to 17 November 2009) and ISO-14001 (awarded by IQNet & AENOR from 17 October 2005 to 17 October 2008) | In process of obtaining the clean industry certificate (April 2008) |
| Works and services assigned for environmental compliance | Purchase order request | Subject to the Law on Public Works and the Law on Procurements, Leases, and Services (tenders) |
| IDB environmental monitoring | Yes (during construction and for two years during the operating phase) | No, there were only requirements in the design phase (ESIR and loan document) |

*Source:* OVE, 2008

## C. Electric power generation in Mexico

1.15 The CFE is Mexico's public agency responsible for the planning, generation, transformation, distribution, and supply of electric energy nationwide. There are also a number of independent producers which are required sell much of the electricity they generate to the CFE.

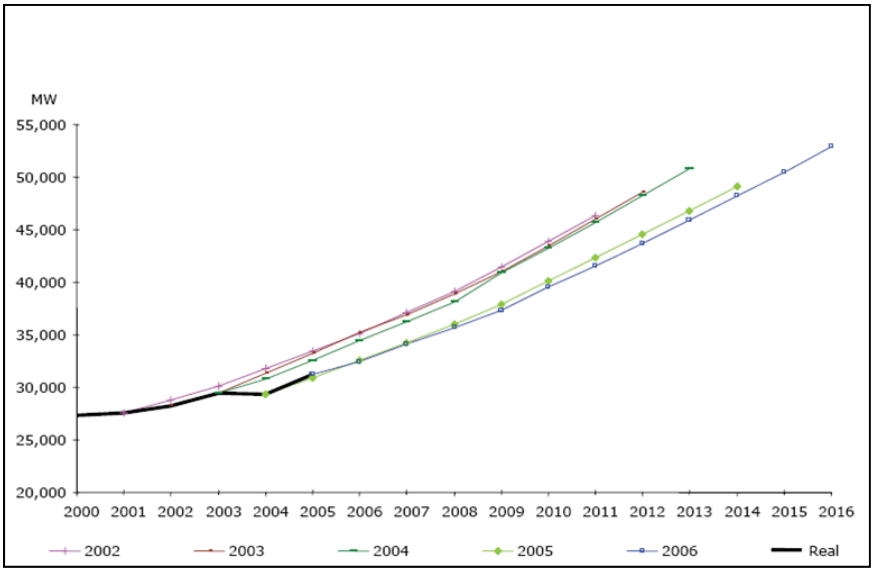
1.16 **Installed power generation technology is dominated by thermoelectric plants** (48.55%) **and hydroelectric plants** (22.53%); independent producers generate 18.10%, while the rest is divided between coal-fired power generation (5.70%) and small proportions of nuclear, geothermal, and wind power (2.99%, 2.11%, and 0.005%, respectively). Of the 48.55% corresponding to thermoelectric power generation, 10.8% is produced in combined-cycle plants run by the CFE, 17.7% is produced in combined-cycle plants operated by independent producers, and 5.6% is produced by turbogas.[5]

1.17 To project future electricity supply and demand, the CFE designed the Programa de Obras e Inversiones del Sector Eléctrico [Electricity Sector Works and Investments Program], which is reviewed annually for the comprehensive planning of the SEN. **The two thermoelectric power plants under study were designed in response to an expected increase in energy demand.** Between 2006 and 2009, there were high energy reserve margins, since in recent years, demand growth has been less than expected as a result of economic development below government projections, and

[5] Given the importance of power generation technologies that use natural gas in the effective capacity of the National Electricity System (SEN), and given the possibility high prices for natural gas in the future or shortages owing to a reduced supply from Petróleos Mexicanos (PEMEX) or imports from United States, the CFE has built liquefied natural gas (LNG) re-gasification terminals to diversify its supply sources. The terminals of Altamira, Costa Azul, and Manzanillo will in the future provide 1.25 billion cubic feet of natural gas per day; but this capacity could increase, depending on the supply of natural gas from PEMEX through the national gas pipeline network.

the difficulty of making short-term adjustments to the generation program.[6] The current forecast of maximum gross demand in the SEN continues to trend downward, along with GDP and sales. Figure 4 compares demand growth projections and actual demand beginning in 2000.

