The Impact of Carbon Credits on Financial Viability of AIJ/JI/CDM Projects

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Abstract

To examine the potential impact of carbon credit revenues on the attractiveness of projects, we conducted a financial assessment of thirty-five energy projects and one forestry project that have been supported with the AIJ/JI/CDM feasibility study subsidy schemes by the Japanese Government. For scenarios with different carbon credit price, we calculated the payback period, internal rate of return (IRR), or net present value (NPV) of the projects. The results indicate that: 1) majority of energy projects proposed were "plant rehabilitation" and "fuel use change"; 2) in general, financial viability of the projects proposed in the subsidy scheme was not so high considering the opportunity cost and transaction cost; 3) revenue from carbon credits will have the most impact for forestry projects. Therefore, for energy projects that are not very attractive to the private sector without carbon credits, the additional incentive provided by such revenues may not be sufficient to induce private investment in many cases.

1. Introduction

The Clean Development Mechanism (CDM) is designed to encourage GHG-mitigating activities that would not occur otherwise. Article 12.5 of the Kyoto Protocol states that emissions reductions from CDM projects shall be certified on the basis of reductions in emissions that are additional to any that would occur in the absence of the certified project activity.[1] The likelihood that a project would be implemented without CDM certification depends on many factors, including the expected financial return of the project, the degree of risk, access to project finance, and corporate investment priorities. The hope is that the revenues from Certified Emissions Reductions (carbon credits), in combination with other benefits that may derive from CDM certification (such as in public relations or strategic market development), may be enough to move a "not likely" project into one that is attractive enough to receive investment (Meyers et al. 2000).

However , at a very minimum, the CDM should preserve environmental integrity; i.e., it should not generate credits for greenhouse gas emission reductions more than what were actually obtained. Indeed, to the extent that the "carbon-neutral" CDM scheme generates unwarranted credits, it will cause a net increase in global carbon emissions. In addition, investment subsidized by the CDM could destroy the competitiveness of local industries, and achieve only 'investment hot air' – or the claim that investment has helped mitigate climate change, when in fact all investors have done is to increase market share at the expense of manufactures in the developed countries (Forsyth 1999).

Another concern is that the cost of forestry project will be cheaper and will crowd out other types of projects, which results in reducing pressures for needed structural changes in energy consumption (Chomitz 1998, Meyers et al. 2000). In addition, the inclusion of forestry projects may have a impact on the regional distribution of investment flows through the CDM. To cope with these concerns, some argue that one option is setting some sort of quantitative cap on the participation of forestry projects in the CDM, perhaps proportional to land-use change and forestry's contribution to greenhouse gas emission (Olander 2000).

For a project developer, the financial value of gaining certification of carbon credits depends on the value of the carbon credits generated by the project, minus the costs associated with gaining certification. The value of the carbon credits depends on the amount of credits gained by the project, the temporal distribution of the credits (those in the future have a lower discounted present value than those do in the near term), and the unit value of carbon credits.

To examine the potential impact of revenue from carbon credits on the attractiveness of projects, we conducted a financial assessment of a number of projects that have been proposed by the Japanese companies under the subsidy schemes of the Japanese Government on the feasibility studies of the possible AIJ/JI/CDM projects in the developing countries[2]. Thirty-five of these are

[1] There exists a range of views as to what might be required for a project to be judged as providing additional emissions reductions. For an overview of perspectives regarding the impacts of the additionality on the project, see Baumert (1998).

[2] The Ministry of International Trade and Industry (MITI) of the Japanese Government started the scheme in 1998 and 40 projects proposal was selected under the criteria that it would have some possibility to be implemented in the future. Each proposals received around 0.4 million US $ for the feasibility study. In 2000, the number of the projects selected has increased to around 100/year because the other governmental agencies started the same type of the subsidy scheme. As of October 2000, no projects under the scheme have been implemented as AIJ/JI/CDM, yet.

energy projects, and one is a forestry project in Indonesia.[3] For three different scenarios of carbon credit price, we calculated a payback period, the internal rate of return (IRR) or net present value (NPV) for each project.

Most of the data on project performance and costs were obtained from the project proposal report (NEDO 2000, Sumitomo Lingyo 2000). In addition to our own calculation, we used the Proform, a computer software developed by the Lawrence Berkeley National Laboratory for IRR and NPV calculation.[4]

2. Methods and Key Assumptions

2.1. Scenarios of Carbon Credits Price

In addition to a case without carbon credits, as shown in Figure 1, we analyzed three scenarios for carbon credit price as Meyers et al.(2000). Each scenario assumes that the Kyoto Protocol takes effect in 2005, resulting in a significant increase in the value of carbon credits compared to the current price.

- Low Growth: The price of carbon credits is $10/tC in 2005, and rises thereafter at 10% per year.
- High Growth: The price of carbon credits is $10/tC in 2005, and rises thereafter at 15% per year, with a ceiling at $500/tC.
- Constant: the price of carbon credit is constant at $20/tC.

