ASIAN DEVELOPMENT BANK
Independent Evaluation Department

EVALUATION KNOWLEDGE BRIEF

ON

GREENHOUSE GAS IMPLICATIONS OF ADB'S ENERGY SECTOR OPERATIONS

In this electronic file, the report is followed by Management's response, and the Board of Directors' Development Effectiveness Committee (DEC) Chair's summary of a discussion of the report by DEC.

ADB

Evaluation Study

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Greenhouse Gas Implications of ADB's Energy Sector Operations

Independent Evaluation Department

Asian Development Bank

ABBREVIATIONS

ADB	–	Asian Development Bank
ADTA	–	advisory technical assistance
APCF	–	Asia–Pacific Carbon Fund
AR4	–	Fourth Assessment Report of IPCC
AWG-KP	–	Ad Hoc Working Group on further commitments for Annex I Parties under the Kyoto Protocol
BAP	–	Bali Action Plan
BAU	–	business as usual
CAP	–	country assistance plan
CCS	–	carbon capture and storage
CDM	–	clean development mechanism
CDMF	–	Clean Development Mechanism Facility
CEFPF	–	clean energy financing partnership facility
CIF	–	Climate Investment Fund
CMI	–	carbon market initiative
CO_2	–	carbon dioxide
COP	–	Conference of Parties
CPS	–	country partnership strategy
CSP	–	country strategy and program
CTF	–	Clean Technology Fund
DMC	–	developing member country
EEI	–	energy efficiency initiative
EKB	–	evaluation knowledge brief
ESP	–	electrostatic precipitator
G5	–	Group of Five
G8	–	Group of Eight
GDP	–	gross domestic product
GEF	–	Global Environment Facility
GHG	–	greenhouse gas
Gt	–	gigaton
GWh	–	gigawatt-hour
IEA	–	International Energy Agency
IFI	–	international financial institution
IPCC	–	intergovernmental panel on climate change
kWh	–	kilowatt-hour
LNG	–	liquefied natural gas
LTSF	–	Long-Term Strategic Framework
MDB	–	multilateral development bank
mmbtu	–	million British thermal unit
MTS	–	Medium-Term Strategy
MW	–	megawatt
OECD	–	Organisation for Economic Co-operation and Development
PM-10	–	particulate matter with a diameter smaller than 10 μm
ppm	–	part per million
PPTA	–	project preparatory technical assistance
PRC	–	People's Republic of China
PREGA	–	Promotion of Renewable Energy, Energy Efficiency, and Greenhouse Gas Abatement
PSOD	–	Private Sector Operations Department

REACH	–	Renewable Energy, Energy Efficiency, and Climate Change
REGA	–	Renewable energy, Energy efficiency, and GHG Abatement
RETA	–	regional technical assistance
RRP	–	report and recommendation of the President
SCF	–	Strategic Climate Fund
SO_2	–	sulfur dioxide
SPTT	–	Strategic Program on Technology Transfer
t	–	ton
T&D	–	transmission and distribution
TA	–	technical assistance
tCO_2e	–	ton of CO_2 equivalent
UNFCCC	–	United Nations Framework Convention on Climate Change
US	–	United States
W	–	watt

NOTE

In this report, "$" refers to US dollars.

Key Words

adb, asian development bank, greenhouse gas, ghg efficiency, energy security, emission saving, greenhouse gas accounting, climate change mitigation in developing asia, adb energy sector operation, ghg indicator, ghg saving

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EXECUTIVE SUMMARY

Background and Context

Globalization and technological advancements have created immense opportunities for wealth creation in all parts of the world. Billions in Asia are now able to contribute to the global economy; and with increased income levels and improved living conditions, millions have risen above poverty levels. Concurrently, production of new goods and services, as well as rising household incomes, have started pushing up energy demand growth rates in Asia, and the developing Asian countries are expected to contribute to more than 58% of incremental global primary energy consumption until 2030. Developing Asian countries rely largely on coal and other fossil fuels to support their economic growth, as did other countries that industrialized previously. Emissions of greenhouse gases (GHGs) from the use of such fuels contribute to climate change impacts.

It is by now also recognized that (i) the warming of the climate system since the mid-20th century is unequivocal and is very likely (with greater than 90% confidence level) a consequence of increased anthropogenic GHG emissions; (ii) developed economies cannot by themselves achieve the most desirable outcome of stabilizing atmospheric GHG concentrations to 450 parts per million carbon dioxide (CO_2) equivalent by 2030; and (iii) technology and finance should be made available to developing countries (including Asian Development Bank [ADB] developing member countries [DMCs]) to move toward a low-carbon growth path.

At the same time, ensuring energy security to meet the energy demand essential for sustained economic growth is of vital importance to the DMCs. Hence, the DMCs need to adopt a low-carbon growth path for their energy sectors to reduce the GHG emissions associated with increased energy consumption as well as to improve the efficiency of energy usage. As the leading development financing institution for developing Asia, ADB has a vital role to play in promoting the deployment of new and efficient low-carbon technologies as they become commercially available and thereby lower the carbon content of energy supplies. This will require (among others) the following: (i) policy interventions for an accelerated shift away from fossil fuels, (ii) financial mechanisms to defer the higher capital costs of new technologies until they become available on a commercial scale, and (iii) capacity building and knowledge dissemination on low-carbon technologies and end-user energy efficiency improvements.

Although most development activities aimed at economic growth result in increased GHG emissions, energy sector development is conspicuous by its direct contribution to GHG emissions and the relative ease of measuring the GHG impacts of energy sector interventions. This evaluation knowledge brief (EKB) examines, from the perspective of GHG emissions, ADB's energy sector assistance over 2001–2008 in selected DMCs. Based thereon, it proceeds to make suggestions on improving the GHG efficiency of ADB's future interventions in the energy sector. As more information and tools become available to reasonably measure the direct and indirect GHG impacts of ADB operations in various sectors, the methodologies developed for the purpose of this EKB may be refined and possibly adapted to assess the GHG efficiency of other sectors of ADB operations.

Assessment Approach

The selected DMCs—Bangladesh, People's Republic of China (PRC), India, Pakistan, Philippines, and Viet Nam—accounted for 80% of ADB's total energy assistance lending approvals during 2001–2008. GHG emissions of energy projects approved during this period were estimated largely on the basis of information available in ADB's project appraisal documents. For projects under implementation, updated information from project sponsors or executing agencies was also incorporated. GHG emission savings were assessed with respect to a project-specific counterfactual.

For the purpose of this EKB, suitable methodologies for GHG accounting—which is the basis for GHG efficiency computations—that were developed or adapted are based on the following principles: (i) all energy sector ADB projects and project components in the six DMCs were included; (ii) annual gross emissions were calculated ex-ante for project components having quantifiable GHG impacts; (iii) GHG emission savings were computed with reference to a static (project- and country-specific) baseline associated with the counterfactual; and (iv) the project boundary was defined as per approved clean development mechanism methodologies (where applicable) or a logical physical or system boundary.

The GHG efficiency of ADB energy sector operations should be a measure of expected GHG emission savings or increases in a DMC compared with a business-as-usual case. To facilitate comparison across the various approved projects and components, a broad set of indicators were adopted to assess the GHG efficiency of ADB portfolio. For each energy project or investment approved from 2001 to 2008 and having direct/quantifiable GHG implications, GHG emission savings were used to compute indicators of GHG efficiency (such as tons of CO_2 equivalent [tCO_2e] of GHG savings per $ million of capital investment or tCO_2e of GHG savings per unit of energy supplied). Such indicators were aggregated by country and by energy subsector (type of project) to give a relative measure across countries and subsectors. With the objective of identifying any strategic shift in ADB's energy sector operations, the GHG efficiency of ADB's average lending approvals during 2006–2008 was compared with that for 2001–2005.

Several projects analyzed as part of this study were approved when GHG efficiency and climate change mitigation issues were not considered as important as now, both within ADB and in the DMCs. Besides, even after climate change issues came to the forefront, not all energy sector-related decisions made by DMCs or the various energy lending and nonlending approvals from ADB have been or would be based on GHG-related considerations alone. Energy security and energy access would remain the key rationale for many projects.

Relevance and Strategic Focus

The six selected DMCs included in the EKB consider the ensuring of adequate energy supplies to maintain the economic growth and improve the living conditions of their people to be of primary importance. GHG efficiency improvement is relevant to the DMCs to the extent that it is consistent with the above-mentioned objectives and contributes to improved energy security, enhanced operational efficiency, and mitigation of local environmental impacts.

The Medium-Term Strategy 2006–2008 also stated that DMCs would need to steer away from the high per-capita energy consumption growth path adopted by the developed economies of today if global climate change impacts were to be maintained at reasonable levels. ADB's long-term strategy adopted in 2008 (Strategy 2020) recognizes as one of the five core operational areas the development of clean energy sources to meet the energy security needs of the DMCs. The recently revised 2009 Energy Policy, which recognizes the enormity of the twin challenges of energy security and climate change, advocates a catalytic role for ADB in advancing the clean energy agenda in Asia and the Pacific. It has brought the mitigation of increasing GHG emissions in the energy sectors of DMCs to the forefront of ADB's energy sector operations, together with energy security and access to energy.

ADB's Institutional Response

A strategic shift in ADB's operations to increase its assistance to key infrastructure sectors (including energy infrastructure) began in 2006. At the same time, ADB formally recognized the need for a focused approach to promote clean energy and energy-efficient investments through the launch of the energy efficiency initiative with the objective of increasing its assistance to clean energy projects to $1 billion by 2008. These have resulted in increased approvals for power generation projects beginning in 2006 to meet the rapidly increasing energy demand in large DMCs; but it also led to a new beginning for high-efficiency (but still high-GHG-emitting) coal-fired power projects.

ADB's energy sector operations are in line with the priorities set in the 2009 Energy Policy. The energy efficiency initiative launched in 2006 has resulted in enhanced management focus as well as increased the institutional capacity and awareness of ADB's operational staff working in the energy sector on the need for a low-carbon approach to energy assistance. The country strategy and programs and country partnership strategies prepared since 2006 for large DMCs with significant GHG emissions explicitly mention the shifting of DMC energy sectors to low-carbon development paths as a primary objective, together with ensuring energy security and energy access. This is evident in the recently approved country strategies (e.g., for the PRC and Pakistan) with targeted operations to increase lending support for renewable energy, energy efficiency, and clean thermal power generation technologies.

ADB's recent emphasis on clean energy investments[1] is reflected in the

(i) increase in annual lending for clean energy investments from about $170 million during 2001–2005 to more than $670 million in 2006–2008;
(ii) increase in the share of approvals for clean energy investments to total energy sector approvals from 26% in 2001–2005 to 44% in 2006–2008;
(iii) increase in the share of advisory technical assistance and project preparatory technical assistance supporting clean energy (to total energy sector advisory technical assistance and project preparatory technical assistance) from 23% and 69%, respectively, during 2001–2005 to 43% and 85%, respectively, during 2006–2008; and
(iv) 12-fold increase in annual approvals for nonsovereign energy sector lending and equity investments from 2001–2005 to 2006–2008, most of which are in the clean energy sector. This demonstrates the opportunity for private sector investment in GHG-efficient businesses if the policy framework is appropriate.

Energy sector approvals at the country level show some significant variations among the six DMCs. A significant increase in ADB's energy sector operations occurred in India, where ADB has diversified its energy sector portfolio from the power transmission and distribution subsector during 2001–2005 to include several power generation projects consisting of renewable technologies such as wind and small hydropower and large coal power plants, deploying more efficient technologies compared with the existing conventional coal power plants. A similar increase of ADB energy sector operations occurred in Pakistan and Viet Nam, and recent approvals include an increasing share of power generation projects that result in

[1] Clean energy includes energy efficiency (including fuel switch), renewable energy, hydropower, clean coal technology, gas-based power generation, and gas infrastructure development projects. Conventional coal-fired power and open-cycle gas turbine-based generation projects, transmission, and distribution projects are not considered as clean energy project in this EKB.

GHG savings compared with country-specific counterfactuals. However, ADB assistance to the power sector in the PRC has reduced, and ADB's recent energy sector approvals have focused on end-user energy efficiency improvement, expansion, and rehabilitation of centralized district heating systems and fuel (natural gas) supply projects.

Results Achieved in terms of Improving GHG Efficiency of ADB's Energy Sector Portfolio

For the purpose of assessing GHG efficiency, ADB's energy sector lending portfolio in the six DMCs is divided into power supply projects, and fuel and thermal energy supply projects. The annual average GHG emission savings due to power supply projects increased from 1.08 million tCO_2e approved during 2001–2005 to 7.3 million tCO_2e for the projects approved during 2006–2008. The annual average GHG savings attributable to ADB (i.e., in proportion to its investment in the total project cost) in the power supply projects increased from 0.58 million tCO_2e for the projects approved during 2001–2005 to 1.65 million tCO_2e for the projects approved during 2006–2008. The improvement in GHG savings in the power supply projects is due to increased ADB financing of power generation projects deploying zero or low emission technologies (renewable energy including hydropower) and to more efficient thermal power technologies such as supercritical coal power plants and combined-cycle gas turbines.

The annual average GHG savings of fuel and thermal energy supply projects approved during 2001–2005 (i.e., 1.53 million tCO_2e) dropped marginally (to 1.31 million tCO_2e) for projects approved during 2006–2008. Consequently, there is a corresponding reduction in the average annual GHG savings attributable to ADB for projects approved during 2001–2005 from 0.44 million tCO_2e to 0.38 million tCO_2e for projects approved during 2006–2008. This was due mainly to the absence in the latter period, of methane destruction projects, which have high GHG savings.

Ranking of Energy Supply Technologies Based on ADB's Energy Sector Portfolio

The energy supply technologies included in ADB's energy sector portfolios in the six DMCs were ranked according to the economic cost of supplying a unit of energy for electricity supply projects. The ranking was done with and without the cost of GHG emissions for a range of fuel price and carbon price scenarios. However, the analysis is limited to the extent that it was undertaken for the projects included in ADB's portfolio, without considering site- and country-specific limitations of deploying different technologies and the fuel and renewable energy resource endowments of the different countries.

In the scenario resembling the prevailing fuel costs and with no value attached to carbon emissions, the following can be inferred: (i) use of coal bed methane for power generation is the most economically attractive, as methane is a by-product of coal mining without any economic value or cost in the absence of the project; (ii) conventional pulverized coal-fired power plants are economically more attractive than the more efficient supercritical steam or fluidized bed generation options, as the savings in coal usage are not sufficient to offset the incremental capital cost of advanced technologies; (iii) large hydropower projects entail higher costs than coal-fired power options, which perhaps reflects the small sample size and specific hydropower project site conditions; (iv) gas-fired combined cycle projects are more expensive than hydropower and coal power projects but more economical than gas-fired open-cycle gas turbine projects; (v) renewable energy options, which normally have a relatively low capacity factor, are in general more expensive than large hydropower and fossil fuel-fired power plants; and (vi) rehabilitation of coal- or gas-fired power plants is not economically attractive when fuel prices are low, as the incremental efficiency gains come with relatively high capital investment requirements.

The analysis also shows that when the costs of GHG emissions are introduced at an assumed GHG price of \$20/tCO_2e (i) renewable energy and hydropower projects become more attractive than coal power plants, and (ii) supercritical coal power plants become more attractive than conventional subcritical power plants. At higher fuel prices and at a higher GHG price of \$60/tCO_2e, the relative advantage of renewable and hydropower plants over thermal power plants becomes even more pronounced. A similar analysis of fuel and thermal energy supply projects shows that the costs of methane destruction and methane transportation and distribution systems remain lower than natural gas supply infrastructure costs under all fuel and carbon price scenarios.

Key Findings

Most supply-side energy investments will necessarily add to GHG emissions in absolute terms. To maintain the economic growth required for sustained poverty reduction in DMCs, the energy supply infrastructure has to keep pace with the increasing demand for energy. This requires investments in new power plants, power transmission and distribution networks, and gas pipelines and related infrastructure. Investments supporting fossil fuel usage directly (e.g., thermal power plants and gas pipelines and related facilities) or indirectly (e.g., increasing electricity generated with fossil fuel by expanding the transmission and distribution network) will result in increased GHG emissions in absolute terms. However, the GHG efficiency of these investments should not be measured in absolute terms but rather in relative terms (i.e., in comparison with the most likely scenario in the absence of ADB intervention).

GHG-efficient investments have been part of ADB's energy sector portfolio for many years without explicit recognition. ADB has been financing GHG-efficient energy sector infrastructure development projects for promoting economic growth in DMCs since well before the beginning of the study period. Prior to 2005, these investments were justified in ADB loan documents on the basis of their economic and financial viability and local environmental impacts, and GHG efficiency improvement was not considered as a reason for ADB support—which is perhaps a reason for the inadequacies of relevant information and data in report and recommendation of the President (RRP) documentation for projects approved prior to 2005.

There has been increased focus on GHG-efficient investments supported by ADB since 2006. ADB's lending to energy sector investments with direct GHG savings have increased since 2006, which is consistent with the recently approved country strategies, in which shifting the energy sector to a low-carbon development trajectory is explicitly identified as an intended development outcome. Besides, progressive commercialization of new and increasingly sophisticated renewable energy technologies, and increasingly higher efficiency fossil fuel-fired power generation, have also increased ADB's maneuverability toward meeting the DMCs' broader development objectives while ensuring an energy-efficient growth path. The operations approved for support by ADB since 2006 that merit specific attention in this context include increasing the share of renewable energy (with the introduction of large wind turbines in the PRC), advanced combined-cycle gas turbines and cleaner coal combustion technologies for power generation (especially in India), developing infrastructure for supply of less GHG-intensive fossil fuels such as natural gas (PRC and India), and industrial energy efficiency projects (PRC).

Renewable energy is still a high-cost option for many DMCs. Although the share of renewable energy in large DMCs such as the PRC and India is increasing in response to fiscal and other incentives and the targets set by the respective governments, the costs per unit of energy from renewable energy projects are higher than the fossil fuel-based alternatives. There is scope for further reducing the cost of energy from renewable sources by developing more appropriate technologies for the Asian region, promoting regional manufacture of renewable energy equipment, and exploiting scale economies arising from increased penetration of renewable energy technologies in the Asian region.

There is scope for expanding ADB investments in industrial energy efficiency projects. The heavy industry sector (e.g., cement, steel, petrochemical) consumes a significant share of energy in rapidly industrializing DMCs, and the industrial energy efficiency of DMCs in terms of energy consumption per unit of industrial output lags behind that of the more advanced countries. However, ADB has not had much success in channeling financing to industrial energy efficiency improvement due to (i) ADB's lack of engagement and expertise in financing industrial projects, (ii) the relatively small size of investment per industrial unit, (iii) ADB's internal policies discouraging it from engaging state-owned enterprises involved in heavy industries, and (iv) the need for financial intermediaries to channel ADB financing to industrial energy efficiency improvement projects.

More emphasis is required in encouraging policy reforms to promote GHG efficiency of energy sector operations. In the six selected DMCs, ADB's policy dialogue has been generally focused on institutional reforms of energy sector entities and less emphasis in initiating broader policy reforms supporting GHG efficiency investments. This may be due to lack of access that ADB has had to policy makers in larger DMCs such as India, where ADB has focused primarily on state-level issues. Even in countries such as Bangladesh, where ADB was highly influential, its policy dialogue was focused primarily on institutional reforms and creating an enabling environment for private sector investments. However, there are exceptions to this trend. In the PRC, ADB has selectively engaged with the Government through a series of technical assistance activities to provide high-level inputs for policy reforms to encourage investments in improved district heating systems and coal-bed methane recovery. In Pakistan, ADB has supported the policy framework for renewable energy investments.

Appropriate indicators are needed in the Results Framework (2008) for tracking implementation of the energy policy. In line with Strategy 2020, ADB's 2009 Energy Policy recognizes the importance of energy security and climate change and sets targets for approvals of ADB's financial support on clean energy technologies. The implementation of the Energy Policy is to be monitored as per the ADB Results Framework, which clearly states that (i) appropriate indicators for clean energy remain to be identified (and that they would be incorporated in future versions of the Results Framework), and (ii) ADB's contribution to country and regional outcomes is to be assessed by aggregating key outputs delivered to DMCs. Hence, appropriate indicators need to be incorporated into the ADB Results Framework to monitor the achievement of targets set in the 2009 Energy Policy, for which some of the indicators and methodologies developed in this EKB could provide a useful basis.

The quality of information and data for GHG efficiency analysis reported in RRPs is highly variable. The quality of GHG efficiency reporting in RRPs correlates well with the quality of economic analysis and the type of project. Many RRPs for energy efficiency, renewable energy, and hydropower projects provide GHG savings estimates or relevant data for making reasonable estimates of GHG savings. For other types of projects (e.g., gas infrastructure development and power transmission and distribution), the inadequacies of data relevant for GHG savings estimation are most evident. The design and monitoring frameworks presented in some recent RRPs also include GHG savings-related targets and indicators—although the methodology for assessing GHG savings is not clearly outlined. The GHG analysis undertaken in the RRPs and the GHG efficiency indicators used do not follow a consistent methodology. As a result, the information provided in RRPs is of little use to monitor the portfolio-wide GHG efficiency of ADB.

There is a large potential for coal-bed and landfill methane capture projects in PRC, India, and Indonesia. These projects have high degrees of GHG efficiency, as methane has a global warming potential 21 times that of CO_2, and the captured methane can be used as a clean fuel source to replace coal in power generation and as a clean residential, commercial, and industrial fuel. ADB could selectively initiate a policy dialogue with government agencies and coal mining enterprises with the objective of expanding its investments in methane capture and use based on its past experience in such projects in the PRC.

Coal remains as the fuel of choice for many DMCs for power generation. Due to their large coal reserves, the relatively low cost, the proven reliability of coal power plants for base-load power generation, and the lack of suitable alternatives to provide the required scale of power generation capacity at an affordable price, coal remains a preferred fuel in several DMCs. Hence, if ADB is to remain relevant to the needs of its DMCs, it could consider supporting coal-based power generation following more advanced and efficient technologies such as supercritical boilers, integrated gasification combined-cycle power plants, and carbon capture and sequestration subject to technical feasibility in the country context. If such advanced technologies are not feasible, conventional coal technologies may have to be supported to ensure energy security at an affordable price. However, these technologies entail a significantly higher cost than conventional coal power plants, and the GHG savings arising from the deployment of such advanced technologies are not eligible for carbon financing at present. Hence, ADB needs to explore appropriate financing mechanisms to encourage such technologies.

ADB's Private Sector Operations Department (PSOD) has the potential to play a significant role in promoting GHG-efficient investments. A review of ADB's lending operations shows that PSOD operations (especially in the PRC and India) have high potential for GHG efficiency improvement. This is due mainly to the type of projects supported by PSOD, which include renewable energy (e.g., wind in India and small hydropower in Pakistan); supercritical coal power plants and liquefied natural gas terminals in India; district heating efficiency, industrial and commercial building energy efficiency, and fuel switching investments in the PRC; and rehabilitation of privatized thermal power plants in Pakistan and Philippines. Although there has been an increase in public sector lending for hydropower projects (in PRC, India, and Viet Nam) and energy efficiency projects (notably in the PRC), most public sector lending continues to be dominated by traditional power transmission and distribution projects.

This EKB puts forward the following recommendations for consideration by ADB Management in its energy sector operations.

Recommendations		Responsible Department	Time Frame
1.	**Assess GHG implications of future investments with significant GHG impacts or savings (para. 116).** During the planning, processing, and implementation of future energy sector investments, the following may be considered:	RSDD, RDs, and PSOD	2011

Recommendations	Responsible Department	Time Frame
(i) **Prepare a consistent framework** for identifying projects with significant GHG impacts or savings at the concept clearance stage and undertaking GHG assessment at appraisal stage for such projects; (ii) **Undertake an ex-ante assessment of GHG impacts** for projects with significant GHG impacts or savings with respect to a plausible counterfactual to the project; and (iii) **Reconfirm the GHG assessment** mentioned in (ii) above at project completion for projects with significant GHG impacts or savings.		
2. **Promote GHG efficient investments (para. 117).** In terms of selecting energy sector investments for ADB support—and taking into account other objectives related to economic growth, energy security, access of affordable energy—the following may be considered: (i) **Mechanism to buy down incremental cost of clean coal technologies** (compared to conventional pulverized coal subcritical power plants) in grid systems that are sufficiently large. ADB should take the lead in mobilizing funds for establishing a financing mechanism that buys down (in part or full) the incremental cost of relatively higher cost but more GHG-efficient coal power plants. (ii) **Scaling up development of appropriate and affordable renewable energy technologies** for DMCs through (a) supporting regional research and development, (b) pilot testing new technologies in selected DMCs, (c) scaling up the deployment of new renewable energy technologies through technology transfer, and (d) supporting regional manufacturing of packaged renewable energy products and subassemblies. (iii) **Aggressively pursuing methane destruction projects.** As a first step, ADB should initiate an assessment of opportunities for reducing anthropogenic methane emissions (from energy sector operations such as coal mining, as well as nonenergy sectors such as municipal solid waste management), and selectively pursuing investment opportunities arising from such an assessment. (iv) **Scaling up investments in industrial energy efficiency improvement.** ADB's standard financial products and lending modalities are not appropriate for expanding its lending to industrial energy efficiency improvement. Hence, ADB should develop a suite of lending modalities to meet the specific requirements of industrial energy efficiency projects and pilot test these in selected DMCs with sufficiently large industrial base.	RDs, PSOD, and RSDD	2012

ADB = Asian Development Bank, DMC = developing member country, GHG = greenhouse gas, PSOD = Private Sector Operations Department, RD = regional department, RSDD = Regional and Sustainable Development Department.

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I. EVALUATION FOCUS

A. Rationale

1. Globalization and technological advancements have created immense opportunities for wealth creation in all parts of the world. Billions in Asia are now able to contribute to the global economy; and with increased income levels and improved living conditions, millions have risen above poverty levels. Concurrently, production of new goods and services, as well as rising household incomes, have started pushing up energy demand growth rates in Asia, and the developing Asian countries are expected to contribute to more than 58% of incremental global primary energy consumption until 2030. However, the energy technologies deployed widely in Asia have not changed at the same pace. Asian nations rely largely on coal and other fossil fuels to support their economic growth, as did other countries that industrialized previously. Emissions of greenhouse gases (GHGs)[1] from the use of such fuels contribute to climate change impacts.

2. At the same time, ensuring energy security to meet the energy demand essential for sustained economic growth is of vital importance to the developing member countries (DMCs). Hence, the DMCs need to adopt a low-carbon growth path for their energy sectors to reduce the GHG emissions associated with increased energy consumption as well as to improve the efficiency of energy usage. As the leading development financing institution for developing Asia, the Asian Development Bank (ADB) has a vital role to play in promoting the deployment of new and efficient low-carbon technologies as they become commercially available and thereby lower the carbon content of energy supplies. This will require (among others) the following: (i) policy interventions for an accelerated shift away from fossil fuels, (ii) financial mechanisms to defer the higher capital costs of new technologies until they become available on a commercial scale, and (iii) capacity building and knowledge dissemination on low-carbon technologies and end-user energy efficiency improvements.

3. Although most development activities aimed at economic growth result in increased GHG emissions, energy sector development is conspicuous by its direct contribution to GHG emissions and the relative ease of measuring the GHG impacts of energy sector interventions. This evaluation knowledge brief (EKB) examines, from the perspective of GHG emissions, ADB's energy sector assistance over 2001–2008 in selected countries. Based thereon, it proceeds to make suggestions on improving the GHG efficiency of ADB's future interventions in the energy sector. As more information and tools become available to reasonably accurately measure the direct and indirect GHG impacts of ADB operations in various sectors, the methodologies developed for the purposes of this EKB may be refined and adapted to other sectors of ADB operations.

B. Evaluation Framework

4. Against this backdrop, the immediate objectives of this EKB are to (i) gain insights concerning the GHG efficiency of ADB's energy sector lending operations as well as the relevant policy dialogue during 2001–2008; and (ii) understand how ADB energy sector operations could be more strategically focused, effective, and sustainable in improving the GHG efficiency of the energy sector in the DMCs.

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[1] GHGs are gases deemed to cause global warming; they include carbon dioxide (CO_2), methane, and several other industrial gases. The relative contributions of different gases to global warming are different; for instance, methane is known to have a climate change impact 21 times that of CO_2.

5. The EKB pertains to the GHG aspects of energy operations alone, and includes the following key assessment areas:

(i) **Component 1: Contextual and strategic assessment.** The linkages among economic growth, energy consumption, and GHG emissions are examined, as is the global response to rising climate change concerns. ADB's strategic focus on climate change, as articulated in ADB's key strategy and policy statements (such as the Long-Term Strategic Framework [LTSF] and Energy Policy), are examined.

(ii) **Component 2: Qualitative assessment of ADB's country level energy sector operations with respect to GHG efficiency enhancement.** The extent to which ADB strategies and policies are reflected in country partnership strategies (CPSs),[2] as well as in the portfolio of programs and projects of selected countries, is examined. The type of policy dialogue and technical assistance (TA) programs are examined from the specific perspective of GHG efficiency enhancement.

(iii) **Component 3: GHG accounting methodologies.** Methodological aspects related to estimation of GHG emission savings (or otherwise) of ADB's lending portfolio are addressed. GHG accounting methodologies are developed for the various categories of energy projects/components. In so doing, the approaches adopted for claiming certified emission reduction credits under the clean development mechanism (CDM) are considered (to the extent available and relevant), as well as economic analyses presented in project appraisal documents.

(iv) **Component 4: GHG efficiency assessment of ADB's energy sector lending operations.** The performance of relevant ADB energy sector projects and investment programs is examined in terms of GHG efficiency. Projects/investment programs approved during 2001–2008 are analyzed by applying the relevant GHG accounting methodologies for each project component.[3] Trends in GHG efficiency of the overall ADB energy sector portfolio are assessed with a view to gauging time trends (if any), for instance, since the launch of the carbon market and energy efficiency initiatives in 2005/06.

6. The EKB also examines learning from past and current good practices in the experience of ADB with the objective of providing guidance for its future energy sector operations to be more focused and effective in improving the GHG efficiency of energy sectors of the DMCs. The key assessment issues addressed in the context of the evaluation framework are shown in the box.

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[2] Previously referred to as country strategy programs, country assistance plan (CAP), or country operational strategies.

[3] Several project loans include components that fall in various subsectors or categories. Each subsector or category is treated separately for purposes of GHG accounting and GHG efficiency analysis.

Key Assessment/Evaluation Issues

Component 1: Contextual and Strategic Assessment

(i) What are the links among economic growth, energy sector development, and GHG emissions for selected countries?

(ii) What is the impetus to GHG emissions abatement that comes from the global community (i.e., the UNFCCC and its agreements, protocols, action plans; the World Bank; bilaterals; country groupings; etc.)?

(iii) What is the importance/priority given to GHG efficiency improvements in ADB strategies and energy sector policies?

Component 2: Qualitative Assessment of ADB's Country Operations with respect to GHG Efficiency

(i) How do ADB strategies and policies encouraging GHG efficiency translate into CPSs?

(ii) To what extent have CPSs incorporated climate change mitigation-related issues?

(iii) To what extent has ADB engaged the DMCs in identifying the linkages between economic growth and GHG emissions and adopting appropriate measures to prepare for limits on GHG emissions of DMCs in the future through international agreements?

(iv) To what extent did ADB promote GHG efficiency in DMCs through policy dialogue (through program loans and nonlending operations)?

(v) To what extent are GHG implications explicitly acknowledged in approved lending projects and investment programs and TA?

Component 3: GHG Accounting Methodologies

(i) What are the key methodological issues with respect to project and component categories that should be considered for GHG emissions accounting and for facilitating aggregation across the portfolio?

(ii) What methodologies should be developed and/or adopted to analyze ADB's project portfolio?

Component 4: GHG Efficiency Assessment of ADB's Energy Sector Lending Operations

(i) What may be relevant and good indicators of GHG efficiency in ADB's portfolio?

(ii) What are the key lessons from past investments in GHG emission-saving and reduction energy supply and end-use projects, and how these can be scaled up?

(iii) What are the portfolio-wide GHG efficiency indicators for different types of projects and their trends during the study period?

(iv) How do the GHG efficiency indicators of ADB energy sector operations vary from country to country?

ADB = Asian Development Bank, CPS = country partnership strategy, DMC = developing member country, GHG = greenhouse gas, TA = technical assistance, UNFCCC = United Nations Framework Convention on Climate Change.
Source: Compiled by the study team.

7. The EKB examines ADB's energy sector operations (in the context of its country policies and strategies) in a select group of DMCs that have made significant contributions to global GHG emissions and thus provide more opportunities for accelerated deployment of low-carbon technologies. The EKB assesses the following:

(i) **Relevance and strategic coherence** of ADB strategies and policies from the viewpoint of consistency with national energy sector strategies and climate change mitigation plans: relevance of ADB's corporate strategies toward steering DMCs to a low-carbon growth path, and strategic focus of ADB's country strategies in improving the GHG efficiency of its energy sector interventions.