**Figure 4. Comparison of maximum gross demand projections, National Interconnected System**



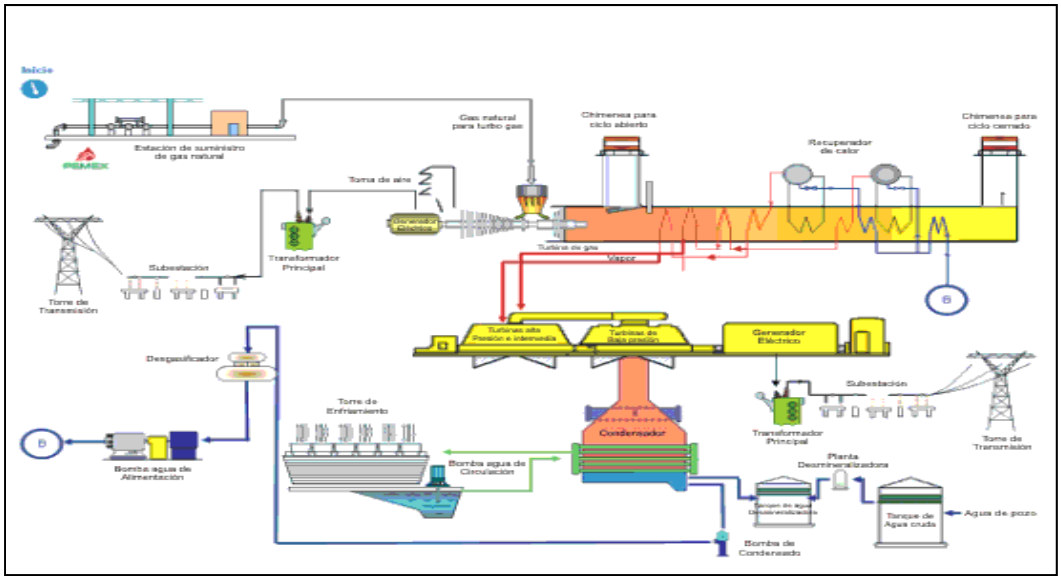

*Source: National Electricity System (SEN), 2008*

## D. Combined-cycle thermoelectric power generation using natural gas

1.18 **Combined-cycle power plants are a power generation alternative with key advantages of high efficiency, greater power generation, less pollution, and great flexibility.** Their major disadvantage is complex technology, because they combine two types of generating units: turbogas and steam. Once the power generating cycle has ended in the turbogas units, the high-temperature exhaust gases are used to heat water into steam, which is then harnessed to generate additional electric power. Combining these two types of generation optimizes fuel use and achieves the greatest thermal efficiency of all types of thermoelectric power generation. Figure 5 shows a model profile of a combined-cycle power plant.

[6] Economic growth was below the historic trend between 2001 and 2005, because the residential, trade, and large-scale industry sectors did not meet their growth expectations.

**Figure 5. General profile of a combined-cycle technology thermoelectric power plant**




*Source: Federal Electricity Commission*

1.19 Both nationally and internationally, the Mexican electricity sector is considered to make intensive use of resources and the environment, with **the main concerns being air pollution and greenhouse gases.** In environmental terms, particularly in relation to air pollution, the main pollutant produced by the combined-cycle technology is the emission of nitrogen oxides ($NO_X$) into the atmosphere, while emissions of other pollutants such as particulates and sulfur dioxide ($SO_2$) are negligible given the type of fuel used (natural gas).

1.20 In 2006, the Centro de Investigaciones Biológicas del Noroeste [North West Biological Research Center], based in La Paz, Baja California Sur, Mexico, made an overall assessment of the environmental impact of the electricity sector in northern Mexico.[7] This included a review of the EIA process and the content and format of environmental impact reports on electric power projects implemented since 1970. Although the assessment acknowledged that improvements had been made in the EIA practice over the course of those years, it also drew attention to the key challenges to be faced in the future. The study criticizes the reductionist approach of the EIAs reviewed (most of them focus on biophysical aspects); and it recommends deeper analysis of social and economic considerations in the projects' areas of influence, taking account of the specific features of northern Mexico, such as the high concentration of electric power plants and industries in highly sensitive ecosystems. It also points out the need to develop specific guidelines for undertaking EIAs for different types of electric power projects, covering all phases

[7] Evaluación de impacto ambiental del sector eléctrico en el norte de México: evolución histórica e implicaciones para la sostenibilidad [Environmental impact assessment of the electricity sector in northern Mexico: historical trend and sustainability implications]. Centro de investigaciones biológicas del Noroeste, La Paz, Baja California Sur. *Economía, Sociedad y Territorio*. Vol. 6, No. pp. 219-263.

of the project cycle. Lastly, the study stresses the need to improve methodologies to support the results of environmental and social assessments.[8]

1.21 A theoretical analysis of the contribution made by thermoelectric power plant emissions to the greenhouse gas effect in Mexico, compared to other power generation alternatives (hydroelectric, wind, solar, nuclear, etc.) is beyond the scope of this study. Nonetheless it can be said that **the use of natural gas (clean fuel) and the installation of state-of-the-art (combined-cycle) power generation technology are considered beneficial and appropriate in climate change and global warming theory,** since both help to reduce rates of carbon dioxide ($CO_2$) emission into the atmosphere per unit of energy produced (MW) compared to the use of traditional fuels such as diesel and coal.

1.22 This was confirmed by the Bank's Private Sector Department (PRI), which performed a preliminary analysis of the carbon footprint of its project portfolio in the power generation sector. Using the methodology developed by the Intergovernmental Panel on Climate Change,[9] the study reaches a number of general conclusions on the Bank's portfolio. In relation to the two thermoelectric plants considered in this ex post OVE environmental assessment (Monterrey III and Samalayuca II), the study concludes that **their emissions are within the typical range for power plants using clean fuels (natural gas) and advanced (combined-cycle) technology.** These thermoelectric projects have low ratios of carbon emissions with respect to electricity generated, producing a marginal improvement in the overall carbon intensity of Mexico's electricity network. The study also concludes that carbon dioxide emissions are comparable, in relation to the total cost of the projects in the PRI portfolio, to those of the portfolio of European Bank for Reconstruction and Development (EBRD).

