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# TURKEY'S ENERGY VIEW, CLEAN ENERGY TECHNOLOGIES AND DETERMINATION OF APPROPRIATE ENERGY POLICY

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## Abstract

*In recent years because of increasing energy demand in our country and the rest of the world and supplying this energy demand by fossil fuels like coal, oil and natural gas cause an increase in carbondioxide emission. Increasing carbondioxide amount and other pollutants released from fosil fuel combustion (methane, nitrogen oxides, hydroflorocarbons, sulfurhexaflor and ozone) absorb the rays coming from sun, partially prevent turn-back to atmosphere and cause warming of atmosphere. Besides causing environmental pollution and global climate change, fosil fuels increase the dependence of energy to foreign countries. By the way Turkey should change her direction to renewable energy sources and when evaluating the national fosil fuel resources it becomes inevitable to take necessary precautions to prevent environmantal pollution. Today going along the barrel price of oil's above 105 $, rising price of natural gas and difficulties in it's procurement makes it necessary to take precautions such as evaluating the national sources, using the clean energy Technologies supplying energy effiency, energy economy and versatility of sources. On the other hand dependance of our energy supply to abroad reaches to 73% and while overcoming this disadvantage by using our native energy source, lignite, we should use the technologies to control the $SO_2$ emissions and $CO_2$ release. In this study Turkey's energy statistics and energy demand estimates are investigated. Research results, about the renewable and clean energy potentials of Turkey, are given. Finally according to these potentials, recommended Turkey's energy policies are discussed. As emerging clean technologies, hydrogen energy, biofuel and underground coal gasification processes are demonstrated.*

# TÜRKİYE'NİN ENERJİ BAKIŞ AÇISI, TEMİZ ENERJİ TEKNOLOJİLERİ VE UYGUN ENERJİ POLİTİKASINA KARAR VERME

**Özetçe**

*Son yıllarda ülkemizde ve dünyada artan enerji ihtiyacı ve bu ihtiyacın önemli oranda kömür, petrol ve doğalgaz gibi fosil yakıtlardan sağlanıyor olması karbondioksit salınımın artmasına sebep olmaktadır. Artan karbondioksit ve kullanılan fosil yakıtlardan kaynaklanan diğer kirleticiler, (metan, azot oksitleri, hidroflorokarbonlar ve kükürthekzaflorür, ozon gibi) güneşten gelen ışınları soğurup amosfere geri dönmelerini kısmen engelleyerek atmosferin ısınmasına sebep olmaktadır. Fosil yakıtların çevreye ve küresel iklim değişikliklerine sebep olmasının yanında ülkemizce dış kaynaklı olarak temin edilmesinden dolayı dışa bağımlılığı da arttırmaktadır. Bu durumda temiz enerji üretimine yönelmemiz ve yerli fosil enerji kaynaklarımızı değerlendirirken çevre kirlenmesini önleyici tedbirleri de almamız kaçınılmaz olmaktadır.*

*Günümüz dünyasında petrolün varilinin 105 doların üzerinde seyretmesi, doğalgazın sürekli artan fiyatı ile birlikte temininde zorluklar yaşanmakta olduğundan ülkemiz için yerli enerji kaynaklarının kullanılması, temiz teknolojilere sahip olunması, enerji verimliliği ve tasarrufu ve enerji çeşitliliğinin sağlanması gibi bir dizi tedbirlerin alınması gerekliliği ortaya çıkmaktadır. Diğer taraftan enerjide dışa bağımlılık oranımız %73'e çıkmış durumda iken yerli enerji kaynaklarımıza yönelmeli, bu aşamada da en önemli enerji kaynağımız olan linyit kömürünü değerlendirirken de $SO_2$ salınımı ve $CO_2$ emisyonlarını kontrol altına alabilecek teknolojileri devreye sokmayalıyız. Bu çalışmada Türkiye enerji sektörü istatikleri verilerek 2020 yılı projeksiyonları ve talep tahminleri incelenmiş, yenilebilir enerji teknolojileri ve temiz enerji teknolojilerinin potansiyeli hakkında araştırma sonuçları verilmiştir. Sonuçta Türkiye için önerilen enerji politikaları sıralanmıştır. Son yıllarda ortaya çıkan hidrojen enerjisi, biyoyakıtlar ve kömürün yeraltı gazlaştırma süreci irdelenmiştir. Son yıllarda ortaya çıkan temiz enerji teknolojilerinden hidrojen enerjisi, biyoyakıtlar ve yeraltı gazlaştırma sistemleri tanıtılmıştır.*

