Climate Investment Funds

February 9, 2009

CLEAN TECHNOLOGY FUND
INVESTMENT CRITERIA FOR PUBLIC SECTOR OPERATIONS[1]

[1] These criteria are applicable to public sector projects. For private sector projects, please see CTF Private Sector Operational Guidelines.

Introduction

1. Among the functions of the Clean Technology Fund (CTF) Trust Fund Committee is "approving programming and pipeline priorities, operational criteria and financing modalities." At its meeting in January 2009, the CTF Trust Fund Committee approved criteria to assess and prioritize proposed programs and projects in investment plans. Recognizing that the CTF is to promote learning-by-doing, it is proposed that the criteria be kept under review by the Trust Fund Committee on the basis of actual experience in their application and that the MDBs prepare a report for consideration by the Committee within the next 18 months to allow of the consideration of any changes that would serve to enhance the effectiveness of criteria.

2. The Committee also approved technical criteria to be applied in CTF financing for carbon capture and storage-ready coal power plants, fuel switching from coal to gas, and rehabilitation of coal-fired power plants. These technical criteria are included as Annex 1 to this document.

Principles

3. The proposed CTF investment criteria take into account the principles agreed by representatives of governments participating in the final design meeting on the Climate Investment Funds (Potsdam, May 2008), and approved by the World Bank's Board at the time of its consideration and approval of the establishment of the CTF in July 2008. These principles are:

(a) The core mission of the MDBs is sustainable economic growth and poverty reduction. Climate change mitigation and adaptation considerations need to be integrated into the sustainable development process as addressing these issues contributes to the basic human needs of the poorest who are disproportionately impacted by the negative effects of climate change;
(b) Multilateral development banks can and should play a role in ensuring access of developing countries to adequate financial resources and appropriate technology for climate actions;
(c) The MDBs should mobilize new and additional financing for adaptation and mitigation programs to address climate change that are country-led and designed to support sustainable development and poverty reduction. Activities financed by the fund should be based on a country-led approach and should be integrated into country-owned development strategies, consistent with the Paris Declaration;
(d) Achieving sustainable outcomes will require sustaining the total wealth -- produced, human, institutional and natural -- on which development depends;
(e) The UN is the appropriate body for broad policy setting on climate change, and the MDBs should not preempt the results of climate change negotiations. Actions to address climate change should be guided by the principles of the UNFCCC;
(f) The MDBs, in collaboration with other development partners, should assist developing countries to build country-level knowledge, capacity and development project experience;

(g) It is appropriate for the MDBs to build partnerships with each other and a wide range of institutions and stakeholders on climate change, including the private sector. In doing so, each MDB should remain accountable to its governing body;
(h) Complementarities between activities foreseen for the CTF and activities of the GEF and the UN, especially at the country level, should be identified, and effective cooperation established, to maximize synergies and avoid overlap; and,
(i) The CTF should provide for transparency and openness in its governance and financing operations.

CTF Investment Criteria

4. Financing from the CTF will be provided on the basis of an investment plan, developed under the leadership of the recipient country in coordination with the MDBs, for the use of CTF resources in the country through a joint MDB program. The investment plan should highlight how it is embedded in national development plans or programs that include low carbon objectives. The investment plan will include a potential project pipeline and associated notional resource envelope. A group of countries may present a proposal for CTF co-financing through a joint investment plan.

5. The CTF will use the following criteria to assess and prioritize the proposed pipeline of programs and projects, with a view to maximizing the impact of CTF resources[2]:

(a) Potential for GHG Emissions Savings
(b) Cost-effectiveness
(c) Demonstration Potential at Scale
(d) Development Impact
(e) Implementation Potential
(f) Additional Costs and Risk Premium

6. The CTF will focus on high abatement opportunities at the country level (but could support sub-regional and regional initiatives[3]) and will be technology-neutral. There will be no *a priori* allocations to specific proven technologies or sectors. Financing from the CTF could cover, among other low carbon technologies, one or more of the following proposed transformational investments:

(a) Power Sector, resulting in substantial reductions in carbon intensity of electricity production (t CO_2 eq./MWh)[4]

[2] The CTF will develop a common database where feasible to support the decision-making process using these investment criteria.
[3] For sub-regional and regional investment plans, the unit of analysis would be the group of countries in the program.
[4] Criteria for CTF co-financing of low-carbon opportunities in coal and gas power investments are contained in Annex 1.

(i) Increase substantially the share of renewable energy (with a primary focus on new renewable energy[5]) in the total electricity supply;
(ii) Switch to highly efficient gas plants resulting in significantly reduced carbon intensity of power generation and gas flaring (see Annex 1, paragraphs 28-31 for more detailed criteria);
(iii) Achieve significant greenhouse gas reductions by adopting best available coal technologies with substantial improvements in energy efficiency (e.g. combined heat and power production) and readiness for implementation of new carbon reduction technologies, such as carbon capture and storage (see Annex 1, paragraphs 14-23 for detailed criteria) ;
(iv) Rehabilitation or retrofit of existing, inefficient thermal power plants with the objective of significant increases in efficiency (see Annex 1, paragraphs 24-27 for more detailed criteria).
(v) Promote regional grid interconnection schemes that support lower carbon energy production;
(vi) Significant reductions in transmission and distribution losses (new T&D systems using energy-efficient technologies, or retrofits/upgrades);
(vii) Adopt utility managed demand management programs for retail and wholesale customers.

