



# Status of Awareness and Readiness of “Carbon Capture and Storage” in TURKEY

**Mücella ERSOY**  
Turkish Coal Enterprises

**Cleaner Electricity Production Forum- Carbon Capture and Storage**  
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# OUTLINE

- Key Drivers for Clean Coal Technologies in Turkey
- Policies and Strategies to reduce CO<sub>2</sub> emissions
- Initiatives on Carbon Capture Storage in Turkey
- Conclusion

# KEY DRIVERS for CCT in TURKEY

- Requirement for developing existing domestic coal resources for **ENERGY SECURITY**
- Commitments for promoting **ENVIRONMENTAL FRIENDLY USAGE** of low quality coal
  - Harmonisation of Turkish Legislation on coal, electricity and environment with EU legislation including Kyoto Protocol
- **COMPETITIVENESS** with the other energy resources, particularly with natural gas

# KEY DRIVERS for CCT- Energy Security

- Dependency of imported energy (2007): 75%

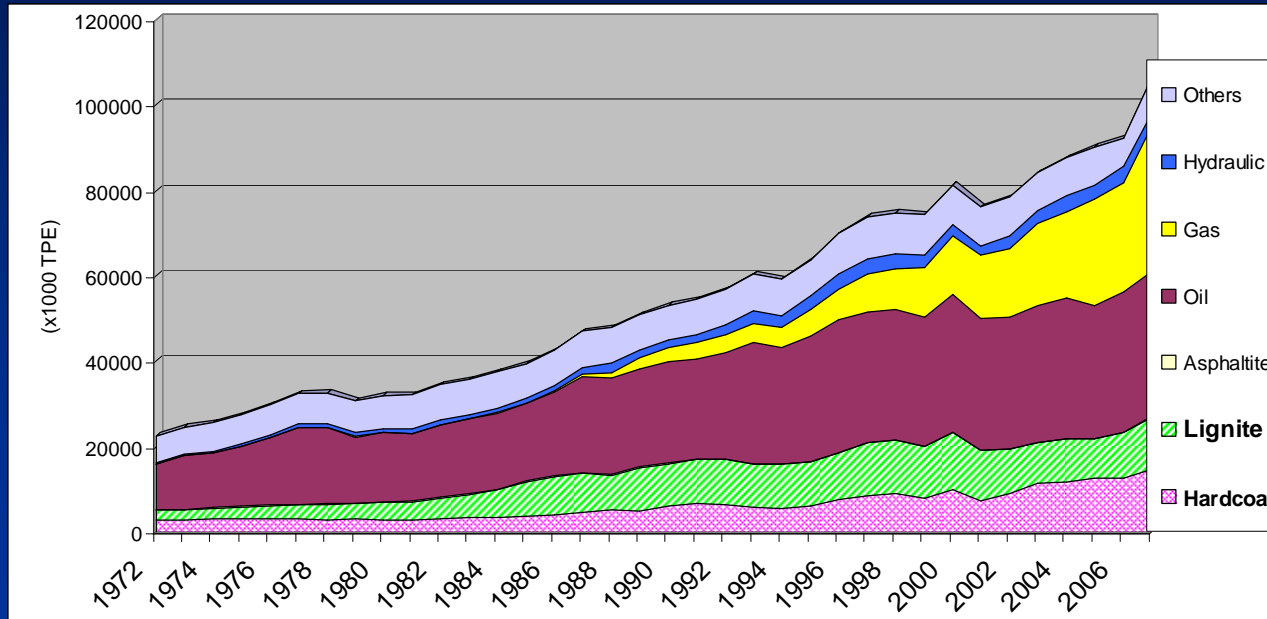
Incase all potentials are taken into account, Domestic resources are not enough to supply increased demand.

