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SOME TECHNOLOGICAL ASPECTS OF AN ENVIRONMENTALLY SUSTAINABLE ENERGY POLICY FOR TURKEY: PATTERNS, CHALLENGES AND ACTIONS*

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Abstract

Environmentally sustainable development requires a balance between economic growth targets and a healthy environment so as to improve the quality of life for present and future generations. By their very nature contributing both to environmental degradation/ resource depletion and economic growth/ development, energy issues are key to this balance. The challenge is to find ways to minimize the energy-related environmental costs of development without frustrating economic growth. Aiming to evaluate the magnitude of this challenge for Turkey, this paper discusses the implications of a counterfactual replacement of existing production technologies by environmentally more friendly alternatives and formulates policy recommendations.

ملخص

تتطلب التنمية المتواصلة للحفاظ على البيئة توازناً بين أهداف النمـو الاقتصادى وبين سلامة البيئة من أجل الارتقاء بنوعية الحياة لأجيال اليوم والغد. وتعتبر شئون الطاقة مفتاحاً لهذا التوازن، ذلك أنها بطبيعتها تتسبب فى تدهور البيئة واستنزاف الموارد من ناحية، وفى النمو الاقتصادى والتنمية الاقتصادية من ناحية أخرى. والتحدى هنا هو كيفية الوصول إلى وسائل من شأنها تقليل التأثير السيء للتنمية على البيئـة نتيجـة استخدام الطاقة. ومن أجل تقييم حجم ذلك التحدى بالنسبة لتركيا، تناقش هـذه الورقة آثار إحلال البدائل الفرضية لتقنيات الانتاج الأكثر محافظة على البيئة محل القائمة حالياً وصياغة توصيات للسياسة الاقتصادية.

INTRODUCTION

The contribution of industrial production activities to economic growth and improvement of material standards of living makes them indispensable for overall economic development. Yet, today's mass industrial production not only exhausts scarce, non-renewable natural resources at a rapid pace, but also requires the use of substantial amounts of produced inputs creating hazardous, and often non-degradable, wastes. For much the larger part of history since the industrial revolution, these externalities were largely ignored as countries either deliberately overlooked or underestimated the environmental costs of development. It has only recently been recognized that the rapid depletion of natural resources coupled with the adverse impact on health and productivity imposed by unchecked discharges of industrial wastes jeopardize the long-term sustainability of development. Within such a context, the problem of designing an environmentally sustainable development (ESD) strategy can be viewed as one of finding a balance between industrial development targets and a healthy environment so as to improve the quality of life for present and future generations alike.

Consideration of energy issues is critical to the achievement of such a balance for two reasons: First, in the broadest sense of the term, energy is an essential input for virtually all industrial production processes. Secondly, both the widespread use of certain types of energy as an input and various technologies employed in the generation of energy itself inflict considerable damage upon ecological processes in the form of environmental pollution. Hence, the production and consumption of energy are among the prime factors behind the current degree of environmental degradation and natural resource depletion in many countries. The major policy challenge, then, is to find ways to minimize the energy-related environmental costs without downturning the rising trend of the standards of living which we owe to industrial progress and economic growth at large.

The purpose of this paper is to evaluate the magnitude of this challenge for Turkey and to formulate policy recommendations based on this evaluation. Within this framework, the paper investigates some implications for Turkey of a hypothetical replacement of existing production technologies by a set of environmentally more friendly alternatives. Various aspects of a policy reform required for such a replacement are also discussed. The organization of the paper is as follows: The next section presents an overview of possible solutions to the problem of minimizing energy-related environmental costs of production without allowing for output reductions. Section 3 attempts to evaluate the intensity of the need for Turkey to develop an ESD strategy with special reference to the adverse effects of energy-related emissions on the environment. The section presents an overview of global and local concerns about CO_2 emissions and surveys the current state of regulations and policies directed towards control of these emissions. Section 4 investigates the potential reductions in emissions achievable via the introduction of alternative production technologies. Finally, Section 5 concludes the paper with a general assessment and presents policy recommendations.

STRATEGIES FOR MINIMIZATION OF ENVIRONMENTAL COSTS OF PRODUCTION: AN OVERVIEW

Although such energy-related factors as nuclear waste and oil wastes also contribute to environmental pollution, the most common type of environmental damage due to production/consumption of energy is toxic gas and particle emissions. The detrimental health and productivity effects of certain types of emissions (e.g., sulphur dioxide, SO_2, and particle emissions) are felt only locally but others such as carbon dioxide (CO_2) emissions act as global pollutants [Diwan and Shafik]. Adding to the difficulty of the task before the policy makers is the increased awareness of the global effects of the latter type of emissions. This awareness raised global concerns relative to the pace of industrial progress and associated increases in production/consumption of energy by individual countries. The assessment of these concerns in various international forums like the Conference on Ecologically Sustainable Industrial Development (Copenhagen, 1991) and United Nations Conference on Environment and Development, UNCED (Rio de Janerio, 1992) eventually led to such international agreements as the Framework Convention on Climate Change which, by requiring the reduction of greenhouse gas emissions, limits the independence of local policy makers in the formulation of national energy policies.

Naturally, a straightforward mechanism for reducing these emissions is a reduction in energy consumption. A contraction of industrial activity would clearly serve this purpose but would be unacceptable due to the implied adverse impact on economic growth. Alternatively, so-called *end-of-pipe* technologies could be employed to remove certain types of emissions, especially particles, without requiring output reductions. But most of these technologies are incapable of removing global pollutants such as CO_2 which, by getting trapped in the atmosphere, causes global warming. As such, the end-of-pipe measures do not satisfy conditions stated in international agreements and, perhaps even more importantly, do not reduce the consumption of energy. Government policies in many countries also contribute to energy overconsumption by legislating subsidies and related discount pricing schemes which make energy available to the industrial sector at a price not reflecting its true economic cost. Coupled with environmental regulations favoring end-of-pipe pollution control over pollution prevention, such policies fail in both removing the global pollutants and discouraging rapid depletion of natural resources [UNIDO].