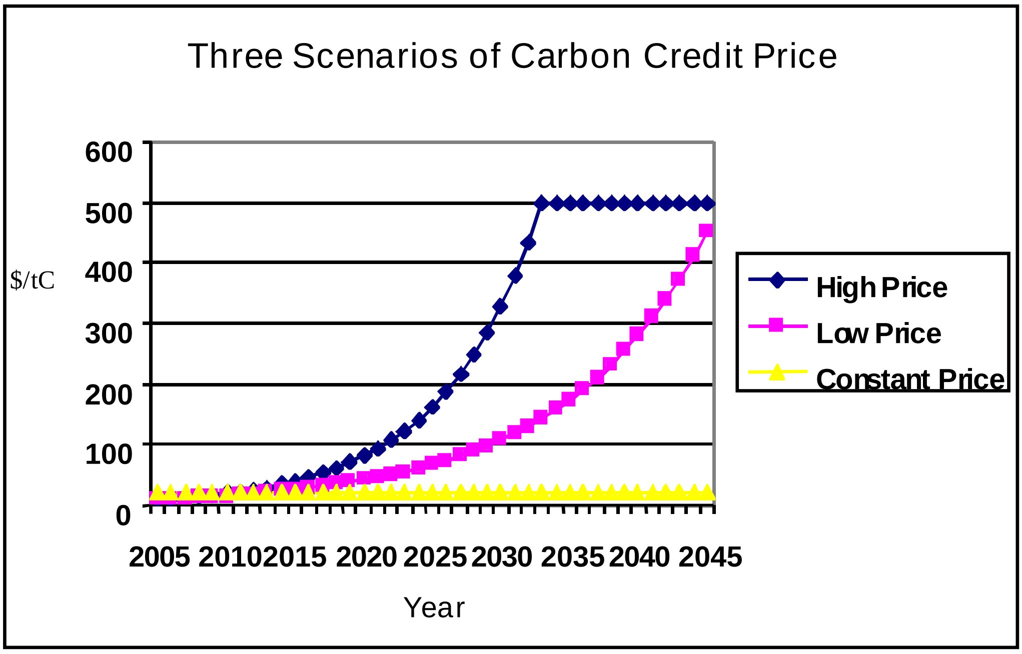


Figure 1. Three scenarios of the carbon credit price

[3] Whether forestry projects will be eligible for CDM is as yet undecided.
[4] Available at http://eetd.lbl.gov/proform/

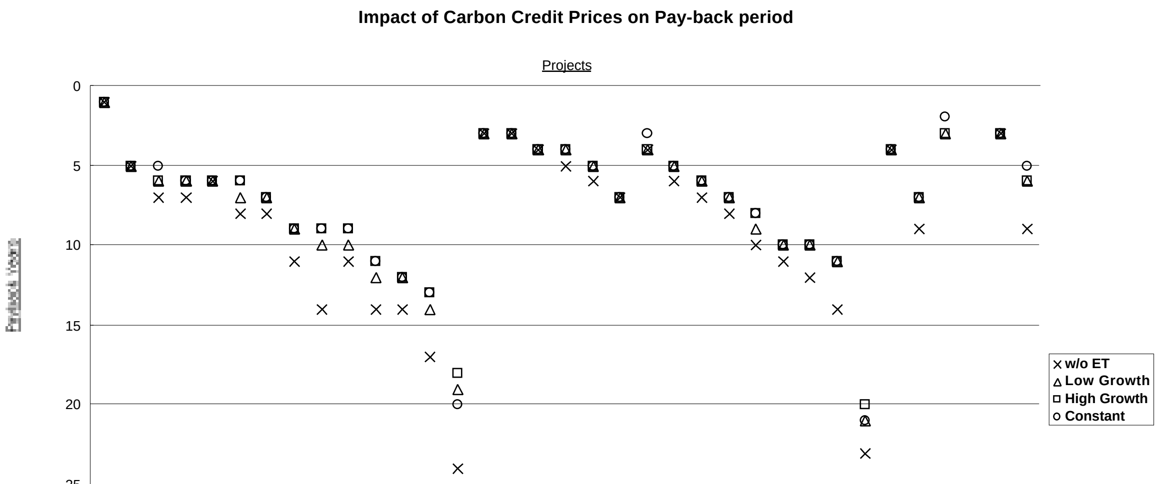
2.2. Financial Assessment

The financial analysis uses data on projected costs (capital and operating) and revenues over the expected lifetime of each project. The projects are assumed to commence operation in January 2005. Revenue from carbon credits is received on an annual basis. We assume that the projects are financed with full equity of the developers.

3. Results

3.1. Pay Back Period of the Energy Projects

Out of 35 energy projects, 14 projects were related to the power plants, 6 projects to steel plants, 9 projects to the oil refinery, 2 projects to the geothermal power generation, 2 projects to the electricity distribution, 1 projects to the cement plant, and one is other type (For details, please see the *Appendix 1*).



	EPG	EPG	EPG	EPG	EPG	EPG	EPG	EPG	EPG	EPG	EPG	EPG	EPG	EPG	STL	STL	STL	STL	STL	STL
w/o ET	1	5	7	7	6	8	8	11	14	11	14	14	17	24	3	3	4	5	6	7
Low Growth	1	5	6	6	6	7	7	9	10	10	12	12	14	19	3	3	4	4	5	7
High Growth	1	5	6	6	6	6	7	9	9	9	11	12	13	18	3	3	4	4	5	7
Constant	1	5	5	6	6	6	7	9	9	9	11	12	13	20	3	3	4	4	5	7

