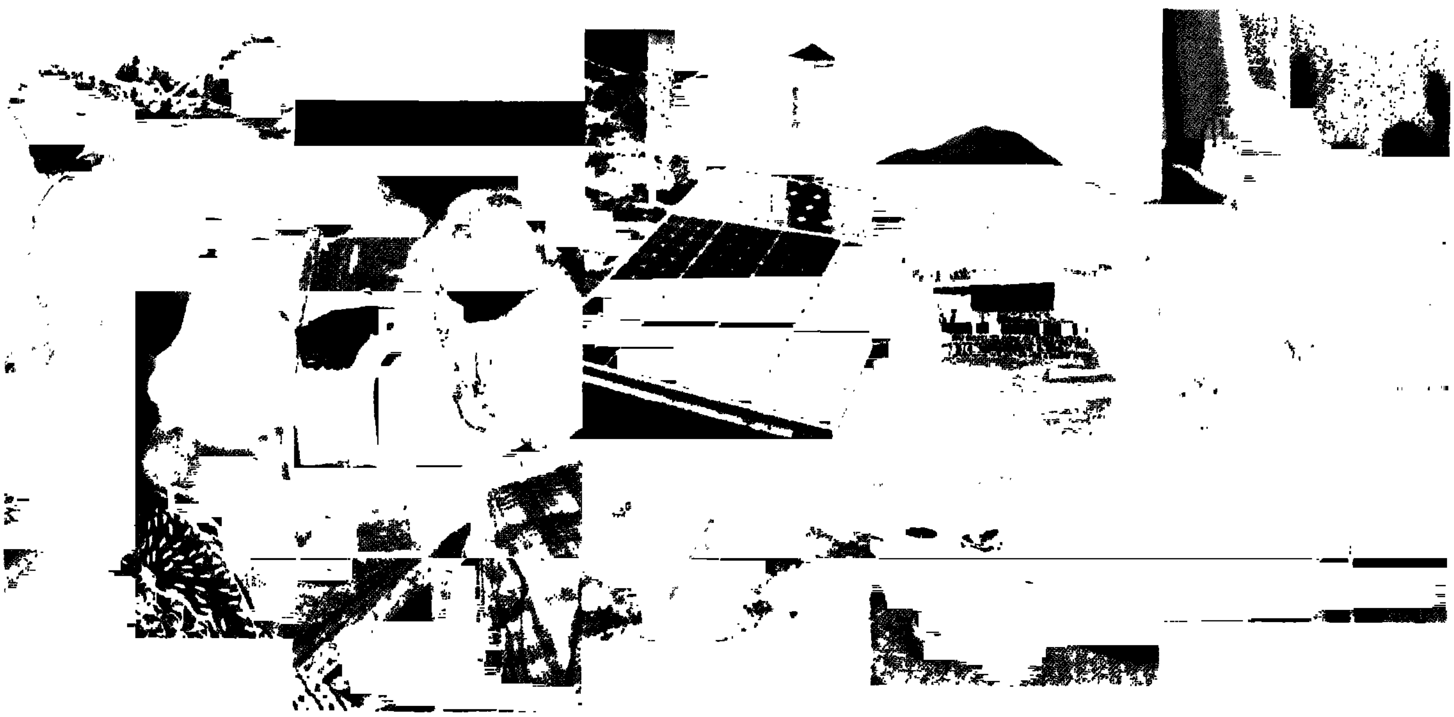
ESM273

Turkey

Energy and Environment Review: Synthesis Report



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Management

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JOINT UNDP / WORLD BANK

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

PURPOSE

The Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) is a special global technical assistance partnership sponsored by the UNDP, the World Bank and bi-lateral official donors. Established with the support of UNDP and bilateral official donors in 1983, ESMAP is managed by the World Bank. ESMAP's mission is to promote the role of energy in poverty reduction and economic growth in an environmentally responsible manner. Its work applies to low-income, emerging, and transition economies and contributes to the achievement of internationally agreed development goals. ESMAP interventions are knowledge products including free technical assistance, specific studies, advisory services, pilot projects, knowledge generation and dissemination, trainings, workshops and seminars, conferences and roundtables, and publications. ESMAP work is focused on three priority areas: access to modern energy for the poorest, the development of sustainable energy markets, and the promotion of environmentally sustainable energy practices.

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FUNDING

ESMAP is a knowledge partnership supported by the World Bank, the UNDP and official donors from Belgium, Canada, Denmark, Finland, France, Germany, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom. ESMAP has also enjoyed the support of private donors as well as in-kind support from a number of partners in the energy and development community.

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Turkey

Energy & Environment Review

Synthesis Report

December 2003

Joint UNDP/World Bank Energy Sector Management Assistance Programme
(ESMAP)

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Abbreviations and Acronyms

ANL	Argonne National Laboratory
AP42	US EPA's emission factor handbook
BAT	Best Available Technology (term used in IPPC)
BOO	Build-own operate
BOT	Build-operate transfer
CAFE	EU's Clean Air For Europe
COP	Conference of the Parties (UNFCCC)
Corinair	Atmospheric emission inventory handbook (Europe)
DOE	US Department of Energy
DSI	General Directorate of State Water Works
DSM	Demand-side management
EER	Energy & Environment Review
EIA (1)	Environmental Impact Assessment
EIA (2)	US Energy Information Administration
EIEI	Elektrik Isleri Etut Idaresi = Electrical Power Resources Survey and Development Administration
ENPEP	ENergy and Power Evaluation Program
EU	European Union
EUAS	Eletrik Uretim Anonim Sirket (Turkish state-owned electricity generating company)
EMEP	Cooperative program for monitoring and evaluation of the long-range transmission of air pollutants in Europe
ESCO	Energy Service Company
ESMAP	Energy Sector Management Assistance Program
ESP	Electrostatic precipitators
FGD	Flue-gas desulfurization
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gases
GT	Gas Turbine
IGCC	Integrated gasification combined-cycle
IIASA	The International Institute for Applied Systems Analysis
Iletim	Turkish Electricity Transmission Corporation
IPCC	International Panel on Climate Change
IPP	Independent power plant
IPPC	Integrated Pollution Prevention & Control Directive (EU)
IRR	Internal Rate of Return

LCPD	Large-combustion plant Directive (EU)
LHV	Lower heating value
LNB	low NOx burner
LRTAP	Long-range transboundary air pollution
LV	Low Voltage
MBI	Market based instrument
MENR	Ministry of Energy and Natural Resources
MoE	Ministry of Environment
MTOE	Million Tonnes of Oil Equivalent
MV	Medium Voltage
NEC	National Emissions Ceiling Directive (EU)
NECC	National Energy Conservation Centre, Turkey
NMVOC	Non-methane Volatile Organic Compound
NPV	Net Present Value
OFA	Overfire Air Burner
PCF	Prototype Carbon Fund
PetDer	The Association of Petroleum Companies.
PFBC	Pressurized Fluidized Bed Combustion
PM	Particulate Matter
PM10	Particulate matter with particle size less than 10μ
POP	Persistent Organic Pollutants
PV	Photovoltaic
SCR	Selective Catalytic Reduction
SIS	State Institute of Statistics
SNCR	Selective Non-catalytic Reduction
SPO	State Planning Organization
T&D	Transmission & Distribution
TEAS	the former Turkish Electricity Company
TEDAS	Turkish Electricity Distribution Company
TETAS	Turkish Electricity Trading Company
TOOR	Transfer of operating rights
TSP	Total Suspended Particulates
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
US EPA	US Environmental Protection Agency
VOC	Volatile Organic Compound
WHO	World Health Organization

1

Introduction

History and background

1.1 Gaps in knowledge about the interface between energy and environment were originally identified in a World Bank report[1] published in April 2000 and by stakeholders at a Workshop held at the Hilton Hotel, Ankara on November 12 1999. A number of Studies were conceived to address these knowledge gaps and to advance the level of understanding by collecting additional information and carrying out specialized analyses. The output of these studies could then be used to prepare a comprehensive energy-environment analysis.

1.2 This *Synthesis* Report summarizes the results of ten studies, collectively referred to as the *Energy & Environment Review,* carried out over a period of 18 months between December 2000 and June 2002.

1.3 Initially six Special Studies were launched:

1) energy demand forecasting.
2) environmental issues associated with the coal/lignite mining and power generation sub-sectors.
3) potential for co-generation in Turkey.
4) assessment of Transmission & Distribution loss reduction.
5) improved management of emissions from non-power sectors.
6) improvement of petroleum fuels quality.

Task 7 was a comprehensive energy-environment analysis. It was described as:

7) technical support to MENR and TEAS to carry out various energy system analyses.

1.4 Financing for the studies was obtained in large part from the Japan Staff and Consultant Trust Fund, administered by the World Bank.

[1] The assessment was published by the World Bank: *Turkey/Energy and the Environment: Issues and Options*, Report 229/00, April 2000.

1.5 The work commenced in December 2000. Additional studies, that had been identified during the preliminary assessment but were not included in the original list, were subsequently launched, including:

8A) environmental institutions.

8B) air quality regulation review.

8C) landfill gas.

1.6 The ten special studies were carried out by a team drawn from eight consulting organizations and two individual consultants[2], all led by Chubu Electric Power Company Inc. under contract to the World Bank and on behalf of the Ministry of Energy & Natural Resources (MENR) and the Ministry of Environment (MoE).

1.7 The project culminated in a second major Workshop on 19 and 20 June, 2002, again held at the Hilton Hotel in Ankara.

Objectives of the Synthesis Report

1.8 The objectives of the *Energy & Environment Review* project was to provide policy makers with critical information to evaluate issues and assess alternative policy options.

1.9 This *Synthesis Report* summarizes the results from the ten studies and describes the implications of these results for Turkey's energy & environment sectors.

1.10 The Synthesis Report comprises:

- a discussion of the issues relating to the energy & environment.
- a description of the key findings and recommendations.
- a summary and conclusions from the work.

The role of planning in a liberalized market

1.11 Much of the analysis presented in this Report was prepared at the time when TEAS had a virtual monopoly in generation and transmission, and TEDAS had a similar monopoly in relation to distribution. In this framework, TEAS prepared and implemented generation and transmission development plans that were approved by MENR and SPO.

1.12 Since then, TEAS has been unbundled into generation, transmission and a trading company and large consumers are now free to choose their own supplier of electricity. The generation company - Elektrik Uretim Anonim Sirket (EUAS) - that was created from TEAS will no longer be responsible for building new power plants.

1.13 The gas market will soon follow the electricity sector with the opening of part of the market to competition. The refineries are also scheduled for privatization.

[2] Dr. Robin Bates and Mr. Stratos Tavoulareas.

1.14 In this new (liberalized) environment, the role of the energy and power sector "plans" that continue to be prepared by MENR and by the newly formed Iletim (Turkish Electricity Transmission Corporation) have changed. Instead of providing the basis for definite investment decisions by any organization, these plans will provide information that is valuable for policy making decisions and that guide the private sector when assessing the future market for electricity or gas.

1.15 The changing role of planning is particularly relevant to the analysis of technologies to combat emissions of SO_2 or greenhouse gases. The analysis shows policy makers how much it would cost to achieve certain emission targets in different ways. This information then helps decide on the best policies (tighter emission standards, compulsory fitting of desulfurization technologies, Best Available Technology[3] criterion that require the use of supercritical technology or fluidized-bed combustion, or SO_2 emission trading).

Acknowledgements

1.16 The team would like to acknowledge the extensive support and assistance provided by individuals from MENR, MoE and TEAS (now Iletim) too numerous to mention individually. Other assistance was provided by a range of organizations in Turkey, again too numerous to mention. We acknowledge additionally the roles of Dr. Robin Bates and Stratos Tavoulareas who helped to conceive the Review and were instrumental throughout the execution of the project.

[3] The IPPC Directive requires that developers use best-available technology and this can be defined to include highly efficient supercritical technology.

2

Issues

Introduction

2.1 Against the background of strong economic growth over the past decade and rapidly increasing energy demand, Turkey is adopting many international standards and participating in a number of international agreements in relation to the environment. MENR and MoE are actively adapting legislation and regulations to approximate to those of the EU and its "acquis communautaire" and energy companies have begun a series of investments in the energy sector that will allow Turkey to match EU and international environmental standards. The electricity market has been liberalized, the gas market will soon follow and the refineries are investing heavily to upgrade petroleum product standards.

2.2 However, unlike countries of Central & Eastern Europe that are seeking accession to the EU, Turkey's economy has grown rapidly since 1990 and the level of emissions today is considerably higher than it was twelve years ago. This poses particular problems in relation to ceilings or targets for emissions that, in many cases, are set relative to 1990 levels.

2.3 The liberalization of the electricity market gives rise to other policy issues. Cogeneration, with high efficiency and correspondingly low fuel consumption and low emissions, will be affected by the opening of the electricity market; in this new market cogeneration plants will be expected to compete with other independent generators. Similarly, power generation using landfill gas might not be commercially attractive unless standards relating to environmental management of landfill sites are tightened and enforced (encouraging the use of methane) or other policies make power generation with landfill gas attractive.

2.4 On the other hand, interest in lignite and coal-fired plants may diminish as private sector investors are attracted by the short construction times and lower risks of gas-fired plants. The demand for natural gas will grow, with corresponding benefits to the environment but increased dependence on imported energy.

2.5 Decision-makers must often make choices between environmental degradation and cost; but they also face trade-offs between other competing objectives such as energy security or employment. The purpose of the *Energy & Environment Review* project has been to provide information about trade-offs that will allow Government to make informed decisions regarding policies that affect the energy sector and the environment. The following sub-sections identify some of the changes facing the energy/environment sectors and the issues that arise from this change.

Air quality and petroleum products

Improvement in air quality

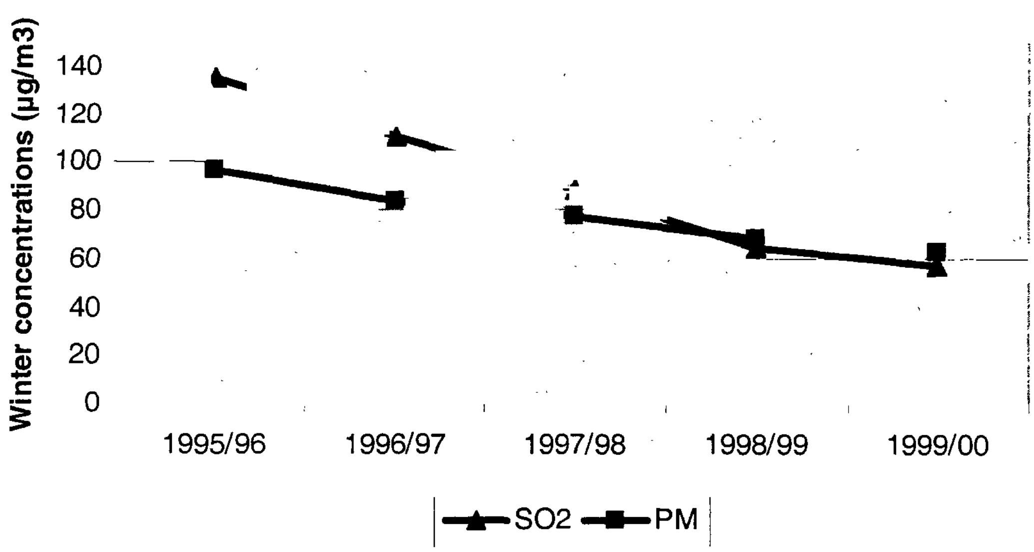
2.6 The improvement in air quality since the late 1980s and early 1990s in Turkey has been dramatic. World Health Organization (WHO) guidelines (2000) propose a limit on SO_2 concentrations averaged over 24 hours of 125 µg/m3 and by the mid-1990s most Turkish cities[4] complied with WHO guidelines for sulfur and particulate matter. WHO also proposes a limit on the annual average concentrations of 50 µg/m3.

2.7 EU standards are based on the Air Quality Framework Directive (1996) and the daughter Directive of 1999. The latter imposes daily average limits of 125µg/m3 which cannot be exceeded more than three times per year. This limit comes into force in the year 2005.

In many cases air quality in Turkey continued to improve during the second half of the 1990s Figure 1 shows, for example, the improvement in air quality in Istanbul since the mid-1990s bringing its average winter concentrations[5] of SO_2 to approximately 60 $\mu g/m^3$. However, in other cities economic growth and increasing demand for fuel have resulted in increasing concentrations of SO_2 and particulate matter.

[4] Some exceptions included Agri, Balikesir, Bilecik, Canakkale, Kirsehir, Kutahya, Nigde, Usak and Yozgat. Most of these are recently industrialized areas scattered around the western part of Turkey.
[5] Average concentrations over 12-month periods are much lower.

Figure 1 Change in Istanbul air quality 1995-00 (μg/m³)



Note: Six-month average.

Transport-related air quality problems

2.8 Even in cities where average air quality has improved, air quality mapping shows problem hot spots located around heavily used roads. Statistics on vehicle ownership density show that cities and regions in central and western Turkey have much higher densities than those to the east and that the concentration of emissions from road traffic is likely to be a less serious problem in the east than it is in the west. For example, in the Marmara region, including Istanbul, the car density is 90 per 1000 people while in Eastern and South-Eastern Anatolia the density is only 20 per 1000 people.

2.9 Cars are thought to migrate to the east as they become older. In the recent past and, perhaps, the present, concentrations of lead emissions in air in the east are likely to be relatively low while concentrations of lead in central and western Turkey are likely to be high; this results from the greater use of premium (Super) leaded gasoline. In future, as cars that use premium (Super) leaded gasoline migrate east then the emissions of lead in these regions will increase while emissions in the west will decline (new cars fitted with catalytic converters will not be able to use leaded gasoline). Policies on the lead content of gasoline will therefore bear heavily on residents to the east of the country - both in terms of emissions and of possible early retirement of old vehicles.

Lead in gasoline and catalytic converters

2.10 By the year 2000 in Turkey, 29% of all passenger cars were fitted with catalytic converters. The increased consumption of unleaded gasoline to 38% of the total gasoline consumed partly reflected the growing number of cars fitted with catalytic converters. It also reflects a switch by other car owners[6] to unleaded gasoline. But sales of premium grade gasoline[7] were still relatively high at 29% of the total in 2000 compared with 34% in 1999. This has the unfortunate result that lead emissions remain high from the higher lead (0.4g-Pb/litre) in premium grade gasoline compared with regular gasoline (0.15g-Pb/litre).

2.11 Projections of the composition of Turkey's vehicle fleet prepared as part of Tasks 5 and 6 suggest that the consumption of leaded gasoline will decline from 2.7 million tonnes in the year 2000 to an estimated 1 million tonnes by 2005 and, even in the absence of policies to restrict the sale of leaded gasoline, will virtually disappear beyond 2012.

2.12 Since the year 2000, the general sale of leaded petrol in EU countries has been banned[8] though it is still available for some specialized uses (e.g., veteran or vintage cars). Worldwide, by the end of 1999 about 35 developing and industrial countries had banned the use of lead in gasoline including countries as diverse as Bangladesh, Thailand, Georgia and El Salvador[9]. Three of the EU member states (Greece, Italy and Spain) have obtained agreement that the prohibition of the sale of leaded gasoline can be delayed, but not beyond 2005.

2.13 Turkish gasoline at the present time is consistent with the pre-2000 EU standards and it is planned that leaded gasoline will cease to be produced in Turkey from 2005.

2.14 The reduction of lead emissions from gasoline should generally be a top priority for any country. Leaded gasoline is extremely damaging to the health of populations exposed to high concentrations of lead, particularly during childhood. However, the pollution from road vehicles depends heavily on the traffic density and this varies significantly between different parts of Turkey.

2.15 Turkey's plan to eliminate leaded gasoline in compliance with EU standards in 2005 is commendable. The analysis suggests that the cost to Turkey's car owners of eliminating leaded gasoline will be relatively low - at around US$5 to US$6 million - while it is widely accepted that the benefits to human health are high[10].

Air quality and the use of heavy fuel oil

2.16 Representatives of the City Municipalities in Ankara, Bursa and Istanbul all claimed that consumption of heavy fuel oil is now very low in these cities and anywhere where natural gas is available. It is also clear that emission regulations

[6] ie cars not fitted with catalytic converters.
[7] The year 2000 is an unusual year, presumably the result of economic problems following the 1999 earthquake. Total gasoline consumption declined but consumption of unleaded gasoline increased.
[8] Directive 98/70/EC.
[9] *Urban Air Quality Management: World Bank Perspectives on Coordinating Transport, Environment, and Energy Policies*, Masami Kojima and Magda Lovei, January 15, 2000.
[10] However, the cost of eliminating leaded gasoline will fall largely on those who use older cars, particularly the poor in rural areas. The cost quoted relates only to the cost to the vehicle fleet.

introduced by the MoE are not consistent with the use of heavy fuel oil in plants without flue-gas desulfurization. Although statistics on air quality certainly show significant improvements in concentrations of SO_2 and particulate matter, nevertheless, statistics on energy consumption in Turkey show that heavy fuel oil remains significant. This suggests that it is used extensively outside of the main western cities. Again, policies on the sulfur content of fuel oils are likely to impact more heavily on users outside the industrialized centers and on users to the east of the country.

International obligations

Introduction

2.17 Turkey is not yet a member of the European Union but has formally been accepted as an applicant to join the EU and has begun a process of screening and approximation[11] to establish the readiness of its regulations and laws. The Kyoto and LRTAP[12] protocols are a part of the EU's acquis communautaire[13] and the adoption of these is part of the approximation process.

2.18 Though Turkey has ratified LRTAP, it has not adopted any of the protocols that impose limitations on emissions on transboundary pollutants.

2.19 The energy sector has undergone a major restructuring with liberalization of the electricity market and planned liberalization of the gas market in conformity with the EU's gas and electricity Directives. Additionally, the refineries are implementing major investment in upgrades that will, by 2005, mean that Turkey will comply with most standards relating to petroleum product quality.

2.20 In the environmental sector, a number of areas of EU legislation have been implemented including those relating to Environmental Impact Assessments (EIA). Others have been examined as part of a study undertaken for the Ministry of Environment with support from the European Commission. Additionally, within the scope of the *Energy & Environment Review*, consideration has been given to EU legislation on:

- Integrated Pollution Prevention & Control.
- Large Combustion Plant Directive.
- National Emission Ceilings Directive.

2.21 In preparation for EU accession, Turkey will also be expected to revise its existing environmental policies and regulations according to the goals and fundamental principles of the EU's Fifth Environmental Action Program, "Towards Sustainable Development". Key areas of this program are: climate change, ozone-depleting substances, air quality and acidification, water quality, urban environment, and waste management.

[11] 'Approximation' is a term used by the EU to describe the process of alignment of legislation, etc., but without full compliance.
[12] Long-Range Transboundary Air Pollution agreement.
[13] The broad body of treaties and directives and Commission decisions that regulate the conduct of affairs within the EU member states.

2.22 The EU's Integrated Pollution Prevention and Control (IPPC) Directive is discussed in the following Section - Integrated Pollution Prevention and Control. Other major EU legislation affecting the energy sector is discussed in the Section - LCPD and National Emission Ceiling Directive. International obligations relating to Kyoto are discussed in Section - Kyoto. Analysis of all of these is described in Section 3.

Integrated Pollution Prevention and Control

2.23 The goal of the IPPC Directive[14] is to achieve an integrated approach to the prevention and control of all pollutants, in preference to a piecemeal approach that can solve some problems but make other problems worse. It seeks to prevent and/or reduce emissions from industrial facilities affecting air, water and land, and environment taken as a whole. The key instrument introduced is a permit, which is required by each facility and covers all environmental impacts (air, water, land, etc.).

2.24 Key elements of the IPPC are:

- Best Available Techniques (BAT) should be used; emission limits are based on technology that is considered BAT. Environmental approvals can require developers to use technology that is best for the environment and can give MoE authority to prescribe, for example, the use of bed-bed combustion technologies for lignite burning power plants.
- Waste production should be avoided or recovered (where technically and economically feasible) or disposed of in a way that minimizes environmental impact.
- Energy must be used efficiently.
- Authorities must update permit conditions periodically and provide the European Commission with emission inventories and sources.

2.25 Turkey has no existing legislation that could be aligned to include the IPPC Directive. Therefore, new legislation needs to be enacted. A specific schedule for enacting such legislation needs to be agreed upon in the context of accession negotiations. Key elements of the legislation include:

- Consolidation of responsibilities between different agencies to avoid overlaps and conflicts that are currently a feature. The Ministry of Environment (MoE) is the competent body responsible for the integrated permits, and its role and responsibilities need to be strengthened.
- The Environmental Impact Assessment (EIA) process needs to be revised to reflect IPPC requirements[15].