The problem then reduces to devising a strategy to reduce the energy consumption, and hence toxic emissions, without allowing for reductions in output. This requires increasing energy efficiency. Government policies can serve this purpose by promoting conservation of energy. Mechanisms for achieving this goal without requiring significant changes in existing technologies and installed capacities include efforts to incorporate the "polluter pays" principle into environmental regulations and a move towards "true-cost" pricing in the energy sector. The introduction of tax and non-tax pollution abatement tools, elimination of energy subsidies and privatization of the energy generation sector would increase the cost of energy inefficiency, hence reducing emissions. Yet, such tools could not be implemented with precision and hence are not sufficient to fully address the issue of energy overconsumption. Hence, complementary measures such as the design of incentives which would promote the transition to more energy efficient technologies must be considered.

Currently, eased financing for certain technologies satisfying the efficiency criteria is made available by various sources including international organizations such as the World Bank [WEA, UNIDO]. Reduced rates of emissions associated with these technologies coupled with their reduced reliance on the use of non-renewable energy resources reinforce the motivation for this support. In the following sections of the paper, energy and emission saving potentials which would be associated with the employment of a set of such technologies in Turkey are investigated. It must be noted, however, that the cleanliness of technologies considered is judged here only by the CO_2 levels emitted under each technology. The exclusion of other types of emissions from the analysis can be defended on the basis of two observations. First, the world is currently emitting more CO_2 into the atmosphere than any other pollutant [Badr and Probert]. Coupled with their nature as global pollutants, CO_2 emissions are given the greatest emphasis in the Framework Convention on Climate Change. Secondly, the emission rates of local pollutants are highly correlated with those of CO_2 [Diwan and Shafik].[1]

ENERGY-RELATED ENVIRONMENTAL CONCERNS IN TURKEY

The Current Situation

Turkey's total emissions of CO_2 reached 147.0 million tons in 1990 and 155.8 million tons in 1992 as indicated in Table 1. While Turkey still has the lowest per capita emissions among all OECD countries (2.65 tons in 1992), the emissions are higher than OECD averages in both absolute terms and in terms of the ratio to the GDP. The rate of increase in emissions is also high as implied by the 250% growth between 1973 and 1992 during which consumption of solid fuels and oil more than doubled for coal and oil products. Likewise, the rising use of oil in the transport sector by more than 100% during the same period contributed to emissions significantly [IEA]. Combined with the increase in total final energy demand from 20.52 million tons of oil equivalent (mtoe) to 42.55 mtoe in 1992 --a growth of more than 100%, these numbers point to a currently low but fast growing level of energy consumption of a country which is completing its development at a rapid pace. Though not shown in Table 1, the following breakdown of this final energy demand by users also supports this observation. As of 1992,

> The residential and commercial sector accounts for the largest share (42%), significantly lower than in 1973 (55%). Industry accounts for almost 34% of TFC [Total Final Consumption], a significantly higher share than in 1973 (21%). The changes in these two sectors reflect the transformation of the Turkish economy with a higher industrial activity. The share of transport remains largely unchanged (21%) but in terms of volume it has more than doubled over the 1973 to 1992 period. Energy intensity (0.730 toe/US$1,000) has declined 7.5% since 1973 and is the second highest of the OECD area. Electrification of the country has increased steeply during the 1970s and the 1980s with yearly consumption growth rates of 11.3% between 1973 and 1979 and 9.0% between 1983 and 1991, increasing by another 10% in 1992 [IEA].

[1] For a detailed sectoral analysis of CO_2 and other types of emissions in Turkey, see Zaim.

Parallel to changes in the composition of energy demand during the last couple of decades, a transformation was observed in the supply side. The fuel mix has changed considerably compared to 1973 when oil (52.1%), coal (26.5%) and hydro (21.4%) accounted for all electricity generation [IEA]. After 1973, the increased use of the country's large hydropower potential in electricity generation for domestic use and seasonal exports to the neighboring countries, raised the share of hydro significantly, almost doubling it to 39.5% in 1992 (Table 1). The remaining 60.5% share goes entirely to thermal generation as different attempts to build nuclear plants have so far failed due to various reasons including the resistance of environmentalist groups.[2] Despite their low quality, Turkey has considerable lignite deposits.[3] Accordingly, solid fuels have the biggest share (67.7% in 1992) in thermal power generation.

Consistently with the findings that reveal environmental quality as a normal good,[4] the share of cleaner sources in thermal power generation in Turkey increases together with the national income. The share of natural gas in thermal power supply has substantially increased after 1989, reaching to about 20.4% in 1992. Also, under increased pressure from the public at large, heavily polluted towns began to switch from coal to natural gas in residential and commercial heating despite huge infrastructure costs of conversion.[5] The natural gas needed for both thermal power generation and heating is supplied almost entirely through imports. Though to a lesser extent, this is also true for oil imports. In 1992, Total Primary Energy Supply (TPES) was 54.97 mtoe with about 50% (27.95 mtoe) imported (Table 1).[6]

Table 2 breaks down the energy use and CO_2 emissions into their sectoral components for 1990 by showing the respective shares of these sectors. By these shares, the contributions to CO_2 emissions by power generation and transportation sectors are lower than the average of the OECD countries, whereas the contribution from industry exceeds the relevant OECD average.

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[2] The debate on proposed construction of a nuclear plant near Akkuyu, a Mediterranean coastal town, currently continues. The pro-nuclear groups point to the environmental threat already facing Turkey because of nuclear plants in Bulgaria and Ukraine --where the notorious Chernobyl plant is. The environmentalist groups strongly resist to Akkuyu plant pointing to the warming of coastal water it could possibly cause.

