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The *Clean Development Mechanism* as a Useful Initiative to Promote the Development of Sustainable Environment Projects with Public-Private Participation: Experiences from Turkey

Gürkan Kumbaroğlu[a], Yıldız Arıkan[b], Arzu Sunam[a]

[a] *Department of Industrial Engineering, Boğaziçi University, Bebek, 34342 Istanbul, Turkey*

[b] *The Graduate School of Management, Sabancı University, Orhanlı, Tuzla, 81474 Istanbul, Turkey*

ABSTRACT

The 1997 Kyoto Protocol established the Clean Development Mechanism (CDM) as a way of promoting sustainable development while minimizing the costs of limiting greenhouse gas emissions. The mechanism features companies from developed countries to earn certified emission reductions in return for investing in a sustainable development project that avoids emissions in a developing country. The Kyoto Protocol has not become legally binding yet, and the process involved in undertaking CDM projects consists of multiple complex and burdensome steps. However, CDM is still very useful in attracting public and private sector participants for the development of sustainable environment projects in developing countries.

In this paper, we share our experiences on establishing business opportunities for CDM project development in Turkey. Six promising project proposals with public-private partnerships that have been initiated through the CDM initiative are described. We conclude that CDM, though it involves many uncertainties, is a useful initiative creating local and global value added by promoting the expansion of sustainable environment projects with public-private participation in developing countries.

Keywords: Kyoto mechanisms, CDM, certified emission reduction

1 INTRODUCTION

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) introduces three flexibility mechanisms, namely international emissions trading (IET), joint implementation (JI), and the clean development mechanism (CDM) for economic efficiency in the reduction of greenhouse gas (GHG) emissions. That is, IET, JI and CDM feature reducing emissions where it is cheapest to do so. The latter two are project-based mechanisms that provide incentives for investors to invest into emission reducing projects in a foreign country when the specific reduction costs are lower. More specifically, the emission reductions of a project in country A are certified and credited towards the emission commitments of the investing party from country B who co-finances the project by buying the *certified emission reductions* (CER) of CDM projects (or so-called *emission reduction units* (ERU) in the case of JI projects). JI covers the cooperation between industrialized countries whereas CDM is defined for the financing of projects in developing countries by investors from industrialized countries. The implementation of CDM projects is of particular importance as developing countries' GHG emissions are projected to increase rapidly, implied by accelerated energy use. Investment choices to meet the growing energy demand in developing countries are typically based on economic considerations rather than environmental concerns. An adoption of expensive clean energy technologies or costly emission abatement technologies could therefore not be expected without subsidies.

Noting that the industrialized economies are historically responsible for the largest share of global GHG emissions, they should take the lead in curtailing the problem as put forward by the UNFCCC (1992). The Brazilian Proposal (1997) for responsibility sharing based on the historical emission contributions has not been implemented, though it is still under discussion at a theoretical level (Rosa et al., 2004). Responsibility sharing based on future emission contributions on the other hand will put a heavy burden on the shoulders of developing countries, i.e. on those least responsible for the current problem. In this context, CDM emerges as a useful mechanism which assumes a “common but differentiated responsibility”: those that have a historical responsibility (industrialized countries, or so-called Annex I countries of the Kyoto Protocol) are encouraged to take action in developing countries, where emissions are expected to grow most rapidly in future. The appeal of CDM is due to the win-win situation it establishes: industrialized countries are supported in reaching their emission targets more economically whereas developing countries get financial support for their activities towards an ecologically sustainable development.

The following section provides an overview on the CDM project cycle from identification to implementation. Section 3 reviews Turkey’s evolution towards UNFCCC ratification, and discusses her status with respect to CDM project hosting. CDM project proposals for Turkey, developed under support by the European Commission, are presented in the next section. Section 5 summarizes and concludes.

2 THE CDM PROJECT CYCLE

The CDM project cycle consists of multiple complex and onerous steps as shown in Figure 1. The identification of the project and development of a project concept note takes into account the local requirements for project eligibility. The quantification of greenhouse gas benefits includes details on project boundaries, baseline and project emissions, and additionality assessment. The results and methodologies used in the quantification of the greenhouse gas benefits are presented in a Project Design Document (PDD), together with details on the financing and crediting period, to the CDM Executive Board for approval. The approval is based on strong refereeing criteria, including detailed scrutiny of the PDD, the institutional capacity of project stakeholders, the calculations of emission reductions, and the systems to be used for monitoring. Registered projects, and those that have entered the implementation phase, are required to maintain internal monitoring systems to demonstrate they are achieving the emission reductions specified in the PDD.