2.26 The IPPC requirements apply to all new facilities in EU countries from October 1999 and to existing facilities starting in October 2007. Turkey would have to negotiate the implementation schedule, consistent with the timing of accession, the

[14] Directive 96/61/EC.
[15] In fact, Turkey, revised the legislation of the EIA process in June 2002.

enactment of new legislation, and the practical limitations associated mainly with compliance of existing installations.

LCPD and National Emission Ceiling Directive

2.27 The EU's new *Large Combustion Plants Directive*[16] (LCPD) came into effect in October 2001. The new directive revises the emission standards for large combustion plants including SO_2, particulate matter and NOx. Most of Turkey's existing lignite and coal-fired power plants will require new emission controls and/or upgrading of existing emission controls to comply with the standards set by this Directive.

2.28 While the standards set in LCPD are firm, the compliance schedule may vary and is subject to negotiation between the Commission and Turkey. Factors that may be considered in setting the compliance schedule may include:

- retirement schedule of the existing units.
- reduced plant utilization, and
- availability of funding.

2.29 For example, the Seytomer 1, 2 and 3, and Tuncbilek B power plants, which were built in the 1970s, will be nearly 40 years in operation by 2010. If retirement is planned around 2010 or shortly thereafter, it will not be rational to install desulfurization equipment in these units but it would be rational to either exempt them until retirement (provided that such retirement is firm) or average their emissions with another plant. Avoiding installation in these four units will reduce investment requirements by approximately US$ 120 million.

2.30 The ***National Emission Ceilings*** (NEC) Directive[17] and the Gothenburg Protocol set specific binding national ceilings for emissions for four pollutants (SO_2, NOx, Volatile Organic Compounds (VOC) and ammonia) and are legally binding for all EU members. This Review focuses primarily on SO_2 and NOx emissions. The specific ceilings negotiated for each country are, in most cases, similar for both the NEC and the Gothenburg Protocol.

2.31 Each country is required to develop a national program to be submitted to the Commission including emission inventories and projections up to year 2010, as well as measures adopted or envisaged to comply with the 2010 emission ceilings. For present EU members, the national program is required to be submitted by October 2002. Following reviews of the programs that are scheduled to take place in 2004-05, ceilings for the years 2015 and 2020 will be set.

2.32 In terms of cost-effectiveness, the most common SO_2 control options are: low-sulfur coal, wet flue-gas desulfurization (FGD) and dry FGD. Other options could reduce SO_2 such as: replacement of coal with natural gas, more efficient pulverized coal designs (e.g., supercritical plants) and advanced power generation technologies (CFB,

[16] Directive 2001/80/EC supercedes Directive 88/609/EC.
[17] Directive 01/81/EC.

PFBC and IGCC)[18]. This last group of options reduces other pollutants too (e.g., particulates and NOx) which need to be taken into account in considering their cost-effectiveness.

2.33 Another option for reducing SO_2 is control of the sulfur content in the transportation sector. Upgrading of existing refineries has the potential to reduce SO_2 emissions and other alternatives, which are not considered "SO_2 control" options should be also included because they very often provide the most cost-effective way to achieve SO_2 reduction.

2.34 Turkey's negotiation of the emission ceilings is a process that will involve a number of different considerations including:

- The emission ceilings adopted for other countries that joined the EU.
- The most likely trajectories of emissions in Turkey under baseline scenarios and eventual compliance with EU's Large Combustion Plant Directive.
- The environmental damage due to the projected emissions and the costs of controlling them.

2.35 Table 1 shows the ceilings adopted by EU members and other applicant countries. Most countries have accepted a 2010 SO_2 ceiling which is 30% to 86% lower than the 1990 SO_2 emissions. The EU average SO_2 emissions in 2010 are projected to be approximately 75% below the 1990 level.

Table 1 SO_2 emission ceilings for selected countries ('000 tonnes)

Country	*1980*	*1990*	*2010 Emission Limit (% reduction from 1990)*
Bulgaria	2,050	2,008	856 (58%)
Czech Republic	2,257	1,876	283 (85%)
Hungary	1,633	1,010	550 (46%)
Poland	4,100	3,210	1397 (56%)
Portugal	266	362	170 (53%)
Romania	1,055	1,311	918 (30%)
Slovakia	780	543	110 (80%)
Slovenia	235	194	27 (86%)
Spain	2959	2182	774 (65%)
EU average	26,456	16,436	4,059 (75%)

[18] CFB = Circulating Fluidized Bed. PFBC= Pressurized Fluidized Bed Combustion. IGCC= Integrated Gasification Combined-Cycle.

2.36 Similarly (see Table 2) NOx emission ceilings in the same countries are 17% to 61% below 1990 levels with an average for the EU of 49%.

Table 2 NOx emission ceilings for selected countries ('000 tonnes)

Country	*1990 levels*	*2010 Emission Limit (% reduction from 1990)*
Bulgaria	361	266 (26%)
Czech Republic	742	286 (61%)
Hungary	238	198 (17%)
Poland	1280	879 (31%)
Portugal	348	260 (25%)
Romania	546	437 (20%)
Slovakia	225	130 (42%)
Slovenia	62	45 (27%)
Spain	1113	847 (24%)
EU	13,161	6,671 (49%)

2.37 Turkey is in a different position to most accession countries. While 1990 energy consumption and emission levels in the countries of Central & Eastern Europe were high but have since declined, both consumption and emission levels in Turkey have grown rapidly. For both SO_2 and NOx it will be difficult or impossible to meet an emission reduction target. Emission estimates and analysis of abatement options are discussed in Section 3.

Kyoto

2.38 The Kyoto Protocol was adopted at COP3[19] on December 11, 1997. It specifies binding emission targets relative to 1990 levels for countries listed in Annexes to the UNFCCC[20]. The Protocol will only enter into force once 55 parties have ratified (or approved, accepted or acceded to) it, as well as there being 55% of the 1990 levels of greenhouse-gas (GHG) emissions accounted for by Annex I parties among the ratifying parties. By 31 May 2002, 55 parties (including two Annex I parties) had ratified the Protocol.

2.39 The UNFCCC maintains two lists of countries: Annex I and Annex II. Annex I countries have targets for GHG emission reductions. These targets apply to the years 2008-2012 and are normally set relative to 1990 emission levels. Countries listed in Annex II are obliged to use their technical and financial resources to help developing countries. The lists normally include developed countries but Turkey, as an OECD

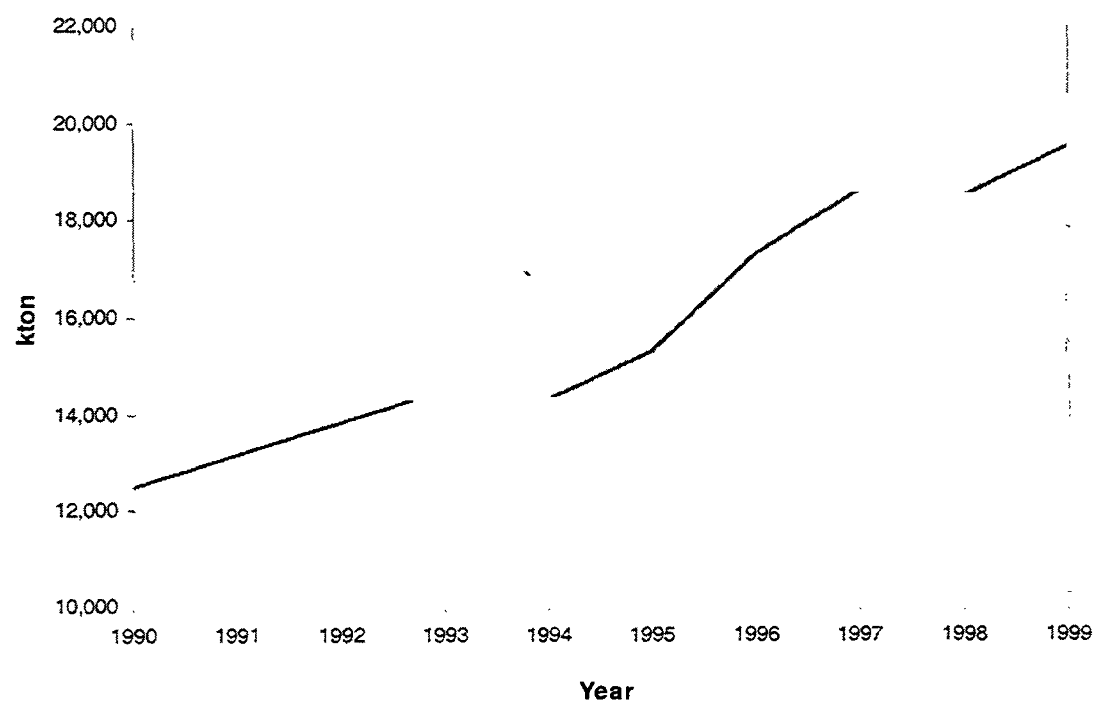
[19] Regular conferences have been held by parties to the Convention and are referred to as the Conference of the Parties (COP). Each conference is known by a number: the third was held in December 1997 was COP3 and the seventh, in November 2001, was COP7.
[20] United Nations Framework Convention on Climate Change.

member, was included on both lists. Turkey contended for a long time that its income levels were too low to allow it to join either list. Recently, parties were invited to recognize Turkey's special circumstances and a proposal was passed at COP7 (November 2001) to remove Turkey from Annex II of the UNFCCC. Turkey remains one of the countries listed in Annex I and will accept an emission target, though no specific target level has been agreed.

2.40 Emission targets may be greater than 1990 levels or below 1990 levels. Some countries, such as Norway, Australia and Iceland, are allowed to increase their emissions but most countries are expected to reduce those emissions. Countries of Central and Eastern Europe are also OECD members and have, largely, accepted emission reduction targets. Most of these countries, however, can easily meet their targets because 1990 emission levels were very high. Turkey will not be able to achieve an emission reduction target and instead will need to agree a substantial increase but one that will be capped.

2.41 The overall growth of CO_2 emissions over the period 1990-1999 was estimated by MENR and TEAS in a Report released in November 2000 and prepared for submission at COP5. These estimates are shown in Figure 2.

Figure 2 Growth in CO_2 emissions in Turkey, 1990-1999



Source: Base case analysis of energy development and CO2 emissions in Turkey, MENR and TEAS, November 2000.

2.42 The annual average growth rate shown in Figure 2 is 4.9% and the total emissions in 1999 reached 19.6 kilo-tonnes. As with ceilings for NOx and SO_2 for the National Emissions Ceiling Directive, it will clearly be difficult for Turkey to achieve emission reduction targets for greenhouse gases relative to 1990 levels. It was revealed at the June 2002 Workshop that agreement had been reached that Turkey's baseline would be 1995 rather than 1990; nevertheless, the conclusion that Turkey will find it impossible to achieve emission reductions remains true even if the base year is 1995.

Fuel markets

Coal and lignite

2.43 Coal is one of the most important energy sources for Turkey as it contributes approximately half of the total primary energy production and one third of the country's electricity generation.

2.44 As of 1998, lignite reserves in Turkey amounted to more than 8.3 billion tonnes. Approximately 40% of these reserves are in the Elbistan region, currently a prime power generating area. Turkish lignite is characterized by high ash and sulfur and a low calorific value that ranges from less than 1,000 up to 4,000 kilocalories/kg. However, approximately 66% of the reserves range between 1,000 and 2,000 kilocalories/kg. Lignite will continue to be used primarily by mine-mouth power plants designed to handle such low quality fuel, from the points of view of both reliability and environmental impact.

2.45 As of the year 2000, Turkey's installed electricity generating capacity was over 27,000 MW, 33% of which was coal-fired. Approximately 95% of the coal used in Turkey is local lignite with the remaining 5% being local and imported hard coal. Consumption of lignite is expected to triple by the year 2020. Also, the share of imported coal is expected to increase. Most thermal power stations in Turkey are relatively inefficient subcritical plants with an output of 150 to 350 MW.

2.46 Key challenges facing the sustainable utilization of coal in Turkey are:

- Local and regional pollution (due to particulates, NOx and SO_2 emissions) is reaching critical levels in some cities, requiring further control. This will become more pressing with Turkey's prospective accession to the European Union (EU), which requires alignment of environmental regulations especially with regard to local and regional air quality pollutants (SO_2, NOx and particulates). The Air Quality Framework Directive (1996) and its daughter Directive of 1999 sets standards for ambient air quality and the recently revised Large Combustion Plant Directive (November 2001) makes emission standards even tighter.
- While Turkey has not yet ratified the Rio and Kyoto Protocols, it is expected to do so. Ratification would certainly impact on the development of coal-fired power generation facilities, putting additional pressure on improving their efficiency.

- Reliability of existing power plants is significantly below world standards. For example, the combined average of forced and scheduled outages of coal-fired plants in Turkey is nearly 40% compared to 10-20% in OECD countries.
- The dominance of domestic coal/lignite is challenged by imported coal and natural gas. In a deregulated market, which Turkey is expected to be, fuel and technology selections would be based on economics and local lignite and coal would have to compete against imported coal and gas.

2.47 New power generation technologies (CCT: Clean Coal Technologies), rehabilitation of existing power plants, and environmental control technologies for coal-fired power plants will play a critical role and determine the long-term sustainability of coal/lignite utilization in Turkey.

Natural gas and security of supply

2.48 Natural gas is playing an increasing role in primary energy supply in Turkey and is being used extensively in the power sector, in industry and by households. In the year 2000 consumption was 15 billion m^3 (including 9.3 billion m3 consumed by the power sector) after growing by nearly 15% per year since 1991. Natural gas has major benefits to the environment and has resulted in dramatic improvements to air quality in Turkey's large cities. However, this has come at the expense of increased dependence on imports for energy supplies. The analysis presented in Section 1 will show that gas is the most attractive source of energy from the viewpoint of cost and environment. The analysis does, however, consider the impact on import dependence of policies aimed at curtailing natural gas consumption in favor of indigenous fuels.

Energy efficiency

Cogeneration

2.49 As of year 2001, over 3,000 MW of capacity or approximately 11% of the installed power generating capacity in Turkey is based on auto-production and cogeneration facilities.

2.50 The terms "auto-production" (power production by an industrial facility for its own use) and "cogeneration" (combined heat and power generation) have been used interchangeably in Turkey in the past. Rule No. 85/9799 was designed to promote the development of such facilities because of fears that there would be insufficient power generating capacity to meet demand. The rule required, among other things, that TEAS and TEDAS purchase power at 85% of the average selling price. This made it attractive for private developers to finance such facilities and contributed to the rapid and uncontrolled growth of autoproduction. To stem the growth of autoproducers MENR tightened the procedures for approval of autoproduction plants and encouraged the development of cogeneration plants in preference to simple condensing plants. The regulation required new autoproducers to install exhaust heat recovery systems. This led factories to install equipment even when they did not have the heat demand to justify the expense.

2.51 New cogeneration facilities in other countries with a typical 2/3 heat and 1/3 electricity output have an efficiency of 80-85%. This compares to an average efficiency of 30%-40% for Turkish autoproduction plants. Merely requiring exhaust heat recovery does not result in high-efficiency or CO_2 emission reductions.

2.52 Turkish policy resulted in growing numbers of cogeneration plants that cannot use the heat/steam available from the plants and which condense the heat to the atmosphere.

2.53 Starting in the summer of 2002 following the liberalization of the electricity market, autoproducers and cogeneration plants will no longer receive privileged access to the market and will be expected to compete with other electricity generators. From 2003 they will also be able to contract to sell power to distribution companies and large consumers (referred to as "eligible" consumers). There is, however, some expectation that wholesale electricity prices will be high because of a number BOT, BOO and TOOR[21] contracts and that autoproducers will therefore be able to find a market and their numbers will continue to grow. It is less certain that the cogeneration (as opposed to IPP generation) will continue to be commercially attractive.

Industrial energy efficiency

2.54 A survey conducted as part of the overall study shows that some of Turkey's industries are already relatively energy efficient. The efficient industries include cement and the automobile industry. There will be little scope in these industries for reductions in energy intensity.

2.55 Other industries surveyed, including iron & steel, sugar, fertilizer and petrochemicals have a mix of energy efficient and less energy efficient plants. Overall improvements in energy efficiency are likely to arise from the rationalization of the industries and closure of some capacity following privatization (e.g., refineries) or investment in new technologies (iron & steel) or both.

2.56 The sugar industry has shown major improvements in energy efficiency but the exposure of this and similar industries (fertilizer) to international competition may reveal further potential for overall improvements in costs and specific energy efficiency measures.

[21] Build-Own Operate (BOO), Build-Own Operate Transfer (BOT), Transfer of Operating Rights (TOOR).

3

Key findings

Introduction

Content of this Section

3.1 The following sub-sections discuss, directly or indirectly, the implications of a range of options and policies on the environment and on costs to the national economy.

3.2 The discussion is based on the special studies plus a number of scenarios[22] that are described fully in the Task 7 Report. Task 7 drew together information from several of the special studies and analyzed a series of scenarios using an energy and environment modeling package[23]. In the *Synthesis Report* we do not repeat the discussion of the scenarios in the Task 7 Report but rather use those scenarios to address, directly or indirectly, policy related issues.

3.3 The policy issues include:

- What will be the costs and benefits if Turkey adopts EU legislation on emissions from large-combustion plants?
- Do clean-coal technologies offer a cost-effective alternative (to natural gas or renewable energy) as a way to achieve a cleaner environment and reduce GHG emissions?
- Should Turkey promote renewable energy to reduce emissions and as a means to achieve targets for Kyoto or LRTAP?
- In a liberalized market, should cogeneration compete on an equal footing with other technologies such as CCGT or conventional coal-fired power plants; or should policies be introduced that make cogeneration more attractive?
- What are the costs and benefits of energy efficiency programs? Should they be promoted?

[22] The scenarios considered include: technical efficiency, nuclear power, demand-side management, cogeneration, renewables, carbon tax, clean-coal technology, petroleum product quality, constraining the use of natural gas for *security of supply* reasons, the introduction of EU standards.
[23] ENPEP: *ENergy and Power Evaluation Program* was developed by Argonne National Laboratory (ANL) and financed by the US Department of Energy and the International Atomic Energy Authority.

- Should EU legislation on the sulfur content of fuel oils be introduced? How should it be achieved? What are the costs of implementing it?
- What benefits will electricity transmission and distribution loss reduction programs provide for the environment?
- Should the use of landfill gas be encouraged?
- What are the implications for the environment, cost and security of energy supply if Turkey constrains the use of natural gas?
- What are cost-effective means to reduce GHG emissions and meet (yet-to-be-decided) Kyoto targets? What are achievable GHG emission targets for Turkey? What would be the cost of meeting those targets?

3.4 Where the policy choice is clear, we make recommendations but where policy choices involve trade-offs between environment, cost and other impacts we stop short of making recommendations but instead leave it to policy makers to draw their own conclusions from the information presented.

Reference Scenario

3.5 A review of MENR's energy demand projections, which form part of the Reference scenario, is presented in the Section – Energy Demand. The analysis of policy issues begins with a "Reference" scenario[24] that is used as a basis for comparison with alternative strategies or policies (From sections Air quality regulations and EU accession To Impact of constraints on gas consumption).

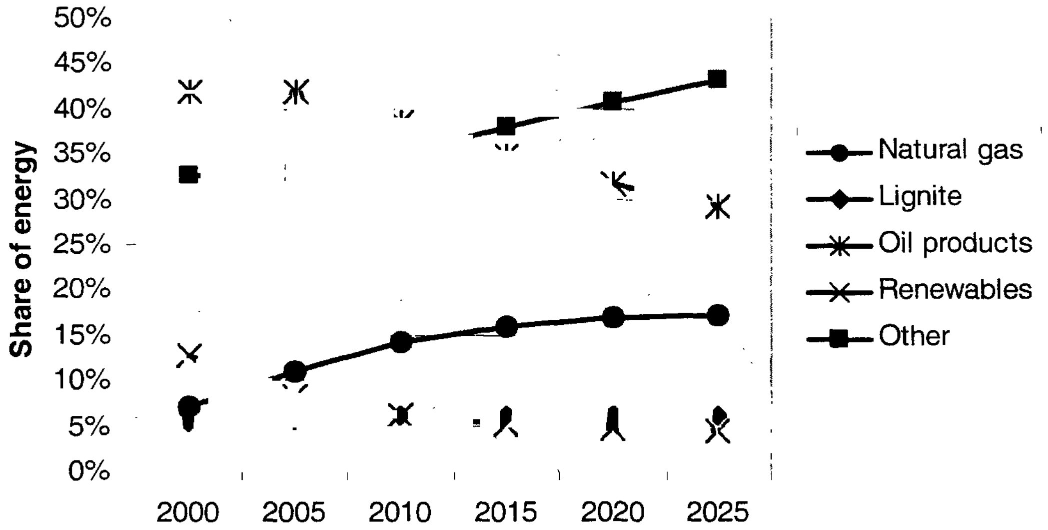
3.6 The Reference scenario describes what might happen if current policies continue into the future in relatively liberal electricity and gas markets. This does not imply that current policies are frozen but it is based on the assumption that there will be no major policy changes over the 25 years planning horizon.

3.7 International fuel prices are common to all strategies or policies. Projections for prices of imported coal, crude oil and natural gas were developed using price indexes derived from World Bank and U.S. Energy Information Administration data. Relative to 2000 price levels of 100, the coal index peaks in 2001 and then continually declines to 96.5 (2025); while the oil and natural gas index drops to 76.2 in 2002 and then gradually increases to 89.0 (2025). It should be noted that since the analysis was carried out the fuel markets have changed substantially with coal price projections revised lower and oil and gas prices higher. For example, IEA's World Energy Outlook of 2000 projected US$ 46.5 per ton of coal for the period 2000-2020; subsequently, IEA's World Energy Outlook of 2002 revised coal prices downward to US$ 39 per ton for the period 2002-2010 and then increasing linearly to US$44 per ton by 2030. Oil and natural gas price are not projected to decline as much as in the reference scenario.

[24] The 'Reference' scenario is not the best scenario since, as the analysis shows, there are some strategies that deliver lower costs and lower emissions. Nor is it, necessarily, the most likely scenario. It is simply a useful base against which other results can be compared.

3.8 The Reference scenario projections for final energy supply are shown in Figure 3.

Figure 3 Final energy supply - share in total



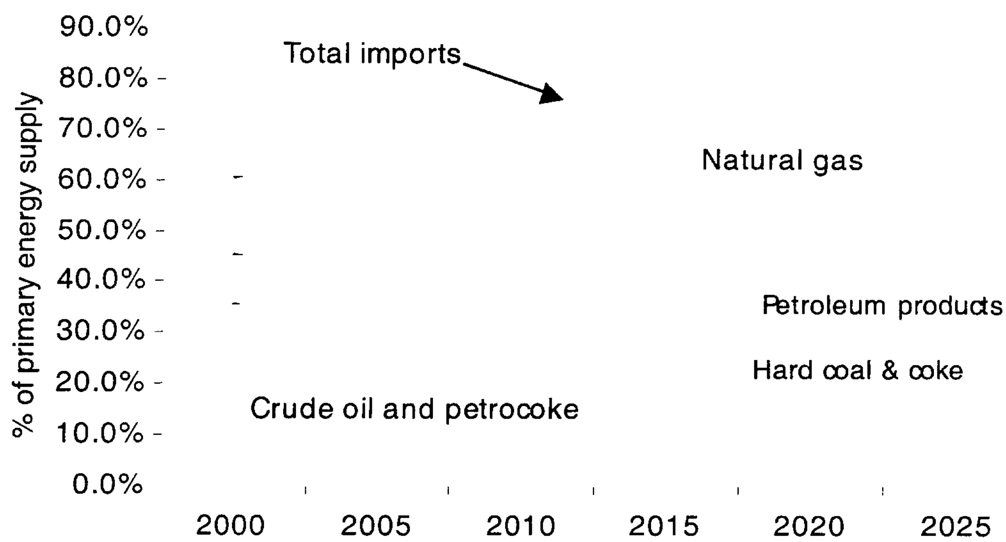
3.9 Figure 3 shows a rapid growth in the use of natural gas with its share climbing from 7% to 17% of final energy supply. But this excludes the use of natural gas in power generation. Natural gas demand including power generation is projected to grow at an annual average rate of 9.6% per annum over the period 2000-2025. Total natural gas consumption then reaches 80 billion m^3 by 2015 and 170 billion m^3 by 2025 from levels of approximately 15 billion m^3 in 2000.

3.10 The shares of oil products fall in the overall energy mix with annual average growth rates in consumption of 4.3% per annum over the period 2000-2025 and with its share falling from 42% in 2000 to 29% by 2025. Consumption of renewable energy outside the power sector is projected to grow at 2% per annum and its share in the overall energy mix is projected to fall from 13% to 4% by the end of the period.

3.11 Figure 3 shows the share of lignite staying relatively constant at around 6% of final energy consumption. Use of lignite outside the power sector is expected to grow at an average rate of around 6.3% per annum.

