PUBLIC

Inter-American Development Bank
Vice Presidency for Sectors and Knowledge

Liquid and Gaseous Fossil Fuel Power Plant Guidelines An Approach to Reconciling the Financing of Fossil Fuel Power Plants with Climate Change Objectives

August 10, 2012

This document was prepared by Paul Suding (VPS/ESG), Emmanuel Boulet (VPS/ESG) and Milena Breisinger (VPS/ESG) under the supervision of Janine Ferretti (VPS/ESG chief).

TABLE OF CONTENTS

I. INTRODUCTION AND APPLICABILITY 1

II. FOSSIL FUEL POWER PLANTS - FUTURE ROLE IN LATIN AMERICA AND THE CARIBBEAN, AND POTENTIAL GHG EMISSIONS IMPACTS 3

III. AVAILABLE TECHNOLOGIES AND GHG EMISSIONS 5

IV. OTHER MDBS' APPROACH TO THE FINANCING OF FOSSIL FUEL POWER PLANTS 10

V. THE IDB'S APPROACH TO FINANCING NEW LIQUID AND GASEOUS FOSSIL FUEL POWER PLANTS 11

ABBREVIATIONS

ADB	Asian Development Bank
BAT	Best Available Technology
CCGT	Combined Cycle Gas Turbine
CHP	Combined heat and power
CCS	Carbon capture and storage
CDM	Clean Development Mechanism
CH_4	Methane
CNG	Compressed natural gas
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CSP	Concentrating solar power
EBRD	European Bank for Reconstruction and Development
EEC	Energy efficiency and conservation
EIB	European Investment Bank
EPA	Environmental Protection Agency
EU	European Union
GHG	Greenhouse gas
Gt	Giga tons
GW	Gigawatt
HFCs	Hydro fluorocarbons
HFO	Heavy fuel oil
HHV	Higher heating value (gross calorific value)
IDB	Inter-American Development Bank
IEA	International Energy Agency
IFC	International Finance Corporation
kWe	Kilowatt electric
kWh	Kilowatt hour
LAC	Latin America and the Caribbean
LCT	Low carbon technology
LFO	Light fuel oil
LHV	Lower heating value (net calorific value)
LNG	Liquefied natural gas
MDBs	Multilateral development banks
MHD	Magneto- hydrodynamics
MIGA	Multilateral Investment Guarantee Agency
MJ	Mega Joules
MPC	Minimum Performance Criteria
Mt	Mega tons

N_2O	Nitrous oxide
OECD	Organization of Economic Cooperation and Development
O&M	Operation and maintenance
PS3	Performance standard 3
PV	Photovoltaic
RE	Renewable energy
SEAP	Sustainable Energy Action Plan
SIEPAC	Central American Electrical Interconnection System
TC	Technical cooperation
TWh	Terawatt hour
WBG	World Bank Group

I. INTRODUCTION AND APPLICABILITY

1.1 The Inter-American Development Bank (IDB) is developing guidelines and technical notes for particular sectors and sub-sectors known to significantly contribute to climate change. Fossil fuel power generation[1] belongs in this category. These sector-specific guidelines are one of the instruments by which the IDB will mainstream climate change mitigation in Bank-funded operations, which is one of the strategic lines of Bank intervention.[2] According to paragraph C.4.4 of the Integrated Strategy for Climate Change Adaptation and Mitigation and Sustainable and Renewable Energy, "the Bank will promote sector-specific principles to meet climate mitigation objectives. In the case of fossil fuel power generation projects, the Bank will be selective in regard to the type of technology proposed for funding, seeking to balance the environmental and economic benefits and, achieve internationally recognized GHG emissions performance standards….The Bank will develop sectoral technical notes containing orientation and best practices for the development of activities in GHG-intensive industries, where the Bank anticipates substantial work."

1.2 According to the Sustainable Energy Sector Guidelines from 2011,[3] "although the Bank will strongly promote the use of energy efficiency and conservation (EEC) and low carbon technologies (LCTs) … investments in "traditional" infrastructure, particularly based on fossil fuels, will continue to be important for the Bank's member countries." IDB, in line with its mandate and guidelines, will continue to support fossil fuel power plants designed to use the best proven available technology appropriate to the particular characteristics of the project. The aim of this support is to promote high efficiency and therefore lower greenhouse gas (GHG) emissions as well as to meet internationally recognized best practices and standards.

1.3 To be evaluated by the IDB as part of its project review, projects presented will be required at the eligibility stage to either comply with the minimum performance criteria (MPC) or commit to complying with those criteria. For a project to be eligible for IDB financing, compliance with MPC must be verified during analysis or due diligence and confirmed prior to Board approval.

1.4 The present guidelines outline the criteria for eligibility and aim to provide clear and quantitative MPC deemed necessary for the IDB to support fossil fuel power plant projects. In addition, they provide guidance on assessing and reducing GHG emissions of projects in accordance with the best available appropriate technologies. Thus, this document "Liquid and Gaseous Fossil Fuel Power Plant Guidelines" is an approach to financing *new* fossil fuel power plants in a manner consistent with the IDB's commitment to protecting the environment and

[1] Fossil fuel combustion power plants use a large variety of fuels that emit greenhouse gases and other pollutants. Fossil fuels, which contain high percentages of carbon, include primary sources such as coal, petroleum, and natural gas and the secondary products derived from them.

[2] Inter-American Development Bank. 2011. Integrated Strategy for Climate Change Adaptation and Mitigation, and Sustainable and Renewable Energy. Reviewed version (document GN-2609-1), Washington, D.C.