***Keywords:*** *Clean energy, biomass, biofuel, renewable energy, coal gasification, hydrogen, energy policy.*
***Anahtar Kelimeler:*** *Temiz enerji, biyokütle, yenilenebilir enerji, biyo yakıt, kömür gazlaştırma, hidrojen, enerji politikası*

## 1. INTRODUCTION

In Turkey and in world energy demand is increasing every year parallel to the developing industry. In order to meet the energy demand the use of fosil fuels increase the carbondioxide release and with the other pollutant gaseous cause a global warming and climate change. In Table 1.1 world energy demand in 2010 and projection of demand estimate is given for the year 2030 [1].

As can be seen from the table although fosil fuel rate decrease from 86% to 83% it keeps it's importance. Because of this it is obvious that carbondioxide release will not decrease in the future. Where as in order to reach the goal of Climate Change Frame Agreement the Developed countries are obliged to supply technology and financial source to developing countries to reduce the emissions of year 2010 under the level of the year 1990 [2].

Current energy trends are patently unsustainable environmentally, economically and socially. Rising $CO_2$ emissions imply inevitable rise in global green house gas concentration and potentially catastrophic climate change. World's energy-related $CO_2$ emission is increasing every year. While in 2007 30 gigatonnes $CO_2$ is emitted, in 2015 it is going to be 32 gigatonnes and in the year 2030, 39 gigatonne [3].

| | 2010 | 2030 |
|---|---|---|
| Total Energy | 11 000 Mtoe | 17 000 Mtoe |
| Oil | %34.6 | %31.8 |
| Coal | %27.6 | %28 |
| Natural Gas | %23.4 | %23.3 |
| Renewables | %8.6 | %10.9 |
| Nuclear | %5.7 | %5.9 |
| Fossil Fuels | %86 | %83 |

Table 1.1. World Energy Demand [1].

World's daily oil demand was 85 million barrel, and it is assumend to be 105 million barrel in the year 2030 [1]. Shortly, at the moment world's electricity, house heating, transportation and other energy consumtion areas is supplied from fosil fuels such as coal, oil and natural gas and this cause an increase in ozone gaseous emission which are mainly carbodioxide, methane, nitrogen oxides hydrofloro carbons and sulfur hexaflor. As a result of this warming of the atmosphere, melting of iceberg of poles, increase in sea level, change of rain regime and finally cause total change of climate occurs. If this trend can not be stopped, catastrophe process will occur in the future that means life in the world will disappear.

## 2. ENERGY SECTOR OF TURKEY

Turkey is one of the countries that best took advantage of the period after the global financial onisis. Growing 9.2% and 8.5% in 2010 and 2011 respectively, Turkey was Europe's fastest growing economy. However due to on going uncertainty and instability in the global markets, the economy of Turkey grew 3.4%,3% and 1.6% in the first three quarters of 2012 respectively. Due to economical growth Turkey's energy demand is increasing every year [4].

In 2005 Turkey's primary Energy Supply is 90.3 MTEP, in 2010 this value is increased to 100 MTEP and by the year 2020 it is assumed to reach to 223.3 MTEP [1,2]. Oil takes the first order in Turkey's energy supply where natural gas, hard coal, lignite and hydraulic proceeds it. In Table 2.1, Turkey's primary energy supply and its distribution percentages according to the sources can be seen.

| Turkey's Energy Supply 2010 : 100 MTEP | |
|---|---|
| Oil | %34 |
| Natural Gas | %28 |
| Hard Coal | %14 |
| Lignite | %13 |
| Hydrolic | %4 |
| Others | %7 |

Table 2.1. Turkey's Primary Energy Supply and Distribution Percentages According to Sources [1].