## II. ENVIRONMENTAL ASSESSMENT OF THE PROJECTS

2.1 This section describes OVE's environmental assessment of the Samalayuca II and Monterrey III thermoelectric projects. Firstly, it analyses the desk review of the quality of the ex ante documentation available to the Bank to verify both projects' environmental viability. It then defines the environmental components and evaluation criteria used for the ex post evaluation of the mitigation measures.

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[8] For the sample of thermoelectric projects included in the study, the main methodologies used were the Leopold matrix and other checklists, which this study considers highly subjective.

[9] With data on the fossil fuel carbon content of the projects and the composition of the national power generation network.

## A. Desk review

2.2 **Based on international best practices,[10] OVE prepared a qualitative checklist to evaluate the quality of the environmental information contained in the Bank's reports.** The checklist includes 27 questions covering five sections: (1) description of the project; (2) description of the local environment and the baseline conditions; (3) identification and evaluation of key impacts; (4) alternatives and mitigation of impacts; and (5) evaluability issues. This desk review analyzed whether the information available is sufficient, correct, and technically sound; whether it is consistent with good practices accepted in environmental assessments, and whether the mitigation measures and their associated monitoring systems are well-defined.[11]

2.3 The checklist was applied to a sample of 22 energy projects (hydroelectric, thermoelectric, transmission lines) in the public and private sectors, including Samalayuca II and Monterrey III.[12] These are part of the 10 thermoelectric power plants in the sample financed by the Bank's private sector window.[13] The fact that all of them obtained similar scores corroborates the solid results of efforts made to standardize the level of evaluation being undertaken by the PRI.[14]

2.4 In the **analysis of the Samalayuca II and Monterrey III projects**, several differences were found in the environmental information validated by the Bank prior to their approval. For section one of the checklist, the Bank's environmental reports provided better information on the project implementation schedule (question 1.2) for Samalayuca II than for Monterrey III. It was not possible to obtain plant situation maps in the case of Monterrey III (1.3), although they were mentioned in the document. In contrast, the description of waste and emissions generated (1.5) is better for Monterrey III than for Samalayuca II. The cumulative impact of the plant in relation to the industrial facilities present in the zone before project construction (1.9) is much more detailed for Samalayuca II, which even provides quantitative data, unlike the case of Monterrey III. On the other hand, information on consultations with the affected population (1.10) is much more systematic and complete for Monterrey III than for Samalayuca II.

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[10] The European Commission checklist (EC, 2001), the Review Package from the EIA Centre of the University of Manchester (Lee and Colley, 2001), and various articles and studies done by other multilateral agencies (World Bank, the United Nations Environment Programme (UNEP), EBRD, etc.). The final version of the checklist and references are included in the annex. It is important to note that the checklist developed by OVE covers all the requirements of the PR-1006 on the Committee on Environmental and Social Impact (CESI) review.

[11] See annex.

[12] The review of the 22 projects analyzed can be found in OVE, 2008 (*draft*). *OVE's Environmental Performance Review applied to the Energy Sector*. Inter-American Development Bank. Washington, D.C.

[13] Most of these 10 projects are combined-cycle thermoelectric plants approved between 1995 and 2000.

[14] This standardization process was formalized in the internal guidelines prepared in 2003 by the PRI (PRI, 2003. *Environmental Guidelines.* Inter-American Development Bank).

2.5 For section two, information on the impact caused by noise (2.1e) is too general in both cases, compared to recommendations made in the specialist literature. Moreover, both provide overly general and vague data on the evaluation methods used (2.4). Section three reveals differences between the two plants in terms of risk and accident management under the contingency plan (3.7 and 4.5), which is much more complete for the Samalayuca II power plant than for Monterrey III. The fourth section shows that the analyses of alternatives (4.1) is much better in Monterrey III than in Samalayuca II, but in both cases a more technical analysis is needed for the alternative of not constructing the thermal plant (4.2). For the final section of the checklist, the Monterrey III document is more accessible to the public, according to the standards recommended by the literature. Environmental monitoring arrangements (5.2) are more detailed in the case of Samalayuca II, but neither case mentions issues relating to the technical additionality (5.4) provided by the Bank in the environmental reports.

## B. Definition of environmental components

2.6 For Samalayuca II and Monterrey III , **mitigation measures were included in the various stages of project execution (site preparation, construction, operation, and maintenance)** to avoid or attenuate adverse effects on the environment surrounding the two facilities.

2.7 As both projects are currently in the operational stage, an **evaluation was made of measures applied to date** (during both construction and operation) by reviewing information contained in the documents submitted by the operators of the two facilities (CFE and Iberdrola), supported by visits and tours inside and outside the power plants. This makes it possible to estimate the results obtained from the mitigation measures in the two projects, and thus evaluate their effectiveness, and also to verify the implementation of mitigation measures not originally envisaged in the two projects' environmental impact manifests. The evaluation of the two plants' environmental management sustainability will generate ideas for overcoming future environmental challenges in these facilities.