	PTR	PTR	PTR	PTR	PTR	PTR	PTR	PTR	PTR	LND	LND	ETF	ETF	CMT	OTR
w/o ET	4	6	7	8	10	11	12	14	23	4	9	99	99	3	9
Low Growth	4	5	6	7	9	10	10	11	21	4	7	3	99	3	6
High Growth	4	5	6	7	8	10	10	11	20	4	7	3	99	3	6
Constant	3	5	6	7	8	10	10	11	21	4	7	2	99	3	5

Remarks

Cases of carbon credit price are defined as follows;
w/o ET: without Carbon credit
Low Growth: $10/tC on the 1st year, increases 15%/year
High Growth:$20/tC on the 1st year, increases 15%/year
Constant:US$20/tC (US$500 Ceiling)

3 alphabetical codes represent project types as follows;

EPG=electricity generation plant, STL=steel plant, PTR=petroleum plant(oil-refinery), LND=Geothermal electricity power generation, ETF=electricity distribution, CMT=cement plant, OTR=other type project

Numbers in the table show the payback perionds(years) of the project. "99" means the project will not be paid back within its project period.

Figure 2. Impact of the carbon credit price on the pay back periods

As shown in Figure 2 above, carbon credits' impact on the projects' pay-pack periods depends on the project type. Projects categorized "electricity generation" and "oil refinery" showed scattered payback years, such as less than 5 years to 24 years. In contrast, the profitability of "steel projects" is relatively better than these projects, resulting in a 7-year payback period for the longest. Other projects categorized as "geothermal electricity power generation", "cement plant", and "other", seemed difficult to generalize profitability due to the extremely limited numbers of the projects. Two projects for "electricity distribution" failed to be paid back during their project period.

In comparison to the no carbon credit case, some of the “electricity generation” projects have experienced a considerable improvement in profitability, i.e. 4-5 years of reduction. These impacts are observed in the projects with relatively longer period of payback in the no carbon credit case. In addition, one “unprofitable electricity distribution project” has turned out to be “profitable” (paid back within its project period).

However, 27 projects out of total 35 had the same payback periods as the “Low Growth” cases, and even the rest of them showed only 1-year improvement. Major reason of the insignificance is that the relative impact of carbon price affecting on total cash-flow is small[5].

3.2. IRR and NPV of the Energy Projects and Forestry Project

Table 1 and Table 2 shows the result of the IRR and NPV calculation of four nearly commercially-viable energy projects and one forestry project (For other projects, please see the *Appendix 2*). As shown, the impact of carbon credits is substantial for the forestry project compared to the case of the energy projects.

Table 1. Internal Rate of Return for Energy Projects (%)

Project description	Without carbon credits	With carbon credits $20 constant	With carbon credits Low Growth	With carbon credits High Growth
a) Coal-fired power plant in China (facility renovation for energy conservation)	16%	18%	18%	18%
b) Steel plant in Russia (facility renovation for energy conservation)	20%	28%	26%	27%
c) Oil refinery in Russia(facility renovation for energy conservation)	16%	20%	19%	20%
d) District heating using Geothermal energy in Russia	27%	28%	28%	29%

Note:

[5] Since the analyses above do not consider returns of debts and interests, the results shown here should be considered as optimistic ones. Thus the revenue by carbon credit might have more importance on profitability of the projects, should these factors be taken into consideration.

a) Rehabilitation of the coal-fired power plant（300MW) in Shandong Province, China. Baseline scenario is the case in which the plant generates same amount of the electricity as the previous facility with the previous efficiency level. Project lifetime is 15 years.
b) Rehabilitation of the steel plant in Pedorovsk, Russia. Baseline scenario is the case in which the plant generates same amount of the steel as the previous facility with the previous efficiency level. Project lifetime is 15 years.
c) Rehabilitation of the oil-refinery in Khavarovsk, Russia. Baseline scenario is the case in which the plant produces same amount of the oil as the previous facility with the previous efficiency level. Project lifetime is 15 years.
d) Construction of the district-heating system using geothermal power in Kamchaka, Russia. Baseline is the use of the oil burning and hot water from coal-fired power plant for heating. Project lifetime is 15 years.

Table 2. Net Present Value and Internal Rate of Return for Forestry Project in Indonesia

Project	Without carbon credits	With carbon credits $20 constant	With carbon credits Low Price	With carbon credits High Price
Plantation in Indonesia	NPV:-4,903,000 IRR:7%	NPV:-1,777,000 IRR:14%	NPV:-889,000 IRR:16%	NPV:2,253,000 IRR:21%

Note:
Aforestation of five species for the plywood in East-Kalimantan, Indonesia. Baseline is regarded as zero emission. Only the sequestration by the aboveground biomass is considered. Project lifetime is 30 years. Revenue is before taxes. We calculated the NPV (US $) with a discount rate of 18%.

4. Conclusion

For developing countries in general, the results indicate that carbon credits revenues will have the most impact for forestry project as pointed out by Meyers et al.(2000). Therefore, for energy projects that are not sufficiently attractive without carbon credits, the additional incentive provided by such revenues might not be sufficient to induce private investment in many cases. If carbon credits have a relatively modest impact on financial viability as we observed with our calculation, they are obviously a small incentive, especially when weighed against the potential transaction costs of gaining such credits. If the process of gaining credits is too costly or time-consuming, many project sponsors may not find it worth the challenge. Therefore, it is probable that: 1) in many energy projects, regardless of profitability, carbon credit may not work as a significant subsidy for the project implementation; 2) to enhance the technology transfer and diffusion of the less cost-competitive but less carbon-intensive energy projects (e.g. renewable technology), it might be necessary to have special treatment to avoid being shut out from the CDM market; 3) strictness of the investment additionality test can be differentiated with the type of the CDM projects.

