Guidelines for Estimating ADB's Investments in Renewable Energy, Energy Efficiency and Clean Fuel Projects

The following guidelines are used to estimate ADB's investments in renewable energy (RE), energy efficiency (EE), and clean fuel (CF) projects:

A) Renewable Energy

1) For RE projects (wind, solar, hydro, geothermal, biomass, biofuel, biogas, landfill gas, municipal waste), the entire ADB loan/assistance is its RE investment.

2) For transmission lines dedicated to transmit RE-generated power, the ADB loan/assistance is its RE investment.

B) Demand Side Energy Efficiency

1) For dedicated EE projects (projects whose sole purpose is energy efficiency improvement), the entire ADB loan/assistance is its EE investment.

2) For other EE projects in other demand sectors (water supply & sanitation, transport, multisector such as central heating system, etc.), the EE investment is proportional to improvement in efficiency or to the reduction of emissions due to improvement in efficiency.

   For example an existing pumping system operating at 62% efficiency (baseline) is replaced by another system that operates at 70% efficiency (project), the percentage EE investment is calculated as follows:

   Percent EE Investment = (70 – 62)/62 = 0.129 or 12.9% (say 13%)

3) For assistance provided to ESCOs and manufacturers of energy efficient appliances and industrial equipment, the entire ADB loan/assistance is its EE investment.

4) For railways, the total EE investment is the present value of the total energy savings over its economic life; the percentage of this savings proportional to ADB loan/assistance is ADB's percent EE investment in railways.

   ADB's EE investment = Present Value (PV) of energy savings proportionate to ADB loans at a discount rate equal to financial internal rate of return (FIRR) of the project.

5) For projects with clearly defined EE components, the project estimates for such components are taken as the EE investments. In such cases, because the costs of the EE components have been calculated and presented in the project documents, there is no need for EE percentage calculations.

   For example, in a multisector project composed of road rehabilitation, water supply non-revenue water reduction, and waste water treatment, the cost estimate for non-revenue water reduction (if clearly separated from other cost components) is taken as the EE investment. Each cubic meter of water saved represents kwh of energy saved in pumping and other production processes.

C) Supply Side Energy Efficiency

1) For new power plant, the clean energy investment is proportional to the CO_2 reduction relative to a defined baseline.

   For example, a combined cycle, gas-fired power plant is to be constructed and a single cycle gas-fired power plant has been defined as the baseline, the clean energy investment is 53.6% of the total investment as calculated below. In the absence of a defined baseline, a default baseline (see Table 2, page 5) is used instead.

   CO_2 emissions (see table 3):
   Combined cycle plant: 0.404 kgCO_2/kwh
   Single cycle plant (baseline): 0.871 kgCO_2/kwh

   Percent clean energy investment = (0.871-0.404)/0.871 = 0.536 or 53.6%

2) For power plant upgrading projects, similar to new power plant projects, the EE investment is proportional to the reduction in CO_2 emissions as a result of efficiency improvement.

   For example, a conventional, oil-fired steam power plant with current efficiency of 29% is upgraded to have an efficiency of 34%, the clean energy investment is 15% of the total investment (see calculation below). Calculations, using typical baseline and upgraded efficiencies for various types of power plants are shown in Table 3, page 6.

   CO_2 emissions: Before upgrading (baseline) = 0.961 kgCO_2/kwh
   After Upgrading = 0.820 kg CO_2/kwh

   Percent EE investment = (0.961-0.820)/0.961 = 0.1467 or 14.67% (or 15% rounded off number)

   Alternatively, based on efficiency numbers alone, percent EE investment may also be calculated as follows:

   Percent EE investment = (34%-29%)/29% = 17.24% (say 17%)

3) For T & D projects, the EE investment is proportional to the improvement in efficiency, similar to that in power plant upgrading.

   For example, a transmission system which can use a conventional AC system (with 8% losses per 1000 Km or 92% efficient), uses an energy efficient HVDC system instead (with 3% losses per 1000 km or 97% efficient), the percentage EE investment is determined as follows:

   Percent EE investment = (97%-92%)/92% = 5.43%

D) Supply Side Fuel Switching

1) For power plant switching from coal or oil to gas, the ADB investment is proportional to the reduction in CO_2 emissions as a result of using less CO_2-emitting fuel.