[3] Inter-American Development Bank. 2011. The Sustainable Energy Sector Guidelines, (document GN-2613), Washington, D.C.

reducing adverse impacts on the global climate as established in its Environment and Safeguards Compliance Policy.[4]

1.5 These guidelines focus on liquid and gaseous fossil fuel fired power plants, as the Bank has already approved specific Guidelines for Coal Power Plants applicable to solid fuel fired plants.[5] These guidelines do not address units with primary non-fossil fuel firing, such as wood, waste, residues, sewage gas, and landfill gas, including those with minor fossil fuels co-firing.

1.6 These guidelines apply only to new power plants or new units being presented to the IDB prior to initiation of operations. The guidelines do not cover the rehabilitation of existing operational plants, which are addressed in the IDB Sustainable Energy Sector Guidelines.[6]

1.7 The present guidelines concern all new power plants, whether they are part of an integrated electricity supply system that connects other power plants that serve many consumers, or operate on a stand-alone basis, supplying one or only a few customers, such as an industrial plant or a non interconnected local grid, with or without connection to a grid for supplementary or reserve service.

1.8 These guidelines apply only to fossil fuelled plants that include a combustion engine (turbine or reciprocating engine) and a generator to produce electricity. Not addressed in these guidelines are: (i) stationary compressors and pumping stations, automobiles, or trains; (ii) electricity generation technologies that do not apply thermodynamic processes, such as fuel cell power generations, magnetohydrodynamics (MHD) and others; and (iii) thermal power plants that do not use combustion processes like nuclear plants.

1.9 These guidelines do not apply to very small generator-engine sets below 20kilowatt electric (kWe). For generator units above 20kWe but below 1 megawatt electric (MWe) capacity no numerical minimum requirements are set, however, the principle to use best proven available technology appropriate to the particular characteristics of the project applies.

1.10 These guidelines implement the IDB's climate change strategy and focus on GHG emissions. Other air emissions, liquid effluents and solid waste, hazardous materials, noise as well as health and safety issues are dealt with in the environmental and social impact analysis (EIA), based on the Environmental and Safeguards Compliance Policy Directive B.11.

1.11 With regard to GHG emissions, power stations release mainly carbon dioxide (CO_2). Other greenhouse gases such as fugitive methane (CH_4), sulfur hexafluoride (SF_6), hydro fluorocarbons (HFCs) or nitrous oxide (N_2O), all with higher global warming potential (GWP), may be emitted in very small quantities from power plants including auxiliaries. This document deals only with CO_2

[4] Directive B.11 of IDB's Environment and Safeguards Compliance Policy states that "[t]he Bank encourages the reduction and control of greenhouse gas emissions in a manner appropriate to the nature and scale of operations."

[5] Inter-American Development Bank. 2009. Coal-fired Power Plants Guidelines; An Approach to Reconciling the Financing of Coal-fired Power Plants with Climate Change Objectives (document GN-2532). Washington, D.C.

[6] IDB Sustainable Energy Sector Guidelines (op. cit.) paragraph 3.10., Rehabilitation of existing thermoelectric plants is considered as supply side efficiency which is generally supported.

emissions. [7] The remainder of the document is divided into four chapters: Chapter (II) presents trends in increased electricity production and the potential role of fossil fuels in generation; (III) discusses the types of fossil fuel power plants and associated environmental issues, with a specific focus on climate change impacts; (IV) provides the approach of other multilateral development banks (MDBs) with regard to financing fossil fuel power plants and the current approach to climate change; and (V) presents IDB's proposed approach to financing fossil fuel power plants.

1.12 This document was developed using background papers elaborated by external consultants[8] and publicly available data. A technical review was undertaken, which included distribution of the guidelines and internal meetings as well as exchanges with other multilateral development institutions, specialized consulting firms and experts. Feedback and comments received were taken into account and were essential to improving these guidelines in form and content.

1.13 These guidelines enter into effect six months after their approval in order to allow time to implement administrative changes and procedures within the institution. The guidelines will apply to operations that enter the Bank's pipeline[9] after the date of their approval.

II. FOSSIL FUEL POWER PLANTS - FUTURE ROLE IN LATIN AMERICA AND THE CARIBBEAN, AND POTENTIAL GHG EMISSIONS IMPACTS

2.2 In 2008, fossil fuels contributed to approximately 41 percent of electricity generation in Latin America and the Caribbean (LAC). Coal accounted for 4.4 percent, while 15.6 percent came from oil and 20.9 percent from natural gas. The greatest amount of electricity was produced from hydropower (53.7 percent). Other renewables contributed 3.2 percent, while nuclear power contributed 2.3 percent.[10]

2.3 In 2008 GHG emissions from electricity and heat supply in LAC amounted to approximately 280 Megatons (Mt) of CO_2e[11] plus approximately 50 Mt from auto-producers. These emissions came mostly from fossil fuel power plants. According to the same compilation, the total GHG emissions from the energy sector in LAC had risen to over 1,477 Mt of CO_2e by 2008. Thus, the electricity and heat supply is responsible for approximately 22 percent of the energy sector emissions. This share has increased since the mid 1990s but stagnated lately since GHG emissions from transport have increased at a greater rate in recent years.

---

[7] All other GHG emissions are not accounted in energy GHG statistics but in other subsectors. Nonetheless the document uses Carbon dioxide equivalents (CO_2e) as common unit. See the delineation of GHG emissions applied by the International Energy Agency (IEA) regarding energy , sector based on conventions in IPCC, International Energy Agency (IEA), CO2 Emissions from Fuel Combustion 2010 Edition, OECD/IEA 2010 Part I Methodology: World Resources Institute (WRI-CAIT) is taking over data for energy sector from IEA.