(ii) **Responsiveness** of ADB's strategies, policies, and operations (lending and nonlending), in particular the following: ADB's institutional response toward improving the GHG efficiency of energy sector operations, resources allocated by

ADB toward mitigating GHG emissions through its own resources and resources mobilized from other aid agencies, ADB's efforts toward mobilizing private sector participation, and accounting of GHG emissions of ADB-financed energy sector projects.

(iii) **Results** that may be attributed to ADB directly or indirectly for supporting GHG efficiency enhancements in DMCs, in particular related to policy reforms promoted by ADB that propel DMCs to a low-carbon growth path; and ADB contribution to GHG emission savings on the basis of lending approvals.

C. Evaluation Approach

8. **Modalities.** The evaluation approach is described in Appendix 1. The assessment was undertaken based on a mix of literature review, desk studies, and interviews with concerned ADB staff and borrower and executing agency personnel. Six DMCs (Bangladesh, People's Republic of China [PRC], India, Pakistan, Philippines, and Viet Nam) are given a detailed evaluation. These six DMCs accounted for 80% of ADB's total energy sector (lending plus nonlending) assistance approvals during 2001–2008. Although Indonesia is one of the largest GHG emitters in the world, mainly due to land use pattern changes, the EKB did not include Indonesia, as ADB did not have significant energy sector interventions during 2001–2008.

9. **Limitations.** The GHG analysis and GHG efficiency estimation is undertaken for over 80 distinct project components with quantifiable GHG impacts belonging to over 50 energy sector investment projects approved by ADB during 2001–2008 in the six DMCs. The quantitative analysis was undertaken only for the investment projects with quantifiable GHG emissions. The GHG impacts of policy reforms supported through program loans, TA, and policy dialogue has not been quantified and is assessed on qualitative terms. The study does not include ADB investments in transport, urban, agriculture, and other sectors, which have implications on the overall energy consumption of the country concerned and GHG emissions. The study is focused on GHG emissions of energy sector operations; hence, the broader climate change-related issues including environmental issues and ADB's effort to prepare the DMCs for adapting to climate change are not addressed in the study.

10. It is recognized that precise GHG emission estimates can be made only when the projects have reached commercial operation. This necessarily implies that loans approved 5 years or more ago must be analyzed. However, such a sampling of projects would clearly miss any changes affected in recent years when climate change mitigation concerns have become increasingly important and ADB's carbon market and energy efficiency initiatives have been launched. The project appraisal documents also do not always provide relevant information on a plausible counterfactual scenario to the project.

11. It is appreciated that most of the projects and components analyzed as part of this study were approved with the objective of ensuring the energy security of the country concerned at least cost. Even after climate change issues came to the forefront, not all energy sector-related decisions made by DMCs or the various energy lending and nonlending approvals from ADB would be based on GHG-related considerations alone, and energy security and energy access remains the key rationale for most of the projects. It is also noted that the cost of GHG emissions is not considered as an economic cost during the economic analysis of ADB-financed projects undertaken at the project appraisal stage. As a result, there is limited information on GHG impacts in ADB’s project appraisal documents, principally the report and recommendation of the President (RRP).

II. CONTEXTUAL AND STRATEGIC ASSESSMENT

A. Energy–Economy–Environment Linkages

12. More than 600 million people in the Asia and Pacific region still live in absolute poverty (with incomes of less than $1 per day), and over 1.7 billion are poor (as measured against a benchmark of less than $2 per day). Although growth rates in ADB DMCs over the last decade have been impressive, even if these continue into the future, by 2020 only the PRC (among the ADB DMCs) will reach a per capita gross domestic product (GDP) that is above the world average. However, increased energy consumption in DMCs, an essential input to sustained economic development, would result in environmental impacts including GHG emissions.

13. Increasing concern over global climate change is not the first time that the trade-off between economic development and environment has come to the forefront of the development agenda. By the 1980s, it was recognized that the unmitigated local environmental consequences of infrastructure development (notably power generation and transportation) impose significant costs on DMC economies.[4] Governments in Asia (as elsewhere) had enacted environmental quality regulations and set emission standards. Recent experience shows that local environmental benefits outweighed compliance costs, and environmental mitigation costs represented a small percentage of project costs in most of the infrastructure projects. However, the situation is very different with GHG. Benefits of GHG emission mitigation are evident mainly at the global level, while the cost of GHG mitigation is to be borne by the DMCs. However, there are significant cost advantages of addressing GHG mitigation, together with the mitigation of local environment impacts if appropriate financial incentives can be provided to the DMCs. Another factor that complicates the allocation of costs and benefits of GHG mitigation is time, as global warming is due to accumulated GHGs in the atmosphere since industrialization began. Hence, today's pollutants are not the sole contributors to global warming, and allocation of differential responsibility for global warming based on the historical contribution of GHG emissions further complicates the ongoing debate on limiting GHG emissions.

14. An increase in carbon emissions in the DMCs in both absolute terms and on per capita terms is unavoidable in the foreseeable future as DMCs' economies are expected to maintain their current growth trajectories. However, the emphasis on economic development and economic efficiency does not necessarily lead to higher GHG emissions, as there are many win-win strategies that offer low carbon development pathways, especially in the larger developing economies in Asia. The magnitude of these increases will be dependent upon the interplay of policies and opportunities in three main areas: (i) technology improvements directed to increased efficiency in energy supply and energy consumption, (ii) energy pricing policy and the reduction of fuel subsidies, and (iii) choice of technologies adopted for energy security enhancements. A detailed discussion on such issues is presented in Appendix 2.

B. The Climate Change Challenge and the Global Response

15. The need for accelerating the global response for managing the adverse climate change impacts of business-as-usual (BAU) growth strategies is becoming increasingly clear, and several initiatives have been taken by the global community to address this. The intergovernmental panel on climate change (IPCC) and various international forums and organizations that have included climate change in their agendas in recent years have

[4] Local environmental consequences include health costs and damage costs to agriculture, forests, and displaced project-affected families.

recognized the primacy of the United Nations Framework Convention on Climate Change (UNFCCC) as the forum for international dialogue on climate change. The details are presented in Appendix 3 and are summarized below. The UNFCCC now has 192 parties (country governments) that review the findings and progress of various initiatives and take decisions on further actions through annual meetings of the Conference of Parties. The UNFCCC has moved gradually from its role of encouraging action to that of seeking commitments to manage the adverse impacts of climate change. It began with somewhat small commitments set in the Kyoto Protocol and is now poised to seek larger commitments from the global community.

16. The IPCC in its Fourth Assessment Report of 2007 has stated that, on the basis of scientific evidence, warming of the climate system since the mid-20th century is unequivocal and that it is very likely (greater than 90% confidence level) a consequence of increased anthropogenic GHG emissions. Substantive reductions in GHG emissions and concentrations are required to keep the average global temperature rise to within 2^{o}C from pre-industrial levels.[5] Containing GHG concentrations at 450 parts per million (ppm) is considered the most desired level to achieve this objective.

17. The International Energy Agency presented multiple GHG emission scenarios at the Group of Eight (G8) countries Hokkaido summit, some of which build on the work of the IPCC. The key findings of the International Energy Agency include the following: (i) as energy-related carbon dioxide (CO_2) accounting for more than 60% of global GHG emissions, the energy sector will be central to the discussions on the level of GHG concentrations to aim for, and how to achieve them; (ii) the target that is set for long-term stabilization of GHG concentrations will determine the pace of the required transformation of the global energy systems; (iii) any major agreement will need to take into account the importance and perspectives of the five largest emitters (United States of America, PRC, European Union, India, and Russia), which together account for nearly two-thirds of global CO_2 emissions; and (iv) the achievement of the most desirable GHG concentration scenario (450 ppm CO_2 equivalent) by 2030 also poses a very difficult challenge—neither can the Organisation for Economic Co-operation and Development countries achieve it by themselves, nor is it quite clear as to whether the scale of transformation required for achieving this target is even technically achievable and whether a more feasible target (550 ppm CO_2 equivalent) should be adopted.

18. Along with other multilateral development banks (MDBs), the World Bank reported on the Clean Energy Investment Framework to the G8[6] in 2008. It defined a forward path for addressing climate change issues, its key elements being (i) MDBs to scale up current activities and develop new activities with respect to the three pillars (access to energy, climate change mitigation, and adaptation to climate change); and (ii) MDBs to increasingly assist their DMCs (including economies in transition) to integrate climate change issues into their development programs.

19. At the 13th meeting of Conference of Parties to UNFCCC in 2007, an agreement was reached on the Bali Action Plan (BAP) for climate change mitigation and adaptation. The key decisions of the BAP vis-à-vis climate change mitigation are (i) launching a comprehensive process to enable the full, effective, and sustained implementation of the UNFCCC through

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5 As per the Fourth Assessment Report of IPCC, to stabilize atmospheric concentrations of GHGs to 450 ppm of CO_2 equivalent, the Annex I countries (i.e., 37 industrialized countries and the European Union, which have emission reduction commitments under Kyoto Protocol) are required to reduce emissions (compared with 1990 levels) by 25–40% by 2020 and 80–95% by 2050.

6 *Joint MDB Report to the G8 on the Implementation of the Clean Energy Investment Framework and Their Climate Change Agenda—Going Forward*, June 2008.

long-term cooperative action to reach an agreement beyond the Kyoto Protocol for the post-2012 period; (ii) a shared vision for long-term cooperative action that incorporates the principle of common but differentiated responsibilities; (iii) enhanced national and international action on mitigation of climate change; (iv) enhanced action on technology development and transfer to support action on mitigation; and (v) enhanced action on the provision of financial resources and investment to support action on mitigation and technology cooperation.

20. In support of the BAP, the World Bank Board of Directors approved the establishment of climate investment funds at the World Bank with the participation of other MDBs (African Development Bank, ADB, European Bank for Reconstruction and Development, and Inter-American Development Bank) in July 2008. The climate investment funds build on the experience gained from the Clean Energy Investment Framework and comprise the (i) Clean Technology Fund, which will support demonstration of clean technologies with potential for scale up, as well as transfer of low-carbon technologies in the power, transport, industry, and agriculture sectors; and (ii) Strategic Climate Fund, which will provide financing to pilot new development approaches or to scale up activities aimed at a specific climate change challenge through targeted programs.

C. ADB's Strategic Response

1. Strategic Policy Framework of ADB Related to Climate Change and GHG Emissions

21. ADB strategies, policies, and initiatives are assessed in terms of their role in influencing ADB's lending and nonlending programs with respect to addressing and mitigating GHG emissions of energy sectors of the DMCs during the evaluation period, 2001–2008. These are explained in detail in Appendix 4. The LTSF 2001–2015[7] recognizes ADB's mission as the reduction of poverty through sustainable and equitable economic growth. It places environmental considerations as an important factor in development decision making and planning of ADB initiatives and operations. However, it does not recognize the linkage among rapid economic growth, increased GHG emissions, and climate change as a significant issue.

22. There was a strategic shift in ADB's operations starting 2005 to increase the relevance of its assistance in the context of the changing priorities and needs of ADB DMCs, especially as a result of the rapid economic growth of some of the large middle-income countries. The Medium-Term Strategy 2006–2008 (MTS II)[8] was prepared in 2005 in response to this; it identified priority sectors for ADB assistance on the basis of ADB's comparative advantage, and identified promotion of sustainable energy sector development as one of the priority areas. The MTS II clearly stated that the Asian countries would have to steer away from the growth path of high per-capita energy consumption adopted by the developed economies of today if the global climate change impacts are to be maintained at a reasonable level. The MTS II recommended ADB to help DMCs to adopt low-carbon technologies including energy efficiency improvement and deployment of renewable energy.

23. In recognition of the strategic shift of the development challenges and priorities of DMCs since the adoption of the LTSF 2001–2015, ADB adopted the LTSF 2008–2020 (Strategy

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[7] ADB. 2001. *Moving the Poverty Agenda Forward in Asia and the Pacific. The Long-Term Strategic Framework of the Asian Development Bank (2001–2015)*. Manila.
[8] ADB. 2006. *Medium-Term Strategy II 2006–2008*. Manila.

2020).[9] Environmental degradation including climate change due to rapid economic growth is identified as one of the major challenges to be addressed in Strategy 2020. In this context, the increasing share of GHG emissions of the energy sectors of developing Asia (from 8% of global GHG emissions in 1980 to 28% in 2005 and 42% in 2030) is mentioned as a major contributory factor to global warming. Strategy 2020 identifies five core areas of specialization to effectively promote the three development agendas promoted in it. These five core areas of specialization explicitly include (i) supporting infrastructure development including expansion of energy supply through clean energy sources; and (ii) promoting sound environment management including shifting of DMCs to low-carbon growth paths through more efficient and clean use of energy, as well as reducing GHG emissions in nonenergy sectors.

2. Energy Sector Policy Framework of ADB (2001–2008)

24. The Energy Policy 2000[10] referred to the possible link between climate change and GHG emissions mitigation due to the possible opportunities for the DMCs to access financing for clean energy projects through carbon markets under the Kyoto Protocol. It must be noted that the Kyoto Protocol was not ratified, and there were no functioning carbon markets in 2000. The Energy Policy 2000 mentioned that ADB would support interventions to increase the use of cleaner forms of energy and initiatives for GHG abatement within the overall framework of the UNFCCC. However, this was not considered as a major policy thrust in the Energy Policy 2000 and was given the same level of importance as addressing localized environmental problems such as acid rain and other impacts related to energy sector development. Nonetheless, it included several other policy recommendations focused on improving overall efficiency and environmental performance of the energy sector that also contribute to improving GHG efficiency.

25. ADB has revised its energy policy with the objective of aligning energy sector operations with Strategy 2020. The 2009 Energy Policy[11] has brought the mitigation of increasing GHG emissions in the DMCs' energy sectors to the forefront of ADB's energy sector operations together with energy security and access to energy. The 2009 Energy Policy thus recommends several operational measures to guide ADB's energy sector operations that include (i) promoting access to carbon markets for clean energy and energy efficiency improvement through the carbon market initiative (CMI) of ADB; (ii) promoting new investment projects in clean energy and energy efficiency through TA, credit enhancement, and grant financing of investment costs through the Clean Energy Financing Partnership Facility (CEFPF); and (iii) proactively promoting new and more efficient coal technologies such as supercritical coal power plants and carbon sequestration.

26. ADB's Safeguard Policy[12] adopted in June 2009 has explicitly recognized the importance of addressing the environmental impacts including GHG emissions of ADB-financed projects. The safeguard policy requires the quantification of direct and indirect[13] GHG emissions for projects resulting in significant GHG emissions defined as over 100,000 tons of CO_2 equivalent (tCO_2e) per year. The safeguard policy also requires ADB borrowers/clients to consider technically and financially feasible options to reduce or offset project-related GHG emissions.

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9 ADB. 2008. *Strategy 2020: The Long-Term Strategic Framework of the Asian Development Bank 2008–2020*. Manila.
10 ADB. 2000. *Energy 2000: Review of the Energy Policy*. Manila.
11 ADB. 2009. *Energy Policy*. Manila.
12 ADB. 2009. *Safeguard Policy Statement*. Manila.
13 Emissions associated with the energy consumed in the manufacture, transportation, and installation of equipment, as well as project testing and commissioning; as also energy consumed at decommissioning.

3. ADB's Operational Initiatives (2001–2008) to Address GHG Emissions of the Energy Sector

a. Renewable Energy, Energy Efficiency, and Climate Change Program (2001–2006)

27. ADB had established the Renewable Energy, Energy Efficiency, and Climate Change (REACH) program as an umbrella program covering several clean energy–environment focused donor trust funds supported by the governments of Canada, Denmark, Finland, and Netherlands. Regional technical assistance (RETA) 5972: Promotion of Renewable Energy, Energy Efficiency, and Greenhouse Gas Abatement (PREGA),[14] which was implemented in 2001–2006, was the flagship initiative under the REACH program. PREGA was aimed at capacity building of domestic stakeholders in 18 DMCs to promote investments in renewable energy, energy efficiency, and GHG abatement technologies. It provided a forum for ADB staff to share information about problems in promoting clean energy technologies in different DMCs and created the initial impetus within ADB to mainstream clean energy technologies in energy sector operations.

b. Energy Efficiency Initiative 2006

28. In recognition of increasing global concerns about rapid growth in GHG emissions from developing Asian countries, their contribution to climate change and increasing emphasis on addressing the GHG emissions in MTS II and Strategy 2020, ADB launched the energy efficiency initiative (EEI) in 2006 with the objective of increasing its assistance to clean energy projects to $1 billion by 2008. The EEI identifies several priority energy subsectors for promoting clean energy investments, including (i) demand-side energy efficiency improvement, (ii) supply-side energy efficiency, and (iii) renewable energy.

29. The CEFPF was established in 2007 under the EEI to mobilize and channel financial resources from bilateral donors for clean energy projects in DMCs. CEFPF resources have been used for (i) grant financing of the incremental costs of more efficient technologies, and (ii) TA for preparing clean energy projects and policy and institutional advice to remove barriers to clean energy deployment. In 2008, ADB also approved the $40 million Climate Change Fund to provide additional resources to the CEFPF.

c. Carbon Market Initiative

30. In anticipation of the emerging opportunities under the CDM, ADB initiated the Credit Marketing Facility (CMF) in 2003 with the objectives of (i) initiating CDM-eligible projects through ADB's existing relationships in DMCs; and (ii) helping project sponsors to prepare documents required for registration at the UNFCCC. The CMF was established as a pilot facility from 2003 to 2006 and was intended to support approximately 16 ADB-financed projects in accessing carbon markets. The experience with the CMF demonstrated that there was a latent demand for an enhanced role for ADB in the rapidly developing carbon markets. In response, ADB launched the CMI in 2006. The CMI was set up with the objectives of addressing several key barriers to CDM-eligible projects in DMCs such as (i) lack of access to long-term project financing and difficulty of finding up-front funding for carbon credits to be generated by investment projects, and (ii) lack of technical capacity and expertise on carbon markets and the

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[14] ADB. 2001. *Technical Assistance for Promotion of Renewable Energy, Energy Efficiency, and Greenhouse Gas Abatement Projects*. Manila (TA 5972-REG, for $5 million, approved on 4 January).

CDM registration process among the executing agencies and project sponsors. The CMI originally consisted of three components: (i) the Asia–Pacific Carbon Fund, which provides the option of monetizing a portion of the expected future revenues during the first commitment period (2008–2012) by buying projected certified emission reductions; (ii) the Technical Support Facility, which provides assistance to project sponsors during project preparation to undertake CDM eligibility assessment, CDM documentation, validation, and registration; and (iii) the Carbon Marketing Facility, which offers to project developers the requisite marketing support in continuation of the assistance provided under the Clean Development Mechanism Facility. Further on, in 2008, the Future Carbon Fund was launched with a mandate to purchase carbon credits expected to be generated after 2012.

III. ADB'S ENERGY SECTOR STRATEGIES AND OPERATIONS

31. ADB's energy sector operations in the six selected DMCs (Bangladesh, PRC, India, Pakistan, Philippines, and Viet Nam) that were allocated over 80% of ADB's energy sector lending during 2001–2008 are analyzed from the point of view of promoting GHG efficiency. The strategic focus of ADB regarding the encouragement of moving to a low-carbon growth path is reviewed in the context of TA and policy dialogue as well as lending operations. Further details on ADB's energy sector strategies and operations in the six DMCs are provided in Supplementary Appendix A.

A. Bangladesh

32. **Strategic Focus.** The Bangladesh government's energy sector strategy may be summarized into three key focus areas: (i) ensuring energy security for the country through adequate investments in natural gas production (being the main source of primary energy) and power generation, (ii) expanding the gas and power transmission and distribution systems to reduce supply bottlenecks and improve access to energy sources, and (iii) improving operational and managerial efficiencies and cost recovery in energy sector utilities. In the recent times, the Bangladesh government has adopted strategies to improve both the supply side and end user energy efficiency and penetration of renewable energy in the total energy supply and set targets for increasing the utilization of renewable energy.

33. The ADB strategy (in Country Strategy and Program [CSP] 2006–2010)[15] for Bangladesh is closely aligned to the government strategy and heavily focused on supporting institutional reforms, promoting private sector investments to ensure energy security, and improving operational efficiencies of the energy sector. Improving GHG efficiency is not identified as an objective to be pursued in its own right in the ADB energy sector strategies for Bangladesh. This may be because Bangladesh is not a large GHG emitter but one of the countries likely to be severely affected by the adverse impacts of climate change. Hence, from a sustainable development point of view, it is important for ADB in its future operations to promote energy efficiency and energy security in Bangladesh.

34. **TA and Policy Dialogue.** Although ADB has played a significant role in formulating the Government's energy policy in Bangladesh, it has not provided policy advice with the explicit objective of improving the GHG efficiency of the energy sector. ADB's policy dialogue in Bangladesh has been focused primarily on promoting institutional reforms to improve the operational and financial performance of energy sector utilities and creating an enabling environment for private sector investments in the energy sector. ADB has also provided policy

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[15] ADB. 2005. *Country Strategy and Program 2006–2010: Bangladesh*. Manila.

advice to reduce distribution losses in both the electricity and gas sectors, which should have contributed to GHG efficiency improvements. ADB has not engaged in policy dialogue with the Government with regards to (i) subsidies and distortions in the pricing of natural gas and the resultant inefficient use of gas, (ii) efficiency improvements in the power generation sector, (iii) enhancing end-user energy efficiency, and (iv) promoting renewable energy development.

35. **Lending Operations.** ADB approved five energy sector projects amounting to $1.25 billion for the Bangladesh energy sector during 2001–2008. Power transmission, power distribution, thermal power generation, and gas infrastructure development projects together with program loans promoting institutional reforms received approximately equal shares of ADB funding. Although GHG efficiency was not an explicit objective of these projects, they contributed to GHG savings through efficiency improvement. There was no major change in the composition of ADB's lending portfolio to the Bangladesh energy sector between 2001–2005 and 2006–2008 except for the absence of lending to gas infrastructure sector during the latter period. It is noted that ADB did not finance any renewable energy or hydropower projects in Bangladesh during 2001–2008, which may have been due to the lack of technical and economic potential for such projects in the country.

B. Peoples Republic of China

36. **Strategic Focus.** Although environmental protection had been emphasized in the PRC's 10th Five-Year Plan and in the ADB Country Operational Strategy 1997,[16] the Country Assistance Plan (CAP) for 2001–2003,[17] and the ADB CSP for 2004–2006 did not have a focused program to reduce GHG emissions from energy sector operations. The emphasis on reducing GHG emissions appeared for the first time in the PRC's National Climate Change Program, and was recognized in the ADB CPS for 2008–2010.[18] Further changes in ADB's energy sector assistance to the PRC in the coming years are expected to be in line with the CPS (2008–2010), in particular (i) increasing recognition of the need to act expeditiously toward slowing down the GHG emissions of energy sector in the PRC, (ii) the PRC's recognition of the importance of the role of the energy sector in shifting its overall economy to a low-carbon growth path; and (iii) ADB's increased efforts toward addressing climate change concerns since the launch of its clean energy and carbon market initiatives.

37. **TA and Policy Dialogue.** For specific energy sector technologies or systems that the PRC has selected to deploy, it has sought ADB's support on specific aspects of policy making to gain a thorough understanding of deployment and scale-up issues in the context of the PRC. ADB has provided technical advice for (among others) centralized district heating, coal bed methane recovery, waste coal utilization, and carbon capture and storage. The policy dialogue, supported by TA, included the following: (i) scientific/technical aspects of a specific technology; (ii) its technical/economic/market potential in the PRC; (iii) social, environmental, institutional, and financial implications associated with its large-scale deployment; and/or (iv) types of issues that need to be addressed at the policy level to facilitate penetration and replication. Based on the inputs obtained through TA and pilot studies, often through more than one TA—the PRC framed its policies and regulations. Long-term TA support, therefore, appears to have contributed to policy formulation.

[16] As quoted in ADB. 2003. *People's Republic of China: Country Strategy and Program (2004–2006)*. Manila (page 18).
[17] ADB. 2000. *People's Republic of China Country Assistance Plan (2001–2003)*. Manila.
[18] ADB. 2008. *People's Republic of China Country Partnership Strategy (2008–2010).* Manila.

38. **Lending Operations.** ADB's lending operations to the energy sector account for less than 1% of total energy sector investments in the PRC. Nonetheless, ADB-financed projects can have a demonstrative or catalytic effect in introducing new technologies or industrial practices. SIx lending projects were approved during 2001–2005, of which three were in the power sector (viz., run-of-river hydro, pumped storage hydro, and a power transmission project). ADB also approved two methane destruction projects to prevent atmospheric release of methane from coal-mining operations and to use captured methane for power generation and municipal gas supply. In addition to contributing significantly to GHG emission reduction (methane has a global warming potential 21 times that of CO_2),[19] the projects have also reduced the use of high GHG-emitting coal, which offers a huge potential for replication, as the PRC is the world's largest consumer and producer of coal.

39. During 2006–2008, ADB increased its lending to projects having direct GHG efficiency improvement with a high degree of replicability, given the overall market size in the PRC. Most ADB-financed projects in the PRC during this period aimed at expanding and improving the energy efficiency of district heating systems, city gas supply systems, and industrial energy efficiency improvement. The private sector investments and commercial bank lending was mobilized through ADB participation in such projects. In addition, ADB also financed hydropower and wind energy projects during the 3-year period. The mix of ADB's energy lending approvals during 2006–2008 in the PRC was unique among the ADB portfolio in terms of its high concentration of energy efficiency improvement projects and relative lack of projects in some of the traditional sectors such as power transmission and distribution.

C. India

40. **Strategic Focus** During 2000–2003, ADB strongly supported the Government's priority of institutional and regulatory reforms to improve the financial viability, operational efficiency, and cost recovery of the power sector at the state level. The efficiency improvements supported by ADB at the state level contributed to the improvement of GHG efficiency improvement through the reduction of power distribution losses. ADB's power sector strategy for India during 2004–2006 was based primarily on supporting the energy sector objectives of the 10th National Plan and the implementation of power sector reforms facilitated under the Electricity Act of 2003. While continuing the state-level reforms aimed at improving financial and operational performance including reduction of power distribution losses and pilferage of electricity, increasing emphasis was placed on augmenting power generation capacity to meet the chronic power shortages using cleaner sources such as hydropower as well as renewable energy. The CSP Update 2005–2007[20] emphasized the importance of supporting large-scale low-carbon power generation and supporting the transmission network to facilitate power evacuation from such sources as well as to enhance connectivity of different regions of India with adequate transmission capacity. The CPS 2009–2012[21] explicitly identifies the importance of GHG efficiency improvement and, together with ensuring energy security, GHG efficiency improvement forms the basis for ADB's proposed assistance to the Indian energy sector.

[19] For analytical purposes in this EKB, methane's global warming potential is assumed as 21 (as for various projects approved by the CDM Executive Board). It may be noted that methane's global warming potentials have been considered as being 23 or 25 also. Refer to (i) Global Environment Facility. 2008. *Manual for Calculating GHG Benefits of GEF Projects: Energy Efficiency and Renewable Energy Projects*. Washington, DC, April; (ii) IPCC. 2007. *Fourth Assessment Report*. Spain, November.
[20] ADB. 2004. *Country Strategy and Program Update 2005–2007: India*. Manila.
[21] ADB. 2009. *India Country Partnership Strategy 2009–2012: Abridged Version*. Manila.

41. **TA and Policy Dialogue.** The policy reforms supported by ADB have pertained mainly to institutional reforms to improve the operating efficiencies of power sector utilities at the state level. Although these reforms have not been explicitly linked to GHG efficiency improvement, the resultant supply-side efficiency improvements such as reduction in technical losses in power distribution have improved the GHG efficiency of the concerned states. ADB has not provided significant policy advice at the national level for energy sector policy formulation or for improving GHG efficiency. Hence, it may be inferred that ADB has not engaged the Indian government in high-level policy dialogue to improve the institutional policy framework for enhancing GHG efficiency.

42. **Lending Operations.** During 2001–2005, ADB focused its lending operations on supporting power sector reforms in selected states such as Assam and Madhya Pradesh. The loans linked to power sector reforms had several components supporting investments in power transmission and expansion and rehabilitation of power distribution network. ADB also financed the strengthening of a high-voltage (400 kilovolts) transmission grid in southern India to remove transmission bottlenecks and a private sector project to evacuate power from the Tala hydropower project in Bhutan. While the former contributed to a reduction in transmission losses and resultant GHG efficiency, the latter increased the share of hydropower in the energy mix of northern India, contributing to significant increase in GHG efficiency of the power system. ADB also financed a liquefied natural gas (LNG) terminal in western India to facilitate the import of LNG, resulting in GHG emission savings due to switching of fuel consumption from more GHG-intensive fuels such as naphtha and furnace oil to regasified LNG.

43. There was a marked increase in projects with potential for GHG efficiency improvement during 2006–2008. Four renewable energy projects financed by ADB consisted of wind and run-of-river hydropower plants, and a large hydropower project. ADB also supported several thermal power projects employing more efficient coal-burning technologies such as supercritical boilers (i.e., a new and more efficient technology in the Indian context). Although these projects have increased gross GHG emissions, they are essential to ensure India's energy security at an affordable price and have shifted India's power sector toward a low-carbon growth path by deploying more efficient coal combustion technologies.

D. Pakistan

44. **Strategic Focus.** The ADB strategy for Pakistan as outlined in the CAP 2001–2003[22] is to address institutional and financial issues in the power sector through sector reforms. In addition to these sector reform initiatives, ADB has supported the renewable energy and oil and gas sector through TA. The Government's Medium-Term Development Framework (2005–2010) focuses on energy security and ensuring the long-term viability of the sector. Although renewable energy and energy efficiency improvement have been mentioned as focus areas in the context of improving energy security, these technologies have the added benefit of limiting the GHG emissions of Pakistan's energy sector. The ADB CPS 2009–2013[23] identifies energy efficiency and renewable energy development sector, together with support for establishing a competitive electricity market, as the key areas for ADB assistance to Pakistan's energy sector in the future.

45. **TA and Policy Dialogue.** As in India and Bangladesh, ADB's main focus of its policy dialogue has been institutional reforms to improve the overall efficiency and viability of the energy sector. However, ADB has undertaken several initiatives in Pakistan to create an

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[22] ADB. 2000. *Country Assistance Plan (2001–2003): Pakistan*. Manila.
[23] ADB. 2009. *Country Partnership Strategy: Pakistan 2009–2013*. Manila.

enabling environment for renewable energy development, and ADB support was instrumental in setting up of the Alternative Energy Development Board. ADB is also supporting the setting up of an integrated energy sector planning model to enable decision makers to evaluate different development scenarios for Pakistan's energy sector. This model would enable the decision makers to evaluate the costs and benefits of a low-carbon energy sector development scenario vs. a BAU case. Recently, ADB has focused its policy dialogue toward energy efficiency improvement through both supply-side and demand-side interventions, but it is too early to say whether these initiatives would result in policy reforms.

46. **Lending Operations.** Lending operations to the Pakistan energy sector during 2001–2008 included (i) the renewable energy development project to promote small- and medium-size hydropower plants as well as a large hydropower project implemented by the private sector, and (ii) rehabilitation and efficiency improvement of gas-fired thermal power plants in Karachi. These projects contributed to GHG efficiency improvement. In addition, several other investments financed by ADB have included (i) a power transmission project to expand the network capacity, (ii) several new thermal power plants using combined-cycle gas turbine technology, and (iii) power distribution rehabilitation and expansion. All these projects are essential to meet the energy sector needs of Pakistan, and would contribute to GHG efficiency improvement.[24]

E. Philippines

47. **Strategic Focus.** In the energy sector, ADB has been the lead development partner in support of power reform, making investments in distribution, privatization of power generation and distribution entities, and capacity building in energy sector regulation.[25] ADB's CAP 2001–2003[26] and CSP Update 2004–2006[27] also supported specific measures to address environmental protection, sustainability, and rehabilitation. The CSP 2005–2007[28] recommended setting priorities for attaining environmental sustainability, without any explicit mention of support related directly to GHG abatement—although it did explicitly acknowledge that GHG emissions were rising. However, with the updated Philippine Energy Plan (2004–2013) and the launch of the Energy Conservation Program in 2005 (which aims to mitigate the impact of high oil prices and protect the environment), the GHG emission reduction objective has been placed on the national agenda.

48. **TA and Policy Dialogue.** Given the need to restore the financial health of the power sector, ADB's policy support to the Philippines has been directed toward meeting that objective. The TA 3820 approved in December 2001[29] supported policy reforms to encourage competition in the power sector with the objective of encouraging efficiency in power generation and supply. The TA 4557 supported strengthening the power sector regulatory framework and privatization of the National Power Corporation's eligible assets. The GHG-reduction benefits of such policy support are essentially indirect; privatization and competition encourage efficient operations with reduced fuel inputs and GHG emissions. ADB also engaged in policy dialogue on initiating several measures to promote energy efficiency as part of the preparation of the energy efficiency loan approved in 2009.