3.12 In the Reference scenario, net energy imports increase from 2000 to 2025, due mostly to higher gas and hard coal imports. This brings Turkey's energy import dependency to 83% by the end of the study period from 62% today as shown in Figure 4. This Figure also shows that by the year 2025 imported natural will account for 42% of primary energy supply compared with a little under 15% in 2000. The projection also implies a substantial increase in net imports of petroleum products from around 1 million tonnes equivalent in 2000 to 47 million tonnes in 2025[25].

Figure 4 Import dependence



3.13 Hard coal and coke imports are also projected to increase as a percentage of the total primary energy supply while crude oil imports are projected to remain constant but to decline as a share of energy supply.

3.14 In the power sector:

- Virtually all load growth in the power sector is met by natural gas resulting in the consumption of natural gas increasing over twelve fold between 2000 and 2025, i.e. at an average annual rate of 10.5%. Gas consumption by the power sector reaches 49 billion m^3 by 2015 and 113 billion m^3 by 2025. By 2025, natural gas would be used to generate 77% of total electricity supply.
- Lignite and hard coal consumption increase by some 40% and 110% respectively from 2000 to 2005 as committed plants are commissioned over the next few years, but then stabilize and even decline slightly. However, at the end of the period, lignite continues to be more important in power generation than hard coal: nearly 13 million tonnes (oil equivalent) of lignite is projected to be used for power generation compared with approximately 2 million tonnes of hard coal.

[25] Imported petroleum products are projected to be 14% of primary energy supply by 2025.

- The contribution of renewables (hydroelectric and geothermal power) increases steadily through 2018 in absolute terms but still accounts for less than 16% of supply in terms of oil equivalent in 2025.

3.15 The resulting projections of emissions are discussed later in this Section but in summary:

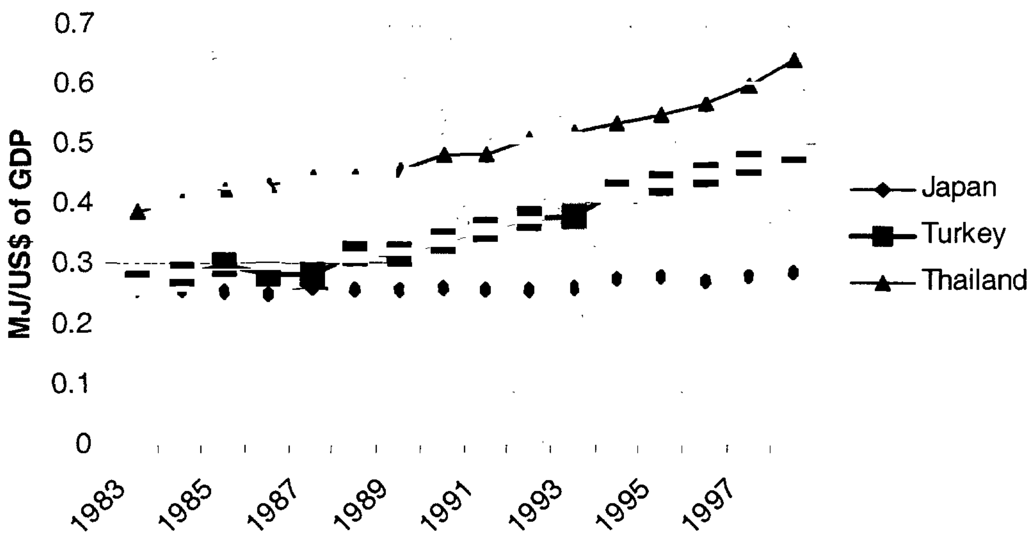
- Emissions of CO_2, greenhouse gases (GHG), particulate matter (PM), SO_2, NOx and ash all increase over the period 2000-2025 at rates below the growth of final energy demand; whilst lead emissions decline:
  - CO_2 emissions grow at about 5.8% per annum reaching over 870 million tonnes per year by 2025.
  - NOx grows at 3.5% per annum.
  - Ash, PM and SO_2 grow at about 2.2% per annum.
  - Lead emissions decline at –5.9% per annum.
- Emissions of CO_2 from the industrial sector grow most rapidly at 7.2% per year and by 2025 account for over 40% of overall CO_2 emissions.
- The relatively low growth rate for local emissions (i.e. ash, PM, SO_2 and NOx) is attributable to the impact of Combined-Cycle Gas Turbines (CCGT) and more extensive fitting of FGD equipment in the power sector.
- The much closer relationship between the growth of GHG/CO_2 emissions and overall energy growth is due to the fact that hydrocarbons continue to dominate the energy mix.
- The decline in lead emissions in absolute terms occurs because all gasoline in Turkey is assumed to be unleaded after 2005.

Energy demand

Background

3.16 Projections of Turkish energy demand have been made some thirty years into the future at a time when income levels will be far higher than today and when Turkey's economy will be similar to more developed western countries today. These western countries may therefore provide an insight into Turkey's future energy demand. Data on other countries is illustrated in Figure 5. Japan is at the bottom of the chart and has one of the lowest energy consumption per US$ of GDP; its energy intensity is declining slightly and it has a very high per-capita income. Other countries, such as Germany (not shown) with a high per-capita income also have declining energy intensity. On the other hand, countries with relatively low per-capita income levels, such as Thailand, have relatively high and growing energy intensity.

Figure 5 Energy intensity in a range of countries



Review of forecasts prepared by MENR

3.17 MENR prepares energy demand forecasts using a detailed bottom-up methodology that relies on projections of a range of economic and demographic variables and relationships. The input assumptions to the MENR energy projections are a combination of official forecasts from the State Planning Office (SPO) and projections of other parameters using available data and the judgment of MENR staff. The latter includes some important parameters, such as energy intensity projections, that are reviewed in this Report.

3.18 A review of the MENR forecast methodology prepared as part of the *Energy & Environment Review* was undertaken using an econometric analysis of historical data for several countries representing different income levels. The analysis recognized that energy consumption in different countries is affected by geographical factors such as the need for heating or cooling and therefore countries were chosen with geographical characteristics as close as possible to Turkey.

3.19 The results suggest that energy intensity when measured as MJ per US$ of GDP reaches a peak at per-capita income levels of approximately US$11,000 (at 1990 prices) and then begins to decline. The results confirm an earlier study for Asian countries, which also suggests that energy intensity reaches a peak and then falls. However, the study for Asian countries suggested that energy intensity (MJ/US$ of GDP) peaked at lower levels of income at approximately US$4,000 per capita (1985 prices).

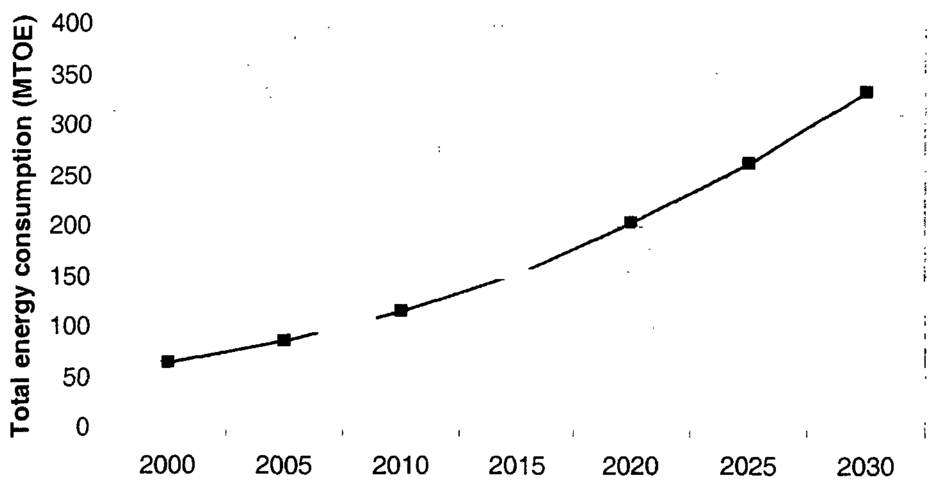
3.20 We used the econometric results to prepare projections of energy and electricity demand using assumptions for GDP and population growth (Table 3) identical to those used by MENR. The projections using this method exceed those of MENR and imply that MENR's forecasting methodology takes account of trends of declining energy intensity that have been experienced in more developed economies.

Table 3 Key parameters affecting energy demand

Variable	*1990-1995*	*1996-2005*	*2006-2010*	*2011-2020*	*2021-2025*	*2026-2030*
Population growth rate	1.7%	5.0%	0.9%	1.0%	0.8%	0.8%
GDP growth rate	3.2%	1.4%	7.7%	6.8%	5.6%	5.6%
Growth rate in GDP/capita	1.4%	3.6%	6.7%	5.7%	4.7%	4.7%

3.21 The MENR energy forecast, originally prepared in 2000, is shown in Figure 6. However, the economic crisis in Turkey during 2001 revealed that even the best forecasting methodologies depend on good forecasts of economic activity and for this reason we present an alternative forecast in the Section – Alternative GDP Scenario below.

Figure 6 MENR energy forecast for Turkey



3.22 This official demand forecast for final energy and for electricity for the 25-year period 2000 to 2025 show average growth rates of:

- Final energy consumption projected at 5.9% p.a.
- Electricity demand projected at 7.4% p.a.

3.23 But the average growth rates do fall from the beginning to the end of the planning horizon:

- From 6.8% p.a. in 2000-2005 to 5.1% p.a. in 2020-2025, in the case of final energy.
- From 8.9% p.a. to 6.0% p.a. in the case of electricity demand.

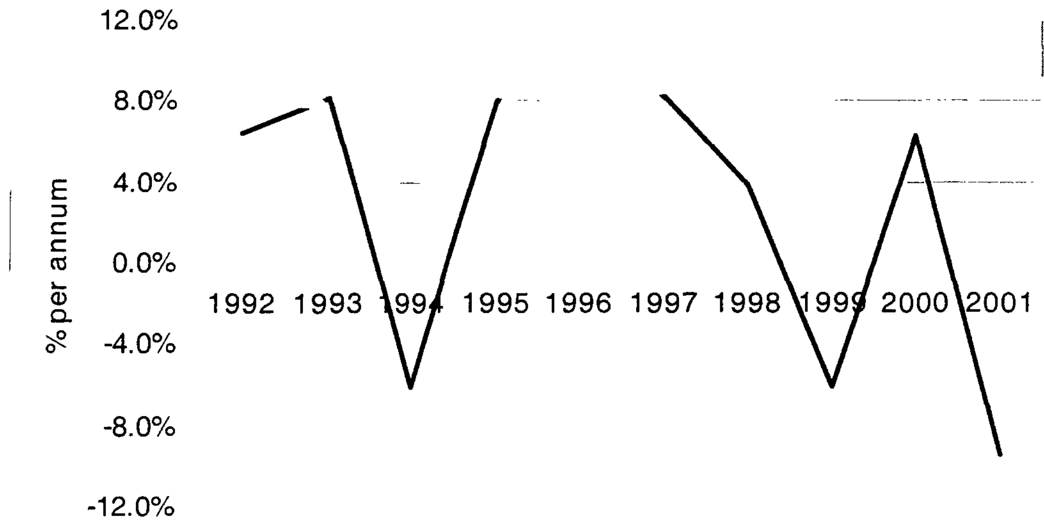
Alternative GDP scenario

3.24 Figure 7 shows the performance of Turkey's economy over the past ten years, from 1992 to the year 2001. Over this period, there have been three crises:

- the first, in 1994, resulted from a declining current account, loss of investor confidence and a banking crisis;
- the second, in 1998/99 was due to the major earthquake; and
- the third, in 2001 was the result of a banking crisis resulting from a widening current account deficit and fragile foreign confidence.

3.25 Though in the intervening years the economy has grown strongly at around 6% per annum, the average growth rate over the 10-year period was only 2.4% per annum.

Figure 7 Historic GNP growth in Turkey



Source: State Institute for Statistics

3.26 Table 4 shows the GDP growth forecasts underlying MENR's 8^{th} FYP energy demand forecast[26]. This forecast suggests that Turkey will sustain growth rates of over 6% per year up to the year 2015. Given the experience of the past 10 years, this may be optimistic. Recent alternative GDP growth forecasts for Turkey have also been

[26] The original forecast for 2000-2005 was 5% per year but it was revised upward for 2002-2006 to reflect a catch-up following the economic crisis of 2001.

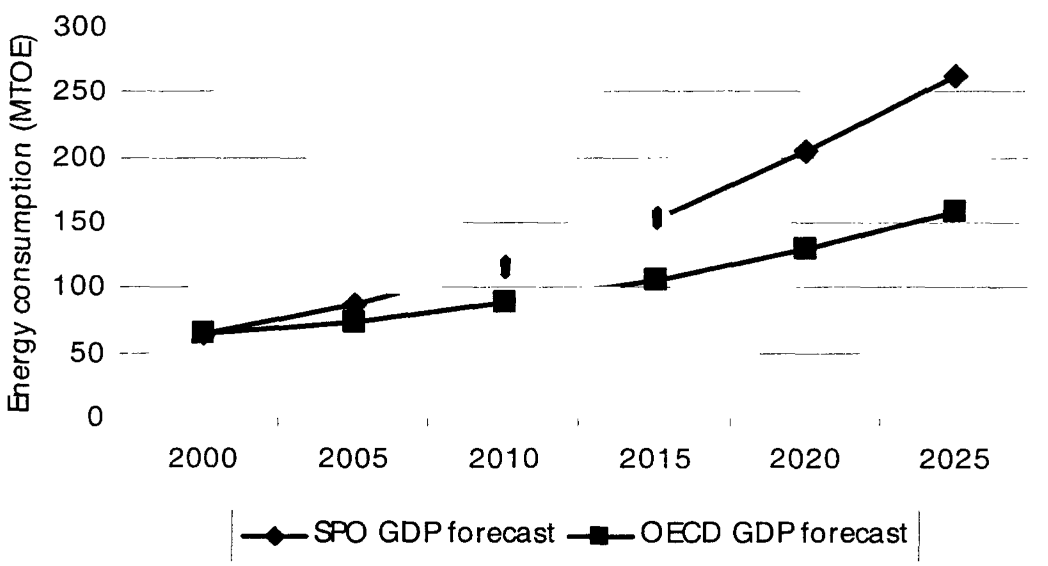
obtained from OECD[27] and the World Bank[28] and these are shown in Table 4. SPO is also revising its GDP projections but these were not available for the study.

Table 4 GDP growth projections for Turkey

Year	SPO, average growth rate (%) of real GDP	OECD, average growth rate (%) of real GDP
2002-05	6.70	4.64
2006-10	7.70	4.69
2011-15	6.80	4.52
2015-20	6.80	-
2021-2030	5.60	-

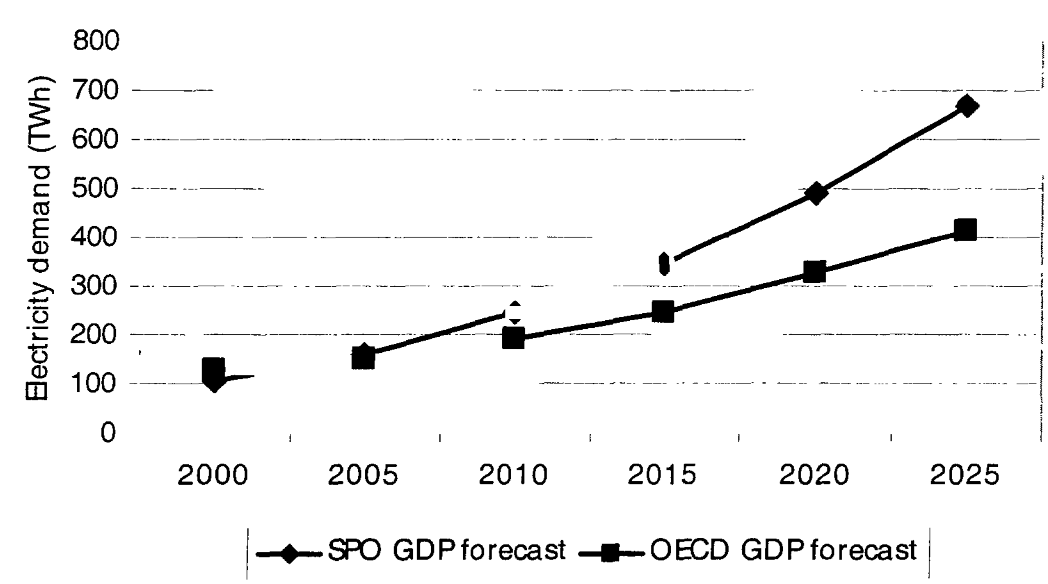
3.27 Energy and electricity demand projections using these alternative scenarios are shown in Figure 8 and Figure 9. The energy demand projection labeled SPO GDP forecast in Figure 8 is identical to the projection in Figure 6 above. The alternative projections are used subsequently to analyze the sensitivity of emissions to demand.

Figure 8 Alternative energy demand projections



[27] OECD, Economic Outlook, 2002; OECD Committee Papers 2001, 2002.
[28] World Bank, Global Economic Prospects, 2002.

Figure 9 Alternative electricity demand projection



Air quality regulations and EU accession

Introduction

3.28 Section – International Obligations described two of the EU's air quality Directives: the Large Combustion Plant Directive (LCPD) and the National Emissions Ceiling Directive (NEC). The following sub-sections describe an analysis of the implications of these regulations for Turkey. The Directive affecting the sulfur content of liquid fuels is described in the Section - Petroleum product quality and transport strategy.

3.29 There is an ongoing program of electrostatic precipitators (ESP) and FGD retrofits at power plants that are expected to take place by 2004. Despite these investments, we estimate that some further reduction of particulates and SO_2 will be needed to comply with Turkey's own emission standards. Such retrofits (mainly SO_2 controls) would require an investment of approximately US$418 million. If these investments are made, the cost of compliance with EU regulations described in subsequent sub-sections would be reduced accordingly (by a total of US$418 million).

Analysis

3.30 The LCPD requires implementation in two steps; the first step in 2010 to meet standards for PM and SO_2 and the second in 2016; the latter reflects further tightening of NOx emission regulations.

3.31 The investment requirements to comply with the LCPD are estimated at US$546 million for Step I and US$140 million for Step II (NOx controls). Table 5 shows the SO_2 and NOx emissions projected from the energy sector in Turkey under baseline and two EU compliance scenarios for the years 2010 and 2020:

- Power sector compliance with the LCPD.
- Compliance by the power sector with the LCPD, as well as refinery upgrading to comply with EU standards for petroleum products (see Chapter 3).

Table 5 Turkish energy sector SO_2 and NOx scenarios

	1990[29]	1995	2000	2010	2020
SO_2 (million tonnes)					
- Baseline	1.4 (0.8)	1.9 (1.0)	2.2 (1.3)	2.2 (0.9)	3.2 (0.9)
- EU compliance	1.4 (0.8)	1.9 (1.0)	2.2 (1.3)		
- Power (LCPD)				1.4 (0.1)	2.4 (0.1)
- Power + Refineries				1.0 (0.1)	1.8 (0.1)
NOx (thousand tonnes)					
- Baseline	661 (116)	641 (146)	706 (204)	900 (208)	1,328 (247)
- EU compliance	661 (116)	641 (146)	706 (204)		
- Power sector				898 (206)	1,266 (185)
- Power + Refineries				898 (206)	1,266 (185)

Notes:
1. Source: Turkey EER Studies, Task 7.
2. Numbers in parentheses indicate power sector emissions

3.32 The baseline projections are that SO_2 emissions will increase by 54% by 2010 relative to 1990. Implementation of the LCPD in the power sector (large power plants) will reduce SO_2 emissions to 3% below 1990 levels, while implementation of the LCPD together with refinery upgrading to match EU standards will reduce SO_2 emissions still further to 28% below 1990 levels. The corresponding costs for these two programs are:

LCPD in the Power Sector:	US$637 million
LCPD in the Power Sector + Petroleum Upgrading:	US$1,355 million

3.33 The cost/tonne of sulfur reduced is about US$47 for undiscounted emissions and US$211 for discounted emissions. Hence, the introduction of EU standards is a cost-effective method of sulfur control, relative to other options.

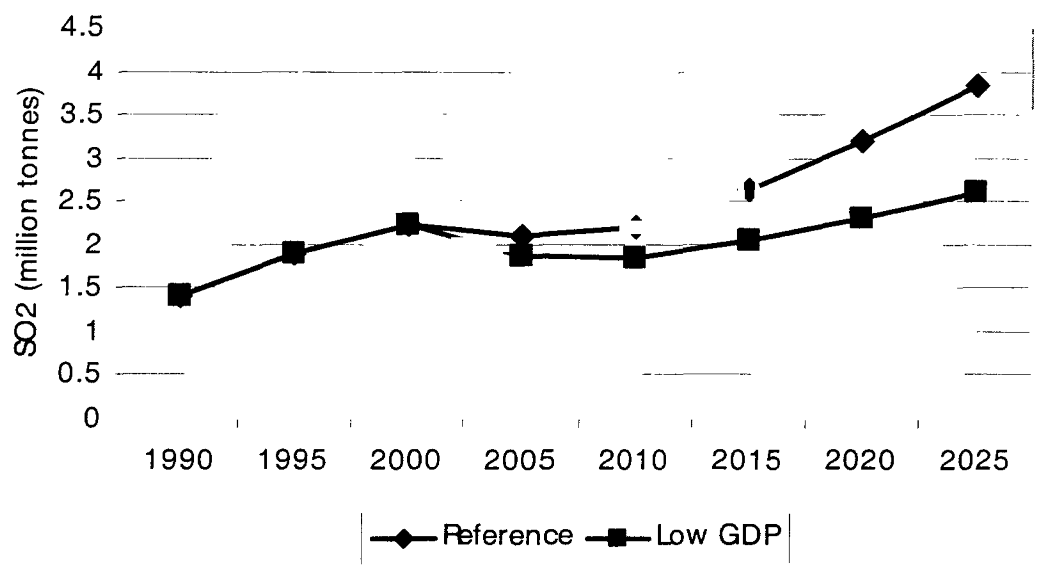
3.34 Additional SO_2 reductions can be achieved through measures in the industrial sector which will become the dominant contributor to emissions; its share grows from 26% in 2000 to 63% in 2010 and 74% in 2020 (under the EU compliance scenario). It should be noted here that there are other EU directives, including IPPC,

[29] Source: TEAS, except energy sector SO_2 for the baseline scenario which was estimated based on the ratio between power and non-power.

which require emission controls and deployment of Best Available Technologies (BAT) in the industrial sector too.

3.35 The team also examined the impact on SO_2 emissions if SPO's GDP scenario is not fulfilled. This is shown in Figure 10. In this scenario, SO_2 emissions overtake their 2000 levels between 2015 and 2020 and, by 2025 they are 17% above 2000 levels compared with 73% higher in the Reference scenario.

Figure 10 Impact of low GDP on SO_2 emissions



3.36 Under the Reference scenario, NOx emissions in the year 2010 are projected to be 36% higher than 1990 levels. With implementation of the LCPD by large power plants, NOx emissions will decline relative to the reference scenario, but not significantly. This is due to the fact that reduction in NOx emissions from coal- and lignite-fired power plants is expected to be counterbalanced by increased NOx emissions from natural gas-fired combined cycle plants. While some reduction can be achieved through additional control of NOx from combined cycle plants, the main contributors would be the industrial and transport sectors, which are expected to contribute 70-75% of the total NOx emissions after 2010. The holding back of NOx emission levels in 2010 to those of 1990 could be achieved by a reduction of approximately 50% by the industrial and transport sectors.

3.37 Looked at in isolation, the cost of ash, PM and NOx control would not appear to be efficient compared with other options; however, the moderate declines in emissions of these pollutants can be regarded as an inexpensive by-product of stricter sulfur emission control.

Conclusions

3.38 FGDs in existing lignite-fired power plants and refinery upgrades to reduce sulfur content of gasoline and diesel have similar cost-effectiveness (US$200-250 per discounted tonne of SO_2 removed) and as such, in principle, they should both be pursued. Refinery upgrades result in higher emission reduction costs (closer to US$250 per tonne), but they are equally important because emissions from oil-fired applications are closer to population centers and have a more direct impact on human health. The cost of compliance with the LCPD in power plants and refinery upgrades is approximately US$1.3 billion.

3.39 If Turkey complies with the LCPD for power plants and the refinery upgrades take place by 2010, it will achieve an SO_2 emission reduction of approximately 28% relative to SO_2 emissions in 1990. The same emission reductions can be achieved at a lower cost (potentially up to 25% savings) under a flexible compliance strategy (e.g., allowing emission averaging or trading). The potential SO_2 reductions from the industrial sector need to be assessed, because they are likely to provide opportunities for additional low-cost SO_2 reductions. Such options could be pursued to achieve further reduction of the total SO_2 emissions or replacement of other more expensive SO_2 control options.