(b) Transportation, resulting in significant emissions reductions (CO_2 per passenger-kilometer or per ton-kilometer) through modal shifts, fuel efficiency or alternative fuel options:

(i) Modal shift to low carbon public transportation in major metropolitan areas, with a substantial change in the number of passenger trips by public transport;
(ii) Modal shift to low-carbon freight transport, with a substantial change in tonnage of freight moved by road transport to rail;
(iii) Improve fuel economy standards and fuel switching;
(iv) Deployment of electric and hybrid (including plug-in) vehicles[6].

(c) Large-scale adoption of renewable energy and energy efficient technologies that significantly lowers emissions and energy use per unit of output in buildings, industry and agriculture:

(i) Low-energy buildings, solar heating, insulation, heat pumps, lighting and appliances;

[5] Consistent with the definition used for new renewable energy in the World Bank Group's Strategic Framework for Development and Climate Change.
[6] Plug-in electric vehicles would be considered only when the energy systems from which they draw the power are less carbon intensive than the emissions from a stand-alone electric hybrid. The calculation of carbon emissions will be on a life cycle basis.

(ii) District heating and district cooling based on efficient or renewable heat or cooling production;
(iii) Energy-intensive industries and equipment (e.g., motors, boilers, fans, drying, and pumping for irrigation and drainage).

7. With respect to low carbon opportunities in coal and gas power investments, the CTF will apply the following criteria (see Annex 1):

a) Net carbon emissions factor of new coal-fired power plants or new units in existing plants should be less than 0.795 t CO_2/MWh, adjusted for site- and country-specific factors.

b) New coal-fired power plants should include CCS readiness considerations in design, such as space, access, storage, transport and costs.

c) Net efficiency improvements in existing coal fired power plants should be at least five percentage points from operating efficiency levels or with net carbon emissions reductions of at least 15%, and will be limited to plants expected to be operational for 15 years after the upgrade.

d) Fuel switching from coal to gas should result in a decrease in CO_2 emissions of at least 50%. Net carbon emissions of new gas-fired power plants or new units in existing plants should be less than 0.398 t CO_2/MWh (net), adjusted for country- and site-specific factors.

Potential for GHG Emissions Savings

8. Emissions Reduction Potential of Investment: The CTF's objective is to invest in projects and programs with high GHG abatement opportunities at the country, regional or sub-regional levels. Each proposal for CTF funding will contain an assessment of direct CO_2-equivalent emissions savings over the lifetime of the proposed program/project. Emission reductions will be calculated by subtracting projected lifetime emissions of the CTF-financed project from the projected lifetime emissions of the business as usual project that the country would have pursued without CTF financing. Higher priority will be given to investment proposals that have greater emissions reductions potential.

9. Technology Development Status: The CTF's priority will be on the deployment, diffusion, and transfer of low carbon technologies that are at, or approaching, the "market take-off" phase and in sectors that make major contributions to GHG emissions. Proposals for CTF co-financing will be assessed on the basis of the technology's stage of development and mitigation potential (t CO_2-equivalent/year). Each project or program proposal will be classified in one of four categories:

Technically Viable – High Mitigation Potential	Commercially Available – High Mitigation Potential
Technically Viable – Low Mitigation Potential	Commercially Available – Low Mitigation Potential

(a) Technically Viable: The basic science has been consistently proven and tested in the laboratory and/or on a limited deployment scale. However, as some technical and cost barriers remain, the technology has yet to be commercially demonstrated on a large scale.

(b) Commercially Available: The technology is available from commercial vendors. Major technical issues have been resolved. Projected capital and O&M costs are well-understood. However, country specific barriers may exist and/or the technology is not yet able to compete against more conventional options without some form of subsidy and/or internalization of emissions externality placed upon all energy options.

(c) Mitigation Potential: High, if wide-spread replication of the technology across the sector will contribute to a significant proportion of emissions reduction at country level.

10. The CTF will not support technologies that are still in the research stage, but should be focused on deployment which may include commercial demonstration of new low-carbon technologies. Priority will be given to proposals for commercially available, significant mitigation potential technologies. Lower priority will be awarded to projects that are at the technically viable stage, but with low mitigation potential.

Cost-Effectiveness

11. Each project/program proposal will include a calculation of the CTF investment per ton of CO_2-equivalent reduced. In order to ensure the greatest impact of the CTF's limited resources, CTF co-financing will ordinarily not be available for investments in which the marginal cost of reducing a ton of CO_2-equivalent exceeds US$200, which according to the International Energy Agency's *Energy Technology Perspectives 2008* Report, is the lower-end estimate of the incentive needed to achieve the objectives of the "BLUE Map Scenario"[7].