**For Energy Security, Coal, particularly lignite is one of the most important domestic energy resources in Turkey**

**Sustainable consumption of coal by CCT is a necessity**

# Role of Coal in ENERGY SECURITY

## - Shares of Coal in Primary Energy Consumption



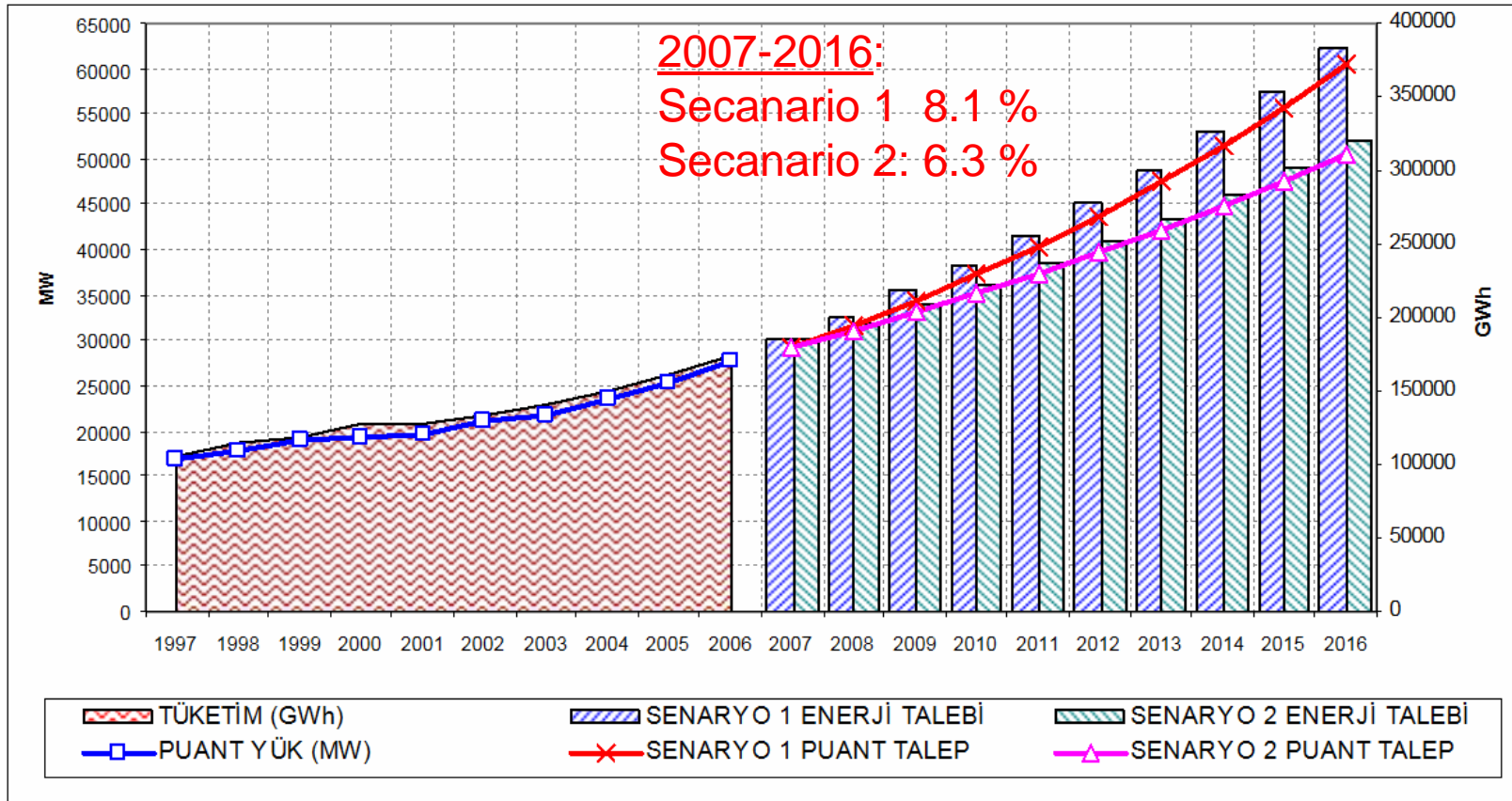
<b>ALL</b>	<b>1972</b>	<b>2007</b>
<b>Domestic:</b>	<b>68%</b>	<b>25%</b>
<b>Imported:</b>	<b>32%</b>	<b>75%</b>

