Wind Energy

and

Technological Diffusion Process in Turkey

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Introduction

Two subsequent oil crises diverted attention from fossil fuels to alternative energy sources for energy generation. Furthermore, fostering the course is the challenge that the whole world has been encountered: It is the environmental sustainability. Energy generation related CO_2 (carbon dioxide) emissions play a significant role in environmental degradation. There are several technical and policy-based choices that can ensure the sustainability to a certain extent. One of them is the application of renewable energy technologies in energy – electricity – generation. In this regard, we will concentrate on wind energy technology from the perspective of Turkish energy policy, and technological change in theoretical approach.

Basically, country-based energy policy encompasses several issues, which are multi-dimensional, and specific to the country analyzed. Within this paper, only two of them are taken into account: **Sustainability** and **dependency** on foreign sources.

There is a social cost in energy consumption: Consumption of fossil fuels causes degradation in the environment**.** In addition to the adverse effects resulted in the environment, being **dependent** on fossil fuel producing countries is another disadvantage of utilizing imported fossil fuels.

Both dimensions are pertinent for Turkey's current and future energy policy. Turkey would definitely be better of exploiting its natural and renewable energy resources; such as wind, solar, geothermal, biomass, and others. Besides, Turkey would become somewhat independent from its energy imports by benefiting large amount of internal natural resources that could help accelerate technological development capability.

On the other hand, the need for sustainable energy sources should not be seen just as a concern at country level. As climate change, loss of biodiversity and ozone layer depletion, fossil fuel energy sources substantially harms the globe, and risk the sustainable development's future, therefore, the issue should be addressed at global level.

In the content of this paper, energy use and its main environmental effects are discussed at the global level in the first section. Following the global level, the focus is given to the case of Turkey regarding increasing energy consumption and energy related greenhouse gas emissions. As the environmental degradation issue is inevitable to be tackled, the importance of alternative energy sources, namely new renewables, and particularly wind energy is analyzed in the following section. Eventual section deals with the issue of technological diffusion process, highlighting blocking mechanisms and policy issues applicable to the Turkish wind energy market.

Section 1

1.1. Energy Supply in the World

Energy is used for varying purposes, such as for transportation fuel, heating, electricity generation and for many other needs. Besides its significance in modern life, energy is one of the most essential keys to become a welfare society. In addition to the several economic indicators, the ratio of per capita energy use has been used for several decades as a socioeconomic development indicator.

On the other hand, according to several researches, projections indicate that the worldwide demand will continue to use fossil fuels to meet the expected surge until the year 2025. Nevertheless, parallel to the issue in the overall awareness of global warming and other side effects of environmental degradation, the need to utilize non-fossil energy sources will gain momentum in the coming years. One of the most important points, in this regard, worth raising is the extent to which current energy sources will be able to offset the word demand (Ultanir, 1999, pp.8).

Although Jacobsson and Johnson (1999) point out the fact that many of these renewable technologies are in their infant phase, they acknowledge that forms of new renewable energy sources will inevitably contribute to meeting the demand for energy supply in the future. When looking at some intergovernmental or policymaking organizations' work on energy issues, this idea can easily be confirmed.

In this regard, the European Union's Green Paper report published in 2000 contains quite substantial amount of information from the Intergovernmental Panel on Climate Change meetings. According to the Panel's findings, since 1990 global warming has been speeding up. The earth has warmed up by an average of 0.3 to 0.6 degrees celcius. As a consequence of global warming effect, among others, the level of oceans has risen between 10 to 25 cm. Subsequently, the Green Paper clarifies the reasons of warming: Global warming is the result of intensification of a natural phenomenon essential to the survival of the planet, that is the *greenhouse effect* (EU, 2000, pp.34). These gases have increased substantially in the atmosphere while the natural capacity to absorb them has been declining. The Panel charges fossil fuels as the prime culprits behind the process.

Policy makers are aware of the hazardous situation the world has now encountered. Since the beginning of the 1990s, there are protocols/agreements, like the Kyoto Protocol in 1997 that charge governments to reduce their greenhouse gas emissions. Compliance with the Kyoto commitments and the control of greenhouse gas emissions in general are essentially a matter of energy and transport policy for the EU, as indicated in the Green Paper. For both sectors, the Green Paper suggests drastic measures. Concrete measures, notably fiscal and regulatory policies geared to energy saving and promotion of renewable energy sources, are among the recommendations undertaken by the EU (EU, 2000, pp.37).

Throughout the twentieth century, as a result of the elimination of boundaries in terms of international economics, and the so-called globalization in social, economic and cultural dimensions, national economies are now required to be more powerful and competitive in the international market. While the co-operation of countries at regional and global level arises significantly, the independence of nations in both economical and political terms, and the individual competitiveness are considered as equally important.

To develop a strong national economy, it is essential to use the limited sources more effectively, to produce and develop the most appropriate technology which best suits to the country's unique characteristics, and to re-define the criteria for the selection of the technology according to the newly emerging economical, social and political conditions and new world order.

To the contrast of the neo-classical approach to the concept of technology, technology is no more just a tool or mechanism transforming the input to the output. Its unavoidable short and long term effects requires developing technology policies which concern their appropriateness to the social, economic, geographic and cultural conditions of nations.

The environmental catastrophes occurred as a consequence of industrialization require a shift regarding the understanding of technology. The criteria for the selection of technology has been shifted from being productive to be social cost-effective, environmental friendly.

1.2. An alternative to ensure and maintain the "sustainability": wind energy

After having briefly introduced two main problems arising out of existing fossil-based energy sources, the discussion now focuses more specifically on issues related to overcome these problems through utilizing sustainable sources, such as wind energy.

Even though the notion of renewables is considered to be "new" in the sense of alternative sorts of energy, wind is, in fact, an old source in terms of mechanical power. Its usage goes back to nearly 3000 years ago, and some specific civilizations have used it more frequently, e.g. the Romans, Byzantines, Persians. Particular concentration was directed to grinding grain, pumping water, and sailing (Ackermann and Söder, 2000; TUBITAK, 2001). The two oil crises that occurred in 1973 and 1979 led the technology to reemerge. Since then, traditional utilization concept has been shifted towards electricity production.

Impetus for the development of wind energy technology may include its environment friendly character, contribution to non-dependence on oil and other fossil fuel extracting and exporting countries, and its positive impact on the balance of payments of any specific country that exports the technology. Probably, the last item is in addition to macroeconomic benefit that the technology confers by lowering the unemployment rate through the creation of a new industry (EU, 1997, pp.4).