12. In addition to a cost-effectiveness calculation of the CTF co-financed investment, proposals will also require an analysis of the expected reduction in the cost of the technology due to technological progress and scale effect at a global level, and/or through organizational learning and scale effects at the country level. Technology learning curves, which show a constant reduction of the investment cost for each doubling of production, can be used to derive cumulative capacity needed for a technology to become competitive. While recognizing the limitations of learning curves, it is possible to quantify deployment costs of a new technology and assess cost-effectiveness relative to the emissions savings potential, for a given learning rate, initial cost of the technology, and cost of the competing incumbent technology.[8] Alternatively, new, innovative measurements of cost-effectiveness due to expected reductions at scale are also encouraged.

[7] IEA BLUE Map scenario explores a reduction of global GHG emissions to 50% of current levels by 2050. According to IEA, average costs are about one-fifth of marginal costs.

[8] IEA Energy Technology Perspectives Report's outlook for cost reductions provides a basis for such estimates.

Demonstration potential at scale

13. The goal of the CTF is to support transformational investments at scale, through thematic programs and large-scale projects, at the sector or sub-sector level in a given country, sub-nationally, or regionally. In prioritizing investments, the CTF will assess the potential for significant reductions in GHG emissions growth as a result of the broader demonstration, deployment and transfer of low carbon technologies financed by the CTF.

14. Scope for avoided annual GHG emissions will be calculated on the basis of the potential emissions saving that would result if the CTF co-financed project were to be replicated throughout the targeted area, region, and/or sector of the country (or countries, for multi-country projects). This indicator will demonstrate both the potential for emissions reductions in absolute terms (i.e., CO_2-equivalent avoided) and relative terms (i.e., as a percentage of total emissions).

15. Transformation Potential: Project/program proposals for CTF co-financing should demonstrate that they constitute a strategic effort to stimulate lasting changes in the structure or function of a sub-sector, sector or market. Such transformation should speed up or deepen market penetration of a low carbon technology relative to business as usual. Strong market transformation will result in economies of scale, enhanced competition and private sector participation, and eventually savings in the unit abatement costs. In the context of the CTF, the term "transformation potential" is defined as the extent to which the deployment, diffusion and transfer of technologies and the implementation of policy reforms result in significant reduction in emissions growth against a national, regional or sector baseline.

16. Each project/program proposal should include at least three GHG emissions trajectories for the sub-sector/sector that is proposed as a target for CTF co-financing[9]:

(a) *Scenario 1* -- a baseline trajectory of GHG emissions for the targeted sector.
(b) *Scenario 2* -- the trajectory of reduced emissions that would result directly from the CTF co-financed project alone.
(c) *Scenario 3* -- the trajectory of reduced emissions that would result if the CTF co-financed project were to be replicated throughout the targeted area, region, and/or sector.

17. A project's relative transformational potential can be measured by the ratio of emissions reduction potential between Scenario 3 and Scenario 2. A project with a larger ratio would have more transformational potential than one with a smaller ratio.[10]

[9] Calculations of projected GHG emissions trajectories should include non-CO_2 GHG emissions, but should not include GHG emissions related to changes in forest cover or land use.
[10] The CTF will consider sector trajectories generated by the countries themselves. Additional resource material is available through the World Bank's Development Prospects Group, which has an underlying data base (GTAP) with over 100 countries and 57 sectors.

Development Impact

18. A key objective of the CTF is to demonstrate the potential for low-carbon technologies to contribute to sustainable development and the achievement of the Millennium Development Goals. The potential development impacts of projects and programs will be assessed consistent with standard MDB appraisal criteria, with particular emphasis on the following three indicators.

19. Potential efficiency gains will be measured by the projected reductions in energy intensity of GDP (as well as of the relevant sector) as a result of the deployment and replication of the low carbon technology throughout the sector or sub-sector.

20. CTF programs/projects that help accelerate access to affordable, modern energy or transport services for the poorest would contribute significantly to the achievement of the MDGs. Investment proposals will be assessed and prioritized according to their potential to increase household electricity access rates, reduce energy supply costs, the extent to which transport services increase access to mobility for those most dependent on them, or increase reliability of power for business and industry.

21. Environmental co-benefits: Reducing emissions of air pollutants from energy-related activities, including electricity production and transportation, as well as reducing contaminant discharges in liquid effluents from energy systems, are important sustainable development objectives. CTF investments should address major impacts of pollutants on health and the environment, particularly fragile ecosystems.

Implementation Potential

22. CTF investment proposals will be assessed on three dimensions that are closely related to successful implementation, consistent with standard MDB appraisal criteria.