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[24] An alternative to gas-based power generation is coal-based power generation, as there are political and other barriers to the development of Pakistan's hydropower potential.
[25] ADB. 2008. *Philippines Country Assistance Program Evaluation: Increasing Strategic Focus for Better Results*. Mania.
[26] ADB. 2000. *Philippines Country Assistance Plan (2001–2003)*. Manila.
[27] ADB. 2003. *Philippines Country Strategy and Program Update (2004–2006)*. Manila.
[28] ADB. 2005. *Philippines Country Strategy and Program (2005–2007)*. Manila.
[29] ADB. 2001. *Technical Assistance to the Republic of the Philippines for a Competition Policy for the Electricity Sector*. Manila (TA 3820-PHI, for $990,000, approved on 19 December).

49. **Lending Operations.** During 2001–2008, two public sector program loans to support power sector reforms (including one with a small power transmission component), two nonsovereign loans (one of them was cancelled without being disbursed) to support the privatization of existing thermal power plants, and one grant were approved. Although the nonsovereign loan has resulted in a net increase of GHG emissions (as a coal-fired power plant has been refurbished to enable substantially higher generation with resultant increase in GHG emissions), in general ADB intervention is expected to catalyze private sector participation in the Philippine power sector (perhaps for new generation projects as well) and eventually lead to reduction in the GHG emissions per unit of generation.

F. Viet Nam

50. **Strategic Focus.** Government policy in Viet Nam is to ensure the energy security of the country by increasing power generation capacity and the production capacity of the fossil fuel resources and to improve the commercial performance of energy sector entities through the introduction of competitive energy markets. At the same time, end-user energy efficiency improvement and renewable energy development are promoted as complementary initiatives by the government. The ADB country operational strategy of 1995 and its various updates promoted environmental protection and more rational use of energy resources.[30] As per the CSP 2007–2010,[31] ADB envisages an enhanced role for the private sector and supports private sector operations in clean energy, power generation, and transmission. ADB has provided TA to improve the policy framework for renewable energy development, energy efficiency investments, and access to the emerging CDM market. However, there has been little focus on GHG mitigation or other climate change-related issues in ADB strategies for the Viet Nam energy sector, especially in ADB's lending operations during 2001–2008.

51. **TA and Policy Dialogue.** Policy dialogue with Viet Nam has focused largely on power sector reform-related issues as well as improving the mitigation of local environmental and social impacts, and such efforts have had only an indirect influence on the GHG efficiency of the energy sector. TA 7024[32] is exploring financial mechanisms through a local financial intermediary as a means to channeling external funds for energy efficiency investment in industry. ADB has also assisted the Government in drafting an energy efficiency law, and plans to assist the Government in the formulation of a renewable energy law.

52. **Lending Operations.** ADB lending to Viet Nam has consisted of six projects or investment programs supporting significant additions to power generation capacity (approximately 2,650 megawatts [MW] of 13,000 MW), including two high efficiency gas-fired combined-cycle projects, a 1,000 MW coal power plant using circulating fluidized bed technology, and a 156 MW hydropower plant. These projects are in the least-cost generation expansion plan and are essential investments to meet the country's energy demand. ADB also financed a significant proportion of investment undertaken during 2001–2008 to expand the capacity of the high-voltage transmission system. Although the thermal power generation projects supported by ADB have increased gross emissions, they have deployed advanced and more efficient—and relatively less GHG-emitting—technologies compared with the existing practice in Viet Nam.

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[30] ADB. 1995. *Viet Nam Country Operational Strategy Study.* Manila; ADB. 1998. *Viet Nam Country Assistance Plan (1999–2001).* Manila; ADB. 2001. *Viet Nam Country Strategy and Program Update (2002–2004).* Manila; and ADB. 2004. *Viet Nam Country Strategy and Program Update (2005–200*6). Manila.

[31] ADB. 2006. *Viet Nam Country Strategy and Program (2007–2010)*. Manila.

[32] ADB. 2007. *Technical Assistance to Viet Nam for Supporting Implementation of the National Energy Efficiency Program Project*. Manila (TA 7024-VIE, for $925,000, approved on 12 December).

IV. GREENHOUSE GAS ACCOUNTING METHODOLOGIES AND EFFICIENCY ESTIMATES

A. Greenhouse Gas Efficiency Indicators

53. In the foreseeable future, even if the rate of economic growth in DMCs continues at the same pace as during the last decade, GHG emissions per capita in most DMCs will remain substantially below the global average, with the possible exception of the PRC. ADB's principal mission as per Strategy 2020 is to assist its DMCs to promote inclusive and sustainable growth, which include supporting the sustainable development of infrastructure facilities. In this context, energy security and access to energy using cleaner, environmentally sustainable, and climate friendly technologies is included as a core area of ADB's operations. Therefore, ADB's loan portfolio may be analyzed from the perspective of assessing ADB's success in facilitating the adoption of more GHG-efficient approaches by DMCs in their energy sectors compared with a BAU scenario.

54. As per its Results Framework (level 2),[33] ADB is required to report its contribution to country and regional development outcomes by aggregating the key outputs delivered in five priority areas (energy, transport, water, finance, and education) to assess the progress in implementing Strategy 2020. Therefore, GHG efficiency of ADB energy sector operations should be measured by the change in GHG emissions of the energy sector in a DMC compared with a BAU case. Because many such interventions involve other donors and financial institutions, the GHG savings that can be attributed to ADB can be apportioned corresponding to its share of investment in a project or component.[34] Furthermore, to facilitate a comparison across the various approved projects and component categories, a broad set of indicators are adopted (Table 1) to assess the GHG efficiency of the ADB portfolio.

55. Given the need to increase energy consumption for economic development and poverty reduction, the gross GHG emissions and the other indicators based on gross GHG emissions do not provide an appropriate basis for reporting ADB's GHG efficiency. This is because most of the energy supply projects result in an increase in GHG emissions. Hence, the approach taken in this EKB is to use indicators that report GHG emissions savings (increases) with respect to a plausible counterfactual to the project. The counterfactual could either be the BAU scenario or the most likely alternative source of energy in the absence of the project. The GHG emissions associated with a counterfactual are assumed to remain static during the operational period of the project. The GHG emissions are quantified on an annual basis during the commercial operation of energy supply projects; indirect emissions associated with equipment manufacturing and construction phases of energy supply projects are not included as they are not significant compared with GHG impacts during operational phase.

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[33] ADB. 2008. *ADB Results Framework*. Manila.

[34] However, the ADB results framework refers to ADB's contribution to country outcomes through key outputs, thereby referring to completed projects. We refer to "ADB's (intended) effectiveness" as loans approved during 2001–2008 are analyzed, and the data provided in RRPs pertains to planned, projected, or intended (rather than actual or measured) levels of key outputs.

Table 1: Greenhouse Gas Efficiency Indicators

Indicator	Units	Remarks
Annual gross GHG emissions	Tons of CO_2-equivalent (tCO_2e)	GHG emissions due to the project or component supported by ADB
Annual GHG emissions savings	tCO_2e	The difference between gross emissions and the emissions for producing the same amount of energy under an appropriately defined counterfactual to the project activity supported by ADB.
Annual GHG emissions savings attributable to ADB	tCO_2e	Pro rata share of emission savings in proportion to ADB's share of total project and component cost
Annual gross GHG emissions per unit of investment	tCO_2e per $ million	Ratio between gross emissions and the total investment in project activity
Annual GHG emission savings per unit of investment	tCO_2e per $ million	Ratio between GHG emission savings and the total investment in project activity
Annual gross GHG emissions per unit of energy	tCO_2e per gigawatt-hour (GWh)	Ratio between gross emissions and the amount of energy generated, saved, or delivered as a result of the project activity. For thermal energy supply or savings projects, the energy in calorific or joule units is converted to GWh.
Annual GHG emission savings per unit of energy	tCO_2e per GWh	Ratio between emission saving and the amount of energy generated, saved, or delivered as a result of the project activity. For thermal energy supply or savings projects, the energy in calorific or joule units is converted to GWh.

ADB = Asian Development bank, CO_2 = carbon dioxide, GHG = greenhouse gas, tCO_2e = ton of CO_2 equivalent.
Source: Compiled by the study team.

B. Greenhouse Gas Efficiency Methodologies Adopted or Developed

56. **Clean Development Mechanism Methodologies and Their Limitations.** Methodologies established by the UNFCCC for GHG accounting for CDM projects are well documented and provide a logical starting point. However, several difficulties arise in applying these methodologies to the GHG assessment of the entire ADB energy portfolio: (i) the approved methodologies cover only subset of ADB-financed energy sector project categories; for instance, transmission projects may well result in GHG emission savings through reduction in transmission losses, but they are unlikely to be additional—consequently, there is no UNFCCC-approved methodology for this transmission project in the ADB portfolio; and (ii) much of the emphasis in the CDM methodologies is on transparency and simplicity to reduce transaction cost. These methodologies are unlikely to be acceptable for large projects, for which project-specific calculation of emissions are required.

57. Therefore, where appropriate, the approach adopted in this EKB is to identify a plausible counterfactual appropriate to the project in question, rather than to use a sector-wide grid emission factor as calculated for CDM purposes. In many instances, the economic analysis presented in the RRP provides a good idea of a plausible counterfactual, for instance where least-cost analysis shows that an ADB-supported pumped-storage hydropower project is more cost-efficient vis-à-vis a gas turbine unit of the same capacity; or where coal-mine methane replaces coal as a fuel in industrial and commercial establishments as well as for residential cooking and water heating.

58. In the interest of assessing GHG emissions and GHG efficiency for the entire energy sector portfolio relating to the six DMCs, no minimum thresholds are applied on the level of ADB assistance ($ million) or quantum of GHG emissions per project or component. For the purpose of GHG efficiency analysis, ADB-financed energy sector projects can be divided into two broad categories: (i) electricity-generating and supply-side or demand-side efficiency improvements resulting in avoided electricity generation, and (ii) fuel supply and efficiency improvements in fuel supply and fuel usage. The specific methodological issues for different types of projects are described below and summarized in Table 2. The broad methodological issues are further explained in Appendix 5, the methodologies developed or adapted for analytical purposes are listed in Appendix 6, and a detailed description of the methodologies is provided in the Supplementary Appendix B.

Table 2: GHG Emission Savings of Various Project or Component Categories

Project or Component Category	Gross Emissions	Emissions as per the Counterfactual to the Project	Emission Savings
Electricity generation, transmission, distribution, and electricity conservation projects			
Renewable energy[a]	Zero	GHG emissions for generating same amount of energy using the existing plant mix connected to the grid	Positive
Hydropower (without reservoir emissions)	Zero	Same as above	Positive
Hydropower (with reservoir emissions)	Reservoir emissions	Same as above	Most likely positive
Pumped storage (PS) hydropower	Emissions associated with generating electricity required to pump water	Same as above	Negative, as more energy is required for pumping than the energy generated for a PS power plant
Gas or coal-fired thermal power	Emissions from the plant	Average GHG emissions for generating the same amount of energy using the existing plant mix and using the most widely used generation technology in the country for the same fuel type	Positive or negative; situation specific
Captured methane-fired thermal power (methane destruction)	Emissions associated with use of methane in a power plant	Release of methane to the atmosphere; plus average GHG emissions for generating the same amount of energy using the existing plant mix	Positive, as methane emissions have a higher GHG impact than CO_2
Renovation of thermal power plants	Emissions associated with incremental generation after renovation	Emissions associated with generating same amount of electricity as the incremental generation. For the sake of simplicity, this was assumed to be equal to the average emissions per unit of energy in the grid.	Positive or negative, depending on whether the emissions per unit of energy in the rehabilitated plant are higher or lower than the average emissions per unit of energy in the grid
Power transmission for power evacuation from an identifiable power	Emissions from respective power plants connected to	Emissions as per average emissions for generating the same amount of energy using	As per respective power plants connected to the transmission line,

Project or Component Category	Gross Emissions	Emissions as per the Counterfactual to the Project	Emission Savings
plant	the transmission line, prorated in proportion to the investment in transmission line	the existing plant mix; prorated in proportion to the investment in transmission line	prorated in proportion to the investment in transmission line
Power transmission (grid strengthening)	Zero	Emissions associated with generating the amount of energy saved due to loss reduction using the existing plant mix in the grid	Positive
Power distribution improvement	Zero	Same as above	Positive
Industrial power use efficiency improvement	Zero	Emissions associated with producing the energy saved as a result of the energy efficiency project	Positive
Fuel supply and fuel efficiency improvement projects			
Centralized district heating	Emissions associated with producing the required amount of heat	Emissions associated with providing the same amount of space heating in the absence of the project	Positive
Gas infrastructure development	Emissions associated with the use of natural gas provided under the project	Emissions associated with alternative fuel replaced by natural gas	Positive, as natural gas has lower emissions compared with most other types of fossil fuel
Captured methane for city gas supply	Emissions associated with use of methane for city gas supply	Release of methane to the atmosphere plus the emissions associated with alternative fuels replaced by methane	Positive

CO_2 = carbon dioxide, GHG = greenhouse gas, PS = pumped storage.
[a] Refers to wind and mini-hydro projects, as found in the Asian Development Bank portfolio.
Source: Compiled by the study team.

59. **Renewable Energy and Hydropower.** Energy generated from renewable energy and hydropower projects is assumed to replace an equal amount of energy from the power grid to which the project is to be connected. Other than methane emissions from hydropower reservoirs, no GHG emissions are considered from renewable and hydropower projects. Although it is difficult to quantify with any degree of certainty the methane emissions from hydropower reservoirs under different climatic and geographical conditions, the UNFCCC (CDM Executive Board) has set simple and transparent criteria for the eligibility of hydropower projects for CDM on the basis of "power density,"[35] expressed as watt of installed capacity per square meter of flooded surface area.[36] Although this may be criticized as being overly simplistic, in the interest of conservative calculations, the CDM protocol for hydropower projects is adopted in this EKB.

60. **Coal Mine Methane Capture and Use.** Where atmospheric release of methane during coal mining operations is avoided, and the captured methane is used for power generation, two aspects are considered for GHG savings computations: (i) the global warming potential of the methane that has been captured as a result of the project (and would have been otherwise

[35] UNFCCC. 2006. *Threshold and Criteria for the Eligibility of Hydroelectric Power Plants with Reservoirs as CDM Project Activities*. *EB 23 Report, Annex 5.* Bonn, 22–24 February.
[36] The choice of watts (capacity) as the numerator is contestable, since energy generation (as methane-rich water from lower levels of the reservoir gets degassed when it flows through turbines) rather than capacity determines the methane (GHG) emissions of a hydropower project. However, capacity has the merit of ease of verification.

released to the atmosphere), and (ii) emissions from a methane-based power plant vis-à-vis the emissions for generating the same amount of electricity using the existing plant mix in the grid. The former takes into account the fact that methane has a global warming potential of 21; and the latter is as per the approved UNFCCC–CDM methodology. Where the captured methane is transmitted and distributed by pipeline to serve industrial, commercial, and residential consumers, which results in switching from a relatively high-emitting fuel (such as coal in the PRC) to a low GHG-emitting fuel (viz., methane),[37] the emission savings are calculated by using the fuel emission factors, end-use efficiencies, and quantity of methane use vs. the displaced fuel.

61. **Energy Efficiency.** Two types of energy efficiency projects were supported by ADB during the study period:

(i) central district heating systems using large and efficient boilers and/or combined-heat-and-power plants with well configured and optimized pipeline networks replacing existing space heating using small, decentralized, and old or inefficient boilers; fuel use "with" and "without" such projects, boiler and system efficiencies, and fuel emission factors are used to estimate GHG emission changes in such cases; and

(ii) inefficient and old electrical equipment in industrial enterprises being replaced by modern and energy-efficient electrical equipment for the same application. In this case, the electricity savings on the end-use side is translated into electricity savings at the dispatch end (with appropriate estimates for transmission and distribution losses), and the grid emission factors as per the UNFCCC–CDM methodologies are applied to estimate the GHG emission changes.

62. **Thermal Power Generation.** In most cases, these plants use domestic fuel supplies, and it is not technically and economically feasible to generate the same amount of energy using renewable sources. The GHG efficiency of ADB-financed thermal power projects is assessed on the basis of whether or not the project supports a more efficient technology to meet the electricity needs of the DMC using available fuel sources. For instance, if ADB supports less efficient technologies such as open-cycle gas turbines when the most obvious and common technology is combined-cycle gas turbines, the project is normally considered GHG inefficient.

63. **Rehabilitation of Thermal Power Plants.** This results in GHG savings due to efficiency improvements, although increased dependable capacity and increased energy generation due to rehabilitation result in additional GHG emissions overall. The change in GHG emissions due to rehabilitation is assessed by comparing the GHG emissions of the incremental generation with the emissions associated with the electricity replaced in the grid. This depends on

(i) whether the system is supply constrained, in which case gross emissions increase because total thermal power generation increases, although it is offset in part by decrease in emissions from standby generators; and

(ii) if the system is not supply constrained, then the change in emissions is a function of the extent of change in the merit order (i.e., the emissions from the displacing plant compared with the displaced plant).

64. **Power Distribution Rehabilitation or Expansion.** Most ADB-financed power distribution projects have resulted in the following outcomes:

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[37] Although methane has a high global warming potential 21 times of CO_2 when released to the atmosphere in its original form, when used as a fuel it is converted to CO_2. The CO_2 emissions intensity of methane combustion is less compared with that for coal and liquid fuels.

(i) reduction in technical losses, which results in savings of GHG emissions due to avoided power generation to supply power to customers serviced prior to the project;
(ii) additional electricity sales in newly electrified areas and resultant GHG emissions due to additional power generation required; and
(iii) reduction in commercial losses, which does not result in savings of GHG emissions if electricity pilferers become paying customers as a result of the project.

65. The GHG efficiency of such projects is difficult to assess, as (i) a breakdown of electricity sales between the original area of supply and the expanded area of supply may not always be available, and (ii) splits between technical and nontechnical losses are not recorded by the executing agencies. It also raises a methodological issue with regard to whether GHG emissions due to additional sales should be included in the GHG efficiency assessment. As improving access to electricity is an important objective of ADB as well as of DMC governments, GHG efficiency computations in this EKB are based on GHG savings due to loss reduction in the original area supplied with electricity before the project. The GHG impacts of providing electricity to new areas depends on the alternative forms of energy usage in the absence of electricity and the grid emission factor for providing grid-connected electricity. However, due to lack of data on electricity consumption in the absence of electricity as well as in recognition of the societal benefits of electrification, this was not considered in the EKB.

66. **Power Transmission.** Transmission projects fall into two broad categories:
(i) **Power evacuation projects from identifiable sources.** Where transmission lines are dedicated to the evacuation of power from a new generation project, the approach is to treat the generation and transmission projects as a single project, and to allocate the gross emissions and GHG emission savings to the transmission component as per its share of the total project cost.
(ii) **Transmission projects for grid strengthening.** While increasing the capacity and reliability of a transmission system, these projects also reduce transmission losses. The resultant transmission loss reduction is assessed from load flow studies, and the resultant avoided generation is used to assess the GHG efficiency of the project. A variant of this is when a transmission project that forms part of a power system expansion plan is analyzed by evaluating the GHG impact of the entire power sector investment program and attributing the GHG impact to ADB-financed transmission lines in proportion to the cost.

67. **Gas Infrastructure Development.** These projects involve the provision of natural gas through pipeline extensions or terminals for importing LNG. GHG efficiency is estimated by considering the effect of fuel switching (i.e., replacement of a different type of fuel with natural gas). The methodological issues in computing the GHG efficiency of this type of project are as follows:
(i) natural gas provided under the project results in fuel switching as well as incremental energy consumption, and the degree of incremental consumption vs. fuel switching is not usually available;
(ii) the quantity of fuel replaced by natural gas is computed based on the calorific value of different types of fuel and natural gas assuming 100% combustion efficiency for each type of fuel; and
(iii) natural gas is used as a fuel as well as feedstock in industries such as oil refineries and fertilizer plants.

V. GREENHOUSE GAS EFFICIENCY ESTIMATES

A. ADB Energy Sector Portfolio in the Six Countries

68. The energy sector lending portfolio based on the approvals during 2001–2008 for Bangladesh, PRC, India, Pakistan, Philippines, and Viet Nam is considered as a good proxy for assessing the GHG efficiency of ADB's energy sector portfolio, as these six countries absorbed over 80% of ADB's lending to the sector. The composition of energy sector projects that ADB supported during 2001–2008 underwent some change in terms of subsectors that ADB supported due to (i) ADB's own strategies and initiatives to encourage DMCs to move to a low-carbon growth path; and (ii) DMCs' requirements and priorities for economic development, in relation to energy security, power system stability, and reliability. The aspect that merits specific attention in this context is the increase in approvals for power generation capacity additions. In particular, ADB financing of coal-fired power stations increased in countries such as India, Philippines, and Viet Nam. ADB supported the introduction of cleaner and more efficient coal combustion technologies such as supercritical boilers in India, circulating fluidized bed boilers in Viet Nam, and postprivatization and rehabilitation of existing coal power plants in the Philippines. However, ADB also supported relatively inefficient open-cycle gas turbines in Bangladesh as a short-term measure to reduce crippling power shortages.

69. ADB's support for hydropower and renewable energy, consisting mainly of wind power and small hydropower projects, more than tripled during 2006–2008 to $750 million mainly in India, Pakistan, and Viet Nam, compared with $215 million in 2001–2005. Methane capture projects, which were present in 2001–2005 in ADB's lending portfolio in the PRC, are conspicuous by their absence during 2006–2008. Such projects entail high GHG efficiency, as they prevent atmospheric release of methane and use the captured methane for power generation and/or as fuel in households and in industrial and commercial applications. ADB's support for methane destruction projects in the PRC catalyzed domestic financing, and a large number of such projects were promoted in recent years without ADB involvement. Also, the share of traditional power transmission and distribution projects reduced from 55% of lending approvals in 2001–2005 to 39% during the last 3 years, and a significant share of power transmission projects supported by ADB in recent times have been dedicated to evacuating electricity from cleaner energy sources such as large-scale hydropower.

70. Fuel (mainly natural gas) and thermal energy supply projects, as well as end-user energy efficiency improvement projects, also form an important subcategory of ADB's energy sector portfolio distinct from the electricity supply projects mentioned above. There is no marked increase in ADB support for such projects, and their share in total energy sector lending remains around 20%. Furthermore, the basic characteristics of fuel supply projects are very different from that of power generation projects in terms of internal fuel processing, storage, and dispatch systems. This explains the large differences in investment requirements per unit of energy output across such technologies; for instance, a $2 billion coal-fired power plant generates about 14,000 gigawatt-hour (GWh) of electricity, while an LNG import facility with a cost of $800 million provides regasified LNG having an energy content of over 80,000 GWh. However, there are additional investment requirement at the end-user level to use the regasified LNG (i.e., for power generation or as an industrial and commercial fuel) supplied from an ADB-financed LNG terminal and energy losses in converting LNG to electricity. Therefore, GHG efficiency indicators for electricity supply projects and fuel or thermal energy supply projects are separately recorded in this EKB.

B. Greenhouse Gas Efficiency Analysis of ADB Energy Sector Lending Approvals of the Six Countries

71. During 2001–2005, ADB energy sector lending approvals for investments with quantifiable GHG impacts in the six countries averaged about $460 million per year, with power supply projects absorbing over 83% of ADB lending; this increased over 2.75 times during the next 3 years to about $1.26 billion per year, with the share in power supply projects increasing to 89%. The portfolio-wide trends of ADB's energy sector portfolio are summarized in Table 3. The leveraging of ADB funding for mobilizing capital investments in the energy sector also increased from 3 to more than 6, with the capital mobilization increasing from $1.4 billion per year in 2001–2005 to $7.8 billion per year in 2006–2008. The increased ADB lending and capital mobilization by ADB to the energy sector resulted in the annual energy output of ADB-financed power supply and fuel or thermal energy supply projects increasing from 4,284 GWh and 13,177 GWh, respectively, during 2001–2005 period to 37,746 GWh and 19,493 GWh, respectively, during 2006–2008.[38] The increase in energy output of power supply projects is due mainly to the recent shift in ADB's energy sector portfolio toward power generation projects (renewable or hydropower as well as thermal power plants) from a high concentration of power transmission and distribution projects during 2001–2005.

72. The GHG savings of ADB-financed projects are estimated using the methodologies described in Chapter IV and shown in Table 3. The GHG emission savings[39] due to ADB-financed power supply projects increased from 1.08 million tCO_2e during 2001–2005 to 7.3 million tCO_2e during 2006–2008. The GHG savings attributable to ADB (i.e., in proportion to its investment in the total project cost) in the power supply projects increased from 0.58 million tCO_2e in 2001–2005 to 1.65 million tCO_2e during 2006–2008. There is a marginal drop in the GHG savings of fuel supply projects to 1.31 million tCO_2e in 2006–2008 from 1.53 million tCO_2e in 2001–2005 and a corresponding reduction in the GHG savings attributable to ADB from 0.44 million tCO_2e to 0.38 million tCO_2e. The trends in the GHG emissions of ADB's energy sector portfolio in each country are further detailed in the Supplementary Appendix C.

73. The increase in GHG savings in the power supply projects was due to increasing ADB financing of power generation projects deploying zero or low emission (renewable energy including hydropower, transmission, and distribution loss reduction) technologies and more efficient thermal power technologies such as supercritical coal power plants and combined-cycle gas turbines. However, there was a reduction in GHG savings per unit of electricity supplied (from 252 tCO_2e/GWh to 193 tCO_2/GWh) in the recent times. This was due mainly to the increase in thermal power plants in ADB's portfolio in recent times. Thermal power plants have lower GHG savings per unit of energy supplied compared with renewable and hydropower plants.

[38] The energy outputs are normalized by dividing by the number of years in the two periods.
[39] The GHG emission savings are normalized by dividing by the number of years in the two periods.

Table 3: ADB Energy Lending Portfolio Indicators for Investment Projects in Six Countries with Quantifiable GHG Impacts

Item	2001–2005	2006–2008	2001–2008
Power Generation and Supply-Side Projects			
ADB's annual average lending ($ million)	383	1,124	661
Annual average capital investment mobilized by ADB ($ million)	1,118	6,888	3,154
Annual average energy supplied from ADB projects (GWh)	4,284	37,746	16,832
Annual average GHG emissions of ADB projects (tCO_2e)	1,499,919	18,461,660	7,860,572
Annual average GHG emission savings (tCO_2e)	1,078,787	7,274,554	3,402,200
Annual average GHG savings attributable to ADB (tCO_2e)	576,702	1,646,556	977,897
Annual energy supplied per unit of investment (GWh/$million)	3.8	5.5	5.3
Annual GHG emission savings per unit of investment (tCO_2e/$ million)	965	1,056	1,079
Annual GHG emissions per unit of energy (tCO_2e/GWh)	350	489	467
Annual GHG emissions savings per unit of energy (tCO_2e/GWh)	252	193	202
Fuel and Thermal Energy Supply Projects			
ADB's annual average lending ($ million)	78	133	99
Annual average capital investment mobilized by ADB ($ million)	266	891	501
Annual average energy supplied (GWh)	13,177	19,493	15,545
Annual average GHG emissions of ADB projects (tCO_2e)	2,826,598	3,692,813	3,151,429
Annual average GHG emission saving (tCO_2e)	1,531,480	1.311,119	1,448,845
Annual average GHG savings attributable to ADB (tCO_2e)	442,575	380,524	419,306
Annual energy supplied per unit of investment (GWh/$million)	49.5	21.9	31.1
Net annual GHG emission savings per unit of investment (tCO_2e/$ million)	5,757	1,471	2,895
Annual GHG emissions per unit of energy (tCO_2e/GWh)	214.5	189.4	202.7
Annual GHG emissions savings per energy unit (tCO_2e/GWh)	116	67	93

ADB = Asian Development bank, GHG = greenhouse gas, GWh = gigawatt-hour, tCO_2e = ton of carbon dioxide equivalent.

Note: Annual energy supplied, ADB lending approvals, capital cost mobilized, GHG emissions, and GHG emission savings are normalized to an annual basis by dividing by the number of years in each period.

Source: Computed by the study team.

C. Country-Wise GHG Efficiency Analysis of Energy Sector Lending Operations

74. The GHG savings resulting from ADB-financed projects in the energy sector indicate that ADB-financed projects are shifting these countries toward a low-carbon growth path, as these projects are contributing to overall economic growth by providing additional energy supply and at the same time contributing to GHG emission savings. This can be further illustrated by comparing the GHG emissions per unit of energy of projects approved for ADB support to the overall GHG emission factor per unit of energy consumed in the country concerned. The emissions of ADB-financed power supply projects are shown in comparison to the operating margin[40] of the power grid in each country in Table 4. For the power supply projects, the emissions per unit of electricity for ADB-financed projects are substantially lower than the operating margin of the power grid of the country concerned except in Philippines and Viet Nam. This implies that ADB-financed projects have contributed to shifting the concerned countries to a low-carbon growth path as incremental emissions are less than the average emissions.

[40] The average emissions (weighted by the energy output of each plant) per unit of electricity sent into the power grid.

Table 4: Country-Wise GHG Efficiency Analysis

Item	Average Grid Emission Factor (tCO_2e/GWh)	Power Supply Projects		Fuel Supply Projects	
		2001–2005	2006–2008	2001–2005	2006–2008
Bangladesh					
Net energy supplied (GWh)		257	718	2,527	
Approved ADB financing ($ million)		98	70	55	
GHG savings (tCO_2e)		7,780	86,391	201,238	
Emissions per unit of energy (tCO_2e/GWh)	634	521	439	202	
People's Republic of China					
Net energy supplied (GWh)		1,203	288	603	9,132
Approved ADB financing ($ million)		65	36	21	83
GHG savings (tCO_2e)		515,560	259,590	670,493	631,024
Emissions per unit of energy (tCO_2e/GWh)	894–1,278	430		475	175
India					
Net energy supplied (GWh)		406	29,880	10,047	10,360
Approved ADB financing ($ million)		88	636	2	50
GHG savings (tCO_2e)		318,840	6,080,434	659,750	680,094
Emissions per unit of energy (tCO_2e/GWh)	1,000	0	498	202	202
Pakistan					
Net energy supplied (GWh)		85	3,965		
Approved ADB financing ($ million)		3	247		
GHG savings (tCO_2e)		39,695	1,100,238		
Emissions per unit of energy (tCO_2e/GWh)	628	0	213		
Philippines					
Net energy supplied (GWh)		14	850		
Approved ADB financing ($ million)		6	62		
GHG savings (tCO_2e)		7,713	(386,067)		
Emissions per unit of energy (tCO_2e/GWh)	657		1,011		
Viet Nam					
Net energy supplied (GWh)		2,318	2,044		
Approved ADB financing ($ million)		123	73		
GHG savings (tCO_2e)		189,199	133,968		
Emissions per unit of energy (tCO_2e/GWh)	567	366	766		

ADB = Asian Development Bank, GHG = greenhouse gas, GWh = gigawatt-hour, tCO_2e = ton of carbon dioxide equivalent.
Note: Net energy supplied, ADB financing approvals and GHG savings are normalized to an annual basis by dividing by the number of years in each period.
Source: Computed by the study team.

75. **Bangladesh.** Although the power transmission and distribution projects in Bangladesh resulted in GHG savings due to reduction in power distribution losses, the open-cycle gas turbine projects that ADB financed as a short-term measure for reducing power shortages had negative GHG savings. This resulted in reduced GHG savings for ADB's power supply portfolio. However, the GHG emissions per unit of ADB-financed projects were lower than the grid emission factor of Bangladesh. The two gas supply projects that ADB financed during 2001–

2005 resulted in significant GHG savings due to replacement of high-emitting fossil fuel and biomass with cleaner natural gas.

76. **People's Republic of China.** A significant reduction in ADB financing of power supply projects in the PRC occurred during 2006–2008 compared with 2001–2005, and a corresponding reduction of GHG savings attributable to ADB-financed power supply projects. However, the GHG savings per unit of energy in the power supply projects increased from about 430 tCO_2e/GWh to 900 tCO_2e/GWh, as ADB's recent investments in the power sector in the PRC were in zero or low-carbon technologies such as renewable energy and hydropower. A significant increase occurred in energy supplied through fuel and thermal energy supply projects in the PRC due to large natural gas infrastructure and centralized district heating projects included in ADB's portfolio in recent times. However, overall, there was a significant reduction in the GHG savings per unit of energy supplied from over 650 tCO_2e/GWh in 2001–2005 to less than 100 tCO_2e/GWh in 2006–2008. This was due mainly to the absence of methane capture projects in the latter period. The emissions per unit of energy for ADB-financed power supply projects was significantly lower than the grid emission factors of all the PRC's major grids.

77. **India.** There was a significant increase in ADB lending approvals to the power supply sector in India ($88 million per year in 2001–2005 to $636 million per year in 2006–2008), and there was even higher capital mobilization due to increased leveraging of ADB financing. The total energy output of ADB-financed power sector projects increased from 406 GWh to 29,880 GWh due to increased ADB lending to large thermal power plants and hydropower plants. As ADB-financed projects including thermal power plants on average emit less than the grid emission factor of India (498 tCO_2e/GWh compared with 1,000 tCO_2e/GWh), a significant amount of GHG savings amounting to 6,080,434 tCO_2e is attributable to ADB projects. However, annual GHG savings per unit of capital investment required for approved projects actually decreased by 33%, from an average of over 2,600 tCO_2e/$ million in 2001–2005 to less than 1,800 tCO_2e/$ million in 2006–2008. This reflects largely the approvals for assistance to setting up (mostly clean coal) thermal power projects during 2006–2008, which resulted in large GHG savings compared with the counterfactual, but the GHG savings per unit of investment were less for such projects compared with renewable and hydropower projects. The large LNG terminal project that ADB financed through two lending operations during the two periods dominated the fuel supply projects in India, and this project's energy content and GHG savings were comparable to several large power plants.