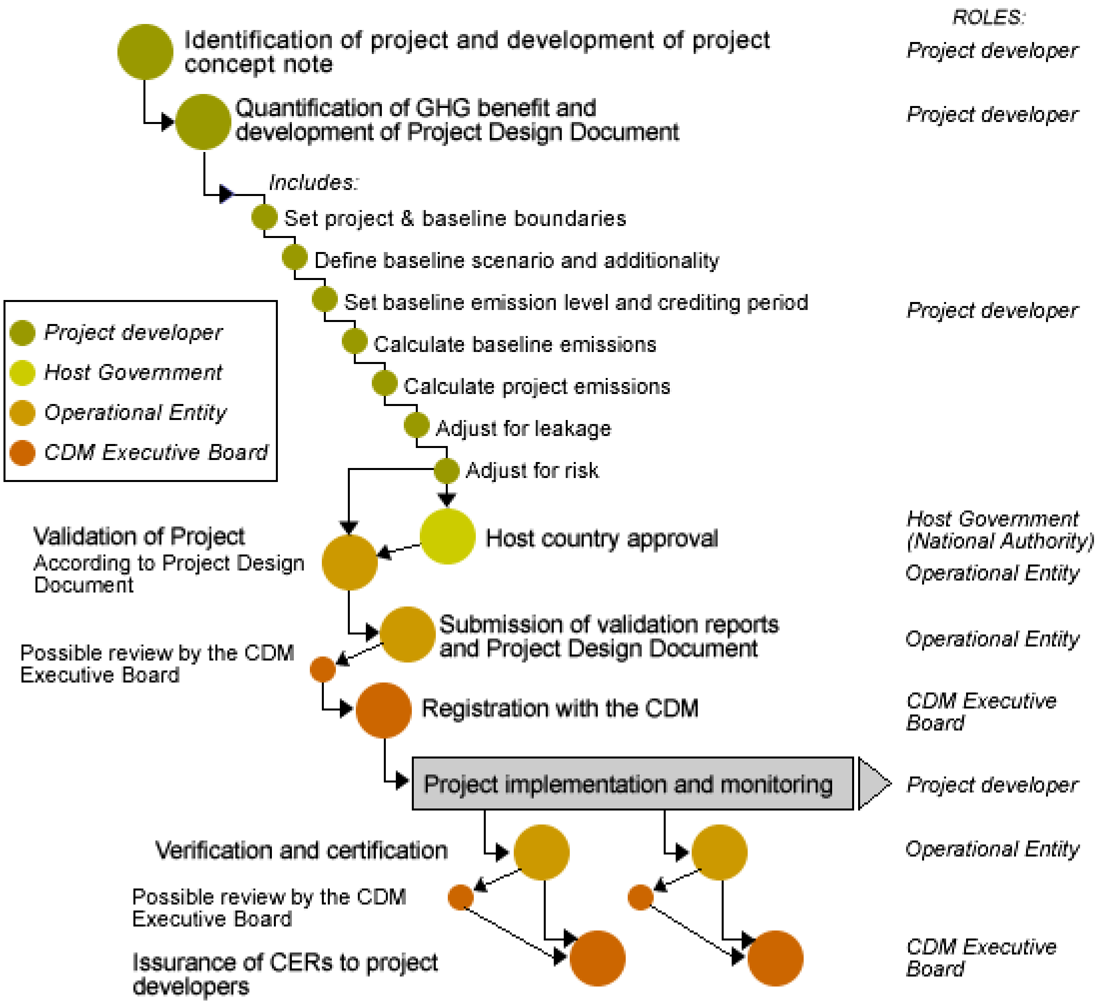

Figure 1. A Simplified CDM Project Flow (Source: Aukland et al., 2002)

3 CAN TURKEY HOST CDM PROJECTS?

Turkey's participation in the UNFCCC has been approved by the Grand National Assembly on October 21, 2003, and since May 2004 Turkey has became the 189th party to the convention. Turkey delayed her accession because of the original annex allocation: as an OECD member country, Turkey had been included in both Annex I (industrialized countries) and Annex II (developed countries which pay for costs of developing countries) to the Convention in 1992. Turkey's request to be withdrawn from the list of both annexes (based on the fact that the country is at an early stage of industrialization) did not find response until 2001 when the deletion of Turkey from Annex II has been accepted at the Marrakech Conference. Turkey retained in Annex I subject to the condition to enjoy favorable conditions in accordance with the "common but differentiated responsibilities" principle of the UNFCCC.

It is the Annex I countries that can invest in JI/CDM projects as well as host JI projects, and non-Annex I countries that can host CDM projects. Hence, strictly speaking, Turkey (as an Annex I country) would not be able to host CDM projects. However, the exception of favorable conditions for Turkey (which primarily means that the country will be in a position to take on a quantified emission reduction commitment, while being in the same position as the economies in transition as regards providing funding for developing countries) might be interpreted/extended to include the hosting of CDM projects as well. Obviously there exists some uncertainty with respect to Turkey's status, which is due to the fact that Turkey has not yet ratified the 1997 Kyoto Protocol (which itself is not a legally binding document at present[1]).

The EU has ratified the Kyoto Protocol committing herself to reduce average GHG emissions by 8% in the first commitment period (2008-2012) compared to 1990 levels. And the EU is going ahead, independent of the entry into force of the Protocol. The European Emission Trading Scheme will become operational by January 2005. Moreover, the EU is currently considering a *Linking Directive* to legalize the use of Kyoto mechanisms in Europe.[2] Environmental sustainability will therefore be on the agenda of Turkey's accession talks with the EU, which can be expected to begin by 2005.[3] It is therefore realistic to expect during the preparatory phase for membership, that the EU will favor CDM project proposals to be hosted in Turkey.