[3] The country's reserves of oil and gas are rather small and not worth mentioning.

[4] The environment is sometimes called a normal good based on the observation that societies demand better environmental quality as their income increases. See, for example, Diwan and Shafik.

[5] The switch is almost complete in Ankara and the work is under way in other towns like Istanbul and Bursa.

[6] TPES is defined as total primary energy production plus net imports.

The Outlook

According to the estimates of Turkish Ministry of Energy and Natural Resources, total primary energy consumption in Turkey is expected to rise to 90 mtoe and the electricity demand to 130 billion kilowatt hours (KWh) by the year 2000 [Koyuncu]. Compared to 54.97 mtoe in 1992 (Table 1), the estimated primary consumption level of 90 mtoe represents an average annual growth rate of about 6.3%. Similarly, the estimated electricity demand figure implies a substantial growth over 67.2 terawatt hours (TWh) --67.2 billion KWh-- of production in 1992 (Table 1). The ministry also estimates that, in 2000, 44% of total primary energy demand will be met by domestic sources implying an increase in the share of imports from about 50% to 56%. With this energy picture for the year 2000, the ministry estimates annual investment needs of the country to be around 1.5-2 billion dollars [Koyuncu].

Turning to the composition of supply, the International Energy Agency (IEA) expects the respective shares of solid fuels and gas in total power generation are estimated to rise from 37% and 16% to 39% and 27% by the year 2000 while hydro and oil are expected to fall (almost to zero for the latter). The IEA estimates that this breakdown will accelerate the annual growth in CO_2 emissions from 1973-1992 average of 5% to 6.5% by the end of the century [IEA]. Tables 3 and 4 show the present authors' estimates of energy use and CO_2 emissions in Turkey in the year 2010. For a comparison, the tables also include the values for 1990 which are given as percentage shares in Table 2. It must be noted that the average annual growth rate implied by the actual and estimated figures for total CO_2 emissions between 1990 and 2010 is 5.98% -- lower than IEA estimate of 6.5%.

A REVIEW OF ENVIRONMENTAL POLICIES AND REGULATIONS

As a middle-income country with considerable public awareness of the global concerns for environment, Turkey has already taken some steps towards prevention of further degradation of environment and has officially recognized the broader need for environmentally sustainable development. Despite such a recognition, Turkey is yet to take concrete steps in many areas so as to have major ESD concerns incorporated into her development policies and regulations especially in the area of energy-related CO_2 emissions. Starting with a brief historical discussion on the evolution of official positions on the environmental problem, this section surveys the current state of regulations and policies directed towards control of these emissions.

This evolution can best be observed from the way five-year development plans addressed environmental concerns. Turkey has a long history with development planning exercises dating back to the 1930s, but the systematic implementation of five-year plans started with the 1963-1967 plan.[7] The 3rd Five-Year Plan (1973-1977), the first plan ever to mention environmental problems facing the country, concluded that environmental policies that could inhibit industrial development are unacceptable. The 4th Plan covering the 1979-1983 period slightly modified

[7] While the plan targets are rather binding on public enterprises, they only provide some advisory guidance, sometimes "sweetened" by production and investment incentives, for private enterprises.

this environmentally inconsiderate position by granting that efforts should be undertaken to clean-up the existing pollution and stressed the need for consideration of environment in the processes of industrialization, modernization in agriculture and urbanization. Going one step further, the 5th Plan (1983-1987) took a stand favoring not only the clean-up efforts for the pollution to date but also the measures to prevent pollution before it occurs so as to assure safeguarding of environment for future generations. The necessity of the "sustainability" of industrialization in Turkey was officially recognized first by the 6th Plan (1990-1994) which adopted "Sustainable Development" as a strategy requiring reconciliation of environmental targets with sectoral and macroeconomic ones [SPO]. The plan takes environmental issues in every sector, including energy, into account and formulates policies which contribute to the control of CO_2 emissions including:

- economic assessment of environmental factors in energy fuel cycles, from production to consumption;
- increased use of natural gas in power generation and in residential heating;
- support for R&D programs to increase the use of renewable energy sources such as increased exploitation of all hydro sources;
- increased emphasis on energy efficiency and energy conservation;
- improved performances of insulation and heating systems in buildings;
- increased use of alternative energy sources in the transportation sector, such as natural gas operated municipal buses and electricity operated railway systems, and
- extended use of geothermal energy projects, supported by loans from the Ministry of Environment [IEA].

Of these, the most successfully implemented policy proposal has been to increase the share of natural gas in power generation and residential heating. Partly due to this, Turkey has managed to reduce the average annual rate of growth of CO_2 emissions (4.1% in 1991-1992 versus 5.4% for each of 1980-1986 and 1986-1990 periods), but the maintenance of this downward tendency is not likely with the current trends.

Building on policy grounds laid in the previous plan periods, the work currently under way for 7th Five-Year Plan underscores the need to integrate environmental targets into sectoral development strategies by considering not only the effects of development on environment but also the effects of environmental protection on development. Aiming to be comprehensive in its coverage of environmental issues, the 7th Plan favors a generally more active stand taken to prevent pollution with revised national targets for the environment that are consistent with the country's commitments in international forums [SPO]. One area where Turkey has not yet committed herself is greenhouse gas emission controls by internationally agreed standards.[8] In June 1992, at the plenary session of UNCED in Rio de Janerio, the Turkish delegation agreed with the target of reducing greenhouse gas emissions (particularly CO_2) which cause global warming and climate change but expressed the reservation that "differences between countries must be taken into consideration when it comes to the sharing of responsibilities and sacrifices towards the solution of the global environmental problems." The main reason underlying this position was Turkey's inclusion among the developed countries listed in Annexes I and II to the

[8] Though likely to change in the near future, this lack of commitment made Turkey the only OECD member to oppose the Framework Convention on Climate Change which required its parties to reduce greenhouse gas emissions.