2.8 In the case of **mitigation measures for the site abandonment stage**, the projects' EIMs state that, at the end of the plants' estimated 25 years of useful life, the site will most likely continue to be used for electric power generation purposes. Should the facilities need to be dismantled to enable the site to be used for a different purpose, restoration of the area will focus on removing debris, bearing in mind the characteristics of the surrounding environment; federal, state, and municipal land use plans and programs; and environmental legislation and laws applicable to land use and industrial waste management in force at the time. It is notable that the Bank's validation reports for both thermal plants, as in most of the 22 projects analyzed qualitatively with the checklist, did not consider measures involved in the dismantling stage of this type of infrastructure project.

2.9 The ex post environmental assessment of the mitigation measures followed the recommendations made in the EIA bibliography on performing a **screening and**

**scoping exercise** (Arts et al, 2001).[15] An ex post environmental screening of this type of infrastructure project is warranted by its complexity and the magnitude of the environmental impacts, as well as by the opportunity to draw on lessons learned from the amount of information compiled by the borrowers during their environmental management of the projects. Based on the review of information contained in the various ex ante environmental analysis documents (EIA and the Bank's validation reports), environmental monitoring and other related literature,[16] environmental issues were selected which were considered most important for evaluating the aggregate ex post environmental impact of the projects and for which sufficient information was available (scoping). Accordingly, environmental parameters were discarded that displayed monitoring figures, validated by SEMARNAP, that were well below the recommended ranges for avoiding significant environmental impacts, or for which information of sufficient quality was not available.

2.10 **These environmental components, and their respective control parameters (or indicators), were weighted** by assigning a score (in percentage terms) based on the potential environmental impacts of this type of project, such that the final total was 100%. For each environmental parameter or indicator, the initial score was assigned on the basis of the characteristics of each parameter and its contribution or influence by type of project. The result is shown in Table 2.

[15] To follow up the EIA (which covers monitoring, audit, and evaluation actions and the environmental management systems), it is advisable to complete the exercise to decide whether an ex post environmental assessment is needed for a specific project (screening), and if so, to prioritize the issues to be studied in detail (scoping).

[16] Guidelines set out in the specialist literature (environmental impact studies by various authors (Conesa, Gómez Orea, Canter), World Bank guidelines for new thermoelectric power plants (World Bank, in *Thermal Power: Guidelines for New Plants* in *Pollution Prevention and Abatement Handbook, July 1998*), and expert opinions from multidisciplinary teams).

**Table 2. Weighting for environmental components and parameters in the evaluation**

| Component | % weight | Comment | Mitigation measures | Parameter | % weight | Comment |
|---|---|---|---|---|---|---|
| Water | 30 | The amounts of water needed for the electric power generation process and the generation of significant amounts of wastewater in this type of power plant have significant repercussions on the local environment. | • Water supplied by an authorized source | Volume of water consumed | 20 | A large volume of water is needed to produce steam and operate the cooling system. |
| | | | • Treatment of effluent to avoid exceeding standard limits | Quality of wastewater generated | 10 | The process alters the physical-chemical characteristics of the water prior to its final discharge. |
| Air | 30 | Atmospheric emissions are significant because combustion is the main process used to generate electric energy. | • Installation of low-$NO_X$ producing burners<br>• Additional measures to reduce atmospheric emissions (more efficient combustion, maintenance, etc.)<br>• Choice of technology and less polluting fuel | $NO._X$ | 20 | This is the main pollutant emitted by the combined-cycle technology. |
| | | | • Use of natural gas as a fuel for power generation | $SO_2$ and particulates | 10 | The use of natural gas generates minimal amounts of $SO_2$ and $PM_{10}$ given the physical-chemical composition of the fuel. |
| Waste | 10 | Large quantities of waste are not generated in this type of facility, but they need to be managed in accordance with their properties. | • Collection, separation, reuse, and/or disposal of nonhazardous waste in authorized sites | Nonhazardous waste | 3 | Nonhazardous waste is handled in the same way as municipal or urban waste. |
| | | | • Collection, temporary storage, transport, and final disposal of hazardous waste by an authorized firm | Hazardous waste | 7 | The management of hazardous waste requires training authorized staff. |
| Perimeter noise | 5 | Noise is a function of the technology and the presence of impacted communities close to the facilities. | • Installation of a perimeter tree barrier and maintenance of equipment<br>• Measurement of perimeter noise levels | Noise | 5 | Perimeter or ambient noise is defined as the undesirable sound emitted by a fixed source that irritates or injures people circulating in the facility's surroundings. The injury caused by exposure depends on the magnitude and number of the hearing threshold per unit of time. |