3.40 An optimum SO_2 compliance strategy for Turkey should include the following elements:

- Low-cost or "no-cost" options such as rehabilitation of existing power plants which have a limited SO_2 reduction potential (1,247 tonnes for the period 2002-2025 or 54 tonnes/year), which should be pursued first because of their attractive cost-effectiveness.
- Emission averaging and trading among power plants.
- NOx emissions by 2010 are expected to be 36% above 1990 levels. Implementation of the LCPD by 2016 does not reverse the trend of increasing NOx. Further reductions from the projected levels can only be achieved through NOx control from the industrial and transportation sectors.
- Turkey should request support from the EU to commission a study in which IIASA expands their transboundary pollution analysis to include Turkey. If negotiations between Turkey and the EU regarding the National Emissions Ceiling Directive do not start before 2004, such modeling effort is planned to be carried out anyway by EU/IIASA.
- Turkey should request from the EU as soon as possible to be involved in Convention on Long-Range Transboundary Air Pollution (CLRTAP) modeling activities and EU's Clean Air For Europe (CAFE) program.

Clean-coal technology and emission controls

Introduction

3.41 Some key statistics on Turkey's electricity market include:

- 33% of Turkey's electricity generation capacity is coal-fired.
- 95% of coal is local lignite (high in ash, moisture and sulfur, and low calorific value).
- consumption of lignite is expected to triple by 2020 in the Reference Scenario.

3.42 Lignite is one of Turkey's main indigenous energy resources. In the year 2000 it represented under 4 million tonnes of oil equivalent but by 2025 production is projected in the Reference Scenario to increase to a little under 17 million tonnes of oil equivalent.

3.43 Since most existing thermal power plants are relatively small and relatively inefficient, this poses particular challenges for the environment.

3.44 In a liberalized market, the private sector is responsible for making investment decisions subject to meeting environmental regulations. Nevertheless, policy makers in Turkey should be aware of the costs that environmental regulations and policies will have on the energy supply industry. Additionally, under EU legislation, environmental licensing authorities should consider Best Available Technologies (BAT) when considering applications for environmental permits.

3.45 Clean-coal technologies were examined as part of a special study (Task 2) of the *Energy & Environment Review*. The results can be used to consider whether the imposition of certain technologies by regulators would lead to excessive costs for the sector. They can also be used more generally to assess how the sector might respond to more general policies or combinations of policies that lead the private sector to consider lignite or coal fuelled technologies[30]. The discussion in the following sub-sections includes the following:

- Clean coal technologies (CCT) including Circulating Fluidized Bed (CFB), PFBC (Pressurized Fluidized Bed Combustion), IGCC (Integrated Gasification Combined Cycle) and supercritical plants.
- Environmental controls including particulate matter removal, SO_2 and NOx controls.
- Power plant rehabilitation.
- Power plant solid waste management.

[30] For example, a constraint on the use of natural gas combined with tight restrictions on emissions of SO_2, particulate matter and solid waste would lead to greater interest by the private sector in clean coal technologies.

Clean coal technologies

3.46 *Circulating Fluidized Bed (CFB)* technology is commercially available up to a size of 250 MW. Ten CFBs of 200-250 MW are presently operating worldwide and larger plants are being planned. CFB technology is suitable for Turkey's low-quality coals and lignites. Presently it is considered appropriate to limit the size of CFBs to 150-160 MW, but larger plants (e.g. 300 MW) will be available within the next 3-5 years. The only barrier is economics as CFBs, especially in sizes less than 160 MW, are more expensive than pulverized coal. As Table 6 shows, CFB become more competitive above 250 MW and are expected to play an important role in Turkey in the long-term.

3.47 ***Pressurized Fluidized Bed Combustion (PFBC)*** is offered commercially up to sizes of 350 MW with six commercial-scale plants in operation worldwide. Most of these boilers are demonstration units, with financial support from government or international agencies.

3.48 While PFBC is suitable for Turkey's lignites and hard coal, there are a number of technical issues still unresolved before PFBC can be considered fully commercial. Uncertainty remains about the coal feed, the gas turbine lifetime, the hot gas clean-up system and the cyclone liner life. Furthermore, higher-than-conventional technology costs (see Table 6) limit its widespread utilization, at least in the short term.

3.49 *Integrated Gasification Combined Cycle (IGCC)* technology has been demonstrated up to 500 MW size and offered commercially, but higher costs (relative to the conventional pulverized coal with Flue Gas Desulfurization (FGD): see Table 6) limit its widespread utilization. Presently, there are six coal-based IGCC demonstration plants in operation (three in the US and three in Europe) with three more IGCC plants utilizing refinery wastes in Italy.

3.50 For the entrained and moving-bed IGCC processes, the main barrier to widespread utilization is the high costs relative to competing technologies. The fluidized-bed gasification process, which is more suitable for Turkey's low quality lignite, requires further development and demonstration. It has yet to demonstrate adequate reliability at large scale (e.g. 100 MW).

3.51 The future of IGCC technology depends on the ability of the industry to reduce its costs and the environmental requirements associated with SO_2, NOx and CO_2 emissions. If CO_2 control becomes more important (e.g. strict requirements arising from the Kyoto Protocol) and CO_2 sequestration is necessary, IGCC may become the technology of choice.

3.52 ***Supercritical Pulverized Coal Technology*** is similar to subcritical in terms of the conceptual plant design, but operates at higher steam temperatures and pressures, and has higher overall plant efficiency. Supercritical plants are commercially available in many countries with approximately 462 coal-fired units operating worldwide.

Table 6 Cost and performance summary - Clean Coal Technologies

Power Generation Technology	Readiness*	Capital (US$/kW)
PC—subcritical, with FGD, 350 MW (Elbistan)	C	1,220
PC—subcritical, FGD by-pass, 700 MW (Imported)	C	970
PC—supercritical, FGD by-pass, 700 MW (Imported)	C	990
PC—subcritical, FGD, 500 MW (Elbistan)	C	1,130
PC—supercritical, FGD, 500 MW (Elbistan)	C	1,160
CFB, 250 MW (Elbistan)	D (3-5 yrs)	1,100
PFBC, 350 MW[3] (Elbistan)	D (~10 yrs)	1000-1300
IGCC, 400 MW (imported coal)	D (~10 yrs)	1200-1600

*C = commercial; D = demo. *: Numbers in parenthesis = projected years to commercial availability.*

3.53 Supercritical technology is suitable for Turkey's coal quality and power system needs. A number of supercritical plants are already in operation using fuels similar to Turkey's. For example, there are four large (up to 933 MW) supercritical plants in Germany burning brown coal (lignite).

3.54 As Table 6 shows, supercritical plants are expected to have marginally higher capital costs than similar size subcritical plants (e.g. US$1,130/kW for a 500 MW Elbistan-fired subcritical compared to US$1,160/kW for supercritical) but have higher efficiency.

3.55 Task 7 analysis shows that if, instead of the new subcritical coal-fired power plants in the reference case, supercritical units are commissioned, a 3.2% reduction in coal and lignite consumption[31] would be achieved by 2025, with corresponding reduction of all pollutants at no additional cost, as the fuel savings counterbalance the increased capital cost requirements. The analysis confirms that supercritical technology relative to subcritical is both economic and cost-effective from the emission reduction point of view.

[31] Total energy consumption would drop by a little over 1% by 2025 compared to the reference case.

Environmental Control Options - desulfurization

3.56 The Task 2 Report describes environmental control options for SO_2, particulate matter and NOx but the following focuses on the findings relating to sulfur emission controls.

3.57 All SO_2 control technologies, including sorbent injection, dry FGD, simplified wet FGD and wet FGD, are feasible and suitable for Turkey. Wet FGD is expected to be the option used in lignite-fired plants, while the lower cost options could be used for hard coal. Lignites require 80-95% SO_2 reduction while hard coals (both imported and domestic) require 40-50%.

3.58 Typical capital costs associated with FGDs in new plants at, for example, Elbistan or Ceyirhan, range from US$150/kW for 100 MW plants to under US$90/kW for 500MW plants. For plants burning hard coal, the costs range from around US$100/kW for 100MW plants to less than US$50/kW for 500 MW plants. The corresponding levelized costs (US$/ton of SO_2 removed) are shown inTable 7.

Table 7 Levelized SOx removal costs for new plants (US$/ton-SOx)

Plant Output (MW)	100	500
Lignite-Elbistan, 95% Wet Scrubber(WS)	145	94
Lignite-Cayirhan, 95% WS	98	64
Domestic Hard Coal, WS bypass Type (50%)	1,052	614
Domestic Hard Coal, 95% WS	840	506
Imported Hard Coal, WS bypass Type (45%)	1,231	698
Imported Hard Coal, 95% WS	937	550

Note: Shaded boxes indicate costs required to satisfy Turkey's SO2 standards

3.59 For existing plants, the requirements are similar;. lignite-fired plants (e.g. Elbistan A) would require 80-95% SO_2 removal efficiency, while hard coal plants (e.g. Catalagzi-B) require 46% SO2 reduction to satisfy Turkey's standards. The costs for Elbistan A and Catalagzi B are shown in Table 8.

Table 8 FGD costs for existing plants

Name of Power Plant	Elbistan-A (340 MW)	Catalagzi-B (150 MW)
Removal Efficiency (%)	95% Wet scrubber type	50% Wet scrubber bypass type
Capital cost (US$/kW)	151	109
Levelized cost (US cents per kWh)	0.62	0.36
SOx removal (1000 tonne/year)	121	3.4
Removal cost (US$/tonne-SOx)	113	1,061

Rehabilitation of Existing Power Plants

3.60 Existing power plants in Turkey have an average efficiency of 30-35% (LHV[32]), which is 3-5% lower than the design efficiency of 38%.

3.61 The reliability of these plants has clearly deteriorated; the average availability of thermal power stations in Turkey is approximately 60% compared to 90% in OECD countries. An assessment of the causes of the problems was undertaken as part of the project and suggested that boiler and boiler auxiliary systems contribute approximately 75% of the total forced outages.

3.62 In addition to the plant-level assessment, an analysis was undertaken as part of Task 7 to examine the impact of carrying out a power plant rehabilitation program throughout the power sector. The analysis assumed that power plant efficiencies increased by 1-3 percentage points with a capital costs and heat rate improvement as follows:

- 1% improvement in efficiency at a cost of US$2/kW.
- 2% improvement in efficiency at a cost of US$10/kW;
- 3% improvement in efficiency at a cost of US$30/kW.

3.63 Power system level analysis confirms that rehabilitation is a "win-win" option. It could be encouraged by the introduction of a range of environmental policies that restrict emissions. Our analysis shows that rehabilitation can achieve reductions in emissions of CO_2, GHG, TSP[33], SO_2, NOx and ash fall over the study period (up to 2025) by 0.3% to 1.6%. This may not seem significant, but it represents high absolute numbers and most importantly it leads to lower overall system costs by US$19.5 million (in net present value terms) relative to the reference case scenario. This makes this scenario an attractive mitigation option for any of the pollutants.

[32] Lower heating value.
[33] Total Suspended Particulates.

Solid waste management at power plants

3.64 In general, Turkey has adequate regulations regarding the handling and disposal of solid wastes from coal-fired power plants. Approximately 90% of the solid wastes being generated are disposed of in wet or dry disposal sites. To the extent that the study team was able to obtain data during three site visits, it seems that standard practices and the regulations are being followed. In one case where solid wastes are being disposed in the sea, provisions are being made to stop this practice by building and utilizing a disposal site.

3.65 Approximately 10% of the solid wastes generated by power plants are being disposed of back in the mines to reclaim the land. Considering that most plants in Turkey are mine-mouth, this practice should be expanded.

3.66 Fly ash in Turkey is suitable for various applications including cement production and construction material applications. An assessment was made based on detailed analyses of the properties of fly ash and the site-specific economics. Fly ash for cement production is economically viable if the cement factory is located within 200 km of the power plant and under the assumption that fly ash. It was concluded that approximately 3.9 million tonnes/year from five power plants can be utilized in cement production facilities. Table 9 provides more details on the specific power plants, cement facilities and amount of fly ash that could be utilized. As a practical matter, the price of fly ash will be determined by the negotiation between the power companies and the user (cement factory). To increase the amount of fly ash use, one option is to lower its price, and another option is to pay a fee to the cement users. More rigorous environmental standards for solid waste management, with accompanying costs, will encourage power plant owners to explore alternatives to disposal of fly ash.

Table 9 Assessment of fly ash utilization potential

Coal-fired power plant	Disposal of fly ash (tonnes/year)	Distance to nearest cement factory (km)	Fly ash Quantity to be utilized (tonnes/year)
		70	
		80	
Catalagzi	764,774	140	
		155	
			over 390,000
Cayirhan	522,116	50	375,000
		65	
		200	
Orhaneli	291,914		
		165	
			291,914
Soma	4,460,014	95	

Coal-fired power plant	Disposal of fly ash (tonnes/year)	Distance to nearest cement factory (km)	Fly ash Quantity to be utilized (tonnes/year)
		200	
		165	
		150	
			2,241,000
		95	
Tuncbilek	754,163	150	
			over 570,000
Total			**over 3,867,914**

3.67 Fly ash for clay replacement and FGD gypsum were shown to be uneconomic considering that natural clay and gypsum are abundant and relatively inexpensive.

3.68 Policies encouraging the utilization of solid wastes, especially mine backfilling and construction applications should be introduced. Such policies should take into account the avoided disposal costs and the environmental impacts being mitigated.

Conclusions

3.69 The following is a summary of the main conclusions from the work on clean-coal technologies and emission controls:

- Circulating Fluidized Bed (CFB) technology has major possibilities in Turkey using low quality lignite which cannot be burned easily in pulverized coal plants. Presently, CFB in sizes less than 150-160 MW is most suitable, but costs are higher than conventional pulverized coal plants.
- Supercritical pulverized coal technology also has major possibilities in Turkey's energy future, as the power sector will be called to reduce, or curtail the increase of, greenhouse gas emissions. Experience with large (up to 930 MW) lignite-fired plants in Germany confirms the technical viability of supecritical plants for Turkish lignites. Supercritical technology should be considered especially for units of 500 MW and 700 MW using imported coal. Units burning Elbistan lignite should be limited to 500 MW in size. Supercritical plants designed appropriately and with the right staff training could contribute to a 10-15% CO_2 emission reduction relative to subcritical coal-fired plants, without significantly higher costs.
- Many of the existing power plants are required to reduce emissions of particulate matter. In plants, which will be retrofitted with wet FGDs (desulfurization), the required particulate emission reduction will be

accomplished by the FGDs without additional particulate control. The remaining plants should carry out site-specific assessments on the cost effectiveness of ESP expansion or upgrading.

- FGD technology will play a very important role and contribute to the sustainable use of coal in Turkey. While FGD installations in both new and existing plants require a major investment, they are essential as determined by both Turkey's and the EU's regulations and they will have a significant beneficial side effect to reduce particulates, in addition to the SO_2 emissions.
- Rehabilitation of existing power plants is clearly a "win-win" option. Decisions on investment will, in future, be taken by the owners of the plants but environmental policies are likely to increase the attractiveness of rehabilitation investments.
- Fly-ash utilization is economic for cement manufacture where the cement plant is located within 200km of the power plant. The practice of utilization should be encouraged with appropriate policies, especially mine backfilling and construction applications.

Renewable energy

3.70 Options were considered for the more extensive use of solar PVs, wind energy and mini-hydroelectric plants. This level of analysis is not ideal for evaluating the relative merits of different renewable energy technologies but the analysis provides valuable information about the contribution that renewable energy could make to achieving certain environmental goals.

3.71 Solar PVs were, however, found to be very expensive except for isolated grids and were dropped from the main analysis.

3.72 The assumption underlying the analysis is that a renewable energy program will start in 2005 bringing the share of wind energy and mini-hydro to nearly 13% of total power system capacity by 2025 but generating only 7% of total electricity supply. The overall share of renewables in total capacity, including large hydropower and geothermal, would then be over 35% by 2025 and they would account for 23% of electricity generated.

3.73 The cost data for solar and wind energy were generic and taken from the US's DOE/EIA (2001) and that for mini-hydros was provided by EIEI[34].

3.74 Additional renewable generation would be expected to replace CCGT generation but substantially more solar and wind capacity is needed to make up for the drop in gas capacity due to the lower availability or capacity factors of the renewable

[34] EIEI = Electrical Power Resources Survey and Development Administration. For wind, based on DOE/EIA data, capital costs and fixed O&M costs in 2000 were assumed to be, respectively, US$1,154/kW and US$26.87 per kW-year; however, an "experience curve" was applied which brings down the capital cost of wind energy to US$609/kW by 2025. For mini-hydro, using EIEI data, average capital costs were assumed at US$1,532/kW for plants with capacity less than 25 MW; and US$1,514/kW for plants with a capacity in the range 25-50 MW.

plants. The Task 7 analysis estimates that this would lead to 11 fewer CCGT units installed (total of 7,700 MW) over the study period and total natural gas consumption would drop substantially.

3.75 The total discounted economic system cost increases because the additional renewables, at least as a package, are more expensive than CCGT in the reference-case. There is a modest abatement of CO_2/GHG emissions (1.0% by 2010 and an average of 1.5% for the period 2000-2025), due to the lower levels of gas combustion in power generation but the impact on emissions of PM, ash, NOx and SO_2 is negligible taking the planning period as a whole. This modest impact on emissions is because the extra renewables contribution essentially only replaces gas, although the beneficial impact of renewables on sulfur does start to show increasingly after 2015.

3.76 Under the renewables scenario, the net energy import bill drops as imported fuels are replaced by domestic renewable resources.

3.77 The conclusions from the analysis suggest that although the total discounted economic system cost increases relative to the reference scenario, wind energy and mini-hydro are cost-effective for the mitigation of CO_2 and GHG, with a cost of US$1.3 per undiscounted tonne of CO_2 reduced (US$4.6 per tonne of undiscounted carbon). This suggests that renewable energy would be cost-effective in meeting GHG targets but that it can be only one part of a strategy.

3.78 Renewable energy can be encouraged through a range of policies including tax incentives, subsidies, a carbon tax or obligations on distribution companies and suppliers to buy a percentage of their requirements from accredited renewable energy plants.

Cogeneration

Introduction

3.79 Policies to encourage cogeneration could help achieve a number of environmental goals as well as reduce the costs of energy supply and reduce dependence on imported fuels.

3.80 While it is not easy to estimate the potential for cogeneration in Turkey (mainly due to lack of data on heat demand in key industries), it is clear that there is significant potential for more cogeneration, especially in the pulp and paper, chemicals and textile industries. Also, there is significant potential in the service sector (hotels, hospitals and large housing complexes), which need heat in the winter and cooling in the summer. The expected accession of Turkey into the EU will provide additional incentives for wider utilization of cogeneration, as the EU has already established a goal to double it cogeneration capacity by year 2010 from 9% to 18% of the total installed power capacity.

Analysis

3.81 In order to illustrate the potential impact of cogeneration on the energy and environment sectors, a scenario was considered in which it was assumed that cogeneration contributes 20% of total electricity generation by 2025. Data from Task 3 indicated that the capital cost of cogeneration plants is US$717/kW for plants with an average capacity of 23.3 MW and average capacity factor of 91.1%. The cost data is consistent with data from US DOE/EIA[35], which assumes $796/kW capital cost for a 25 MW cogeneration unit.

3.82 The main impact of cogeneration program is to increase industrial natural gas consumption at the expense of coal, lignite and oil products:

- Industrial natural gas consumption increases by more than half over the reference case by 2010; and more than doubles by 2025 from 38 billion m^3 to 77 billion m^3. The average growth rate of gas consumption under the cogeneration scenario is 14.6% p.a. from 2000-2025, compared with 11.5% p.a. under the reference case. Industry accounts for 43% of total gas consumption as compared to 23% under the reference case.
- By 2025, consumption of hard coal and coke drops by 34%; lignite drops by 35%; and oil products drop by 20% by 2025 - all relative to the reference case.

3.83 The corollary is a reduction in power sector grid load of 20% by 2025, leading to more moderate power sector gas expansion and a drop in gas-fired power generation:

- 90 new 700 MW CCGT units plus five new 275 MW CCGT units coming on-line between 2002 and 2025 versus 123 CCGTs and six GTs under the reference case.
- Compared to the reference case, power sector gas consumption in 2025 drops from 113 billion m^3 to 83 billion m^3.

3.84 The net effect of the growth in industrial gas consumption and the drop in power sector gas consumption is an overall increase by 5.5% in gas demand compared to the reference case: from 169 to 179 billion m^3.

3.85 Total discounted economic system cost falls, due to the higher overall efficiency of cogeneration: the overall fuel savings and the lower capital investment requirements in the power sector more than offset the additional costs involved in expanding cogeneration.

3.86 Emissions of CO_2, GHG, particulate matter, SO_2, NOx and ash all decline by 3-9% over the study period.

[35] US Department of Energy's Energy Information Administration.

Conclusions

3.87 The results of the analysis are provisional since data on potential heat demand by different industries and the heat and cooling demand of the service sector (hotels, hospitals and large housing complexes) are not available. Nevertheless, the analysis provides useful results.

3.88 The scenario suggests that cogeneration is a "win-win" strategy, achieving lower emissions (CO_2, GHG, PM, SO_2, NOx and ash) at a lower total discounted economic cost than the reference case scenario. The scenario is therefore cost-effective in terms of each type of pollutant.

3.89 The recent "autogeneration" policies that led to the construction of cogeneration facilities where there was no demand for the heat/steam have now ended following the liberalization of the electricity market. Future policies that encourage cogeneration should attempt to avoid these earlier problems.

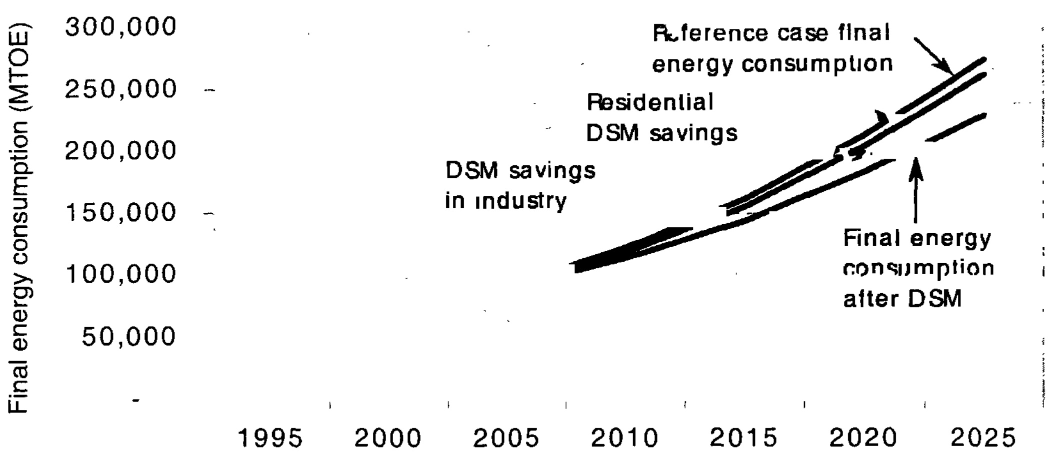
3.90 Some market based mechanisms, such as carbon taxes or carbon-weighted fuel taxes, will automatically encourage cogeneration in preference to other facilities, but, as with renewable energy policies, other policies could also be attractive such as the provision of favorable tax incentives to facilities with high overall efficiency (e.g., above 70%) and that are genuinely cogeneration plants. Another alternative would be an obligation on suppliers to purchase a certain percentage of their electricity from accredited cogeneration facilities.

Energy efficiency (DSM)

3.91 In addition to supply-side energy efficiency measures discussed in other parts of this Section, the review has also considered the potential impacts of demand-side management (DSM) measures on energy and the environment including total energy system costs and emissions.

3.92 The estimated potential for DSM/energy conservation in Turkey is well documented: in particular, useful studies were done by the National Energy Conservation Center (NECC) for the 1998 National Report on Climate Change. However, there is an absence of data on costs associated with DSM for the transport, household and services sectors. The DSM scenario therefore put the main focus on industry, although some provisions were included for the residential sector.

Figure 11 Impact of DSM on final energy consumption



3.93 For the industrial sector:

- NECC estimated industrial conservation potential to be 23.5% of total final energy consumption in 1996. A target value of 22% was therefore assumed for the year 2025 in the scenario.
- The costs of achieving this potential were estimated by NECC to be US$2.3 billion. Adjusted to year 2000 price levels, this implies costs of US$2.6 billion.

3.94 For the residential sector:

- NECC estimated that 10% of energy could be conserved at no cost whilst 30% conservation could be accomplished with some investment, but the costs were not provided. The scenario assumed the mid-point (20%) level could be reached by 2025 with no investment required.