Convention, forcing it to make commitments which the Turkish government founded incompatible with the country's level of development. Accordingly, Turkey has not signed the Convention nor has adopted a national greenhouse gas or CO_2 reduction target officially arguing that Turkey's contribution to global CO_2 emissions is negligible. Nonetheless, the Turkish government recognized the need to participate in the joint efforts by almost all countries to reduce greenhouse gas emissions, and promised to consider signing and ratifying the Convention as soon as Turkey is excluded from the list of developed countries. Despite the lack of any CO_2 or greenhouse gas reduction target, the Government is attempting to minimize energy-related CO_2 emissions through measures aimed at improving energy efficiency and conservation and trying to increase the shares of new and renewable energy sources in its energy production [IEA].

To limit emissions of air pollutants including greenhouse gases, three groups of measures have been taken so far: the Environment Law (1983), the Instruction for Fuel Saving and Heating Insulation in Buildings and for the Diminution of Air Pollution (1985), and the Air Quality Control Regulation (1986) imposing severe restrictions on energy production and transformation areas, especially coal-fired power stations. A decision requiring all newly built coal- or lignite-fired power stations to be equipped with flue gas desulphurisation was put into effect in 1990. Similar restrictions apply for other air pollutants, including greenhouse gases.

In order to reduce CO_2 emissions from the transport sector, work is under way to replace diesel railway engines by those running on electricity. Similarly, municipal buses are gradually being converted from regular fuel-operated systems to natural gas operated systems. Subway constructions are continuing in big cities like Istanbul and Ankara that is also a participant in the Urban CO_2 Reduction Project. Sponsored by the Council of Local Environmental Initiatives (ICLEI), the project requires the development of local action plans for reducing CO_2 emissions in Ankara and other participating cities in Italy, Germany, Canada and the U.S. A long-term CO_2 reduction program for Ankara prepared in 1993, aims to stabilize the city's per capita CO_2 emissions at 1990 levels by 2005. This target is expected to be achieved through measures such as switching from coal and oil to natural gas in residential and commercial heating (see footnote 5), improvements to the public transport system, and the use of solar energy.

ESD ORIENTED RESTRUCTURING: PROBLEMS AND ALTERNATIVES

Overview of Problems

The government's share in the economy is still high, particularly in the energy sector. This contributes to energy overconsumption and an excessive utilization of non-renewable resources. This is due in large part to the facts that outdated technologies are widely employed in the public industrial sector and that senior management officials do not have significant incentives to cut waste or to conserve energy [SPO]. However, the emphasis which has been placed on the goal of privatization in recent development plans represents an encouraging step relative to the implementation of ESD-compatible policies. Legal reform designed to rehabilitate the energy-generation sector was introduced in 1984 and 1985. The Law 3096 was enacted in 1984 to facilitate privatization in the energy sector through the introduction of "Transfer of Operation Rights" (TOR) and "Build-Operate-Transfer" (BOT) schemes. This law authorizes domestic and foreign investors to build new power plants, to operate existing plants and trade the power generated under contracts signed with the Ministry of Energy and Natural Resources. The contracts are needed since the ownership of facilities, old or new, covered under TOR and BOT schemes will remain with the state. To make the law operational, further legal arrangements removing the generation, transmission, distribution and trading of power from the state monopoly followed in 1985.[9] This also eliminated barriers preventing autoproduction/cogeneration activities by private firms. In addition, nine thermal plants representing 26% of total installed power generation capacity of the country are included in the privatization program to be sold in whole to private entrepreneurs [Koyuncu].

While it is easier to impose tighter emission standards on new plants in general, and those power plants built under BOT or TOR schemes in particular, the imposition and enforcement of such standards on older establishments are problematic, regardless of whether these establishments are consumers or producers of energy. Sizable financing requirements for replacement of highly pollutive production technologies with environmentally friendly ones create a bias favoring traditional end-of-pipe pollution control over pollution prevention methods in privately and publicly owned establishments alike. Their contribution to the reduction of local pollutants notwithstanding, such end-of-pipe measures are of limited use relative to reducing emissions of global pollutants and have no effect on current levels of energy consumption as previously noted . One strategy that would simultaneously promote the realization of the goals of protecting the biosphere and reducing the energy overconsumption is the promotion of production technologies that are known to reduce CO_2 and other emissions by increasing energy efficiency and saving on the use of non-renewable energy sources. Despite higher costs associated with such technologies, the Turkish Ministry of Energy and Natural Resources expects net gains from implementation of energy efficiency projects in the power generation sector and is currently working to develop the legal and institutional framework to encourage the introduction of these technologies under BOT and TOR schemes [Koyuncu].

Estimation of Gains from Alternative Technologies

This paper expands on the scope of the ministry's studies which focus solely on energy consumption in the power generation sector, as it estimates both potential reductions in energy consumption and CO_2 emissions which would be associated with alternative production technologies for a wide range of industrial sectors as well as building and transportation sectors. The alternative technologies considered here are known as *Best Available Technologies* or shortly BATs.

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[9] Since 1985, a 34 megawatt (MW) power generation capacity has been created through BOT projects made possible under Law 3096, with 3.6 MW currently under construction. The agreements were also signed to create a total additional capacity of 3,032 MW in 15 projects with 5 other projects for 845 MW of new capacity waiting approval. In addition, project applications pending with the ministry propose a total of 7,484 MW of capacity. In the area of transfer of operation rights, two joint establishments were created with the private sector with 6 others are about to be formed [Koyuncu].