4 CDM PROJECT PROPOSALS FOR TURKEY

In total, there are six CDM project proposals developed for Turkey. Five of these are projects proposed by private sector companies as the major shareholder, while the other one is a university origined project. This section provides a brief description of the projects, and presents the targeted emission reductions computed as the difference between baseline and project emissions. Financial information for all projects is provided together with CER price offerings, which represent the project proposers' expectations for additional cash inflow for the investment to be realized.

The first three projects described below are proposed by the same private sector company (IGATAS), whose majority shares belong to the Metropolitan Municipality of Istanbul (MMI). Furthermore, consumer of the renewable energy output of these projects is the MMI. Because of these facts, these three projects are unified under the title of "*Eurasia- İstanbul Municipality Renewable Energy Project*s". Although the three projects defined below have different financial and investment plans regarding their technology and timings, and are described separately, evaluating them under the same roof will enable to balance their cash flows.

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[1] The ratification of 55 industrialized nations accounting for at least 55% of the global greenhouse gas emissions in 1990 is required for the Protocol to become legally binding.

[2] The directive links the EU emissions trading scheme to the Kyoto Protocol mechanisms. It allows credits from emissions reduction projects, primarily outside the EU, to be used to offset emissions within the EU under the emissions trading scheme. The Irish Presidency has declared that it considers the Linking Directive to be the most important of the climate issues for its six-month tenure.

[3] The EU has agreed to decide upon Turkey's progress in fulfilling the Copenhagen political criteria in December 2004, and then begin accession talks without delay should the country pass the review.

4.1. A wind energy project for ISKI (Istanbul Water Authority) Durusu district pumping station

This project is proposed by IGATAS, which has been established with the mission to supply energy requirement of MMI and its affiliate companies. The company's activities are mostly based on renewable energy technology applications, sustainability and clean development. Together with MMI, the Istanbul Water Authority (ISKI) is also a shareholder of IGATAS. Due to weakness in sustainable energy supply, ISKI is facing energy bottleneck problems for its pumping and purifying stations. To overcome this weakness, alternative energy sources should be introduced. In this project, IGATAS aims to eliminate interruptions in water supply due to electricity outage at the pumping stations by introducing wind power. In this regard, wind energy is not only essential for environmental sustainability but also important for the sustainability of public services. Besides the continuity of public services, this project also reduces costs that ISKI bears due to electricity shortage. These costs can be considered to be composed of three sources

- Reduced income as ISKI cannot sale water during the off time.
- Corrosion problem of pipelines when the line is empty.
- Inertia momentum for the restart of pumps, which consumes more energy till regular conditions are reached.

This project aims to cover 50 % of the energy requirements of ISKI Durusu Osmangazi pumping station by wind power. The Durusu region has a good capacity in terms of wind energy. As far as the measurements are concerned, there is more then 20 GWh production capacity in the region. This capacity will be utilized by installing state-of-the art windmills. After a pre-feasibility study including 12 months of measurement of Durusu wind energy characteristics**,** IGATAS has found 3 feasible points to install wind energy turbines with the capacity of 7,2 MW. The average production capacity factor is expected to be 32 %.

As this is a wind energy project, there are no emissions associated with it. Therefore, the amount of reduced emissions equals the baseline emissions (from conventional power generation sources that the wind energy substitutes). The calculations are as follows:

Annual baseline emissions $= 0.537\ t\ CO_2/MWh$[4] $\times 20{,}235.6\ MWh = 10{,}866.5\ t\ CO_2$

Annual emission reduction $= 10{,}866.5\ t\ CO_2 - 0\ t\ CO_2 = 10{,}866.5\ t\ CO_2$

Total emission reduction $= 10 \times 10{,}866.5\ t\ CO_2 = 108{,}665.0\ t\ CO_2$
(Over the project crediting lifetime of 10 years)

The financing information over the project-crediting lifetime for this project is summarized in Table 1.

[4] Weighted average emission factor for power generation in Turkey in year 2001.

Table 1. Financing Information for the Durusu Wind Energy Project

Costs			Revenues				
Fixed Cost	Var. cost (over 10 years)	Total cost (over 10 years)	CER price	CER revenue (over 10 years)	Service price	Service revenue (over 10 years)	Total revenue (over 10 years)
€	€	€	€/t CO_2	€	€cent/kWh	€	€
7,906,100	1,770,000	9,676,100	5	543,330	5.61	11,352,170	11,895,500

4.2. An LFG-to-energy project: Capturing the landfill gas (LFG) from municipal solid waste storage areas to generate electricity in gas turbines

This project is again proposed by IGATAS, an MMI conglomeration, under the title of "*Eurasia- İstanbul Municipality Renewable Energy Projects*", as previously mentioned. MMI is responsible for removal of nearly 3.5 million tones per year municipal solid waste (MSW) that is collected from 28 providence and 13 commune municipalities with bearing considerable costs. The daily waste production per capita is approximately 0.8-0.9 kg, which makes 9400 t/day.