23. Public policies and institutions should support deployment, diffusion and transfer of low carbon technologies, demonstrated through:

(a) Country and sector strategies: Key policy, institutional and other issues relevant to achievement of sector objectives are addressed.
(b) Institutional and implementation arrangements: Institutions responsible for implementation identified, with capacity to support technology adoption or capacity can be developed in the short term.
(c) Sustainability: Evidence of commitment to and ownership of project and relevant policies, as well as arrangements for long terms operations and maintenance.

24. A key objective of the CTF is to mobilize resources at scale for the deployment, diffusion and transfer of low carbon technologies. Investment proposal will be prioritized on the basis of the co-financing leveraged from domestic public and private sector sources, including carbon finance, as well as bilateral and multilateral development partners.

Additional Costs and Risk Premium

25. CTF financing will provide a grant element tailored to cover the identifiable additional cost of an investment, or the risk premium required, in order to make the investment viable. A project/program will be considered for CTF co-financing in any of the following scenarios of financial viability based on rate of return without CTF concessional resources:

(a) Negative rate of return
(b) Rate of return below normal market threshold
(c) Rate of return above normal market threshold, but below risk premium for project type, technology, sector or country
(d) Rate of return above normal market threshold, but acceleration of low carbon investments has higher opportunity costs

26. Each project/program proposal should clearly identify the additional costs or risk premium that affect the rate of return of the investment on account of reduction of GHG emissions and outline how the grant element in the CTF financing covers such additional costs or risk premium. The proposal should also demonstrate how CTF co-financing could be used, possibly in combination with revenues from emissions reductions, to make low carbon investments financially attractive by improving the internal rates of return on such investments. This analysis should be embedded in the multilateral development banks' standard projection of financial internal rates of return in their project documents.

27. In particular, it is recognized that risks could drive the required rate of return of commercial finance higher than that required for more familiar project investments. Therefore, concessional funding may be necessary to raise a "risky" project to a high enough rate of return to make it viable. Similarly, accelerating the deployment of low carbon technologies might require financial incentives, given competing budget demands on national/local authorities and the climate change mitigation benefits of earlier action.

28. It is proposed that the CTF should aim to go beyond the scope of the CDM, whilst remaining open to co-supporting eligible projects and technologies. In practice this means that the CTF would not fund projects that would be routinely financed by CDM. Rather the CTF could fund technologies that CDM is failing to deploy at scale or where CDM is unable to provide support – such as financing long distance transmission and many cases of buildings or transport energy efficiency. The key decision criterion is whether carbon finance is an insufficient incentive to deploy the low carbon technology at scale in the recipient country.

29. CTF financing should also complement the GEF through scaled-up deployment, diffusion and transfer of technologies to prove they can work on a commercial scale and/or to reduce costs through learning by doing. GEF's mandate in the climate change mitigation area provides financing: (a) to pilot and demonstration innovative technologies; (b) to remove barriers to transform markets, and (c) for capacity building, in particular creation of an enabling environment, including establishment of codes, norms and standards.

ANNEX 1
CLEAN TECHNOLOGY FUND
CRITERIA FOR FINANCING LOW-CARBON OPPORTUNITIES IN COAL AND GAS POWER INVESTMENTS

Introduction

1. The CTF Trust Fund Committee, at its meeting in November 2008 "reviewed the criteria proposed in document CTF/TFC.1/3 and approved the paper, with the exception of paragraph 7, subject to the revisions proposed by the Committee". The Secretariat was also requested to prepare a technical note regarding the criteria to be applied in CTF financing for carbon capture and storage-ready coal power plants, fuel switching from coal to gas, and rehabilitation of coal-fired power plants.

2. The CTF design document agreed in Potsdam in May 2008, which provides the basis for the World Bank Board's consideration and approval of the establishment of the Climate Investment Funds, states that financing from the CTF could cover, among other low carbon technologies such as renewable energy, the following transformational investments:

> "Switch to highly efficient gas plants resulting in reduced carbon intensity of power generation"; and
>
> "Achieve significant greenhouse gas reductions by adopting best available coal technologies with substantial improvements in energy efficiency and readiness for implementation of carbon capture and storage."

3. The design document further states that the CTF "would not support technologies that are still in the research stage, but should be focused on deployment which may include demonstration of new low-carbon technologies".

4. The purpose of this note is to provide more detailed criteria for CTF co-financing of low carbon opportunities in coal and gas power investments. The document draws on analyses and conclusions contained in the IPCC Fourth Assessment Report, the International Energy Agency's Energy Technology Perspectives 2008, and the Massachusetts Institute of Technology's study on "The Future of Coal" (MIT, 2007).

Analyses of mitigation technology options

Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report

5. The IPCC Fourth Assessment Report states that "there is no single economic technical solution to reduce GHG emissions from the energy sector.

> "... currently, fossil fuels provide almost 80% of world energy supply; a transition away from their traditional use to zero- and low-carbon emitting modern energy systems (including carbon dioxide capture and storage (CCS) (IPCC, 2005), as

well as improved energy efficiency, would be part solutions to GHG-emission reduction. It is yet to be determined which technologies will facilitate this transition and which policies will provide appropriate impetus, although security of energy supply, aligned with GHG-reduction goals, are co-policy drivers for many governments wishing to ensure that future generations will be able to provide for their own well-being without their need for energy services being compromised.