The reduction of industrial pollution through BATs can be viewed as one way of restructuring energy demand patterns of the country in an ESD-compatible way. By reducing energy consumption and promoting a shift towards the utilization of renewable energy resources, these technologies have not only the potential to improve the quality of environment through considerable savings in the emissions of major greenhouse gases (GHG), but also to increase the competitiveness and profitability of industry. Some of the BATs are already on the market with low market penetration (e.g. conventional combined heat and power technologies); some are well developed and beginning to enter the market (e.g. wind energy converters, gas condensing boilers), and others with significant market potential in the near future are in the late phases of development (e.g. integrated coal gasification combined cycle power plants). A list of all BATs considered in this study is given in Table 5.

Springmann evaluates each BAT by the following criteria:

- Its specific fuel and electricity savings relative to the presently used technology to be replaced;
- Its maximum technical potential that can be exploited;[10]
- Its annual investment costs reflecting interest costs and depreciation with the annual investment costs related to potential fuel and electricity savings expressed in ECUs per Giga Joule (GJ) of primary energy savings;
- Its fuel and electricity savings in monetary terms with the conversion of savings made through multiplication by sectoral energy prices representing the average values for the twelve member states of the European community in 1985;
- Its annual net costs per primary energy type saved, i.e., the difference between annual investment costs and annual energy cost savings;
- Its savings of CO_2, SO_2, NO_x, Volatile Organic Compounds (VOCs), and CO emissions;
- Its annual net costs per ton or kilogram emission saved for each of the five pollutants stated above.[11]

Springmann calculates energy and emission savings under the assumption that each BAT under consideration would completely and instantaneously replace the current technology in use implying that saving potentials are maximum technical potentials. The time needed to implement the technology and economic and administrative barriers are not taken into account and costs considered are related to this technical potential. In calculating the potential savings of energy and CO_2 emissions in Turkey in 1990, we assume also that currently used technologies, processes and energy input prices are the same in Turkey as in EU, and that there are no tariff and non-tariff barriers for imports of these technologies. Consistently with the first assumption, no calibration is undertaken here implying a degree of similarity of 1 although it is possible to determine the exact degree of similarity through a separate and detailed market and industry survey. The second assumption simulates the conditions which will prevail after the recent Customs Union agreement between Turkey and EU is put into effect. This eliminates the

[10] This potential is 100% if the BAT is capable of completely replacing the existing technology from a technological point of view, and if the BAT has not been introduced to the market yet.

[11] Differently from Springmann, we concentrate on CO_2 emissions alone. This treatment was defended in Section 3 of the paper.

possibility of implementation cost differentials that may arise between the EU and Turkey for non-technological reasons.

In the calculations for Turkey, all 109 BATs listed in Table 5 are aggregated into 10 sectors:

- Electricity production, oil refineries and coking plants (Energy);
- Iron & steel, non-ferrous metals, chemical, non-metallic mineral and others (Industry);
- Transportation, and
- Private households and tertiary sectors (Buildings).

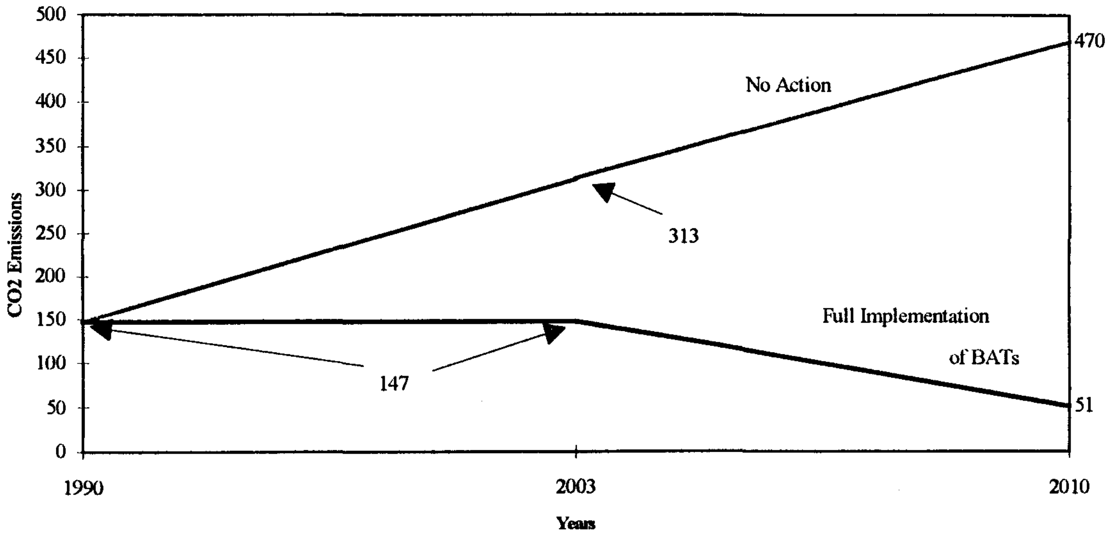
The results reported account for only 86 of the 109 BATs as 23 technologies with positive annual net costs are excluded in order to ensure cost-effectiveness. These 23 BATs excluded are given in Table 6.

The results from remaining 86 BATs show that 18.14% (7.871 mtoe) of total energy used by these sectors in 1990 could have been saved by using BATs with negative or zero net costs. The energy savings amount to 3.51% in energy sector, 4.10% in transportation, 5.53% in buildings and 5% in industry. Likewise, total CO_2 emission saving is estimated to reach 24 million tons (16.39% of total CO_2 emissions from these sectors). The sectoral breakdown of these emission savings is as follows: 2.23% in energy sector, 4.70% in transportation, 4.72% in buildings and 4.74% in industry (Tables 7-8).

