CLEAN DEVELOPMENT MECHANISM AND GEOTHERMAL POWER

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Summary - The Clean Development Mechanism (CDM), promoted by the Kyoto Protocol, encourages developed countries to invest in renewable energy projects based in developing countries and receive credit for the carbon emissions saved by these projects for use to offset the greenhouse gas emissions in their own countries. The aim of the mechanism is to foster financial partnerships that provide access to affordable low-greenhouse gas emitting commercial energy technologies for developing countries.

This paper examines the financial implications for geothermal projects in developing countries for two levels of carbon tax which have been reported. How geothermal compares against wind and biomass renewable energy systems in competing for this clean development investment credit is also examined.

1 INTRODUCTION

Renewable energy continues to make inroads on the world's energy industries but progress has been slower than many expected. At the 6th World Renewable Energy Congress, held from 1 to 7 July 2000 at Brighton, UK, it was estimated that the global renewable energy market would be worth US$11 billion over the next five years. At the Congress the merits of wind, solar and biomass renewable energy systems were fully debated, however, there seems to have been little said about the merits of renewable geothermal energy (WREN, 2000) despite it appearing as a topic in the pre-congress advertising.

The Clean Development Mechanism (CDM), promoted by the Kyoto Protocol, encourages developed countries to invest in renewable energy projects in developing countries and receive credit for the carbon emissions saved by these projects to offset the greenhouse gas emissions in their own countries.

The aim of the mechanism is to foster financial partnerships that link access for developing countries to affordable low-greenhouse gas emitting commercial energy technologies. As yet, the rules for the Clean Development Mechanism have not been set, but these are expected to be finalised at the COP6 meeting 13-24 November 2000 (MfE, 1999).

In January 1999, the New Zealand Ministry for the Environment released a domestic policy options statement to discuss options for addressing the issue of climate change. It sought submissions on how New Zealand's commitment to the Kyoto Protocol could be implemented (MfE, 1999). This document detailed three options for the trading of carbon emissions or the introduction of a carbon charge. The preferred option will be determined after the COP6 meeting.

The potential trade in carbon emissions has been estimated to be worth US$48 billion a year in traders commission alone so the whole process is rapidly gaining momentum. In this paper an attempt has been made to evaluate the worth of geothermal energy in comparison to wind and biomass renewable energy systems in this CDM market in offsetting the carbon emissions from: -

(a) natural gas fired combined cycle plant
(b) fuel oil fired conventional thermal plant
(c) coal fired conventional thermal power plant.

2 GREENHOUSE GAS EMISSIONS

Geothermal fluids contain minerals leached from the reservoir rock and variable quantities of gas, mainly carbon dioxide and a smaller amount of hydrogen sulphide. The gas composition and quantity depend on the geological conditions encountered in the different fields. Virtually the entire mineral content of the fluid and some of the gasses are reinjected back into the reservoir. Most of the non- condensable gasses are released to the environment, although some plants remove the H_2S in a gas treatment process.

CO_2 emissions from high-temperature geothermal fields used for electricity generation vary widely at individual locations but average about 150g/kWh, whereas the CO_2 emissions are 450 g/kWh for natural gas combined cycle plants, 900 g/kWh for oil and 1050 g/kWh for coal fired conventional thermal plants. Gas emissions from low-temperature geothermal fields are only a hction of the emissions from high-temperature fields (Fridleifsson, 2000).

Replacing a combined cycle natural gas fired plant with a geothermal power plant would give a net saving of 300g/kWh of generation. Similarly, if a fuel oil plant is replaced the net saving would be 750 g/kWh, and for a coal-fired plant the saving would be 900 g/kWh, based on Fridleifsson's figures.

However, the figure used for the efficiency of natural gas conversion appears a little low. The Energy Efficiency and Conservation Authority provide figures for CO_2 emission from combustion of coal (320g/kWh), fuel oil (265g/kWh), and gas (190g/kWh) (Everett, 1999). Using these figures the power conversion efficiency for coal and oil thermal plants is 30% and the gas combined cycle plant is 42%. New combined cycle plants have higher efficiency and the saving in CO_2 emission is quite sensitive to this; using an efficiency of 60% gives 320g/kWh for the gas plant. This means the geothermal saving is reduced to 170g/kWh on average and will become very location specific due to the CO_2 variation between fields.

With the biomass plant it is assumed that the carbon sink created by growing the biomass fuel will cancel out the release of carbon when the fuel is consumed in the power plant. The wind and biomass plants therefore have the maximum possible net saving in CO_2 emissions of 450g/kWh, 900g/kWh and 1050 g/kWh; for gas, fuel oil and coal respectively.