However, wind is sensitive to variations in terrain topography and weather patterns, and variation may occur from year to year, or season to season, and even during the same day. Hence, some regions are more suitable for the utilization of wind energy. The highest potential for exploitation is in North America, Ukraine, Australia, Denmark, the Netherlands, the north of Gibraltar, Southern France, the United Kingdom, Ireland, Scotland, Greece, Spain and Turkey (Borhan, 1998, pp.353-354; Ackermann and Söder, 2000, pp.324).

1.3 Economics of wind energy

It is generally accepted that new renewable energy resources are rather expensive in comparison to conventional sources. Although it may be widely agreed upon, the fact remains that this result excludes or underestimates the existence of **social costs**. Besides the threat of global warming and probability of an accident that may occur during the process of mining, transporting and other phases regarding conventional energy sources verifies the existence of social cost. The Chernobyl nuclear reactor leakage in 1986 in the former USSR, the Exxon Valdez oil spill in Alaska in 1989, and others may be included in specifying the social costs (Smil, 2000). If the social costs were included in the total cost, the discussion of "expense" would take a different direction.

The cost of generated electricity has been decreasing significantly. According to one study, the production cost of wind turbines, and consequently power production costs, decline at the order of 15 percent when the cumulative volume doubles (UN, 1998, pp.5).[1] Another statistical analysis claims that cost of producing one kilowatt hour (kWh) electricity has decreased to one fifth of the cost (DWTMA, 2001, pp. 8).

If the positive development in cost reduction is considered to be a success, such a success can occur as a result of some technological improvements in areas such as better aerodynamics design; use of composite materials in turbine production; increased generation capacity; increased sales volume, hence advantages brought by mass production; and lastly, the

[1] According to Ackermann and Söder (2000), when the number of manufactured wind turbines doubled, the cost declined by about 20 percent (pp. 349).

recognition of the new technology and its effect on financial confidence (McGowan and Connors, 2000; Guey-Lee, 2001, pp. 82).

A key question concerns the future pattern in terms of cost, and research is done in this field. McGowan and Connors (2000) cite the US Department of Energy's study and state that by the year to 2005, the cost will drop to 740 per kW. The decrease is mainly attributed to mass production. The same source cites a study with data from Denmark that adds another factor on cost reduction, and that is learning by doing and the contribution of experience. The industrial experience in installation, operation, design, material selection, construction and siting has been increasing, and is defined as a necessity for achieving significant cost reductions. Calculated experience curves and technological improvement analyse using the Danish data assume that as long as the growth rate of 15 to 20 percent is maintained, the cost of generated electricity could drop by 45 percent over the next two decades.

Two other studies also make projections of future cost reductions. According to the Danish Energy Agency, by the year 2020, cost reduction of 50 percent is expected to be achieved. The European Union forecasts a reduction of 30 percent expected between 1998 and 2010 (EU, 1997). As the variations in predictions clearly show that the future cost pattern is difficult to estimate, it should not be taken for granted (Ackermann and Söder, 2000, pp. 349). Anderson (1997) states that impressive developments have occurred during the last 25 years in technology, and they are manifested in reduced costs. Although the industry still comprises a small proportion of total electricity production, with the contribution of good policies and continued innovation, it is anticipated to provide further cost reductions as the markets expand.

The question of whether wind energy is economic or not, is discussed substantially in literature from the EU's Green Paper, and other sources such as those cited in Jacobsson and Johnson (1999) referred to in this review. The World Energy Council – WEC (2000) stresses that there is no single answer to this question. Local regimes, prices of competing sources and other institutional factors are among the other variables determining the economic feasibility of renewables. In the same report, the WEC indicates that wind energy is striving to become cost competitive with energy from the conventional fuels in the industrialized west. Jacobsson and Johnson (1999) also contribute to the discussion of economics of renewable technologies. They recognize that today wind energy is often subsidized. However, they note that it is approaching a cost level, which makes it economically attractive. They claim that the idea is valid, as long as the weather conditions are appropriate for wind technology (Jacobsson and Johnson, 1999, pp.5).

1. 4. The future expectations

As the technology matures, size and volume of electricity generation increases. Today, major manufacturers have prototype machines of 2 MW in operation, and there exist plans for 5 MW sizes (McGowan and Connors, 2000). As the size of turbine increases, so do land considerations for highly populated areas. A solution for siting of large turbines is the alternative use of offshore deployment.

Even though the first experience in offshore wind took place in the US in the 1970s, the US did not continue on this path. Instead, some European countries have started to exploit the alternatives. Denmark, United Kingdom and the Netherlands are among the leading European countries in that respect. In the year 2000, off the coast from Copenhagen, a new offshore wind farm was installed for the anticipated compensation of Copenhagen's total electricity demand. This 40 MW wind farm is not only the largest application in the field, but also a good example of collaboration between utility company of Copenhagen and the Midelgrunden wind cooperative, both of which are the owner organizations. It is also considered to be a good example of what can be achieved by small and big investors working together in a project of this kind (DWTMA, 2001, pp. 11).

While development is expected in offshore sites for larger applications, smaller applications may also be developed in the future. According to the World Bank estimates, there are nearly two billion people in the world who are hardly able to access contemporary forms of energy. Therefore, smaller applications with the stimulus of international collaboration, proper regulations, capacity building and skilled human resource development may seem to contribute to speeding up the prospective extensions of access to energy.

The biggest hurdle for the wider diffusion of wind energy technology is its high initial investment capital cost. It is indicated that the price of electricity from wind is higher owing to the fact that energy prices do not properly reflect the actual cost for conventional sources. With respect to this issue, it has been strongly recommended to internalize the environmental externalities in that sense – for example by means of applying carbon taxes to fossil fuels. A further obstacle is defined as the lack of confidence arising on the part of users, investors, and governments. Generally, this is caused by the lack of familiarity with renewable energy's technical and economic potential. The resistance obviously emerges in response to new ideas and change, as is the case for most of the new innovative technologies (EU, 1997, pp.6).

Greater electricity generation from the wind resource depends on many factors. The greater attention to environmental degradation resulting from energy related carbon emissions, leading to steps to solve the current and prospective problems in future, is an important determinant of the future level of use. However, the general expectation is that wind energy's contribution to total energy output will increase compared to today's volume. Several scenarios of future developments support that expectation.