Currently there are two designed waste storage areas in Istanbul, one in each side of the Bosphorus: Komurcuoda (on Asian side with capacity of 3000 t/day, 20 years life-span) and Odayeri (European side, with capacity 6000 t/day, less than 8 years life-span). Landfill gas, which occurs as a natural by-product of anaerobic fermentation, is currently penetrating into the atmosphere. In this project, the LFG will be gathered and used to produce electricity by gas engines or turbines. The experimental studies show that 1 ton MSW produces approx. 10 m^3 LFG per year, which implies the diffusion of 743.35 kg CO_2 and 320.5 kg CH_4 into the atmosphere (over a lifetime of 22 years). The resulting total CO2-eq. emissions amount to 7473.85 kg, considering the fact that the CO2-equivalence of methane is about 21. As the accumulated current storage of MSW at Komurcuoda and Odayeri totals 23.5 million tons, the total emissions emitted over the lifespan of the LFG (22 years) are computed as

$$23{,}500{,}000\ t\ MSW \times 7{,}473.85\ kg\ CO_2\text{-}eq\ /\ t\ MSW = 175{,}635{,}475\ t\ CO_2\text{-}eq$$

Assuming a uniform distribution over the 22 years, the annual baseline emissions are computed as

$$\text{Annual baseline emissions} = 175{,}635{,}475\ t\ CO_2\text{-}eq\ /\ 22 = 7{,}983{,}430\ t\ CO_2\text{-}eq$$

In this project, the LFG is collected by pipeline under negative pressure from wheel, which has 25 cm diameter and 8-15 meters depth. After conditioning and purifying the LFG, will be used as a fuel of the gas engine or turbine. For the sake of efficiency the combined cycle, which means gas engine/ turbine plus steam engine will be used to get benefit of the idle thermal energy after combustion in the engine. The produced electricity will be connected to the grid to supply the energy requirement of MMI. Although the LFG to Electricity technology is very common worldwide, this technology will serve as a replicable model for other such projects in Turkey.

The objectives of the project can be summarized as minimizing the MSW inventory, optimizing land usage for the MSW, and introducing new alternative domestic energy supply alternatives.

As a result of a detailed feasibility study, a 15 MW combined cycle power plant is assessed as feasible for utilizing the LFG potential. At a duration of 8000 hours, it is expected that 120,000,000 kWh power will be generated annually. Hence, the project emissions and implied emission reductions are computed as

Annual project emissions $= 120{,}000{,}000\ kWh \times 0.631\ kg\ CO_2/kWh$[5] $= 75{,}720\ t\ CO_2$

Annual emission reduction $= 7{,}983{,}430\ t\ CO_2\text{-}eq - 75{,}720\ t\ CO_2 = 7{,}907{,}710\ t\ CO_2\text{-}eq$

Total emission reduction $= 10 \times 7{,}907{,}710\ t\ CO_2\text{-}eq = 79{,}077{,}100\ t\ CO_2\text{-}eq$
(over the project crediting lifetime of 10 years)

The financing information over the project crediting lifetime for this project is summarized in Table 2 below.

Table 2. Financing Information for the LFG-to-Energy project

Costs			Revenues				
Fixed Cost	Var. cost (over 10 years)	Total cost (over 10 years)	CER price	CER revenue (over 10 years)	Service price	Service revenue (over 10 years)	Total revenue (over 10 years)
€	€	€	€/t CO_2	€	€cent/kWh	€	€
16,795,000	41,600,000	58,395,000	5	395,385,500	5.61	67,864,220	463,249,720

4.3. A pyrolysis-gasificiation of MSW-to-electricity project: Turning wastes into energy-rich fuels by heating the waste under controlled conditions.

This is the last project proposed by IGATAS under the title of "*Eurasia- İstanbul Municipality Renewable Energy Projects*". As mentioned in the foregoing section, there are two landfill waste storage areas for the MSW of Istanbul. These areas are supplied by 400 specially designed big-size trucks, which bring the MSW from six transfer stations. The MSW from all of the 32 provinces first visits one of these transfer stations. Table 3 below provides an overview of the distances and open space areas.

Table 3. MSW Transfer Stations

Transfer Station	Landfill area	Distance to LF Area	Open space
HALKALI	ODAYERİ / European Side	43 Km	40,000 m^2
YENİBOSNA		38 Km	40,000 m^2
BARUTHANE		26 Km	20,000 m^2
AYDINLI	KÖMÜRCÜODA / Asian Side	53 Km	40,000 m^2
K.BAKKALKÖY		48 Km	20,000 m^2
HEKİMBAŞI		44 Km	30,000 m^2

[5] Source: InnovEnergy LFG ERC Report (2000)

In this project, it is proposed that 1000 tpd MSW be treated in transfer stations to produce electricity. As a result, 400 journeys of big-capacity-transfer trucks in a day to an average distance of 100 km (two-way) will be eliminated. Given that the utilized Diesel Cummins Garbage trucks emit 1,371 g CO_2-eq / km, their annual emissions are computed as

$$400 \text{ veh/day} \times 365 \text{ days/year} \times 100 \text{ km/veh} \times 1371 \text{ g } CO_2\text{-eq / km}$$
$$= 20{,}016.6 \text{ t } CO_2\text{–eq / year}$$