3. CARBONVALUE

The Kyoto protocol provides for trading of emission allowances between countries, but individual governments will decide whether companies in their own countries are able to trade in an open market. Taxing the emission of CO_2 within their own countries is one mechanism available to governments to control emission levels.

The preferred mechanisms for meeting the Kyoto protocol commitments are still being debated within the international community, with the possible level of carbon tax and value of tradeable emissions generating considerable discussion. Figures quoted for carbon tax have ranged from as low as US$2.80/tonne to as high as US$12/tonne. The New Zealand Ministry for the Environment used figures of between US$6 and US$15/tonne for its assessment of the likely value of tradeable emissions. For the purpose of this exercise the savings achieved by the three renewable energy system have been calculated for both the low and high carbon tax values.

4. ECONOMIC AND GENERATION PLANT LOAD FACTORS

In this assessment the annual plant load factors for the renewable energy systems studied have been taken as: geothermal 0.90, biomass 0.80 and wind 0.50.

The respective CO_2 reductions and equivalent carbon tax savings have been calculated on one MW of annual generation and the Present Worth of this annual carbon tax saving has been calculated using a discount rate of 10% for a plant life of 25 years (USPWF = 9.077).

5. CDM CARBON VALUE

The Present Value of the CO_2 saving is calculated as follows...

Annual value = MW * hrs * LF * savedCO_2 * $/t

where MW = plant power capacity
hrs = 8760 hours per year
LF = plant annual load factor
savedCO_2 = saving in CO_2 (kg/kWh)
$/t = CO_2 value ($/tonne)

Using carbon values of US$2.80 and US$15.00, the net present value was determined for wind, biomass and geothermal to replace natural gas, fuel oil and coal. Results are shown in Table 1a for two values of natural gas efficiency; low (42%), and high (60%). Tablelb shows results for fuel oil and coal (30% efficiency).

The relative value of each MW of generation capacity can be seen in Figure 1.

Table 1a: CDM incentive credit for replacing natural gas fired combined cycle power plants

	Natural gas (low efficiency – 42%)		Natural gas (high efficiency – 60%)	
	US$2.80 /tonne	US$15 /tonne	US$2.80 /tonne	US$15 /tonne
Geothermal	US$60,100	US$322,000	US$34,100	US$182,500
Biomass	US$80,200	US$429,400	US$57,000	US$305,300
Wind	US$50,000	US$268,300	US$35,600	US$190,800

	Fuel oil		coal	
	US$2.80 /tonne	US$15 /tonne	US$2.80 /tonne	US$15 /tonne
Geothermal	US$150,200	US$805,100	US$180,400	US$966,100
Biomass	US$160,300	US$858,700	US$187,000	US$1,001,900
Wind	US$100,200	US$536,700	US$116,900	US$625,100