As a fuel switching example, consider an oil thermal power plant (baseline) which was retrofitted to run on gas. The percent EE investment is calculated as follows:

CO_2 emission, oil thermal power plant (baseline) = 0.820 kgCO_2/kwh
CO_2 emission, gas-fired power plant (Project) = 0.594 kgCO_2/kwh

Percent ADB investment = (0.820 – 0.594)/0.820 = 27.56% (say 28%)

2. For gas storage and pipelines dedicated to gas-fired power plants, the percent ADB investment follows the values that apply to specific power plants where the gas will be used. These values vary from 35% to 75% (see Table 1, page 4)

A summary of percent investment for various RE, EE & CF projects using default values are shown in Table 1, page 4. For calculation details refer to Tables 2, page 5 and Table 3, page 6.

TABLE 1- PERCENTAGES RE/EE/CF INVESTMENT

NOTES:

1. The percent RE/EE/CF investments represents the degree of "cleanliness" of a project relative to a default baseline. For baseline other than the default baseline, please see NOTES on the worksheet/spreadsheet calculations
2. These percentages will be used only for clean energy projects in the pipeline with insufficient information. Validation of percentages will be done for each project as soon as relevant information become available.

Projects	Fuel	% RE/EE/CF Investment	Remarks/Assumptions
A. Renewable Energy			
Power/Energy Generation using Wind, Solar, Hydro, Geothermal, biomass, biofuel, biogas, landfill gas, municipal wastes		100%	RE projects are carbon neutral
Dedicated T&D from RE sources		100%	T & D is considered part of the RE project
B. Demand Side Energy Efficiency			
Dedicated EE projects (i.e. Guangdong EPP,etc.)		100%	Entire investment is used to improve demand side energy efficiency
Reduction of non-revenue water (NRW)		15%	Baseline is the typical NRW losses of 35% (65% efficiency) with reduced losses of about 25% (75% efficiency) after the project. The factor would be (75 – 65)/ 65 = 0.154 or a rounded number of 15%. Use actual numbers if available
Railways		20%	Percentage represents the average proportion of the present value of energy savings attributable to ADB loans. Road transport is considered the baseline.
Assistance to ESCOs, and manufacturers of energy efficient appliances and industrial equipments		100%	Entire investment is used to make energy efficient equipment avaialble in the market
C. Supply Side Energy Efficiency			
C-1 New Power Plant			
Single Cycle Combustion Turbines	Nat. Gas	35%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
	Fuel Oil	15%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
Combined Cycle Combustion Turbines	Nat. Gas	60%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
	Diesel	45%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
	Fuel Oil	45%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
Conventional Steam Turbines	Nat. Gas	40%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
	Diesel	20%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
	Fuel Oil	20%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
	Coal	0%	DEFAULT BASELINE POWER PLANT
Cogeneration	Nat. Gas	75%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
	Diesel	65%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
	Fuel Oil	65%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
	Coal	60%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
IGCC	Coal	20%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
Supercritical	Coal	20%	See Tables 2 (Power Gen Tech 1 worksheet) for spreadsheet calculations
C-2 Power Plant Upgrading			
Single Cycle Combustion Turbines		15%	See Tables 3 (Power Plant Upgrades work sheet) for spreadsheet calculations
Combined Cycle Combustion Turbines		10%	See Tables 3 (Power Plant Upgrades work sheet) for spreadsheet calculations
Conventional Steam Turbines		15%	See Tables 3 (Power Plant Upgrades work sheet) for spreadsheet calculations
Cogeneration		6%	See Tables 3 (Power Plant Upgrades work sheet) for spreadsheet calculations
IGCC		10%	See Tables 3 (Power Plant Upgrades work sheet) for spreadsheet calculations
Supercritical		10%	See Tables 3 (Power Plant Upgrades work sheet) for spreadsheet calculations
C-3. Transmission & Distribution (T & D)			
HVDC & Superconductors		6%	Baseline is 750 kv AC transmission system with losses taken at about 8%/1000 km (92% efficient). HVDC losses at about 800 kv is about 2.5%/1000 or about 3% (97% efficient) considering the relatively small voltage difference. The factor would be (97 - 92)/92 = 0.054 or 5.4%. Use 6%. Use actual numbers if available.
T & D Retrofits and Upgrades		7%	The factor is based on 5% reduction in losses. (Efficiency improvement = $((E_{after} - E_{before})/E_{before})$. The factor could be higher depending on improvement in efficiency. Assume a typical baseline losses of 25% (baseline efficiency = 75%) and a 20% losses after upgrading (efficiency = 80%). The factor would be (80 – 75)/75 = 0.0667 or 6.67%, use 7%. Use actual numbers if available
D. Cleaner Fuel (Natural Gas)			
Dedicated Pipelines and storage facilities for gas-fired plants		30%-75%	Values vary according to the type of power plants (assuming gas is to be used for power generation)
NOTE: For power plants using gas see Section C-1 above			