78. **Pakistan.** There was a significant increase in ADB lending to the power sector in Pakistan during 2006–2008 compared with 2001–2005, when only a single hydropower project was financed by ADB. The projects financed by ADB during 2006–2008 consisted of thermal (gas-fired) power plants and hydropower plants, power transmission, and distribution expansion projects. These projects resulted in significant GHG savings compared with the counterfactual, as the GHG emissions of the ADB portfolio (213 tCO_2e/GWh) were significantly less than the grid emission factor for Pakistan.

79. **Philippines.** The GHG efficiency of only two project or components belonging to 2001–2005 and 2006–2008, respectively, could be analyzed for GHG efficiency.[41] The results clearly reflect the fact that a transmission loss reduction project (approved during the first time period) was associated with low GHG emission reductions. The rehabilitation of coal-fired power plant (approved during the second time period) led to an increase of GHG emissions, even if its

[41] Other loans or components were essentially focused on sector reforms or capacity building, which have only indirect implications for GHG efficiency.

conversion efficiency was enhanced as it is increasing the share of coal power generation in the overall generation mix. This also led to ADB-financed projects resulting in higher GHG emissions, as the emissions of the ADB portfolio (766 tCO_2/GWh) were higher than the grid emission factor for the Philippines.

80. **Viet Nam.** The amount of energy supplied by ADB-financed projects and the ADB financing of energy sector projects in Viet Nam remained roughly the same in the two periods. The ADB projects approved during 2001–2005 consisted of combined-cycle gas turbine projects and power transmission projects, while in 2006–2008 ADB approved financing for a large hydropower project and a large coal power plant. Although the emissions per unit of energy of ADB projects during 2006–2008 exceeded the average grid emission factor due to the presence of the coal power plant, the coal power plant also resulted in emission savings with respect to the project-specific counterfactual.

D. Ranking of Energy Supply Technologies Based on ADB-Supported Projects in the Six Countries

81. With the objective of assessing the effect of including GHG emission costs to the least-cost planning process of selecting power supply technologies, the power supply projects included in the ADB's portfolio are ranked as follows:[42]

(i) the traditional economic cost per unit of energy ($/kilowatt-hour [kWh]), where the cost comprises the annualized capital cost plus annual fixed operating cost plus fuel costs per unit of energy; and

(ii) the traditional economic cost per unit of energy ($/kWh) plus global environment-related cost, which is computed as the cost associated with gross GHG emissions on a per kWh basis.

82. The rationale for adding the GHG emission cost to the economic cost is based on the findings of the IPCC that indicate GHG concentrations have already exceeded the atmospheric capacity to hold GHGs without adversely impacting the global climate.[43] Hence, gross emissions have an economic cost at a global level. It is recognized, however, that such an aggregation of economic and GHG emission-related costs is not used for the purposes of making investment decisions. The technology ranking based on ADB's energy sector portfolio is subject to the following limitations:

(i) site-specific constraints in deploying certain technologies and site-specific costs are not considered;

(ii) technology penetration limitations (i.e., the share of total energy supply that can be based on renewable energy such as wind without affecting the stability or reliability of the entire power supply system) are not considered;

(iii) the peculiar characteristics of different power generation technologies are not considered, for instance, coal or gas-fired power generation is dispatchable, while renewable energy-based generation is not;

(iv) the ranking does not consider the fuel availability situation within the country or the country's fuel import options; and

(v) cost incurred by energy users to switch fuels (say from coal to gas) is not considered.

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[42] It is recognized that the ranking may change if the abatement costs of local pollutants are also added.

[43] Therefore, any additional GHG emission sources (such as several types of new energy projects in DMCs including those supported by ADB) would contribute to global climate change. It may, therefore, be worthwhile to attribute a cost to the equivalent CO_2 emissions from such energy projects in line with carbon market prices.

83. For the purpose of ranking, two main energy price scenarios are considered; and for each energy price scenario, two sets of carbon price levels are considered. The six resulting scenarios may be described as follows:

(i) two BAU scenarios in which no value is placed on carbon emissions even though the impact of any incremental GHG emissions leads to further climate change; in the low-fuel price BAU scenario, coal and gas prices are assumed at \$60/t and \$5/million British thermal units (mmbtu), respectively; in the high-fuel price BAU scenario, coal and gas prices are assumed at \$90/t and \$7/mmbtu, respectively.

(ii) a low-carbon price scenario in which the carbon price reflects present day levels of about \$20/tCO_2e; costs are thus analyzed for a combination of low-fuel/low-carbon price and high-fuel/low-carbon price scenarios; and

(iii) a high-carbon price scenario in which the carbon price reflects an expected future price level (most likely post-2012) of about \$60/tCO_2e; energy project costs are thus estimated for low-fuel/high-carbon price and high-fuel/high-carbon price scenarios.

84. Figures 1–6 provide the costs per unit of energy for the power generation/savings options supported by ADB since 2001. Although the results are based on a relatively small sample of projects and components approved for ADB support,[44] some broadly indicative insights are possible. For the low-fuel price scenario without considering the GHG costs, the following can be deduced:

(i) methane destruction projects are the most economical; methane destruction is economically attractive because the methane resource cost reflects only the cost of methane capture, storage, and pipelines;[45]

(ii) conventional pulverized coal-fired power plants are more attractive than the more efficient supercritical steam or fluidized bed generation options as the low-fuel price is not sufficient to offset the incremental capital cost of advanced technologies;

(iii) large hydropower projects entail higher costs than coal-fired power options, which perhaps reflects the sample size and the site specific conditions for hydro plants in the sample;

(iv) gas-fired combined cycle-turbine projects are more expensive than hydropower projects but more economical than gas-fired open-cycle turbine projects;

(v) renewable energy options, which normally have a relatively low capacity factor, are in general more expensive than large hydropower and fossil fuel-fired power plants;

(vi) rehabilitation of coal- or gas-fired power plants is not economically efficient when fuel prices are low, as the incremental efficiency gains come with relatively high capital investment requirements;

(vii) pumped storage hydropower projects are the least attractive power generation options, reflecting the high energy input required to pump up water on a daily basis;

[44] The small sample of projects and components of certain categories may not be sufficiently representative of the population of projects that can be developed in ADB DMCs. Moreover, costs and energy outputs of certain project and component categories are more site or location specific than others.

[45] Methane resource costs do not include the cost of coal mining operations.

(viii) investment in transmission and distribution system[46] improvements is the least attractive as an alternative to power generation through avoided generation resulting from loss reduction.

85. The comparison of the high-fuel price scenario with the low-fuel price scenario, as well as the introduction of carbon prices under the high-carbon price and low-carbon price scenarios shows that the higher the fuel price and the carbon price ;

(i) the higher capital cost supercritical or fluidized bed-based power plants become more attractive vis-à-vis conventional pulverized coal-fired power plants;
(ii) large hydropower and renewable energy options become more attractive; in fact, at a carbon price of $60/t, hydropower projects may even be more attractive than some of the methane destruction-cum-power generation projects; and
(iii) win-win energy supply options that results in increased economic benefits and GHG savings (such as end-user efficiency) become even more attractive opportunities.

86. In view of the anticipated rise in carbon market prices (especially after 2012), it may be worthwhile for ADB to consider the following:

(i) supporting power projects based on clean coal technologies (rather than conventional pulverized coal subcritical power plants) in grid systems that are sufficiently large;
(ii) continuing and perhaps accelerating support for large hydropower, renewable, and transmission grid-strengthening projects;
(iii) not supporting financing of open-cycle gas turbine projects (unless they are considered as a first phase of planned combined cycle power plants);
(iv) selectively supporting pumped storage hydropower projects (if they can be shown to result in reduction in overall system operating cost); and
(v) aggressively pursuing end-user efficiency and methane destruction projects.

[46] Pumped storage projects and power transmission projects are undertaken mainly for improving the operational performance of power systems. The loss reduction or otherwise is a minor consideration in the investment decision-making process. It can be also shown if a system-wide study is undertaken for pump storage project when they are operated with large nuclear power plants, the overall cost is reduced as a result of the pump storage projects.

RANKING OF POWER SUPPLY PROJECTS FOR FUEL AND CARBON PRICE SCENARIOS

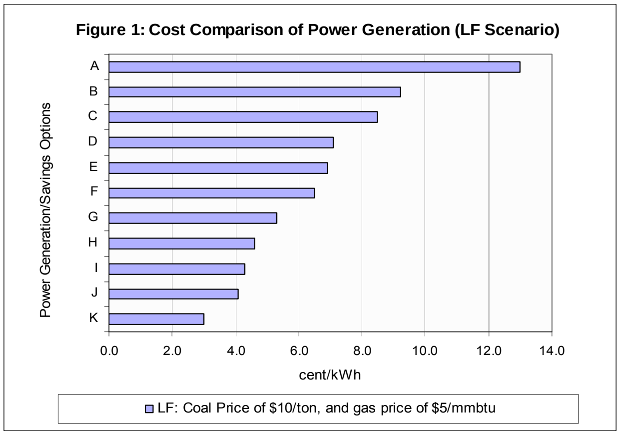

Figure 1: Cost Comparison of Power Generation (LF Scenario)

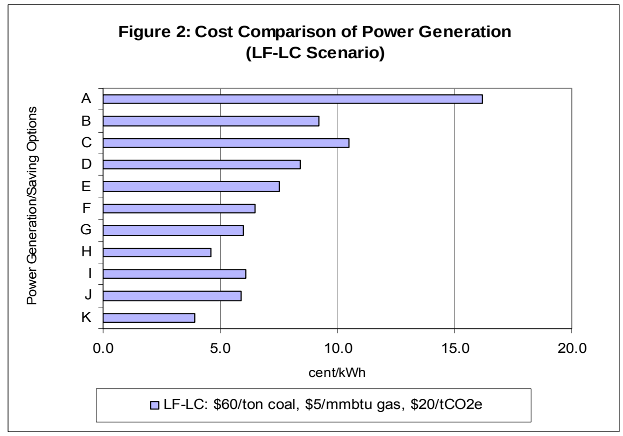

Figure 2: Cost Comparison of Power Generation (LF-LC Scenario)

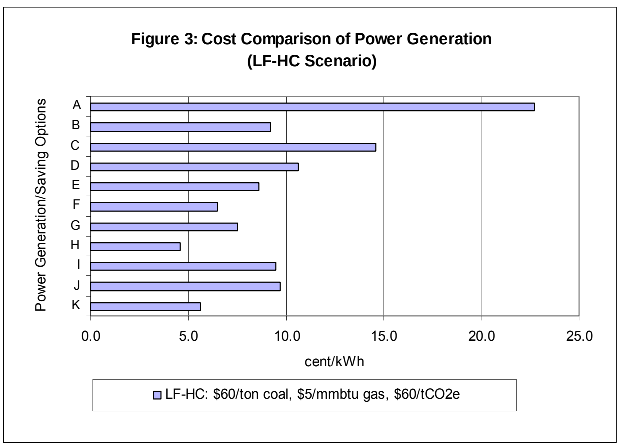

Figure 3: Cost Comparison of Power Generation (LF-HC Scenario)

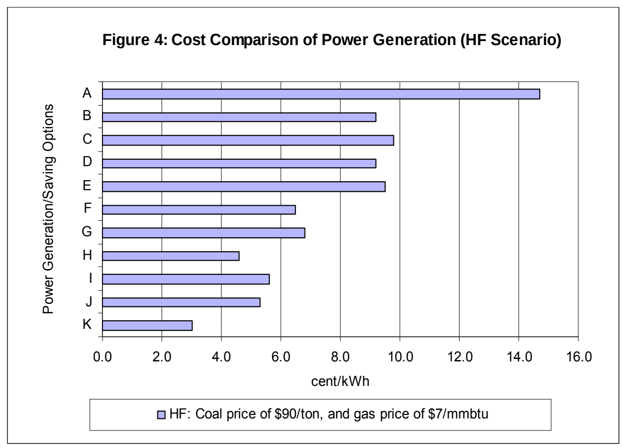

Figure 4: Cost Comparison of Power Generation (HF Scenario)

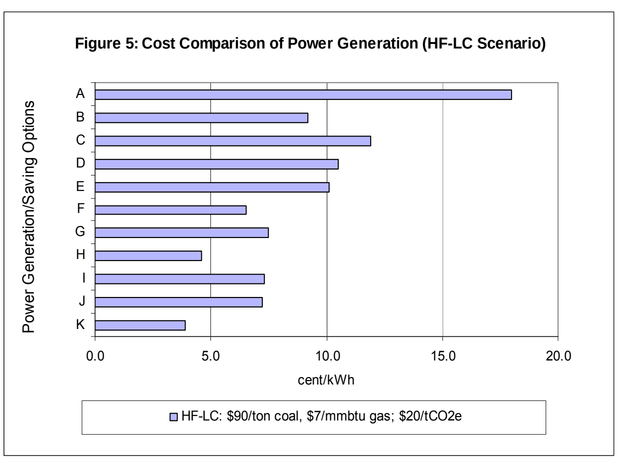

Figure 5: Cost Comparison of Power Generation (HF-LC Scenario)

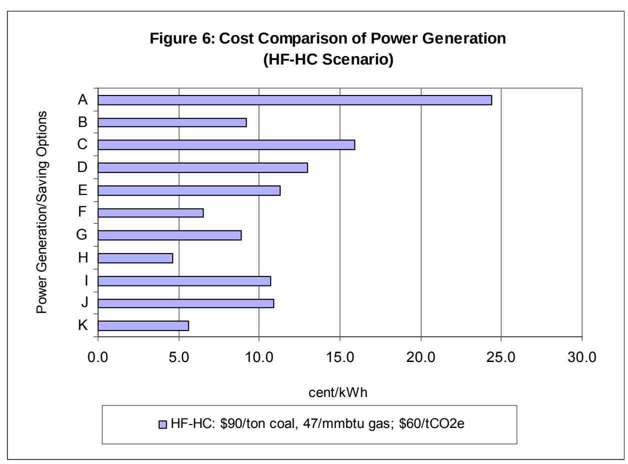

Figure 6: Cost Comparison of Power Generation (HF-HC Scenario)

Note:
A = Pumped storage hydro
B = Transmission loss reduction
C = Rehabilitation of coal-fired power plant
D = Gas-fired turbine in open cycle mode
E = Rehabilitation of gas-fired power plant
F = Renewable energy
G = Gas-fired combined cycle
H = Large hydropower
I = Coal-fired power generation (efficient)
J = Coal-fired power generation (conventional)
K = Methane destruction (captured methane-fired)
Source: Prepared by the study team.

VI. EVALUATION OF GREENHOUSE GAS EFFICIENCY OF ADB'S ENERGY SECTOR OPERATIONS

A. Relevance and Strategic Focus

1. Relevance of ADB's Energy Sector Operations to Climate Change Mitigation

87. It is by now recognized that (i) the warming of the climate system since the mid-20th century is unequivocal and is very likely (with more than 90% confidence level) a consequence of increased anthropogenic GHG emissions; (ii) developed economies cannot by themselves achieve the most desirable outcome of stabilizing atmospheric GHG concentrations at 450 ppm CO_2 equivalent by 2030; (iii) technology and finance should be made available to developing countries (including ADB DMCs) to move toward a low-carbon growth path; and (iv) developing Asian countries are expected to contribute to more than half of incremental global primary energy consumption to 2030 as well as a significant share of incremental global GHG emissions to 2030. This backdrop provides the rationale for increasing attention in recent years within ADB to climate change-related issues, including GHG emission savings of energy sector operations.

2. Strategic Focus of National Energy Sector Strategies with respect to Greenhouse Gas Efficiency

88. All six selected DMCs consider the ensuring of adequate energy supplies to maintain economic growth and improve the living conditions of their people to be of primary importance. GHG efficiency is encouraged to the extent that it is consistent with the above-mentioned objectives and when GHG efficiency improvement contributes to improved energy security, enhanced operational efficiency, and mitigation of local environmental impacts. Although GHG mitigation is an objective in its own right, the primary objective of these measures is to improve the energy security and sustainability of the energy sector. In the longer term, wide deployment of clean energy technologies would result in significant scale economies as well as substantial GHG savings.

89. Although it is not explicitly recognized as such, all the selected DMCs have adopted strategies to improve the GHG efficiency of their energy sectors. The PRC and India have taken specific actions to improve the thermal efficiency of power generation by deploying more efficient technologies and in the PRC's case by shutting down old and inefficient coal power plants. All six countries have taken measures to increase the share of renewable energy in their energy mix and to improve end-user energy efficiency. The efficacy of these measures varies from country to country, but there is a general trend toward increased renewable energy generation in PRC, India, and Pakistan.

90. Even in countries such as PRC, India, and Viet Nam, where climate change is viewed in a comprehensive manner, the main focus is on preparing for the adverse impacts of climate change, and the leading DMCs (PRC and India) have encouraged the deployment of more efficient and advanced technologies in their energy sectors as long as these technologies are economically and financially viable. The developed economies are expected to facilitate technology transfer as well as extend financial support as per the UNFCCC BAP to facilitate GHG mitigation.

3. Strategic Focus of ADB Strategies on Greenhouse Gas Efficiency of Energy Sector Operations

91. ADB's long-term strategy adopted in 2008 (Strategy 2020) recognizes as one of the five core operational areas the development of clean energy sources to meet the energy security needs of the DMCs. The 2009 Energy Policy recognizes the enormity of the twin challenges of energy security and climate change, advocates a catalytic role for ADB in advancing the clean energy agenda in Asia and Pacific. It has brought the mitigation of increasing GHG emissions in the energy sectors of DMCs to the forefront of ADB's energy sector operations together with energy security and access to energy. Implementation of the Energy Policy is to be monitored as per the ADB Results Framework, which explicitly states that appropriate indicators of clean energy and energy efficiency are to be identified and incorporated in the results framework. In recent years, therefore, ADB has adopted forward-looking strategies and policies that are intended to guide its energy sector operations in keeping with DMCs' development priorities such as energy security, energy access to all at affordable prices, as well as global interest in shifting developing Asia to a low-carbon development path.

4. Strategic Focus of ADB Country Strategies with Respect to Greenhouse Gas Efficiency Improvement of Energy Sector Operations

92. ADB has taken a conscious decision to focus on encouraging the deployment of clean energy technologies in its energy sector operations since 2006. The ADB country strategies approved prior to 2006 for Bangladesh, India, and Pakistan were focused mainly on institutional reforms in energy sector utilities and improving energy access. Likewise, prior to 2006, the Philippines country strategies focused essentially on sector reform. In the PRC and Viet Nam, the CSPs prior to 2006 gave emphasis to addressing of local environmental impacts of energy sector projects. In the PRC, in particular, supply- and demand-side energy efficiency improvement and renewable energy sector development were encouraged as a means for improving the overall efficiency of the sector and to ensure the development of the sector in an environmentally sustainable manner, but not necessarily to reduce GHG emissions.

93. However, the CSPs/CPSs prepared since 2006 have explicitly mentioned the shifting of the DMC energy sectors to a low-carbon development path as a primary objective together with ensuring energy security and energy access. This is evident in the recently approved country strategies for the PRC and Pakistan with targeted operations to increase lending to support renewable energy, energy efficiency, and cleaner thermal power generation technologies.

B. Responsiveness

1. ADB's Institutional Response to Improve Greenhouse Gas Efficiency of Energy Sector Operations

94. ADB's response to climate change concerns have evolved in four phases: (i) analysis phase, when the Asia Least-Cost Greenhouse Gas Abatement Strategy study[47] was carried out with inputs from national technical experts from 12 DMCs to formulate key strategic priorities for the national GHG abatement strategies during the late 1990s; (ii) capacity-building phase, when the REACH program's PREGA RETA was conducted from 2001 to 2006 for capacity building of in-country stakeholders in 18 DMCs in renewable energy, energy efficiency, and other GHG abatement technologies; (iii) operationalization phase, which followed from the initial impetus provided by PREGA to mainstream GHG abatement technologies in energy sector operations,

[47] ADB. 1998. *Asia Least-Cost Greenhouse Gas Abatement Strategy*. Manila.

the entry into force of the Kyoto Protocol, and the launch of the Climate Change Program in 2006 consisting of EEI (to promote renewable energy and energy efficiency investments, policy reforms, and institutional capacity building for creating an enabling environment for clean energy investment) and CMI (to provide access to carbon markets to eligible clean energy projects from DMCs); and (iv) operations sustaining phase, with the introduction of climate change implementation plans on a regional basis, their (ongoing) integration with CPSs, the launch of the Future Carbon Fund (which at this time is the only carbon fund that encourages projects with GHG savings beyond 2012), as well as the CEFPF, which provides additional resources to prepare GHG efficient investments. Most of the initiatives taken since 2006 are coordinated by the Regional and Sustainable Development Department. These initiatives have resulted in enhanced management focus, increased institutional capacity, and awareness of ADB's staff working in the energy sector on operations promoting GHG efficiency.

2. Resource Allocation for Greenhouse Gas Efficient Operations

95. ADB's lending to the energy sector in the six countries increased recently, with cumulative lending increasing from $3,113 million to $4,679 million and annualized lending increasing from $623 million in 2001–2005 to $1,560 million in 2006–2008. Together with the overall increase in the lending volume, the allocation to clean energy projects[48] increased in absolute terms (viz., $171 million on annualized basis in 2001–2005 to $693 million during 2006–2008). As a share of total energy sector lending approvals, clean energy lending approvals increased from 26% in 2001–2005 to 44% in 2006–2008. There was a significant increase in ADB financing of renewable energy, hydropower, and advanced (i.e., supercritical) thermal power plants and a reduction in traditional power transmission and distribution projects during 2006–2008 compared with the earlier period. There was also a significant increase in nonlending interventions supporting GHG-efficient policy reforms, capacity building, and project preparation during 2006–2008 compared with 2001–2005 as illustrated in Table 5. Increasing number of TAs approved during 2006–2008 with GHG efficiency improvement objectives was supported by the CEFPF.

Table 5: Resource Allocation for GHG Emission Reduction for Six Selected Countries

Item	Unit	2001–2005	2006–2008	2001–2008
Cum. energy loan approvals	$ million	3,113	4,679	7,792
Cum. clean energy loan approvals	$ million	853	2,078	2,931
Annualized energy loan approvals	$ million	623	1,560	974
Annualized clean energy loan approvals	$ million	171	693	366
Share of clean energy in total energy lending approvals[a]	%	26%	44%	38%
Clean energy ADTA approvals	$ million	5.7	7.6	13.2
Clean energy PPTA approvals	$ million	5.9	10.9	16.8
Share of clean energy in total energy sector ADTA approvals	%	23%	43%	32%
Share of clean energy tin total energy sector PPTA approvals	%	69%	85%	78%

ADTA = advisory technical assistance, PPTA = project preparatory technical assistance.
[a] Clean energy includes energy efficiency (including fuel switch), renewable energy, hydropower, clean coal technology, gas-based power generation, and gas infrastructure development projects. Conventional coal-fired power and open-cycle gas turbine-based generation projects, transmission, and distribution projects are not included.
Source: Study team.

[48] This refers only to clean energy investments included in the energy sector projects. The clean energy investments embedded in other sectors such as transport or water supply are not included here.

3. Mobilization of Private Sector Investments to Promote Greenhouse Gas Efficiency

96. The roles of the private sector and nonsovereign operations are increasingly recognized in ADB's energy sector operations, although ADB has not financed private sector energy projects have not been financed by ADB in Bangladesh and Viet Nam since 2002. Most nonsovereign energy sector projects that ADB approved from 2001 to 2008 were for clean energy investments.[49] With the recognition that ADB is playing a role in catalyzing private participation through introduction of new technologies, financial mechanisms, and business models, the following merit specific attention: (i) supporting high-efficiency supercritical coal-fired power generation projects in India through private sector or nonsovereign operations involving state-owned enterprises; (ii) supporting private sector investments and public-private partnerships in renewable energy (e.g., small hydropower, wind) in PRC, India, and Pakistan; (iii) supported the post privatization rehabilitation of existing thermal power plants in Pakistan and Philippines as well as new investments in thermal power generation by a privatized entity in Pakistan; and (iv) guarantee support to partly cover market risk of commercial banks that finance building energy efficiency projects in the PRC.

97. There was a substantial increase in nonsovereign operations in the energy sector during 2006–2008 compared with 2001–2005, with annualized approvals increasing by 13-fold. More than 95% of nonsovereign energy approvals were for clean energy projects. There was a corresponding increase in total private sector investments mobilized by ADB in the clean energy sector, with ADB's nonsovereign operations mobilizing over $3.4 billion of investments for the clean energy sector. This is illustrated in Table 6.

Table 6: Private Sector Participation in Six Selected Countries

Item	Unit	2001–2005	2006–2008	2001–2008
Annualized lending approvals for energy projects	$ million	623	1,560	974
Annualized nonsovereign lending approvals to energy sector	$ million	38	494	214
Annualized clean energy lending approvals in nonsovereign energy sector lending	$ million	25	469	192
Annualized investments mobilized due to ADB's nonsovereign operations for clean energy investments	$ million	316	3,431	1,484
Share of nonsovereign loans in total loans to energy sector	%	6%	32%	22%
Share of clean energy loans in nonsovereign loans to energy sector	%	66%	95%	90%
Leveraging of investments to clean energy	times	12.6	7.3	7.7

Source: Compiled by the study team.

4. Accounting of Greenhouse Gas Emissions of ADB-Financed Energy Sector Projects

98. Since 2006, ADB has taken several measures to account for the GHG emissions of its energy sector projects. ADB's Results Framework has included the GHG emissions of energy sector operations as one of the level 2 indicators.[50] The indicator for the Results Framework is

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[49] It may be argued that the following are clean energy projects: (i) acquisition and rehabilitation of a subcritical coal-fired power plant in the Philippines—the rehabilitation resulted in significant increases in plant efficiency; (ii) a transmission line for power evacuation from a hydropower project (borrower in India); and (iii) rehabilitation, upgradation, and expansion of transmission system plus capacity-building support to a privatized power utility in Pakistan.

[50] At the same time, ADB has set a target for its investments in clean energy ($1 billion by 2008 and $2 billion by 2013). Both the 2008 and 2013 targets are set in terms of loan approvals rather than actual disbursements within the year.

the annual GHG savings realized as a result of an ADB-financed project once the project reaches full commercial operation based on the estimates made at project appraisal and project completion. At present, ADB does not have a consistent set of guidelines to assess the GHG savings attributable to ADB-supported investments in the energy sector. Therefore, it would be useful to develop guidelines on data collection during project preparation and processing that would estimate GHG emission reduction, keeping in view the type of methodological issues discussed in Chapter 4 for arriving at portfolio-wide estimates of GHG savings.

99. Nonetheless, there is a substantial increase in the recognition of climate change and the GHG implications of energy projects and investment programs since 2006. The coverage and quality of data required for GHG efficiency analysis that are available from RRPs (and other documents prepared during loan processing) have improved. GHG impact assessment in RRPs increased from 22% during 2001–2005 to more than 45% during 2006–2008 (Table 7). However, the indicators used in GHG impact assessment in the RRPs do not use consistent set of methodologies and assumptions. The data and assumptions used are also not always provided in the RRPs. However, there is a relatively high prevalence in reporting GHG savings for energy efficiency, renewable energy, and large hydropower projects compared with other types of projects. The degree of GHG assessment undertaken in RRPs for various categories of energy sector projects is shown in Table 7.

Table 7: GHG Implications Reported at RRPs (% of components by category)

Item	2001–2005	2006–2008	2001–2008
Energy efficiency improvement	83	60	73
Renewable energy	—	100	100
Hydropower	67	75	71
Gas infrastructure development	0	20	9
Thermal power generation	25	10	14
Transmission	10	50	21
Distribution	10	40	20
Total	**22**	**45**	**33**

GHG = greenhouse gas, RRP = report and recommendation of the President.
Source: Compiled by the study team.

C. Results

1. Policy Reforms Promoted by ADB that Propel Developing Member Countries to a Low-Carbon Growth Path

100. The policy and institutional reforms supported by ADB toward GHG efficiency through advisory technical assistance and policy dialogue in the six countries are assessed in terms of the adequacy, efficacy, and overall impact of ADB intervention. The assessments of policy interventions supported by ADB for each of the countries studied are provided in Chapter 3. It can be inferred that ADB has not engaged national-level policy makers to initiate broad policy reforms to improve the GHG efficiency of the energy sector in the concerned DMCs. However, ADB has selectively supported policy reforms to achieve GHG efficiency improvement in the PRC and Pakistan. In the PRC, ADB has provided a series of TA grants to improve the overall energy efficiency of district heating, coal-bed methane recovery, industrial energy efficiency, and waste coal utilization. ADB has also provided TA to assess the feasibility of new technologies such as integrated gasification combined cycle power plants and shallow ground geo-energy. In Pakistan, ADB was instrumental in setting up institutional arrangements for promoting renewable energy. ADB has recently engaged the governments of Philippines and

Viet Nam to promote policy reforms to improve end-user energy efficiencies. In Bangladesh and India, the policy reforms initiated by ADB are focused primarily on improving the operational efficiencies of power sector utilities, which should have indirect impact on the overall GHG efficiency of the energy sector through reduction of power distribution losses.

2. ADB Contribution to Greenhouse Gas Emissions Reduction

101. From a high concentration of transmission and distribution projects approved for support, especially in South Asia during 2001–2005, ADB's energy portfolio has diversified since 2006. Although no methane destruction projects have been approved for ADB support since 2006, the clean energy portfolio has included several other inherently relatively cleaner energy options such as (i) renewable energy and hydropower projects approved for support in PRC, India, and Pakistan; (ii) an industrial energy efficiency project in the PRC to reduce electricity consumption per unit of industrial output; (iii) improved district heating services with higher efficiency heat generation and heat distribution systems in the PRC; and (iv) gas infrastructure development projects in the PRC and India, intended to substitute gas for higher GHG-emitting coal and petroleum products in residential, commercial, transport, and industrial applications. However, ADB has also expanded its lending to large thermal power generation including coal-fired power plants, which result in significant GHG emissions. These projects were essential for ensuring the energy security of the countries concerned and energy access to all at an affordable price. Most of ADB-financed thermal power projects deployed advanced efficient technologies subject to technical constraints present in a specific country and have contributed to GHG savings compared with the BAU scenario in the absence of ADB intervention.

102. The trends in GHG emissions of ADB-financed energy sector projects including GHG emission savings and attribution of GHG emission savings to ADB in proportion to ADB financing are explained in Chapter V. In summary, ADB financing of the energy sector has increased significantly during recent years, and some of these investments have resulted in increased gross GHG emissions. However, GHG emission savings have also increased as a result of ADB-financed projects resulting in fewer emissions compared with the BAU scenario. Hence, it can be inferred that ADB has shifted its energy assistance to a low-carbon growth path.

VII. KEY FINDINGS AND RECOMMENDATIONS

A. The Backdrop

103. This EKB includes a review of ADB policies, country strategies, national development priorities and strategies, as well as ADB lending and nonlending interventions, some of which were in place before (i) the Kyoto Protocol had entered into force (February 2005); (ii) the Fourth Assessment Report of IPCC (2007) had been released, which stated that global warming is very likely (more than 90% confidence level) a consequence of increased anthropogenic emissions; (iii) ADB had launched initiatives (2005 and 2006) to support the development of GHG abatement projects; and/or (iv) the DMCs' environment management policies and programs had come to recognize climate change issues. Yet, this does not mean that no projects or investment programs that lead to GHG emission reductions were supported by ADB in the early years of the study period. Rather, as evident from chapters 3, 4, and 5, ADB did approve the financing of many such projects right from the beginning of the study period (and even earlier), but without necessarily recognizing the associated GHG benefits. The stated objectives were often improvement of the local environment, cost reduction, and/or energy

security (or in some cases, even better safety in coal mining operations). The key findings discussed below recognize this fact.

B. Key Findings

104. **Most supply-side energy investments will necessarily add to GHG emissions in absolute terms.** To maintain the economic growth required for sustained poverty reduction in DMCs, the energy supply infrastructure has to keep pace with the increasing demand for energy. This requires investments in new power plants, power transmission and distribution networks, and gas pipelines and related infrastructure. Investments supporting fossil fuel usage directly (e.g., thermal power plants, gas pipelines, and related facilities) or indirectly (e.g., increasing electricity generated with fossil fuel by expanding the transmission and distribution network) will result in increased GHG emissions in absolute terms. However, the GHG efficiency of these investments should not be measured in absolute terms but rather in relative terms (i.e., in comparison to the most likely scenario in the absence of the intervention).