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Appendix 1: Description of the Energy Projects

(1/7)

NEDO No.	Project Name	Summary	Baseline
1	Energy Conservation of Nobo-Baku Refineries in Baku, Azerbaidjan	1.remodelling of heat exchangers system 2.applying FCC Power Recovery System technology	Comparing with the current amount of energy consumtion
2	Improvement of the waste management system of Tapioka starch manufacturing plant	Improve the waste management system of Tapioka starch manufacturing plants scattered throughout the Republic of Indonesia in order to resolve regional pollution problems, and to reduce the amount of greenhouse effect gases(GHGs) emitted to the atmosphere. 1.Compost Solid wastes(peels, fibres) 2.Aerobic treatment for waste water 3.Recovery of methane gas from waste water using aerobic treatment	Amount of CO2 and methane gas emitted from the existing plant
3	Energy Conservation of Zaporozhye steel plant	Improvement of combustion control at hot stoves	Amount of CO2 emitted from the existing steel plants due to heat loss from the current hot stoves.
		Waste heat recovery equipment for hot stoves	Amount of CO2 emitted from the existing steel plant due to heat loss from the current hot stoves.
		Blast furnace top pressure recovery turbine (TRT) power generating equipment	Amount of electricity deducted by implementing the project and the amount of CO2 emitted if the existing thermal power is being used to produce the same amount of electricity with the new equipment installed.
		Blast furnace gas recovery equipment	Amount of CO2 emitted from the existing blast furnace for over one year
		Changeover from open hearth furnace to basic oxygen furnace	Amount of CO2 emitted from the open hearth furnace
		Adoption of continuous casting (CC) in place of slabbing process	Amount of CO2 emitted from the current existing steel plants (specifically from steel making, blooming and heating process)
		Improvement of yield in slabs produced by slabbing	Amount of CO2 emitted from the current steel production
		Shortening of track time	Amount of CO2 emission after the yield ratio improvement due to the project implementation
		Reduction of insertion temperature in direct hot charge rolling	Amount of CO2 emitted after the project of blooming heat furnace steel charging temperature increase.
		Gas turbine cogeneration plant	Amount of electricity deducted by implementing the project and the amount of CO2 emitted if the existing thermal power is being used to produce the same amount of electricity with the new equipment installed.

NEDO No.	Project Name	Summary	Baseline
4	Scrap & Build of Atyrau Refinery in Kazakhstan	Through modernizing the current refinery, aims to improve the energy efficiency, reduction of carbon emission through conservation of energy as well as improvement of refinery products and economic benefit.	1. Annual carbon emissions=Carbon emissions per unit of energy (tC/TJ)*Annual fuel use(Tj/Y) 2.Amount of Oxidized Carbon=amount of annual carbon emissions*ratio of oxidized carbon 3.Amount of CO2 emissions=amount of oxidized carbon*propotion of CO2 and carbon(44/12) 4.Total amount of CO2 emissions=add up all the CO2 emissions from individual equipments and the added up amount is considered as the total amount of CO2 emissions from the refinery.
5	Conservation of energy for boilers	For the 399 boilers targeted in the study (out of 1125 registered boilers, excluded the ones which are small in scale and for generation purposes), conduct partial reconstruction, total reconstruction, as well as install cogeneration system in order to reduce the consumption of crude oil by 23 ML per year and for coal 299.8 kton per year which would result in CO2 reduction of 791.5 kton per year.	Annual CO2 emissions from the targeted 399 boilers (annual capacity operating rate, amount of steams generated, efficiency of boilers amount of fuel consumption, and amount of heat generated from fuels) at the time of research conducted (1998. 10A 1999.1)
6	Katowice, Poland steel mine energy conservation	coking process CDQ device (Case 1)	Current performance
		coking process CDQ/CMC device (Case 2)	
		coking process CDQ/CMC device (Case 3)	
		sintering process reconstruction of ignition furnace	
		sintering process recovery of exhaust gas	
		blast furnace process TRT device	
		blast furnace process recovery of waste heat from air heating furnace	
7	Conversion of Poland coal-fired power plants to combined cycle	To convert the exsiting old coal-fired power plants to a natural gas combined cycle. Targetted facilities are the two thermal power facilities in Konin and Kaweczyn cities and the heat generation plants of three chemical factories in Tarnow, Oswiecim, and Kedzierzyn which are private power generations. Will consider two cases in which one will install natural gas (ACC)and the other one is coal gassification (IGCC).	IGCC ACC-operate the existing warm water boiler and for the shortage of electricity in Warsaw city, assume importing some electricity from other regions. IGCC-Assume the maximum operation of coal fluidized bed boiler ACC IGCC(case1) IGCC(case2) ACC ACC Assume using the existing CHP plant and generate the same amount of electricity with the project case