<b>COAL:</b>	<b>1972</b>	<b>2007</b>
<b>Domestic:</b>	<b>25 %</b>	<b>13%</b>
<b>Imported:</b>	<b>0%</b>	<b>13%</b>
<b>Total:</b>	<b>25%</b>	<b>26%</b>

<b>N.GAS</b>	<b>1972</b>	<b>2007</b>
<b>Domestic:</b>	<b>0%</b>	<b>0.8%</b>
<b>Imported:</b>	<b>0%</b>	<b>31%</b>
<b>Total:</b>	<b>0%</b>	<b>31.8%</b>

Source:ETBK

# High Growth of Demand Expected

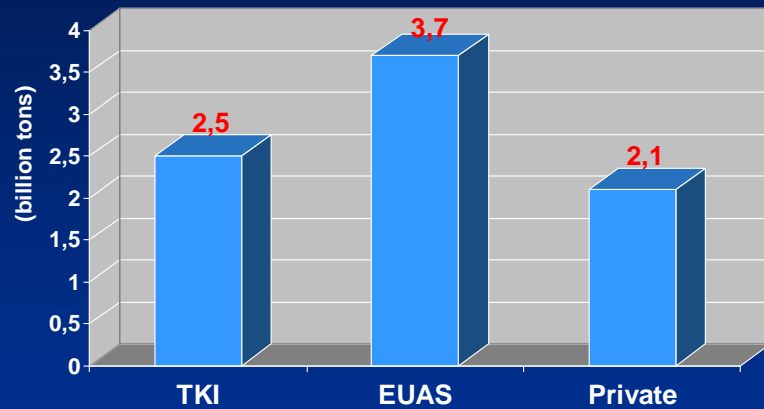


Source: TEIAS, 2007

# Role of Coal in ENERGY SECURITY

## - Coal Reserves

Lignite reserves



### Total Coal Reserves:

- 1,3 billion tonnes hardcoal (all state)
- 8,3 billion tonnes lignite (75% state)

### LIGNITE EXPLORATION PROJECT (2005-2010)

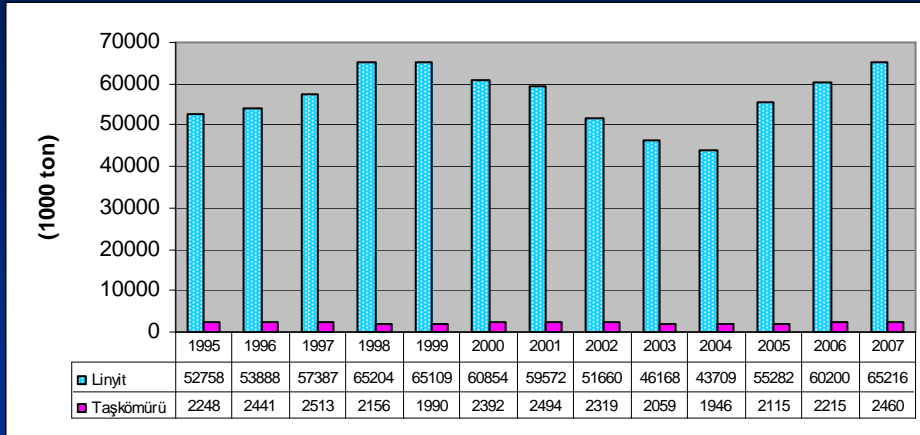
According to unofficial figures: 2.3 billion tonnes additional new resources have been discovered → 10,6 billion tonnes

Base on Proved Coal Reserve and current production level accepted as constant: Coal life is about 100 years