[8] Gomelsky, Roberto, Available technologies and thermal plants prospective potential in Latin America. IDB KCP Paper 2010. Figueroa de la Vega, F. and Gomelsky, R. Papel de las Plantas de Energías Fósiles en la futura generación eléctrica de América Latina e impacto en las emisiones de gases de efecto invernadero, Programa de Cooperación BID/GIZ. Proyecto: Cambio Climático y Energía en América Latina y el Caribe, 31/3/2011.

[9] Entering the Bank's pipeline means (a) after the signing of the mandate letter, for NSG, and (b) after the project number has been issued, for public sector operations.

[10] Data from International Energy Agency (IEA); sum non OECD-LAC and Mexico ., http://www.iea.org/stats

[11] International Energy Agency (IEA), CO_2 Emissions from Fuel Combustion, 2010 Edition, OECD/IEA 2010 Tables for Latin America and Mexico.

2.4 Results of three possible scenarios show that between 2007 and 2032 there will be a 100 to 150 percent increase in electricity demand in LAC.[12] Even if, with concerted efforts to conserve energy and use it more efficiently, the countries of the region embark on a lower electricity-demand growth path, meeting this demand will require a doubling of installed power capacity from over 287GW in 2011[13] to over 500GW in 2030.[14]

2.5 The scenarios show, that the potential role of non-coal fossil fuel plants in covering the electricity demand in Latin America and the Caribbean has a wide scope resulting in very different GHG emissions, depending on policy choices.[15]

i. In the low thermal power scenario, in which renewable energy (RE) technologies, including hydro power, are applied with priority, some additional 30GW of new liquid and gaseous fossil fuel power capacities would still be needed by 2030 to provide operational flexibility. Approximately 27GW of new non-coal fossil fuel power capacities would be added in Latin America by 2030 and another 3GW in the Caribbean, using as much as possible the most efficient technology for the available fuel. This would make it possible to keep power generation GHG emissions from growing substantially.

ii. In case that new RE technologies would not be deployed as quickly, and hydropower potential would not be exploited as extensively as expected, the role of fossil fuels would be much more important, with approximately 200GW capacity and 1000Terawatt hours (TWh) production needed by 2030 (high thermal/low efficiency scenario). This would double the GHG emissions from electricity and heat production if no special attention would be given to energy efficiency.

iii. If the most efficient technology for the available fuel would be chosen, in the high thermal high efficiency scenario, the increase of GHG emissions from the power and heat production could be reduced by more than 40%.

2.6 This demonstrates the importance of choosing low carbon and efficient fossil fuel technology, in addition to renewable energy. The combination of renewable energy and an efficient use of fossil fuel would make it possible to avoid GHG emissions growth from power generation and maintain the status of LAC as a minor contributor to global GHG emissions. If, however, the vigorous growth in renewable power generation does not happen, choice of high efficiency technologies can mitigate GHG emission growth significantly.

---

[12] R. Gomelsky, F. Figueroa, et al.; OLADE, LAC Energy Prospective to 2032.

[13] Combined record of Mexico and other Latin America and Caribbean according to IEA, World Energy Outlook 2011; International Energy Agency Paris 2011.

[14] Figueroa and Gomelsky, in the background study for IDB/GIZ estimate a capacity requirement between 492 and 513 GW for Latin America alone. See F. Figueroa, R. Gomelsky, op. cit. In addition, the Caribbean is projected to require around 25 to 30 GW, if Cuba is included. For scenarios for Caribbean countries except Cuba, see Nexant, Caribbean Regional Electricity Generation, Interconnection and Fuels Supply Strategy. Final Report submitted to World Bank, 2010, http://www.caricom.org/jsp/community_organs/energy_programme/electricity_gifs_strategy_final_report.pdf

[15] For more details of scenarios and regions see the Annex and the background paper on potential future role of the various technologies in covering electricity demand by F. Figueroa and R. Gomelsky, op. cit.

2.7 With respect to the potential volume of new oil- or gas- fired new capacity, the scenarios indicate that between 30 and 100GW of new non-coal fossil fuel capacities will be installed in the LAC region in the next 20 years. Even in the lower range, with strong expansion of RE capacities (including hydropower), this would represent an investment of at least USD 30 billion.

III. AVAILABLE TECHNOLOGIES AND GHG EMISSIONS

3.1 Fossil fuel power plants involve a large variety of fuel sources and technologies. Technologies are characterized by their thermodynamic cycle, operational temperatures, and pressures, which determine their efficiency, the types of fuels that may be used (some technologies allow burning different fuels), useful life, speed of start-up, and investment and operational costs (fuel, fixed operation and maintenance (O&M), and variable O&M).

3.2 The fossil fuel input may be solid (coal, lignite, peat, petroleum coke), liquid (products from crude oil, oil sands or oil shale like gasoline, diesel, light and various types of heavy fuel oil including marine bunker[16] or liquefied solid fuel), or gaseous (natural gas, petroleum and refinery gases, or gas from coal such as mine gas, coal bed gas, high furnace gas, coke gas).