| Component | % weight | Comment | Mitigation measures | Parameter | % weight | Comment |
|---|---|---|---|---|---|---|
| Labor safety[17] | 12 | Effects on staff have repercussions both for the functioning of the power plants and for their reputation outside (sensitivity). | • Use of noise suppressors and maintenance of equipment<br>• Provision of hearing protection to workers exposed to the noise | Occupational noise | 6 | Noise in the work environment may cause injury to the facility's staff. |
| | | | • Accident prevention program (for workers and the community) | Incidents and accidents | 6 | The absence of occupational and environmental incidents and accidents result in better operation. |
| Social and economic | 10 | In addition to supporting the community, internal and external actions (training and worker awareness campaigns) affect the perception (positive/ negative) of the facilities. | • Environmental education program | Training courses | 3 | Training courses promote rapid staff response in cases of local emergency and raise community awareness of environmental issues. |
| | | | • Social action plans | Support arrangements | 7 | Community support arrangements affect the perception held by the local population. |
| Vegetation | 3 | The loss of plant cover is irreversible; green areas are created to make up for that loss. | • Implementation of green areas at the end of the construction stage with typical local species | Green areas | 3 | - - - |
| **Total** | **100** | - - - | | | **100** | - - - |

*Source: OVE, 2008*

[17] Technical, educational, medical, and psychological measures used to prevent accidents, to eliminate unsafe conditions in the environment, and instruct or convince people of the need to implement preventive practices.

## C. Evaluation criteria

2.11 The mitigation measures implemented in the Samalayuca II and Monterrey III thermoelectric plants have been environmentally assessed in accordance with the following evaluation criteria:

a. The **relevance** of the mitigation measures proposed, compared to those recommended in the literature for this type of project, in order to verify that the most important impacts were appropriately identified, as reviewed in the literature, and evaluate the relevance and usefulness of the actions proposed to manage those impacts.

b. The **efficiency** of resource use (economic, human, technical) and the time taken to implement the mitigation measures, relative to those included in the EIA, compared to the implementation status of each measure in terms of what was programmed and what was executed. Measures not initially envisaged will also be considered.

c. The **sustainability** of environmental management of the power plants, once the Bank's involvement has ended, based on the institutional capacities developed, particularly the technical and budgetary resources available for monitoring and updating the mitigation measures. Also, to evaluate the capacity of public agencies responsible for controlling the main environmental variables impacted by the process.

d. The **additionality** provided by the Bank, in the form of value added to the design and evaluation of the projects' environmental and social viability;[18] and the Bank's monitoring actions during project execution. This criterion is particularly important in this evaluation, which aims to compare the environmental management of the two power plants, considering the support for the required monitoring and supervision (which only occurred in the case of Monterrey III, where there was ongoing monitoring by the Bank during the loan disbursement period, but not in Samalayuca II).

e. As a methodological contribution, instruments to quantify the **effectiveness of the mitigation measures on the quality of the environment in the affected area**[19] have been proposed, which are useful for environmental management decision-making. The quantitative results of the indicators are analyzed to

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[18] Comparing the Bank's ESIR with the EIAs produced by the borrower.

[19] Intersystemic relations are highly complex. The uncertainty surrounding the environmental impact of power generation projects makes it hard to evaluate the overall environmental quality of the ecosystem in relation to the mitigation measures proposed in the projects. To prioritize certain key impacts and make management decisions on them, the system must be simplified. This can be done by choosing indicators to evaluate specific environmental factors, which, while not leading to general conclusions on the ecosystemic impact of the mitigation measures applied, do make it possible to analyze their effectiveness in mitigating impacts on the selected features of the environment.

identify environmental quality trends in the zone (data series) and their interpretation (explanation of peaks, impact from other sources). Guidelines are also set for using the information from the indicators and turning them into **environmental quality units**. For that purpose, several environmental indicators were selected, and **transformation functions** were applied similar to those used by the Battelle Institute, drawing on measurements from monitoring done by firms and environmental authorities, consultation of the bibliography specializing in environmental impact, and expert opinions.[20]

2.12 The evaluation criteria (relevance, additionality, sustainability, efficiency, and effectiveness) are assessed independently for each institution, using the following scale:

- 0.0 – 1.0: Unsatisfactory
- 1.1 – 2.0: Partially acceptable
- 2.1 – 3.0: Satisfactory
- 3.1 – 4.0: Highly satisfactory

**Table 3. Evaluation criteria for the mitigation measures implemented at the Samalayuca II and Monterrey III power plants**

| Factor | Evaluation scale | | | |
|---|---|---|---|---|
| | **0.0 – 1.0** | **1.1 – 2.0** | **2.1 – 3.0** | **3.1 – 4.0** |
| | **Unsatisfactory** | **Partially acceptable** | **Satisfactory** | **Highly satisfactory** |
| **Relevance** | No consideration was given to the most important mitigation measures recommended in the literature for similar experiences, and environment quality may have deteriorated. | The measures included are not deemed relevant in similar experiences, and in the consultants' opinion they are not deemed irrelevant in this case either. | The key measures recommended in the literature were applied, although not all significant environmental impacts were addressed. | The measures recommended in the literature were applied, and they are considered very important for maintaining the area's environmental quality. |
| **Additionality** | The Bank did not add any useful technical recommendation for obtaining better results in environmental management, or its recommendations were not relevant for the borrower's environmental management. | The Bank's additionality and the measures it proposed during monitoring were poor and insufficient to improve environmental management. | The measures recommended by the Bank were effective and significant. | The Bank's contribution was decisive in improving the environmental management of the affected environmental factor. |