Moreover, by treatment of MSW at the very beginning, the penetration of LFG to the atmosphere will be prevented. It is proposed that 1000 t/day MSW will be used to generate electricity. Given the same emission factor (7,473.85 kg CO_2-eq/t) as explained in the foregoing section, the annual emissions of the 1000 t/d MSW are computed as

$$1000 \text{ t/day} \times 365 \text{ days/year} \times 7{,}473.85 \text{ kg } CO_2\text{-eq / t} = 2{,}727{,}955.3 \text{ t } CO_2\text{-eq}$$

Hence, the baseline emissions are

$$\text{Annual baseline emissions} = 20{,}016.6 + 2{,}727{,}955.3 = 2{,}747{,}971.8 \text{ t } CO_2\text{-eq}$$

Both pyrolysis and gasification turn wastes into energy-rich fuels by heating the waste under controlled conditions. In contrast to incineration, which fully converts the input waste into energy and ash, these processes deliberately limit the conversion so that combustion does not take place directly. Instead, they convert the waste into valuable intermediates that can be further processed for materials recycling or energy recovery i.e. syngas, oils and char. The gasification technology gives the versatility and flexibility to solve many municipal and industrial waste disposal problems.

Considering the composition of Istanbul MSW as depicted in Table 4, the power generation capacity will be around 41 MW for the 1000 tons MSW. At duration of 8064 h/year, this implies 330,624,000 kWh annual electricity productions. The resulting project emissions and implied emission reductions are

$$\text{Annual project emissions} = 330{,}624{,}000 \text{ kWh} \times 0.537 \text{ kg } CO_2/\text{kWh}^{6} = 177{,}545 \text{ t } CO_2$$

$$\text{Annual emission reduction} = 2{,}747{,}972 \text{ t}CO_2\text{-eq} – 177{,}545 \text{ t}CO_2 = 2{,}570{,}427 \text{ t}CO_2\text{-eq}$$

$$\text{Total emission reduction} = 10 \times 2{,}570{,}427 \text{ t } CO_2\text{-eq} = 25{,}704{,}270 \text{ t } CO_2\text{-eq}$$
(over the project crediting lifetime of 10 years)

Table 4. Istanbul Municipal Solid Waste Analysis Results*

Material Class	European Side %		Asian Side %	
	Original basis	Dried basis	Original basis	Dried basis
Paper	9.70	7.53	5.21	3.74
Glass	4.85	8.17	3.90	6.07
Metal	1.39	2.34	1.95	2.94
Diaper	7.20	6.18	6.51	5.17
Organic	52.86	39.17	54.66	43.39

[6] This emission factor represents an approximation as no specific estimate was available for CO_2 emission through pyrolysis/gasification of MSW.

Table 4 cont'd

Material Class	European Side %		Asian Side %	
	Original basis	Dried basis	Original basis	Dried basis
Plastic bag	9.58	15.80	10.41	15.88
PE or PVC	2.24	3.77	1.30	2.02
Cardboard can	0.57	0.96	1.95	3.02
Textile	3.66	3.85	5.21	5.03
Plastic bottles	1.02	1.71	1.74	2.71
Ash & Others	6.93	10.52	7.16	10.03
Total	100.00	100.00	100.00	100.00

*: Analysis has been done by Yildiz Technical University

The financing information for this project is summarized in Table 5 below.

Table 5. Financing Information for the Pyrolysis-Gasification of MSW-to-Electricity Project

Costs			Revenues				
Fixed Cost €	Var. cost (over 10 years) €	Total cost (over 10 years) €	CER price €/t CO_2	CER revenue (over 10 years) €	Service price €cent/kWh	Service revenue (over 10 years) €	Total revenue (over 10 years) €
123,840,000	142,150,000	265,990,000	3	77,112,810	5.61	185,495,550	262,608,360

4.4. Energy Efficient Schools in the City of Erzurum

This project is proposed by IZOCAM, which is an insulation material producing company traded in the Istanbul stock exchange that belongs to Koc Group, which is the biggest group in Turkey with 108 conglomerates. The company offers a wide range of products providing high quality insulation materials against heat, cold, sound, fire and water proofing. In this project, IZOCAM proposes to decrease emissions in educational buildings in the city of Erzurum by employing various energy conservation measures and techniques.

The building sector with 34% of final energy consumption in Turkey, comparing to about 20 and 4% final energy use in the transport and agriculture sectors respectively, is by far the largest end-user in total fossil fuels by 85%. Educational buildings make up almost 0.37% of the total building stock (due to the Building Census 2000) in Turkey. The project "Energy Efficient Schools" is a large-scale first implementation of the energy conservation efforts to reduce GHG emissions from buildings in Turkey. The city of Erzurum (in the East Anatolian Region) has been chosen for implementation due to a quite high number of heating degree days (4990 degree days p.a.). With the compilation of the project, greenhouse gas emissions from schools in Erzurum will be reduced by energy efficiency improvements using retrofit measures, readily available efficiency technologies (such as energy efficient light bulbs), and renewable energy applications. This project will transform unqualified schools to qualified educational buildings aiming to reduce GHG emissions with a target of reaching zero emission level.