Due to these datum Turkey's energy supply is dependent to abroad. The abroad dependence value reaches to 73% [5]. In Today's world's barrel price increases to higher than 105$ and natural gas price is increasing continously the necessary precautions that should be taken in to condideration for our country are; evaluation of national energy sources using clean and national technology, sustaining energy efficiency and energy economy and sustaining energy versatility. In Table 2.2 comparison of energy datum per person between Turkey and OECD countries and world mean datum is given. In electricity production coal's share is 94% in Poland, 92% in South Africa, 78% in China, 71% in Kazakhistan, 67% in Chech Republic, 64% in Greece, 51% in USA and Germany. And in Turkey coal's share is 26% in electricity production [6].

| Parameters | Turkey | OECD | World |
|---|---|---|---|
| Energy supply per person (Toe/person-year) | 1.2 | 4.74 | 1.68 |
| Electricity Consumption per person (kWh/yıl) | 1.817 | 8.089 | 2.343 |
| $CO_2$ Emission Based on fuel consumption ($MtCO_2$/y), year 2000 | 204 | 12.450 | 23.395 |
| $CO_2$ Emission Based on fuel consumption per person ($tonCO_2$/person-y) | 3.0 | 11.1 | 3.9 |

Table 2.2. Comparison of Turkey, OECD and World's Energy Consumption and $CO_2$ Emission Datum per person [2].

Besides these necessary precautions waste management, waste evaluation and energy production from waste should be used widespreadly.

## 3. CLEAN ENERGY PRODUCTION:

As Compared to the traditional methods with less waste production, disuse of unrenewable sources or use at a limited rate, production of serice, product and process is called “clean technologies”. Datum related to world’s clean energy sector is given in Table 3.1. Taking into consideration that world oil and natural gas reserves are decreasing it can be understood that coal is the most important source amonay the fosil fuels. Since 1990’s developed countries, firstly USA, the term “Clean Coal Technology” is considered that based on developing high thermal efficiency tecnologies. The huge advantage of hydrogen is that when burnt in an engine or in a fuel cell, there is no pollution, only a small amount of water forms.

| | 2006 | 2016 |
|---|---|---|
| Biofuel Market | 20,5 billion USD | 80,9 billion USD |
| Wind Energy Sector | 17,9 billion USD | 60,8 billion USD |
| Solar Photovoltaic Sector | 15,6 billion USD | 69,3 billion USD |
| Fuel Cell and Hydrogen Market | 1,4 billion USD | 15,6 billion USD |

Table 3.1. World Clean Energy Sector [2].

In this study clean energy production is examined in three cathegories;

1) Hydrogen energy
2) Renewable Energy
3) Fossil Fuel and Clean Coal Technologies

And these topics are examined as respectively belove;

### 3.1. Hydrogen Energy

In the future Hydrogen is defined as the world’s most important energy source. It can be produced by both water decomposition and coal/biomass and waste gasification/decomposition [2]. Hydrogen is not a primary energy

source like coal and gas. It is an energy carrier. Producing hydrogen in the large quantities necessary for the transport and stationary power markets could become a vitally important in 21st century since it is an emission free future based on sustainable energy [7].

In the longer term, renewable energy sources will become the most important source for the production of hydrogen. Fuel cells will be used in a wide range of products, ranging from very small fuel cells in portable devices such as mobile phones and laptops, through mobile applications like cars, delivery vehicles, busses and ships, to heat and power generators in stationary applications in the domestic and industrial sector. In the US and Japan there is strong investment and industrial activity in the hydrogen and fuel-cell [7]. The installed capacity of 10 000 MW is aimed by Japan due to year 2020. The existing hydrogen pipeline network in Europe (some 1100 km) which has served industry for many years, could be developed for initial demonstrations. Liquid hydrogen is also routinely distributed by truck, and existing capacitiy could be readily developed to cope with up to 5% of new vehicles. Hydrogen can be produced by many ways. Electrolysis, reforming, gasification, thermochemical cycles and biological production are the different methods of hydrogen production. All the methods have advantageous and disadvantageous. For Turkey, gasification of native lignite for hydrogen production seems to be the most appropriate method, since the others are commercially more complex and not yet complete large scale production step [7]

### 3.2. Renewable Energy Technologies

Renewable energy production is developing in all over the world. In recent years as an emerging techology renewable energy kinds are as follows;

#### 3.2.1. Biomass

Bio energy is a kind of energy that is produced from living organisms or side products of it. General name of the several biologicel sources that bio energy produced is called biomass. Biomass used is classified into two groups; fuel wood and animal waste. Besides these, organic parts of the municipal

solid wastes is also a source of biomass fuel. And energy obtaine from biomass fuel is called biomass energy. Today world's 14% energy consumption is supplied from biomass. 25% of this is consumed by industrialized countries and 75% of it is consumed by developing countries [8]. And today annual conventional bioenergy consumption is 38 EJ. In the form of processed fuel and electricity like new energy the consumption of world's biomass energy reaches to 7 EJ. Ministry of Energy declared that in 2009. Turkey's primary energy supply is 100 MTEP. And 4.6 MTEP of it is obtained from biomass, those of 76% is wood. Turkey's electricity production is 194 813 GWh and 0.17% of this is obtained from biomass. And this potential can be inereased up to 2%. Biomass Energy potential of bomass in Turkey is 15-19 MTEP/y [2].