…. A mix of options to lower the energy per unit of GDP and carbon intensity of energy systems (as well as lowering the energy intensity of end uses) will be needed to achieve a truly sustainable energy future."

6. Similarly, the IPCC Third Assessment Report notes that "energy supply and end-use-efficiency technology options … showed special promise for reducing CO_2 emissions from the industrial and energy sectors. Opportunities included more efficient electrical power generation from fossil fuels, greater use of renewable energy technologies and nuclear power, utilization of transport biofuels, biological carbon sequestration and CCS." The IPCC concluded that low-carbon technologies and systems, such as optimization of generation plant-conversion efficiencies, fossil-fuel switching, renewable energy and CCS, "are unlikely to be widely deployed unless they become cheaper than traditional generation or if policies to support their update (such as carbon pricing or government subsidies and incentives) are adopted."

7. The IPCC assessment is based on the fact that coal is the world's most abundant fossil fuel and continues to be a vital resource for many countries. In 2005, coal accounted for around 25% of the total world energy consumption and approximately 9.2 $GtCO_2$/yr into the atmosphere. "The demand for coal is expected to more than double by 2030 and IEA has estimated that more than 4500 GW of new power plants (half each in developing and developed countries) will be required in this period …. The implementation of modern high-efficiency and clean utilization coal technologies is key to the development of economies if effects on society and environment are to be minimized."

8. With respect to gas, the IPCC Fourth Assessment Report states that natural gas production has been increasing globally, from 1994-2004; it showed an annual growth rate of 2.3%. Natural gas presently accounts for 21% of global consumption of modern energy and 5.5 $GtCO_2$ annually to the atmosphere. "Natural gas-fired power generation has grown rapidly since the 1980s because it is relatively superior to other fossil-fuel technologies in terms of investment costs, fuel efficiency, operating flexibility, rapid deployment and environmental benefits, especially when fuel costs were relatively low. Combined cycle, gas turbine (CCGT) plants produce less CO_2 per unit energy output than coal or oil technologies because of the higher hydrogen-carbon ratio of methane and the relatively high thermal efficiency of the technology …. Despite rising prices, natural gas is forecast to continue to be the fastest growing fossil fuel energy source worldwide IEA 2006), maintaining average growth of 2.0% annually …."

9. The Fourth Assessment Report conducted an analysis of electricity-supply mitigation potential by 2030, which concluded that between 3.95 and 7.22 $GtCO_2$-eq could be avoided by fuel switching, CCS and displacing some fossil fuel generation with low carbon options of wind, solar, geothermal, hydro, nuclear and biomass. In the higher mitigation scenario (which is a reduction of around 45% of GHG emissions below the baseline scenario):

a) Efficient fossil-fuel generation without CCS would account for 37% of total generation
b) New renewable energy generation would increase to 34% of total generation
c) Nuclear power would account for 17%
d) Coal- and gas-fired power plants with CCS 12%.

International Energy Agency (IEA) Energy Technology Perspectives 2008

10. The IEA Energy Technology Perspectives (ETP) 2008 concluded that the global energy economy will need to be transformed over the coming decades if global CO_2 emissions are to be reduced by 50% from current levels by 2050, so that global warming can be confined to between 2 degrees C and 2.4 degrees C (IPCC, Fourth Assessment Report). According to IEA, energy efficiency improvements in buildings, appliances, transport, industry, and power generation represent the largest and least costly savings. Next in the hierarchy of importance come measures to substantially decarbonize power generation. This can be achieved through a massive deployment of renewables, nuclear power, and carbon capture and storage (CCS). The key message of the IEA report is that "emissions can only be cut significantly if all CO_2-free options play a role".

11. The IEA report projects that end-use energy efficiency will account for 36% to 44% of emissions reductions in ACT (returning global emissions to today's level by 2050) and BLUE (halving emissions by 2050) map scenarios, compared to the baseline. . In the BLUE scenario, renewables represent 21%, CCS represents 19% of reductions, power generation efficiency and fuel switching 7%, and nuclear 6%.

12. In the BLUE map scenario, the share of coal in power generation declines from 52% in the baseline scenario to 13%. The share of gas declines from 21% to 17%, reflecting the fact that CCS – applied to virtually all coal-fired power plants in this scenario – is significantly more expensive per ton of CO_2 saved for gas than coal. About 76% of gas-fired power is generated from plants equipped with CCS. In capacity terms, however, the share of plants with CCS is much lower, as gas peaking plants play an important role in the scenario. They act as backup for variable renewable energy, with a low number of operating hours.

Massachusetts Institute of Technology (MIT): The Future of Coal

13. In 2007, MIT conducted a study of "the role of coal as an energy source in a world where constraints on carbon emissions are adopted to mitigate global warming". It concluded that:

a) The challenge for governments and industry is to find a path that mitigates carbon emissions yet continues to utilize coal to meet urgent energy needs, especially in developing economies.
b) Coal use will increase under any foreseeable scenario because it is cheap and abundant.
c) Carbon capture and storage (CCS) is the critical enabling technology that would reduce CO_2 emissions significantly while also allowing coal to meet the world's pressing energy needs.