105. **GHG-efficient investments have been part of ADB's energy sector portfolio for many years without explicitly recognizing them as such.** ADB has been financing GHG-efficient energy sector infrastructure development projects for promoting economic growth in DMCs since well before the beginning of the study period. Prior to 2005, these investments were justified in ADB loan documents on the basis of their economic and financial viability, and local environmental impacts and GHG efficiency improvement were not considered as a reason for ADB support—which is perhaps a reason for the inadequacies of relevant information and data in RRPs for projects approved prior to 2005.

106. **There has been increased focus on GHG-efficient investments supported by ADB since 2006.** ADB's lending to energy sector investments with direct GHG savings have increased since 2006, which is consistent with the recently approved country strategies, where shifting the energy sector to a low-carbon development trajectory is explicitly identified as an intended development outcome. Besides, progressive commercialization of new and increasingly sophisticated renewable energy technologies, and increasingly higher efficiency fossil fuel-fired power generation have also increased ADB's maneuverability toward meeting the DMCs' broader development objectives while ensuring an energy-efficient growth path. The operations approved for support by ADB since 2006 that merit specific attention in this context include an increasing share of renewable energy (with introduction of large wind turbines in the PRC), advanced combined-cycle gas turbines and cleaner coal combustion technologies for power generation (especially in India), developing infrastructure for supply of less GHG-intensive fossil fuels such as natural gas (PRC and India), and deployment of efficient electrical equipment in industry (PRC).

107. **ADB's Private Sector Operations Department has the potential to play a significant role in promoting GHG-efficient investments** in the six selected countries. A review of ADB's lending operations shows that the Private Sector Operations Department (PSOD) operations (especially in the PRC and India) have high potential for GHG efficiency improvement. This is due mainly to the type of projects supported by PSOD, which include renewable energy (e.g., wind in India and small hydropower in Pakistan); supercritical coal power plants and LNG terminals in India; district heating efficiency, industrial and commercial building energy efficiency, and fuel switching investments in the PRC; and rehabilitation of privatized thermal power plants in Pakistan and Philippines. Although there has been an increase in public sector lending for hydropower projects (in PRC, India, and Viet Nam) and energy efficiency projects

(notably in the PRC), most of public sector lending continues to be dominated by traditional power transmission and distribution projects.

108. **Renewable energy is still a high-cost option for many DMCs.** Although the share of renewable energy in large DMCs such as the PRC and India is increasing in response to fiscal and other incentives and the targets set by respective governments, the costs per unit of energy from renewable energy projects are higher than the fossil fuel-based alternatives. There is scope for further reducing the cost of energy from renewable energy by developing more appropriate technologies for the Asian region, promoting regional manufacturing of renewable energy equipment, and exploiting scale economies arising from increased penetration of renewable energy technologies in the Asian region.

109. **There is scope for expanding ADB investments in industrial energy efficiency projects**. The heavy industry sector (cement, steel, petrochemicals, etc.) consumes a significant share of energy in the rapidly industrializing DMCs, and the industrial energy efficiency of DMCs in terms of energy consumption per unit of industrial output lags behind that of more advanced countries. However, ADB has not had much success in channeling financing to industrial energy efficiency improvement due to (i) ADB's lack of engagement and expertise in financing industrial projects, (ii) the relatively small size of investment per industrial unit, (iii) ADB's internal policies discouraging it from assisting state-owned enterprises engaged in heavy industries, and (iv) the need for financial intermediaries to channel ADB financing to industrial energy efficiency improvement projects.

110. **More emphasis is required in encouraging policy reforms to promote GHG efficiency.** In the six selected countries, ADB's policy dialogues have been generally focused on institutional reforms of energy sector entities and less emphasis in initiating broader policy reforms supporting GHG efficiency investments. This may be due to lack of access that ADB has had to policy makers in larger DMCs such as India, where ADB has focused primarily on state-level issues. Even in countries such as Bangladesh, where ADB was highly influential, its policy dialogue was focused primarily on institutional reforms and creating an enabling environment for private sector investments. However, there are exceptions to this trend. In the PRC, ADB has selectively engaged with the government through a series of TA activities to provide high-level inputs for policy reforms to encourage investments in improved district heating systems and coal-bed methane recovery. In Pakistan, ADB has supported the policy framework for renewable energy investments.

111. **Appropriate indicators are needed in the Results Framework (2008) for tracking implementation of the energy policy.** In line with Strategy 2020, ADB's 2009 Energy Policy recognizes the importance of energy security and climate change and sets targets for approvals of ADB's financial support on clean energy technologies. The implementation of the Energy Policy is to be monitored as per the ADB Results Framework, which clearly states that (i) appropriate indicators for clean energy remain to be identified (and that they would be incorporated in future versions of the Results Framework), and (ii) ADB's contribution to country and regional outcomes is to be assessed by aggregating key outputs delivered to DMCs. Hence, appropriate indicators need to be incorporated into ADB's Results Framework to monitor the achievement of targets set in the 2009 Energy Policy, for which some of the indicators and methodologies developed in this EKB could provide a useful basis.

112. **The quality of information and data for GHG efficiency analysis reported in RRPs is highly variable.** The quality of GHG efficiency reporting in RRPs correlates well with the quality of economic analysis and the type of project. Many RRPs for energy efficiency,

renewable energy, and hydropower projects provide GHG savings estimates or relevant data for making reasonable estimates of GHG savings. For other types of projects (e.g., gas supply and infrastructure development), the inadequacies of data relevant to GHG savings estimation are most evident. The design and monitoring frameworks presented in some of the recent RRPs also include GHG savings-related targets and indicators—although the baseline indicators or the methodology for assessing GHG savings are not clearly outlined. However, the GHG analysis undertaken in the RRPs and the GHG efficiency indicators used do not follow a consistent methodology. As a result, the information provided in RRPs is of little use to monitor ADB's portfolio-wide GHG efficiency.

113. **ADB has not actively promoted methane capturing and utilization projects in recent times.** There is large potential for coal-bed and land-fill methane capturing projects in PRC, India, and Indonesia. These projects have a high degree of GHG efficiency, as methane has a global warming potential 21 times of that of CO_2, and the captured methane can be used as a clean fuel source to replace coal usage in power generation and as a clean residential, commercial, and industrial fuel. ADB should selectively initiate policy dialogue with government agencies and coal mining enterprises with the objective of expanding its investments in methane capture and use based on its past experience in such projects in the PRC.

114. **Coal remains the fuel of choice for many DMCs for power generation** due to the presence of large coal reserves in many DMCs, the relatively low cost, the proven reliability of coal power plants for base load power generation, and lack of suitable alternatives to provide the required scale of power generation capacity at an affordable price. Hence, if ADB is to remain relevant to the needs of the DMCs, it should consider supporting coal-based power generation based on more advanced and efficient coal-based power generation technologies such as supercritical boilers, integrated gasification combined-cycle power plants, and carbon capture and sequestration subject to technical feasibility. If such advanced technologies are not feasible, conventional coal technologies may have to be supported to ensure energy security at an affordable price. However, these technologies entail a significantly higher cost than conventional coal power plants, and the GHG savings arising from the deployment of such advanced technologies are not eligible for carbon financing at present. Hence, there exists a need for ADB to explore appropriate financing mechanisms to encourage such technologies.

C. Recommendations

115. Based on the key findings of the study, the EKB proposes recommendations for Management consideration to improve ADB's internal reporting requirements of GHG impacts of its energy sector operations and to scale up ADB investments in cleaner energy supply technologies that contribute to shifting the DMCs to a low-carbon growth path.

116. **Assess GHG implications of future investments.** To better record and account for GHG implications of future energy sector interventions (paras. 111–112) in a consistent manner and taking into account the progress made on post-Kyoto negotiations under UNFCCC, ADB should consider the following:

(i) preparing a consistent framework to identify proposed energy sector interventions with significant GHG impacts or savings at the concept clearing stage and to undertake a GHG assessment at appraisal stage, giving due consideration to country-specific and location-specific issues and options;

(ii) assessing ex-ante the GHG implications of projects with significant GHG impacts or savings with respect to a plausible counterfactual (in the context of the country concerned) to the project, which is most likely to happen in the absence of ADB-financed project; and

(iii) reconfirming the GHG assessment at project completion on an ex-post basis for such projects by incorporating changes in technical design (if any) as well as performance data (if available). The net GHG savings of the project with respect to the counterfactual could be incorporated to ADB's Results Framework.

117. **Promote GHG efficient investments.** ADB may consider the following for promoting GHG efficient investments where technically and commercially feasible and relevant:

(i) given that coal is likely to continue to be a preferred fuel for several DMCs (para. 114), ADB should take the lead in mobilizing funds for establishing a financing mechanism that buys down (in part or full) the incremental cost of relatively higher cost but more GHG-efficient coal power plants;

(ii) as a means to bring down the cost of renewable energy options (para. 108) and facilitating scale up of appropriate and affordable renewable energy technologies increase support for research and development of selected technologies within the region, pilot testing of promising new designs or technologies in certain DMCs, technology transfer (through technology licensing, technical collaborations, etc.) as well as manufacturing of renewable energy products or subassemblies within the Asian region;

(iii) toward exploiting the large GHG saving potential of methane capturing projects (para. 113) undertake an assessment of opportunities for reducing anthropogenic methane emissions—both from coal fields (where methane recovery and capture is economically viable), as well as from nonenergy sectors (such as municipal waste management)—for both power generation and city gas supply and scaling up ADB financing of such projects; and

(iv) scale-up of industrial energy efficiency improvement projects (para. 109) by developing a suite of lending modalities to meet the specific requirements of energy efficiency projects (which may entail small investments in any one enterprise, but are scaleable and replicable); such modalities should be pilot tested in selected DMCs. For such emphasis on GHG efficient interventions, technical and financial expertise required within ADB would need to be assessed and (to the extent required) suitably enhanced.

EVALUATION APPROACH

1. **Modalities.** The evaluation approach includes a mix of literature review, desk studies, as well as interviews with concerned Asian Development Bank (ADB) staff and borrower and executing agency personnel for data gathering purposes. More specifically:

(i) **Contextual and qualitative assessment of ADB energy sector strategies and operations**, the literature review encompassed, agreements, protocols, action plans, and findings of various international organizations and country groupings, as well as ADB's strategic frameworks, relevant sector policies, country strategies, and recently launched relevant initiatives. Particularly pertaining to activities related to ADB initiatives such as the carbon market initiative and the energy efficiency initiative, discussions with concerned ADB personnel were also held.

(ii) **Greenhouse gas (GHG) accounting methodologies were developed**, with the limited objective of firming up methodologies for various categories of energy projects and components, the literature review covered available information on methodological issues, the methodologies approved by the clean development mechanism Executive Board, and technical literature that reports the findings regarding specific methodological issues pertaining to energy projects.

(iii) **GHG efficiency assessment of energy sector operations**, the broad approach was to apply the methodologies developed or adapted (for purposes of this evaluation knowledge brief) in (ii) above by using relevant (preferably) project-specific data or, where such data were not available, then suitable generic and default data from quotable and reliable sources.

2. The GHG efficiency of a large number of energy projects was analyzed to (i) understand the overall GHG efficiency for the entire portfolio, and (ii) discern time trends of GHG efficiency (if any). Given that several approved projects included project components that covered more than one category or type of energy sector investment (for instance, fossil fuel-fired power capacity, renewable energy generation, and energy efficiency), the GHG efficiency was in fact analyzed project component-wise. The approach was to base the analysis on (i) a review of the reports and recommendations of the President, as well as supplementary appendixes, feasibility reports, and/or other reports prepared through project preparation technical assistance, where available; (ii) updates (since approval) on project design or other relevant parameters obtained from relevant ADB staff; and (iii) data obtained from the concerned executing agency (public sector projects) or borrower (nonsovereign and private sector projects), but only if information from ADB's internal sources was lacking. In all cases, however, the preference was to use project-specific technical performance data[1] for estimating GHG efficiency; only in the absence of such project-specific data were generic data from local or in-country sources or global defaults from recognized and reliable sources considered.

3. However, the underlying approach for GHG analysis (no matter how sophisticated and detailed the GHG accounting methodologies may have been) could not yield precise GHG efficiency estimates for the concerned projects and components. Precision could be achieved only when actual project performance data were available—for which, of course, a necessary precondition was that the project must be completed and in operation. This necessarily implies that projects approved some 5 years or more ago had to be analyzed. However, such a sample of projects would clearly miss any changes affected in recent years, when climate change

[1] For instance, regarding fuel calorific values, power plant auxiliary consumption, power plant heat rates, transmission losses, distribution losses, pipeline losses, capacity factors, etc.

mitigation concerns have become increasingly important and ADB initiatives such as the carbon market initiative and energy efficiency initiative have been launched.

4. **Scope of GHG Efficiency Analysis.** For analytical purposes, the portfolio considered comprised the energy sector projects and investment programs approved from 2001 through 2008 in six countries—Bangladesh, People's Republic of China, India, Pakistan, Philippines, and Viet Nam. The six countries accounted for 80% of total ADB assistance approved for energy sector development during the 8-year period (Table A1.1).[2]

Table A1.1: Approvals for ADB's Energy Sector Operations from 2001 to 2008 ($ million)

Country(ies)	Financial Assistance[a]	Technical Assistance	Total Assistance
Bangladesh	1,257.5	6.1	1,263.7
PRC	1,353.3	16.4	1,369.7
India	3,347.9	14.7	3,362.5
Pakistan	1,057.1	8.4	1,065.4
Philippines	691.5	5.0	696.5
Viet Nam	853.9	13.2	867.1
Subtotal (6 DMCs)	8,561.1	63.7	8,724.8
Total (All DMCs)	10,666.5	113.1	10,779.6
Share of 6 DMCs	80%	56%	80%

ADB = Asian Development Bank, DMC = developing member country, PRC = People's Republic of China.
[a] Includes financial assistance from ordinary capital resources; Asian Development Fund; grant-financed projects; as well as nonsovereign loans, equity, and regional activities.
Sources: ADB Intranet and listing of loan, technical assistance, grant, and equity approvals accessed on 26 June 2009.

5. Energy sector assistance spans a large variety of projects in various energy subsectors (e.g., power, oil and gas, renewables, efficiency improvement) for supply-side expansion and growth (e.g., power generation, transmission) as well as demand-side interventions (e.g., industrial energy efficiency improvements, conversion of gasoline using motor vehicles to using compressed natural gas, etc.). Several approved projects include distinct components that are classified under different categories. Table A1.2 shows the distribution of ADB lending support for various categories of project components.

[2] The same six developing member countries also accounted for over 71% of ADB's total approvals during 2001–2008 for lending and nonlending support in all sectors for all developing member countries.

Table A1.2: ADB Portfolio Approved for Energy Sector Lending from 2001 to 2008

Item		Number of Project Components		ADB Financial Assistance	
		Number	%	$ million	%
Energy efficiency improvement	EEI	13	10	519	7
Renewable energy	REN	7	6	355	5
Large hydropower generation	HYD	7	6	611	8
Thermal power generation	TPG	14	11	1,237	16
Gas infrastructure development	GID	12	9	498	6
Power transmission	TRANS	31	24	2,810	36
Power distribution	DIST	19	15	759	10
Power sector reform	PSR	7	6	926	12
Capacity building	CB	17	13	78	1
Total		**127**	**100**	**7,792**[a]	**100**

ADB = Asian Development Bank.

[a] The difference of $769 million from the total ADB financial assistance figure Table A1.1 ($8,561.1 million) is because the following are excluded: (i) equity investment of $9.67 million for IND-7192, $2.6 million for IND-7227, $25 million for PRC-7244, and $2.75 million for PAK-7265; (ii) loans through complementary financing scheme of $225 million for IND-7242, $75 million for PRC-7244, and $200 million for PRC-7279; (iii) loan guarantee of $44 million for PAK-7265 and partial credit guarantee of $107 million for PRC-7271; (iv) political risk guarantee of $25 million for VIE-7176 and $35 million for VIE-7178; (v) $11 million in nonenergy components of PRC-1922; and (vi) grant-financed projects of $7.3 million.

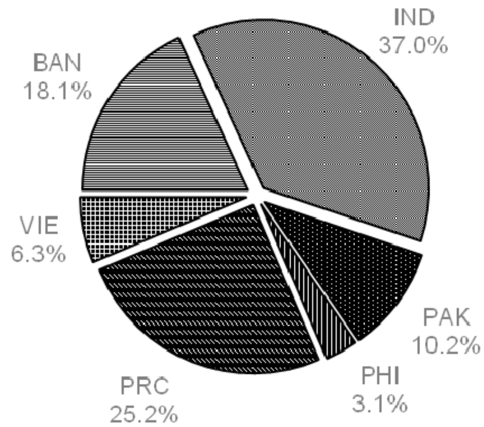
Source: Compiled by the study team.

6. The GHG efficiency of the entire set of energy efficiency, renewable energy, hydropower, thermal power, power transmission and distribution, and gas infrastructure development projects was assessed. However, as ADB's assistance for power sector reforms and capacity building impacts GHG emissions (or emission reductions) only indirectly,[3] it is difficult (if at all possible) to assess the contribution of such interventions to GHG efficiency improvements. Therefore, the 24 project components in these two categories that accounted for 13% of the energy sector portfolio were not analyzed from the GHG efficiency perspective.

7. **Overview of Country-Wise Energy Lending Portfolio.** India was by far the largest borrower in the energy sector, followed by Bangladesh and Pakistan. Combined, the three South Asian countries comprised nearly two thirds of the 127 project components (Figure A1.1) in projects and investment programs approved from 2001 to 2008, and nearly 60% of the approved financial assistance support (Figure A1.2).

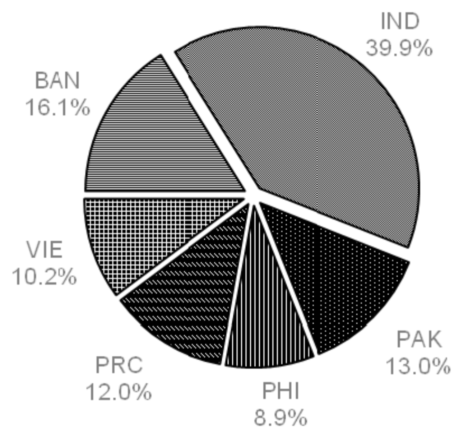
[3] For instance, as a result of reforms, the power utility may introduce modern management methods, which over a period of time lead to operational efficiency improvements, and/or its ability to raise finances may improve. Similarly, through capacity-building efforts, the utility's ability to manage large investment programs (with lower time and cost overruns) may increase, and/or its ability to absorb newer and inherently more efficient technologies improves, etc. The causal linkage between ADB intervention and utility performance improvement is difficult to ascertain (particularly so if the utility is also undertaking some performance improvement measures on its own, and/or with support from another development partner). Likewise, the extent to which ADB support actually contributes to replication of certain activities (such as commercial agreements between unbundled entities and private players, or upgrading skills of technical personnel utility-wide) over a period of time is also difficult to ascertain.

Figure A1.1: Project Components by Country



BAN = Bangladesh, PRC = People's Republic of China, IND = India, PAK = Pakistan, PHI = Philippines, VIE = Viet Nam.
Source: Compiled by the study team.

Figure A1.2: Lending Approvals by Country



BAN = Bangladesh, PRC = People's Republic of China, IND = India, PAK = Pakistan, PHI = Philippines, VIE = Viet Nam.
Source: Compiled by the study team.

ECONOMIC GROWTH–ENERGY–CLIMATE CHANGE NEXUS

1. More than 600 million people in the Asia and Pacific region still live in absolute poverty defined as less than $1 a day. Almost half of the world's absolute poor live in South Asia alone. One of every two individuals in the region—or 1.7 billion people—remains poor, as measured against the $2-a-day benchmark.[1] This is one and a half times the combined population of the developed nations of the Organisation for Economic Co-operation and Development (OECD). In the People's Republic of China (PRC), 452 million people live under this $2-a-day poverty marker, while in India the figure is 868 million.

2. Poverty reduction has been an important feature of the planning and operations of the Asian Development Bank (ADB) since its establishment and its overarching goal since 1999. The extraordinary economic expansion of recent years has made the eradication of income poverty (i.e., those living on less than $1 a day) a possibility by 2020. All of ADB's shareholders—borrowers and nonborrowers alike—and its development partners agree that the elimination of poverty is the paramount development objective, and that economic growth and development are the principal route to its achievement. Indeed, most of ADB's developing member countries (DMCs) are poor, and their gross national incomes per capita remain far below those of the developed countries (less than $6,000/capita in the DMCs, but $45,840 per capita in the United States and $34,750 per capita in Japan) (Table A2.1).

Table A2.1: Gross National Income per Capita in Purchasing Power Parity ($)

Country	1980	1990	2000	2007	% Growth (1990–2007)	2020 Forecast
Bangladesh	290	510	830	1,330	5.8	2,616
Cambodia			860	1,720	10.4	5,644
People's Republic of China	250	800	2,330	5,420	11.9	20,918
India	420	860	1,500	2,740	7.1	6,209
Indonesia	620	1,430	2,240	3,570	5.5	6,810
Lao People's Democratic Republic		730	1,230	2,080	6.4	4,356
Malaysia	2,250	4,590	8,350	13,230	6.4	27,931
Pakistan	610	1,260	1,690	2,540	4.2	4,166
Philippines	1,240	1,750	2,480	3,710	4.5	6,306
Sri Lanka	740	1,450	2,660	4,200	6.5	8,898
Thailand	1,070	2,950	4,990	7,880	5.9	15,766
Viet Nam		610	1,390	2,530	8.7	6,906
Euro area	8,985	16,695	24,659	32,560	4.0	52,175
Japan	8,920	18,870	25,910	34,750	3.7	53,474
United States	12,150	22,940	35,190	45,840	4.2	74,726
Singapore	6,720	17,620	32,740	47,950	6.1	97,206
World	2,762	4,817	6,887	9,947	4.4	16,595

Source: World Bank World Development Indicators database.

A. Economic Growth Agenda

3. Although growth rates in the DMCs over the last decade have been impressive, even if these continue into the future, by 2020 among ADB's DMCs only the PRC will have a per capita gross domestic product (GDP) above the world average.[2] But increased energy consumption is

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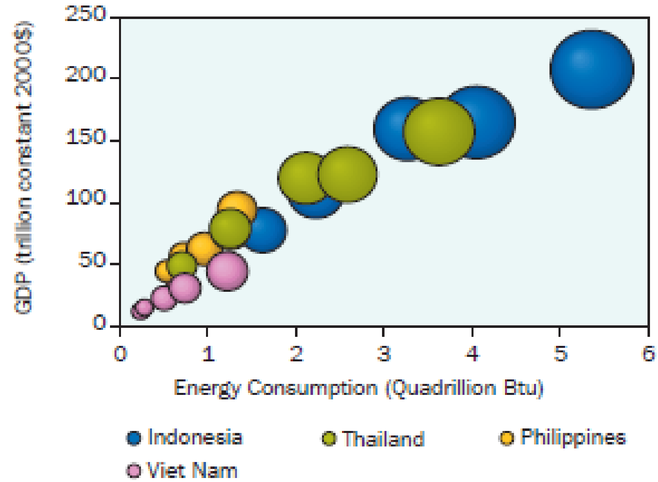
[1] ADB. 2008. *Strategy 2020: The Long-Term Strategic Framework of the Asian Development Bank (2008–2020)*. Manila.

[2] A recent ADB study of four countries in Southeast Asia (Indonesia, Philippines, Thailand, and Viet Nam) (ADB. 2009. *The Economics of Climate Change in Southeast Asia: A Regional Review*. Manila) highlights both the progress and the remaining challenges of poverty reduction in the region. Rapid economic growth and structural transformation have helped lift millions of Southeast Asians out of extreme poverty: during 1990–2005, poverty incidence in Indonesia declined by 32.8, Philippines by 7.0, Thailand by 9.0, and Viet Nam by 11.4 percentage points. But as of 2005, about 93 million (18.8%) Southeast Asians still lived below the $1.25-a-day poverty line, and 221 million (44.6%) below the $2-a-day poverty line.

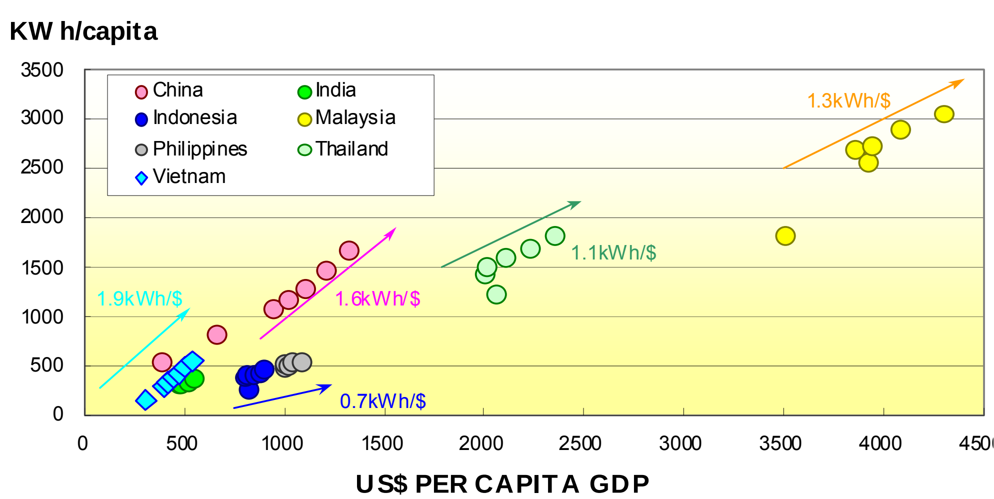
the unavoidable companion of economic development: both total energy (Figure A2.1) and electricity consumption (Figure A2.2) are highly correlated with GDP growth—and with increased energy consumption comes increased greenhouse gas (GHG) emissions.

Figure A2.1: Gross Domestic Product and Energy Consumption



CO_2 = carbon dioxide, GDP = gross domestic product.
Note: Size of bubble indicates CO_2 emissions. Data shown for 1985, 1990, 1995, 2000, and 2005.
Source: Asian Development Bank. 2009. *The Economics of Climate Change in Southeast Asia: A Regional Review*. Manila.

Figure A2.2: Electricity Consumption and Per Capita GDP

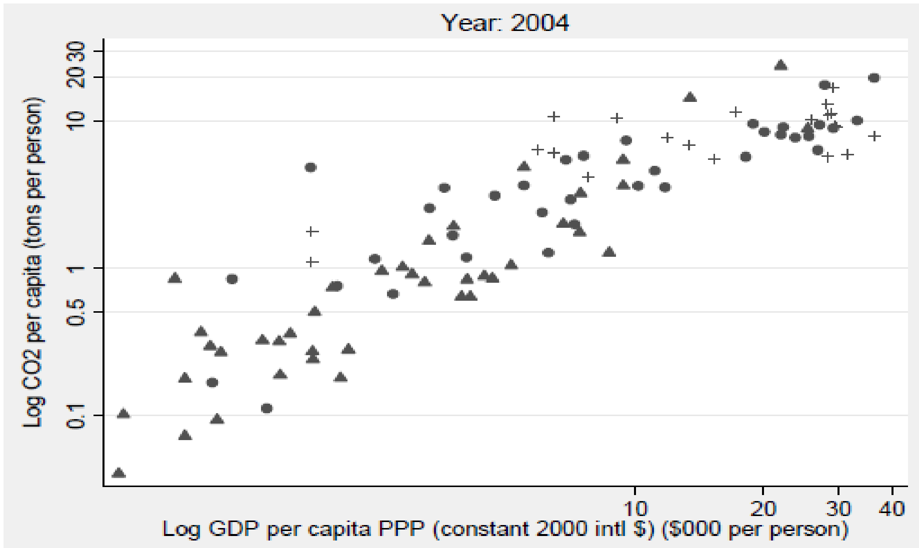


GDP = gross domestic product, kWh = kilowatt-hour, PRC = People's Republic of China, US = United States.
Source: Japan International Cooperation Agency. 2007. *Viet Nam: A Study on National Energy Master Plan*.

4. The energy intensity of economic development will vary across countries for many reasons (a relationship captured by the slope of the development paths shown in Figure A2.2—ranging from 0.7 kilowatt-hour [kWh] for each additional dollar of GDP in Indonesia to 1.9 kWh/$ of GDP in Viet Nam), including their respective resource endowments (particularly the mix of low-carbon resources such as hydropower and gas as against high-carbon resources such as coal), and their development strategies (the PRC has become the world's manufacturing workshop, so the emissions associated with consumer goods once made in the United States and Europe now occur

in the PRC rather than in the consuming countries).[3] Indeed, when one examines the relationship between emissions per capita and GDP/capita, while there is obviously a strong relationship between the two (Figure A2.3). The energy/GDP ratio depends upon the mix of services, agriculture, and industry; on local resource endowments; and on climate.[4]

Figure A2.3: GHG Emissions/Capita v. GDP/Capita (Log Scale)



CO_2 = carbon dioxide, GDP = gross domestic product, GHG = greenhouse gas, PPP = purchasing power parity.
Source: World Bank Independent Evaluation Group, Climate Change and the World Bank Group: Phase I - An Evaluation of World Bank Win-Win Energy Policy Reforms, August 2008, Figure 3. The warmest countries are shown as triangles; temperate countries are circles, and the coldest ones are pluses.

5. Economic growth in the poorest countries will generate little pressure on global emissions. According to the World Bank, the 50 least developed countries with a population of 725 million emitted 121 metric tons (t) carbon dioxide (CO_2), e.g., in 2004, against the OECD's 12,949 t CO_2. One hundred percent growth in the poorest countries would generate about the same increase in GHG emissions as a 1% growth in OECD. Thus, with the notable exceptions of the PRC and India, economic development and GHG emissions growth in ADB's DMCs will play only a small role in the global emissions picture, though of course the impacts of climate change will disproportionately affect the poorest countries, and many of the countries most immediately threatened by sea level rise—the small island nations of the Pacific and Indian oceans, and the countries with large populations in low-lying coastal deltas like the Ganges–Brahmaputra–Meghna estuaries in Bangladesh and the Mekong delta in Viet Nam—are among ADB's DMCs.

B. Energy and Environment

6. The current increasing concern over global climate change is not the first time that the trade-off between economic development and environment has come to the forefront of the development agenda. By the 1980s, it was recognized that the unmitigated local environmental consequences of infrastructure development (notably power generation and transportation)

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[3] Some estimates suggest that as much as 25% of the PRC's GHG emissions are embedded in its exports, which some argue should be charged to the consuming countries rather than to the PRC: see Leggett, J. 2008. *China's Greenhouse Gas Emissions and Mitigation Policies*. Congressional Research Service; and Weber, Christopher L., Glen P. Peters, Dabo Guan, and Klaus Hubacek. The Contribution of Chinese Exports to Climate Change. *Energy Policy*. doi:10.1016/j.enpol.2008.06.009.

[4] All other things equal, the colder the climate, the greater the energy intensity. However, as the air-conditioning load in tropical and subtropical developing countries increases, this differential will narrow.

imposed significant costs on the economies of the DMCs, including health costs and damage to agriculture, forests, and cost of displacement of people due to adverse climate events: the Asian region also has some of the world's most polluted cities. Throughout Asia (as elsewhere in the world), governments enacted environmental quality regulations and emission standards in the recognition that the compliance costs were outweighed by the environmental benefits. Moreover, the environmental mitigation costs represented just a small percentage of most infrastructure project costs, and there is no evidence that the introduction of local environmental standards and the requirement for pollution control reduced GDP growth rates in the region.

7. However, the avoidance of GHG emissions has a very different impact on the economic calculus from that of avoided local environmental damage costs. Installation of electrostatic precipitators (ESPs) at a coal-burning power plant results in direct benefits (avoidance of health damage costs) to the local population, and passing the incremental costs of ESPs to local consumers should not therefore be opposed by a rational DMC decision maker. But the benefits of adopting expensive carbon capture and storage technology, or foregoing coal for significantly more expensive liquefied natural gas (LNG) power generation, accrue not to the consumers in the DMC, but to the global community. Particularly in the case of small developing countries, the extent to which they mitigate GHG emissions has no measurable effect on the damage costs they will experience from sea level rise or reduced rainfall—which are largely a function of the extent to which the large emitters that dominate the global emissions picture abate their emissions. More importantly, the costs of foregoing coal as the power generation fuel of choice—in favor of renewable energy or natural gas—or of carbon capture and storage (the analogous pollution control technology to flue gas desulfurization and ESPs) have much higher cost consequences than the mitigation of the local environmental impacts, or of adherence to the established environmental safeguards policies of the international financial institutions.[5]

8. Estimates of the damage costs of GHG vary widely, but may reasonably be assumed to lie somewhere between \$15/t CO_2 (the average of the 2008 primary clean development mechanism market) and \$85/t CO_2 (the estimate of the social cost of carbon in the Stern Review)—though the carbon transaction price in the current global carbon markets cannot be taken as evidence of actual damage costs.[6]

C. GHG Emissions

9. With the exception of the PRC, whose 2005 emissions per capita were close to the world average (and whose absolute emissions now exceed those of the United States), the majority of ADB DMCs have per capita emissions an order of magnitude smaller than the world average (Table A2.2). Per capita emissions in India, Indonesia, and Viet Nam are about 25% of the world average. The global community recognizes that there would be very little logic or equity in imposing GHG emission cuts on the poorest countries of the world, and the clean development

[5] The costs of carbon capture and storage (CCS) at coal-burning power plants still have high uncertainty, but the latest estimates suggest the cost of power at a supercritical coal project fitted with CCS would be about 70% higher than the same plant without CCS (equivalent to a carbon price of around \$70 t CO_2). The proposition that poor DMCs should absorb such increases in the cost of electricity is neither reasonable nor equitable. This compares to a roughly 5% increase in the cost of power generation when fitted with flue gas desulfurization for sulfur dioxide removal. For a recent review of CCS technology and its prospects and costs, see e.g., Rubin, E. *Global Outlook for Coal-Based Power Generation: Implications for Developing Countries*. Presentation at the 2009 World Bank Energy Week, April. Available: http://siteresources.worldbank.org/INTENERGY/Resources/335544-1232567547944/5755469-1239633250635/Ed_Rubin.pdf).