3.3 The fuel is used to produce thermal energy comprised of steam or gaseous fluid. The expanding thermal energy then drives rotating machinery (a turbine or a reciprocating engine), which then operates an electrical generator. Depending on where fuel combustion takes place, thermal power generation plants can be grouped into external combustion (such as steam plants using the Rankin cycle or Stirling engines) and internal combustion engines, which can be further divided into continuous combustion (gas turbines, with Brayton cycle) or intermittent combustions (reciprocating engines with Diesel or Otto cycle). Combined cycle power plants are designed based on the Brayton and Rankin cycles: the exhaust heat from the gas turbine is used to generate steam for driving a steam turbine.

3.4 Table 1 contains an overview of characteristics of the main technologies of thermal power generation from liquid or gaseous fuels, which are relevant for investment in LAC for power services in a foreseeable future. The overview includes main cost characteristics which determine the respective competitive situation in investment and dispatch.

3.5 In larger interconnected power systems the technologies of larger unit sizes can be considered, such as combined cycle plants for base load, condensing steam plants for medium load, and single cycle turbines for peak load. Diesel and Otto cycle installations are rather typical for smaller punctiform (industrial) or smaller electrical systems demands, which exist not only in the Caribbean but also in remote areas of large countries in the region. Smaller unit sizes of generator sets below 1MW may also be relevant in the region, e.g. in rural electrification.

[16] Diesel and light fuel oil are (LFO) practically identical, both belong to the number 2 fuel oil cut. The LFO used for heating, industrial purposes and power generation may be a somewhat lighter cut of hydrocarbons and is commercialized in several countries under a different name (Gas Oil). A much wider quality range (number 4, 5 and 6 fuel oil) of mineral oil products is summarized under heavy fuel oil or bunker oil.

3.6 Backpressure steam turbines (fixed relation of combined heat and power) are used in industry when electricity and significant heat load have similar profiles, or in urban heating and power networks, condensing with steam extraction. These cogeneration applications are used by large customers, which in many cases sell excess power to the interconnected public networks. Producing other energy products in the power plant simultaneously with electricity generation significantly increases the combined efficiency. Heat production may reduce power generation in case of condensing extraction steam turbines, but it produces other value outputs, such as process steam, mostly within an industrial plant. If there is combined heat/cold and power production, known as tri-generation, the heat may be used in an absorption process to operate absorption chillers.

Table 1. Characteristics of the Main Technologies for Liquid and Gaseous Fossil Fuel Power Generation (> 1 MWe)

Engine (Thermodynamic cycle)	Type of plant	Applications	Unit sizes range (MW)	Investment range (1) (US$D2010/kW)	Useful life (years)	Electrical Efficiency range (2) (%, HHV, net)	Main Fuels (temporary or add.)	Non-fuel O&M (US$2010/MWh)	Dispatch (plant factors in %)
Steam turbines (Rankine cycle)	**Back-pressure (3)**	Industry (CHP)	5-50	1,200-2,000	30	33-38 (3)	**HFO:** Natural gas	~15	Base load (65 - 80)
	Condensing power plant, simple or reheat	Interconnected grid; industry (CHP)	50-750	1,200-2,000	40	35-41	**HFO;** LFO/Natural Gas	~15	Base or Medium load (60-85)
Gas turbines (Brayton cycle)	**Combined cycle**	Interconnected grid; captive; industry (CHP)	150-800	900-2,000	20/30	40-55	**Natural Gas;** LFO	~10	Base or Medium load (50-85)
	Single cycle Turbines	Interconnected grid; captive	20-300	500-800	20	26-36	**Natural Gas;** LFO	~5	Peak load (10-15)
	Aero-derivative	Medium grid; captive;	5-40	500-800	15	25-35	**Natural Gas**; LFO	5	Peak load (10-15)
Reciprocating engines; Compression ignition (Diesel cycle)	**High speed** (1000 -3600 rpm)	Small grids, captive; Industry (CHP)	Up to 4	800-1000	20	34-40	**Natural Gas, Diesel**/ (dual,5)	~25	Peak-medium (30-50%)
	Medium speed (275-1000 rpm)	Medium grids; captive Industry (CHP)	Up to 45	800-1000	25	34-42	**HFO;** Natural GasDiesel, (Dual)	~20	Base & Medium (50-85%)
	Slow speed (60-275 rpm)	Medium grids; Industry (CHP)	2 - 85	800-1000	25	38-48	**HFO;** Natural Gas	~15	Base & Medium (50-85%)
Reciprocating engines; Spark ignition (Otto cycle)	**Lean Burn (4)**	Small grids; Industry captive (CHP)	Up to 20	800-1000	20	35-42	**Natural Gas,** Dual (Diesel)	~20	Peak-Medium (30-50%)

(1) The investment cost range is wide depending on site, construction time; cost per kW increase with quality, efficiency; emission control and other factors.
(2) Following the IDB Coal Power Plant Guidelines, the higher heat value (HHV) and net electricity output at the bar of the respective units are used. These efficiencies are measured at full load. The part load performance of reciprocating engines is relatively better than that gas turbines and combined cycle units. All technologies offer some possibilities to use the heat extracted from in backpressure, condensing steam or exhaust gases, in addition to generating electricity, with or without a diminishing effect on the electricity output.
(3) Back-pressure steam plants are fixed ratio combined heat and power plants and used, when a parallel heat and electricity demand can be covered. Total net efficiency is in the range of 75-81% (HHV).
(4) Rich burn engines are available in the capacity class of below 1 MW. In dual firing, the engine is operated mainly on natural gas, with some diesel injected for the ignition. Some sources speak of combined diesel-otto cycle.
Sources: Roberto Gomelsky, Fossil Fuel Power Plants: Available Technologies and Thermal Plants' Prospective Potential in Latin America. IDB paper 2010.
European Commission: Reference Document for Best Available Technology BREF: Large Combustion Plants, 2006; EPA: Technology Characterization Gas Turbines 2008; EPA: Technology Characterization Reciprocating Engines; IFC/WBG Environment Health, and Safety Guidelines for Thermal Power Plants, 2008, ; IEA/ETSAP TECHDES Technology Briefs, Gas Fired Power Plants2010; IEA/NEA: Projected Costs of Generating Electricity; 2010 Edition1.
KPMG: Image Study Diesel Power Plants, written on behalf of MAN, 2010.