Section 2

2.1. General overview on energy in Turkey

Although Turkey is surrounded by fuel rich countries in southeastern part, the country is not rich in fossil fuel reserves – A map is available at Annex 2. In contrast to fossil fuel reserves, Turkey can be considered as a prosperous country with regard to some renewable energy sources; particularly hydro, solar, geothermal and wind. This chapter will first present a brief analysis and a general overview of Turkish energy issues. It will then discuss the appropriateness of wind energy for Turkey.

Electrical energy is a relatively challenging topic, which sometimes has held problematic nature in Turkey over the last few years. [2] Up until now, the state has played a dominant role in energy production, transmission and distribution. New investments required for capacity development have always been made by the Turkish State, although their total volume has been decreasing for some time. Therefore, the demand for electricity has by now exceeded the electricity supply, causing a supply problem that has affected the public in general. The supply problem arose mainly as a consequence of the lack of financial sources, mostly owing to the state's budgetary constraints. Thus, in order to tackle the problem, one of the recent governments promulgated a law to liberalize the energy market by opening the market to the private sector in 1984. Subsequent governments have followed suit.

Regarding natural energy sources, Turkey has basically water and coal reserves that can be utilized in electricity production processes. Rivers are basically located in the eastern parts of the country, and most of the hydroelectric power plants are located in the same region. In addition to water sources, another type of fuel for electricity production is lignite coal. Generally, the heat efficiency of lignite is low in Turkey. As opposed to its low performance with respect to heat efficiency, lignite's contribution to air pollution is high (Atasoy, 2000, pp.6; Gulbahar and Kilinc, 2000, pp.785). Hydro power plants are driven by dams, so their performance highly depends on climatic conditions.

Moreover, thermal power plants use several different sources, such as hard coal, lignite, fuel oil, natural gas, and lastly a new renewable form of energy, geothermal. The sources that TEAS applies in most power plants are lignite and natural gas (Eroglu, 2001, pp. 2).

Turkey changed its energy policy concerning the use of oil after the two oil crises. Instead of oil, natural gas has become a more dominant fuel, and consumption of natural gas is expected

[2] In the year 2000, public and private offices changed their working hours in order to utiize more of the daylight and thus contribute to energy conservation targets. While most of the private organizations had started working at 9:00 am, the starting hour was set backwards to 8:30 am. Most of the lightings in the streets were controlled. This precautionary action lasted throughout the year 2001.

to grow rapidly. Nearly all of the natural gas imported to Turkey comes from the Russian Federation. However, Turkey plans to diversify its sources of supply, in order to lessen the risk of being dependent on a single country (DoE, 2001, pp.3).

Coal is another source, with imports from the US, Australia, South Africa and the Russian Federation reaching a 6 million tons every year. On the other hand, as mentioned before, Turkey is relatively rich in terms of lignite sources, and about 75 percent of Turkish lignite is used in electricity production (DoE, 2001, pp.3).

Another relatively rich source for electricity production, compared to neighbouring countries in the south and southeast, is hydropower. There has been 108 hydro power plants built in Turkey by the end of 1999. The Turkish State plans to increase the number of hydro power plants to 485 by the year 2010. This long-term target requires an additional capacity cost of more than USD 30 billion (DoE, 2001, pp.3).

Given the type of natural reserves, Turkey utilizes mainly thermal and hydropower in electricity production facility. With regard to installed capacity, as of 1999, thermal power overran hydropower with a share of 59 percent. The share of hydro stood at 40, and lastly wind's share stood at 0.03 percent. The production profile of TEAS strongly influences this pattern. Since TEAS's capacity is based mainly on hydro power plants, the private companies tend to utilize more thermal power, as can be seen in Table 6. The reason can simply be attributed to the greater financial burden of the large hydro power plants, as these sorts of investments necessitate higher investment expenses.

Turkey is one of the fastest growing power markets in the world, as the Turkish population's per capita electricity consumption is comparatively lower than that of the developed world. During 1990s, electricity consumption grew at around 8 percent a year, and this growth is expected to reach the 8 to 10 percent levels within the next 15 years, according to TEAS's estimates (Eroglu, 2001, pp.2).

2.1. Potentials for the future of the Turkish electricity sector

The State Planning Organization (SPO) prepares five-year development plans in Turkey. The one currently in force is the 8th five-year development plan. Within that framework, several sector-based projects are to be completed with the contributions of experts in the respective fields. One of the sectors is obviously electricity. A Special Expert Commission has made a report for electricity energy, and within the report made some predictions about the future demand and supply for electricity energy (SPO, 2001).

In line with the estimation of future demand and supply trends, the World Bank suggested a model for the purpose of making predictions in 1984. Subsequently, the model has been applied by the Turkish authorities. Additionally, the work done in collaboration with the US based Argonne National Laboratory developed a new model named Energy and Power Evaluation to create scenarios of future power consumption. The model includes Balance of Energy Supplies and Demands with an IMPACTS (environmental burdens and resource requirements of energy sector) module, and an ELECTRIC (WASP III – Wien Automatic System Planning Package) module. Factors in social, economic and technical areas are taken into account. To make predictions about "electricity demand" for the 8th five year development plan, the module of Wien Automatic System Planning Package was used for the term from 2000 to 2020 (SPO, 2001, pp.3-1, 3-2). [3] The results are exhibited in the Table 7 below.