### 3.2.2. Biogas

From different biomass resources, especially thermal degradation of wood, biogas is obtained. Widespread known biogas production from the 18$^{th}$ centry is biomethanization process (anaerobic fermantation). Biogas is a flammable gas which contains 60-70% methane, 30% carbondioxide and small arrounts of water, nitrogen, hydrogen, hydrogen sulfur, chlor and ammonia. Many anaerobic fermentation tank reactor was designed, continous, batch reactors one or/and several step processes are known. Many sources are used in biogas production such as wood, fatty seed (rapeseed, sunflower, olieve etc.), sugary plants (sugar beet, sugar cane etc.), carbonhydrate plants (potatoe, wheat etc.) and municipal and industrial wastes. Due to high methane percentage (up to 70%) biogas can be used as an alternative fuel to otto and diesel motors [9]. Turkey's sugar production is in the 5$^{th}$ row in the world. Annually 2,5-3 million ton sugar is produced in Turkey. World's production is 143,5 million ton. 12-14 tons of sugar and 3-4 tons of molasses is obtained from 100 tons of beet sugar. High organic content of sugar waste water have a potential of 730 $m^3$/d biogas, 560 $m^3$/d natural gas and 1700 kWh electricity [10]. It is posible to produce biogas by anaerobic fermentation process from municipal wastes and plant waste. In addition rapeseed plant's seed and straw&stalk can be evaluated in obtaining liquid and gas fuel by using thermal degradation methods [11].

### 3.2.3. Bio fuel/Biodiesel

Biofuel $SO_2$ hydrocarbon emission is lower than fuel-oil. Biofuel consist of 24% water, 23-26% pyroltic lignin, 14% carboxylic acid, 19% aldehyde, 9% sugar, 6% ketons and 4% alcohol. For example production of biodiesel from algae is studied [12]. Algal oils, as well as vegetable oils, are highly viscous, with viscosities ranging 10-20 times those of no.2 diesel fuel. Transesterification of the oil to its comespading fatty ester is the most promising solution to the high viscosity problem. China's biomass share in final energy consumption is 23.5%, Europe this is 3.5% and in North America 2.7%. And bioethanol is an alcohol made by fermenting and distilling simple sugars. Bioethanol is a fuel devised from renewable sources of feedstocks; typically plants, such as wheat, sugar beet, corn, straw and wood. Bioethanol is a petrol addivite/substitute. It is possible that wood, straw and ever household wastes may be economically converted to bioethanol. Bioethanol can be used as a 5 blend with petrol under the EU quality standart EN 228 [12]. This blend requires no engine modification, bioethanol can be used at high levels, for example, E85 (85% bioethanol). Turkey's biofuel potential and sector development is investigated in two groups as motor vehicle biofuel and production and development of advanced biofuel technologies. First commercial biofuel application is started in 2005. Turkey's probable biofuel capacity is 100 million liter/y [2].

### 3.2.4. Wind Energy

In recent years wind energy becomes one of the cheapest renewable energy source. Wind energy economyy depends on the place(wind speed); at 5m/s wind speed electricity cost is 9.6 cent/kWh and at 10m/s wind speed it decreases to 3,4 cent/kWh. Turkey's theoretical wind energy potential is estimated as 160 000 MW and in the year 2025 it is assumed to reach to 15 000 MW plant capacity. Wind generators of 10-100 kW independantt from electricity network, and wind turbines connected to elecricity network are available. 2011 Turkey's plant capacity is assumed to be 1400 MW [2].