3.95 No information was available on the costs of implementing energy conservation in the transport sector, so it was not included in the DSM scenario Analysis

3.96 The analysis shows that the assumed program for DSM/energy conservation has a major impact on energy demand and consequently on energy requirements. By 2025, compared with the reference case:

- Total energy supply drops by more than 17% (hard coal and natural gas each drop by around 24%; lignite drops by nearly 14%; and oil products by over 17%).
- Energy imports are 19% lower.
- Total gas consumption declines from 80 billion m^3 in the reference case to 61 billion m^3 by 2015; and from 169 billion m^3 in the reference case to 128 billion m^3 by 2025.

- Total discounted economic system cost falls, as do imports of energy.
- Emissions of CO_2, GHG, PM, SO_2, NOx and ash all decline significantly. CO_2/GHG emissions are reduced by about 18% per year and SO_2 emissions drop by over 16% per year.

3.97 The DSM scenario is therefore "win-win". The total discounted economic system cost, at a 10% discount rate, falls along with emissions of CO_2, GHG, PM, SO_2, NOx and ash.

3.98 In a liberalized market, without monopoly power and gas companies, DSM policies are less easy to implement. Nevertheless, it is still possible to combine DSM policy with the new market arrangements. DSM measures can, for example, be promoted through state agencies that disseminate information or through private Energy Service Companies (ESCOs) that provide energy efficiency services on behalf of private companies.

Petroleum product quality and transport strategy

Introduction

3.99 The Turkish refineries spent approximately US$1 billion between 1989 and 1997 on upgrades, and they plan to spend a further US$0.8 billion before 2005 on a range of measures that will produce petroleum products in compliance, in general, with EU standards for gasoline and diesel - including sulfur and lead - and that are similar to standards in Japan and the USA. The refineries will, however, continue to produce high sulfur heavy fuel oil and heating oils with sulfur contents of 3.5% and 1.0% respectively[36]. However, the use of heavy fuel oil with sulfur content exceeding 1% is generally prohibited in the EU except under certain conditions. EU regulations also limit the sulfur content of heating oil to 0.2% at present but the regulations will tighten to 0.1% by 2008.

3.100 Limited derogations[37] against the EU legislation have been permitted for Greece, Portugal, Spain and France in relation to gas oils but only for marine use and in some areas of the country. Derogations from EU legislation prohibiting the use of heavy fuel oil with sulfur content exceeding 1% are allowed but generally only in plants that comply with strict emission limit standards. This effectively prevents the use of high sulfur heavy fuel oil in large plants that are not fitted with desulfurization.

3.101 Some key questions then arise:

- Should desulfurization be introduced at the refineries to reduce the sulfur content of fuel oils or should Turkey buy low sulfur crude to produce low sulfur fuel oils?
- Is some fuel switching (e.g., heavy fuel oil to natural gas) plus some desulfurization at combustion plants a more cost effective solution?
- Or should Turkey import low sulfur petroleum products?

3.102 The study provides some of the answer to these questions.

Low sulfur fuel oil and heating oil

3.103 Task 6 provided estimates of the costs of upgrades to reduce the sulfur content of fuel oil. This is not, however, the only possible solution and the results from the Task 6 study, together with other analysis described earlier in relation to air quality regulations, can help Turkey decide on an optimal strategy to comply with EU regulations.

3.104 Analysis using refinery optimization software suggests that further investments of US$185 million, US$210 million, US$135 million and $120 million will be required in Residue HDS at Izmir, Izmit, Kirikkale and Atas - as shown in Table 10.

[36] The standard for heavy fuel oil is 4% but the actual sulfur level is 3.5%.
[37] Temporary exemptions.

Table 10 Investment costs for sulfur reduction in refineries

Refinery	*US$ million*
Izmir	185
Izmit	210
Kirikkale	135
Atas	120 + 32*
Total	682

* *Gas oil.*

3.105 Analysis of sulfur reduction strategies based on sulfur removal in the refineries (Task 7) shows that the increase in total discounted economic system cost, caused by the refinery improvements, is accompanied by a substantial drop in sulfur emissions. Overall, SO_2 emissions are reduced by 13% in 2003 and by nearly 20% by 2025.

3.106 The largest SO_2 reductions are projected for the industrial sector, with 82% of total emission reductions. The remaining SO_2 emission reductions come from the supply sector (self-consumption of energy industry) with 11%, the transport sector[38] with 5% and the residential sector with 2%.

3.107 The cost/tonne of sulfur reduced is US$66 for undiscounted emissions and US$252 for discounted emissions. This compares with a cost/tonne of sulfur reduced by desulfurization at power plants (FGD) of about US$47 for undiscounted emissions and US$211 for discounted emissions.

3.108 This suggests that sulfur reduction in refineries could be a cost-effective method of sulfur control and, as described in the Section – Air quality Regulations and EU accession, could contribute to meeting Turkish emission targets under the EU's National Emission's Ceiling Directive and the Gothenburg protocol.

3.109 Other alternatives to desulfurization of fuel oil and heating oil in Turkey's refineries (in addition to desulfurization of emissions in power plants using FGD) are:

- use of low sulfur crude oil by the refineries.
- substitution of fuel oil and heating oil by natural gas.
- importation of low sulfur products.

3.110 The first of these was considered in the Task 6 analysis but rejected for technical and cost reasons. Subsequent information provided by TUPRAS suggested that it might be feasible. This strategy is estimated to reduce the overall investment costs to approximately US$100 million. The team was unable to estimate the impact on emissions.

[38] Shipping and rail.

3.111 The second option, substitution of fuel oil and heating oil by natural gas, would be feasible but would increase still further Turkey's dependence on natural gas. However, conversion to natural gas would probably be preferred by most industries - for reasons of cost - to the use of low sulfur fuel oil.

3.112 The most effective strategy is likely to be a combination of all four options. As the refineries are upgraded through time to increase the production of lighter products, the volumes of residual fuel oils will decline and the need for desulfurization investments will be reduced. This, combined with the increasing penetration of natural gas into the industrial market will further reduce the use of high sulfur fuels. Remaining fuel oils that are marketed will then have reduced sulfur through desulfurization or through the use of low sulfur crude or through the import of low sulfur products.

Transmission & Distribution loss reduction

Introduction

3.113 Reduction of electricity transmission & distribution (T&D) losses could have important indirect implications for the environment. T&D losses account for over 20% of electricity generated by Turkey's power plants and any improvement in these loss levels will significantly reduce fuel consumption, emissions of various gases, the production of solid wastes and the pre-emption of land for hydropower and mining.

3.114 Task 4 of the Energy & Environment Review focused on T&D loss reduction while Task 7 considered the impact of energy efficiency improvements on energy consumption and emissions.

3.115 With regard to transmission losses, the former Turkish Electricity Transmission Co. (TEAS) had made significant strides in reducing technical losses and rationalising the Turkish tranmission grid. In the 1970s the loss rate fluctuated between 4% and 6% but in recent years it has been reduced to around 3% or less. This is an extremely low figure in comparison with transmission grids in neighboring countries. Turkey's loss values are at or near the operating norms of OECD countries including the US, Japan, and the UK.[39] This low level of losses suggests that the potential for further transmission loss reduction in Turkey will be small. The team's analysis confirmed the validity of the figures reported by TEAS.

3.116 The following Section summarizes the study findings relating to distribution losses.

3.117 Distribution losses can be divided into:

- technical losses (physical losses), and
- non-technical losses (which can be described loosely as "theft" or unbilled electricity).

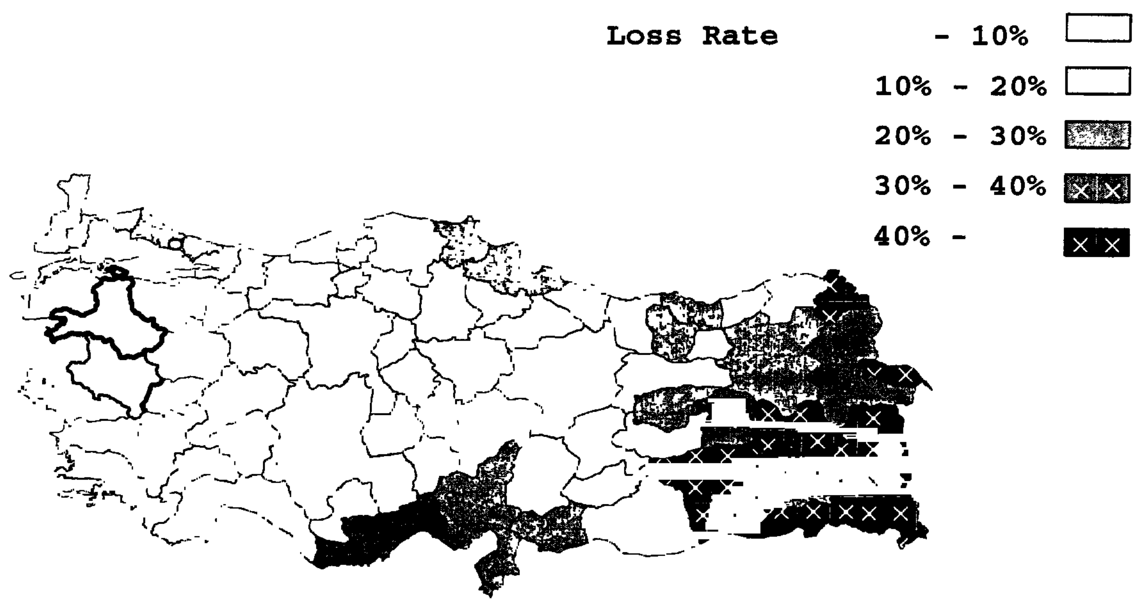
[39] TEAS Annual Report, 2000.

3.118 There is a third category of losses that relates to electricity that is metered but the money is not collected or which is given free to religious establishments or for municipal street lighting and some Government municipal buildings and for use in TEDAS buildings. The latter category, though important, is not discussed here.

Geographical and historical trends: distribution losses

3.119 TEDAS was established in 1995 as the electric distribution company of Turkey. The World Bank's Energy Sector Management Assistance Program (ESMAP) reports TEDAS' average distribution loss levels in 1999 at 10% for technical losses plus another 9% for non-technical losses. Both types of loss are substantially higher in underdeveloped areas than in industrialized areas. The loss figures range from under 10% to over 60% across these areas, as can be seen in Figure 12.

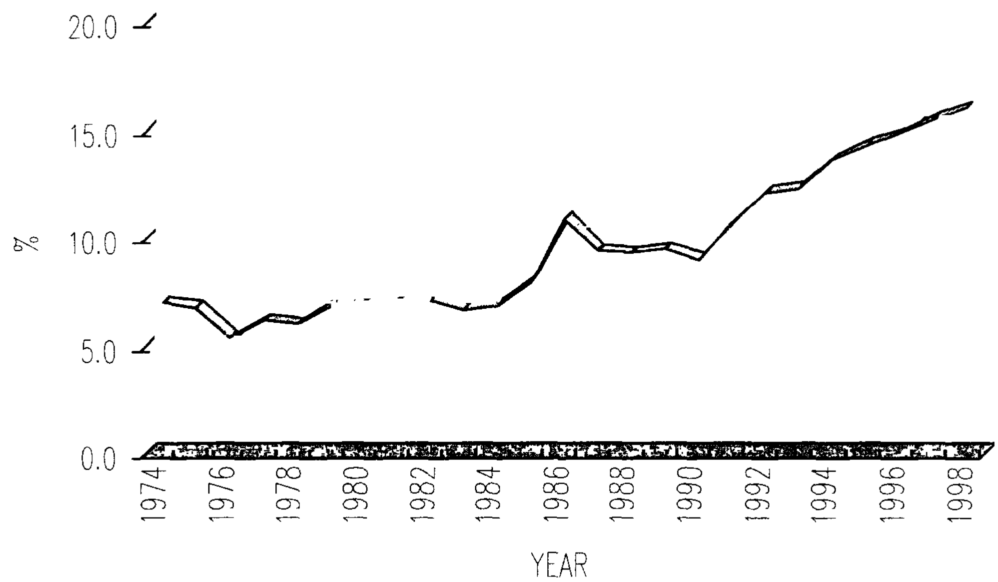
Figure 12 Loss rates of TEDAS by areas (1999)



3.120 Figure 13 shows changing energy loss rates between 1973 and 1998 for the whole power distribution system in Turkey calculated on the basis of net generation.[40] The loss rates between 1974 and 1984 were 5% to 7% but rose to 9% between 1985 and 1990. System losses have grown steadily worse from 1991 to the present day.

[40] TEAS Statistics ' TURKIYE ELEKTRIK URETIM-ILETIM ISTATISTIKLERI 1999'

Figure 13 Trends in energy loss rate for the Turkish distribution system



(Expressed as % net generation energy)

Analysis of distribution losses

3.121 Technical losses caused in individual power circuits can be calculated accurately, given power load and the physical or electrical characteristics of circuits. The assessment of technical losses in the distribution system was done by detailed analysis of three sample "case study" areas: Van, Balikesir and Manisa.

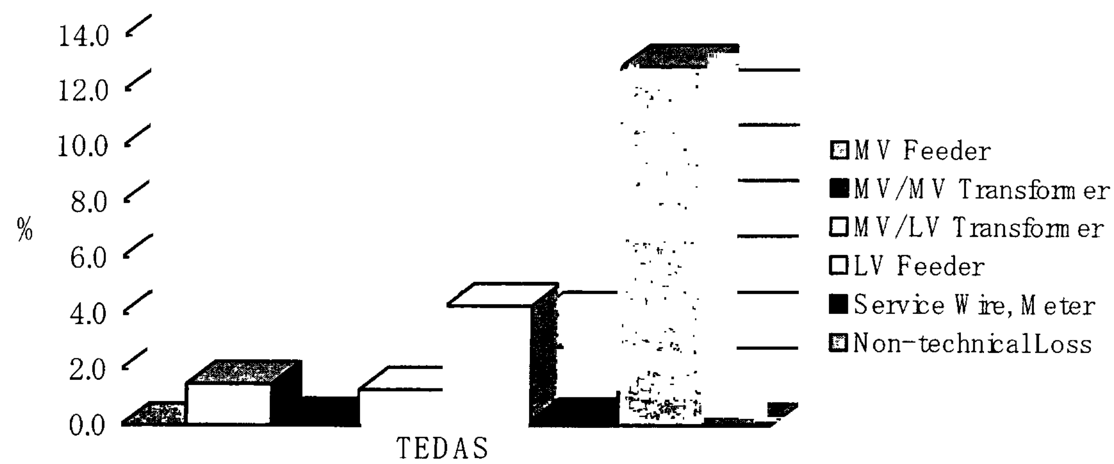
3.122 Non-technical losses can then be calculated by subtracting technical losses from the total loss.

3.123 The results for the three representative Districts were then extrapolated to estimate the entire technical losses of TEDAS. The team used statistical data - peak load, length of Medium Voltage lines, capacity of MV/MV transformers, capacity of MV/LV transformers, length of LV lines, utilization ratio of transformers, load factor, loss factor, and number of customers – to calculate the overall technical losses according to the particular characteristics of equipment and operations within each TEDAS operating subsidiary and District.

3.124 The overall results for TEDAS – the sum of individual District results – are shown in Figure 14. Overall Distribution losses for TEDAS were 21.6% in the year 2000, consisting approximately 7.9% in technical losses and 13.7% in non-technical losses[41]. This suggests that there is ample room for reducing both technical and non-technical losses.

[41] This is based on figures of 7.5% and 12.9% for technical and non-technical losses in 1999 and extrapolated to 2000.

Figure 14 Main sources of losses in the overall distribution network



(Expressed as % of energy input at TEAS substation.)

Recommended measures

3.125 A number of technical loss reduction measures in the MV and LV feeder system are described in the Task 4 report.

3.126 With regard to non-technical loss reduction, TEDAS is certainly aware of the problem and has been taking steps to improve the situation. These steps include special instructions to District staff, a policy of staff dismissal if theft takes place with their knowledge, and a special proclamation of the year 2000 as the year to fight losses and theft. Such efforts have resulted in some impressive statistics: 2,565,252 customers investigated and 268,252 theft cases (10.5%) found, invoices of 32.4 trillion TL (US$25million) to these customers and collection of 14.9 trillion TL (US$11.5million).

3.127 Electricity theft or diversion is of course illegal in Turkey, as it is in most countries. However, the fines are negligible, especially since they do not increase to match Turkey's inflation. A number of recommendations were made in the Report to improve non-technical losses.

Summary

3.128 The study concludes that given the high level of non-technical losses, loss reduction measures should focus on non-technical losses first, followed by the technical loss reduction measures. In this fashion an integrated approach will yield the greatest improvement with the minimum amount of investment by TEDAS.

3.129 Table 11 shows the integrated program developed by selecting these most economical technical and non-technical loss reduction measures.

Table 11 Integrated Loss Reduction Program – all of TEDAS

	Item	Investment Cost (US$ million)	Loss Reduction (percentage points)	IERR (%)
Non-technical loss reduction	in Rural Area	301	4.7	144
Technical loss reduction	Dividing LV Feeders in General Area	77	0.6	53
	Dividing LV Feeders in Coastal Area	28	0.2	49
	Boosting of 6kV in whole TEDAS	43	0.2	49
Total		449	5.7	-

3.130 It is estimated that an optimal, integrated loss reduction program would cut TEDAS' non-technical losses by about 4.7 percentage points - a decrease from 14.1% to 9.4% - through the investment of some US$300 million in rural areas. This investment would be in the form of inspections and investigations, meter relocation and customer service drop improvements, and billing and enforcement measures. A technical loss reduction program that would enable TEDAS to reduce its losses by another one percentage point should accompany the non-technical loss reduction program. The integrated result of these combined non-technical and technical loss reduction measures would be to reduce TEDAS losses from 21.6% to 15.9% - a 5.7 percentage point reduction. This decrease would result in a TEDAS loss rate that is about three times as large (rather than four times as large) as the 5-6% total loss rate that is typical of European, Japanese and American utilities.

Landfill gas

3.131 Each tonne of typical household waste dumped may result in approximately 120 - 300 m^3 of landfill gas during the lifetime of the landfill, typically 20 years. This gas is an environmental hazard but, when properly harnessed, an energy resource. By using the gas for energy generation:

- harmful emissions are reduced,
- energy is produced that would otherwise be produced in other, polluting, plants,
- imports of energy are reduced.

3.132 Impacts of landfill include:

- Explosions and fires due to release of landfill gas.
- Risk to human accidents (for example, at one landfill site a mudslide killed many people in the City of Umraniye in Turkey in 1993).
- Adverse impacts on crops and vegetation.
- Dust clouds formed in windy conditions.

- Seepage into underground and surface water.
- Odor.
- Greenhouse gases (landfill gas is principally methane).

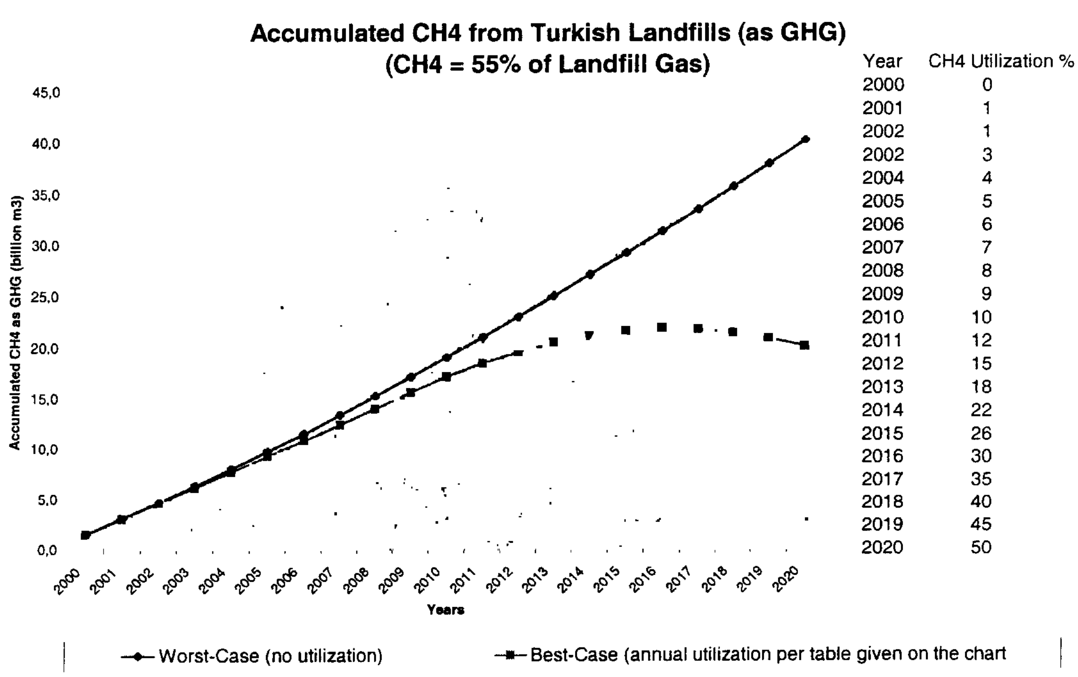
3.133 The majority of towns and medium sized cities in Turkey dispose municipal waste in open landfills creating significant pollution in these cities.

3.134 Total landfill gas potential in Turkey, based on pilot case studies in Istanbul, Bursa, Izmir and İzmit conducted as part of this study, and that could be utilized for energy production is estimated to be 73 billion m^3 between 2000 - 2020. Assuming 55% of this gas is methane, this implies 40 billion m^3 by the end of the period to 2020 (see Figure 15).

3.135 The feasibility of landfill gas utilization depends on site-specific conditions including proximity to the electrical grid, economies of scale (power generation may be uneconomic for small power plants at landfill sites close to small cities) and the age profile of the landfill waste. The price of electricity is also an important factor in the feasibility of landfill gas utilization.

3.136 If 50 % of the gas could be utilized according to EC practices, the level of GHG emissions would decrease to a level of 20 billion m^3 and would produce about 29 TWh of electricity over this twenty-year period (compared with an annual generation for the whole of Turkey of 127 TWh in 2001).

Figure 15 GHG potential of landfill methane in Turkey (1980-2020)



3.137 For this utilization potential to be realized, Turkey will need to adopt better solid waste management practices. Additionally, policies should be introduced that provide incentives to private and municipal enterprises to develop landfill utilization gas projects. Funding sources such as the PCF (Prototype Carbon Fund) of the World Bank, and bilateral funds (e.g., Dutch ERUPT) may provide incremental funding to improve the financial attractiveness of landfill gas projects.

Impact of constraints on gas consumption

3.138 The Reference scenario is dominated by natural gas in the power sector and more widely in industry and households because it is cheap and clean and requires less expensive emission control systems. An alternative scenario was considered in order to examine the impact on costs and emissions that would be incurred by constraining the power system to rely more on imported coal and lignite plants. The constraint on gas usage could arise in several ways. For example:

- Government might wish to maintain diversity in the sources of energy or might be concerned about the Balance of Payments implications of imported gas and might therefore introduce policy measures to restrict the use of imported gas or encourage the use of lignite. This would result in higher emissions of various pollutants.
- The private sector might wish to avoid being locked into long-term contracts for natural gas, it might have concerns about the future availability of gas or it might expect gas prices to rise relative to lignite. Without policy intervention, this would result in higher emissions; Government might therefore wish to introduce policies to encourage the use of natural gas.

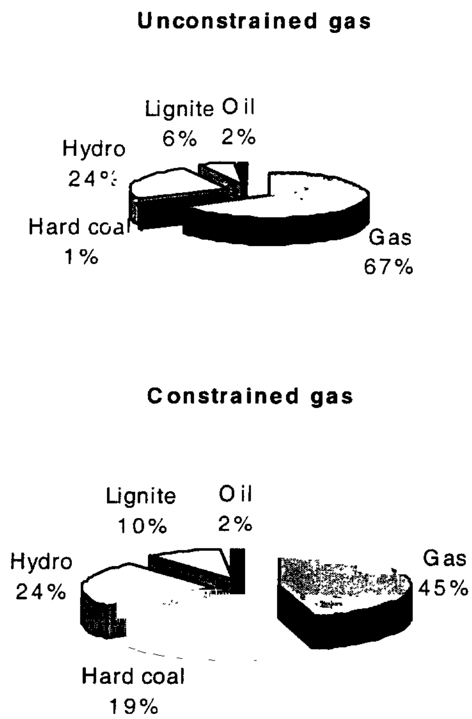
3.139 Furthermore, it should be recognized that the results of each analysis are sensitive to small changes in the assumed inputs. Considering that the levelized costs of natural gas and imported coal plants do not differ significantly (gas costs are slightly lower at high capacity factors), under slightly different input assumptions coal could be selected to play a role in Turkey's power generation expansion.

3.140 Under the constrained gas scenario[42], a total of 5,500 MW of additional lignite-fired capacity comes on line (thus fully utilizing the domestic lignite resources at Elbistan) as well as 25,900 MW of imported coal-fired capacity.