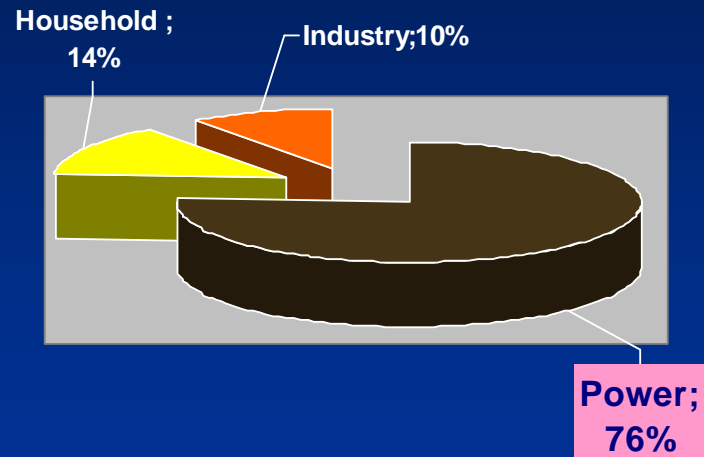
**HOWEVER there is a requirement to increase existing production level BECAUSE OF HIGH GROWTH RATE**

# Role of Coal in ENERGY SECURITY

## - Coal Production & Consumption

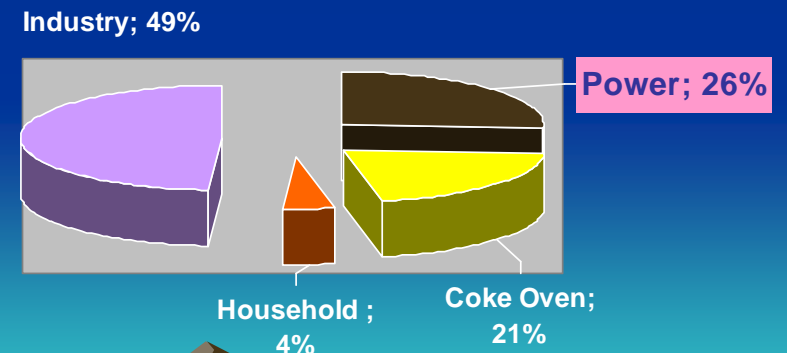


Distribution of Lignite Consumption (65,2 Mt, 2007)



- 2007 World lignite production: 945 million ton (IEA)
- Turkey: 7% of world lignite production
- ~90% of Lignite production state owned (TKİ+EÜAŞ)
- (Shares of private sector within state production by leasing or contract mining 20-25 %)
- 20.5 Mt hard coal imported in 2007.

Distribution of Hard Coal consumption (23 Mt, 2007)



# KEY DRIVERS for CCT

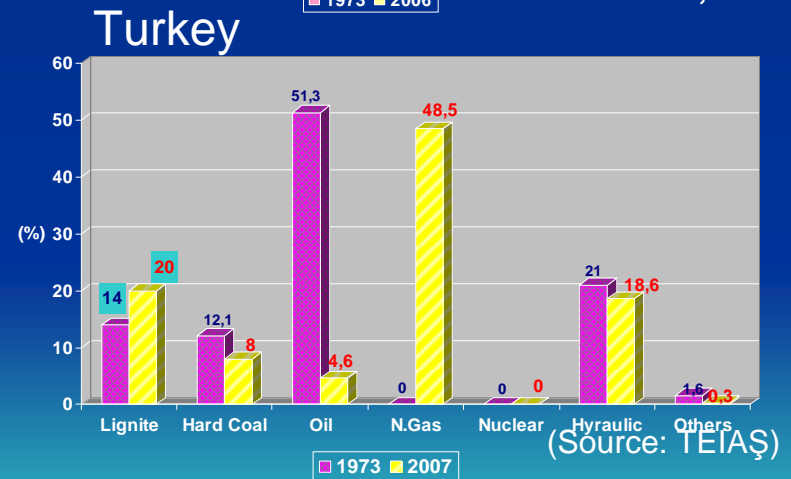
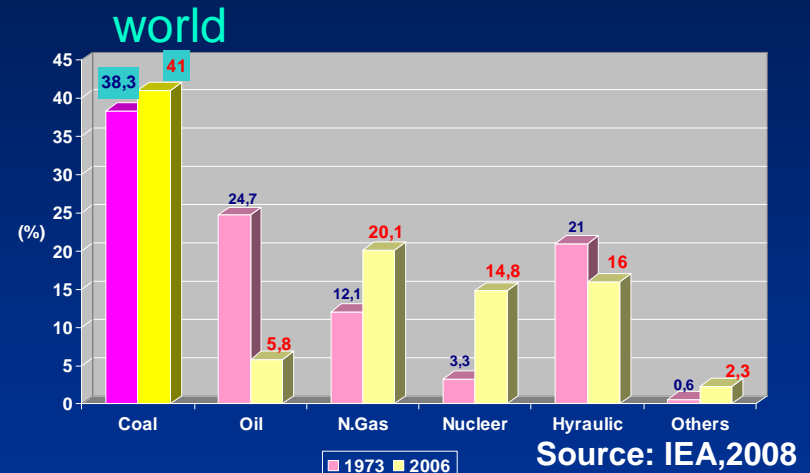