[6] World Bank. 2009. *State and Trends of the Carbon Market 2009*. Washington, DC. In 2008, the volume in the global market almost doubled, from 2.98 billion t CO_2 in 2007 to 4.81 billion, and the average transaction cost increased from \$21.25 t CO_2 in 2007 to \$26.25/t CO_2. By far, the largest volume of transactions, 3.03 billion t, occurred in the European Union Emission Trading System, followed by the primary CDM market with 389 million t CO_2. The average price in the primary CDM market was \$16.76 t CO_2.

mechanism and other carbon finance initiatives have been expressly introduced to facilitate low-carbon options in poor developing countries.[7]

Table A2.2: Greenhouse Gas Emissions Per Capita

Country	1970	1980	1990	2000	2005
Bangladesh	0.05	0.09	0.14	0.20	0.26
Cambodia	0.17	0.04	0.05	0.04	0.04
PRC	0.94	1.51	2.11	2.64	4.26
India	0.35	0.51	0.80	1.14	1.28
Indonesia	0.28	0.63	0.84	1.36	1.90
Lao PDR	0.22	0.06	0.06	0.20	0.25
Myanmar	0.16	0.14	0.11	0.19	0.24
Philippines	0.67	0.76	0.72	1.02	0.89
Pakistan	0.39	0.38	0.63	0.77	0.86
Sri Lanka	0.29	0.22	0.22	0.54	0.56
Viet Nam	0.66	0.31	0.32	0.69	1.23
Euro area	8.26	9.26	8.39	7.95	8.07
Japan	7.08	7.88	8.75	9.49	9.63
Singapore	8.77	12.47	13.76	12.89	13.19
United States	20.57	20.26	19.22	20.01	19.52
World	4.06	4.41	4.29	4.07	4.53

PRC = People's Republic of China, Lao PDR = Lao People's Democratic Republic.
Source: World Bank World Development Indicators database.

10. That carbon emissions in the poor DMCs will increase in both absolute terms and as emissions per capita is unavoidable. But even for the poorest countries, an emphasis on economic development and economic efficiency does not necessarily lead to higher GHG emissions, for there are many win-win strategies that offer sustainable development pathways. But the magnitude of these increases will be dependent upon the interplay of policies and opportunities in three main areas:

(i) technology improvements, directed to the increase of efficiency in energy supply and energy consumption;
(ii) energy pricing policy and the reduction of fuel subsidies; and
(iii) energy security enhancements (in some countries, diversification of supply increases carbon intensity; in others it decreases carbon intensity).

D. Efficiency Improvements

11. The potential for energy efficiency improvement is very large, including higher efficiencies in power generation, reduced losses in transmission and distribution (T&D), and a range of improvements in end use across all the major sectors. Particularly in South Asia, electricity T&D losses are very high, providing many cost-effective opportunities for improving the efficiency of the sector (and the focus of many ADB-supported projects in these countries).[8] Even where a high proportion of these losses is from pilferage, commercial loss reduction will

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[7] However, the CDM market is dominated by the PRC—which in 2008 accounted for 84% of the volumes supplied; followed by India with 4%, and the rest of Asia 4%. Brazil accounted for 3%, the rest of Latin America 2%, Africa 2%, and Europe/Central Asia 1% (see World Bank. 2009. *State and Trends of the Carbon Market*). Primary CDM market transactions declined somewhat in 2008, reflecting a combination of the economic downturn, CDM regulatory delays, and uncertainties over post-2012 policy.

[8] For example, Rehabilitation of the Dhaka Distribution System in Bangladesh (Loan 1730) (where T&D losses were almost 40%), or the T&D rehabilitation projects in Madhya Pradesh (India) (Loans 1868/1869 and 2323/2324).

also reduce consumption (because the newly metered former pilferers will consume less as they have to pay for their consumption).[9]

12. Yet despite the large potential for end-use energy efficiency improvements, and the many studies and analyses, efforts to improve end-use efficiency have consistently fallen short of expectations. Energy efficiency is simply not as visible as energy generation, and a lack of rigorous monitoring and evaluation and the perception of electricity utilities that end-use efficiency improvements are not in their self-interest hinder progress. And, as noted below, subsidized energy prices constitute a further barrier to consumer-driven energy efficiency improvement.

13. Energy efficiency projects supported by the international financial institutions are much more staff intensive than large supply-side projects, and disbursing large sums is difficult (perhaps with the exception of mass distribution of compact fluorescent lamps) when compared with loans for large generation projects. Several DMCs have enacted energy efficiency laws (such as India in 2001 and the PRC in 1998), and a new law is expected shortly in Viet Nam. In 2004, the PRC National Development and Reform Commission issued its *Medium and Long-Term Plan for Energy Conservation*, which set out specific energy efficiency improvement targets for the industry, transport, and building sectors. ADB has supported a number of energy efficiency projects in the PRC as reviewed in this study.

14. The importance of energy efficiency, and the difficulties of implementing energy efficiency projects, are noted in a recent ADB special evaluation study.[10] The study notes that correcting inefficiencies offers the potential for large financial returns and improved environmental outcomes, and argues that improving energy efficiency by examining both demand-side and supply-side alternatives should be made the single highest priority in ADB's updated energy strategy. Before investing in new energy generation capacity, all feasible efforts should be made to decrease the demand through energy efficiency initiatives and increases in system efficiencies. The study notes three positive outcomes from using less energy: (i) capital costs are reduced, since energy efficiency efforts are generally half the cost of adding additional capacity; (ii) GHG emissions and other sources of air pollution are reduced; and (iii) energy security is enhanced.

15. On the supply side, in the PRC, much of the recent (and highly publicized) construction of new coal-burning power generation capacity is in fact to replace small, old, and highly inefficient coal projects built more than 20 years ago:[11] in 2006, only 43% of the total coal-fired capacity was in modern units of 300 megawatts (MW) or more, the rest being made up of small units of very low efficiency (Table A2.3). Even if the main motivation for this policy is to reduce the emissions of local air pollutants (nitrogen oxide, particulate matter with a diameter smaller than 10 µm, and sodium oxide), the concomitant reduction of GHG emissions is nevertheless an important global benefit of this policy (and a good example of how efficiency improvements benefit several objectives simultaneously). Indeed, the transition to large supercritical units not

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[9] However, many of the systems in South Asia that have high commercial T&D losses also suffered from high levels of unserved demand. Therefore, the kilowatt hour freed up by lower technical losses and reduced consumption of former pilferers is taken up by customers who were previously subject to power cuts. But even though the net result of such a response is no change in total grid-based generation, there is still a net reduction in GHG emissions, because generation by diesel standby and captive generation is reduced.

[10] ADB. 2007. *Energy Policy 2000 Review: Energy Efficiency for a Better Future*. Manila.

[11] Mao, Xianxiong. 2009. *How does China Reduce CO_2 Emissions from Coal-fired Power Generation: Activities and Deployment of Clean Coal Power Generation and Carbon Capture in China*. World Bank Energy Week.

only lowers GHG emissions per kWh, but the higher efficiency also significantly reduces coal transportation costs.[12]

Table A2.3: Efficiency of the People's Republic of China Coal Plants

Technology	**MW**	**Net Coal Consumption** (g/kWh)	**Net Efficiency** (%)
Ultra supercritical	1,000	286.5	43.03
Ultra supercritical	600	292	42.09
Supercritical	600	299	41.10
Subcritical	300	340	36.15
	100	410	29.98
	50	440	27.93
	25	500	24.53
	12	550	22.35
	6	600+	29.48
Average 2005		367	33.49
Average 2006		357	34.43

g/kWh = gram per kilowatt hour, MW = megawatt.

Source: Mao, Xianxiong. 2009. *How does China Reduce CO_2 Emissions from Coal-Fired Power Generation: Activities and Deployment of Clean Coal Power Generation and Carbon Capture in China*. World Bank Energy Week.

E. Energy Pricing and Subsidies

16. Energy subsidies, particularly those that encourage consumption by setting tariffs below cost, are a drain on government budgets, reduce economic efficiency (consuming more resources to supply over consumption than is economically optimal), and generally impose costs on the local and global environment (since more than optimal thermal generation results in unnecessary local and GHG emission). Worse, despite the political rhetoric and the best of intentions, the targeting performance of many energy subsidies is often very low: little of the subsidy reaches the poor, and most accrues to the urban middle classes, who consume the bulk of the commercial energy.[13] And perhaps best exemplified by the Indian experience, subsidies can create financial pressures on electricity distribution companies, resulting in severe degradation of service quality to all, and imposing large costs on the presumed beneficiaries.[14] In short, as stated by the World Bank, energy subsidies are "large, burdensome, regressive, and climate damaging."[15]

17. To be sure, there are some types of subsidies that do increase welfare. Subsidies to provide electricity to the rural poor often have significant social and equity benefits: more importantly, these tend to have good targeting performance (i.e., most of the cost does indeed reach the poorest sections of society); and given the low level of consumption in newly electrified households, the incremental burden of GHG emissions is miniscule compared with that of the growth of the urban and industrial economy. The World Bank estimates that providing

[12] Coal in the PRC is transported over distances of up to 1,000 kilometers (incurring transportation costs of $10/metric ton to plants located on the Eastern seaboard). Thus, the difference between 36% efficiency in a 300 megawatts subcritical plant and 41% efficiency in a supercritical plant translates into a reduction of about 15% in transportation cost per net kWh. Similar distances are involved in coal supply in India from the eastern state of Bihar to coal-fired projects in the greater Delhi region.

[13] Komives, K., Foster V., Halpern J., and Wodon Q. 2005. *Water, Electricity and the Poor: Who Benefits from Utility Subsidies*. World Bank. Washington, DC.

[14] World Bank studies in Andhra Pradesh and Haryana have shown that the costs of rewinding pump motors several times a year exceed the cost of a remunerative tariff (South Asia Regional Office. 2001. *India: Power Supply to Agriculture*. Report 22171-IN. Energy Sector Unit, June). Fortunately, this widespread Indian practice of free (or almost free) electricity to farmers is followed by few others.

[15] World Bank Independent Evaluation Group. 2008. *Climate Change and the World Bank Group: Phase I—An Evaluation of World Bank Win-Win Energy Policy Reforms*. Washington, DC.

2 billion people with electricity access consuming 30 kWh/household/month would boost global GHG emissions by less than 0.4% even if power were provided entirely by the most carbon-intensive means: the rest of the world increases its carbon emissions by this amount about every 2 months.

18. The benefits of electricity access to the poor also far exceed any conceivable environmental damage from the associated emissions. Results from many rural electrification projects show that the willingness to pay for grid-connected electricity[16] is in the range of $0.45–$1.00/kWh (Table A2.4) for the first tranche of electricity consumption, typically used for lighting and television watching.[17] With typical emission factors of 0.6 kilograms of CO_2 and a carbon shadow price of $50/t CO_2, the gross benefits would be reduced by only 3–6%.

Table A2.4: Welfare Benefits and Greenhouse Gas Costs of Rural Electrification

Item		Indonesia	Lao PDR	Philippines
Consumption	kWh/HH/month	15.50	13.80	15.30
WTP	$/kWh	0.71	0.81	0.47
	$/year	132.00	134.00	86.00
GHG emissions	t/year	0.11	0.10	0.11
Damage cost @$50/t CO_2	$/year	5.60	5.00	5.50
		4.2%	3.7%	6.4%

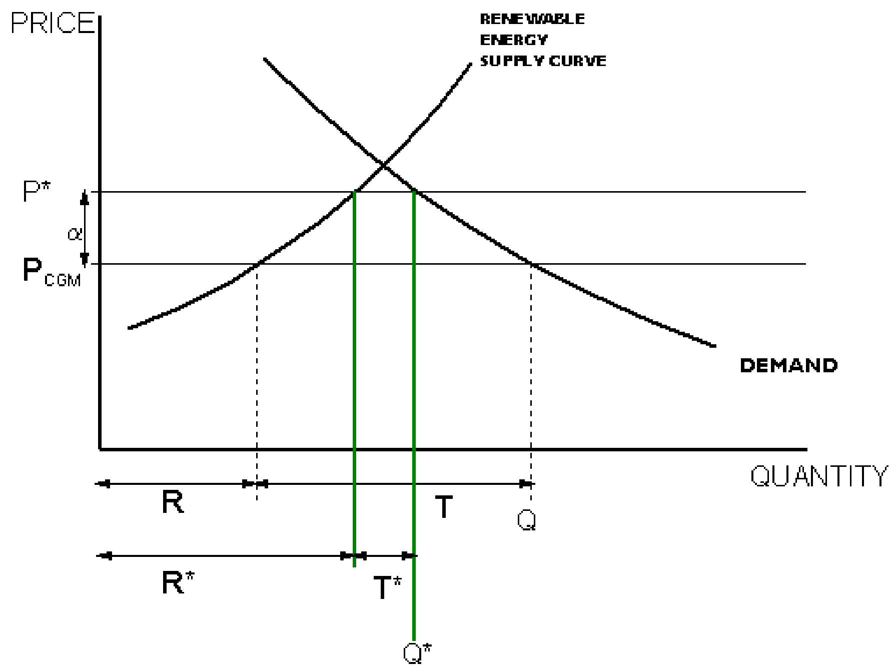
CO_2 = carbon dioxide, GHG = greenhouse gas, HH = household, kWh = kilowatt hour, Lao PDR = Lao People's Democratic Republic, t = metric ton, WTP = water treatment plant.
Source: Household energy surveys conducted by the World Bank.

19. Subsidies expressly targeted to redress a specific market failure may also improve welfare, for example because local environmental damage costs are not reflected in market prices for electricity, subsidizing renewable energy producers up to the value of the social avoided cost—i.e., including health damage costs—increases social welfare. A 2007 United Nations Framework Convention on Climate Change report[18] estimates that annual energy subsidies are between $250 billion and $300 billion net of taxes, and account for 0.6–0.7% of world GDP. This compares with support for low-carbon sources of $33 billion, of which only $10 billion is for renewables, $6 billion for biofuels, and $16 billion for existing nuclear power plants.

20. The impact of fuel subsidies is readily illustrated. Consider Figure A2.4, which shows the demand for electricity, the renewable energy supply curve, and the price of thermal energy in a competitive generation market, $\boldsymbol{P_{CGM}}$, assuming that the coal price is subsidized in the amount.[19] The quantity consumed at this price, $\boldsymbol{Q}$, is given by the intersection of the demand curve with $\boldsymbol{P_{CGM}}$. The amount of renewables will be $\boldsymbol{R}$ (namely that quantity whose production cost is less than $\boldsymbol{P_{CGM}}$), and the balance will be fossil generation, $\boldsymbol{T}$ ($\boldsymbol{R+T=Q}$).

[16] For a discussion of the methodology for such water treatment plant (WTP) estimates, see, e.g., Choynowski, P. 2002. *Measuring Willingness to Pay for Electricity*. Economics and Research Department. Technical Note 3. Manila: ADB, July.
[17] See also World Bank Independent Evaluation Group. *Welfare Impact of Rural Electrification, A Reassessment of the Costs and Benefits:* This report cites a range of $0.47–1.11/kWh as the WTP.
[18] Morgan, T. *Energy Subsidies: Their Magnitude, How They Affect Energy Investment and Greenhouse Gas Emissions, and Prospects for Reform*. UNFCCC Secretariat, Financial and Technical Support Program.
[19] This situation would apply to a number of ADB's DMCs. For example in Viet Nam, both gas and domestic coal are provided to the electricity sector at below economic cost; a competitive generation market will be introduced shortly, and renewable energy producers have access to the grid at the avoided (financial) cost of the buyer.

Figure A2.4: Impact of Coal Price Subsidies



Source: Study team.

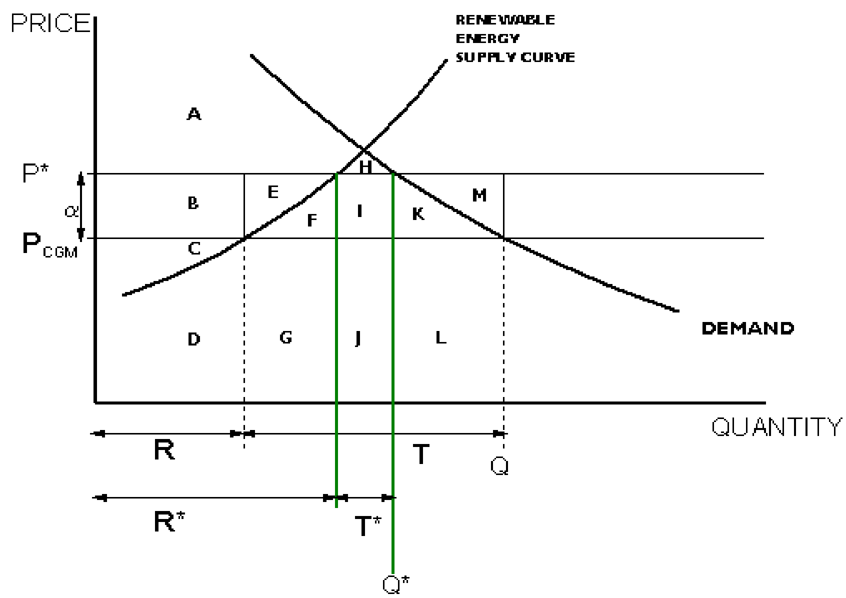
21. Now suppose that the subsidy on domestic coal is removed, which increases the price to ***P****. At this higher price, the demand curve intersects at ***Q****. More renewable energy will be economic at the higher price ***P****, and the quantity of fossil energy reduces to ***T**** (***R*+T*=Q****). Thus, there are three important consequences of reducing the subsidy on coal: (i) less electricity is consumed; (ii) the amount of fossil energy, and hence GHG emissions, is reduced; and (iii) the amount of renewable energy is increased. It is easily shown (box) that both social and global welfare increases as a result of the elimination of the subsidy: the reduction in fossil fuel subsidies is win-win.

22. While all this is well enough known in principle, the magnitude of the costs involved has only recently gained the attention it deserves. The 1999 International Energy Agency (IEA) World Energy Outlook[20] analyzed energy subsidies in eight non-OECD countries (including, among ADB's DMCs, PRC, India, Indonesia, and Kazakhstan) for which on average end-use prices are 20% below their opportunity cost or market-based reference levels. The studies found that removal of these subsidies would reduce primary energy consumption by 13%, lower GHG emissions by 16%, and increase GDP through higher efficiency by almost 1%.

[20] IEA. 1999. Insights, *World Energy Outlook: Looking at Energy Subsidies: Getting the Price Right.*

Welfare Effects of Fuel Subsidies

The cost of the fuel subsidy to government is equal to area ***E+F+I+K+M.*** At the subsidized level of consumption ***Q***, consumers enjoy a net benefit equal to the area under the supply curve less their cost, the so-called consumer surplus, equal to the area ***A+B+E+F+I+H+K.*** Renewable energy producers enjoy the producers surplus **C**. And GHG emissions are ***T x EF*** where ***EF*** is the relevant emission factor.



Once the subsidy is eliminated, the government benefits by the amount of that subsidy. The consumer surplus shrinks to ***A+H***, but renewable energy producers increase their surplus to ***C+B+E***. So the balance of costs and benefits can be shown as in the table below:

Beneficiary	With Subsidy	No Subsidy	Net Impact
Government (subsidy cost)	-E-F-I-K-M	0	+E+F+I+K+M
Consumers	+A+B+E+F+H+I+K	A+H	-B-E-F-I-K
Renewable energy producers	+C	C+B+E	+B+E
Society (i.e. domestic)	A+B+C+H-M	A+B+C+B+E+H	+E+M
Global environment	-T x EF	-T* x EF	[T –T*] x EF

In other words, society gains (because the cost of the subsidy exceeds the increase in consumer surplus enjoyed by them under the subsidy), and the global environment gains (because there is less fossil generation).

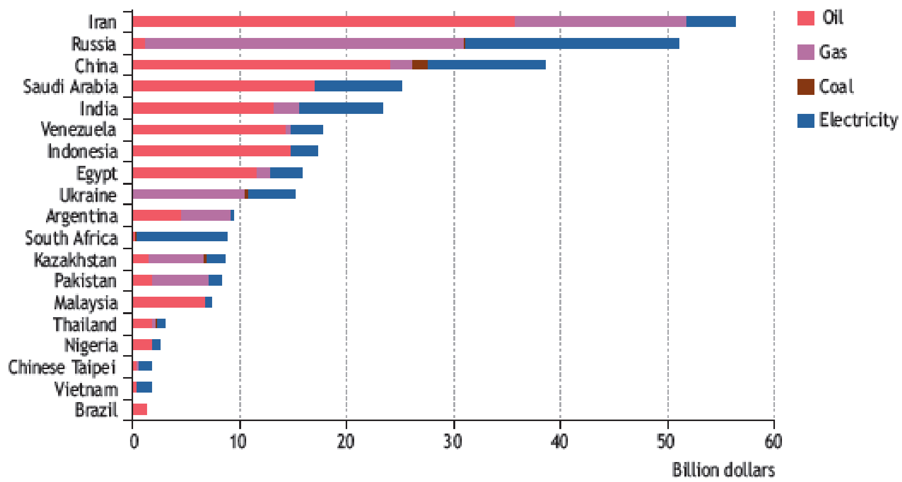
Source: Study team.

23. The 2008 IEA Energy Outlook[21] estimates subsidies on energy consumption in the 20 largest non-OECD countries at $310 billion in 2007 (Figure A2.5). ADB's DMCs are prominent among the countries with large subsidies (PRC, India, and Indonesia rank 3, 5, and 7, respectively). Most countries have declared policies to eliminate these subsidies, but the process is slow, for sudden removal of subsidies often has significant political repercussions. Viet Nam is a case in point: notwithstanding the declared intention of removing subsidies for fuels used in power generation, and the commitment to market principles declared in the Electricity Law, both domestic coal and natural gas prices remain subsidized.[22] The main difficulty is that even though the poor often receive only a small part of the total subsidy, for

[21] IEA *World Energy Outlook 2008*.
[22] Whether the use of subsidized fuel prices also distorts power sector investment decisions is unclear. An assessment of the use of financial rather than economic prices in Viet Nam's Sixth Power Development Plan found little impact on the optimal capacity mix as proposed by the Plan.

them the subsidy makes a big difference, and removal of the subsidy imposes real hardship. However, direct cash payments to the poor would much better achieve the social objective of assisting them, without imposing high efficiency costs on the rest of the economy.

Figure A2.5: Energy Subsidies by Fuel in Non-Organisation for Economic Co-operation and Development Countries



PRC = People's Republic of China.
Source*:* International Energy Agency World Energy Outlook 2008.

24. Recent programs in Indonesia and Ghana illustrate some new approaches. In May 2008, Indonesia offset petroleum product price increases by cash payments to the poor (estimated at 15.5 million poor and near-poor households receiving $30 per quarter), distributed through the post office system.[23] In 2004–2005, the Government of Ghana implemented a series of mitigation measures to offset the impact of a 50% fuel price hike on the poor. These measures followed extensive public consultation[24] and included the elimination of school fees at government-run primary and junior secondary schools and a program to improve public transport. Although the price increases were opposed by the trade unions, the public accepted them, and no large-scale demonstrations occurred.

F. Role of Energy Security

25. All the large energy-importing countries of the world have energy security concerns with respect to their dependence on imports. The October 1973 Arab oil embargo against the United States first exposed the strategic dangers of excessive reliance on imported fuel, and the failure of the United States to reduce its dependence on imported oil is widely seen as an important geopolitical disadvantage: in 1973, the United States imported 35% of its oil, today it imports 60%.[25] The current debate in the European Union over the excessive reliance on Russian gas is equally pressing. And thus it should not be surprising that the PRC and India—whose energy imports will account for an increasing share of global energy trade—have similar concerns.[26]

[23] Bacon, and K. Masami. 2006. *Phasing Out Subsidies*. Public Policy for the Private Sector. Note 310.
[24] The Ghana Poverty and Social Impact Assessment for Fuel demonstrated that the price subsidies most benefited the better-off, and the public awareness campaign of the costs of subsidy was launched by the Minister of Finance, involving wide consultations with stakeholders, including the trade unions and government officials.
[25] However, although net oil imports now account for 60% of the US oil consumption, in 2007 the sources of supply are well diversified, the largest single share being 17.2% from Canada, followed by 12.4% from Mexico, 10.7% from Saudi Arabia, 10.4% from Venezuela, and 8.1% from Nigeria United States Energy Information Administration.
[26] The 2007 IEA World Energy Outlook examines the energy security concerns of both PRC and India in some detail.

26. Energy security is no less a concern to ADB's smaller DMCs: but for most of these, diversification of fuel supplies through imports is seen as a way to increase energy security. To be sure, those who make the point that freedom from electricity imports enhances security, and that the higher cost of an all-hydro system represents an insurance policy against possible disruptions of electricity supply from neighboring countries. However, all-hydro systems are not risk-free, given the nature of hydrological uncertainty: for example, inadequate thermal capacity in drought years has caused significant disruptions. Indeed, those countries that have not diversified have incurred significant economic costs as a result.

27. In some cases, the concern over energy security is confused with concerns about price. In Viet Nam in 2008, the high price of imported coal raised concerns about the wisdom of the imported coal-based power sector expansion plan, and the fear of shortages—particularly in light of the announcement by the Government of Indonesia that further expansion of coal exports would be limited (in favor of using coal for domestic power generation). But there is never a shortage of coal at the current market price: and the whole point of diversification is that the system as a whole becomes more robust.[27]

28. Thus, the relationship between energy security and climate change depends largely on the extent to which countries are endowed with their own fossil fuel, and particularly coal. Increased energy security of countries with no (or limited) indigenous fossil fuels drives least-cost energy development into more carbon-intensive options; whereas in countries that do have their own fossil fuels, increased energy security means that development generally implies diversification into less carbon-intensive options.

29. Sri Lanka is a good example of the former. Its only conventional energy resource is hydropower, which until the early 1990s accounted for the bulk of electricity generation. Over the last 20years, as conventional hydro options have become exhausted, most power generation expansion has been based on oil, so the carbon intensity of electricity generation has risen. And its costly dependence on imported oil has added new urgency to the construction of coal-based power plants—which will increase carbon intensity still further, but will significantly improve energy security through greater diversification of supply. In Sri Lanka, diversification implies increasing carbon intensity.

30. The PRC and India are both examples of the latter. Both are heavily dependent upon domestic coal for electricity generation and industrial process heat (and in the PRC for residential heating as well), so diversification means increased imports of oil, LNG, Russian pipeline gas for the PRC, possibly Iranian or even Central Asian gas for India, as well as imports of coal from Australia and South Africa. In India, even imported coal (slightly) reduces the carbon footprint, because the better quality of imported coal reduces auxiliary power requirements.

31. Several DMCs have plans for nuclear power, notably the PRC and India, which represents another diversification of supply mix, and which will also reduce the carbon footprint. Although nuclear power has its critics, the consensus of the scientific literature is that the life-cycle emissions of nuclear power generation (i.e., including all the emissions associated with the fuel cycle, reprocessing, construction, and decommissioning) is in the range of 20–25 grams of

[27] Over the long run at the global level, coal prices are linked to oil prices (as are LNG prices). But many supply-demand imbalances in particular fuels are due to local factors (such as the dispute between the Russian Federation and the Ukraine that affects European Union gas supplies, or labor disputes in Australian coal mines, or nationalization of Venezuelan oil assets).

carbon dioxide equivalent per kilowatt hour (gCO_2/kWh), compared with 900–1,000 gCO_2/kWh for coal.[28]

32. Increasing the share of renewable energy is the most obvious route to diversification and increasing energy security, though whether the ambitious targets announced by some DMCs can actually be met remains unclear.[29] For example, Sri Lanka has a target of 10% of electricity generation by 2015, requiring an additional 375 MW of capacity over the 162.5 MW in place in 2009.[30] Viet Nam's target is a more modest 3% by 2015, though small hydro (less than 30 MW) is expected to account for over 750 MW of additional renewable energy capacity by 2015.[31]

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[28] Hondo, H. 2005. *Life-Cycle GHG Emission Analysis of Power Generation Systems: The Japanese Case*, Energy (30) 2042–2056; Source: University of Sydney. 2006. *Life-Cycle Energy Balance and GHG Emissions of Nuclear Energy in Australia*. Report to the Australian Government, 3 November, Table 6.13; Source: Weisser, D., *A Guide to Life-Cycle GHG Emissions from Electric Supply Technologies*. 2007. Energy (32), pp. 1543–1559.

[29] There is a growing literature on the question of whether renewables reduce portfolio risk (akin to the role of treasuries in an optimal financial portfolio): see, e.g., Hertzmark, Donald. 2007. *Risk Assessment Methods for Power Utility Planning*. World Bank). However, there are a wide variety of other approaches to reducing risk in electricity and energy portfolios, including the creation of strategic petroleum reserves (as in the US) and hedging with conventional futures. One of the problems is that renewable energy projects also have year-on-year variability (wind speeds, hydro inflows) that effectively impose variation on renewable energy production costs little different from variations in oil-based power generation production costs.

[30] Ceylon Electricity Board. 2008. *Long-Term Generation Expansion Plan 2009–2022*. December.

[31] Ministry of Industry and Trade. 2009. *Renewable Energy Masterplan*. January.

OVERVIEW OF THE CONTEXT FOR GREENHOUSE GAS EFFICIENCY IMPROVEMENTS PROVIDED BY THE INTERNATIONAL COMMUNITY

A. The Backdrop

1. That the climate change issue calls for sustained cooperation on the part of the global community came to be recognized widely more than two decades ago. While a good and (most likely) sustained beginning has been made toward addressing climate change issues, the needs for accelerating the global response to climate change and for a more active role by the global development community and the United Nations Framework Convention on Climate Change (UNFCCC) are becoming increasingly clear.

2. The intergovernmental panel on climate change (IPCC) and various international forums and organizations that have included climate change in their agendas in recent years recognize the primacy of the UNFCCC for holding complex and composite international dialogue on climate change mitigation. The activities of many such organizations and forums provide valuable knowledge and insights to the UNFCCC, in particular (i) IPCC, which in recent years has tried to establish the causal linkage between increased anthropogenic greenhouse gas (GHG) emissions and climate change; (ii) the International Energy Agency (IEA), which has shown that for GHG concentrations to stabilize at desirable levels, energy-efficient and low-carbon technologies (including some that are yet to be proven) must be diffused and deployed quickly; and (iii) the multilateral development banks (MDBs), which have a wealth of experience in financing development that can shift the developing countries to low carbon growth path.

3. On their part, the Group of Eight (G8) highly industrialized nations has acknowledged the important and leadership role that the G8 countries must play in addressing global climate change issues. Likewise, five major developing countries (Brazil, People's Republic of China [PRC], India, Mexico, and South Africa), collectively known as the Group of Five (G5), have also stated their joint position toward management of global GHG emissions as their economies expand and diversify in the coming decades.

4. That the climate change issue must be taken more seriously has become increasingly evident in recent years. The findings of the Stern Review[1] and the Fourth Assessment Report of IPCC (AR4)[2] are discussed in sections B and C, respectively. Section D provides an overview of the stands and commitments by the G8 and G5. The findings of major works commissioned by the G8 to IEA and the World Bank are discussed in sections E and F, respectively. Section G provides an overview of how the learnings and findings from such work have prompted UNFCCC to increase the thrust of negotiations toward greater commitments post-2012. Section H highlights the key features of the recently launched Strategic Program on Technology Transfer and Climate Investment Funds to provide additional financing to developing countries.

B. The Stern Review

5. The Stern Review of 2006, although not the first economic report on climate change, is the most widely known and discussed study of the subject. Although not without controversy—particularly regarding the treatment of uncertainties of future energy consumption levels and technology improvements—its broad conclusions have generally been accepted. It suggests that climate change threatens to be the greatest and widest ranging market failure ever seen,

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[1] Sir Nicholas Stern. 2006. Stern Review: *The Economics of Climate Change*. Cambridge University Press: London.
[2] IPCC. 2007. *Fourth Assessment Report, Climate Change 2007*. Valencia.

and points out that (i) the benefits of early action on climate change (estimated to cost 1% of gross domestic product to achieve necessary reductions in atmospheric GHG concentrations by 2050) outweigh costs in terms of reduced welfare equivalent of a per capita consumption reduction of some 5%–20%); and (ii) the impacts of climate change are not evenly distributed—with the poorest countries likely to suffer the earliest and the most. Other key highlights of the Stern Review are shown in Box A3.1.