Table 7: Turkish Electricity Demand estimations according to source from 2000 to 2020 (MW)

Years	Natural Gas	Lignite	Coal	Fuel oil	Coal-Import	Nuclear	Thermal	Hydro + Renewable	Total
2000	7,553	6,410	555	1,636	0	0	16,154	11,246	27,400
2001	7,553	6,410	555	1,636	0	0	16,154	11,918	28,072
2002	9,653	6,710	555	1,636	0	0	18,554	11,918	30,472
2003	10,353	7,410	555	1,636	1,000	0	20,954	11,918	32,872
2004	11,753	8,110	555	1,636	1,000	0	23,054	12,825	35,879
2005	13,153	8,810	555	1,636	1,500	0	25,654	14,242	39,896
2010	19,543	13,810	555	1,636	3,500	2,000	40,954	19,536	60,490
2015	26,453	15,460	1,755	2,236	6,000	4,000	55,904	25,262	81,166
2020	34,853	16,060	1,755	4,636	10,000	9,000	76,304	28,589	104,893

Source: State Planning Organization, Special Expertise Commission on Electricity Energy Report, 2001, pp.5-9

First of all, it should be noted that total electricity demand is estimated to increase by nearly 290 percent within 20 years time, having a more than 30 percent yearly average. From 2000 to 2005, increase in total demand would show a smoother pattern, as the first steep increase is expected to occur between 2005 and 2010. For each of the sources, natural gas is expected to rise slightly from 27 percent to 33 percent between 2000 and 2020. Lignite's share is expected to decrease from 23 to 15 percent within the same term. Demand for coal also decreases slightly from 2 percent in total to 1.6 percent. A small percentage decrease is

[3] The model was put into operation in October 1999 and was intended to be revised in 2000 in accordance with the supply data. But information about whether the results had changed drastically or not could not be obtained during the period,in which this thesis was written.

estimated for fuel oil, from nearly 5 to 4.4 percent. The imported coal is expected to have a 9.5 percent share in 2020, a significant increase from zero level in 2000.

Another long discussed public issue has been the investment in nuclear energy technology. Although the decision to establish a power plant on the Mediterranean coast was cancelled in the year 2000, the Special Committee expects that nuclear power will have an 8.5 percent share of electricity production in 2020. Thermal power keeps its dominant role both in 2000 and 2020. The demand for electricity generated from thermal power is estimated to reach 72 percent in 2020, from 59 percent in 2000. Hydro and renewable power are estimated to decline in total demand figures. This share is expected to decline to 27 percent from the current level of 41 percent.

2.2. Energy and related environmental issues in Turkey

To address environmental problems, Turkey has been making progress by setting up an infrastructure, especially during the last two decades (DoE, 2001, pp.9; UNFCC, 2001, pp. 7). Turkey has several laws and regulations to protect the environment. The eldest of them is the General Public Health Law, which has been in operation since 1930. A framework law that directly relates to environmental issues is the Environmental Law that was promulgated in 1983. The law aims to protect the environment, and to manage natural resources and land. In short, a more straightforward definition of its goal is to leave a sustainable future for the next generations (BSER, 1997, pp.2-3-4).

Additional to the some of the regulations to protect the environment, there is also a specific attempt to address climate change issues. A group called National Climate Coordination is supposed to prepare a national greenhouse gas inventory, and to set up a climate assessment procedure for various sectors and ecosystems. The third and final purpose of its work is to develop scenarios regarding climate change and increases in sea level (BSER, 1997, pp.2-3-4).

On the other hand, despite positive developments towards a sustainable development, it is claimed that environmental issues have not been incorporated into economic and social dimensions of the decision making process. This inadequacy has been recognized and a national action plan was therefore incorporated into the 7th five-year development plan for 1996-2000 (UNFCC, 2001, pp.7). Within that framework, the State Planning Organization coordinates a project supported by the World Bank. The project is called the Turkish Environmental Strategy and Action Plan. The plan contains actions to be implemented to reduce and/or limit greenhouse gas emissions (BSER, 1997, pp. 2-3-4).

In addition to some domestic actions taken to achieve tighter regulation, it is also necessary to take part in international movements for the protection of the environment. Turkey is already party to several environmental treaties on air pollution control, bio-diversity, desertification, hazardous wastes, nuclear test bans, and others.

As for the well–known United Nations Framework on Climate Change Control, Turkey has neither signed nor ratified the Kyoto Protocol. Turkey claims to be eliminated from the so called “Annex 1” and “Annex 2” groups, which are constituted of developed countries, and to be positioned within the group of developing countries. In this connection, Turkey states that it does not contribute to climate change as much as developed countries (DoE, 2001, pp.9). In summary, Turkey does not deny the necessity of all the actions with regard to climate change. Instead, the country claims that it is not able to comply with the requirements under the current special conditions. In order to comprehend whether the claim is valid or not, it is useful to look into some statistical comparisons of the greenhouse gas emissions. Of particular interest is the level of CO_2 emissions.

The Special Commission on Climate Change, a working arm for the 8th five- year development plan of the State Planning Organization, published a report that draws upon the work of the US Department of Energy's Energy Information Agency. The report draws a picture for future energy related CO_2 emissions and Turkey's contribution, compared to other countries (and group of countries). Table 8 provides comparative data regarding CO_2 emissions.

Table 8: Energy Related CO2 Emissions[4] (million ton carbon, according to 1999 reference case)

Countries	**1996**	**2000**	**2010**	**2020**	**Avg. increase rate % (1996-2020)**
Developed**	2980 (50)*	3157 (49)	3535 (44)	3907 (40)	1,1
Developing	2161 (36)	2447 (38)	3547 (44)	4886 (50)	3,5
R. of China	805 (13)	930 (14)	1391 (17)	2031 (21)	3,9
India	230 (4)	273 (4)	386 (5)	494 (5)	3,2
S. Korea	113 (2)	112 (2)	168 (2)	230 (3)	3

[4] The shares of methane and N_20 are not included in the table, as their shares are negligible compared to CO_2. For those interested, an analysis for these gases is available in the same study (pages 33 to 38).

Turkey	**43 (<1)**	**46 (<1)**	**65 (<1)**	**81 (<1)**	**2,7**
Others***	848 (14)	827 (13)	935 (12)	1024 (10)	0,8
World	**5983 (100)**	**6430 (100)**	**8018 (100)**	**9817 (100)**	**2,1**

Source: Special Commission on Climate Change Report, State Planning Organization, 2000, for 8th five-year development plan, pp. 21

* parenthesis indicate the share of related party's contribution in total volume

** USA, Western Europe and Japan

*** Former USSR and Eastern European countries

As can be seen in the Table 8 above, Turkey's contribution to global CO_2 emissions will remain at a level of below one percent until 2020. But, another interesting figure is the rate of increase from 1996 to 2020, which is 2.7 percent, higher than the total world increase. As a concluding remark for the discussion about ratifying the Kyoto Protocol, Turkey's thesis that it should be removed from the group of developed countries seems appropriate for two apparent reasons: 1. Turkey is a developing country, therefore it is not financially capable of complying with the actions stipulated within the Protocol. 2. Developed countries' share of CO_2 emissions is profoundly higher than that of Turkey.