Criteria for Financing Highly Efficient and CCS-Ready Coal-Fired Power Plants

14. The CTF will finance new coal-fired power plants[11] that achieve significant greenhouse gas reductions by adopting best available coal technologies with substantial improvements in energy efficiency and readiness for implementation of carbon capture and storage. In order to ensure that the CTF supports low carbon energy supply options, and to provide operational guidance to recipient countries and MDB staff, it is necessary to have a practical working definition of "high efficiency" and "CCS-ready" for coal-fired power plants.

15. According to the IEA's ETP 2008 report, new subcritical steam power plants using hard coal with conventional environmental controls operate at about 40.2% efficiency, with emissions factor of 0.83 t CO_2/MWh (net).[12] IEA states that supercritical steam-cycle plants operate with net thermal efficiencies in the range of 42-44%. The emission factor for the typical supercritical plant (250 bar/560°C/560°C) is 0.80 t CO_2/MWh (net); it "has become the system of choice for new commercial coal-fired plants in many countries".[13] [14] In most developing countries, CO_2 intensity of coal-fired power plants is higher.

16. The CTF's objective is to finance transformational action.[15] Therefore, its investments should reflect a step-change in the carbon intensity of coal-fired power plants in order to qualify as a low carbon technology. For purposes of eligibility for CTF co-financing of new coal-fired power plants, the following approach is proposed:

a) Carbon intensity of the power plant must be lower than 0.795 t CO_2/MWh (net) based on a reference plant with defined site ambient conditions and coal type, as outlined in Annex 1.[16]

[11] Includes greenfield Combined Heat and Power projects.
[12] Using different operating assumptions, the MIT study projects an efficiency level of 34.3% for subcritical plants and CO_2 emissions of 0.93 t CO_2/MWh.
[13] Using different operating assumptions, the MIT study projects an efficiency level of 37-40% for supercritical plants and emissions of 0.83 t CO_2/MWh.
[14] The MIT study notes that "there is no clear dividing line between supercritical and ultra-supercritical".
[15] At its November 2008 meeting, the CTF Trust Fund Committee "reaffirmed that, in any case, CTF funds will not be used to support sub- or super-critical coal power plants".
[16] "Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity Final Report", U.S. Department of Energy/National Energy Technology Laboratory, August 2007.

b) For each specific proposal for CTF co-financing, the 0.795 t CO_2/MWh (net) threshold will be adjusted to reflect the fact that efficiency and emissions are affected by the following country and site-specific factors:

i. **Ambient conditions -** Temperature and pressure of air and cooling water are the primary determinants; air humidity is a second order determinant, too. Elevation also has an impact, affecting temperature, pressure and air density. Higher temperature and pressure reduces plant efficiency, while lower temperature and pressure increase efficiency. The higher the elevation, the lower the efficiency.

ii. **Choice of the cooling type** –
   a. Direct Cooling: Direct cooling system is most efficient due to heat exchanging characteristics with compact condensers. The most efficient of the three options, but water needs to be available.
   b. Tower cooling is used when the direct cooling is not possible, requiring plenty of make up water. Efficiency in between air-cooled and direct cooling.
   c. Air-cooled due to unavailability of water supply for the cooling system. The least efficient of the three options, but maybe be necessary when there is no water available.

iii. **Coal quality**; Coal quality has many characteristics which impact the heat rate and CO2 emissions –
   - Heating value the higher the heating value, the higher the efficiency
   - Fixed Carbon
   - Volatile Matter
   - Ash content
   - Carbon content
   - Sulfur content
   - Moisture; higher moisture results in lower efficiency and vice versa. All the other coal quality factors have a second or third order impact on plant efficiency (heat rate).

iv. **Capacity factor**: Criteria of efficiency/heat rate can be at designed efficiency (at full load or at specified load patters, or at annual average). Design value can be tested at the performance test at taking over of the plant. Annual average will need monitoring after the plant is commissioned.

17. Therefore, an adjustment will be made to the reference plant's emissions factor (0.795 t CO_2/MWh) to reflect these country and site-specific-variables.[17] Then the proposed design's emissions factor will be compared to the "adjusted reference plant". Plant designs, which are at or exceed the maximum carbon intensity of 0.795 t CO_2/MWh adjusted to the site- and country-specific conditions, will not be financed.

[17] Guidance for MDB staff on adjustments to the reference plant's emissions factor will be prepared.