### 3.2.5. Solar Energy

Turkey has the solar energy advantage according to many countries due to it's georaphical location. Turkey's annual solar energy amount is 1015 kWh and this is 10 000 times bigger than our energy production. Annual radiation amount is changing between 1400-2000 kWh/$m^2$ [13]. And average direct sunlight time is 7,5 hours. Unlicensed electrical energy production especially with photovoltaic system is becoming popular, because this system can supply stable energy. Turkey's total solar energy potential is 10 000 MW. Prior solar energy Technologies are active heating system, thermal power and photovoltaic system [2].

### 3.2.6. Geothermal Energy

After 1950 Turkey started searching for opportunities of geotermal energy application. Today 24 countries in all over the world can produce electricity from goetermal energy. World's geotermal energy installed capacity is 11000 MW. West, Middle and East Anatolia has the geotermal sources in Turkey [13]. According to the MTA datum Turkey has 170 geotermal field which have more than 40°C fluid temperature . Today Turkey's installed geotermal energy capacity is 20 MW and through $9^{th}$ Developing Plan (2007-2013) this capacity is assumed to be 550 MW. Turkey's economic (useful) electricity capacity is 35 000 MW. Except East Black sea Çoruh Regions important big basins are evaluated at higher rate. In Recent years "Small scale hydroelectric power plants" are getting started and with the planned 534 projects total power plant capacity is going to reach 20 000 MW [2].

### 3.2.7. Hydroelectric Energy

Turkey's annual average rainfall is 643 mm. Which means 500 $km^3$ flow rate. And taking into consideratio the to pographic and geological restrictions total consumable water volume decreases to 107 $km^3$ [13]. According to the DSI (Government Water Sources Department) datum 35% of the existing potential is in use at the moment. End the rest panentra is at the

Project step. The biggest problem of hydro electric energy is drought. In the long-time drought energy crisis is possible. And this disadvantage can be over come by using instegrated energy installation with hydro electric, solar and wind energy together in the same region but on the other hand another advantage of hydroelectrical power stations is that the life time of the hydroelectrical power stations is 50 years where as thermal power stations' life time is 25 years.

### 3.3. Fossil Fuel and Clean Coal Technologies

Today, world's 87 % energy demand is supplied by fossil fuels (coal, oil and natural gas) and the rest is supplied by hydrolic, nuclear and other sources. In Turkey fossil fuel's share in energy supply is 91% in 2011. According to the recent known coal reserves in the world, the lifetime of coal is 240 years, where as oil reserves have 60 years lifetime . For this reason coal is now the most reliable energy source. And also as Turkey's national energy source coal (especially lignite) has an important potential for decreasing the energy dependence to abroad [14]. To overcome the $CO_2$ emissions coming from coal combustion flue gas desulfurization processes can be constructed at 2% of coal combustion units' capital investment. Gasification technology has been known for 150 years, after the year 2000 it began to be an important candidate technology for both electricitiy generation and liquid fuel production. In addition Turkey has 8 billion ton lignite reserve which should be given more importance, Although Turkish lignite have low calorific value and high sulfur this disadvantage can be overcome by using Beypazarı trona reserves that can be used as a sorbent in desulfurization proceses at lignite using thermal power plants [15].

In 2010 there are 447 gasifiers in 140 gasifier plants which have a 55 000 MWth production capacity. And 49% of coal, 36% pet-coke and 15% biomass and waste is 27% electricity, 37% chemicals and 36% liquid and gas fuels [1]. Gasification is a process which carbonmonoxide, hydrogen and methane is produced from carboneceous materials. Mechanism of liquid, solid fuels and chemicals obtained from gasification of carbonaceous materials is shown in the below [14].

Carboneceous Materials+$O_3$(or steam)(limited) $\longrightarrow$ $CO_2$+CO+$H_2O$+$H_2$+$CH_4$

(Coal, petroleum residues, petcoke, biomass, Industrial wastes) HCN, $NH_3$, HCl, $H_2S$, $SO_2$ Tar+Char+Dust

Gasification of coal processes has the highest efficiency in electricity generation. The most important clean energy process is Integrated Gasification of Combined Coal (IGCC) Technology. Besides obtaining gas and liquid fuels, methanol and ammonia are produced by coal gasification. In recent years coal gasification is applied in coal mines as underground gasification which have relatively low production costs.