3.141 As shown in Figure 16, by 2025, the capacity mix is 10% lignite, 19% hard coal, 46%gas and 24% hydro with the balance from oil-fired plant. This compares with the share of lignite and hard coal combined accounting for only 7.0% of the total installed capacity in 2025 in the Reference scenario with gas accounting for 67%.

[42] In this scenario, all new plants are assumed to be sub-critical. An alternative scenario was considered in which all of the capacity is supercritical. This is reported in the Task 7 Report.

Figure 16 Electricity capacity mix in constrained gas scenario

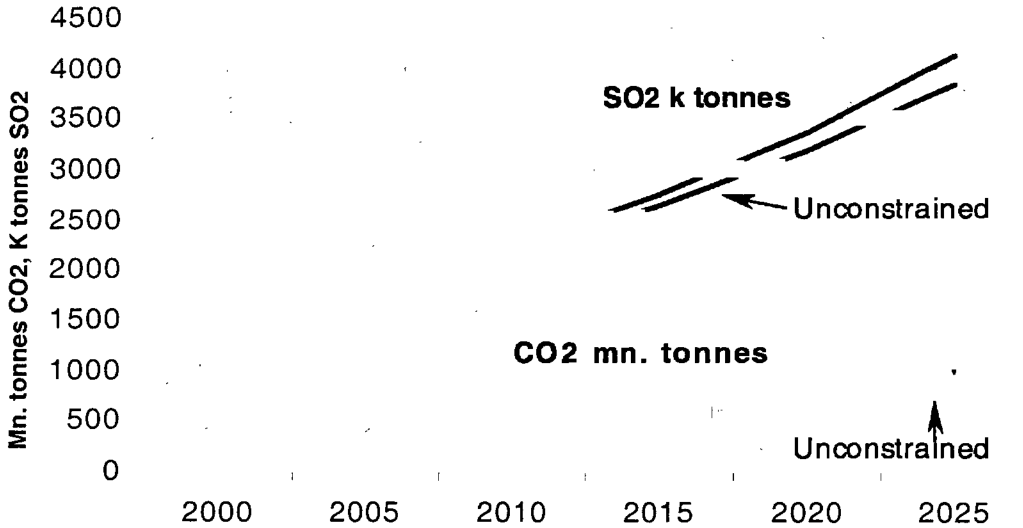


3.142 In this scenario, by 2025, gas would provide 50% of total electricity generation, down from 77% under the least-cost scenario. Total gas consumption would reach 65 billion m^3 by 2015 (80 billion m^3 in the Reference scenario) and 130 billion m^3 by 2025 (169 billion m^3 in the Reference scenario). Coal generation in 2025 would supply nearly 35% of the electricity.

3.143 The net energy import bill would be reduced to some extent because of the shift from gas to coal but the level of fuel import dependence remains relatively high at 81% compared with 83% in the Reference scenario. Total discounted economic system cost is estimated to increase by 1% due to the constraint on gas use.

Due to the shift from natural gas to lignite and imported coal, emissions of PM, SO_2, NOx, CO_2 and ash all increase substantially relative to the Reference scenario. The impact on SO_2 and CO_2 are shown in Figure 17.

Figure 17 Impact of gas constraints on emissions



3.144 In summary:

- From the environmental and cost viewpoint, the Reference scenario is "win-win" compared with the constrained gas scenario. Analysis of the difference between the costs and emissions in the two cases provides a quantitative estimate of the benefits of using additional gas, compared with the additional lignite and coal in the constrained gas scenario. The difference is most striking for CO_2 (see also Section – Greenhouse gas strategy).
- A constraint on the use of natural gas does reduce dependence on imported fuels but the impact is marginal largely because natural gas is mostly substituted by imported coal. To the extent that imported coal can be sourced from a range of suppliers, this does increase security of energy supplies to some extent.

Greenhouse gas strategy

Issues

3.145 There are several major issues regarding climate change policies but the immediate issue is:

- What should be Turkey's emission target?

3.146 Linked to this is the question:

- How should that target be achieved?

3.147 The *Energy & Environment Review* project has, directly and indirectly, considered strategies for achieving GHG emission reductions. The estimates of the costs of these emission reductions will help decision makers in choosing achievable emission reduction targets for Kyoto.

3.148 For signatory countries to the UNFCCC, the baseline year is designated as 1990, but Turkey has not yet signed the treaty. Turkey's baseline could, for example, be 1995 or 2000. More important is the target relative to the baseline. For convenience, the following discussion considers emissions relative to the year 2000.

Targets for other countries

3.149 The analysis of Task 7 shows that in the absence of policies to curb greenhouse gas emissions, there will be a major growth in emissions by an average of 5.7% per annum over a 25-year period under the Reference Scenario. At this growth rate, emissions in 2010 will be 75% above the levels of the year 2000. By 2025 the results suggest a 300% increase relative to 2000 levels. Relative to 1990 emission levels, the situation would be markedly worse, with an increase of nearly 600%.

3.150 Countries with the most lenient targets are Australia (8% increase), Iceland (10% increase) and Norway (1% increase), as shown in Table 12. The EU as a whole has a target of 8% reduction relative to 1990. A similar target is set for most countries of Central & Eastern Europe that are in transition. Japan has a target of 6% reduction while the US target would be 7% reduction. Within the EU a burden sharing agreement has been introduced that allows countries to distribute the 8% reduction according to the difficulty of achieving the target: the UK, because of the switch from coal to gas during the 1990s, can easily meet the target while others, such as France, Sweden and Finland, that have substantial amounts of nuclear power that may be phased out, have accepted more modest targets[43].

Table 12 Emission targets for different countries

Country	Target relative to 1990 reduction (-), increase (+)
Portugal	+27%
Greece	+25%
Spain	+15%
Japan	-6%
US	-7%
EU average	-8%
Central & Eastern Europe	(in general) -8%

3.151

[43] No reduction relative to 1990 for France.

Impacts on emissions of various strategies

3.152 Various policies are discussed individually in Sections - Clean coal technology and emission controls to Energy Efficiency (DSM) and Section - Impact of Constraints on Gas Consumption, above. These policies impact on GHG[44] emissions but also have important impacts on emissions of other pollutants and on costs. They cannot, therefore, be considered solely in terms of GHG strategies but do have an important impact on GHG emissions.

3.153 The largest contributions are shown to come from the wider use of natural gas[45], DSM and cogeneration, as shown in Table 13. The reductions in Table 13 describe CO_2 emission reductions in 2010 relative to emissions in the year 2010 in the "constrained" gas scenario.

Table 13 Percentage reduction in emissions from strategies

Strategy[46]	CO_2 emission reductions (2010)
Wider use of natural gas	4.5%
Renewable energy (wind, mini-hydro)	0.9%
Energy efficiency (DSM)	5.5%
Technical efficiency in electricity supply	0.6%
Cogeneration	2.2%

3.154 Table 14 shows that, in the absence of any abatement strategies (and if there is a constraint on the use of gas), CO_2 emissions are estimated to be 91% higher in 2010 than in 2000. The wider use of natural gas (Reference scenario) brings this down to 82%; the wider use of natural gas combined with renewable energy brings it down further to 81%; etc. The combined effect of the five strategies is to bring the increase (2010 to 2000) down from 91% to 65%. In other words, even after implementing the five strategies, CO_2 emissions in 2010 will still be 65% higher in 2010 than they were in 2000, 120% higher than in 1995 and nearly 180% higher than in 1990.

[44] GHG emissions include a range of gases that have different greenhouse warming properties. The Kyoto targets are based on a basket of six gases that include CO_2, CH4, N2O and three fluorinated gases. These are converted to CO_2 equivalents based on the global warming properties: CO_2 has a value of 1, CH_4 has a value of 21 and N_2O has a value of 310. The dominant greenhouse gas is CO_2 and throughout the analysis we have concentrated on changes to CO_2 emissions but strictly speaking this is only one of the six greenhouse gases listed in the Kyoto protocol.
A tonne of carbon combines with oxygen to create CO_2 and when describing the cost of emission abatement, the practice is to refer to US$ per tonne of CO_2 or per tonne of carbon; a tonne of carbon results in 3.67 tonnes of CO_2.

[45] See Section 0 for an explanation of this scenario.

[46] The nuclear does not appear until after 2010 and is not included in
Table 13 and

Table 14. It is considered as an option for later years.

Table 14 Impact of strategies on emissions in 2010

Strategy	Emission increase in 2010 relative to 2000
Constrained gas scenario - no GHG strategies	91%
Wider use of natural gas	82%
Above plus renewable energy (wind, mini-hydro)	81%
Above plus energy efficiency (DSM)	70%
Above plus technical efficiency in electricity supply	69%
Above plus cogeneration	65%

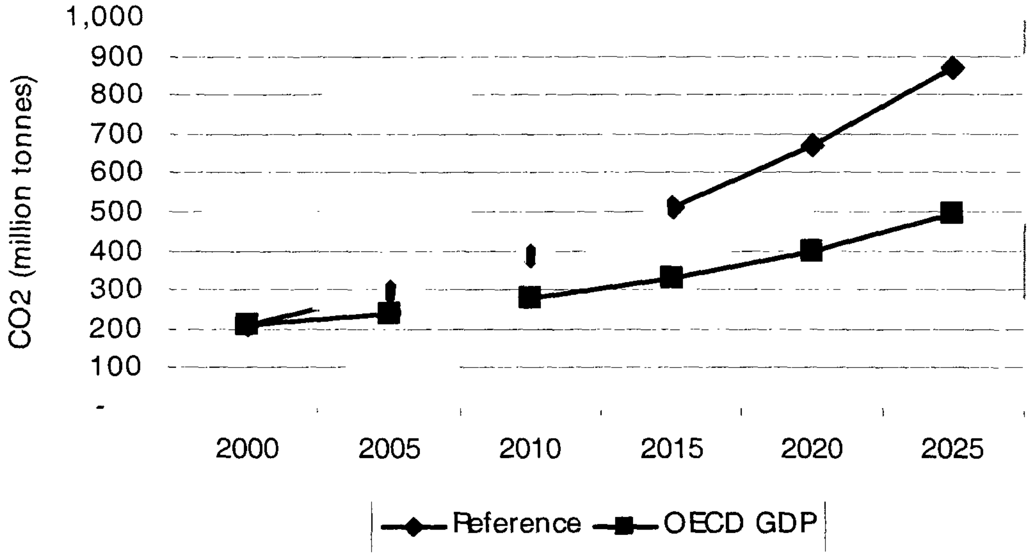
3.155 It should be acknowledged that emission reductions that can be achieved by the year 2010[47] are less than those that can be achieved in the longer term.

3.156 In terms of the estimated 5.5% reduction in emissions through demand-side management by 2010 and 10% in the longer term, the potential for DSM may have been underestimated but similarly the implementation costs for DSM may also have been underestimated.

3.157 Analysis using alternative energy demand projections based on OECD GDP projections, suggests that CO_2 emissions will be considerably lower - as shown in Figure 18. For example, the lower demand projections mean that CO_2 emissions are only 31% higher in 2010 relative to 2000; this compares with an increase of 82% for the Reference scenario.

[47] Estimated emissions increase by 300% over the period to 2025. Each 1% reduction in emissions in the year 2025 brings the increase down by 4%. So, a 5% saving means that the increase between 2000 and 2025 would be 280% instead of 300%.

Figure 18 Impact of lower economic growth on CO_2 emissions



Costs of GHG strategies

3.158 In formulating a national policy to combat GHG emissions a number of strategies analyzed as part of the study are win-win. These are:

- improved technical efficiency in the power sector.
- cogeneration in industry.
- Demand-Side Management.

3.159 With these policies, the economic cost of energy supplied and the cost of energy imports will be lower while helping achieve GHG emission reduction targets. There will also be other benefits to the environment.

3.160 We evaluated the negative impact of a policy that constrains the use of natural gas but this can also be interpreted to show the beneficial impact on greenhouse gas emissions resulting from relaxation of any constraints on the use of natural gas. This is also a win-win strategy.

3.161 Other strategies that impact on GHG emissions include:

- nuclear power.
- renewables, and
- a carbon tax.

3.162 As benchmarks for evaluating the cost of GHG emission reduction strategies, the following World Bank-managed organizations provide some guidelines:

- *Global Environment Facility (GEF)*: GEF's operational strategy uses a unit abatement cost ceiling of US$10/tonne of carbon or US$2.73/tonne CO_2 when evaluating GEF short-term projects.
- *Prototype Carbon Fund (PCF)*: PCF is willing to pay for emission reduction credits up to approximately US$7 or US$8 per tonne of CO_2. This suggests that abatement costs below US$8 per tonne of CO_2 might be acceptable.

3.163 The costs per tonne of CO_2 abated for the strategies discussed above are shown in table 15.

Table 15 Cost of GHG abatement strategies

Strategy	US$/tonne of CO_2
Wider use of natural gas	win-win
Energy efficiency (DSM)	win-win
Technical efficiency in electricity supply	win-win
Cogeneration	win-win
Renewable energy (wind, mini-hydro)	1.3
Nuclear	7.3

Note: CO_2 emissions are undiscounted.

3.164 The analysis shows that renewables could play a role in GHG reduction policy. The analysis has not considered policies individually but mini-hydro and wind-power as a bundle are shown to be promising with a low cost for reducing CO_2 emissions at an estimated US$1.3 per undiscounted tonne of CO_2 (and US$4.6 per tonne of undiscounted carbon). But the analysis suggests that the scope for abatement of CO_2 emissions using wind and mini-hydro could be less than 2% over the period 2000-2025.

3.165 The analysis shows that ***nuclear power*** is not attractive for GHG reduction, even though the net energy import bill drops. It is relatively expensive with an abatement cost of US$7.3/tonne[48] of CO_2. This exceeds GEF guidelines and is at the top end of the range for emission reduction measures of the Prototype Carbon Fund. Nuclear plants also have their own environmental problems. Lastly, the scope for CO_2 emissions abatement is also limited. The results suggest that abatement would be less than 1% over the period 2000-2025; this reflects the expected dominance of natural gas in Turkey's electricity sector. By replacing gas-fired CCGTs, new nuclear units inevitably have lesser environmental benefits.

[48] Undiscounted.

Carbon tax

3.166 A carbon tax could be applied in a number of different ways but as part of the study the team considered a tax per tonne of CO_2 that would be initiated in 2004 using a value of US$4 per tonne CO_2 (equivalent to $14.7 per tonne of carbon). In reality, the tax would be introduced in some other way, for example depending on the carbon content of the fuel. The scenario nevertheless gives an indication of the potential impacts of such a tax.

3.167 The carbon tax would bring about some beneficial inter-fuel substitution, inducing consumers to use less carbon intensive fuels including gas and to use more renewables and cogeneration in preference to coal and lignite but at the tax rate considered (US$4/ tonne of CO_2) the results suggest that the level of CO_2 emissions is only 1.2% lower over the planning horizon, so much higher tax rates are likely to be required to bring about substantial reductions.

Conclusions

3.168 Turkey has not agreed a GHG emission target. A target increase greater than that agreed by the European Commission for Portugal or Greece would be reasonable. But to achieve a target increase of, say, 65% relative to 2000 or 120% relative to 1995 will require the implementation of a GHG abatement strategy. The analysis suggests that emissions are very sensitive to the choice of GDP projections and corresponding energy demand. If OECD GDP projections are accepted then even without abatement strategies, emissions in 2010 would be only 35% above levels of 2000.

3.169 As table 14 shows that options for emission abatement applied individually do not have a major impact on CO_2 emissions: an effective national policy on climate change will have to rely on the application of a combination of options, e.g., DSM, cogeneration in industry, improved technical efficiency in the power sector, greater natural gas utilization and some investment in mini-hydro and wind power.

4

Summary and Conclusions

Introduction

4.1 Turkey is adopting many international standards and participating in a number of international agreements in relation to SO_2, NOx and greenhouse gases. MENR and MoE are actively adapting legislation and regulations to approximate to those of the EU and its "acquis communautaire" and energy companies have begun a series of investments in the energy sector that will allow Turkey to match EU and international environmental standards. The electricity market has been liberalized, the gas market will soon follow and the refineries are investing heavily to upgrade petroleum product standards.

4.2 However, Turkey's growing economy and energy demand and increasing levels of emissions of greenhouse gases and SO_2 pose particular problems in relation to ceilings or targets for emissions that, in many cases, are set relative to 1990 levels.

4.3 With the liberalization of the electricity market, interest in lignite and coal-fired plants will diminish as private sector investors are attracted by the short construction times and lower risks of gas-fired plants. In the Reference Scenario, the demand for natural gas would grow at an estimated 9.6% per annum over the period 2000-2025 with total consumption reaching 80 billion m^3 by 2015 and 170 billion m^3 by 2025 from levels of approximately 15 billion m^3 in 2000.

4.4 This growth in gas demand would have corresponding benefits to the environment but, we estimate, would lead to increased dependence on imported energy to 83% by the end of the study period from 62%in 2000. In the Reference scenario, the share of gas in net energy imports doubles between 2000 and 2025, from 20% to 40%. Lignite and hard coal consumption in the power sector would increase by some 50% and 150% respectively from 2000 to 2005 as committed plants are commissioned over the next few years, but then stabilize and even decline slightly. More generally we estimate that the share of coal and lignite in the overall energy mix would increase from 18% in 2000 to 24% in 2025.

4.5 Decision-makers must often make difficult choices between the environment on the one hand and cost on the other; but they also face trade-offs between other competing objectives such as energy security or employment. The purpose of the *Energy & Environment Review* project has been to provide the information about trade-offs that will allow Government to make informed decisions about policies that affect the energy sector and the environment.

4.6 Examples of some of the key questions that are addressed, indirectly or directly, by the study include:

- What will be the costs and benefits if Turkey adopts EU legislation on emissions from large-combustion plant?
- Do clean-coal technologies offer a cost-effective alternative (to natural gas or renewable energy) as a way to achieve a cleaner environment and reduce GHG emissions?
- Should EU legislation on the sulfur content of fuel oils be introduced? How should it be achieved? What are the costs of implementing it?
- What are the costs and benefits of energy efficiency programs? Should they be promoted?
- What are the implications for the environment, cost and security of energy supply if Turkey constrains the use of natural gas?
- What are cost-effective means to reduce GHG emissions and meet (yet-to-be-decided) Kyoto targets? What are achievable GHG emission targets for Turkey? What would be the cost of meeting those targets?

4.7 These answers to these questions suggested by the Study are summarized below.

EU air quality regulations

4.8 The EU's *Large Combustion Plants Directive* (LCPD) imposes strict emission standards for large combustion plants including SO_2, particulate matter and NOx. If Turkey is to comply with these standards then most of Turkey's existing lignite and coal-fired power plants will require new emission controls and/or upgrading of existing emission controls.

4.9 The EU's *National Emission Ceilings* (NEC) Directive and the Gothenburg Protocol set specific binding national ceilings for emissions for four pollutants but the *Energy & Environment Review* study has focused primarily on SO_2 and NOx emissions. No target has yet been negotiated for Turkey but the information provided in the Energy & Environment Review should help in understanding the possibilities of reducing emissions and the cost of those emission reductions. Examples of SO_2 emission reduction targets for other EU countries or applicants are shown in Table 16.

Table 16 Examples of SO2 emission targets for EU countries

Country	*Emission reduction, 2010 relative to 1990*
Poland	56%
Portugal	53%
Spain	65%
EU average	75%

4.10 The most cost-effective SO_2 control options for helping to meet the target ceiling are low-sulfur coal, wet flue-gas desulfurization (FGD) and dry FGD. Upgrading of existing refineries has the potential to reduce SO_2 emissions but other policies, such as fuel substitution and more efficient power plant technologies, also provide very cost-effective ways to achieve SO_2 reduction and simultaneously achieve other environmental benefits.

4.11 There is an ongoing program of FGD retrofits and environmental upgrades at power plants that are expected to take place by 2004. Despite these investments, the study estimates that some further reduction of particulates and SO_2 will be needed to comply with Turkey's own emission standards. Such retrofits (mainly SO_2 controls) would require an investment of approximately US$418 million.

4.12 The retrofit investment requirements to comply with the LCPD are estimated at approximately US$550 million by 2010 and US$140 million by 2016 (NOx controls).

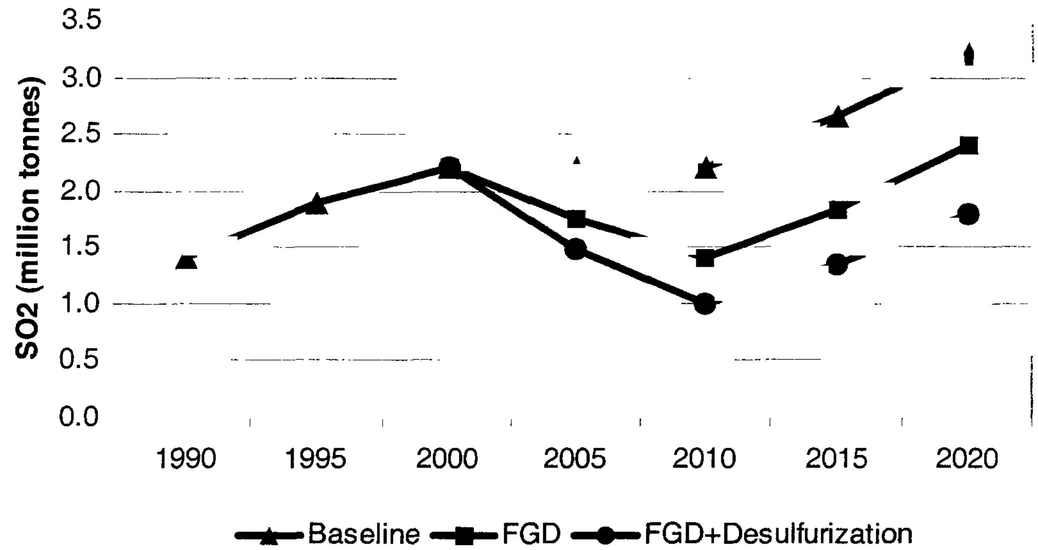
4.13 Investment in refinery desulfurization as an option to meet emission reduction targets or to satisfy another item of EU legislation - the Directive on the Sulphur Content of Liquid Fuels - is estimated at US$720 million. The total costs of both FGD retrofits and refinery desulfurization are estimated at US$1.4 billion.

4.14 The cost/tonne of sulfur reduced using FGD was estimated by the Consultants at approximately US$55[49]. This compares with a cost/tonne resulting from refinery desulfurization of approximately US$66[50].

As Figure 19 shows, if Turkey complies with the LCPD for power plants and implements refinery desulfurization by 2010, it will achieve an SO_2 emission reduction of approximately 28% relative to SO_2 emissions in 1990. This compares with Reference case projections of an increase in SO_2 emissions of 54% by 2010 relative to 1990. Implementation of the LCPD in the power sector (large power plants) alone will reduce SO_2 emissions to 3% below 1990 levels. The results are also shown in Figure 19.

[49] US$55/tonne for undiscounted emissions and $233 for discounted emissions.
[50] US$66/tonne for undiscounted emissions and US$252 for discounted emissions.

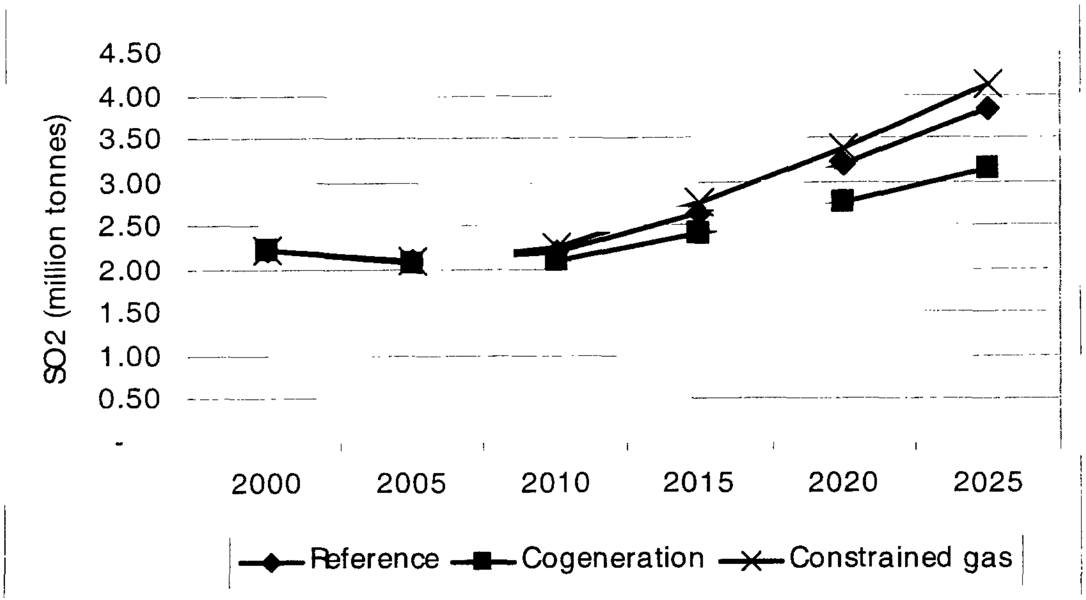
Figure 19 Energy sector SO_2 emissions



4.15 The share of industry in total SO_2 emissions grows from 26% in 2000 to 63% in 2010 and 74% in 2020 (under the EU compliance scenario). The potential SO_2 reductions from the industrial sector therefore need to be assessed, because they are likely to provide opportunities for additional low-cost SO_2 reductions. Such options could be pursued to achieve further reduction of the total SO_2 emissions or replacement of other more expensive SO_2 control options.