Carbon Capture and Storage-Ready

18. Carbon capture and storage (CCS) involves four main steps:

a) CO_2 capture
b) Transportation to an injection sink
c) Underground geological injection and permanent storage
d) Monitoring and verification

19. CCS technology for power plants is currently at the pre-commercial stage and therefore will not qualify for CTF co-financing. Key technical barriers include the need to improve reliability, reduce costs, demonstrate and validate a high degree of CO_2 retention in various geological formations, and to identify potential leakage routes and long-term isolation procedures. Furthermore, IEA concluded that legal, financial and regulatory frameworks (such as those related to onshore and offshore storage, liability and international movement) "do not currently make CCS from fossil fuel-power power plants economically justifiable". However, the IEA notes that "CO_2 capture and storage for power generation and industry is the most important single new technology for CO_2 savings in both ACT Map and BLUE Map scenarios".

20. According to IEA, four large-scale (over 0.5 Mt injected per year) anthropogenic CO_2 projects were in operation around the world in 2007. The European Union Zero Emissions Technology Platform aims to support the development of 10-12 demonstration plants within Europe by 2020.

21. In parallel with pilot projects to address technological issues, as well as legal and regulatory barriers, IEA's technology roadmap for CCS in fossil fuel power generation recommends "that new power plants should include capture/storage readiness considerations within design by 2015". Drawing on the IEA Greenhouse Gas R&D Programme's study of capture-ready plants, it is proposed that, for CTF co-financing, a new coal-fired plant will be considered CCS-ready if it satisfies the following conditions:

a) Adequate space and access requirements for additional equipment needed to capture CO_2;
b) Identified storage reservoir with enough storage capacity for the lifetime of the plant and feasible transportation options;
c) An economic analysis of CCS options, including economic viability of plant with CCS operation.

22. These conditions match the provisions of draft EU Policy note on Capture Ready[18], which is yet to be finalized as a final EU directive. They are also consistent with the conclusions of the IPPC Fourth Assessment Report:

[18] Accessible at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52008PC0018:EN:NOT or http://ec.europa.eu/environment/climat/ccs/eccp1_en.htm . The proposed directive is the most comprehensive approach available.

"New power plants built today could be designed and located to be CCS-ready if rapid deployment is desired (Gibbins et al. 2006). All types of power plants can be made CCS-ready, although the costs and technical measures vary between different types of power plants. However, beyond space reservations for the capture, installation and siting of the plant to enable access to storage reservoirs, significant capital pre-investment at build time do not appear to be justified by cost reductions that can be achieved (Bohm, 2006; Sekar, 2005)."

23. There are multiple candidate technologies for electricity production with CCS; however, limited number of coal technology has been demonstrated with CCS. Therefore, the CTF will not pick a technology "winner". As noted in the MIT study, "the reality is that the diversity of coal type … imply different operating conditions for any application and multiple technologies will likely be deployed." Key factors in assessing technology options will be: the pre-CCS emissions factor; efficiency reduction from no-capture to capture; and the cost of applying CCS to the power plant.

Criteria for Financing Rehabilitation and Retrofitting of Inefficient Thermal Power Plants

24. It is proposed that efficiency improvements of existing power plants should qualify for CTF co-financing due to the potential large impact on CO_2 emissions, while recognizing that the preferred option is to switch to new state-of-the-art plants. The IEA notes that "efficiency improvements can significantly reduce CO_2 and other emissions …. Improvements in the average efficiency of coal-fired power plants are already feasible. Two-thirds of all coal-fired plants are over 20 years old. Such plants have an average net efficiency of 29% or lower, and emit at least 3.9 Gt CO_2 per year."

25. For many developing countries, the ability to meet energy demand has been a long-standing problem. In such circumstances, power plants are typically operated well-beyond their normal life expectancy and regular maintenance is less than usual in an effort to reduce black-outs and load shedding. Given the relatively high cost of load shedding to the economy, such an approach is economically prudent. It is not unusual for utilities to invest in life extension to such plants, but there are limited incentives to improve plant efficiency. Plant efficiency upgrades are more expensive than life extension investments and vary considerably depending on the technology and plant condition. A rough estimate of the incremental cost would be $300 - 1000/kW.

26. CTF co-financing could provide positive incentives to power plant operators so that, when plants are taken out of service for life extension investments, they are also upgraded to reduce emissions. Low cost improvements could improve plant efficiency from its operating efficiency by about 2 percentage points (moving, for example, from 28% to 30% efficiency). For CTF eligibility, improvements that would be considered transformational in reducing the carbon intensity of the power sector should require that:

a) Efficiency gains would push the technical limits to 5 percentage points (improvements from, say, 28% to 33%). Improvements beyond 5 percentage

points are expected to be beyond what is generally technically viable as these plants are typically old[19]; OR,

b) CO_2 emissions reduction per kWh should be at least 15%.

27. Plants with such investments should be expected to be operational for at least 15 years after the upgrade is complete. Furthermore, the introduction of best practice in plant operation and plan maintenance after retrofitting will be required for CTF co-financing eligibility. Monitoring and verifying efficiency improvements for a certain period of time after retrofitting should be a part of project design.