Nevertheless, in spite of all the discussions to change Turkey's status with respect to the Kyoto Protocol, and all regulative efforts made up until now, there is another unavoidable threat to sustainable development that Turkey now confronts. The State Planning Organization's Special Commission on Climate Change report considers that Turkey is under the threat of depletion of water resources, forest blazes, desertification, and drought, because of environmental degradation occurring throughout the country. In addition, the potential adverse effects of global warming places Turkey in the risk group (SPO, 2000, pp. 8-9).

In order to reveal the extent of this threat, it is necessary to look into other statistical data, which is CO_2 emissions released per capita. Regarding the referred issue, the level has increased from 1 ton CO_2/person to 3.88 CO_2/person. Per capita CO_2 emission is projected to increase more steeply after the 2000s. For instance, for the year 2010, the same indicator is expected to reach the level of 6.56 tons CO_2/person (SPO, 2000, pp. 43).

Focusing more on the electricity sector, a sector-based analysis is available from the Turkish State Statistical Institution's sources for the same investigation. Within that context, historical data revealed that energy consumption contributes to the total CO_2 emission at a level of 28 percent. This level is expected to reach 39 percent in 2000, and 46 percent in 2010 (SPO, 2000, pp. 32).

In Turkey, demand for electricity has been growing faster than gross national product. And, as for the electricity consumption, in parallel to the demand for electricity, CO_2 emissions from electricity use increase accordingly. Table 9 below depicts the comparison of the weight size in grams of CO_2 emissions released into the atmosphere for each kWh of electricity use between 1990 and 2010.

Table 9: Year based increase of CO_2 emissions in Turkey (g*/KWh)

Year	**CO_2 emission**
1990	527
1995	509
2000	580
2005	646
2010	656

Source: Special Commission on Climate Change Report, State Planning Organization, 2000, for 8th five year development plan, pp. 46
* g: gram = 10^{-3} kg

It is assumed that grams of CO_2 emissions from electricity use are going to increase by 36 percent within less than 10 years. The information clearly reveals that increasing demand would inevitably result in an increase of CO_2 emissions. Therefore, it seems that there is strong justification for taking firm action against the climate change, for the sake of both the country's own future, and its responsibility towards the world.

Section 3

3.1. Wind Energy and Its Potential in Turkey

Following the analysis regarding the problems emerging as a result of conventional energy production technologies in the first two sections, the potential of wind energy in Turkey is analyzed in this section.

Among other parameters, wind energy depends strongly on the speed of the wind. Power extracted from wind is the cube power of the wind speed. Therefore, in order to find the appropriate locations for establishing wind power systems - regardless of size, and whether it is for either a single wind turbine or a wind farm - it is highly necessary to assess the characteristics of the wind, basically the speed and the direction.

Reminded of that crucial fact, we can perceive the importance of research on wind characteristics. In order to make a comment on Turkey's potential with regard to the availability of wind power for electricity generation, it is necessary to take account of the speed of wind, and to define which regions or specific locations are the most appropriate ones for wind power installations.

The first modern wind turbine was built in Cesme – Izmir in 1984 with a 55 kW capacity power (Hanagasioglu, 1999, pp. 824).[5] Before that concrete action, the first research studies evidently started at Turkish universities and research centers. Among the universities, one of the recent studies was done by Tolun et al. in 1979. The idea came after a visit to Bozcada island[6]. Even though the island has high wind potential according to the meteorological measurements, its electricity was supplied by diesel generators. That observation stimulated the academics to start a pilot project that was based at Gokceada island[10]. Rather than Bozcada, Gokceada was selected because of limited financial resources. The pilot study included the production of a small power wind turbine. On the other hand, the main purpose of the study was to acquire data regarding how much power could be extracted by the application of 200-300 kW size turbines. Furthermore, the study intended to accumulate the "technological knowledge" for future applications of larger size wind turbines (Tolun et al., 1994, pp.1).

Additional efforts were made by the research centers. TUBITAK Marmara Research Center commenced a study for the purpose of preparing a wind atlas for Turkey in 1986, as described

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[5] This application is for a hotel's electricty generation. The same system still generates electricity. Cesme is a region with abundant wind power that is situated on the Aegean coast of Turkey.

[6] Both Bozcada and Gokceada are located in the south of the Marmara region, on the shore of the city of Canakkale (the ancient name of the city was Dardanelles).

by Uyar et al (1986). To date, the Turkish wind atlas has not been delivered yet. However, it is predicted that it will be completed by the end of 2001 (TMMOB, 2001, pp.8; Dundar et al., 2000, pp.821).

3.2. Meteorological aspects of wind in Turkey

Before evaluating the research results in terms of potential sites in Turkey, a review of meteorological aspects of the winds that affect Turkey will be beneficial. Within the reviewed literature, Tolun et al. (1994) and Oztopal et al. (2000) have surveyed the characteristics of wind structure throughout Turkey. Oztopal et al. (2000) defines Turkey's wind structure from the meteorological point of view as follows: [7]

"Turkey has a Mediterranean type of climate extending from the southern coastal plains almost to the northwestern part of the country. The southern parts of the region are particularly affected by the southwesterly and westerly winds caused by cyclonic disturbances coming from the Azores high pressure and Basra low-pressure centers depending on the season of the year. On the other hand, the northwestern part of Turkey is under the Iceland low-pressure influence, which gives rise to northerly and northwesterly winds, especially in the northern Aegean sea. The so called Etesian winds play a significant role along the Aegean coast of Turkey which includes the most important wind energy potential areas…

…along the black sea coastal line, Turkey is exposed to northerly and northeasterly winds originating from Siberia and middle Black Sea range receives most of the wind speed and hence energy. The interior of Turkey has a continental climate where there are some locations with rugged mountains such as eastern Turkey where wind speeds reach significant energy generable levels along many valleys…" (pp.190).

The previous technical research proves that some parts of Turkey are endowed with strong wind conditions. Particularly, south of the Marmara region, coastal and some inner parts of the Aegean region, some parts of the Black Sea, the eastern part of the Mediterranean, and locations with rugged mountains in Eastern Anatolia are especially promising regions, as stated by Oztopal et al. (2000, pp. 190).