4.16 The impact of other policies on SO_2 emissions is illustrated in Figure 20. Constraining the use of natural gas is shown to increase SO_2 emissions while DSM and cogeneration are both shown to lead to substantial, and approximately equal, reductions in emissions (only the impact of cogeneration is shown in Figure 20 but DSM would have a very similar impact). Both cogeneration and DSM could contribute to meeting an SO_2 emission target. Other policies, such as renewable energy and technical efficiency in power production (not shown) will have a modest impact on SO_2 emission targets.

Figure 20 Impact of other policies on SO_2 emissions



4.17 If GDP does not grow at the rate projected by SPO then SO_2 emission levels will be considerably lower and targets will be easier to achieve. In 2010, in the absence of any air pollution policies, emissions would then be 32% higher than 1990 (compared with 54% in the Reference case).

4.18 In conclusion, the cost per tonne of SO_2 emission reduction from retrofitting FGDs in existing lignite-fired power plants is slightly higher but of a similar order-of-magnitude to the cost of refinery desulfurization. If Turkey wishes to comply with the EU's LCPD then emission controls at power plants are unavoidable. The key issue relates to timing. For some older thermal plants with limited residual lives, the retrofitting of FGD will not be cost effective.

4.19 There are, however, other options to desulfurization of fuel oils at refineries that are discussed in Section - Petroleum product quality below.

Clean coal technology

4.20 The analysis of clean-coal technologies can help environmental regulators identify appropriate equipment that complies with Best Available Technology (BAT) [51] criterion; the analysis can also help electricity companies and owners of large combustion plant decide on how best to meet emission standards. Mandatory technologies could include, for example, desulfurization or low NOx burners but could require companies to use supercritical technology or fluidized-bed combustion for lignite-fuelled power plants.

[51] The Integrated Pollution Prevention and Control (IPPC) Directive requires that developers use Best-Available Technology.

4.21 The clean-coal technology special study (Task 2) of the Energy & Environment Review, together with Task 7, considered a range of technical issues relating to clean coal combustion.

4.22 It concluded that:

- Circulating Fluidized Bed (CFB) technology has major possibilities in Turkey using low quality lignite that cannot be burned easily in pulverized coal plants.
- Supercritical pulverized coal technology also has major possibilities in Turkey's energy future, as the power sector will be called upon to reduce, or curtail the increase of, greenhouse gas emissions. Supercritical plants could contribute to a 10-15% CO_2 emission reduction relative to sub-critical coal-fired plants, without significantly higher costs.
- FGD technology will play a very important role and contribute to the sustainable use of coal in Turkey. While FGD installations in both new and existing plants require a major investment, they are essential as determined by both Turkey's and the EU's regulations and they will have a significant beneficial side effect to reduce particulates, in addition to the SO_2 emission reductions.
- Rehabilitation of existing power plants is clearly a "win-win" option and should be pursued as soon as possible.
- Fly-ash utilization is economic for cement manufacture where the cement plant is located within 200km of the power plant. The practice of utilization should be encouraged with appropriate policies.

Petroleum product quality

4.23 The Turkish refineries are undergoing major upgrades that will allow the refineries to produce petroleum products that, in general, will comply with EU standards for gasoline and diesel - including sulfur and lead - and that are similar to standards in Japan and the USA. The refineries will, however, continue to produce high sulfur heavy fuel oil and heating oils with sulfur contents of 3.5% and 1.0% respectively[52]. However, the use of heavy fuel oil with sulfur content exceeding 1% is generally prohibited in the EU except under certain conditions. EU regulations also limit the sulfur content of heating oil to 0.2% at present but the regulations will tighten to 0.1% by 2008.

4.24 Analysis using refinery optimization software suggests that strict compliance with EU standards for fuel oil and heating oil, would require further investments of US$185 million, US$210 million, US$135 million and $120 million in Residue HDS at Izmir, Izmit, Kirikkale and Atas.

4.25 Analysis of the impact of these investments shows that overall SO_2 emissions would be reduced by 13% in 2003 and by nearly 20% by 2025. The largest

[52] The standard for heavy fuel oil is 4% but the actual sulfur level is 3.5%.

SO_2 reductions are projected for the industrial sector, with 82% of total emission reductions. The remaining SO_2 emission reductions come from the supply sector (self-consumption of energy industry) with 11%, the transport sector[53] with 5% and the residential sector with 2%.

4.26 The cost/tonne of sulfur reduced is estimated at US$66 for undiscounted emissions and US$252 for discounted emissions. This compares with a cost/tonne of sulfur reduced by desulfurization at power plants (FGD) of about US$55 for undiscounted emissions and US$233 for discounted emissions. This suggest that sulfur reduction in refineries could be a cost-effective method of sulfur control and could contribute to meeting Turkish emission targets under the EU's National Emission's Ceiling Directive and the Gothenburg protocol.

4.27 Three alternatives to desulfurization of fuel oil and heating oil in Turkey's refineries (in addition to desulfurization of emissions in power plants) are:

- use of low sulfur crude oil by refineries.
- substitution of fuel oil and heating oil by natural gas.
- importation of low sulfur products.
- The optimum strategy is likely to be a combination of all four options.

Energy efficiency measures

4.28 Some of Turkey's industries, such as cement and the automobile industry, are already relatively energy efficient. Other industries, such as iron & steel, sugar, fertilizer and petrochemicals, have a mix of energy efficient and less energy efficient plants. Overall improvements in energy efficiency are likely to arise from the rationalization of the industries and closure of some capacity following privatization (e.g., refineries) or investment in new technologies (iron & steel) or both.

4.29 Analysis conducted as part of the study shows that an assumed program of DSM/energy conservation measures would have a major impact on energy demand, energy imports and emissions. A 17% drop in energy supply relative to the Reference scenario resulting from a DSM program is estimated to result in 19% less energy imports, lower discounted total system costs, 18% reduction in GHG emissions and 16% less SO_2 emissions.

4.30 The DSM scenario is therefore considered "win-win" and could play an important role in meeting both GHG targets and SO_2 targets.

4.31 In a liberalized market, without monopoly power and gas companies, DSM policies are less easy to implement. Nevertheless, DSM measures can be implemented in various ways, preferably using the market mechanism (such as ESCOs) or through one or more state agencies when they might be financed from a levy on electricity or energy consumers.

[53] Shipping and rail.

4.32 Electricity transmission & distribution (T&D) losses have important indirect implications for the environment. T&D losses account for over 20% of electricity generated by Turkey's power plants.

4.33 The majority of losses (over 14%) are non-technical (theft and unbilled consumption) while the balance (7%) is technical (physical losses). The Task 4 study concluded that loss reduction measures should focus on non-technical losses first, followed by the technical loss reduction measures.

4.34 The study estimates that, with an investment of some US$300 million in rural areas, a loss reduction program would cut TEDAS' non-technical losses by about 4.7%, or a decrease from 14.1% to 9.4%. This investment would be in the form of inspections and investigations, meter relocation and customer service drop improvements, and billing and enforcement measures. The study also estimates that a technical loss reduction program would enable TEDAS to reduce its losses by another one percentage point. The combination of non-technical and technical loss reduction measures would reduce TEDAS's losses from 21.6% to 15.9% - a 5.7% point reduction but this would still leave TEDAS with a loss rate that is about three times higher than the 5-6% total loss rate that is typical of European, Japanese and American utilities.

Impact of constraints on gas consumption

4.35 The Reference scenario suggests that in the absence of any constraints to the availability of natural gas there would be a rapid growth in the use of natural gas with an annual average growth rate of 9.6% per annum over the period 2000-2025 and that the total natural gas consumption would reach the levels shown in Table 17.

Table 17 Natural gas demand projections

Year	*Unconstrained demand (billion m3)*	*Constrained demand (billion m3)*
2000	15	15
2015	80	65
2025	170	130

4.36 However, this level of gas demand might not emerge. For example:

- the construction of pipelines may be delayed;
- Government policy measures may be introduced that constrain gas consumption in order to maintain diversity of sources of energy;
- the private sector might prefer the flexibility of coal/lignite in preference to long-term contracts for natural gas;

4.37 Furthermore, coal may become more competitive; its prices may decline and the coal-gas price differential may increase from the projected levels. This could be the outcome of international fuel market fluctuations and/or restructuring of the domestic lignite production industry.

4.38 An alternative scenario was therefore considered in order to examine the impact on emissions if the power system relied more heavily on imported coal and lignite plants.

4.39 A scenario is examined in which the share of lignite and hard-coal power plants increase and total gas consumption would reach a lower level of 65 billion m^3 by 2015 and 130 billion m^3 by 2025 (Table 17).

4.40 The impact of the constraint on gas demand would be to reduce Turkey's import dependence from 83% in the unconstrained scenario to 81% in the constrained gas scenario (much of the coal in this scenario is imported coal). The impact on energy security of supply is not, therefore, dramatic. The constraint on gas use is estimated to result in an increase in total discounted economic system cost by 1%.

4.41 The constraint results in an 8% increase in GHG emission levels as well as increases in costs and emissions of other pollutants and production of ash.

Greenhouse gas strategy

4.42 Turkey will negotiate an emission target for greenhouse gases. Emission targets may be greater than, or less than, the baseline. A few signatories to the Kyoto protocol will be allowed to increase their emissions relative to the baseline[54] but most countries are expected to reduce emissions. Countries of Central and Eastern Europe are also OECD members and have, largely, accepted emission reduction targets of around 8%. Most of these countries, however, can easily meet their targets because 1990 emission levels were very high. Turkey will not be able to achieve an emission reduction target and instead will need to agree a substantial increase.

4.43 The choice of emission target is affected by estimates of the costs of emission reductions relative to a baseline. The *Energy & Environment Review* has provided information on the cost to Turkey of greenhouse gas abatement strategies. The results can be used both to assess an appropriate target and to identify the most cost-effective abatement strategies once the target has been agreed.

4.44 We estimate that by 2010, if the use of gas in the power sector in Turkey is constrained, emissions of GHG will increase by over 90% compared with levels of the year 2000 or by nearly 160% relative to 1995 levels. This is very high when compared with target reductions by most candidate accession countries of Central & Eastern Europe of 8%.

4.45 Figure 21 illustrates the impact on emissions of various strategies that might be pursued. The vertical height of the two columns represents total emissions in the absence of any GHG policies *and for the year 2010 it assumes that the use of natural gas in the power sector is constrained (see Section).* The impact of various policies on

[54] The baseline in most cases is emission levels of 1990 though we understand that for Turkey a baseline of 1995 has been agreed.

emissions for the year 2010 is then shown, starting with the topmost "slice," in the following order:

- relaxing constraints on, or encouraging the use of, natural gas.
- Renewables.
- energy efficiency (DSM).
- technical efficiency in electricity supply.
- Cogeneration.

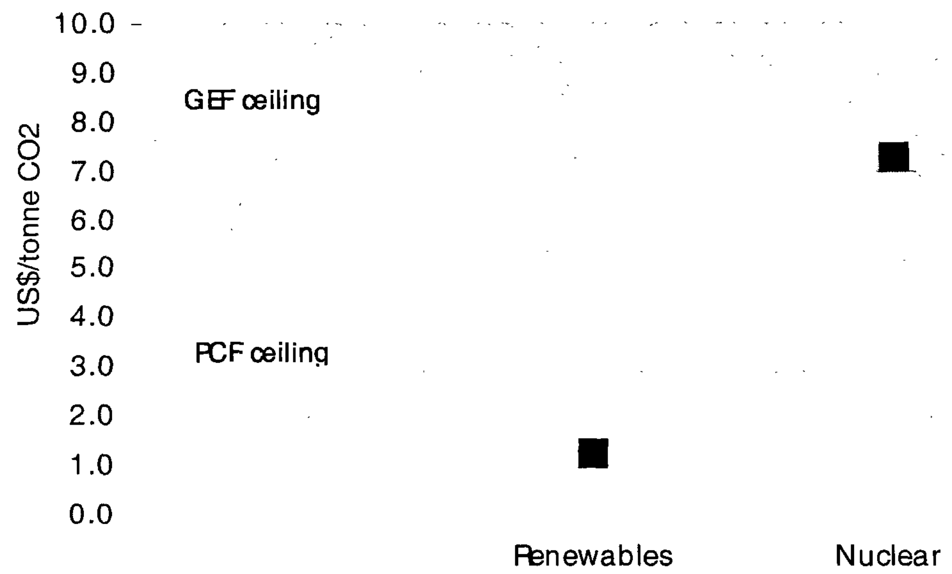
Figure 21 GHG emissions and abatement strategies (CO_2 equivalent)

4.46 In formulating a national policy to combat GHG emissions a number of strategies analyzed as part of the study are win-win; ie., they achieve emission reductions at no cost. These include the wider use of natural gas, demand-side management, cogeneration and improved technical efficiency in the power sector.

4.47 For example, analysis suggests that cogeneration lowers the total discounted cost of energy supply and simultaneously reduces emissions (CO_2, GHG, PM, SO_2, NOx and ash). GHG emissions are estimated to reduce by 5% over the whole period (2000-2025) if cogeneration is pursued more vigorously. The recent "autogeneration" policies that led to led to the construction of cogeneration facilities where there was no demand for the heat/steam have now ended following the liberalization of the electricity market. Future policies that encourage cogeneration should attempt to attract cogeneration facilities that have genuine heat demand. Fiscal incentives could be attractive; such as the provision of favorable tax exemptions to facilities with high overall efficiency (e.g., above 70%) and that are genuinely cogeneration plants.

Two other options are shown to reduce CO_2 emissions but result in some net increase in costs. These are shown in Figure 22.

Figure 22 Cost-effectiveness of GHG strategies



4.48 Figure 22 shows that nuclear power could achieve emission reduction but at a high cost of US$7.3/tonne of CO_2, making it unattractive compared with ceiling benchmark prices of US$2.7 to US$8/tonne of CO_2 indicated by the Prototype Carbon Fund and the Global Environment Facility.

4.49 Figure 22 shows renewables (mini-hydro and windmills) could reduce emissions at a cost of only US$1.3/tonne of CO_2. A strategy to encourage the use of renewable energy focused on solar photovoltaic (PV), wind and mini-hydro. Solar PVs were found to be very expensive except for isolated grids and were dropped from the main analysis. The results for wind and mini-hydro suggest that although the total discounted economic system cost increases relative to the reference scenario, wind energy and mini-hydro are cost-effective for the mitigation of GHG emissions. The impact on emissions of PM, ash, NOx and SO_2 is negligible taking the planning period as a whole which suggests that the main benefit relates to GHG. However, the net energy import bill drops as imported fuels are replaced by domestic renewable resources so that renewable energy has benefits to energy supply security.

4.50 Analysis using alternative energy demand projections based on OECD GDP projections, suggests that CO_2 emissions will be only 31% higher in 2010 than in 2000 compared with a ratio of 82% for the Reference scenario.

Joint UNDP/World Bank
ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

LIST OF REPORTS ON COMPLETED ACTIVITIES

Region/Country	*Activity/Report Title*	*Date*	*Number*
	SUB-SAHARAN AFRICA (AFR)		
Africa Regional	Anglophone Africa Household Energy Workshop (English)	07/88	085/88
	Regional Power Seminar on Reducing Electric Power System Losses in Africa (English)	08/88	087/88
	Institutional Evaluation of EGL (English)	02/89	098/89
	Biomass Mapping Regional Workshops (English)	05/89	--
	Francophone Household Energy Workshop (French)	08/89	--
	Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development (English)	03/90	112/90
	Biomass Assessment and Mapping (English)	03/90	--
	Symposium on Power Sector Reform and Efficiency Improvement in Sub-Saharan Africa (English)	06/96	182/96
	Commercialization of Marginal Gas Fields (English)	12/97	201/97
	Commercilizing Natural Gas: Lessons from the Seminar in Nairobi for Sub-Saharan Africa and Beyond	01/00	225/00
	Africa Gas Initiative – Main Report: Volume I	02/01	240/01
	First World Bank Workshop on the Petroleum Products Sector in Sub-Saharan Africa	09/01	245/01
	Ministerial Workshop on Women in Energy	10/01	250/01
	Energy and Poverty Reduction: Proceedings from a Multi-Sector And Multi-Stakeholder Workshop Addis Ababa, Ethiopia, October 23-25, 2002.	03/03	266/03
Angola	Energy Assessment (English and Portuguese)	05/89	4708-ANG
	Power Rehabilitation and Technical Assistance (English)	10/91	142/91
	Africa Gas Initiative – Angola: Volume II	02/01	240/01
Benin	Energy Assessment (English and French)	06/85	5222-BEN
Botswana	Energy Assessment (English)	09/84	4998-BT
	Pump Electrification Prefeasibility Study (English)	01/86	047/86
	Review of Electricity Service Connection Policy (English)	07/87	071/87
	Tuli Block Farms Electrification Study (English)	07/87	072/87
	Household Energy Issues Study (English)	02/88	--
	Urban Household Energy Strategy Study (English)	05/91	132/91
Burkina Faso	Energy Assessment (English and French)	01/86	5730-BUR
	Technical Assistance Program (English)	03/86	052/86
	Urban Household Energy Strategy Study (English and French)	06/91	134/91
Burundi	Energy Assessment (English)	06/82	3778-BU
	Petroleum Supply Management (English)	01/84	012/84
	Status Report (English and French)	02/84	011/84
	Presentation of Energy Projects for the Fourth Five-Year Plan (1983-1987) (English and French)	05/85	036/85
	Improved Charcoal Cookstove Strategy (English and French)	09/85	042/85
	Peat Utilization Project (English)	11/85	046/85
	Energy Assessment (English and French)	01/92	9215-BU
Cameroon	Africa Gas Initiative – Cameroon: Volume III	02/01	240/01
Cape Verde	Energy Assessment (English and Portuguese)	08/84	5073-CV
	Household Energy Strategy Study (English)	02/90	110/90
Central African Republic	Energy Assessment (French)	08/92	9898-CAR

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Chad	Elements of Strategy for Urban Household Energy The Case of N'djamena (French)	12/93	160/94
Comoros	Energy Assessment (English and French)	01/88	7104-COM
	In Search of Better Ways to Develop Solar Markets: The Case of Comoros	05/00	230/00
Congo	Energy Assessment (English)	01/88	6420-COB
	Power Development Plan (English and French)	03/90	106/90
	Africa Gas Initiative – Congo: Volume IV	02/01	240/01
Côte d'Ivoire	Energy Assessment (English and French)	04/85	5250-IVC
	Improved Biomass Utilization (English and French)	04/87	069/87
	Power System Efficiency Study (English)	12/87	--
	Power Sector Efficiency Study (French)	02/92	140/91
	Project of Energy Efficiency in Buildings (English)	09/95	175/95
	Africa Gas Initiative – Côte d'Ivoire: Volume V	02/01	240/01
Ethiopia	Energy Assessment (English)	07/84	4741-ET
	Power System Efficiency Study (English)	10/85	045/85
	Agricultural Residue Briquetting Pilot Project (English)	12/86	062/86
	Bagasse Study (English)	12/86	063/86
	Cooking Efficiency Project (English)	12/87	--
	Energy Assessment (English)	02/96	179/96
Gabon	Energy Assessment (English)	07/88	6915-GA
	Africa Gas Initiative – Gabon: Volume VI	02/01	240/01
The Gambia	Energy Assessment (English)	11/83	4743-GM
	Solar Water Heating Retrofit Project (English)	02/85	030/85
	Solar Photovoltaic Applications (English)	03/85	032/85
	Petroleum Supply Management Assistance (English)	04/85	035/85
Ghana	Energy Assessment (English)	11/86	6234-GH
	Energy Rationalization in the Industrial Sector (English)	06/88	084/88
	Sawmill Residues Utilization Study (English)	11/88	074/87
	Industrial Energy Efficiency (English)	11/92	148/92
	Corporatization of Distribution Concessions through Capitalization	12/03	272/03
Guinea	Energy Assessment (English)	11/86	6137-GUI
	Household Energy Strategy (English and French)	01/94	163/94
Guinea-Bissau	Energy Assessment (English and Portuguese)	08/84	5083-GUB
	Recommended Technical Assistance Projects (English & Portuguese)	04/85	033/85
	Management Options for the Electric Power and Water Supply Subsectors (English)	02/90	100/90
	Power and Water Institutional Restructuring (French)	04/91	118/91
Kenya	Energy Assessment (English)	05/82	3800-KE
	Power System Efficiency Study (English)	03/84	014/84
	Status Report (English)	05/84	016/84
	Coal Conversion Action Plan (English)	02/87	--
	Solar Water Heating Study (English)	02/87	066/87
	Peri-Urban Woodfuel Development (English)	10/87	076/87
	Power Master Plan (English)	11/87	--
	Power Loss Reduction Study (English)	09/96	186/96
	Implementation Manual: Financing Mechanisms for Solar Electric Equipment	07/00	231/00
Lesotho	Energy Assessment (English)	01/84	4676-LSO
Liberia	Energy Assessment (English)	12/84	5279-LBR
	Recommended Technical Assistance Projects (English)	06/85	038/85
	Power System Efficiency Study (English)	12/87	081/87

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Madagascar	Energy Assessment (English)	01/87	5700-MAG
	Power System Efficiency Study (English and French)	12/87	075/87
	Environmental Impact of Woodfuels (French)	10/95	176/95
Malawi	Energy Assessment (English)	08/82	3903-MAL
	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry (English)	11/83	009/83
	Status Report (English)	01/84	013/84
Mali	Energy Assessment (English and French)	11/91	8423-MLI
	Household Energy Strategy (English and French)	03/92	147/92
Islamic Republic of Mauritania	Energy Assessment (English and French)	04/85	5224-MAU
	Household Energy Strategy Study (English and French)	07/90	123/90
Mauritius	Energy Assessment (English)	12/81	3510-MAS
	Status Report (English)	10/83	008/83
	Power System Efficiency Audit (English)	05/87	070/87
	Bagasse Power Potential (English)	10/87	077/87
	Energy Sector Review (English)	12/94	3643-MAS
Mozambique	Energy Assessment (English)	01/87	6128-MOZ
	Household Electricity Utilization Study (English)	03/90	113/90
	Electricity Tariffs Study (English)	06/96	181/96
	Sample Survey of Low Voltage Electricity Customers	06/97	195/97
Namibia	Energy Assessment (English)	03/93	11320-NAM
Niger	Energy Assessment (French)	05/84	4642-NIR
	Status Report (English and French)	02/86	051/86
	Improved Stoves Project (English and French)	12/87	080/87
	Household Energy Conservation and Substitution (English and French)	01/88	082/88
Nigeria	Energy Assessment (English)	08/83	4440-UNI
	Energy Assessment (English)	07/93	11672-UNI
Rwanda	Energy Assessment (English)	06/82	3779-RW
	Status Report (English and French)	05/84	017/84
	Improved Charcoal Cookstove Strategy (English and French)	08/86	059/86
	Improved Charcoal Production Techniques (English and French)	02/87	065/87
	Energy Assessment (English and French)	07/91	8017-RW
	Commercialization of Improved Charcoal Stoves and Carbonization Techniques Mid-Term Progress Report (English and French)	12/91	141/91
SADC	SADC Regional Power Interconnection Study, Vols. I-IV (English)	12/93	-
SADCC	SADCC Regional Sector: Regional Capacity-Building Program for Energy Surveys and Policy Analysis (English)	11/91	-
Sao Tome and Principe	Energy Assessment (English)	10/85	5803-STP
Senegal	Energy Assessment (English)	07/83	4182-SE
	Status Report (English and French)	10/84	025/84
	Industrial Energy Conservation Study (English)	05/85	037/85
	Preparatory Assistance for Donor Meeting (English and French)	04/86	056/86
	Urban Household Energy Strategy (English)	02/89	096/89
	Industrial Energy Conservation Program (English)	05/94	165/94
Seychelles	Energy Assessment (English)	01/84	4693-SEY
	Electric Power System Efficiency Study (English)	08/84	021/84
Sierra Leone	Energy Assessment (English)	10/87	6597-SL
Somalia	Energy Assessment (English)	12/85	5796-SO
Republic of South Africa	Options for the Structure and Regulation of Natural Gas Industry (English)	05/95	172/95