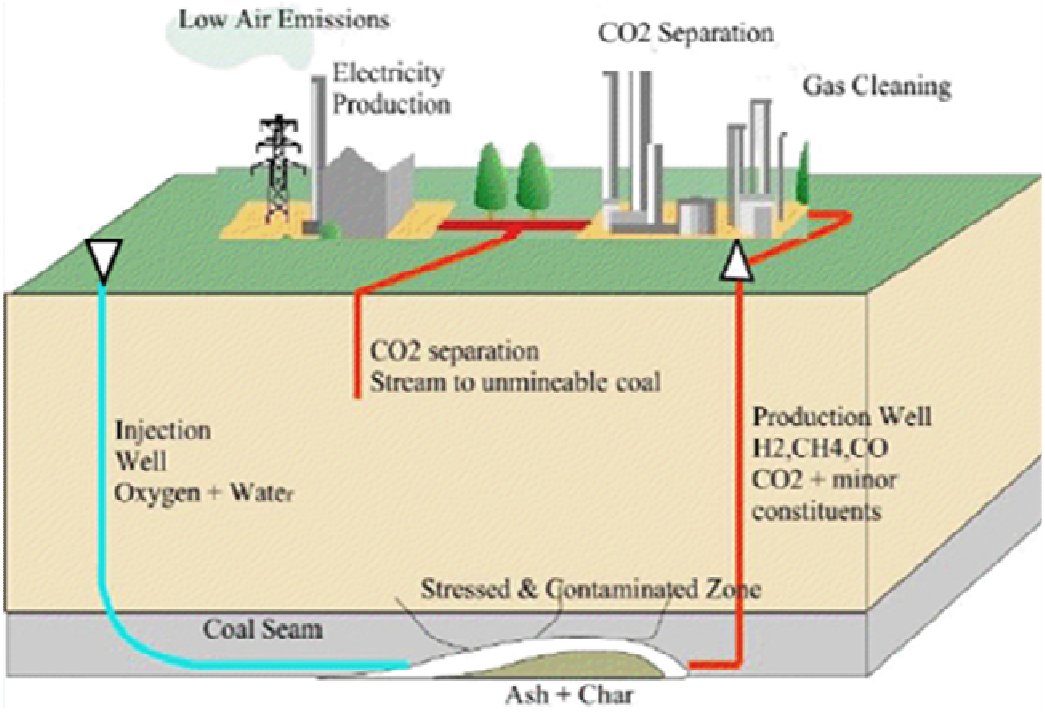


Figure 3.1. Schematic demonstration of underground coal gasification process [1].

The process of generating a combustible gas from coal is called "coal gasification". The first technology which exists commercially, gasifies coal in surface after mining it by conventional technigues. The second potential method for commercial coal gasification is to generate gaseous products from coal in place, that is, In-situ or Under Ground Coal Gasification (UCG). In the figure 3.1 schematic demonstration of underground coal gasification process is shown. During in-situ coal gasification, the coal is ignited injecting a gaseous oxidizing agent through a pore hole drilled into a coal seam [16]. The most critical step in an underground coal gasification operation is the creation of a highly permeable pathway between the injection and production wells. The natural permeability of the coal seam is not sufficient for an efficient UCG process. The enhancement of the natural permeability of the coal seam can be accomplished by five different methods which are known as directional drilling, electrolinking, hydrofracturing, explosives and reverse combustion. Underground coal gasification has some advantages over classical mining follwed by surface gasification. In in-situ gasification process coal seam is utilized as a chemical reactor, so that the chemical investment is much less when compared with surface gasification. The process is carried out underground , ash and waste product remain under the surface. The gas product can be used as both gas energy and chemical synthesis gas. Since the gas product contains 11 % $H_2$ and 3 % methane with the calorific value of 5 $MJ/m^3$. And 20 kg of gas is obtained from 7 kg coal at the 900-1100 $^0C$ reaction temperature [16]. This gas product can be used as an alternative to natural gas (syngas : CO, $H_2$ and $CH_4$). And also $CO_2$ can be captured by this system at the $CO_2$ separation unit.

Liquefaction of coal is another way to produce fuel from coal. Indirect coal liquefaction, coal is extracted by solvent under high pressure and high temperature. This process is higly efficient but result product is refined. In indirect coal liquefaction, coal is firstly gasified and "syngas" is produced (mixture of $H_2$ and CO). Then the gas is desulfrized and mixture is adjusted according to the desired product. Syngas (synthetic gas) is condensed on a catalyzer and by Ficher-tropch synthesis and high quality alternavite liquid fuels as clean diesel, methanol and dimetlyether. In South Africa (Sasol Process) the 40% of oil demand is supplied by coal liquefaction method. And

in China 10 billion US dollars is invested for 10 million ton/year liquid fuel production capacity plant is going to be finished in 2014 [14].