Box A3.1: Key Findings of the Stern Review

(i) Climate change is a major obstacle to continued poverty reduction in developing countries. The impacts of climate change are not evenly distributed – with the poorest countries likely to suffer the earliest and the most.

(ii) The benefits of early action on climate change (estimated to cost 1% of GDP to achieve necessary reductions in atmospheric GHG concentrations by 2050) outweigh costs (i.e., reduced welfare equivalent of a per capita consumption reduction of some 5–20%).[a]

(iii) Even if mitigation measures are adopted in the near term, some impacts of climate change are inevitable.

(iv) The challenge to reduce emissions and move to a low-carbon growth path in both developed and developing countries requires coordinated global intervention.

(v) Existing technologies can deliver the emission reductions required in both developed and developing countries while maintaining economic growth.

(vi) However, strong policy initiatives are required to remove existing barriers and bring down costs.

(vii) The international development community should mobilize additional concessional funds to scale up investment in clean energy and climate change projects in developing countries.

(viii) Carbon finance can accelerate action in developing countries, but capital flows into clean energy and other climate change projects in developing countries must be scaled up.

GDP = gross domestic product, GHG = greenhouse gas.

[a] In April 2008, Stern admitted that the risks of damage associated with temperature increases were underestimated, as also the probabilities of temperature increases. And by June 2008, in acknowledging that global warming is happening faster than predicted in his report, he conceded that the cost to reduce carbon would be even sharper, at 2% of GDP instead of 1% as projected in the original report.

Source: Study team.

C. The Intergovernmental Panel on Climate Change and the Fourth Assessment Report

6. IPCC[3] was set up in 1988 to assess available scientific, technical, and socioeconomic information relevant for enhancing the understanding of climate change, its potential impacts, and options for mitigation and adaptation.

7. For the first time, in AR4 of 2007, IPCC clearly stated on the basis of scientific evidence, that warming of the climate system since the mid-20th century is unequivocal, and that it is very likely (with more than a 90% confidence level) a consequence of increased anthropogenic GHG emissions. Such climate change can slow the pace of progress toward sustainable development. AR4 also points out that anthropogenic warming over the past decades has likely had a discernable influence at the global scale of observed changes in many physical and biological systems. And the more the temperatures rise, the greater is the likelihood of more such disruptive changes (Box A3.2).

[3] IPCC was established by the World Meteorological Organization and the United Nations Environment Programme.

Box A3.2: Key Findings of IPCC's AR4

(i) Warming of the climate system since the mid-20th century is unequivocal, and is very likely a consequence of increased anthropogenic GHG emissions. Warming of about 0.2°C per decade is projected for a range of emission scenarios.
(ii) The impacts of climate change are very likely to impose net annual costs that will increase over time as global temperatures rise. GDP growth rates will also slow down.
(iii) Some systems and regions are particularly vulnerable to climate change. In Asia, the climate change impacts will include glacier melts in the Himalayan region; decreased freshwater availability in central, south, east, and southeast Asia; and flooding of coastal mega-delta areas.
(iv) Many impacts can be reduced, delayed, or avoided by mitigation efforts.
(v) The UNFCCC and the Kyoto Protocol, which have stimulated an array of national policy responses, institutional mechanisms, and the carbon market, provide the foundations for future mitigation efforts.
(vi) Large-scale penetration of low-carbon energy technologies already available (and nearing commercialization) may take many decades.
(vii) Mobilizing financing of incremental costs of low-carbon technologies, substantial investment flows, and effective technology transfer are necessary for achieving significant GHG emission reductions.

AR4 = Fourth Assessment Report of IPCC, GDP = gross domestic product, GHG = greenhouse gas, IPCC = intergovernmental panel on climate change, UNFCCC = United Nations Framework Convention on Climate Change.
Source: Study team.

8. AR4 also shows the need for substantive reductions in GHG emissions if average global temperature rise is to be contained within reasonable levels (Table A3.1). The targeted emission reductions are far higher than the commitments contained in the Kyoto Protocol.

Table A3.1: Ranges of Differences between 1990 Emissions and Emission Allowances in 2020 and 2050 for Various Target GHG Concentration Levels

Scenario Category	Region	2020	2050
A. 450 ppm CO_2-eq *(temp rise of approximately 2°C)*	Annex I[a] Non-Annex I	-25% to -40% Substantial deviation from baseline in Latin America, Middle East, East Asia, and central Asia	-80% to -95% Substantial deviation from baseline in all regions
B. 550 ppm CO_2-eq *(temp rise of approximately 3°C)*	Annex I Non-Annex I	-10% to -30% Deviation from baseline in Latin America, Middle East, and East Asia	-40% to -90% Deviation from baseline in most regions, especially in Latin America and Middle East
C. 650 ppm CO_2-eq *(temp rise of approximately 3.6°C)*	Annex I Non-Annex I	0% to -25% Baseline	-30% to -80% Deviations from baseline in Latin America, Middle East, and East Asia

CO_2 = carbon dioxide, GHG = greenhouse gas, ppm = part per million.
[a] Refers to the 37 industrialized countries and the European Union, which have emission reductions commitments under the Kyoto Protocol.
Source: Intergovernmental panel on climate change AR4, Working Group III report (pp. 227, 776).

D. The G8 and G5

9. The G8 Gleneagles 2005 Declaration[4] articulates a commitment to advance the goals and objectives of tackling climate change and promoting clean energy technologies (while

[4] G8. 2005. *Climate Change, Clean Energy and Sustainable Development.* Gleneagles.

pursuing energy security and sustainable development) and to work with the UNFCCC to move forward the global discussions on long-term cooperative action to address climate change. The Declaration is supported by the Gleneagles Plan of Action, which calls for taking forward actions regarding transforming the way energy is used by (i) promoting research and development, and (ii) financing the transition to clean energy.[5]

10. The Gleneagles Declaration also sets out a multi pronged agenda to work with appropriate partnerships, institutions, and initiatives including IEA and the World Bank Group. The World Bank has co-opted other MDBs including ADB for this initiative. The findings of the reports at the G8 summit in Hokkaido in July 2008 are discussed briefly below.

11. Spurred by the findings of IPCC, IEA, and the World Bank, the G8 at Hokkaido summit articulated their goal of achieving at least 50% reduction of global emissions by 2050, and to share this vision with all parties to the UNFCCC. Due recognition was also given to the fact that this global challenge can be met only by a global response from all major economies, and with contributions that are consistent with the principle of common but differentiated responsibilities and respective capabilities. However, the G8 leadership failed to specify the baseline against which the stated goal of at least 50% emission reduction is set.

12. The G5 countries comprising of 5 larger developing economies called for an integrated approach to international energy cooperation and international development cooperation that ensures access to energy in developing countries in an equitable and sustained manner. The G5 urges the international community to set a long-term global goal for GHG emission reductions, and work toward it through an equitable burden-sharing paradigm that (i) ensures equal sustainable development potential for all citizens of the world, and (ii) takes into account historical responsibilities and respective capabilities.

E. The International Energy Agency and Its World Energy Outlook

13. In support of the G8 Plan of Action on climate change, clean energy, and sustainable development, the IEA report[6] presents multiple GHG emission scenarios,[7] some of which build on the work of IPCC. IEA's objectives were more to assess the energy alternatives and technology choices available to stabilize atmospheric GHG concentrations to specific levels under the various scenarios. The most salient scenarios are as follows:

(i) Reference Scenario, in which GHG (carbon dioxide [CO_2]-equivalent) emissions relating to energy increase from 27.9 gigatons (Gt) in 2005 to 40.6 Gt in 2030, and GHG concentrations exceed 1,000 parts per million (ppm). Four countries (PRC, India, Russian Federation, and United States [US]) contribute two thirds of the increase. These trends are in line with a long term temperature rise of up to $6^{o}C$ from pre-industrial levels.

(ii) Alternate Policy Scenario (or 550 Policy Scenario, where GHG concentrations stabilize at 550 ppm), in which world energy demand grows annually by 1.2% to 2030 (vs. 1.6% per year in the Reference Scenario). The share of fossil fuels falls markedly, and carbon capture and storage is deployed in about 160 gigawatts worldwide (of which about 70% is in Organisation for Economic Co-operation and

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[5] The Gleneagles Plan of Action also proposes to manage climate change and its adverse impact by tackling illegal logging.

[6] IEA. 2008. *Towards a Sustainable Energy Future: IEA Program of Work on Climate Change, Clean Energy, and Sustainable Development (In support of G8 Plan of Action)*. 2008.

[7] Scenarios are drawn from IEA, *World Energy Outlook 2008.*

Development [OECD] countries). This scenario equates to a rise in global temperatures of approximately 3°C from pre-industrial levels.

(iii) 450 Policy Scenario (which describes a notional pathway of energy use that is consistent with an increase in temperature to a maximum of about 2°C, the smallest increase in any of the IPCC scenarios), in which energy-related GHG emissions peak in 2012 and then fall to 23 Gt by 2030. This scenario requires emissions in OECD countries to be reduced by 40% in 2030 compared with 2006 levels; and other major economies are required to limit their emissions growth to 20%. Much stronger and broader policy action is called for, including wide participation in an international emissions trading system, faster deployment of renewables (biomass, wind, other) in power generation to account for 40% capacity worldwide, and 350 gigawatts of carbon capture and storage deployment in fossil-fired power generation.

14. Against the backdrop of its global energy demand/supply and energy-related GHG emissions scenarios that reinforce the need to substantially scale up emission reduction efforts at the earliest (see Box A3.3 for more information on the Asian context and emission abatement), IEA expects that the post-2012 climate change policy regime will provide the international framework for strong and coordinated action to curb the growth in GHG emissions.

Box A3.3: International Energy Agency Energy and Greenhouse Gas Emission Scenarios

According to the business-as-usual scenario of IEA, energy-related GHG emissions will increase from 27.9 gigatons (Gt) of CO_2 equivalent in 2005[a] to 40.6 Gt in 2030 with developing Asia's contribution of energy-related GHG emissions increasing to 17.3 Gt in 2030 compared with 8.4 Gt in 2006. On incremental terms, developing Asia will contribute to 71% of global increase in energy-related GHG emissions, with the PRC and India's contributions being 48% and 16%, respectively. However, the per capita CO_2 emissions of developing Asia (other than the PRC's) will remain below OECD levels. The global atmospheric concentration of CO_2 has increased from the pre-industrial level of 280 ppm to 385 ppm by 2006. It may further increase to 850–1,000 ppm by 2030 along with a rise in average global temperature of 6°C, if the present pattern of development and energy consumption continues. According to IPCC, this level of atmospheric concentration of CO_2 is likely to result in significant changes in the global climate, resulting in multifaceted adverse consequences.

According to a recent study,[b] energy-related GHG emissions can be reduced by 16 Gt by deploying presently available technologies at a marginal abatement cost of €40 per ton. It is estimated that the CO_2 concentration would increase to 450 ppm and stabilize at that level under this scenario[c] and the eventual rise in the temperature would be in the range of 2.4–2.8°C. The power generation will result in 17.8 Gt of GHG emissions by 2030 under the business-as-usual case, which can be reduced to 7.2 Gt at a marginal abatement cost below €40 through demand reduction (GHG savings of 3.7 Gt at zero or negative cost), CCS (3.1 Gt at €20–30/t), increased use of renewable and nuclear energy (2.5 Gt at €5 per t), and improving the GHG efficiency of conventional fossil fuel-based power generation. A further 6 Gt of GHG emissions can be reduced in manufacturing industries through more efficient use of energy (e.g., combined heat and power plants, fuel switching, variable speed mortars, improved thermal insulation).

CCS = carbon capture and storage, CO_2 = carbon dioxide, GHG = greenhouse gas, IEA = International Energy Agency, IPCC = intergovernmental panel on climate change, OECD = Organisation for Economic Co-operation and Development, ppm = part per million, PRC = People's Republic of China.

[a] The total GHG emission in 2004 was 44 Gt and is expected to increase to 60 billion t by 2030.

[b] The McKinney Quarterly. 2007. *A Cost Curve for Greenhouse Gas Reductions*.

[c] It is also assumed that nonenergy-related sectors will also contribute 11 billion t of GHG emission reduction under this scenario.

Source: Study team.

15. Among the key findings of IEA are the following:
   (i) With energy-related CO_2 accounting for 61% of global GHG emissions, the energy sector will be central to the discussions on the level of concentrations to aim for, and how to achieve them.
   (ii) Consequently, the target that is set for long-term stabilization of GHG concentrations will determine the pace of the required transformation of the global energy system, as well as how stringent the policy responses will need to be.
   (iii) Therefore, targets for global GHG emission reductions and the trajectory for these reductions will need to take into account technological and cost aspects; and it is important to recognize upfront the high costs associated with early retirement of conventional capital equipment for replacement by low-carbon capital equipment.[8]
   (iv) Any major agreement will need to take into account the importance and perspectives of the five largest emitters (US, PRC, European Union, India, and Russian Federation), which together account for nearly two thirds of global CO_2 emissions. In particular, the contributions to emission reductions by US and the PRC will be critical to reaching a stabilization goal.
   (v) The insurmountable challenges of achieving the most desirable 450 Policy Scenario are recognized. Besides country-level policy and international cooperation challenges, the stark reality is that the total global emissions in 2030 in the 450 Policy Scenario are less than the level of projected emissions for non-OECD countries in the Reference Scenario. This means that the OECD countries alone cannot lead the world to a 450 ppm trajectory even if they completely eliminate their GHG emissions. And whether or not the scale of transformation is even technically achievable is not quite clear, as broad deployment of as yet unproven technologies is assumed.

F. The World Bank and the Clean Energy Investment Framework

16. In response to the G8 Gleneagles Declaration, the World Bank coopted other MDBs[9] into reporting on the Clean Energy Investment Framework and related programs at the G8 Hokkaido summit.[10] Prior to 2005, the various MDBs had been working individually and collectively on the climate change agenda, particularly energy efficiency and renewables. The Gleneagles G8 summit provided the impetus for the development of a coherent and focused MDB response to the climate change challenge, while simultaneously accelerating efforts to increasing energy supply to those without access to modern energy services.

17. In defining a forward path for addressing climate change issues and helping their clients mitigate the impact of past and future development programs on climate change, the MDBs' goals are summarized as follows:
   (i) MDBs are in the process of refining and deepening their climate change interventions to reflect emerging global priorities. With specific reference to fine-tuning of their mitigation strategies, for example (a) the European Bank for

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[8] The useful economic life of much of energy sector capital equipment is long (up to two decades or even more) and that with the normal cycle of capital replacement, the penetration of low-carbon technologies is expected to be gradual at best.

[9] These include the African Development Bank, Asian Development Bank, European Bank for Reconstruction and Development, European Investment Bank, and Inter-American Development Bank.

[10] *Joint MDB Report to the G8 on the Implementation of the Clean Energy Investment Framework and Their Climate Change Agenda – Going Forward*. 2008.

Reconstruction and Development Board is focusing on further scale-up, as well as innovation in both instruments and new thematic areas; (b) the Inter-American Development Bank is focusing on implementation and on translating its broad targets into specific programs and projects; and (c) the Asian Development Bank is transforming its project pipeline to help its developing member countries move toward lower carbon economies, considering ways to remove barriers to introduction of clean technologies and better leverage the resources available from its public and private windows.

(ii) The MDBs are prepared to scale up the current activities and are developing new activities with respect to the three pillars in energy and environment sector strategies (access, mitigation, and adaptation). In that sense, the MDBs consider any scaling up to be a process of logical evolution of their climate change policies, programs, and initiatives.

(iii) There is considerable "no-regrets" potential for GHG emission reduction by improving the effectiveness of existing assets through better use of technology, improved financing capacity in the sector, and institution building.[11] Where relevant, suitable pilot projects are also being developed.[12]

(iv) Increasingly, the emphasis will be on assisting the developing member countries (including economies in transition) to integrate climate change issues into their development programs. The MDBs will support this country-led approach through finance, technology transfer, and capacity building.

(v) Although the new and accelerated agenda can be accomplished through existing assistance instruments and programs, further scaling up calls for access to additional sources of targeted concessional finance.

(vi) For this endeavor to succeed, the MDBs will require significant additional staff and further improvements in the way they work together.

G. The United Nations Framework Convention on Climate Change Platform

18. The UNFCCC was established in 1992, its goal being the avoidance of anthropogenic interference with the climate system through (among other initiatives) a framework for action to stabilize atmospheric concentrations of GHGs. The UNFCCC entered into force on 21 March 1994 and now has 192 parties that continue to review progress and make decisions on further actions through meetings of the Conference of Parties (COP), normally held annually.[13]

19. In line with the findings of the Stern Review, IPCC, IEA, and the MDBs, the UNFCCC has been moving gradually from its role of encouraging action to manage climate change to that of seeking commitments. It began with somewhat small commitments set in the Kyoto Protocol and is now poised to seek larger commitments from the global community.

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[11] By way of an example, a three-pronged approach is being developed that centers around the improved financial health of power sector entities so as to enable accelerated (i) implementation of new plants, thus reducing the duty cycle of old coal-fired plants; (ii) refurbishment of old and inefficient plants that have more than 10 years of residual life; and (iii) replacement of plants that are nearing the end of their useful economic life.

[12] For instance, the World Bank (with Global Environment Facility support) is preparing two pilot projects in PRC and India for refurbishment of coal-fired power plants.

[13] The COP is supported by other bodies. Two such bodies were established in 1995: the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation. Since 2005, two more subsidiary bodies have been added, one to investigate further commitments from Annex I countries to the Kyoto Protocol, and the second to focus on a long term cooperative action.

20. The Kyoto Protocol was adopted by the UNFCCC in COP 3 (1997) and entered into force on 16 February 2005.[14] Its major features are

(i) three flexible mechanisms to manage emission reductions—the clean development mechanism, emissions trading, and joint implementation; and
(ii) for the first time, an agreement under the UNFCCC actually committing 37 industrialized nations and the European Union to reduce GHG emissions (to an average of 5% against 1990 levels over the 5-year period 2008–2012).

21. Rules and operational details that govern how countries will reduce emissions and measure their emission reductions were detailed in the Marrakesh Accords, which were formally adopted at COP 11 and COP/MOP1 (2005) in Montreal.

22. Discussions at COP 11 also led to two other major decisions:

(i) to establish a new subsidiary body, the Ad Hoc Working Group on further commitments for Annex I Parties under the Kyoto Protocol (AWG-KP); and
(ii) to constitute a Convention Dialogue that would continue until COP 13 (2007) to consider long-term cooperation regarding climate change matters.

23. At COP 13 (2007), the Convention Dialogue resulted in an agreement on the Bali Action Plan (BAP). The key decisions of BAP vis-à-vis climate change mitigation efforts are[15]

(i) to "launch a comprehensive process to enable the full, effective, and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012, in order to reach an agreed outcome …;"
(ii) a shared vision for long-term cooperative action that incorporates the principle of common but differentiated responsibilities—which led to the establishment of the Ad Hoc Working Group on Long-Term Cooperative Action, with the objective of launching a comprehensive process on long-term cooperation for completion by 2009 and adoption at COP 15 (2009);
(iii) enhanced national/international action on mitigation of climate change;
(iv) enhanced action on technology development and transfer to support action on mitigation; and
(v) enhanced action on the provision of financial resources and investment to support action on mitigation and technology cooperation.

24. At AWG-KP's August 2007 meeting, focused on the findings of IPCC[16]—particularly that GHG emissions need to peak in the next 10–15 years and then be reduced to well below half of 2000 levels by 2050 so as to stabilize atmospheric concentrations to 450 ppm CO_2 equivalent. The AWG-KP's conclusion was that Annex I parties to the Kyoto Protocol would be required to reduce their emissions by 25–40% below the 1990 levels by 2020 set the tone for further negotiations under the UNFCCC.

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[14] As of 14 January 2009, 183 countries and one regional economic integration organization (the European Economic Community) have deposited instruments of ratification, accession, approval, or acceptance.

[15] Enhanced national and international action on adaptation is also one of the key decisions of BAP.

[16] In particular, to the IPCC AR4 Working Group III Report, "Mitigation of Climate Change," which addressed five issues relevant to policy makers worldwide: (i) What can we do to reduce or avoid climate change?; (ii) What are the costs of these actions and how do they relate to costs of inaction?; (iii) How much time is available to realize the drastic reductions needed to stabilize GHG concentrations in the atmosphere?; (iv) What are the policy actions that can overcome the barriers to implementation?; and (v) How can climate mitigation policy be aligned with sustainable development policies?

25. At COP 13 (2007), the AWG-KP identified a series of issues to be addressed during a review of the Kyoto Protocol at COP 14. The progress made during the preparatory meetings prior to and at COP 14 is highlighted in Table A3.2. It is clear that the findings of AR4 and the IEA influenced the decisions regarding the post-2012 period.

Table A3.2: Ad Hoc Working Group-Kyoto Protocol Deliberations Regarding Post–2012 Period

Place, Date	Issues Discussed/Decisions Reached
Bali, December 2007	• Identified issues to be addressed in the Kyoto Protocol review – CDM, AR4, adaptation, effectiveness, implementation, compliance
Bangkok, April 2008	• Concluded that the flexible mechanisms under the Kyoto Protocol (CDM, joint implementation, and emissions training) should continue in the post-2012 period, and be supplemental to domestic actions in Annex I countries
Bonn, June 2008	• Addressed four specific issues: (i) land use, land use-change, and forestry (LULUCF); (ii) GHGs, sectors, and source categories; (iii) the three flexible mechanisms; and (iv) possible approaches targeting sector emissions • Considered relevant methodological issues
Accra, August 2008	• Focused on the means for Annex I countries to reach emission reduction targets • Considered other issues comprising GHG emissions, sectors, and source categories; approaches targeting sector emissions; methodological issues; spillover effects
Poznan, December 2008	• Agreed that future commitments for Annex I parties for the next commitment period should principally take the form of quantified emission limitation and reduction objectives (QELROs) • Noted that the scale of emission reductions to be achieved by Annex I parties in aggregate should take into account scientific information, including AR4 • Noted that QELROs for the various Annex I parties may vary widely and depend on different national circumstances; mitigation potential; and effectiveness, efficiency, costs, and benefits of current and future policies • Noted that emissions trading, project-based mechanisms, as well as LULUCF should continue to be available to Annex I countries • Noted the pledges for emission reduction targets made by some Annex I countries, and invited other Annex I countries to submit their possible QELROs before the next session of AWG-KP
Bonn, March 2009	• Noted information, including scientific information, and views submitted by parties on the scale of emission reductions to be achieved by Annex I parties in aggregate, the contribution of Annex I parties individually or jointly, consistent with Article 4 of the Kyoto Protocol • Noted information on possible QELROs as provided by some Annex I parties; also reiterated the invitation to Annex I parties to submit further information on possible QELROs before the June 2009 session of the AWG-KP with a view to completing its work by COP 15 • Noted information on recent scientific analysis on stabilization of GHG concentrations in the atmosphere at levels below the ones assessed by the IPCC in AR4, hence, a greater urgency to address climate change • Agreed to continue deliberations on the scale of emission reductions to be achieved by Annex I parties in aggregate as a key focus of the June 2009 session of AWG-KP • Continued deliberations on possible improvements to emissions trading and project-based mechanisms, and agreed to continue deliberations in the June 2009 session of AWG-KP • Continued deliberations on how to address, where applicable, the definitions,

Place, Date	Issues Discussed/Decisions Reached
	modalities, rules, and guidelines for the treatment of LULUCF; AWG-KP encouraged parties to share information, particularly data where available, before its session in June 2009 to enhance understanding of the implications of options and proposals for the treatment of LULUCF
Bonn, June 2009	• AWG-KP presented two documents: a proposal on amendments to the Kyoto Protocol pursuant to Article 3.9 (Annex I parties' further commitments); and a text on other issues, such as LULUCF; the flexibility mechanisms; common metrics and GHG, sectors, and source categories, as agreed upon during the session in March 2009 • Considered the various proposals put forth by the Annex I parties under the Kyoto Protocol, but parties were unable to reach an agreement on emission reduction targets post-2012 • Noted that although options for the treatment of LULUCF to reduce emissions had made progress, both aggregate emission reduction targets and individual targets had yet to be decided • Encouraged parties to share before the informal meeting on 10–14 August 2009, views on the possible need for information and data to facilitate parties' understanding of the implications of the options for the treatment of LULUCF discussed and considered at the June 2009 session

AR4 = Fourth Assessment Report of IPCC, AWG-KP = Ad Hoc Working Group on further commitments for Annex I Parties under the Kyoto Protocol, CDM = clean development mechanism, GHG = greenhouse gas, LULUCF = Land Use, Land-Use Change, and Forestry; QELRO = Quantified Emission Limitation and Reduction Objective.
Source: Study team.

26. Much more work needs to be done on many of the issues addressed thus far, and whether or not that can be accomplished by the time COP 15 is held in December 2009 remains unclear. AWG-KP is continuing its ambitious work and convened three sessions prior to COP 15: March 2009 (Bonn), June 2009 (Bonn), and September 2009 (Bangkok). The results of the sessions will be summarized in a text to be submitted for decision at COP 15 (December 2009) in Copenhagen.

H. Recent Initiatives to Accelerate Climate Change Projects

1. Poznan Strategic Program on Technology Transfer

27. The Poznan Strategic Program on Technology Transfer (SPTT)[17] is a step toward scaling up the level of technology transfer to help developing countries address their needs for environmentally sound technologies. In keeping with the contribution that this strategic program could make to enhancing technology transfer activities in line with the BAP, the Global Environment Facility (GEF) was given a fresh mandate at COP 14 to lead the SPTT, which is in keeping with the BAP. In particular, GEF is required to

(i) build on its previous technology needs assessment work for developing countries by collaborating with its implementing agencies and updating (or preparing, as appropriate) the technology needs assessments, and
(ii) facilitate developing countries in the preparation of projects for approval and implementation under the SPTT.

28. GEF is required to report on the progress made on this effort at COP 16 in 2010.

[17] Previously referred to as strategic program of the Global Environment Facility, renamed SPTT at COP 14.

2. Climate Investment Funds

29. The Climate Investment Funds (CIF), approved by the World Bank's Board of Directors on 1 July 2008, have been established jointly with other MDBs (Asian Development Bank, African Development Bank, European Bank for Reconstruction and Development, and Inter-American Development Bank). The CIFs are in support of the BAP, in particular, and in general in recognition of the need to scale up the climate change management effort in developing countries.

30. The CIFs identified the need for increased financial resources and instruments to fill the financing gap to scale up clean energy investments and to integrate resilience into development assistance. The CIFs comprise

(i) the Clean Technology Fund (CTF), which seeks to fill a gap in the international architecture for concessional development finance available at a scale necessary to provide incentives to developing countries to integrate appropriate mitigation actions into investment decisions; the CTF is designed to support scaled-up demonstration units and transfer of low-carbon technologies in the power, transport, industry, and agriculture sectors; and

(ii) the Strategic Climate Fund (SCF), which is to provide financing to pilot new development approaches or to scale up activities aimed at a specific climate change challenge through targeted programs; the first SCF program that is already approved is the Pilot Program for Climate Resilience; among the mitigation programs that are under consideration are support for (a) investments to scale up renewable energy in low-income countries, and (b) a forest investment program.

31. The CIFs will build upon the activities of the GEF to pilot and demonstrate innovative technologies, remove barriers to transform markets, and create an enabling environment through capacity building and establishment of codes, norms, and standards.

32. The CIFs will complement existing bilateral and multilateral financial mechanisms, and funding provided through CIFs will be additional to existing levels of official development assistance. The CTF will utilize a range of concessional financing instruments (such as grants and concessional loans) and risk mitigation instruments (such as guarantees), which will be tailored on a case-by-case basis to identifiable incremental costs of low-carbon projects or risk premium necessary to make a project viable.[18] Grant and highly concessional funding available through the SCF will be blended with existing resources of concessional funding and national resources to promote specific initiatives to mitigate GHG emissions.

33. The CIFs are designed to support UNFCCC negotiations and recognize the primacy of the UNFCCC in climate negotiations. To ensure that they do not prejudice ongoing UNFCCC deliberations regarding the future of the climate change regime, all funds and programs under the CIFs have a limited period of operation. The CIFs will share with the UNFCCC their experience gained through a learning-by-doing process.

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[18] Projects deploying proven technologies with low marginal abatement costs may require a small proportion of concessional financing or guarantee cover, while projects deploying high-risk and high-cost (as yet unproven) technologies may require larger amounts of concessional finance to make them financially attractive.

ADB EFFORTS AND INITIATIVES

A. Strategic Policy Framework of ADB Related to Climate Change and Greenhouse Gas Emissions

1. The Asian Development Bank's (ADB) strategies, policies, and initiatives were assessed in terms of their role in influencing ADB's lending and nonlending programs with respect to addressing and mitigating greenhouse gas (GHG) emissions of energy sector operations during the evaluation period 2001–2008. The Long-Term Strategic Framework 2001–2015 (LTSF 2001–2015) and the Medium-Term Strategy (MTS) 2001–2005 provided the overall strategic framework for ADB's operations during 2001–2005, and the Energy 2000: Review of the Energy Policy of ADB provides specific guidelines and priorities for its operations in the energy sector.

2. The LTSF recognizes ADB's mission as the reduction of poverty through sustainable and equitable economic growth. It identifies environmentally sustainable and socially inclusive economic growth as one of the core strategic areas of ADB's assistance. The LTSF places environmental considerations in the forefront of all development decision making and planning in ADB initiatives. It requires ADB to play a proactive role in mitigating adverse environmental impacts of its investments as well as reversing environmental degradation due to unplanned development activities undertaken in the past. However, the linkages among rapid economic growth, increased GHG emissions, and climate change had not been recognized as a significant issue to be addressed during the implementation of LTSF 2001–2015.

3. There has been a strategic shift in ADB's operations starting from 2005 to increase the relevance of its assistance in the context of the changing priorities and needs of its member countries as a result of the rapid economic growth experienced in some of the large middle-income countries. MTS II 2006–2008 was prepared in 2005 in response to this. MTS II recognized the environmental costs of the high growth scenario and its linkages with environmental degradation ranging from localized issues such as loss of forest cover and biodiversity to global impacts like climate change. MTS II identified priority sectors for ADB assistance based on its comparative advantage, and promotion of sustainable energy was selected as one of the priority areas. MTS II clearly started that Asian countries would have to steer away from the growth path of high per capita energy consumption, adopted by the developed economies of today, if global climate change impacts are to be maintained at reasonable levels. MTS II recommended that ADB help its developing member countries (DMCs) acquire low-carbon technologies and adopt energy efficiency and renewable energy projects on a "no-regret" basis.

4. In recognition of the strategic shift of the development challenges and priorities of DMCs since the adoption of LTSF 2001–2015, ADB has adopted LTSF 2008–2020 (Strategy 2020). Environmental degradation including climate change due to rapid economic growth is identified as one of the major challenges to be addressed in Strategy 2020. In this context, the increasing share of GHG emissions from the energy sectors of developing Asia (from 8% of global GHG emissions in 1980 to 28% in 2005 and 42% in 2030) is mentioned as a major contributory factor to global warming. Environmentally sustainable growth including mitigation and adaptation for climate change is one of the three distinct but complementary development agendas recommended in Strategy 2020.

5. Strategy 2020 identifies five core areas of specialization to effectively promote its three development agendas. The five core areas of specialization explicitly include

(i) supporting infrastructure development including expansion of energy supply through clean energy sources; promotion of energy efficiency through supply-side and demand-side measures; and removal of policy, institutional, regulatory, technological, and legal barriers to clean and renewable energy development; and
(ii) promoting sound environment management including shifting of DMCs to low-carbon growth paths through more efficient and clean use of energy; reducing GHG emissions in nonenergy sectors such as forestry, land use, and agricultural and municipal waste; and modernizing efficient transport systems.

6. Strategy 2020 also recommends escalated assistance to support environmentally sustainable development including assistance to address GHG emissions and climate change as one of the operational goals to be achieved by 2012.

B. Energy Sector Policy Framework of ADB (2001–2008)

7. ADB's Energy 2000: Review of Energy Policy (Energy 2000) refers to the possible link between climate change and GHG emissions due to increased use of fossil fuel and to the possible opportunities for the DMCs to access financing for clean energy projects through carbon markets under the Kyoto Protocol. However, the Kyoto Protocol was not ratified, and there were no functioning carbon markets in 2000. Energy 2000 mentions that ADB would support interventions to increase the use of cleaner forms of energy and initiatives for GHG abatement within the overall framework of the United Nations Framework Convention on Climate Change (UNFCCC). However, this was not considered as a major policy thrust in Energy 2000, nor was it given the same level of importance as addressing localized environmental problems such as acid rains and other impacts related to energy sector development. However, several other policy recommendations were made in Energy 2000 with the primary objective of improving the overall efficiency and environmental performance of the energy sector, which would have also contributed to improving GHG efficiency. These include
(i) policy advice and dialogue on withdrawal of subsidies and price distortions in energy sectors in a socially sensitive manner;
(ii) efficiency improvement in energy supply and use including energy conservation and demand-side management;
(iii) promoting clean coal technologies including more GHG-efficient technologies such as extracting of coal-bed methane, supercritical boilers, and integrated coal gasification plants;
(iv) promoting combined heat and power plants when there is demand for district heating and efficiency improvements in district heating networks; and
(v) support for cost-effective renewable energy projects and policy dialogue for policy reforms to remove policy and institutional barriers to the uptake of renewable energy.