[20] See annex.

| Factor | Evaluation scale | | | |
|---|---|---|---|---|
| | 0.0 – 1.0 | 1.1 – 2.0 | 2.1 – 3.0 | 3.1 – 4.0 |
| | Unsatisfactory | Partially acceptable | Satisfactory | Highly satisfactory |
| **Efficiency** | No resources were allocated or money invested in the measures. | The resources and money invested in the measures are insufficient. | Adequate resources, time, and money were allocated to the measures. | Resources were allocated optimally in time and form. |
| **Sustainability** | Environmental management will probably not continue or will considerably worsen in the years to come. | Environmental management will probably continue, although only on a reactive basis or at the request of the authorities. | In general, environmental management actions are likely to continue, although the institutional mechanisms needed to provide continuity are not clear. | Environmental management and compliance is excellent, and institutional mechanisms are in place to ensure their continuity. |
| **Effectiveness** | The measures have not been effective in reducing the project's adverse environmental impacts. Environmental quality is on a downtrend and indicators are below the baseline as a result of the project. | The measures have had poor results (negative environmental quality trend, indicators below the baseline), not caused directly by the project's activities; or the project considerably worsens the environmental quality of an already degraded zone. | The measures applied seem to help alleviate the environmental impacts ( values equal to the baseline). | The results of the mitigation measures have been excellent and reduce the adverse impacts (values above the baseline, or adjusted to benchmark levels). |

*Source*: OVE, 2008

## III. RESULTS OF THE EX POST ANALYSIS OF MITIGATION MEASURES

### A. Relevance

3.1 In both power plants the choice of technology (combined-cycle and natural gas) eliminated the production of **atmospheric emissions** such as sulfur oxides and particulate material, and also reduced the output of carbon dioxide per unit of electricity generated, compared to other thermoelectric generation technologies. Chimney stack measurements and the installation of air quality measurement stations are measures recommended by the literature to mitigate impacts related to nitrogen oxides.

3.2 As both plants are located in desert zones with serious water stress problems, mitigation measures on the **volume of water consumed** introduced by Iberdrola in Monterrey (recycled water to supply the plant) seem to be more appropriate, according to the literature, than those introduced by CFE in Samalayuca II (water from an already overexploited aquifer). Nonetheless the low rate of water use in Samalayuca II for this type of power plant facility, makes it possible to extend the useful life of the aquifer and use the resource rationally.

3.3 Also, given the lack of scientific certainty regarding the consequences, the alternative of sending **wastewater** to infiltration basins, after treatment, as is done in Samalayuca II, seems less appropriate than sending it to the municipal wastewater system, as Iberdrola ultimately decided to do. Studies would be needed to ensure that the infiltration of water has beneficial effects for the aquifer and there are no pollution problems.

3.4 Both power plants adopted the same measures for the **mitigation of perimeter and workplace noise, the prevention of incidents and accidents, the management of hazardous and nonhazardous waste, loss of plant cover, and training courses for workers—**all of which are considered relevant in the literature.

3.5 Despite being highly recommended by the literature, neither of the projects included measures to improve their relations with the community (social action plans) from the outset.

## B. Additionality

3.6 In the case of **atmospheric emissions**, the Bank encouraged maintenance of the air quality monitoring stations by regularly requesting the respective data. In contrast, in the case of Samalayuca II, the stations fell into disuse a few months after the plant came on line, due to lack of maintenance. Nonetheless, the low quality of the data collected by the perimeter measurement stations at Monterrey III, and the zero correlation between the concentrations measured and plant emissions (since there was no weather data) meant that the additional measures requested by the Bank were not useful in improving the plant's air quality results. In this case, the only potential benefit entailed transferring the management of these stations from Iberdrola to the Integrated Environmental Monitoring System (SIMA) of the Government of the State of Nuevo León. This type of synergy between the environmental authorities and electric power generating firms could be promoted by the Bank through technical cooperation operations to ensure that environmental requirements imposed on firms are really useful for environmental decision-making in the area.

3.7 **Wastewater discharge** was one of the issues most closely analyzed in the Bank's ESIR for the Monterrey III power plant. The additional requirements imposed by the Bank to authorize discharge into the Benavides Creek ultimately caused the company to change plans. Although a potential use for treated water for irrigation in a semiarid zone with few natural water sources (socioeconomic benefits) was eliminated, the uncertainty about the quality of the water that might reach the aquifer (possibly carrying pollutants) seems to technically justify the Bank's consultations (precautionary principle). Another important point is that, given the fragmentation of information on environmental monitoring by the Bank, the final modifications to wastewater discharge were not clear; nor, apparently, were the consequences of the measures recommended by the Bank evaluated in relation to this environmental parameter.