The potential savings of energy and CO_2 emissions by sectors are reported in Table 9. In the table, a relatively higher sectoral energy saving potential implies a higher degree of current energy inefficiency for the sector under consideration. For example, 20.46% energy saving potential for transportation sector indicates the percentage of energy consumption that can potentially be saved, and points to a lower energy efficiency than, say, iron and steel industry. It is notable that this figure in building sector is as high as 37.90%.

Using 1990 energy data and 1985 ECU rates, total benefit from potential energy savings is calculated to be 1,563 millions of ECUs (excluding multiplier effect of investment). Turning now to CO_2 emissions, we estimate that CO_2 emissions will reach to 470 million ton in 2010 if the present pattern of energy consumption continues. Fortunately, substantial savings of emissions are possible through introduction to industrial use and full implementation after 1998 of BATs. The emission savings shown in Figure point to the possibility of maintaining CO_2 emissions at 1990 the level of 147 million tons in 2003, to reduce them later to 51 million tons in 2010.

Figure: Strategy to Stabilize CO2 Emissions and to Improve Energy Efficiency in Turkey



CONCLUSIONS

These results suggest that the implementation of BATs can play an important role in an environmentally sustainable development strategy by decreasing the reliance on non-renewable resources, improving energy efficiency, and reducing CO_2 emissions. As such, they are not only more effective than conventional end-of-pipe technologies relative to pollution abatement but are also capable of reducing the rate of natural resource depletion. In addition, the fact that they are usually cost-effective and require relatively small investment outlays suggests a favorable impact on industrial competitiveness.

Naturally, the demonstration of their technical savings potentials alone does not necessarily guarantee the actual replacement of current technologies with the BATs. The Turkish government, having already taken some of the necessary steps towards cutting down energy waste through legal reform and an ambitious privatization program, must view the adoption of technological change and capacity generation as the next logical step of developing an ESD strategy. Although there have been steps in this direction, the current government has limited consideration of the promotion of energy efficient technologies mostly to the power generation sector. In addition to intensifying these efforts, the government must extend the promotion of BATs to other sectors. To ensure rapid uptake of BATs by the private sector, their benefits should be advertised and the private sector should be encouraged to incorporate the integration of environmental considerations into all decision making processes. Institutional capacity building which stimulates the exchange of information on environmentally sound management and energy conservation techniques, R&D and technology cooperation is also essential. The adoption of new technologies should be made attractive through various incentives including eased financing. The government should consider subsidizing loans to energy efficiency projects rather than subsidizing the energy supplied to the manufacturing sectors. Access to financing sources, domestic or abroad, must also be facilitated.

Besides adopting the promotion of BATs as a medium to long-run strategy, other policy measures should be implemented as short-run means of achieving the objectives of environmentally sustainable development. Introduction of carbon and energy taxes, internalization of externalities in pricing, requirement of environmental assessment reports in licensing plant constructions, development of standards for valuation of natural and environmental resources used by industry can be cited as examples of such short-run tools, most of which have not yet been adopted or not effectively enforced in Turkey.

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Table 1: Summary Energy Balance of Turkey (million tons of oil equivalent)

	1974	1980	1986	1990	1991	1992
Primary Production	**15.98**	**17.61**	**23.69**	**26.49**	**26.52**	**27.02**
Solids	5.59	6.57	11.92	12.55	11.95	12.21
Oil	3.38	2.38	2.45	3.79	4.46	4.37
Natural Gas	0.00	0.00	0.38	0.17	0.17	0.16
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00
Hydro	0.29	0.98	1.02	1.99	1.95	2.28
Geothermal	0.00	0.00	0.04	0.07	0.07	0.06
Biomass	6.72	7.68	7.89	7.91	7.92	7.93
Net Imports	**9.95**	**14.34**	**19.12**	**27.72**	**25.70**	**27.95**
Solids	0.10	0.71	1.94	4.17	4.58	4.20
Oil	9.85	13.52	17.11	20.93	17.77	20.11
Crude Oil	10.18	10.72	17.36	20.50	18.02	19.74
Oil Products	-0.33	2.80	-0.24	0.43	-0.25	0.37
Natural Gas	0.00	0.00	0.00	2.68	3.32	3.65
Electricity	0.00	0.12	0.07	-0.06	0.02	-0.01
Biomass	0.00	0.00	0.00	0.00	0.00	0.00
Gross Inland Consumption	**25.32**	**31.89**	**42.43**	**53.21**	**53.91**	**55.53**
Solids	5.59	7.57	13.92	17.00	17.52	17.29
Oil	12.73	15.55	19.11	23.46	22.94	24.16
Natural Gas	0.00	0.00	0.38	2.85	3.49	3.81
Other (*)	7.00	8.77	9.02	9.90	9.96	10.26
Electricity Generation (Twh)	**13.27**	**23.14**	**39.70**	**57.54**	**60.25**	**67.34**
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00
Hydro	3.36	11.35	11.87	23.15	22.68	26.57
Thermal	9.92	11.79	27.82	34.40	37.56	40.77
Generation Capacity (GWh)	**3.73**	**5.12**	**10.71**	**16.32**	**16.94**	**na**
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00
Hydro	1.44	2.13	3.88	6.76	6.84	na
Thermal	2.28	2.99	6.84	9.55	10.09	na
Average Load Factor (%)	**40.65**	**51.60**	**42.30**	**40.26**	**40.61**	**na**
Fuel Inputs for Thermal Power Generation	**2.87**	**3.08**	**7.65**	**9.19**	**9.53**	**10.47**
Solids	1.46	1.60	5.30	5.69	6.18	7.09
Oil	1.27	1.48	1.97	1.30	0.91	1.18
Gas	0.00	0.00	0.34	2.13	2.36	2.14
Geothermal	0.00	0.00	0.04	0.07	0.07	0.06
Biomass	0.14	0.00	0.00	0.00	0.00	0.00
Average Thermal Efficiency (%)	29.71	32.94	31.30	32.20	33.91	33.49
Non-Energy Uses	0.39	0.49	1.08	1.06	1.26	1.14
Total Final Energy Demand	**20.52**	**26.66**	**32.08**	**40.64**	**41.18**	**42.55**
Solids	3.48	4.84	6.67	8.51	8.82	8.37
Oil	9.50	12.42	14.80	19.63	19.27	20.26
Gas	0.04	0.04	0.07	0.72	1.12	1.54
Electricity	0.92	1.68	2.65	3.87	4.04	4.45
Heat	0.00	0.00	0.00	0.00	0.00	0.00
Biomass	6.57	7.68	7.89	7.91	7.92	7.93
CO2 Emissions (Mton)	**69.00**	**86.80**	**119.20**	**147.00**	**149.60**	**155.80**
Excluding Bunkers and Air Transport	68.40	86.40	118.30	145.50	148.00	154.00
Indicators						
Population (million)	39.00	44.50	51.30	56.10	57.40	58.80
GDP (Index 1985=100)	60.00	79.30	108.30	133.30	133.70	140.30
Gross Inland Consumption/GDP (toe/1985 MECU)	610.00	581.00	566.00	577.00	583.00	572.00
Gross Inland Consumption/Capita (toe/inhabitant)	0.65	0.72	0.83	0.95	0.94	0.94
Electricity Generated/Capita (KWh/inhabitant)	340.00	520.00	774.00	1026.00	1050.00	1146.00
CO2 Emissions/Capita (ton/inhabitant)	1.77	1.95	2.32	2.62	2.61	2.65
Import Dependency (%)	**39.20**	**45.00**	**44.80**	**52.00**	**47.50**	**50.20**