Emission Factors of Various Fuels

Fuels	Emission Factors, kg CO2/GJ	
Natural Gas	56.1	
Diesel	74.1	
Fuel Oil	77.4	
Coal	94.6	
Conversion Factors		
1 kwh =	3.6	MJ
1 GJ =	1000	MJ

The Emission coefficient is calculated as:

kgCO2/Kwh = kgCO2/GJ/Efficiency*3.6/1000

Table 2 - Percent EE/CF Investment for New Power Generation Projects

Technologies	Baseline Fuel	Baseline Efficiency	Baseline Emission, kgCO2/Kwh	Project's Fuel	Project Efficiency	Project Emission , kgCO2/Kwh	%EE/CF Investment	%EE/CF Inv. (rounded off number)
Single Cycle Combustion			1.002	Nat. Gas	32%	0.631	37%	**35%**
			1.002	Fuel Oil	32%	0.871	13%	**15%**
Combined Cycle Combustion Turbines			1.002	Nat. Gas	50%	0.404	60%	**60%**
			1.002	Diesel	50%	0.534	47%	**45%**
			1.002	Fuel Oil	50%	0.557	44%	**45%**
Conventional Steam Turbines			1.002	Nat. Gas	34%	0.594	41%	**40%**
			1.002	Diesel	34%	0.785	22%	**20%**
			1.002	Fuel Oil	34%	0.820	18%	**20%**
	Coal	34%	1.002	Coal	34%	1.002	0%	**0%**
Cogeneration			1.002	Nat. Gas	80%	0.252	75%	**75%**
			1.002	Diesel	80%	0.333	67%	**65%**
			1.002	Fuel Oil	80%	0.348	65%	**65%**
			1.002	Coal	80%	0.426	58%	**60%**
IGCC			1.002	Coal	42%	0.811	19%	**20%**
Supercritical			1.002	Coal	42%	0.811	19%	**20%**

Default Baseline
Values used in the NOTE below

NOTE: If baseline power plant is not the conventional coal fired units (default), then the emission corresponding to that baseline power plant will be used as baseline emission . For example, if a combined cycle, gas-fired combustion turbine power plant is to be implemented in a DMC and the baseline is considered to be a single cycle oil-fired combustion turbine (instead of conventional coal -the default baseline power plant), then, the baseline emission would be 0.871 kgCO2/kwh and the percentage clean energy investment would be (0.871-0.404)/0.871 or 53.6%

Table 3 - Percentage EE Investment for Upgrading Power Projects

Technologies	Fuel	Baseline Efficiency (Degraded Efficiency),ε b	Baseline Emission Coefficient, kgCO2/Kwh, Eb	Project Efficiency (Restored/ upgraded efficiency),ε p	Project Emission Coefficient, kgCO2/Kwh, Ep	%EE Investment computed based on emissions	%EE Investment (rounded off numbers)
Single Cycle Combustion Turbines	Natural Gas	27%	0.748	32%	0.631	16%	15%
	Fuel Oil	27%	1.032	32%	0.871	16%	15%
Combined Cycle Combustion Turbines	Natural Gas	45%	0.449	50%	0.404	10%	10%
	Diesel	45%	0.593	50%	0.534	10%	10%
	Fuel Oil	45%	0.619	50%	0.557	10%	10%
Conventional Steam Turbines	Natural Gas	29%	0.696	34%	0.594	15%	15%
	Diesel	29%	0.920	34%	0.785	15%	15%
	Fuel Oil	29%	0.961	34%	0.820	15%	15%
	Coal	29%	1.174	34%	1.002	15%	15%
Cogeneration	Natural Gas	75%	0.269	80%	0.252	6%	6%
	Diesel	75%	0.356	80%	0.333	6%	6%
	Fuel Oil	75%	0.372	80%	0.348	6%	6%
	Coal	75%	0.454	80%	0.426	6%	6%
IGCC	Coal	37%	0.920	42%	0.811	12%	10%
Supercritical	Coal	37%	0.920	42%	0.811	12%	10%

NOTE: If the actual baseline and project efficiency values are not the same as the assumed values above, the actual values may be inputted in the above table to allow Excel to recalculate Percent EE Investment There are two formulas to calculate % EE investment: one using emissions and another using efficiency numbers

%EE Investment = (Eb - Ep)*100% / Eb
where: Ep = Baseline emissions
Ep = Project emissions

% EE Investment = (εp - εb)*100 / εb
where: εp=upgraded efficiency
εb=baseline efficiency