3.8 The evaluation did not find any evidence of technical value added by the Bank (either in the design for Samalayuca II, or in the design or monitoring during execution in Monterrey III) for the other environmental factors (**perimeter and workplace noise, prevention of incidents and accidents, volume of water used, management of hazardous and nonhazardous waste, restoration of green areas, social action plans, and training courses for workers).**

3.9 Lastly, in the interviews held for this evaluation, those responsible for environmental management in Monterrey commented that, although the Bank provided little additionality to the design, its recommendations and monitoring requirements served to **improve information and environmental management systems**, and also had repercussions on the firm's environmental management model in other generating plants. Nonetheless, it is hard to attribute the contribution relating to environmental management certification systems such as ISO-14001 and ISO-9001, also adopted by Iberdrola, to the Bank.

## C. Efficiency

3.10 In the case of **atmospheric emissions**, both thermoelectric power plants are below the regulatory thresholds, bearing in mind that the use of technology avoids other environmental impacts on air quality. Nonetheless, in Monterrey III the efficiency of installing monitoring stations and generating data is minimal in the absence of weather data, and it is impossible to correlate with stack emissions.

3.11 In Samalayuca II, there were problems implementing several mitigation measures (delay in consolidating the perimeter tree barrier to mitigate the **noise**, reforestation to offset the **loss of plant cover**, preparation of the **accident prevention program**, and the disbursement of amounts committed for **the community**).

## D. Sustainability

3.12 The issue of **atmospheric emissions** seems to be covered by the annual reports for the Cédula de Operación Anual [Annual Operating Certificate] and the environmental management of the plants themselves.

3.13 The sustainability of the **water supply** for the plants may be compromised in both cases: in Monterrey III, because of possible technical problems in the supply of treated water, and the potential lack of a contingency plan in this regard (which the OVE evaluation was unaware of during its review of information and plant visit). In the case of Samalayuca II, sustainability with respect to this environmental factor may be compromised due to overexploitation of the aquifer and competition among different water uses. Accordingly, in both cases it would be advisable to develop savings programs and have alternative management options in place.

3.14 In the case of Monterrey III, the environmental management by Iberdrola seems to ensure continuity for the environmental factors of **perimeter noise** and **prevention of incidents and accidents**. The same is true of Samalayuca II for some of the

plant's basic environmental management parameters (such as the **management of hazardous and nonhazardous waste)**. Nonetheless, the evaluation raises questions about the potential for implementing or sustaining certain mitigation measures over time, such as those related to **perimeter and workplace noise**, **reforestation**, and **social action plans**, owing to the bureaucratic difficulty of mobilizing resources more quickly through the federal government's annual resource authorizations.

## E. Effectiveness

3.15 In the case of **atmospheric emissions of nitrogen oxides**, the atmospheric simulations of $NO_2$ made in this evaluation,[21] and a review of the information available at each plant (stack emissions data and air quality data in the area surrounding the plants ("inmission" values)), show that the mitigation measures used have been effective, because the plants have not worsened the air quality in their area of influence.

3.16 Considering the generation of **nitrogen oxides** as the only potential impact on air quality for this type of natural-gas-fired thermoelectric power plant, the evaluation performed new ex post simulations using stack monitoring data, and compared them with the air quality data available in the power plant areas. The conclusion was that air quality indexes (IMECA) for $NO_2$ did not deteriorate when Monterrey III came on line. According to the atmospheric modeling undertaken by OVE, the maximum impact occurs 15 km of the south of the power plant in an unpopulated area; and the effect on the urbanized zone is insignificant. Moreover, the peak emission level from Monterrey III is just 30% of the cumulative effect caused by the two other thermoelectric plants located on the same property (Huinalá and Monterrey).

3.17 In the case of Samalayuca II, although the environmental authority does not publish air quality data with the detail available for the state of Nuevo León and Monterrey III, the atmospheric simulation done by OVE shows that the maximum impact occurs in the immediate plant surroundings, thus affecting the Samalayuca community. The figure in question is half of the standard value when only the effect of Samalayuca II is considered, but rises to 90% when measuring the cumulative effect of Samalayuca I and II. In this case, the Samalayuca II plant also reduces emission rates by 30% with respect to the cumulative effect.

3.18 With regard to **carbon dioxide emissions**, Monterrey III has one of the lowest $CO_2$ emission rates per energy unit in the Bank's portfolio of thermoelectric power plants, at 375 kg $CO_2$/MWh, whereas the rate at Samalayuca II is approximately 445 kg $CO_2$/MWh.[22]

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[21] See annex.

[22] Information obtained from the *Report on Inter-American Development Bank – Private Sector Department Activities to Address Climate Change (forthcoming).* The data provided by Iberdrola for this evaluation are even lower than those reported in this Bank report.

3.19 The results of the **outdoor noise pollution** studies show that the standard limits are not exceeded. In the case of Samalayuca II, **workplace noise** levels are on the threshold of the upper limits. There are some work areas where they are exceeded; and these need to be appropriately identified, mitigated with worker protection equipment, and time limits imposed for remaining in these areas. The same applies to the limits for **wastewater** discharged in both plants.