In the pilot phase, energy auditing is done for a pilot school with subsequent improvement of insulation, glazing, installation of solar water heaters and solar PV, low energy light bulbs, energy management and control system, etc. Furthermore, energy savings will be measured and monitored. In continuation, as the second phase, it is planned to expand the measures to 354 other schools in Erzurum, which may well be followed by a third phase of promoting the actions across Turkey.

As the starting point of this project, it is aimed to ensure heating with maximum conservation and minimum consumption of energy, and reduce emissions by providing increased indoor comfort conditions. By improvement of building structure and heating system with the support of heat recovery, thermal storage and RES, it is planned to reach "zero or low emission" target.

Therefore,
Total Direct Project Emissions ≈ 0

The schools in Erzurum have an emission potential of nearly 64 kt CO_2/year . Hence,

Annual baseline emissions= 64,000 t CO_2/year

Annual emission reduction = 64,000-0=64,000 t CO_2/year

Total emission reduction $= 10 \times 64{,}000\ t\ CO_2 = 640{,}000\ t\ CO_2$
(over the project crediting lifetime of 10 years)

The financing information over the project-crediting lifetime for this project is summarized in Table 6 below.

Table 6. Financing Information for the Energy Efficient Schools Project

Costs			Revenues				
Fixed Cost €	Var. cost (over 10 years) €	Total cost (over 10 years) €	CER price €/t CO_2	CER revenue (over 10 years) €	Service price €cent/kWh	Service revenue (over 10 years) €	Total revenue (over 10 years) €
35,000,000	uncertain	≥35,000,000[7]	55	35,200,000	uncertain	uncertain[8]	35,200,000

4.5. Borehole Ground Cooling for Telecommunication

This project is proposed by Cukurova University Center for Environmental Research, who has been involved in thermal energy storage (TES) projects for 10 years, has been representing Turkey in International Energy Agency Energy Storage Implementing Agreement since 1995, and has been serving as the operating agent for Annex 14 cooling with TES international collaborative projects since 1999. The project is going to be implemented in collaboration with SWECO, a Swedish company, which provides leading-edge services ranging from expert advice in planning and pre-investment

[7] Variable costs shall be added to the fixed costs to compute the total cost. However, as no reliable estimates for the variable cost component are available yet, the fixed cost of 35 million € is presented as a minimum.
[8] The project will lead to significant savings in fuel cost, however it is unclear if these can be considered as project revenues for the project owner.

studies to integrated services in design and project implementation. In this project, it is planned to employ TES systems for the cooling of radio base stations.

The telecommunication services for mobile phones are given through radio base stations (RBS). The number of these stations in Turkey is estimated to reach 50000 by 2005. The station is a small airtight cabinet with electronic equipment inside. The continuous heat dissipation by electronic equipment in the cabinet increases the ambient temperature. Cooling is required to maintain an optimum temperature of 23-25ºC. Currently used split systems vary in capacity between 2,5-7 kW. The proposed ground cooling with boreholes project replaces the cooling unit using electricity generated mostly by fossil fuel power plants and utilizes renewable natural resources namely thermal energy storage for direct cooling of these stations. With the application of direct cooling units, besides the utilization of natural cold resources, a substantial amount of electricity is expected to be conserved. The reduction in electricity consumption will decrease greenhouse gas emissions.

The proposed system uses ground cooling unit with borehole heat exchangers (BHEX), outdoor-air and ambient air cooling units with fan coils. There are two circulation loops, one connects the ambient cooling unit with ground cooling unit and the second connects outside-air unit to the main loop via a heat exchanger. For a system with 100 m borehole, the cooling capacity will be in the range of 2-5 kW. For the project, a cooling capacity of 4 kW is considered to be sufficient with estimated total cooling time of 6000 hours per year. Accordingly, the project will generate 24 MWh of cooling power for each telecommunication station annually. Assuming that ground cooling will be used for 3000 stations, the total annual generated cooling energy will be 72 GWh.

The telecommunication station cooling project emissions are related to electricity consumption to run one circulation pump (0.20 kW capacity) and one fan (0.30 kW capacity). The outside-air loop will provide 2000 hours and ground cooling will provide 4000 hours; 1000 hours of cold recharging can be done. The corresponding electricity consumption of each telecommunication station per year will be:

1. Outside-air loop: $(0.30 + 0.20) \times 2000 = 1000$ kWh
2. Ground cooling: $(0.30 + 0.20) \times 4000 = 2000$ kWh
3. Recharging: $(0.30 + 0.20) \times 1000 = 500$ kWh

TOTAL = 3500 kWh = 3.5 MWh

Direct Project Emissions per station = 3.5 MWh × 0.537 t CO2/MWh = 1.9 t CO_2.

For the baseline scenario, considering the consumption of an equivalent conventional cooling unit of 12 MWh (per year per station), annual baseline emissions and implied emission reductions are found as

Annual baseline emissions per station = 0.537 t CO2/MWh × 12 MWh = 6.4 t CO_2.