3.7 All of these technologies can be operated in principle with a liquid and gaseous fuel derived from oil or natural gas. Thus, even if the combined cycle technology is applicable in countries without a natural gas supply, GHG emissions are significantly lower when natural gas, rather than light or heavy fuel oil (HFO), is used.

3.8 The market prices of light fuel oil (LFO)/diesel, however, render the use of this fuel uneconomical in a large power plant with high operation hours (plant factor) vis-a-vis plants with low operation cost. Even a combined cycle power plant would only be exceptionally or temporarily fuelled by LFO instead of natural gas.

3.9 With the view of developing climate change related requirements, the technologies in question are presented in Table 2 in more detail with their standard and range of performance generally achievable both in terms of efficiency (same as in Table 1) and GHG emissions intensity, which is different for natural gas, diesel or LFO and HFO. These GHG emissions were calculated from the efficiencies and fuels according to formula and factors shown at the bottom of the table.

3.10 Table 2 demonstrates that there is a range of more than 100 percent in emissions per MWh produced for similar purposes (medium or base load) between the cleanest technology (combined cycle natural gas) and the oil-fired condensing steam turbine or the medium-speed diesel engine. This shows that by choosing a lower carbon fuel and the best available technology, GHG emissions per kilowatt hour (kWh) can be substantially reduced.

3.11 Natural gas is becoming available in more countries from indigenous resources or imports by pipeline, and in the forms of liquefied natural gas (LNG) or compressed natural gas (CNG). This increased availability, as well as high efficiency and low emission technologies, feeds expectations of further expansion of natural gas in power generation. In countries without domestic fossil fuel resources, price variability expectations may keep them from engaging in long-term LNG import schemes.

3.12 GHG emissions originating from fossil fuel power plants cannot be significantly abated with existing technologies. In the future, carbon capture and storage (CCS) may be a possible way to mitigate climate change impacts of fossil fuel power plants. It is a promising development for effective mitigation of GHG emissions from fossil fuel power plants, although capturing and compressing CO_2 requires additional energy and would increase fuel requirements. These and other system costs are estimated to increase the cost of energy from a new power plant with CCS.

Table 2. Energy Efficiencies and GHG Emissions of Selected Power Generation Technologies

	Technology	Electrical efficiency range, (1) in %, HHV, net/unit)	GHG Emissions (kg CO_2e /MWh) (2)		
			Natural Gas (3)	Diesel/ LFO (3)	HFO (3)
Steam turbines (Rankine cycle)	**Steam turbine, back pressure**	**33-38**	555-480	n.a.	**800-695**
	Steam turbine, condensing	**35-41**	520-450	n.a.	**755-645**
	Combined Cycle	**40-55**	**455-330**	630-460	n.a.
Gas turbines (Brayton cycle)	**Gas turbine, large**	**26-36**	**700-505**	970-700	n.a.
	Aero-derivative gas turbine	**25-35**	**730-550**	1010-720	n.a.
Reciprocating engines	**High speed diesel**	**34-40**	**540-455**	**740-630**	n.a.
	Medium speed diesel	**36-42**	**505-435**	700-600	**733-630**
	Slow speed diesel	**38-48**	480-380	660-525	**695-550**
	Lean burn otto	**35-42**	**520–435**	720-600	n.a.

(1) The efficiencies and emissions are calculated without the use of heat; the more heat is effectively used, the higher the overall efficiency and the lower the emission intensity.

(2) CO_2 Emissions (kg/MWh)=(3.6/Efficiency (%))*CO_2 from fuel (kg/Gigajoule of fuel consumed). based on information from IPCC (GHG emissions by fuels per Gigajoule consumed); see table.

Assumed IPCC CO_2 factors by fuel (kg/Gigajoule of fuel consumed, gross calorific value)	
Natural Gas	50.8
Diesel/LFO	69.9
HFO	73.3

(3) Bold figures indicate the most common fuels for the specific technology. Fuels with higher carbon content like heavy fuel oil are available at h lower prices than LFO, and most of the time also as natural gas. They can be deployed in steam turbines and slow and medium-speed diesel engines.

IV. OTHER MDB$_S$' APPROACH TO THE FINANCING OF FOSSIL FUEL POWER PLANTS

4.1 Most MDBs finance fossil fuel power plants (new plants and rehabilitation of existing plants), while being selective with respect to the type of technology supported to balance the environmental and economic benefits, and rather stringent with respect to their emissions performance. The IDB is the first MDB to propose specific guidelines with MPC related to GHG emissions for fossil fuel power plants. Several commercial banks have taken IDB sector guidelines as reference.

4.2 The World Bank Group's (WBG) Strategic Framework for Development and Climate Change, adopted in October 2008, lays out general criteria that operations should meet in order to receive financing from any of the entities within the WBG, including the International Finance Corporation (IFC) and the Multilateral Investment Guarantee Agency (MIGA). Under this Strategic Framework, the WBG has adopted a set of criteria to guide its operations, including the use of best appropriate available technology for screening coal projects[17] but not for other fossil fuels. Currently, in the context of a new energy sector strategy, the WBG is considering limiting the financing of coal power stations to the least developed countries.