(*) Includes nuclear, hydro and wind, net imports of electricity, and biomass.

Source: EC - DG17, Energy in Europe, 1993 Annual Energy Review, Special Issue June 1994.

Table 2: Energy Consumption and CO_2 Emissions in Turkey Sectoral Shares for 1990 (in percentages)

Sectors	Energy Consumption	CO_2 Emissions
Electricity Production	22.37	22.34
Oil Refineries	3.15	2.83
Coking Plants	4.11	4.96
Iron & Steel	6.60	7.47
Non-ferrous Metal	0.82	0.78
Chemical	9.63	8.93
Non-Metallic Mineral	5.29	5.94
Other Industry	9.09	9.26
Transportation	22.53	20.26
Private Households & Tertiary Sector	16.41	17.23
TOTAL	100.00	100.00

Source: Authors' own estimates.

Table 3: Energy Consumption in Turkey (ktoe)

SECTORS	1990	2010
Electricity Production	8,632.00	49,576.51
Oil Refineries	1,214.00	2,707.23
Coking Plants	1,587.00	751.00
Iron & Steel	2,545.00	8,838.79
Non-ferrous Metal	315.00	665.29
Chemical	3,715.00	14,309.57
Non-Metallic Mineral	2,040.00	6,975.21
Other Industry	3,507.00	13,802.64
Transportation	8,694.00	21,647.30
Private Households & Tertiary Sector	6,331.00	13,322.11
TOTAL	38,580.00	132,595.65

Source: Authors' own calculations

Table 4: CO2 Emissions in Turkey (mton) (*)

SECTORS	1990	2010
Electricity Production	29.519843	169.5424868
Oil Refineries	3.735478	8.33014439
Coking Plants	6.550122	3.099648155
Iron & Steel	9.867356	35.31912341
Non-ferrous Metal	1.030995	2.293358336
Chemical	11.8049	40.20396362
Non-Metallic Mineral	7.853511	27.73849464
Other Industry	12.235596	44.79778066
Transportation	26.768931	66.65230619
Private Households & Tertiary Sector	22.765247	44.68193267
TOTAL	132.131979	442.6592388
(*) Including Bunkers and Air Transport		
Grand Total CO_2 Emissions in mton	147	470
Agriculture	6	11
Non-Energy Use	3	6
Energy Loss	6	10

Source: Authors' own estimates and projections

Table 5: Sectoral Distribution of All Best Available Technologies (BAT)

Sector	BAT Number	BAT
Electricity Production	1101	Industrial CHP w/ Gas Turbines
	1102	Industrial CHP w/ Int. Comb. Eng.
	1103	Ind. CHP w/ Gas Comb. Cycle Plants
	1104	Industrial CHP with Turbines
	1105	Domestic CHP w/ Int. Comb. Engines
	1106	On-Shore Wind Energy Converters
	1107	Off-Shore Wind Energy Converters
	1108	Photovoltaic Cells
	1109	Run of River Plant
	1110	Integrated Coal Gasific. Comb.Cyc.
	1111	Comb. Cycle w/ Fluid. Bed Comb.
	1112	Gas Combined Cycle Power Plant
Oil Refineries	1201	Pinch Technology/Process Integration
	1202	Impr. Process Control by Micro Elec.
	1203	Impr. Atmospheric Crude Oil Dist.
Coke Plants	1204	Gasoline Prod. w/ Molecular Sieves
	1205	Dry Quenching of Coke
Other Industry	2001	Pinch Technology/Process Integration
	2002	Waste Heat Recovery with Regen.Burners
	2003	Waste Heat Recovery with Heat Pumps
	2004	Waste Heat Recovery w/ the ORC-Proc.
	2005	Air Inlet Control on Burners
	2006	Exhaust Gas Afterburning
	2007	Improved Buildings Insulation
	2008	Adjustable Speed Drives
	2009	High Efficiency Fluorescent Lamps
Iron & Steel	3101	Heating the Blend with Recovered Heat
	3102	Top Gas Expansion Turbine
	3103	Heat Recovery From Slag
	3104	Optimizing the Cowper Control
	3105	Heat Recovery From Cowper Gases
	3106	Gas Recovery
	3107	Heat Recovery From Slag
	3108	Proheat of Scrap Charge
	3109	Closing the Fourth Hole
	3110	Substitution by Continuous Casting
	3111	Slab Cooling Tank
	3112	Hot & Direct Rolling
	3113	Optimizing the Control of Furnaces
Non-Ferrous Metal Industry	3201	Best Practice Hall Process
	3202	Cathode of Titenium Diboride
	3203	Aluminium Chloride Electrolysis
	3204	Scrap Preheating & Molten Metal Recir.
	3205	Waste Heat Recovery
	3206	Improved Desing of Furnaces
	3207	Heat Recovery from Sintering Plant
	3208	Combustion of Blast Furnace Gas
	3209	Heat Recovery From Cooling Water
Chemical Industry	33101	Digestion in Tubes & Fluid. Bed Calcin
	33102	Membrane Process
	33103	Ethylenedichloride process
	33104	Recovery of Sensible Heat
	33105	AMV Process