Criteria for Financing Fuel-Switching to Highly Efficient Gas-Fired Power Plants

28. In many developing countries, new coal-fired plants emit roughly 0.950 t/MWh of CO_2 while older plants emit well over 1 t/MWh in well-run utilities and as high as 1.35 t/MWh for older plants. Gas-fired combined cycle power plants could reduce such emissions considerably as CO_2 emissions would typically be less than half that of a coal-fired plant. But in countries with indigenous coal, this switch is not happening due to under-developed gas markets and policy frameworks, and for price and security of supply reasons. Unlocking the value of gas through effective policy interventions will decrease the cost of importing gas – either by pipe or LNG – and could potentially decrease emissions in a 300 MW plant by more than 1 million tons CO_2 per year.

29. CTF funds could be used to initially buy-down the incremental cost of gas relative to coal. These funds could be used to partially fund either a gas pipeline or an LNG terminal for natural gas, combined cycle plants, either of which would be transformative in decreasing CO_2 emissions as outlined above. The pipeline/LNG terminal could be sized to fulfill multiple power plants, broadening the impact. It is recommended that the net result of the use of gas would be to decrease CO_2 emissions by at least 50% compared to the "Business-As-Usual" case. This would require that high efficiency gas-fired technologies be used.

30. Net carbon intensity of the new gas-fired power plant, or new units within an existing plant, must be lower than 0.398 t CO_2/MWh (net), which is 50% of the threshold for coal-fired power plants. Assumptions regarding natural gas composition for the reference plant are presented in Annex 1. For each specific proposal for CTF co-financing, the 0.398 t CO_2/MWh (net) threshold will be adjusted to reflect the fact that efficiency and emissions are affected by the following country and site-specific factors.

31. Given limited CTF resources, CCS-readiness would be eligible, but not required, for CTF investments in gas-fired power plants, since the lower carbon intensity of gas makes CCS significantly more expensive per ton of CO_2 saved for gas than coal.

[19] For rehabilitation projects requiring a conversion of electricity power plants into combined heat and power (CHP), the efficiency gain of five percentage points will be adjusted to reflect the difference between power and heat production.

Summary of CTF Criteria for Coal and Gas Investments

32. In summary, the CTF will apply the following criteria for low carbon opportunities in coal and gas power investments:

e) Net carbon emissions factor of new coal-fired power plants or new units in existing plants should be less than 0.795 t CO_2/MWh, adjusted for site- and country-specific factors.

f) New coal-fired power plants should include CCS readiness considerations in design, such as space, access, storage, transport and costs.

g) Net efficiency improvements in existing coal fired power plants should be at least five percentage points from operating efficiency levels or with net carbon emissions reductions of at least 15%, and will be limited to plants expected to be operational for 15 years after the upgrade.

h) Fuel switching from coal to gas should result in a decrease in CO_2 emissions of at least 50%. Net carbon emissions of new gas-fired power plants or new units in existing plants should be less than 0.398 t CO_2/MWh (net), adjusted for country- and site-specific factors.

Annex 1: Assumptions for Coal- and Gas-Fired Reference Plants [20]

Exhibit 2-1 Site Ambient Conditions

Elevation, m (ft)	0
Barometric Pressure, MPa (psia)	0.10 (14.696)
Design Ambient Temperature, Dry Bulb, °C (°F)	15 (59)
Design Ambient Temperature, Wet Bulb, °C (°F)	11 (51.5)
Design Ambient Relative Humidity, %	60

Exhibit 2-3 Design Coal

Rank	Bituminous	
Seam	Illinois No. 6 (Herrin)	
Source	Old Ben Mine	
Proximate Analysis (weight %) (Note A)		
	As Received	**Dry**
Moisture	11.12	0.00
Ash	9.70	10.91
Volatile Matter	34.99	39.37
Fixed Carbon	44.19	49.72
Total	100.00	100.00
Sulfur	2.51	2.82
HHV, kJ/kg	27,113	30,506
HHV, Btu/lb	11,666	13,126
LHV, kJ/kg	26,151	29,544
LHV, Btu/lb	11,252	12,712
Ultimate Analysis (weight %)		
	As Received	**Dry**
Moisture	11.12	0.00
Carbon	63.75	71.72
Hydrogen	4.50	5.06
Nitrogen	1.25	1.41
Chlorine	0.29	0.33
Sulfur	2.51	2.82
Ash	9.70	10.91
Oxygen (Note B)	6.88	7.75
Total	100.00	100.00

[20] "Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity Final Report", U.S. Department of Energy/National Energy Technology Laboratory, August 2007.

Exhibit 2-4 Natural Gas Composition

Component		Volume Percentage	
Methane	CH_4	93.9	
Ethane	C_2H_6	3.2	
Propane	C_3H_8	0.7	
n-Butane	C_4H_{10}	0.4	
Carbon Dioxide	CO_2	1.0	
Nitrogen	N_2	0.8	
	Total	100.0	
	LHV		**HHV**
kJ/kg	47,764		52,970
MJ/scm	35		39
Btu/lb	20,552		22,792
Btu/scf	939		1,040