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Sudan	Management Assistance to the Ministry of Energy and Mining	05/83	003/83
	Energy Assessment (English)	07/83	4511-SU
	Power System Efficiency Study (English)	06/84	018/84
	Status Report (English)	11/84	026/84
	Wood Energy/Forestry Feasibility (English)	07/87	073/87
Swaziland	Energy Assessment (English)	02/87	6262-SW
	Household Energy Strategy Study	10/97	198/97
Tanzania	Energy Assessment (English)	11/84	4969-TA
	Peri-Urban Woodfuels Feasibility Study (English)	08/88	086/88
	Tobacco Curing Efficiency Study (English)	05/89	102/89
	Remote Sensing and Mapping of Woodlands (English)	06/90	--
	Industrial Energy Efficiency Technical Assistance (English)	08/90	122/90
	Power Loss Reduction Volume 1: Transmission and Distribution SystemTechnical Loss Reduction and Network Development (English)	06/98	204A/98
	Power Loss Reduction Volume 2: Reduction of Non-Technical Losses (English)	06/98	204B/98
Togo	Energy Assessment (English)	06/85	5221-TO
	Wood Recovery in the Nangbeto Lake (English and French)	04/86	055/86
	Power Efficiency Improvement (English and French)	12/87	078/87
Uganda	Energy Assessment (English)	07/83	4453-UG
	Status Report (English)	08/84	020/84
	Institutional Review of the Energy Sector (English)	01/85	029/85
	Energy Efficiency in Tobacco Curing Industry (English)	02/86	049/86
	Fuelwood/Forestry Feasibility Study (English)	03/86	053/86
	Power System Efficiency Study (English)	12/88	092/88
	Energy Efficiency Improvement in the Brick and Tile Industry (English)	02/89	097/89
	Tobacco Curing Pilot Project (English)	03/89	UNDP Terminal Report
	Energy Assessment (English)	12/96	193/96
	Rural Electrification Strategy Study	09/99	221/99
Zaire	Energy Assessment (English)	05/86	5837-ZR
Zambia	Energy Assessment (English)	01/83	4110-ZA
	Status Report (English)	08/85	039/85
	Energy Sector Institutional Review (English)	11/86	060/86
	Power Subsector Efficiency Study (English)	02/89	093/88
	Energy Strategy Study (English)	02/89	094/88
	Urban Household Energy Strategy Study (English)	08/90	121/90
Zimbabwe	Energy Assessment (English)	06/82	3765-ZIM
	Power System Efficiency Study (English)	06/83	005/83
	Status Report (English)	08/84	019/84
	Power Sector Management Assistance Project (English)	04/85	034/85
	Power Sector Management Institution Building (English)	09/89	--
	Petroleum Management Assistance (English)	12/89	109/89
	Charcoal Utilization Prefeasibility Study (English)	06/90	119/90
	Integrated Energy Strategy Evaluation (English)	01/92	8768-ZIM
	Energy Efficiency Technical Assistance Project: Strategic Framework for a National Energy Efficiency Improvement Program (English)	04/94	--
	Capacity Building for the National Energy Efficiency Improvement Programme (NEEIP) (English)	12/94	--
	Rural Electrification Study	03/00	228/00

Region/Country	Activity/Report Title	Date	Number

EAST ASIA AND PACIFIC (EAP)

Asia Regional	Pacific Household and Rural Energy Seminar (English)	11/90	--
China	County-Level Rural Energy Assessments (English)	05/89	101/89
	Fuelwood Forestry Preinvestment Study (English)	12/89	105/89
	Strategic Options for Power Sector Reform in China (English)	07/93	156/93
	Energy Efficiency and Pollution Control in Township and Village Enterprises (TVE) Industry (English)	11/94	168/94
	Energy for Rural Development in China: An Assessment Based on a Joint Chinese/ESMAP Study in Six Counties (English)	06/96	183/96
	Improving the Technical Efficiency of Decentralized Power Companies	09/99	222/99
	Air Pollution and Acid Rain Control: The Case of Shijiazhuang City and the Changsha Triangle Area	10/03	267/03
Fiji	Energy Assessment (English)	06/83	4462-FIJ
Indonesia	Energy Assessment (English)	11/81	3543-IND
	Status Report (English)	09/84	022/84
	Power Generation Efficiency Study (English)	02/86	050/86
	Energy Efficiency in the Brick, Tile and Lime Industries (English)	04/87	067/87
	Diesel Generating Plant Efficiency Study (English)	12/88	095/88
	Urban Household Energy Strategy Study (English)	02/90	107/90
	Biomass Gasifier Preinvestment Study Vols. I & II (English)	12/90	124/90
	Prospects for Biomass Power Generation with Emphasis on Palm Oil, Sugar, Rubberwood and Plywood Residues (English)	11/94	167/94
Lao PDR	Urban Electricity Demand Assessment Study (English)	03/93	154/93
	Institutional Development for Off-Grid Electrification	06/99	215/99
Malaysia	Sabah Power System Efficiency Study (English)	03/87	068/87
	Gas Utilization Study (English)	09/91	9645-MA
Mongolia	Energy Efficiency in the Electricity and District Heating Sectors	10/01	247/01
	Improved Space Heating Stoves for Ulaanbaatar	03/02	254/02
Myanmar	Energy Assessment (English)	06/85	5416-BA
Papua New Guinea	Energy Assessment (English)	06/82	3882-PNG
	Status Report (English)	07/83	006/83
	Institutional Review in the Energy Sector (English)	10/84	023/84
	Power Tariff Study (English)	10/84	024/84
Philippines	Commercial Potential for Power Production from Agricultural Residues (English)	12/93	157/93
	Energy Conservation Study (English)	08/94	--
	Strengthening the Non-Conventional and Rural Energy Development Program in the Philippines: A Policy Framework and Action Plan	08/01	243/01
	Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits	05/02	255/02
Solomon Islands	Energy Assessment (English)	06/83	4404-SOL
	Energy Assessment (English)	01/92	979-SOL
South Pacific	Petroleum Transport in the South Pacific (English)	05/86	--
Thailand	Energy Assessment (English)	09/85	5793-TH
	Rural Energy Issues and Options (English)	09/85	044/85
Thailand	Accelerated Dissemination of Improved Stoves and Charcoal Kilns (English)	09/87	079/87

Region/Country	Activity/Report Title	Date	Number
	Northeast Region Village Forestry and Woodfuels Preinvestment Study (English)	02/88	083/88
	Impact of Lower Oil Prices (English)	08/88	--
	Coal Development and Utilization Study (English)	10/89	--
	Why Liberalization May Stall in a Mature Power Market: A Review of the Technical and Political Economy Factors that Constrained the Electricity Sector Reform in Thailand 1998-2002	12/03	270/03
Tonga	Energy Assessment (English)	06/85	5498-TON
Vanuatu	Energy Assessment (English)	06/85	5577-VA
Vietnam	Rural and Household Energy-Issues and Options (English)	01/94	161/94
	Power Sector Reform and Restructuring in Vietnam: Final Report to the Steering Committee (English and Vietnamese)	09/95	174/95
	Household Energy Technical Assistance: Improved Coal Briquetting and Commercialized Dissemination of Higher Efficiency Biomass and Coal Stoves (English)	01/96	178/96
	Petroleum Fiscal Issues and Policies for Fluctuating Oil Prices In Vietnam	02/01	236/01
	An Overnight Success: Vietnam's Switch to Unleaded Gasoline	08/02	257/02
	The Electricity Law for Vietnam—Status and Policy Issues—The Socialist Republic of Vietnam	08/02	259/02
	Petroleum Sector Technical Assistance for the Revision of the Existing Legal and Regulatory Framework	12/03	269/03
Western Samoa	Energy Assessment (English)	06/85	5497-WSO

SOUTH ASIA (SAS)

Region/Country	Activity/Report Title	Date	Number
Bangladesh	Energy Assessment (English)	10/82	3873-BD
	Priority Investment Program (English)	05/83	002/83
	Status Report (English)	04/84	015/84
	Power System Efficiency Study (English)	02/85	031/85
	Small Scale Uses of Gas Prefeasibility Study (English)	12/88	--
	Reducing Emissions from Baby-Taxis in Dhaka	01/02	253/02
India	Opportunities for Commercialization of Nonconventional Energy Systems (English)	11/88	091/88
	Maharashtra Bagasse Energy Efficiency Project (English)	07/90	120/90
	Mini-Hydro Development on Irrigation Dams and Canal Drops Vols. I, II and III (English)	07/91	139/91
	WindFarm Pre-Investment Study (English)	12/92	150/92
	Power Sector Reform Seminar (English)	04/94	166/94
	Environmental Issues in the Power Sector (English)	06/98	205/98
	Environmental Issues in the Power Sector: Manual for Environmental Decision Making (English)	06/99	213/99
	Household Energy Strategies for Urban India: The Case of Hyderabad	06/99	214/99
	Greenhouse Gas Mitigation In the Power Sector: Case Studies From India	02/01	237/01
	Energy Strategies for Rural India: Evidence from Six States	08/02	258/02
	Household Energy, Indoor Air Pollution, and Health	11/02	261/02
	Access of the Poor to Clean Household Fuels	07/03	263/03
Nepal	Energy Assessment (English)	08/83	4474-NEP
	Status Report (English)	01/85	028/84
	Energy Efficiency & Fuel Substitution in Industries (English)	06/93	158/93

Region/Country	*Activity/Report Title*	*Date*	*Number*
Pakistan	Household Energy Assessment (English)	05/88	--
	Assessment of Photovoltaic Programs, Applications, and Markets (English)	10/89	103/89
Pakistan	National Household Energy Survey and Strategy Formulation Study: Project Terminal Report (English)	03/94	--
	Managing the Energy Transition (English)	10/94	--
	Lighting Efficiency Improvement Program Phase 1: Commercial Buildings Five Year Plan (English)	10/94	--
	Clean Fuels	10/01	246/01
Sri Lanka	Energy Assessment (English)	05/82	3792-CE
	Power System Loss Reduction Study (English)	07/83	007/83
	Status Report (English)	01/84	010/84
	Industrial Energy Conservation Study (English)	03/86	054/86
	Sustainable Transport Options for Sri Lanka: Vol. I	02/03	262/03
	Greenhouse Gas Mitigation Options in the Sri Lanka Power Sector: Vol. II	02/03	262/03
	Sri Lanka Electric Power Technology Assessment (SLEPTA): Vol. III	02/03	262/03
	Energy and Poverty Reduction: Proceedings from South Asia Practitioners Workshop How Can Modern Energy Services Contribute to Poverty Reduction? Colombo, Sri Lanka, June 2-4, 2003	11/03	268/03

EUROPE AND CENTRAL ASIA (ECA)

Bulgaria	Natural Gas Policies and Issues (English)	10/96	188/96
	Energy Environment Review	10/02	260/02
Central Asia and The Caucasus	Cleaner Transport Fuels in Central Asia and the Caucasus	08/01	242/01
Central and Eastern Europe	Power Sector Reform in Selected Countries	07/97	196/97
	Increasing the Efficiency of Heating Systems in Central and Eastern Europe and the Former Soviet Union (English and Russian)	08/00	234/00
	The Future of Natural Gas in Eastern Europe (English)	08/92	149/92
Kazakhstan	Natural Gas Investment Study, Volumes 1, 2 & 3	12/97	199/97
Kazakhstan & Kyrgyzstan	Opportunities for Renewable Energy Development	11/97	16855-KAZ
Poland	Energy Sector Restructuring Program Vols. I-V (English)	01/93	153/93
	Natural Gas Upstream Policy (English and Polish)	08/98	206/98
	Energy Sector Restructuring Program: Establishing the Energy Regulation Authority	10/98	208/98
Portugal	Energy Assessment (English)	04/84	4824-PO
Romania	Natural Gas Development Strategy (English)	12/96	192/96
Slovenia	Workshop on Private Participation in the Power Sector (English)	02/99	211/99
Turkey	Energy Assessment (English)	03/83	3877-TU
	Energy and the Environment: Issues and Options Paper	04/00	229/00
	Energy and Environment Review: Synthesis Report	12/03	273/03

Region/Country	*Activity/Report Title*	*Date*	*Number*

MIDDLE EAST AND NORTH AFRICA (MNA)

Arab Republic of Egypt	Energy Assessment (English)	10/96	189/96
	Energy Assessment (English and French)	03/84	4157-MOR
	Status Report (English and French)	01/86	048/86
Morocco	Energy Sector Institutional Development Study (English and French)	07/95	173/95
	Natural Gas Pricing Study (French)	10/98	209/98
	Gas Development Plan Phase II (French)	02/99	210/99
Syria	Energy Assessment (English)	05/86	5822-SYR
	Electric Power Efficiency Study (English)	09/88	089/88
	Energy Efficiency Improvement in the Cement Sector (English)	04/89	099/89
	Energy Efficiency Improvement in the Fertilizer Sector (English)	06/90	115/90
Tunisia	Fuel Substitution (English and French)	03/90	--
	Power Efficiency Study (English and French)	02/92	136/91
	Energy Management Strategy in the Residential and Tertiary Sectors (English)	04/92	146/92
	Renewable Energy Strategy Study, Volume I (French)	11/96	190A/96
	Renewable Energy Strategy Study, Volume II (French)	11/96	190B/96
Yemen	Energy Assessment (English)	12/84	4892-YAR
	Energy Investment Priorities (English)	02/87	6376-YAR
	Household Energy Strategy Study Phase I (English)	03/91	126/91

LATIN AMERICA AND THE CARIBBEAN REGION (LCR)

LCR Regional	Regional Seminar on Electric Power System Loss Reduction in the Caribbean (English)	07/89	--
	Elimination of Lead in Gasoline in Latin America and the Caribbean (English and Spanish)	04/97	194/97
	Elimination of Lead in Gasoline in Latin America and the Caribbean - Status Report (English and Spanish)	12/97	200/97
	Harmonization of Fuels Specifications in Latin America and the Caribbean (English and Spanish)	06/98	203/98
Bolivia	Energy Assessment (English)	04/83	4213-BO
	National Energy Plan (English)	12/87	--
	La Paz Private Power Technical Assistance (English)	11/90	111/90
	Prefeasibility Evaluation Rural Electrification and Demand Assessment (English and Spanish)	04/91	129/91
	National Energy Plan (Spanish)	08/91	131/91
	Private Power Generation and Transmission (English)	01/92	137/91
	Natural Gas Distribution: Economics and Regulation (English)	03/92	125/92
	Natural Gas Sector Policies and Issues (English and Spanish)	12/93	164/93
	Household Rural Energy Strategy (English and Spanish)	01/94	162/94
	Preparation of Capitalization of the Hydrocarbon Sector	12/96	191/96
	Introducing Competition into the Electricity Supply Industry in Developing Countries: Lessons from Bolivia	08/00	233/00
	Final Report on Operational Activities Rural Energy and Energy Efficiency	08/00	235/00
	Oil Industry Training for Indigenous People: The Bolivian Experience (English and Spanish)	09/01	244/01
Brazil	Energy Efficiency & Conservation: Strategic Partnership for Energy Efficiency in Brazil (English)	01/95	170/95
	Hydro and Thermal Power Sector Study	09/97	197/97

Region/Country	*Activity/Report Title*	*Date*	*Number*
	Rural Electrification with Renewable Energy Systems in the Northeast: A Preinvestment Study	07/00	232/00
	Reducing Energy Costs in Municipal Water Supply Operations "Learning-while-doing" Energy M&T on the Brazilian Frontlines	07/03	265/03
Chile	Energy Sector Review (English)	08/88	7129-CH
Colombia	Energy Strategy Paper (English)	12/86	--
	Power Sector Restructuring (English)	11/94	169/94
Colombia	Energy Efficiency Report for the Commercial and Public Sector (English)	06/96	184/96
Costa Rica	Energy Assessment (English and Spanish)	01/84	4655-CR
	Recommended Technical Assistance Projects (English)	11/84	027/84
	Forest Residues Utilization Study (English and Spanish)	02/90	108/90
Dominican Republic	Energy Assessment (English)	05/91	8234-DO
Ecuador	Energy Assessment (Spanish)	12/85	5865-EC
	Energy Strategy Phase I (Spanish)	07/88	--
	Energy Strategy (English)	04/91	--
	Private Mini-hydropower Development Study (English)	11/92	--
	Energy Pricing Subsidies and Interfuel Substitution (English)	08/94	11798-EC
	Energy Pricing, Poverty and Social Mitigation (English)	08/94	12831-EC
Guatemala	Issues and Options in the Energy Sector (English)	09/93	12160-GU
Haiti	Energy Assessment (English and French)	06/82	3672-HA
	Status Report (English and French)	08/85	041/85
	Household Energy Strategy (English and French)	12/91	143/91
Honduras	Energy Assessment (English)	08/87	6476-HO
	Petroleum Supply Management (English)	03/91	128/91
Jamaica	Energy Assessment (English)	04/85	5466-JM
	Petroleum Procurement, Refining, and Distribution Study (English)	11/86	061/86
	Energy Efficiency Building Code Phase I (English)	03/88	--
	Energy Efficiency Standards and Labels Phase I (English)	03/88	--
	Management Information System Phase I (English)	03/88	--
	Charcoal Production Project (English)	09/88	090/88
	FIDCO Sawmill Residues Utilization Study (English)	09/88	088/88
	Energy Sector Strategy and Investment Planning Study (English)	07/92	135/92
Mexico	Improved Charcoal Production Within Forest Management for the State of Veracruz (English and Spanish)	08/91	138/91
	Energy Efficiency Management Technical Assistance to the Comisión Nacional para el Ahorro de Energía (CONAE) (English)	04/96	180/96
	Energy Environment Review	05/01	241/01
Nicaragua	Modernizing the Fuelwood Sector in Managua and León	12/01	252/01
Panama	Power System Efficiency Study (English)	06/83	004/83
Paraguay	Energy Assessment (English)	10/84	5145-PA
	Recommended Technical Assistance Projects (English)	09/85	--
	Status Report (English and Spanish)	09/85	043/85
Peru	Energy Assessment (English)	01/84	4677-PE
	Status Report (English)	08/85	040/85
	Proposal for a Stove Dissemination Program in the Sierra (English and Spanish)	02/87	064/87
	Energy Strategy (English and Spanish)	12/90	--

Region/Country	*Activity/Report Title*	*Date*	*Number*
	Study of Energy Taxation and Liberalization of the Hydrocarbons Sector (English and Spanish)	120/93	159/93
	Reform and Privatization in the Hydrocarbon Sector (English and Spanish)	07/99	216/99
	Rural Electrification	02/01	238/01
Saint Lucia	Energy Assessment (English)	09/84	5111-SLU
St. Vincent and the Grenadines	Energy Assessment (English)	09/84	5103-STV
Sub Andean	Environmental and Social Regulation of Oil and Gas Operations in Sensitive Areas of the Sub-Andean Basin (English and Spanish)	07/99	217/99
Trinidad and Tobago	Energy Assessment (English)	12/85	5930-TR

GLOBAL

	Energy End Use Efficiency: Research and Strategy (English)	11/89	--
	Women and Energy--A Resource Guide The International Network: Policies and Experience (English)	04/90	--
	Guidelines for Utility Customer Management and Metering (English and Spanish)	07/91	--
	Assessment of Personal Computer Models for Energy Planning in Developing Countries (English)	10/91	--
	Long-Term Gas Contracts Principles and Applications (English)	02/93	152/93
	Comparative Behavior of Firms Under Public and Private Ownership (English)	05/93	155/93
	Development of Regional Electric Power Networks (English)	10/94	--
	Roundtable on Energy Efficiency (English)	02/95	171/95
	Assessing Pollution Abatement Policies with a Case Study of Ankara (English)	11/95	177/95
	A Synopsis of the Third Annual Roundtable on Independent Power Projects: Rhetoric and Reality (English)	08/96	187/96
	Rural Energy and Development Roundtable (English)	05/98	202/98
	A Synopsis of the Second Roundtable on Energy Efficiency: Institutional and Financial Delivery Mechanisms (English)	09/98	207/98
	The Effect of a Shadow Price on Carbon Emission in the Energy Portfolio of the World Bank: A Carbon Backcasting Exercise (English)	02/99	212/99
	Increasing the Efficiency of Gas Distribution Phase 1: Case Studies and Thematic Data Sheets	07/99	218/99
	Global Energy Sector Reform in Developing Countries: A Scorecard	07/99	219/99
	Global Lighting Services for the Poor Phase II: Text Marketing of Small "Solar" Batteries for Rural Electrification Purposes	08/99	220/99
	A Review of the Renewable Energy Activities of the UNDP/ World Bank Energy Sector Management Assistance Programme 1993 to 1998	11/99	223/99
	Energy, Transportation and Environment: Policy Options for Environmental Improvement	12/99	224/99

Region/Country	Activity/Report Title	Date	Number
	Privatization, Competition and Regulation in the British Electricity Industry, With Implications for Developing Countries	02/00	226/00
	Reducing the Cost of Grid Extension for Rural Electrification	02/00	227/00
	Undeveloped Oil and Gas Fields in the Industrializing World	02/01	239/01
	Best Practice Manual: Promoting Decentralized Electrification Investment	10/01	248/01
	Peri-Urban Electricity Consumers—A Forgotten but Important Group: What Can We Do to Electrify Them?	10/01	249/01
	Village Power 2000: Empowering People and Transforming Markets	10/01	251/01
	Private Financing for Community Infrastructure	05/02	256/02
	Stakeholder Involvement in Options Assessment: Promoting Dialogue in Meeting Water and Energy Needs: A Sourcebook	07/03	264/03
	A Review of ESMAP Energy Efficiency Portfolio	11/03	271/03

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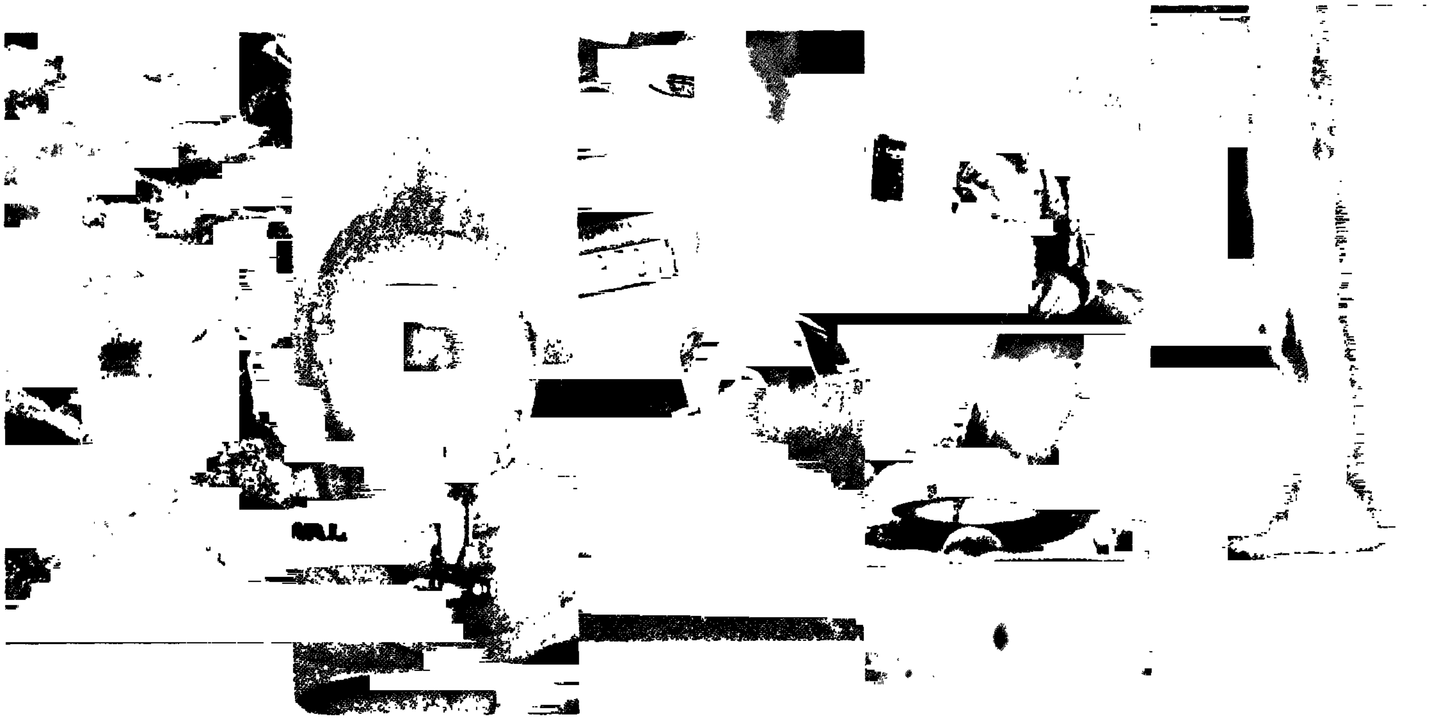

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