Coal, particularly lignite is very important potential for electricity generation in Turkey.



## COMPETITION OF COAL WITH N.GAS

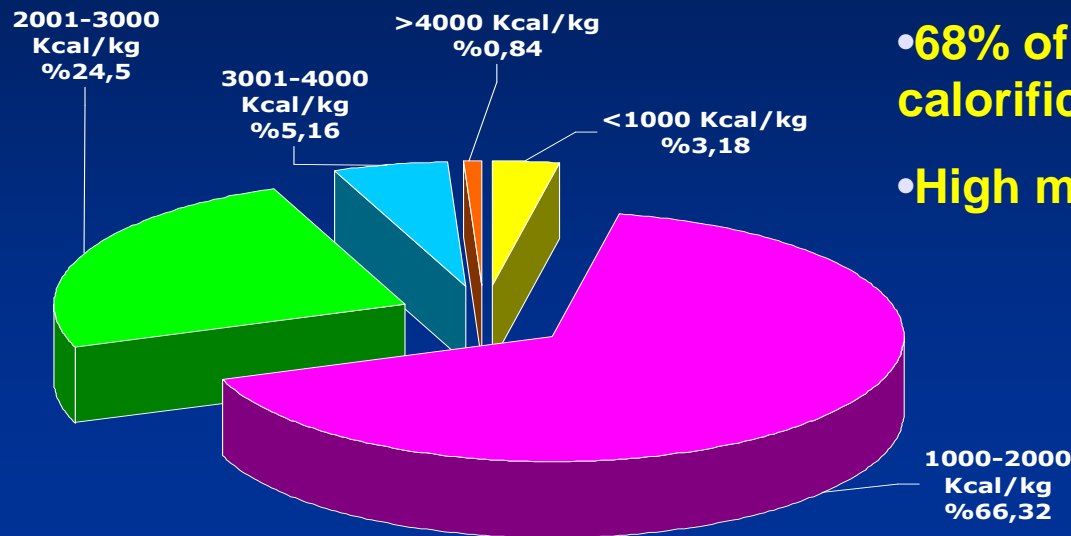
- Share of Domestic Coal in Electricity Generation is very Low (28%) comparing world average(41%).
- Fuel distribution in electricity generation threatens the country's energy security, Natural gas usage has increased to about 50%.



## TURKEY

	1973	1986	2006	2007
Coal (%)	26.1	49	27.7	27,9
N.Gas(%)	0	6	43	48,5

# KEY DRIVERS for CCT- Environment



- 68% of lignite reserves has low calorific value
- High moisture and ash

Turkey has major lignite reserves (10 million tonnes)  
**HOWEVER QUALITY IS VERY LOW.**

**SOLUTION: CLEAN COAL TECHNOLOGIES**

# Studies on CCT in Turkey

- Follow up new developments in the world (IEA-CIAB membership, participating in UNECE energy related activities, etc))
- Development close cooperation with universities, international and national institutes on CCT
- Organization of seminars, workshops, brain storming meetings on CCT
- Increase in capacity of coal washing, packing and briquetting
- Carry out rehabilitation studies on existing power plants
- Initiate to use of clean-coal technologies at its new power plants
- Involvement of R&D studies on CCT by the support of national (TUBITAK) and EU (Framework Programmes) funding
- Carrying out Harmonisation of Turkish Legislation on coal, electricity and environment with EU legislation including Kyoto Protocol
- Studies done to establish energy technology platform