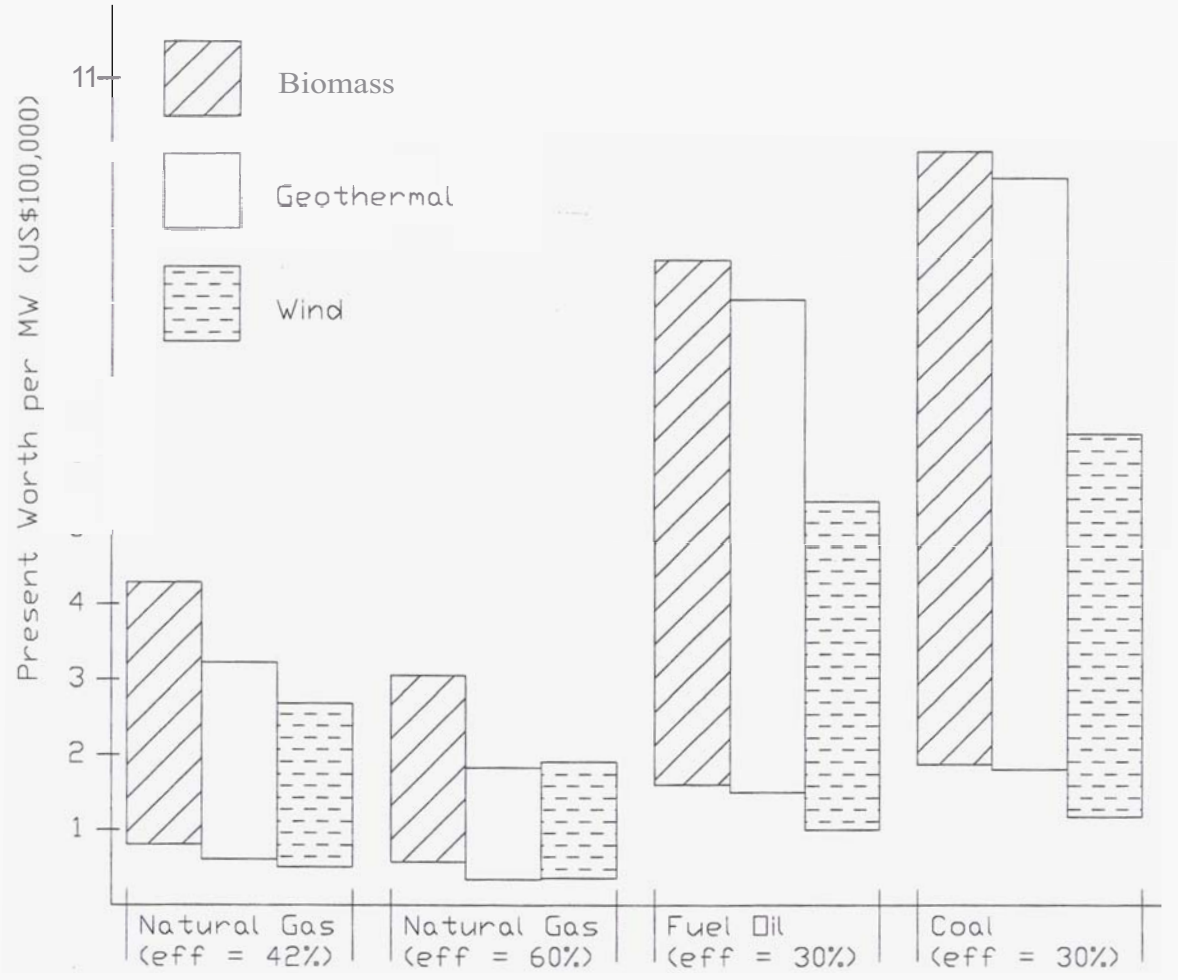

Figure 1: Comparison of CDM incentives for three renewable energy options

For example, when geothermal replaces low efficiency gas at US$2.80 /tonne.

1MWx 8760x 0.9 x 0.3kg/kWh x US$2.80/tonne =US$6,620/MWy

Present worth of this annual saving over a plant life of 25 years at a discount rate of 10% = US$6,620 x USPWF 9.077 = US$60,100/MW

When biomass replaces low efficiency gas at US$2.80 /tonne

1MWx 8760x 0.80 x 0.45kg/kWh x US$2.80/tonne = US$8,830/MWy

Present worth as above: =US$80,200 x USPWF 9.077=US$80,160/ MW

Figure 1 shows that geothermal energy loses its relative advantage against wind as the efficiency of natural gas plants improves. This is because geothermal developments emit some CO_2. High efficiency natural gas will also have a large competitive advantage in CO_2 reduction if replacement of coal or oil is undertaken.

6. CDM IMPACT ON GEOTHERMAL DEVELOPMENT

Assuming a geothermal power plant cost of US$2 million per MW installed then the percentage of this cost, which could possibly be met from CDM incentives arising from the replacement of carbon emissions from the fossil fuels identified above, are shown in Table 2 below.

Table 2: Percentage of Geothermal plant installation cost that could be met from CDM incentive credits

	Carbon Tax	
	US$2.80/Tonne	US$15/Tonne
Natural Gas	3%	16%
Fuel Oil	7.5%	40%
coal	9%	49%

7. DIRECT USE SAVINGS IN CO_2

Substitution of fossil fuels by geothermal has the potential for a much greater relative advantage if the steam is used directly. A comparison can be made using the figures of Everett (1999) for CO_2 emissions from fuel assuming electricity is generated from geothermal steam at an efficiency between 10 and 15%. Using this steam directly would result in the emission of about 15-20 g/kWh of heat supplied. This compares very favourably with coal (320g/kWh), fuel oil (265g/kWh), and even gas (190g/kWh).

The CO_2 saving over gas was in the range 45-65% for electricity generation whereas the saving is 90% or more for *direct* use. Replacement of coal or fuel oil would result in even greater relative savings.

Projects for the direct use of geothermal energy would probably be implemented in a similar manner to electrical developments using the Clean Development Mechanism.

8. CONCLUSION

From Table 2 it can be seen that substantial CDM credit incentives for geothermal electrical development will only be realized if the carbon value exceeds around US$8 per tonne of CO_2 released to the atmosphere. At this level CDM credit incentives could contribute around 25% of the plants installation costs. A larger potential for savings exits in *direct* use projects.

9. REFERENCES

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