Annual emission reduction per station= 6.4 t CO2 – 1.9 t CO2 = 4.5 t CO_2

Annual emission reduction for 3000 stations = 4.5 t CO2× 3,000 = 13,500 t CO_2

Total emission reduction = 10 × 13,500 t CO_2 *= 135,000 t* CO_2
(over the project crediting lifetime of 10 years)

The financing information over the project crediting lifetime for the project is summarized in Table 7 below.

Table 7. Financing Information for the Borehole Ground Cooling Project

Costs			Revenues				
Fixed Cost €	Var. cost (over 10 years) €	Total cost (over 10 years) €	CER price €/tCO_2	CER revenue (over 10 years) €	Service price €cent/kWh	Service revenue (over 10 years) €	Total revenue (over 10 years) €
12,682,300	66,650	12,748,950	8	1,080,000	23.5	6,000,000	7,080,000

4.6. Power Plant Efficiency Monitoring and Optimization

This project is proposed by BGM engineering, a private sector company that provides control system engineering, consultancy, and maintenance and construction services. The main interest area of BGM is power plant automation including steam generators, balance of plant, switchyard system and plant coordination. In this project, BGM proposes to decrease emissions by improving energy efficiency in specific power plants through developing and implementing a professional software called 'Sigmapower'. Sigmapower Performance Monitoring and Optimization, which is planned to be a universally adaptable and compatible performance monitoring and optimization system, will be applied to two larger-scale producers and some smaller separate customers in the Turkish energy market. The two big companies, namely Akenerji and Enerjisa, have a total of 540+370 MW power generation capacity. With the addition of other customers that have declared to employ Sigmapower if subsidized through CDM, the total installed capacity with Sigmapower implementation is planned to be 1500 MW of natural gas combined cycle power plant. A 1% efficiency improvement is expected through Sigmapower implementation, increasing the efficiency from 0.49 to 0.50. Employing an emission factor of 0.21 kg CO_2/kWh, and assuming a low capacity factor (duration of 1000 hours) due to uncertain market conditions, the baseline emissions, project emissions, and implied emission reductions are computed as

Annual baseline emissions
$= 0.21\ tCO_2/MWh \times 1{,}500{,}000\ MWh/year / 0.49 = 642{,}857\ t\ CO_2/year$

Annual project emissions
$= 0.21\ tCO_2/MWh \times 1{,}500{,}000\ MWh/year / 0.50 = 630{,}000\ t\ CO_2/year$

Annual emission reduction $= 642{,}857\ t\ CO_2 - 630{,}000\ t\ CO_2 = 12{,}857\ t\ CO_2$

Total emission reduction $= 10 \times 12{,}857\ t\ CO2 = 128{,}570\ t\ CO_2$
(over the project crediting lifetime of 10 years)

The financing information for this project is summarized in Table 8 below.

Table 8. Financing Information for the Energy Efficiency Software Project

Costs			Revenues				
Fixed Cost €	Var. cost (over 10 years) €	Total cost (over 10 years) €	CER price €/t CO_2	CER revenue (over 10 years) €	Service price €cent/kWh	Service revenue (over 10 years) €	Total revenue (over 10 years) €
636,000	50,000	686,000	5	642,850	1.8	270,000	912,850

5. SUMMARY AND CONCLUSIONS

All of the CDM project proposals described in this paper have been developed with a common methodology (developed in the frame of a project supported by the European Commission under the SYNERGY program[9]), and have passed a pre-feasibility analysis. The pre-feasibility analysis includes a technical, financial and risk analysis, as well as a sustainable development analysis. The viability check for project risks includes an analysis of various risk categories including baseline risk, project emission risk, emission reduction verfication risk, Kyoto Protocol risk, market/price risk, technology risk, construction risk, supply risk, business risk, financial risk, political risk, contractual risk, credit risk, environmental risk, social risk, capacity risk and force majeure. For the sustainable development check, various criteria and indicators are explored to assess the projects' contribution to sustainable development considering its commonly accepted dimensions: environmental, social, economic and technological.

The Turkish experience shows that CDM is a useful initiative to promote the development of sustainable environment project proposals with public-private participation. The projects enhance their profitability and become attractive only through CER revenues. This is in line with the investment additionality requirement[10] for CDM projects, which has also been verified using the barriers approach (various approaches for defining investment additionaltiy are discussed in Greiner/Michaelowa, 2003). The financial viability of the projects implies different CER price offerings ranging from 3-55 €/t CO_2-eq. as evident in Table A1. The upper limit, set by the 'energy efficient schools' project, is an outlier occuring due to the fact that the energy savings'are not considered as an income since it is unclear if these can be considered as project revenues for the project owner. The project, however, has a very strong contribution to the sustainable development goals of the country as it is to be implemented in the schools of an exceptionally low-income region in Turkey. In this respect, it can become interesting once the uncertainty about project revenues is resolved, and additional financing by development funds becomes avaliable so that CER offer prices decrease. The other projects' CER prices are decent in the range 3-8 €/t CO_2-eq.