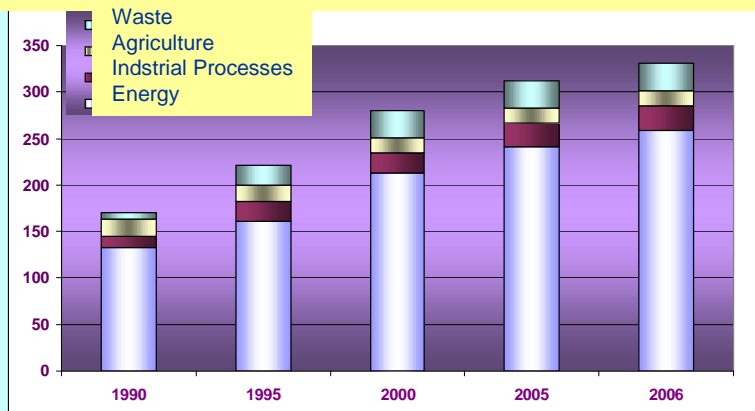
## Comparision of Some Energy Indicators of Turkey with the Other Emerging Economies, OECD and World

	Population (Million)	GDP (billion 2000\$)	GDP PPP (billion 2000\$)	TPES (Mtoe)	Elect.Cons./ pop. (KWh/capita)	CO2 Emission (Mt of CO2)	CO2 /pop (tCO2/capita)	CO2/TPES (tCO2/toe)
<b>Selected East Central and South-East Europe Countries</b>								
Czech Rep.	10,27	72,50	196,69	46,05	6864	120,97	11,78	2,63
Greece	11,15	164,00	259,04	31,12	5372	93,96	8,43	3,02
Hungary	10,07	61,50	160,68	27,59	5883	56,37	5,60	2,04
Poland	38,13	211,60	498,83	97,72	3586	305,96	5,32	3,13
<b>Turkey</b>	<b>72,97</b>	<b>261,20</b>	<b>576,82</b>	<b>94,00</b>	<b>2053</b>	<b>239,74</b>	<b>3,29</b>	<b>2,55</b>
<b>OECD</b>	1178,00	29169,00	31158,00	5537,00	8381	12874,00	10,93	2,32
<b>World</b>	6536,00	37759,00	57564,00	11740,00	2659	28003,00	4,28	2,39

Source:Key World Energy Statistics, IEA, 2008

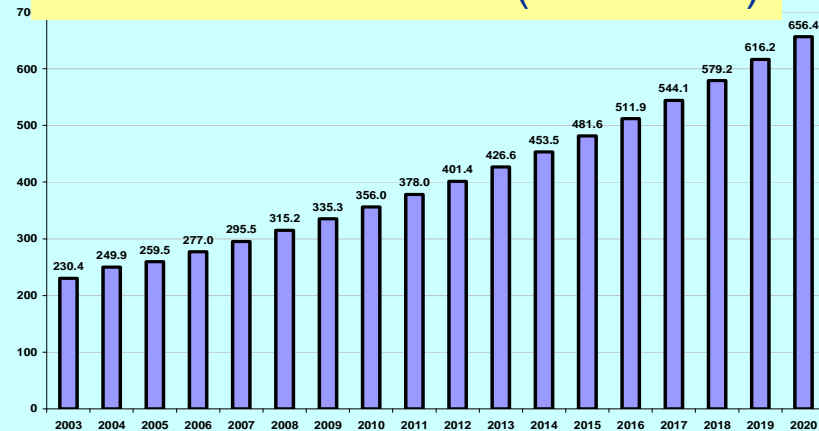
# Turkey Greenhouse Gases Emissions (GHG) Inventory(2006):

Total GHG Emissions Mt CO2 equil.