Table 5: (cont.)

Sector	BAT Number	BAT
Chemical Industry	33201 33202 33203 33204 33205 33206 33207 33208 33209	Split Flow Coils Process Integrated Heat Exchange Heat Recovery & Tail Gas Quenching Steam Reforming & Partial Oxidation Low Energy Concept Modif. Chlorination&Tail Gas Heat Exch Linear Low-Density Polyethylene Masse Process Gas Phase Process
Non-metallic Mineral Industry	3401 3402 3403 3404 3405 3406 3407 3408 3409 3410 3411 3412 3413 3414 3415	Direct-Curr./Counter Curr. Regen. Kiln Heat Recovery in Rotary Kilns Double-Layer Bricks In Rotary Kilns Roller Mills Dry Process Short Rotary Kiln Double-Layer Bricks In Rotary Kilns Roller Milles Computer Based Process Control Computer Aided Drying Facilities Improved Insulation and Burners Exhaust Gas Heat Excharger Improved Insulation and Burners Exhaust Gas Heat Recovery Contin. Oxygen Trim to Optim. Combust.
Other Industry	3501 3502 3503 3504 3505 3506 3507 3508	Pressure/Thermo Stone Ground Wood Continuous Pulp Digestion Improved Bleaching Process Improved Grinding Process Pressing with Higher Pressing Impulse Silent Dryer Drive Waste Heat Recovery Humidity Control on Drying Hoods
Transportation	4001 4002 4003 4004	Technical Improvements to Cars Technical Improvements to Cars Recovery of Brake Energy Technical Improvements to Trucks
Private Households	5101 5102 5103 5104 5105 5106 5107 5108 5109 5110 5111	Improved Insulation Passive Solar Energy Use Active Solar Energy Use Gas-Fired Condensing Boilers Expansion of Distr. Heating with CHP Solar Water Heating Improved Gas and Electr. Cookers Miniature Fluorescent Bulbs Improved Washing Machine Improved Refrigerator Improved Freezer
Tertiary Sector	5201 5202 5203 5204 5205 5206 5207 5208 5209	Improved Insulation Passive Solar Energy Use Active Solar Energy Use Improved Heating Control Gas-Fired Condensing Boilers Expansion of Distr. Heating with CHP Gas Driven Heat Pump Solar Water Heating High Efficiency Fluorescent Lamps

Source: Frank Springmann, "Analysis of The Ecological Impact of Demonstration Projects in The Field of Rational Use of Energy — Development of Evaluation Criteria," 1991, Study on behalf of the European Commission, DG XVII.

Table 6 : List of BATs with Positive Net Costs

Technology	BAT Number	Total Saving (PJ)	Total Saving (ktoe)	Annual Net Cost (Million ECU)	Energy Saving (%)	CO_2 Saving (%)
Industrial CHP GT	1101	204.00	4,872.00	602.00	0.52	0.50
Industrial CHP combined engine	1102	52.00	1,242.00	90.00	0.13	0.12
Industrial CHP CCPP	1103	146.00	3,487.00	239.00	0.37	0.34
On-shore Wind	1106	1,171.00	27,969.00	692.00	2.99	2.48
Off-shore Wind	1107	330.00	7,882.00	2,012.00	0.84	0.70
Photovoltaic cells	1108	646.00	15,429.00	22,587.00	1.65	1.37
IGCC-PP	1110	150.00	3,583.00	1,706.00	0.38	0.59
PFBCC-PP	1111	117.00	2,794.00	1,501.00	0.30	0.47
Gas-CCPP	1112	85.00	2,030.00	187.00	0.22	0.19
Heat Pumps	2003	480.00	11,465.00	45.00	1.22	1.41
Building Insulation	2007	90.00	2,150.00	738.00	0.23	0.23
Sinter Heat Recovery	3207	2.00	48.00	1.00	0.00	0.00
Cooling Water Heat Recovery	3209	2.00	48.00	1.00	0.00	0.00
Building Insulation	5101	1,993.00	47,602.00	8,927.00	5.08	5.43
Passive Solar Energy	5102	302.00	7,213.00	1,203.00	0.77	0.82
Active Solar	5103	215.00	5,135.00	6,004.00	0.55	0.58
Solar Water Heating	5106	568.00	13,566.00	2,202.00	1.45	1.32
Improved Washing Machines	5109	123.00	2,938.00	56.00	0.31	0.26
Building Insulation	5201	638.00	15,238.00	3,101.00	1.63	1.68
Passive Solar Energy	5202	43.00	1,027.00	189.00	0.11	0.11
Active Solar	5203	31.00	740.00	868.00	0.08	0.08
Gas Heat Pump	5207	77.00	1,839.00	268.00	0.20	0.20
Solar Water Heating	5208	92.00	2,197.00	354.00	0.24	0.22

Source: Springmann, 1991.

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