Having briefly described the potential regions, it can be stated that some specific parts of Turkey carry higher potential for the utilization of wind energy for the production of electrical energy. Generally speaking, the magnitude of the potential varies in accordance with the researchers and their studies' results:

[7] The definition is almost the same. The definition of Tolun et al. (1994) is available at pages 6 and 7 (in Turkish). Oztopal et al. (2000) was quoted owing to the fact that meteorological information includes some peculiar technical terms that can not be easily interpreted and translated.

- According to the Special Commission on Electrical Energy of the State Planning Organization (2001), the potential is 10,000 Mw, citing the study of Elektrik Isleri Etud Idaresi – EIE (Electrical Power Resources Surveying Administration).
- Furthermore, it is stated in the same report that according to the satellite pictures taken by the United States during space related research, the wind energy potential in Turkey is extremely abundant (pp.33).

3.3 Regional potential analysis

The previous technical research proves that some parts of Turkey are endowed with strong wind conditions. Particularly, the south of the Marmara region, the coastal and some inner parts of the Aegean region, some parts of the Black Sea, the eastern part of the Mediterranean, and locations with rugged mountains in Eastern Anatolia are especially promising regions, as stated by Oztopal et al. (2000, pp. 190). In general, the Aegean coast is defined as one of the most promising regions. Similarly, Tolun et al. (1995) indicate that Gokceada island as having a similar potential pattern compared to the potential with Denmark and Great Britain. Consequently, they suggest that Gokceada should be placed in the European wind atlas. In addition, the same source states that the northern Aegean region also demonstrates a high wind potential (pp. 684). Furthermore, Borhan (1998) illuminates the reasons of the strong potential on the northern Aegean region, by identifying winter and summer weather patterns and meso-scale circulations over the eastern Mediterranean and the Aegean sea. It is stated that although several reasons can be found for the high potential, the strongest point among them is attributed to the surface pressure gradients in the northern Aegean coast. These gradients cause a powerful wind structure, particularly on the Bozcada and Gokceada islands and in the Canakkale region (pp. 359).

Within the reviewed literature, another somewhat broader analysis was conducted by Oztopal et al. (2000). In the study, 42 stations throughout Turkey were used for the measurements, revealing their values at 5 and 50 meters. The average wind speed record was taken at 10 minutes interval between the years 1990 and 1995.

The concluding remarks from the 5 year long study identify the potential sites in Turkey. Generally, higher potential sites are located within the northwestern, northern and along the Aegean coastal lines. Gokceada island and Bandirma justify special attention. The middle Black Sea region (Sinop) and eastern Mediterranean (Iskenderun) parts are among the other potential regions. On the other hand, within the inland parts, Diyarbakir in southeastern Anatolia delivers promising results[8] (Oztopal et al., 2000, pp.195,196,200).

[8] Oztopal et.al (2000) draw the limit for wind speed at above 3.5 meter/second. The promising sites are nominated in line with that criterion.

3.3.1. Future expectations for wind energy in Turkey

Regarding the future utilization of wind energy in Turkey, according to the estimations for the next 25 years by the EIE, the total capacity is expected to reach to the level of 11.200 Mw, or 3.5 percent of the total supply (Hertzman, 2001, pp. 30). This expected amount is nearly equal to half of the whole installed wind energy capacity around the world as of 2000.

With 5 years interval period, installed capacity development, and wind's share in total supply according to the estimations can be seen in Table 13 below.

Table 13: Estimated future wind capacity by 2025 in Turkey

Years	**Installed capacity (Mw)**	**Percentage of supply %**
2000	19	0.1
2005	1.359	1.53
2010	2.979	2.31
2015	5.142	2.91
2020	7.849	3.23
2025	11.200	3.55

Source: Hertzman, 2001, pp. 30

According to Ultanir's (1998) modeling results for wind energy capacity development and its share of total supply, the results are the same as those of the EIE work, except for the year 2000. [9]

[9] Ultanir (1998) predicted the capacity would reach to 300 Mw (pp.140)

Section 4

In this subsection, the theoretical approach of technical change is first analyzed. Subsequent description is related to the practical aspects of the technological diffusion issue from the Turkish wind industry perspective.

4.1. How to Improve the Conditions to Diffuse the Technology: Theoretical approach

Energy generation from wind turbines is a technical change – the process of technology choice- also when looked from the perspective of the Turkish energy sector. Commercial application of technology is relatively new in Turkey. Therefore, it is essential to highlight the dynamics from the perspective of technical change. In this respect, our approach will be to define the technical change by reviewing related literature in the technological systems discipline.

There has been substantial research to explore factors over technical change. According to the studies in related area, it has been widely claimed that technical change is shaped by the combination of social, economic, political, organizational as well as the technical processes (Tushman and Rosenkopf, 1992, pp. 312).

Highlighting wind energy's typology regarding interrelatedness with socio-political factors, so as to enhance founding determinants of diffusion of a specific technology, a further approach would be beneficial set from the innovation systems perspective. Jacobsson and Johnson (1999) realized an analytical approach for the Swedish industrial dynamics case for wind energy technology. A deep analysis of inducement and blocking mechanisms encountering a newly emerging technology was done, and solution methodology was suggested highlighting high level potential of wind energy for future prospects.

Generally, it is acknowledged that emergence, improvement and diffusion of a new technology can be viewed from different economic perspectives. Accepting these perspectives' difference, as well as their interrelatedness, Jacobbson and Johnson (1999) brings another, which takes into account innovation systems perspective. According to their definition; entrepreneurial act is the core determinant in innovation and diffusion of a new technology. Furthermore:

a. Innovation and technological diffusion process is an individual and collective act

b. The determinants of technology choice are not only found in individual firms, rather reside in an innovation system. And the innovation system includes a large number of variables (pp.6).

Given the brief characteristics of innovation and the determinants of technology choice, Carlsson and Jacobsson, and Jacobsson and Johnson (1999) define what the technology system holds for. Technological system is "…networks of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse and use the technology" (Jacobsson and Johnson, 1999, pp.6; Carlsson and Jacobsson, pp.268-269).

A technological system has three constituents: Actors and/or economic competence, networks and institutions. These constituents are analysed below:

a. Actors and economic competence: Technical change can be seen as a learning process, which is gradual and cumulative in character. Firms build upon their existing knowledge base and other assets when they search for new opportunities. When either product or process based innovative technologies become available, the bounded visions of managers imply that firms may differ greatly in their perception of these opportunities. In this respect, there are risk faced by technology diffusion. These are;

- Firms, institutions and networks may become locked in old technologies
- If a search is undertaken outside traditional areas, it is done in a highly localized fashion
- They manage actually to hinder the process of diversity creation in the local economy (Carlsson and Jacobsson, pp.269).