NEDO No.	Project Name	Summary	Baseline
8	Myanmmar national electric power loss reduction project	Aims at reduction of CO2 by improving the transmission/distribution loss in the power supply system	Annual CO2 emissions (ton/year)=electric loss(kW)*annual electric loss coefficient(MWh/kW)*CO2 emission coefficient (Gg-C/10^19kcal)*860/(Heat efficienty*10^4)*CO2/C coefficient 1.national grid line annual CO2 emissions (ton/year)=28,533*4229*0.5639*860/(0.4*10^4)*44/12=54,524 2.33kV electric transmission annual CO2 emissions(ton/year) =1,565.8*4,229*0.5639*860/(0.4*10^4)*44/12 3.6/6kV&400V distribution line
9	Optimization of pipeline system including gas pipeline reconstruction in order to reduce GHGs in Russia	Conduct repair work to stop the leakage of methane and CO2 from Permtransgaz pipeline system	Current facilities (annual GHGs emissions from the permatransgaz pipeline system)
10	Khabarovsk, Russia refinery energy conservation	Apart from the distillation column and heating furnace which have already been reconstructed, the project aims to replace all the other equipments using Japan's technology including its modern conservation energy technology.	for the case of liquid fuel CO2 emissions=annual fuel consumption (9.063kt.yr)*net calorific values of residual oil (40.19Tj/kt)*per unit of carbon emission (21.1)*coefficient of oxidized carbon ratio (0.99)*proportion of CO2 and carbon(44/12)=27,898t/yr=27.898Gg/yr
11	Conversion of coal-fired power plant to natural gas-fired plant in Sakhalin State	Through renewing the generation device to the efficient device which use natural gass affluent to Sakhalin island, aims to reduce CO2 emissions as well as reducing the energy unit price.	CO2 emissions(KtCO2/yr)=annual fuel consumption(KtCoal/year,ktOil/year, Nm3NG/year)*CO2 emissions unit(tC/TJ)*44(kgCO2/kmolCO2)/12(kgC/kmolC)*low order heat generation(kJ/kg or kJ/Nm3)*coefficient of oxidized carbon ratio/1,000,000(1/M)(3)
12	Russian Konakovo power plant combined cycle plan	Renew 4 out of 8 thermal power equipments (300MW) with gas turbine combined cycle generation device	annual CO2 emission from the current devices=CO2 generation from crude oil + CO2 generation from gas fuel=1970,000+4,430,000+6,400,000t-CO2/year
13	Russian coal-fired power plant CO2 emissions reductions	In 1998, a total of 48 projects were proposed to Japan by RAO EES (ROSSII). 8 of these plants, except the coal-fired power plants that have been the subject of special feasibility studies during the present fiscal year, and one plant studied at the request of RAO EES ROSII-that is, a total of nine plants- have been the subject of special case studies, and their names are as follows: 1.Dorogobuzh Power Plant 2.Reftinskaya Power plant 3.Verkhne-tagil Power Plant 4.Troitsk Power Plant 5.Novo-Irkutsuk Power Plant 6.Cherpet Power Plant 7.Ulanude Power Plant 8.No.2 Kamchatka Power Plant	Current situation with the existing facilities (rate of utilization set to 70%)

NEDO No.	Project Name	Summary	Baseline
14	Khabarovsk, thermal power plant renewal work and Joint Implementation Feasibility Study	Most of the thermal power plants in Khabarovsk are old and the generation efficiency is lowering remarkably. In this study, one of those generating plants, Khabarovsk generation plant no.1, is going to be demolished and as a replacement, Khabarovsk no.4 will be established.	Current situation of the existing facility (total amount of CO2 emissions from generation plants no.1 and no.3 as well as plants from other districts all added up)
15	Utilizing geothermal power for the district heating in Kamchatka, Russia	Replacing the current energy sources of the hot water (fossil fuel power and thermal power plant) with natural geothermal hot water and/or Geothermal Heat pump systems (GHP) in order to reduce the Greenhouse gas emissions.	the amount of CO2 emitted from fossil fuel burning in order to supply hot water
16	Fuel Conversion Project for no.1 and no.9 combined heat and power generation plants of Irkutsk, Russia	By replacing fuels from coal to natural gas for no.1 and no.9 heat and power generation plants, aims to reduce carbon emission unit and reduce the amount of CO2 emissions. 1.Variation1-Add the natural gas receiving facility for the existing power generation plant and revamp the relevant boiler facility with the conversion of the fuel. 2.In addition to Variation 1, revamp the water treatment facility which decreases the capability of the heat and electricity supply because of being too old. 3.Put together the boilers and steam turbine generations(Gas turbine generator is not adopted). 4.Dismantle the existing power generation plant and instal a new power generation plant with gas turbine. *Between variation 1 and 2, there will be a difference in profitability and cost effectiveness, however, there will be no difference in the amount of GHGs emissions reductions.	Case1 Amount of CO2 emitted from the Operation mode close to the base operation load Case2 Amount of CO2 emitted from the Average operation load in 1996 and 1997.
17	Possible joint-projects for carbon dioxide reductions in Russia	Renewal of facilities which produce forged steel and iron of a Russian heavy machinery manufacturing company, Uralmash, as well as to improve the efficiency of generation facilities of SveldorvEnergy, a local utility company which supplies electricity to Uralmash.	Amount of CO2 emitted if Uralmash produced the targetted amount using the existing facilities. For SveldorvEnergy, amount of CO2 emissions from IV line and V line (generation facilities are formulated from I~V lines in which IV and V lines are renewed).
18	Magnitogorsk, Russia Steelworks energy conservation	coking process CDQ device coking process CMC device coking process ACC device sintering process ignition furnace renewal Blast furnace process TRT device steel converter process LDG recovery metal rolling process heat furnace energy saving provision heat furance reduction of electricity oxygen plant renewal of oxygen plant	Actual performance in 1997