## 4. RESULTS AND EVALUATION:

Our world is coming across to a catastroph because of global warming. For this reason limiting the fossil fuel use and carbondioxide capturing systems (UCG) are to be developed in the near future. In Turkey while preventing the environmental problems inorder to stop the dependance of energy to abroad these necessary energy policies are recommended;

1. The most important tool for Turkey's policy against global warming prevention is energy efficiency and energy saving. By energy efficiency acts in industry and domestical use it is possible to save 10% of energy totally.

2. In OECD countries coal using thermal power plants' efficiency is increased from 38% to 45% by converting the conventional combustion systems to pressurized fluidized bed systems. By this way emissions from coal combustion and elecricity production price is decreased with the incresed efficiency. And in Turkey the efficiency of thermal power plants using coal is 27%.

3. Turkey urgently start to use national energy source, lignite, which have a 8.3 billion tons reserve, and evaluate the clean energy technologies. In order to overcome the green house effect of this energy source, flue gas desulfurization plants can be constructed to 2% of the combustion plant's capital investment.

4. The native coal's share of Turkey can be increased to 30-40%, in electricity production as in the year 1998. Liquid fuel production from coal provides energy safety and clean energy for electricity production and domestic house heating and prevents the increase of oil prices.

5. Coal gasification technology has 140 plants in all over the

world, and Turkey should rely on gasification processes and increase the number of gasification units. Since by gasification processes both obtaining energy with highest efficiency and producing chemicals such as methanol, ammonia is possible. IGCC (Integrated Gasification of Combined Coal) is the most efficient way to produce gas energy as alternative to natural gas from coal.

6. Very large capital investments are required for a dedicated hydrogen infrastructure, in the order of some hundreds of bilions of euoros in Europe. Hydrogen fuelling stations can be installed, using locally or industrially produced hydrogen.And for Turkey, commercial scale hydrogen production by coal gasification Technologies should be widely used. As in Japan, until 2020, 10 000 MW installed capacity should be aimed.

7. Clean energy sector should become more popular in Turkey. Especially production of hydrogen should be performed widespreadly. Without a cause of environmental pollution the most advanced energy species is hydrogen, for this reason hydrogen should be used both in transportation system and in defence industry especially in submarines.

8. Turkey has 170 geotermal field and the share of geothermal energy in electricity generation can be increased to more than 5 000 MW, which is 10% of recent installed plant capacity.

9. Biofuel/biodiesel obtained biomass is going to be evaluated in land and naval vehicles. The percentage of biofuel can be increased to 2% of the total energy need.

10. Wind energy potential is 160 000 MW in Turkey. Especially in Nort-west and North Aegen Regions wind power plants should be used widespreadly.

11. Creating funds for Research and Development activities is going to be stimulated and alternative energy sources ought to be economically competetive.

12. As a result by using our national reserve, lignite, renewable energy sources such as hydrolic, wind, biofuel, solar and geothermal, it is posible to decrease the energy dependancy to abroad from 73% to 30%.

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**Abbreviations**

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|---|---|
| **OECD** | **:** Oil Exporting Countries |
| **MTEP** | **:** Million Ton Equivalent Petroleum |
| **Mt** | **:** Million Ton |
| **IGCC** | **:** Integrated Gasification of Combined Coal |
| **$MtCO_2/y$** | **:** Million ton carbondioxide per year |
| **$CO_2$** | **:** Carbondioxide |
| **CO** | **:** Carbonmonoxide |
| **$H_2O$** | **:** Water |
| **$H_2$** | **:** Hydrogen |
| **$CH_4$** | **:** Methane |
| **HCN** | **:** Hydrogen Cyanur |
| **$NH_3$** | **:** Ammonia |
| **HCl** | **:** Hydrochloric Acid |
| **$H_2S$** | **:** Hydrogen Sulphur |
| **$SO_2$** | **:** Sulphur Dioxide |
| **UCG** | **:** Underground Coal Gasification |
| **IGCC** | **:** Integrated Gasification of Combined Coal |
| **EJ** | **:** Eksajul ($10^{18}$ jul) |