   Additionally, Jacobsson and Johnson (1999) highlight the effects of prime movers to identify the roles of actors in technological systems. Prime movers have been defined as the actors that may drive the development and diffusion of new technologies (pp.7).

b. Networks: Learning and technical change are local in nature and include strong elements of path dependency. Technological knowledge is to a varying degree tacit in nature. Constituent elements may not always be verbalized or written in blueprints in a specific technology, hence, sometimes knowledge can not be diffused easily. Therefore, networks are important link providers for the transfer of tacit knowledge. Supplier-buyer links, and bridging institutions are network constituent elements. University-industry, institutes-industry, and industry-industry may be taken as an example to bridging institutions (Jacobsson and Johnson, 1999, pp.7).

c. Institutions: Not only individuals, but also institutions play major role on the course of technical change (Carlsson and Jacobsson, pp.271). Regarding the types of institutions, Jacobsson and Johnson (1999) define two basic institutions as hard and soft institutions. Hard institutions include education, financial, regulative systems. For the soft side of institutions, culture is given as a specific example (pp.7). As networks do, institutions may also demonstrate two opposite effects: They either support technological systems' diversity creation, or diminish the same effect, according to Carlsson and Jacobsson (pp.272).

Jacobsson and Johnson (1999) studied the diffusion issue from the perspective of a technology's transformation process in renewable energy sector. Basically, the obstacles that may block the transformation process were analyzed in terms of types of failures. These were referred as market, network, and institution failures (pp.9).

With respect to market failures, for the aim of creating variety in knowledge base, research and development programs are considered critical for the generation of new knowledge. Policy should stimulate the availability of funding sources to research and development. Furthermore, policy should also improve the linkages in a system for the diffusion of technology (Jacobsson and Johnson, 1999, pp.13).

Regarding the institutional failures, it is highly possible that existing institutional framework may block the development and diffusion of new technology. Specific country-based wind energy experience are given for clarification. Both Sweden and the Netherlands confronted barriers in gathering building permits from the governments. Conversely, the German government conducted a good policy on wind farm plant's building permits, and guided the most appropriate land for wind farm projects (Jacobsson and Johnson 1999, pp.13).

Finally in policy context, formation of prime movers is a necessary process. In relation to technological diffusion process, prime movers conduct four main tasks: Raise awareness, make necessary investments, provide legitimacy, and lastly diffuse the new technology. Prime movers could be in capital goods industry, and be formed either as clusters of small firms, or large firms. There is a need for an environment in which actors are able to find each other to form a network (Jacobsson and Johnson, 1999, pp.16).

Furthermore, broader policy analyses from the perspective of technological system was held by Carlsson and Jacobsson. According to their study, the general purpose of policy should provide the entire system function in orchestrated manner. Moreover, the timing is crucial, and policy should be formed for the early identification of promising technological development fields. In order to avoid from the "myopic" characteristic of policy, it should cover a long-term view, as the learning process may need substantial amount of time, particularly in specific cases (pp.290-291)

As a conclusion to theoretical background, it should be borne in mind that creation of a process or product innovation[10], and diffusion of them throughout local, regional and national applications has not been easy course of development. Emergence of new technological

[10] Edquist et al. (1998) make clear definition regarding the product and process innovations.

system requires long-term supportive effort from several institutional structure, both private-public, and individual-corporate (Jacobsson and Johnson 1999, pp.1-2-4-6-7-8).

4.2. Combining theoretical and empirical approach to diffusion

Some geographical parts of Turkey are promising sites for wind farm development. There are interested parties from both domestic and foreign investors for commercial establishments as wind energy plants. Currently, there are three foreign wind turbine manufacturing companies active in Turkey. [11] In addition, experts from the academic and practical world have stated their views that Turkey is a promising country in wind energy development (Mentes, 2001; Tolun, 2001; Temiz, 2001; Moose, 2001; Ugurel, 2001).

Most of the experts have added their views that Turkey has the capacity for completing the production cycle within the country. There are already some efforts in that direction. A Turkish company builds towers, and exports them to Italy. A company already active in the sector plans to establish turbine wing production facility with technical know-how from a foreign manufacturer (Temiz, 2001; Yalcin, 2001). All these efforts can bring fruitful and long lasting results as long as mass production levels can be reached.

From the perspective of wind energy, another advantage for Turkey is the distribution of the country's natural energy sources, as opposed to the geographical electricity consumption distribution pattern. After thermal energy, Turkey depends strongly on hydropower, and the most numerous and largest hydro power plants are located in the eastern Anatolian part of Turkey. On the other hand, the higher level consumption is found in the western part of the country. This imbalance brings about the establishment of properly working transmission lines. It is unfortunate that lack of investment in the renovation of transmission and distribution lines, compounded by illegal use, have caused an unexpected number of power losses. [12] Therefore, as wind energy is more available in the coastal western part of the country, wind plant investments in these regions will contribute to reducing power losses to acceptable levels.[13]

But, in order to turn the potential into established production capacity, wind energy needs to be supported by an incentive mechanism in Turkey. In this respect, the former Minister of Energy and Natural Resources has declared that The Word Bank and Undersecretariat of Treasury are in the process of preparing appropriate incentive mechanism (TMMOB, 2001).

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[11] These are Nordex, Enercon and De Wind (Johaness, 2001)

[12] Among other developing countries, Turkey's technical capacity is considered to be very high for electricty generation.On the other hand, transmission losses are nearly 3 percent, and distribution losses are on avarage 19 percent (Alexander et.al, 1999, pp.11). That some portion of energy is lost during transmission and distribution is inevitable.

[13] Acceptable level is relative. In the US this level is more than 8 percent, in Japan nearly 4 percent, and in Germany it is 5 percent (Gulbahar and Kilinc, 2000, pp.787)

Investors generally claim to foresee a stable and promising future for their businesses. Hence, giving a purchase price guarantee is mostly requested in order to favour the diffusion of wind technology (Moore, 2001). There are other additional incentives applicable in wind energy sector: Tax incentives, faster investment depreciation techniques, and renewable portfolio standards are among them - the incentive mechanism encompasses large amount of information, therefore, it should be skipped, and it has been preferred to leave the subject to another research.