NEDO No.	Project Name	Summary	Baseline
19	Igunovskaya plant fuel conversion	For the suspended 300 MW coal-fired power plant construction, install 450MW class combined cycle as well as convert fuels to natural gas in order to reduce the emissions of GHGs	Amount of CO2 emitted from the existing generation plant as well as the plant which the construction work has been suspended from.
20	Repowering of gas based thermal power plants (three power plants)	Renew three power plants in Russia which are Kirishi Power Station in Leningrad state, Puskovskaya Power station in Puskov state, and Iriklinskaya Power station in Orenburg State in order to reduce the greenhouse gas emissions. In particular, improve the heating efficiency and reduce fuel consumption as a central focus.	CO2 emissions=PGV*FC*4.1868TJ/Tcal*CEF*FCO*44/12 1.PGV: Power Generation Volume 2.FC:Fuel Consumption (Kcal/Kwh) 3.4.1868TJ/Tcal 4.CEF: Carbon Emissions factor (tC/TJ) 5.FCO:Fraction of Carbon Oxidized 6.44/12: Proportion of CO2 and carbon
21	Achinsk Refinery energy conservation project	Energy efficiency of the Achinsk refinery is low with the average of 60 to 70%. Thus it results in fuel consumption that is more than normally required. This project aims to conserve energy in this refinery.	CO2 emissions without the project that is estimated from the amount of fuels consumption.
22	Fuel conversion plan from coal to natural gas for the Amursk heat and power station	Convert heat and power generation (coal-fired power plant of 285 MW, heat generation power of 764Gcal/h) to natural gas and reduce the greenhouse gas emissions.	CO2 emission from both heat and power generation. For power generation, use 1993 as a base year in the existing power plant, and for heat generation, use 1998 as a base year.
23	Kuznetsk steel works converter installation	cutback basic steel production to 2million tonnes per year.	Amount of CO2 emissions from energy consumption for the year 1998.
		Suspension of open-hearth furnace no.1 and production increase for the electric furnace no.2 and establishment of electric furnace no.3.	Assume that the annual production of basic steel is 2million ton per year, considered the CO2 emissions from both electric and open-hearth furnace using their 1997 performance for the rate of utilization.
24	Total plan of thermal power plant rehabilitation in maritime provinces	The objectives of the project comprises the following; 1. Replacement and extension of the boilers at Vladivostok Thermal power plant no.2(Vladivostok TPP), which at present has a total electric capacity of 575 MW and a maximum heat supply capacity of 1300 Gcal/h. 2.Shutdown of the existing Partizansk Thermal Power Plant (Partizansk TPP), which at present has a total electric capcity of 212 MW and a maximum heat supply capacity of 80 Gcal/h, and construction of new Partizansk Power Plant. 3.New construction of Ussuriisk Thermal Power Plant (Ussuriisk TPP), the construction of the plant which at present has been suspended. Through the conversion of fuel and by the higher efficiency of the new equipment which will result from implementation of the above plan, the project aims to achieve a significant reduction of GHGs emissions.	CO2 emissions=annual fuel consumption (Kt/y)*the amount of carbon with in fuels (Ct/kt)*imperfect combustion adjustment coefficeint*44/12

NEDO No.	Project Name	Summary	Baseline
25	Renewal of Schekinskaya thermal power plant	Schekinskaya power plant TPP block 1 (units 8,9,&10) and Novomoskovskaya TPP block 1 which contains 100MW generation plants. The above devices are old and require renewal. For the Novemoskovskaya TPP, install 800MW class gas turbine combined cycle generation plant in order to improve heat efficiency.	annual CO2 gas emissions (ton) annual CO2 gas emissiosn=amount of carbon consumed*carbon imperfect combusion adjustment coefficient*3.667(convert carbon to CO2 unit)=984,062(tC)*0.995*3.667=3,590,514 (ton)
26	Renewal of Ryazanskaya thermal power plant	Renewal of old generation plants in Ryazanskaya and also with the fuel conversion aim to reduce the greenhouse gas emissions.	Amount of CO2 emitted from the existing plant
27	Master plan for the boiler renewal in Novgorod Province	Most of the local governments' boilers houses specialized in the heat supply system are as old as 30 years, thus they suffer from low thermal efficiency and because most of these are either coal-fired or crude oil-fired boilers, they negatively affect the workload and the safety of the plant workers. Thus the project aims to mitigate such problems as well as to reduce the greenhouse gas emissions.	1.the amount of CO2 emissions per 1MW of coal-fired boiler 18.7(annual energy consumed by a boiler per 1MW of output(TJ/MW*Y)*25.8(amoount of carbon comprised(tonC/TJ))*0.98=1,734(tonCO2/ MW*Y) 2.the amount of CO2 emissions per 1MW of crude oil-fired boiler 18.7*21.2*(44/12)*0.99=1,439 3.the amount of CO2 emissions per 1MW of natural gas-fired boiler 14.4*15.3*(44/12)*0.995=804
28	Renewal of heating furnace in oil refineries of Kuiibyshev, Syzran, and Novokuibyshev	In order to reduce greenhouse gases, the project aims to investigate the plausible ways of energy conservation for heating furnace in oil refineries of Kuiibyshev, Syzran, and Novokuibyshev all located in samara state.	the amount of CO2 emissions=amount of fuel consumption with oil conversion unit (kton/year)*the energy unit of fuels (42.08TJ/kton)*emissions unit of carbon(20.0ton-C/TJ)*fraction of carbon oxydized(0.99)*proportion of CO2 and carbon (44/12)
29	Methane recovery and usage from coal mines in China	investigated the availability of methanol, city gas and electric generation from methane recovered from the Yangquan coal and Panjiang coal mining leakages.	the amount of methane emission expected from the existing facility in the year 2000
30	Waste heat power generation from the Chinese cement plant	The cement industry utilizes a vast amount of energy, thus efficient use of heat energy is required. Most of the large sized cement plants in Japan are equipped with a waste heat power generation unit. As China is one of the largest cement producers in the world, it is essential to investigate the effect of installing waste heat power generation units for the cement plants.	the amount of annual fossil fuel consumption (t/y) =annual electricity consumption(kW)*annual operation days(day/year)*24(h/day)*coefficient of oil conversion(kcal/kWh) *4.1868(kJ/kcal)/crude oil net calorific values(TJ/kt)/10^6 annual CO2 generated(t/y) =annual consumption of fossil fuels from the existing power generation*Chinese crude oil net calorific Values (TJ/kW)*Carbon emission factor*Fraction of Carbon Oxidized*CO2/Ccoefficient/10^3 -Tongling Cement Plant in Anhui Province annual fossil fuel consumption(t/y) =4667(kW)*330d/y*24h/d*2,646(kcal/kWh)*4.1868(kJ/kcal)/42.62(Tj/kt)/10^6 =96,070(t/y) annual CO2 emissions(t/y) =96,070(t/y)*42.62(TJ/kt)*20(TC/TJ)*0.99 *(44/12)/10^3