3.20 At the date of the evaluation visit, both plants had an **accident prevention** program in place. According to monitoring data, thus far there have fortunately been no serious incidents or accidents in either plant, so the legal requirement for planning and prevention of events of this type is considered fulfilled.

3.21 In no case have **water supply** problems been reported, although the use of water from the aquifer in Samalayuca II, while not causing serious problems at the present time, could compromise regional development policies in the medium term. No problems been reported in either of the two plants regarding the quality of **wastewater** effluents, although in the case of Samalayuca II infiltration would also have to be studied, even though effluent pollutant levels are satisfactory. There are no problems with hazardous and nonhazardous waste.

3.22 Neither of the two plants goes beyond attempting to reduce the visual impact with tree planting; no native plants are used, and there is no operational reforestation plan, as indicated in the EIA.

## IV. CONCLUSIONS AND RECOMMENDATIONS

### A. Conclusions

4.1 **A high level of thermal efficiency, greater power generation, the use of a clean fuel (natural gas), a less polluting process, and highly flexible operation** make combined-cycle power plants a good alternative to other types of thermoelectric power generation plants, despite their complex technology.

4.2 Using the evaluation criteria and measurement scale shown below, the **mitigation measures** implemented in the Samalayuca II and Monterrey III thermoelectric power generation projects obtained the following aggregate results:

**Table 4. Assessment of evaluation criteria**

| | **Evaluation criterion** | | | | |
|---|---|---|---|---|---|
| | **Relevance** | **Additionality** | **Efficiency** | **Sustainability** | **Effectiveness** |
| **Monterrey III** | **3.1** | **1.2** | **3.2** | **2.8** | **3.1** |
| Assessment | Highly satisfactory | Partially acceptable | Highly satisfactory | Satisfactory | Highly satisfactory |
| **Samalayuca II** | **2.9** | **1.0** | **2.4** | **2.5** | **2.4** |
| Assessment | Satisfactory | Unsatisfactory | Satisfactory | Satisfactory | Satisfactory |

*Source:* OVE, 2008

4.3 In general, it can be concluded that both thermoelectric power plants considered most of the environmental impacts and associated mitigation measures recommended by the literature (**highly satisfactory/satisfactory assessments**). Thus, both plants meet the legal requirements under the Mexican regulatory framework, particularly as regards the presentation of prior studies, such as the EIA.

4.4 The **additionality provided by the Bank** for improving the environmental management of these projects was insufficient or poor (**unsatisfactory/partially acceptable**) in both cases. In the case of Monterrey III, the Bank's recommendations on managing the plant's wastewater satisfactorily applied the precautionary principle. Nonetheless, some of the Bank's requirements did not directly help improve the borrower's environmental performance (such as information generated by the air quality measurement stations installed by Iberdrola at the Bank's request). In the case of Samalayuca II, where the Bank only supported the CFE by validating the ex ante environmental viability studies, no significant technical additionality was identified.

4.5 Environmental mitigation measures for all environmental factors are more **efficient** on average in the case of Monterrey III (**highly satisfactory**), since there was an adequate management of resources, time, and money in implementing measures that definitely helped the project achieve its environmental quality objectives. In the case of Samalayuca II, shortcomings were identified in the application of certain measures with regard to the times planned, owing mainly to shortcomings in CFE's capacity to mobilize resources for streamlined environmental management (**satisfactory efficiency**).

4.6 The **sustainability of environmental management is satisfactory** in both plants, so the OVE evaluation considers it highly likely that the environmental management actions will continue over time, as is currently the case following the withdrawal of Bank funding. In the case of Samalayuca II, a number of institutional mechanisms need to be improved to ensure the fulfillment of measures and their constant adaptation to changing needs.

4.7 **Mitigation measures are more effective** in the case of Monterrey III (**highly satisfactory**) than in Samalayuca II (**satisfactory**). The measures taken by Iberdrola seem to have been effective, because the environmental quality trends for each of the environmental factors considered are generally positive, and no problems of noncompliance have been reported. In the case of Samalayuca II, many of the baseline values have been maintained, although more detailed studies are needed to determine whether the thermoelectric project's activity is not worsening an already critical environmental situation, such as the availability of water in the area and the cumulative impact of air pollution caused by power plants in the area.

## B. Recommendations

4.8 To enhance **technical value added**, the Bank should play a more active role in the design and supervision of the projects it finances, and in their monitoring. Proposals for monitoring environmental, social, and economic aspects of the projects must be accompanied by clear methodologies, defining key indexes and indicators that are economically viable, while ensuring the institutional capacity to carry them out, so as to avoid information becoming fragmented or data being collected that cannot be evaluated.

4.9 **Social action plans** need to be considered, as well as local community participation, during project design and monitoring. These considerations should be defined and addressed at an early stage and managed actively throughout the project, to increase its chances of success and justify its social sustainability.

4.10 **Specific studies** to solve environmental problems reduce uncertainty when choosing alternatives for managing project risks. Participation in evaluation and monitoring reports by multidisciplinary teams and local specialists would improve the approach to specific technical aspects.

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