8. ADB has recently revised its energy policy with the objective of aligning energy sector operations with Strategy 2020. The 2009 Energy Policy has brought the mitigation of the increasing GHG emissions in the energy sector to the forefront of ADB's energy sector operations together with energy security and access to energy. It specifically addresses the environmental sustainability of energy sector development in the context of increasing concerns about the causal link between increasing fossil fuel-based energy consumption and climate change. Hence, it recommends several operational measures to guide ADB's energy sector operations to promote energy efficiency and clean energy to reduce the carbon intensity of energy usage in developing Asia while recognizing the importance of energy security and

access to modern forms of energy to the overall development of developing Asia. These specific measures include

(i) promoting access to carbon markets for clean energy and energy efficiency improvement through ADB's carbon market initiative (CMI);
(ii) promoting new investment projects in clean energy and energy efficiency through technical assistance, credit enhancement, and grant financing of investment costs through the clean energy financing partnership facility; in this regard, ADB has set a target of $1 billion of investments in clean energy by 2008 and $2 billion by 2013;
(iii) proactively promoting new and more efficient coal technologies such as supercritical coal power plants and carbon sequestration carbon capture;
(iv) in recognition of coal's importance to energy security in many DMCs, supporting the improvement of environmental and social standards in coal mining; and
(v) given the more benign GHG emission characteristics of natural gas-based power generation, continuing to support gas-based power plants and gas infrastructure including liquefied natural gas terminals.

C. ADB's Operational Initiatives (2001–2008) to Address Greenhouse Gas Emissions in the Energy Sector

1. Renewable Energy, Energy Efficiency, and Climate Change Program (2001–2006)

9. ADB established the Renewable Energy, Energy Efficiency, and Climate Change (REACH) program as an umbrella covering several energy-environment single donor trust funds supported by the governments of Canada, Denmark, Finland, and Netherlands. Regional technical assistance 5972: Promotion of Renewable Energy, Energy Efficiency, and Greenhouse Gas Abatement (PREGA), which was implemented over 2001–2006, was the flagship initiative under the REACH program. PREGA was aimed at capacity building of domestic stakeholders in 18 DMCs to promote investments in renewable energy, energy efficiency, and GHG abatement technologies. The expected outcomes and outputs of the PREGA were

(i) increased awareness of renewable energy, energy efficiency, and GHG abatement (REGA) technologies among policy makers, project developers, and financiers;
(ii) enhanced capacity among stakeholders to prepare, promote, and appraise REGA projects eligible for clean development mechanism (CDM) financing;
(iii) policy and institutional analysis to remove barriers to REGA technologies;
(iv) feasibility studies for a pipeline of REGA projects with CDM potential;
(v) country reports on policy and institutional issues impacting on REGA technologies; and
(vi) financing models for REGA projects.

10. The PREGA program was primarily a capacity-building one and was not intended to provide financing for subprojects developed under PREGA; and to that extent PREGA achieved most of its intended outcomes. It also provided a forum for ADB staff to share information about problems in promoting REGA technologies in DMCs and created the initial impetus within ADB to mainstream REGA technologies in energy sector operations.

2. Energy Efficiency Initiative 2006

11. In recognition of increasing global concerns about rapid growth in GHG emissions in developing Asian countries and their contribution to climate change, and of increasing emphasis on addressing GHG emissions in MTS II and Strategy 2020, ADB launched the energy efficiency initiative (EEI) in 2006 with the objective of increasing its assistance to clean energy projects to $1 billion by 2008. The EEI, together with the CMI, form the key operational initiatives taken by ADB under the Climate Change Program to address GHG emissions in the energy sectors of developing Asia. The Clean Energy and Environment Program also includes the sustainable transport initiative, energy for all initiative, and adaptation for climate change, but these initiatives are outside the scope of this evaluation knowledge brief. The EEI has identified several priority energy subsectors for promoting clean energy investments. These include the following:

(i) Demand-side energy efficiency improvement: Demand-side energy efficiency improvements compound the energy savings through the energy value chain. These efficiency improvements can be achieved in the industry and commerce sectors through employing more efficient plants and machinery and in the residential sector through efficient lighting, heating, and cooling systems. The EEI has identified awareness building and appropriate lending instruments for channeling the funding to end users as the main barriers for increasing ADB lending to demand-side energy efficiency improvement.

(ii) Supply-side energy efficiency: This involves the promotion of advanced fossil fuel combustion technologies such as supercritical coal plants, fuel switching to cleaner fuel such as natural gas, rehabilitation of existing thermal power plants to improve thermal efficiency, as well as improving transmission and distribution networks to reduce technical losses.

(iii) Renewable energy: Under the EEI, ADB has increased its assistance to renewable energy projects such as hydro, wind, geothermal, and biomass cogeneration projects. In addition to financial assistance, ADB has provided assistance for policy reforms to remove barriers to investments in renewable energy projects.

12. The clean energy financing partnership facility (CEFPF) was established in 2007 under the EEI to mobilize and channel financial resources to clean energy projects. The CEFPF is set up as an umbrella trust fund where different bilateral and multilateral agencies including ADB have provided financial resources. CEFPF resources have been used for (i) grant financing of incremental costs as complementary financing for ADB's lending for more efficient technologies that would not have been deployed otherwise, and (ii) technical assistance for preparing clean energy projects and policy and institutional advice to remove barriers to clean energy deployment. The possibility of using CEFPF resources for leveraging financing by domestic financial institutions for clean energy investments through risk sharing arrangements is also being explored.

13. In 2008, ADB approved the $40 million Climate Change Fund to provide additional resources to the CEFPF to complement the funds provided by bilateral donors to the CEFPF. The Climate Change Fund is also expected to complement the proposed $5 billion Climate Investment Fund aimed at channeling funds to high-impact climate change investments through multilateral development banks such as ADB.

3. Carbon Market Initiative

14. The CDM under the UNFCCC framework, which came into force in 2005, provided access by ADB's DMCs to carbon markets for clean energy projects that are GHG efficient compared with the business-as-usual scenario. In anticipation of the emerging opportunities under the CDM, ADB initiated the CDM Facility (CDMF) in 2003 with the objective of (i) initiating CDM-eligible projects through ADB's existing relationships in DMCs, (ii) helping project sponsors to prepare documents required for registration with the UNFCCC as a CDM project, and (iii) providing information and advice to project sponsors about the opportunities for trading carbon credits. The CDMF, established as a pilot facility from 2003 to 2006, was intended to support approximately 16 ADB-financed projects in accessing carbon markets.

15. The experience with the CDMF demonstrated the demand for an enhanced role for ADB in the rapidly developing carbon markets and ADB started the CMI in 2006 in response to this need. The CMI was set up with the objective of addressing several key barriers to CDM-eligible projects in DMCs such as (i) lack of access to long-term project financing and difficulty of finding upfront funding for carbon credits to be generated by investment projects, and (ii) lack of technical capacity and expertise in carbon markets and the CDM registration process among the executing agencies and project sponsors. The overall objective of the CMI is to increase ADB investment in CDM-eligible projects, which include a significant share of clean energy projects. The CMI originally comprised three components:

(i) Asia–Pacific Carbon Fund (APCF): The APCF provides the option of monetizing a portion of the expected future revenues during the first commitment period (2008–2012) by selling projected certified emission reductions in exchange for upfront finance. This funding can reduce the initial capital requirement for implementing a project.

(ii) Technical Support Facility: The technical support facility provides assistance to project sponsors during project preparation to undertake CDM eligibility assessment, CDM documentation, validation, and registration; and during project implementation to ensure the delivery of carbon credits.

(iii) Credit Marketing Facility: The Credit Marketing Facility will offer project developers marketing support for project sponsors in continuation of the assistance provided under the CDMF.

16. As there was a dearth of ADB-financed CDM-eligible projects likely to be commissioned during the first commitment period, the mandate of the APCF was expanded to include non-ADB-financed CDM-eligible projects in ADB's DMCs. With the likelihood of agreement being reached on post-Kyoto Protocol carbon markets beyond 2012, ADB launched the Future Carbon Fund in 2008 with a mandate for purchasing carbon credits expected to be generated after 2012. Clean energy projects such as energy, efficiency, renewable energy, and methane capture and utilization have been identified as priority areas for the Future Carbon Fund.

GREENHOUSE GAS EFFICIENCY AND ACCOUNTING METHODOLOGIES

A. Issues in Greenhouse Gas Accounting

1. The basis for any measure of greenhouse gas (GHG) efficiency is GHG accounting. However, despite concerted efforts on the part of the United Nations Framework Convention on Climate Change and its various bodies (such as the clean development mechanism Executive Board) and the various multilateral development banks (MDBs), there is not much clarity about the principles of GHG accounting. Progress has been painstakingly slow. Only recently have the MDBs begun estimating GHG emissions associated with their operations.[1] As per a survey of various MDBs and other international financial institutions (IFIs) reported in 2008,[2] there was little convergence in the scope or sweep of GHG accounting of their operations. The wide variance was in terms of (i) types of assistance—whether only direct loans are considered and/or operations supported through equity holdings and/or financial intermediation are also covered; (ii) assistance level—whether all projects are covered or only those with assistance above a certain minimum value; (iii) type of projects—whether the entire portfolio is covered or only some mix of energy efficiency, renewable energy, and fuel switch projects; (iv) size of projects—whether all projects are covered or only those with emission implications above a certain minimum threshold; (v) GHG reporting metrics—whether emissions are calculated ex-ante or are recalculated annually, whether annual emissions are reported or life-cycle emissions, whether the life cycle refers to useful project life or the period of MDBs' or IFIs' active involvement in the project, whether absolute emissions are reported or change in GHG emissions resulting from the project, whether the change of emissions is benchmarked against a static baseline (pre-investment emissions) or a dynamic baseline (evolution without the project); and (vi) project boundary—whether it is delineated on the basis of ownership/control or it is a physical boundary, and whether or not changes in emissions elsewhere as a result of the project are considered.

2. The wide variation in GHG accounting practices that have been (or are being) adopted in the MDBs and IFIs perhaps reflects the fact that the underlying objectives and corporate drivers themselves vary widely. For some, the key objective is largely to have better inputs for project and component financial models. For others, there may be more strategic goals—such as meeting environmental policy requirements, and/or improving upon their country partnership and assistance strategies, and/or making disclosures to stakeholders.

B. General Methodological Issues

3. **Scope of Emissions.** Emissions (or avoided emissions) that are a direct consequence of the Asian Development Bank (ADB)-supported project or component activity, referred to as Scope 1 emissions, are considered. Emissions arising from fuel combustion in fossil-fuel fired power plants, as well as avoided incremental emissions owing to the commissioning of renewable energy projects or from methane capture, or reduction in technical losses in electricity and gas transmission and distribution are Scope 1 emissions. Scope 2 emissions, which are emissions associated with purchased electricity, are particularly relevant for ADB-supported end-use efficiency projects and are also considered. Scope 3 emissions, which are indirect and a consequence of activities of an ADB-supported project, but occur in facilities not owned or controlled by the project, may be considered on a case-by-case basis. For instance, in a coal gasification project in which coal is gasified with the intention of distributing coal-gas to end-users who switch from highly emitting coal to lower emitting coal-gas, the avoided emissions from the conversion are considered. However, methane emissions associated with

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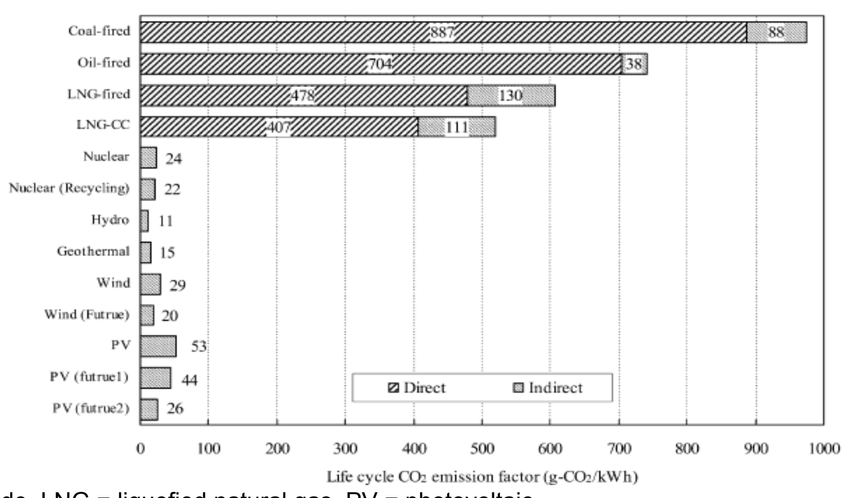
[1] Efforts until a few years back focused largely on carbon footprinting of their respective organizations (headquarters and other offices, as well as annual meetings).
[2] Survey report presented at the October 2008 meeting of the Multilateral Financial Institution Working Group on Environment.

coal mining to supply coal to a newly set up coal-fired power plant are not considered, for reasons evident from the life-cycle emissions related discussion below.

4. **Annual vs. Life-Cycle Emissions.** There is little doubt that the bulk of net Scope 1 and Scope 2 GHG emissions or emission reductions (savings) occur during the useful economic life of the project or component. The increased focus on life-cycle emissions is largely a consequence of criticism about claims regarding the GHG benefits owing to indirect emissions that are not normally accounted for; for instance (i) hydropower plants with large reservoirs release methane; and (ii) all renewable energy technologies (such as wind, run-of-river small hydro, and solar photovoltaic) lead to some GHG emissions by virtue of the energy required for the manufacture of equipment, as well as equipment transport, installation, commissioning, and decommissioning.[3] Whether or not these life-cycle impacts should be considered for the purposes of this evaluation knowledge brief (EKB) depends on (i) how large these indirect emissions are vis-à-vis direct emissions, and (ii) whether or not reliable calculations of indirect emissions can be made.

5. The consensus of the technical literature appears to be that, in general, the indirect emissions associated with mining, transport, material inputs, construction, and decommissioning represent 5–10% of life-cycle emissions for most fossil fuel technologies. Figure A5.1 summarizes the results of emissions from power generation activity in Japan. The indirect emissions from coal-fired and oil-fired power generation are about 10% and 6%, respectively.[4] The vast data requirements for this computation include (among others) the following: (i) energy use for equipment manufacture; (ii) for a coal-fired power plant, the energy used in mining, extracting, cleaning, and transporting coal to the power plant site; (iii) for an oil-fired plant, the energy consumed for upstream activities (exploration, field development, and production) as well as in refining and transportation to power plant site; (iv) for a gas-based power plant, the energy used in upstream operations (exploration, field development, and production) as well as in gas treatment and pipeline transportation to power plant site; and (v) for a re-gasified liquefied natural gas-based power plant, the same as for the gas-based power plant, plus liquefaction, shipping, and re-gasification. The seemingly large incremental effort would only help in fine-tuning the emission impacts to a few percentage points.

Figure A5.1: Life-Cycle Emission Factors in Japan



CO_2 = carbon dioxide, LNG = liquefied natural gas, PV = photovoltaic.

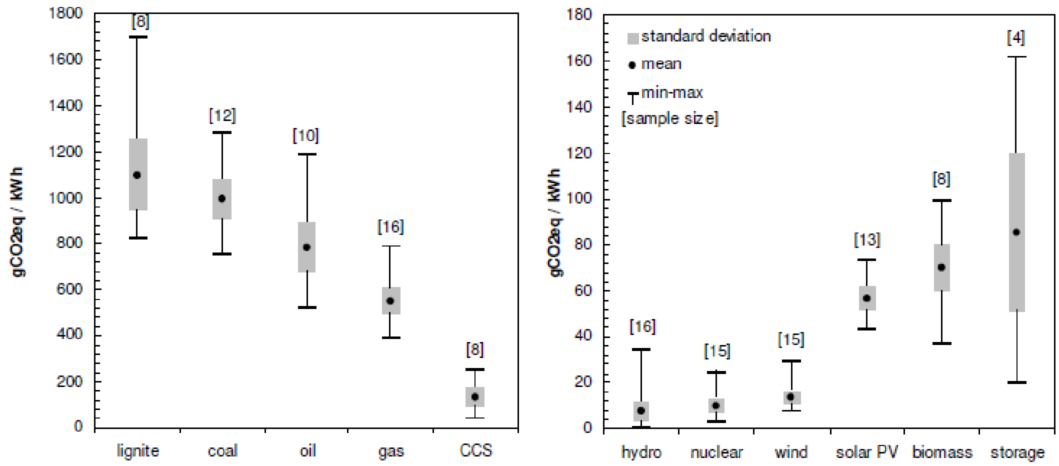
Source: Hondo, H. 2005. *Life Cycle GHG Emission Analysis of Power Generation Systems: The Japanese Case*. Energy 30, pp. 2042–2056.

3 Likewise, claims regarding GHG benefits of nuclear generation have also been questioned.

4 The high indirect emissions from liquefied natural gas-fired power generation, at 111–130 grams carbon dioxide per kilowatt-hour is due largely to the high carbon dioxide content of Indonesian natural gas (some 20–30%), which is released during processing and liquefaction.

6. Figure A5.2 summarizes the life-cycle emission estimates from over 50 studies. The following observations (regarding technology choices of interest to ADB, given the type of projects and components supported thus far) are useful: (i) total life-cycle emissions from solid fuels are in the 500–1,700 grams of carbon dioxide equivalent per kilowatt hour (gCO_2e/kWh) range; (ii) total life-cycle emissions from oil- and gas-based power generation are in the 400–1,200 gCO_2e/kWh range; and (iii) total life-cycle emissions from wind and hydro are in the 1–40 gCO_2e/kWh range. Clearly, accounting for indirect emissions associated with wind and hydropower projects makes little sense.

Figure A5.2: Life-Cycle GHG Emissions by Power Generation Technology



CCS = carbon capture and storage, GHG = greenhouse gas, PV = photovoltaic.
Source: Weisser, D. 2007. *A Guide to Life-Cycle GHG Emissions from Electric Supply Technologies*. Energy (32), pp.1543–1559.

7. In the context of this EKB, GHG emissions estimates are being made ex-ante when (i) only indicative or typical values can be ascribed to technical performance parameters of the project or component (rather than actual performance-based values); and (ii) technical design changes (albeit minor), which may actually be made during the project implementation phase, cannot be taken into account (especially if a loan has been approved in recent years). In addition, uncertainties regarding GHG emissions during the useful life also come from insufficient data in many cases.

8. **Aggregation to Portfolio Level.** While aggregating the GHG efficiencies across the project portfolio, an issue that comes up is whether all projects should be considered, or only those that result in GHG emissions or GHG emission savings above a certain threshold. Given that the EKB is being carried out for projects as appraised, and that project-specific data in many cases are limited, it was decided to include all projects for which sufficient data (to make reasonable estimates) are available. However, it is important to note that annual GHG emissions/savings are aggregated: (i) for several types of projects with different useful economic lifetimes and expected to be commissioned and reach full capacity utilization at different points of time, and (ii) even though the analysis reveals that the reliability or precision of the GHG efficiency varies significantly across projects/components.

METHODOLOGIES ADOPTED OR DEVELOPED FOR GREENHOUS GAS EFFICIENCY ASSESSMENT OF ENERGY SECTOR PROJECTS AND COMPONENTS

Project/ Component Category	Specific Project/Component Type	Reference to the Supp. Appendix B	Basis for Methodology
Renewable Energy	Grid-connected electricity generation from renewable sources (wind, hydro)	RE1	As per approved consolidated methodology for CDM (ref ACM0002 of UNFCC); grid emission factor applied to estimate GHG savings
Energy Efficiency Improvement	Coal mine methane and/or coal bed methane capture and use for power generation	EE1	As per approved consolidated methodology for CDM (ref ACM0008); baseline methane emissions and power grid emission factor applied to estimate GHG savings
	Coal mine methane and/or coal bed methane capture and use for industrial, commercial, and residential applications	EE2	As per approved consolidated methodology for CDM (ref ACM0008); baseline methane emissions and emissions from use of other fuel applied to estimate GHG savings
	Efficiency improvements in centralized district heating	EE3	Counterfactual – continued use of old, small, inefficient coal-fired boilers, as well as inefficient pipeline network
	Efficiency power plant	EE4	Counterfactual – generation with average grid emission factor
Hydropower	Reservoir hydro	RE1	As per approved consolidated methodology for CDM (ref ACM0002); grid emission factor applied to estimate GHG savings
	Pumped storage hydropower	LH1	Counterfactual – gas-fired gas turbine of same capacity
Thermal Power Generation	Thermal power plant (any coal-fired technology; any gas/oil-fired technology)	TPG1	This methodology is relevant when a technology different from the conventional technology is introduced as a result of ADB-financed intervention; and/or when power system planners would like to meet certain overall targets regarding generation fuel-mix or hydro-thermal mix. Counterfactual is the combined margin consisting of the operating margin (i.e., average grid emission factor per unit of energy supplied of the grid to which the plant is connected) and the build margin consisting of a typical power plant using the same type of fuel but using the most common technology in the country.
	Rehabilitation of old coal-fired power plant	TPR	Counterfactual – plant continues to operate inefficiently and the increased energy supply after rehabilitation is supplied by the other plants connected to the grid.
Gas Infrastructure Development	LNG regasification, pipeline supply, and end-use	NG1	Same as above.
	Gas transmission and distribution expansion	NG2	The counterfactual to the project is use of other types of fossil fuel that are replaced by the gas supplied under the project.
Power Transmission	Power evacuation from identified power sources	TL1	Investment in specific power project as well as associated transmission line/substations

Project/ Component Category	Specific Project/Component Type	Reference to the Supp. Appendix B	Basis for Methodology
			is considered. Counterfactual – in the "without project" scenario, the existing power plants in the power system provided the energy generated from the power plants connected to the transmission line funded by ADB.
	Power evacuation plus grid strengthening	TL2	Investments in generation and transmission during a certain time-slice are considered. Counterfactual – in the "without time-slice investment" scenario, the pre-time-slice generation and transmission system is stretched to its performance limits, and resultant power shortages are met by diesel-fired self-generation.
	Transmission projects for loss reduction	TL3	Relevant when, for instance, high voltage lines are introduced or are used to replace existing lines. Load flow studies are normally required to assess loss reduction.
	Power evacuation	TL4	Relevant when the decision on a power plant location is to be made, with the fuel transport vs. power transmission as key criteria. Counterfactual – in the "without project" case, it is assumed that the power plant is located near a load center where fuel needs to be transported (e.g., coal transport by rail)
Power Distribution Network	33 kV and 11 kV system improvement (technical loss reduction), low voltage level (technical and/or nontechnical loss reduction), conversion of low voltage to 11 kV operation, extension and efficiency improvement, and rural electrification	DER1	The project emissions are the emissions associated with electricity supplied to meet the electricity demand created under the project. The counterfactual is meeting the electricity demand with the network that existed prior to the project. The reduction in technical losses under two scenarios results in GHG savings, but the increase in electricity sales due to expanded network coverage would result in GHG emissions increases.

ADB = Asian Development Bank, CDM = clean development mechanism, DER = distribution expansion and rehabilitation, EE = energy efficiency, GHG = greenhouse gas, kV = kilovolt, LH = large hydropower, LNG = liquefied natural gas, NG = natural gas, RE = renewable energy, TL = transmission line, TPG = thermal power generation, TPR = thermal power rehabilitation, UNFCCC = United Nations Framework Convention on Climate Change.
Source: Study team.

MANAGEMENT RESPONSE TO THE EVALUATION KNOWLEDGE BRIEF ON THE GREENHOUSE GAS IMPLICATIONS OF ADB'S ENERGY SECTOR OPERATIONS

On 16 November 2009, the Director General, Independent Evaluation Department, received the following response from the Managing Director General on behalf of Management:

I. General Comments

1. We welcome IED's Evaluation Knowledge Brief (EKB) on Greenhouse Gas (GHG) Implications of ADB's Energy Sector Operations. The EKB assesses recent ADB operations, develops analytical tools and offers suggestions for enlarging GHG-efficient investments in the energy sector. The report incorporates comments from the energy committee of ADB's energy community of practice (representing all operational departments).

2. We note the EKB's overall positive assessment of ADB's energy investments in selected countries, specifically the increase in annual lending for clean energy, the very large increase in nonsovereign energy sector lending and equity investments that also have GHG reductions, and the seven-fold increase in *ex-ante* GHG emission savings between the periods 2001–2005 and 2006–2008. The EKB has also ranked the energy supply technologies based on economic cost, and as generally accepted, has noted that a clear price for GHG emission reduction will be necessary to improve the ranking of renewable and other low carbon options.

3. GHG-efficient investments comprise a part of ADB's overall energy sector operations, and it is important to bear in mind the objective of ADB's Energy Policy (2009), which affirms the importance of energy security in ADB's developing member countries (DMCs) and ADB's vision of a region free of poverty. The objective of the Energy Policy is for ADB "to help DMCs to provide reliable, adequate, and affordable energy supplies for inclusive growth in a socially, economically, and environmentally sustainable way. It will emphasize promoting energy efficiency and renewable energy, maximizing access to energy for all, and promoting energy sector reforms, capacity building, and governance." In this regard, while the EKB focuses on the design of ADB energy sector projects in six high energy consuming countries, in most other DMCs that contribute little to global GHG emissions (and have low GDP), greater attention has to be placed on inclusive economic growth and the adaptation aspects of climate change.

II. Comments on Specific Recommendations

5. **Recommendation 1: Assess GHG implications of future investments with significant GHG impacts or savings.** We agree. Under the United Nations Framework Convention for Climate Change, procedures for measuring country-level annual GHG emissions are in place, but they need to be disaggregated to enterprise and project levels. While this disaggregation will be highly complex, we expect that a valid and internationally accepted accounting mechanism

should be in place by 2011. In the interim, ADB will continue to use a framework to quantify GHG impacts or savings of future energy projects, and will refine it as necessary. This interim framework has been used to quantify the GHG emission reduction of completed projects that have been included in ADB's annual development effectiveness reviews.

6. **Recommendation 2(i): Mechanism to buy down incremental costs of clean coal technologies**. We agree. In carbon dioxide capture and storage (CCS) for example, the area that will have the highest incremental cost, ADB has partnered with the Global CCS Institute, Australia to identify options in DMCs with large coal use and to provide grant assistance for front-end investigations and capacity building. The Climate Change Fund will also provide grant funds for an integrated gasification and combined cycle project (currently being processed) to partly buy down the incremental cost. For project proposals that use supercritical and ultra-supercritical technologies, ADB's participation and risk enhancement mechanisms help lower the cost of capital, but more needs to be done. Where possible, assistance will be provided for registration under the Clean Development Mechanism (CDM) of the Kyoto Protocol, so that additional revenue streams can be generated. As more donor contributions become available under the Clean Energy Financing Partnership Facility, ADB's support for meeting such incremental costs can also increase.

7. **Recommendation 2(ii): Scaling up development of appropriate and affordable renewable energy technologies.** We agree. Technologies and know-how are essential for scaling up renewable energy projects in DMCs. ADB is implementing a study on establishment of a low carbon technology market place, which would bring technology vendors and buyers together. We are also cooperating with an international philanthropy to scale up solar power technology in India. With the grant resources of the Clean Energy Financing Partnership Facility, we are supporting DMCs on pilot projects that use advanced solar lighting and storage technologies. We will continue seeking options for introducing and scaling up renewable energy technologies in DMCs.

8. **Recommendation 2(iii): Aggressively pursuing methane destruction projects.** We agree. We will seek opportunities to extend support for coalbed methane extraction and use in the South Asia region, which has large coal reserves. We will also seek opportunities to support landfill methane capture in other regions with large quantities of urban waste. The uptake of such projects has been helped by CDM, and when the post-Kyoto international agreement (post-2013) is in place, it is expected that more projects will be implemented in DMCs. ADB has invested in some methane capturing and utilization projects using the Asia Pacific Carbon Fund.

9. With respect to the above, the following issues will have to be taken into account: (i) Implementation time: in the People's Republic of China, which has the highest use of methane, the investigations started in the mid-1990s, and it took nearly 10 years to implement demonstration-scale projects; (ii) Regulatory and administrative regimes: except for the People's Republic of China, methane destruction projects will require a change in DMCs' regulatory and administrative regimes as gaseous fuels are treated differently; and (iii) Attractiveness to the private sector: Once the regulatory regime is clear, ADB's participation may be

limited as the high returns from the dual revenue stream, i.e. fuel and CDM, will attract private sector financing.

9. **Recommendation 2(iv): Scaling up investments in industrial energy efficiency improvement.** We agree. We welcome the recommendation because of the greater GHG-efficiency through reduction in energy demand following higher industrial energy efficiency. We will acquire suitable expertise and develop innovative mechanisms as we identify options for reducing energy use by the industrial sector; the energy community of practice will assist in building capability.

DEVELOPMENT EFFECTIVENESS COMMITTEE (DEC)

Chair's Summary of the Committee Discussion on 17 November 2009

EVALUATION KNOWLEDGE BRIEF: GREENHOUSE GAS IMPLICATIONS OF ADB'S ENERGY SECTOR OPERATIONS

1. The evaluation knowledge brief (EKB) aimed to identify implications of energy operations of ADB on greenhouse gas (GHG) emissions, and to draw lesson to guide future energy assistance. The study aims to improve GHG efficiency of ADB's energy sector assistance and thereby help DMCs adopt a low carbon path, which is the prime objective of the ADB's energy policy.

2. The EKB concluded that ADB has done fairly well in recent years in terms of the emphasis that has been attached to the energy sector, the assistance to clean energy, the proportion of clean energy to the total, and the GHG savings realized from the energy portfolio in recent years (2006-2008) compared to the earlier period. Director General, IED, noted that as a mainstreaming measure, GHG assessment should be a part of regular assessment done for projects with significant GHG emissions.

3. Management (represented by Practice Leader for Energy; and Chair, Energy Committee) acknowledged the usefulness of the EKB in dialogues with governments. Management raised concern on accounting for the GHG emissions without recognizing the development impacts of the projects. Management mentioned ADB's efforts to improve its operations in countries where it can have an impact.

4. DEC Chair inquired about the additional cost that DMCs incurred for producing cleaner energy. Cost of clean energy should be compared to the cost of producing the same using the least-cost option that may not be the cleanest form of energy. This would enable DMCs to make informed decisions on technology options, taking into account both the GHG impacts and the cost implications. One DEC member recognized that although DMCs would incur high costs for renewable energy, such initiatives should continue, perhaps with the help of other development partners and the private sector. Another DEC member noted the positive response of Management to the IED recommendations, and looked forward to the monitoring of the implementation of the recommendations, which may take longer time. The DEC member also inquired on other financing mechanisms to support the recommendations for mechanisms to buy down incremental costs of clean coal technologies. Lastly, the DEC member recommended greater emphasis on the EKB's finding that ADB should encourage policy reforms to promote GHG efficiency in energy sector.

5. IED clarified that ADB does not saddle countries with the high cost technologies solely aimed at achieving savings in GHG emissions. DMCs recognize their priorities in making investment choices; the higher priority is energy supply (energy security and access) at an affordable price. It is acknowledged that GHG efficiency is a desirable outcome but it is not a major factor in the decision making process at present as DMCs do not have a legally binding obligation to reduce the GHG emissions. Management mentioned that new safeguard guidelines require the gross GHG impacts to be quantified for projects with significant GHG emissions. The project level financial and economic analysis is undertaken without taking into account the global benefits due to GHG savings. This ensures that the project is financially and economically attractive to the DMC.

6. On the additional buy-down mechanisms, IED noted that there are already mechanisms in place. Management mentioned some existing mechanisms, including Clean Energy Financing Partnership Facility (CEFPF) and the proposed Climate Investment Fund to be administered by the World Bank with ADB as a participating agency. Management and IED also expressed the hope that appropriate mechanisms for technology transfer and financing of incremental cost of advanced energy technologies would be agreed upon in the forthcoming negotiations in Copenhagen.

7. On the recommendation for policy reforms, Management explained that policy dialogue is part of CPSs and road maps, and supporting the implementation of the climate change action plans. It was noted that policy reforms would be applicable to countries with significant GHG emissions.

Conclusions

8. DEC noted that GHG-efficient investments have been a part of ADB's energy sector portfolio for many years without explicit recognition. ADB has been increasingly focused on GHG-efficient investments since 2006.

9. DEC looked forward to further refinements to evaluation methodology and presentation that would include benefits and costs of enhanced environmentally efficient energy investments.

Ashok K. Lahiri
Chair, Development Effectiveness Committee