NEDO No.	Project Name	Summary	Baseline
31	the diffusion of Fluidized bed cement kiln system in China	investigate the effect of converting the existing vertical shaft kiln process of two cement companies in China with fluidized bed cement kiln system developed by center for coal utilization Japan.	the amount of CO2 emitted from the existing kiln system
32	Joint implementation project feasibility study for CO2 emission reduction by Keio University	Conduct a comprehensive study to find ways to avoid urban environment pollution due to coal burnig and to assess potential methods to reduce CO2 and other greenhouse gas emissions and consider ways to improve the efficiency of heat supplying businesses in Beijing. The study will limits its target on home stoves, decentralized boilers, and heat sypplying businesses.	(the amount of emissions are stated but no equation provided)
33	Feasibility study of CO2 emissions reductions using the petroleum coke residue generated as fuel for power generation in Chinese oil refineries	By installing IGCC(integrated gasification combined cycle) in the Nanjing Refinery of Jinling Petrochemical Corporation, it enables the refinery to utlize the residue (of petroleuk coke) as fuel for power generation, thus results in CO2 emissions reductions from the existing power plants.	1)the amount of CO2 emissions resulting from generating the power from coal-fired power plant in order to supply electricity for the existing oil refinery. 2)CO2 emissions from utilizing petroleum coke residues. *the emissions from 2) will differ according to different methods, thus it requires to calculate emissions by assuming 4different cases as follows; 1.case 1-utilize all as burning fuels 2.case2-utilize all as power generation 3.case3-utilize all in such a way so that CO2 will not be emitted 4.case4-utilize some for burning fuels, power generation, and for other purposes.
34	Probability of rationalization and joint execution of energy use in Chinese steel industry(study on the introduction of scrap preheating system for electric furnace)	Installation of scrap preheating system to electric furnace steel plants for Wuyang Iron and Steel Co. Ltd, Tianjin Steel Pipe Corp., Shanghai Pudong Iron&Steel(group)CO., Ltd., Shanghai No.5 Steel(Group)CO., LTD	Current performance
35	Investigating the feasibility to increase the efficiency of the existing coal-fired power plants in China	Reduce the CO2 emissions from coal-fired generation by increasing the generation efficiency of the existing plants.	CO2 emissions from the plants prior to their renewal (consider two cases after the renewals, one with no changes in the utilization ratio of power plants and the other with the 80% increase in their utilization ratio).
36	Rehabilitation of 300MW coal-fired power plants in China	Improve the efficiency of energy utilization in the following three 300MW coal-fired power plants: 1. Shandong Province Zouxian Power Plant 2. Anhui Province Luohe Power Plant, and 3.Henan Province Yaomeng Power Plant	Current performance
37	Improvement of the low-grade coal quality in Chongqing city in China in order to reduce CO2 emissions (researched the possibility of coal-biomass briquette production)	Aims to improve air pollution due to the coal burning in Chongqing and reduce CO2 emissions through installing bio-briquette production technology.	the amount of CO2 emitted from coals without using bio-briquette
38	A study of BFG MONO-firing gas turbine combined cycle power plant application for the steel mill of China	Aims to reduce CO2 emissions by applying 1100 degrees celcius class combined cycle power plant	CO2 emissions from the coal-fired power plants
39	Energy conservation project for electric furnaces of the Shen Yang Iron and Steel Complex in Liaoning Province	weed out electric furnace that are small in scale or are old, and convert furnace that are energy efficient and are environmentally sound.	Assume the increase in yield ratio through installing some new facilities to the current performance and consider that as baseline.