4.3 In the Environmental, Health, and Safety Guidelines for Thermal Power Plants, IFC and the WBG provide Emission Guidelines for air emissions.[18] For GHG emissions, these guidelines provide information on typical CO2e emissions performance of new power plants, but no limits for the case of Particulate Matter, SO_2, NOx and Excess O_2 content of dry gas. A list of recommendations is given as to fuel choice, combined heat and power (CHP), energy efficiency (aimed to be in top quartile of the country/region average), tradeoffs between capital cost and operating cost, monitoring and process control techniques, emission offsets, transmission and distribution loss reduction and demand side measures, consider site opportunities (use of other fuel and use of waste heat, etc.)

4.4 These IFC/WBG guidelines are used concomitantly with IFC's approach to project-level GHG emissions defined in IFC Performance Standard 3 on pollution prevention and abatement[19] Among the relevant requirements is that the client "incorporate in its operations resource conservation and energy efficiency measures" and "promote the reduction in project-related greenhouse gas (GHG) emissions in a manner appropriate to the nature and scale of project operations and impacts."

4.5 Under its 2009 Energy Policy, the Asian Development Bank (ADB) does not exclude financing fossil fuel power plants while encouraging the use of cleaner technologies.[20]

---

[17] World Bank, Criteria for Screening Coal Projects under the Strategic Framework for Development and Climate Change Washington DC, 2010.
[18] IFC, World Bank Group, Environmental, Health, and Safety Guidelines for Thermal Power Plants, December 19, 2008.
[19] International Finance Corporation's Performance Standards on Social & Environmental Sustainability, April 30, 2006.
[20] ADB Energy Policy June 2009, paragraph 33.

4.6 The European Bank for Reconstruction and Development (EBRD) refers to CO_2 and GHG emissions in its 2008 Environmental Policy and several of the supporting Performance Requirements. There are provisions for both, measuring GHGs and consideration of reductions through "technically and financially feasible and cost-effective options," and promoting GHG emissions "in a manner appropriate to the nature and scale of the project operations and impacts." The client is asked to "assess technically and financially feasible and cost-effective options to reduce its carbon intensity during the design and operation of the project, and pursue appropriate options." EBRD applies EU environmental standards on all projects, subject to project definition. All thermal power projects are subject to a Best Available Techniques (BAT) Assessment in line with the requirements set out in the EU Industrial Emissions Directive of 2010 and benchmarked according to the respective BAT Reference Document (BREF). All thermal power projects that would result in a capacity increase of the power plant above 300MW thermal, or are 300MW thermal greenfield plants, are categorized as "A" and require a full Environmental Social Impact Assessment (ESIA), inclusive of public consultation and disclosure prior to Board consideration.

The European Investment Bank (EIB) has adopted screening criteria for coal/lignite power stations with respect to GHG emissions in order to ensure that the use of carbon intensive fuel is compatible with overall emission targets. EIB may finance fossil fuel power plants under the necessary conditions that: (i) the best available technology is used and be "carbon capture ready"; (ii) are cost effective, taking CO_2 externalities into account; and (iii) should replace existing plants in the system and involve a decrease of at least 20% in the carbon intensity of power generation.[21]

V. THE IDB'S APPROACH TO FINANCING NEW LIQUID AND GASEOUS FOSSIL FUEL POWER PLANTS

5.1 IDB will support the development of new liquid and gaseous fossil fuel power plants that adhere to the principle of sustainable development[22] and reduced impact on climate change. Both principles are essential for an industry that already emits high levels of CO_2 and has a growing market outlook.

5.2 In order to promote development and self-sufficiency with electricity while not undermining its support for climate change mitigation efforts or its commitment to environmental protection, IDB will continue supporting those fossil fuel power plants that are designed to meet minimum efficiency and GHG emissions performance criteria and to use the best appropriate available technology to allow for high efficiency and lower GHG emissions intensity.

5.3 Projects presented to the IDB will be required at the eligibility stage to either comply with the MPC or commit to complying with those criteria. Compliance with the MPC shall be confirmed during the due diligence prior to Board approval.

---

[21] The EIB approach to coal/and lignite fuelled power stations. Annex 3 to A Clean Energy for Europe: A reinforced EIB contribution, w/o year.

[22] See IDB's Sustainable Energy Sector Guidelines, (op. cit.) paragraph 3.28.

5.4 Table 3 lays out the MPC for the IDB to finance new fossil fuel power plants. The MPC are based on the range design specifications for currently newly built fossil fuel power plants (see Table 2). As in the case of the coal fired power plant guidelines, two criteria are applied to preclude conversion to higher-emission fuel in particular with dual or multiple fuel plants;

i. Minimum energy efficiency of the plant (the energy input—higher heat value—related to net electricity output of the generator at the bar) in percent.

ii. Maximum CO_2 emission intensity (kg CO_2e/net kWh).