Additional necessity is to complete the wind atlas of Turkey as immediately as possible. The collaborative work among organizations is expected to be concluded by the end of 2001, but up until now, it has not been completed yet. Completion of the work appears to further attract the investors' attention to the Turkish wind energy market. With respect to recent struggles to create a wind atlas for Turkey, it is necessary to avoid overlapping efforts coming from different organizations, if any. Instead, the collaboration among organizations, either private or public should strongly be supported.

Regarding the necessity of collaboration, the research is obviously done mostly at the universities and research centers. In that respect, the need for efficient university – business relation maintains its significance. The field work should be channelled to industry to the practitioners, and reverse chanelling in the direction is needed as well, to carry the practical experience back to the universities in order to open new research areas. If any barrier exists, efforts by the parties have to be intensified, and raised in this regard, certainly by obtaining the support of regulative authorities. These efforts will eventually bring profound savings in human and financial capital.

Collaboration is needed with local authorities and the local public as well. As wind turbines are large artifacts, their visual and noise effect, and probable other adverse effect on wild life might be points of disturbance from the public standpoint. Collaborating with local authorities, having a good information network, taking into account the views of the public and sharing the benefits with them, are all measures that can certainly help to facilitate the development process.

Denmark's achievement is a good example in that respect. As also can be a good model for Turkey, Danish wind cooperatives are owned by members of the public, and the industry's contribution to lowering the rate of unemployment certainly helps to create an encouraging and supportive environment for wind farms.

Large wind systems have been deemed as more convenient for many reasons. One of them is the cost advantage borne by mass production. Apart from that view, it should be recalled that wind is also an appropriate source of energy for small communities and isolated systems. Bozcaada island on the Ageans coast can be a good example of an isolated system.

Before the establishment of a wind plant in Bozcaada, the inhabitants were supplied electricity solely from diesel generators. After midnight, the power was cut off. To supply electricity all day long, cables underneath the sea were built to transmit electricity from the city of Canakkale. After a 10,2 MW wind plant that was eventually erected now not only covers the island's need, but has also provides electricity to the city of Canakkale since the year 2000 (Gunel, 2000).

Finally, energy sector is supposed to be well regulated, since it is an imperative input to many parts of public and business life. On the other hand, the bureaucracy that comes with regulations should be at a proper level, particularly in terms of the time consumption and pre-approval financial burden required to complete the necessary procedure before submitting the investment project to the related authorities. In other words, the three parties - namely public, state and entrepreneurs – should benefit at equal levels as much as possible.

To reach the targeted levels in installed capacity for wind energy, Turkey apparently needs to compose an institutional structure. [14] As far as the wind energy sector is concerned, the state has a directive role in relation to prospective investors in many respects: By the directive role demanded, they are those summarized below required:

- Specifying conditions of making an investment in Turkey regarding wind energy sector
- Establishing appropriate type of company in the related field
- Determining tax and regulation issues in related fields
- Developing incentives/mechanisms specific to the sector
- Establishing and/or enhancing the role of capital markets, i.e., long and short term financing mechanisms and their availability
- Finding the appropriate site for wind farms
- Disseminating the information related to wind speed measurements
- Feasibility report preparation methodology, and in many other areas

In short, "codified knowledge" is inevitably necessary in order to enhance the efficiency in wind energy development.

[14] A detailed analysis is available in Akbulut (2000) and Akbulut (2001) regarding energy planning and its importance for Turkish case.

Conclusion

Fossil fuels suffice for the needs of several kinds of energy for our world at present, but they are now being consumed at a high rate. Moreover, they are not infinite sources, and they cause some unsustainable damage to the environment.

For the last few decades, therefore, some countries have put research and development effort into new renewable energy sources such as wind power. In this respect, exploitation of wind energy source requires substantial concentration from the countries that wish to utilize clean energy, and do not want to be strategically dependent on fossil fuel producing countries.

At present, Turkey struggles to reach sufficient levels of energy supply, and depends on other countries for certain types of energy like electricity. So as to cope with the increasing demand, electricity is imported from neighboring countries to some extent by causing depletion of already strict foreign exchange reserves. Another equally important issue lies in the country's dependency: As the country is located in a politically "soft" region, therefore, importing electricity from foreign sources may substantially affect the conditions that sometimes may bring instability on the overall energy strategy.

However, the country is very rich in specific types of natural energy sources. Seemingly, these natural and clean energy sources are not exploited sufficiently and properly. Instead, high amount of financial and human resource have been allocated on other sources of energy: Among others, the Turkish state plans to build new hydro dams, the cost of which is estimated to reach to the level of USD 30 billion for the next 10 years. Although hydropower does not pollute as much as fossil fuels do, , inhabitants who are within the construction field are affected substantially. Recently built Birecik dam has covered a large area, and forced inhabitants to leave their agricultural plants. Another negative impact has been observed over the historical monument named as Zeugma, so called the "Second Pompei". The dam water has covered most of the mosaic art.

There are several obstacles in order to have these technologies diffusing wider within national boundaries. Innovation systems approach enables to bring the perspective to put into analytical exercises. Within innovation systems framework, three determinants are found to be highly effective on the diffusion of specific technology. These are defined as; actors and their competence, institutions and networks. Innovation systems approach's findings are also applicable for Turkey's wind energy case. Therefore, as every each of those three items may block or induce the diffusion process, it should be analyzed by energy policy- makers, bearing in mind the fact that energy-policy should not be apart from social and economic policies.

Specifically for Turkey, as financial determinants take proportionally higher role on the decision making practice both for end-users and investors, one of the imperative blocking mechanisms is the cost of energy that is extracted from wind turbines. It is acknowledged that energy from wind has to be subsidized for the time being. However, according to the estimates, as the mass production levels are reached, the cost has been declining and continue to decline. Furthermore, yet the so-called “social cost” has not been added over the estimations. If it is achieved, general perception may change, hence direct the policy makers further towards new renewables.

Besides the issue raised above, Turkish population is widely spread to rural areas. Wind and other renewable sources are very much appropriate for those who need electricity power living in isolated communities. Instead of spending in transmission lines from on-grid electricity sources, making an investment to wind plants, supported by solar power systems will be much beneficial, as these sources do not harm the environment.

Finally, Turkey has to immediately compose a strategic approach, ensuring general public’s rights towards renewables in order to climb to a sustainable developed country level.

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