Appendix 2: Calculation Result of Energy projects

(1/2)

#	Name of Project	Case	Category	Payback Years: w/o ET	Payback Years: Constant	Payback Years: Low	Payback Years: High	IRR (%): w/o ET	IRR (%): Constant	IRR (%): Low	IRR (%): High
1	Energy Conservation of Nobo-Baku Refineries in Baku, Azerbaidjan	crude oil distilling apparatus for Nobo-Baku oil refineries	OIL	4	3	4	4	27%	34%	32%	33%
		FCC equipment for Nobo-Baku oil refineries	OIL	11	10	10	10	5%	7%	7%	7%
		crude oil normal pressure distilling apparatus for Nobo-Baku oil	OIL	7	6	6	6	13%	17%	16%	18%
2	Improvement of the waste management system of Tapioka starch manufacturing plant	Total 10 plants	OTR	9	5	6	6	8%	19%	17%	19%
3	Energy Conservation of Zaporozhye steel plant		STL	4	4	4	4	28%	30%	30%	30%
5	Conservation of energy for boilers		GEO	9	7	7	7	8%	14%	13%	15%
8	Myanmmar national electric power loss reduction project		ETF	N/A	2	3	3	N/A	68%	43%	48%
9	Optimization of pipeline system including gas pipeline reconstruction in order to reduce GHGs in Russia		ETF	N/A	N/A	N/A	N/A	N/A	-7%	-6%	-3%
10	Khabarovsk, Russia refinery energy conservation	only re-restructuring heat	OIL	6	5	5	5	16%	20%	19%	20%
11	Conversion of coal-fired power plant to natural gas-fired plant in Sakhalin		EPG	1	1	1	1	105%	106%	105%	105%
14	Khabarovsk, thermal power plant renewal work and Joint Implementation Feasibility Study	30 years of coal firing	EPG	14	11	12	11	6%	8%	9%	12%
15	Utilizing geothermal power for the district heating in Kamchatka, Russia		GEO	4	4	4	4	27%	29%	28%	29%
16	Fuel Conversion Project for no.1 and no.9 combined heat and power generation plants of Irkutsk, Russia	Variation 4 case 2 power plant no.1	EPG	8	6	7	6	13%	17%	17%	18%
		Variation 4 case 2 power plant no.9	EPG	8	7	7	7	13%	15%	15%	15%
17	Possible joint-projects for carbon dioxide reduction in Russia	Modernization of Uralmash steel mills	STL	5	4	4	4	20%	28%	26%	27%
19	Igunovskaya plant fuel conversion		EPG	5	5	5	5	21%	24%	24%	25%
21	Achinsk Refinery energy conservation project	crude oil distilling apparatus case 1, Bitumen equipment, boiler equipment	OIL	8	7	7	7	10%	14%	13%	14%
22	Fuel conversion plan from coal to natural gas for the Amursk heat and power station	electricity power charge：0.0153US$/kWh	EPG	11	9	9	9	8%	11%	11%	13%
23	Kuznetsk steel works converter installation	After modernization	STL	6	5	5	5	18%	22%	21%	22%
24	Total plan of thermal power plant rehabilitation in maritime provinces	Vladivostok Thermal Power	EPG	7	5	6	6	16%	20%	20%	21%
		Partizansk Thermal power plant	EPG	17	13	14	13	4%	7%	8%	10%
		Ussuriisk Thermal Power Plant	EPG	24	20	19	18	2%	3%	4%	6%
25	Renewal of Schekinskaya thermal power plant	case 1	EPG	7	6	6	6	15%	18%	18%	19%
26	Renewal of Ryazanskaya thermal power plant	case 2	EPG	14	13	13	12	6%	7%	8%	10%
28	Renewal of heating furnace in oil refineries of Kuiibyshev, Syzran, and Novokuibyshev	Kuiibyshev oil refinery	OIL	12	10	10	10	3%	7%	7%	8%
		Novokuibyshev oil refinery	OIL	10	8	9	8	6%	10%	9%	10%
		Syzran oil refinery	OIL	14	11	11	11	2%	5%	5%	6%
30	Waste heat power generation from the Chinese cement plant		CMT	3	3	3	3	35%	40%	38%	39%

#	Name of Project	Case	Category	Payback Years				IRR (%)			
				w/o ET	Constant	Low	High	w/o ET	Constant	Low	High
34	Probability of rationalization and joint execution of energy use in Chinese steel industry(study on the introduction of scrap preheating system for electric furnace)	Wuyang Iron and Steel Co. ltd	STL	3	3	3	3	40%	43%	42%	42%
		Tianjin Steel Pipe Corp.	STL	3	3	3	3	35%	37%	37%	37%
36	Rehabilitation of 300MW coal-fired power plants in China	Zuoxian Power plant	EPG	6	6	6	6	16%	18%	18%	18%
		Luoher Power plant	EPG	11	9	10	9	5%	8%	8%	8%
		Yaomeng Power plant	EPG	14	12	12	12	1%	4%	4%	5%

***Category:**
EPG= Electric Power Generation, STL=Steel Project, OIL=Oil Refinery, GEO=Geothermal Electricity Power Generation, ETF=Electricity Transfer, CMT=Cement, OTR=Other

***Emissions Trading**
w/o = no emissions trading, Low =Low Growth, High=High Growth