The CER price offerings imply roughly calculated cost/revenue (C/R) ratios of 0.81, 0.13, 1.01, 1.00, 1.80 and 0.75 for the projects 4.1, 4.2, 4.3, 4.4, 4.5 and 4.6 respectively. This shows that the LfG-to-Electricity project 4.2 is quite attractive from a financial point of view. Indeed, the service revenues over the 10 years crediting period are alone sufficient to cover all costs of this project. Similarly, the wind energy project 4.1 can cover all its costs through service revenues in 10 years, and the pyrolysis-gasification project 4.3 can cover 99% of its costs. The energy efficient schools project 4.4 has a C/R ratio about 1 because CER price offerings are computed such that all costs are covered through CER revenues. The comparatively high price offering for this project might fall to a reasonable level if uncertainties related to its service revenues are resolved. An attractive CER price offer of 5 €/t CO_2 is given for the energy efficiency software project 4.6 with a C/R ratio of 0.75. The borehole ground cooling project 4.5 has the highest C/R ratio because its CER price is kept

[9] http://meda-cdm.epu.ntua.gr/
[10]The CDM project should not be a business-as-usual scenario, i.e. CERs issued through CDM should not represent emission reductions that would happen anyway.

reasonable at 8 €/t CO_2 , and not increased to cover all project costs in excess of those covered by service revenues. In other words, the total CER revenues of this project cover only 8.5% of total costs; 47.1% comes from service revenues, and 44.4% are covered from other financing sources. It should be noted that the C/R indicator represents only a rough calculation, and also ignores all non-monetary benefits of the projects.

The Kyoto Protocol is not a legally binding document yet. However, project-based emission reductions are currently being traded in informal markets as investor countries want to profit form early low prices. Presently, the unofficial trading occurs at prices of about 5 \$/ton CO_2-eq. In general, observers believe that such prices are too low to make JI or CDM projects attractive. The case of Turkey, however, indicates that such prices might well be attractive enough to initiate clean development project proposals, although none of the proposed projects can be considered as having a high internal rate of return (which is characteristic for CDM/JI projects as they would otherwise be part of the baseline, i.e. they would possibly be realized even without the financial assistance through CDM/JI, and could not be considered as CDM/JI projects because of not satisfying additionality). Obviously, the CER offer prices are barely enough to make the projects become financially attractive. Therefore, taking the uncertainty regarding Turkey's status into account, it should be mentioned that if the country's hosting of JI rather than CDM projects would become possible, than the prices of ERUs for the presented project proposals could be expected to be roughly twice as high assuming that reduced emissions are shared between the involved parties. Still, the projects remain attractive for investors as price expectations for the official trading period climb up to 74 \$/ton CO_2-eq. with an average of 27 \$/ton CO_2-eq. (Springer/Varilek, 2004).

If the current Turkish CDM project proposals are successfully implemented, they might obviously serve as a model for other similar implementations. It is therefore essential that uncertainties regarding the implementation of CDM projects are resolved. Their potential to increase environmental awareness, mitigate GHG emissions, and contribute to sustainable development in the developing world, suggests that ways to realize CDM projects should be elaborated even if Kyoto does not become a legally binding document.

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APPENDIX

Table A1. Financial Information for the Turkish CDM Project Proposals[i]

Project	Costs			Revenues					Cost / Rev.	Emission Reductions
	Fixed Cost	Var. cost (over 10 years)	Total cost (over 10 years)	CER price offer [ii]	CER revenue (over 10 years)	Service price	Service revenue (over 10 years)	Total revenue (over 10 years)	C/R Ratio	Total reductions (over 10 years)
	€	€	€	€/t CO_2	€	€cent/kWh	€	€		t CO_2-eq
4.1. Durusu Wind Energy	7,906,100	1,770,000	9,676,100	5	543,330	5.61	11,352,170	11,895,500	0.81	108,665
4.2. LFG-to-Electricity	16,795,000	41,600,000	58,395,000	5	395,385,500	5.61	67,864,220	463,249,720	0.13	79,077,100
4.3. Pyrolysis-Gasification	123,840,000	142,150,000	265,990,000	3	77,112,810	5.61	185,495,550	262,608,360	1.01	25,704,270
4.4. Energy Efficient Schools	35,000,000	uncertain	>35,000,000[iii]	55	35,200,000	uncertain	uncertain[iv]	35,200,000	> 1	640,000
4.5. Borehole Ground Cooling	12,682,300	66,650	12,748,950	8	1,080,000	23.5	6,000,000	7,080,000	1.80	135,000
4.6. Energy Efficiency Software	636,000	50,000	686,000	5	642,850	1.8	270,000	912,850	0.75	128,570

[i] All financial data and emission reductions are given as 10-year totals since it corresponds to the project crediting lifetime (which is common for all projects). The totals represent a 10-year sum value (without discounting).
[ii] These figures represent CER prices expected by the project proposers to realize the investment. The comparatively high expectation in project 4.4 is due to the uncertainty in service revenues, which have been assumed to be nil because of the uncertainty regarding their ownership (see endnote iv).
[iii] Variable costs shall be added to the fixed costs to compute the total cost. However, as no reliable estimates for the variable cost component are available yet, the fixed cost of 35 million € is presented as a minimum.
[iv] The project will lead to significant savings in fuel cost, however it is unclear if these can be considered as project revenues for the project owner.