Table 3: Fossil Fuel Power Plant Requirements for Efficiency (minimum) and Specific Emissions (maximum); new unit at full load

Technology	Minimum Efficiency (Electrical, HHV, net, %) [1]	Maximum GHG Emissions (kg CO_2 e./netMWh)		
		Natural Gas	Diesel (LFO)	HFO
Steam turbine, back pressure	>37	495	n.a.	**710**
Steam turbine	>39	470	n.a.	**675**
Combined Cycle Gas turbine	>47	**390**	535	n.a.
Open cycle gas turbine (large or aero derived) [2]	>32	**570**	785	n.a.
Reciprocating engine, diesel high speed [3]	>38%	480	**660**	**n.a.**
Reciprocating engine, diesel medium speed	>40%	460	630	**660**
Reciprocating engine, diesel slow speed	>42%	435	600	**630**
Reciprocating engine, otto cycle	>40%	**460**	630	660

Notes:
1. When CHP is applied, the minimum acceptable total efficiency (electrical plus thermal) is 50%.
2. Single cycle gas turbines are only acceptable when operated to cover peak load.
3. High speed diesel units are only acceptable for up to 5 MW total capacity in one plant.

5.5 The goal of applying the MPC is to prevent IDB from financing inefficient fossil fuel power plants, without excluding any type of technology or fuel that might be appropriate under particular project circumstances. The principles for setting the MPC are:

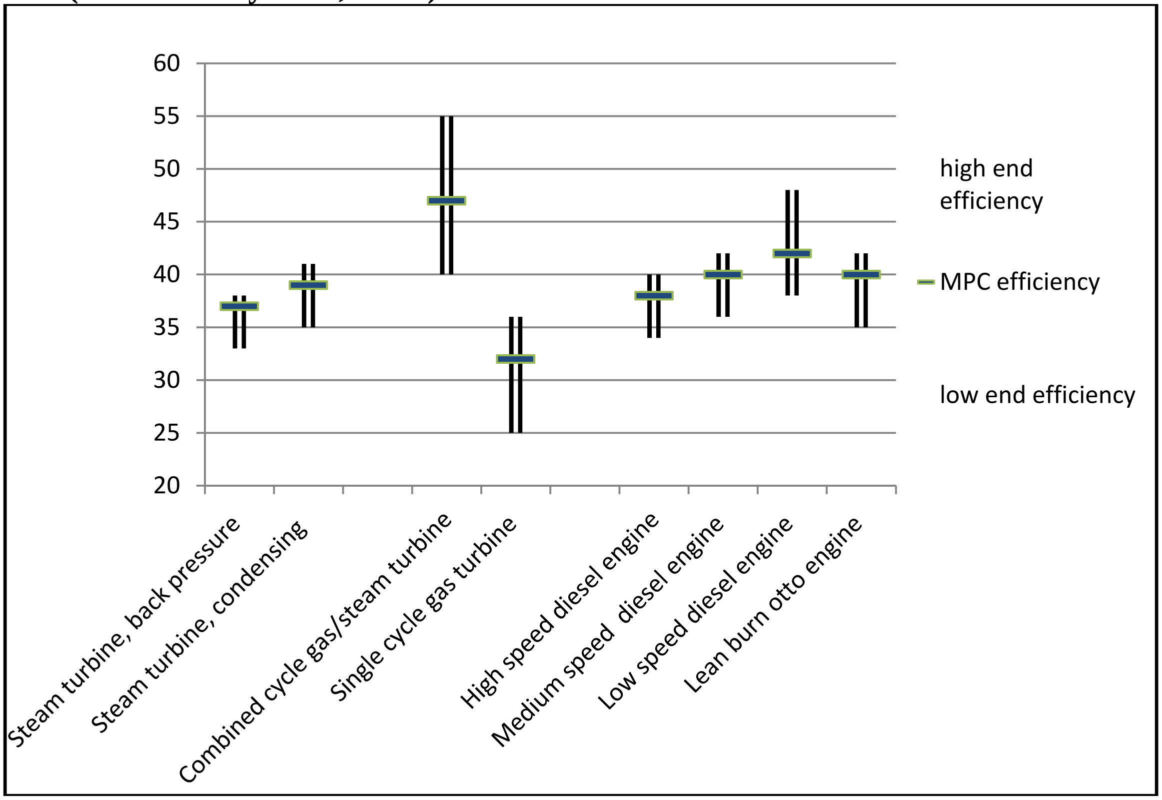
i. Allow for the application of all types of technologies to cover the broad range of needs and conditions.

ii. Require stricter efficiency requirements for technologies of higher emission intensity. This choice is illustrated in Chart 1 below.

iii. Limit low efficient technologies (single cycle turbine or high speed diesel) to specific application.

iv. Allow for a technology, when CHP generation is applied to a significant extent.

Chart 1: Efficiency Performance Ranges and Minimum Criteria, new unit at full load (Net efficiency in %, HHV)



5.6 In these guidelines the quantified minimum requirements are only developed for units of more than 1MW electric capacity. Smaller units may also be financed by the IDB under specific circumstances, for specific purposes or as part of a larger lot. Such situations will be addressed specifically.

5.7 Prior to granting eligibility of the project it should be determined whether the project's existing technology and fuel are acceptable. The MPC do not exclude types of technologies or fuels. Nonetheless, a discussion of opportunities and their feasibility in each specific case must take place during the eligibility stage of the project cycle, at which time an informed decision on the preferred fuel and technology should be made with respect to basic project characteristics.

5.8 During the due diligence or appraisal process, the IDB will work with potential borrowers committing to comply with the Bank's MPC to develop ways for the projects to meet the criteria. Prior to Board approval, compliance with the MPC and other basic characteristics must be verified.

5.9 If the plant and the fuel choice under consideration is part of a Sustainable Energy Action Plan (SEAP), which IDB has established with the respective country[23], due diligence will confirm that the MPC are attained with the particular plant design. If a SEAP does not exist, the project will be required at the eligibility stage to

[23] Inter-American Development Bank. 2011. The Sustainable Energy Sector Guidelines, (op.cit.) paragraph 3.2.

either comply with the MPC or commit to complying with those criteria. In addition, prior to granting eligibility it should be determined whether the project's existing technology and fuel are acceptable, taking into consideration the particular characteristics of the project (size, location, environmental and social considerations) and its environment. The following items will be looked at in addition to the MPC before accepting eligibility:

i. Availability of natural gas in the short or medium term (5 years) at conditions (verified with country energy planning): If natural gas becomes an option, this might change the optimality of the fuel and, possibly, the technology choice, since:

    a. Combined Cycle Gas Turbine (CCGT) on natural gas plants are the most appropriate technology; under special circumstances these may also operate temporarily on LFO/diesel.

    b. Large condensing steam plants with intermediate extraction, customary in interconnected power systems, achieve good performance in case of natural gas firing but still far less than CCGT plants.

    c. Open cycle gas turbines fired with natural gas are acceptable as peak load devices only; the use of diesel oil in gas turbines may only be accepted when there is no possibility of obtaining a supply of natural gas and where and when there is no other possibility for cover peak load.

    d. Diesel cycle plants achieve significantly better emission performance levels when operating on natural gas.

ii. Fuel oil-fired steam and internal combustion plants, only if natural gas is not available in the short or medium term in the country and cannot be imported specifically for the plant at a reasonable benefit/cost-relation and a financially feasible price: Large steam plants may be justified if the best steam technology is applied. It may be convenient to analyze the inclusion of the "readiness" to implement carbon capture[24] in the plant design as this technology evolves and becomes cost-effective, in particular if the carbon can be re-injected in situ or be used in production processes.

iii. Opportunities for cogeneration or use of waste heat from the plant for other purposes: Minimum requirements are set for electricity generation only and do not include thermal uses of waste gas and waste heat. The efficiency parameters of steam plants can be improved significantly if cogeneration is applied, by intermediate heat extraction in a condensation plant or by back pressure steam plants, even in combined cycle plants. Also the heat from reciprocating engines can be used for heating purposes and/or for cooling with absorption chillers. The minimum requirements are considered achieved if the

[24] IPCC Special Report on Carbon Dioxide Capture and Storage. IPCC, 2005 - Bert Metz, Ogunlade Davidson, Heleen de Coninck, Manuela Loos and Leo Meyer (Eds.). Cambridge University Press, United Kingdom.

total electrical plus thermal efficiency of the unit is higher than 50%, even if the electrical efficiency fails to attain the minimum requirement.

iv. Potential use of locally available fuels such as byproducts of oil and gas extraction (e.g. associated gas, coal bed gas, or mine gas): This is highly recommended, particularly when a GHG (as in the case of methane) may otherwise escape into the atmosphere or could be flared without generating useful energy. In remote production sites, reciprocating engine plants using e.g. associated or mine gas instead of releasing it can supply heat as well as electricity.

v. Opportunities for co-firing with residues: availability of waste biomass or biomass derived fuel to be co-fired in the plant.

5.10 The following technologies should not be promoted through IDB financing, except in very special cases (emergency, disaster risk management, backup, on-site renewable energy hybrid):

i. Gasoline fuelled reciprocating engines, Otto cycle of any size.

ii. Self-generation without cogeneration, the type of small diesel generators in buildings and industry.

iii. Diesel generators as part of off-grid electrification of any size, including back-up variable on-site renewable energy generation.

iv. Thermal steam plants, without cogeneration that are crude-oil fired.

5.11 The MPC presented in Table 3 and Chart 1 will be reviewed periodically by IDB to take into account new technological and institutional developments. A regular revision is scheduled 5 years after approval, if experience or new developments do not suggests an earlier adjustment. In updating the criteria, the Bank will consider the increased availability of reliable energy efficiency and CO_2 emissions data from fossil fuel power plants, plant performance and mitigation options, including its experience in implementing these guidelines within projects. Additionally, the regular review and update will be performed in light of changing global objectives regarding GHG emissions. Revisions may include refining the criteria as well as proposing new criteria or mitigation measures.

5.12 Projects that meet the criteria and guidelines when declared eligible for IDB financing will be grandfathered with regard to any future changes specific to this sector or subsector. The grandfathering in of projects vis-à-vis these guidelines' performance criteria and guidelines applicable at the eligibility stage will allow the IDB to react dynamically to new climate change developments while keeping its commitments to borrowers or clients.

5.13 The Bank will accept offsetting according to its GHG Emissions Offsetting Guidelines. As long as GHG Offsetting Guidelines are not adopted, only offsets based on compliance schemes such as Clean Development Mechanism (CDM) will be accepted, provided that compensating carbon offsets are acquired and retired over the lifetime of the project.

5.14 An effort will be made to help finance the cost differential associated with cleaner technologies. The IDB is interested in applying currently existing and emerging financial instruments, to provide incentives to adopt cleaner fossil fuel power plant technologies and, in particular, to cover the incremental costs of adopting low carbon technologies.

5.15 IDB may also help transfer more advanced fossil fuel power technologies and research and development to the countries by, for example, providing technical cooperation (TC) to research and development activities and implementing pilot projects.

5.16 IDB will strengthen its support for the development of appropriate national regulatory frameworks that reflect environmental costs, including CO_2 emissions, in the cost-benefit analysis of a project, either through the development of standalone TC projects or as part of targeted country environmental analysis or country-specific analysis.