2003-2020

Total CO2 Emissions (Million ton)

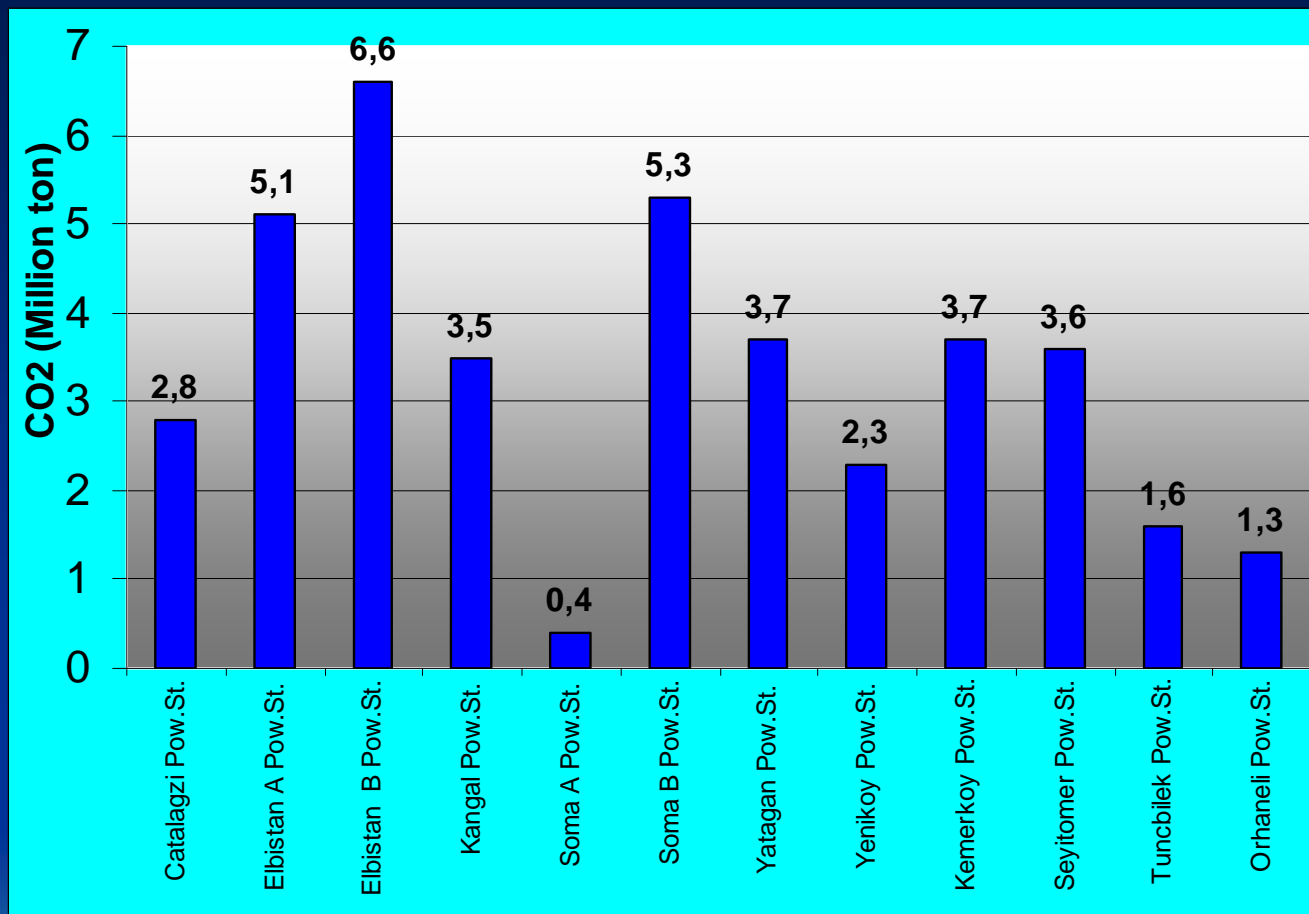


Turkey's Total GHG Emissions: 332 Million ton  
(273 million ton(82%): CO2 emissions)

Source: H.Cetin, ETKB

3.9 CO2 t/capita  
78% GHG emissions  
Energy related sources

## CO2 Emissions of Turkish Coal-Fired Power Stations in 2007\*



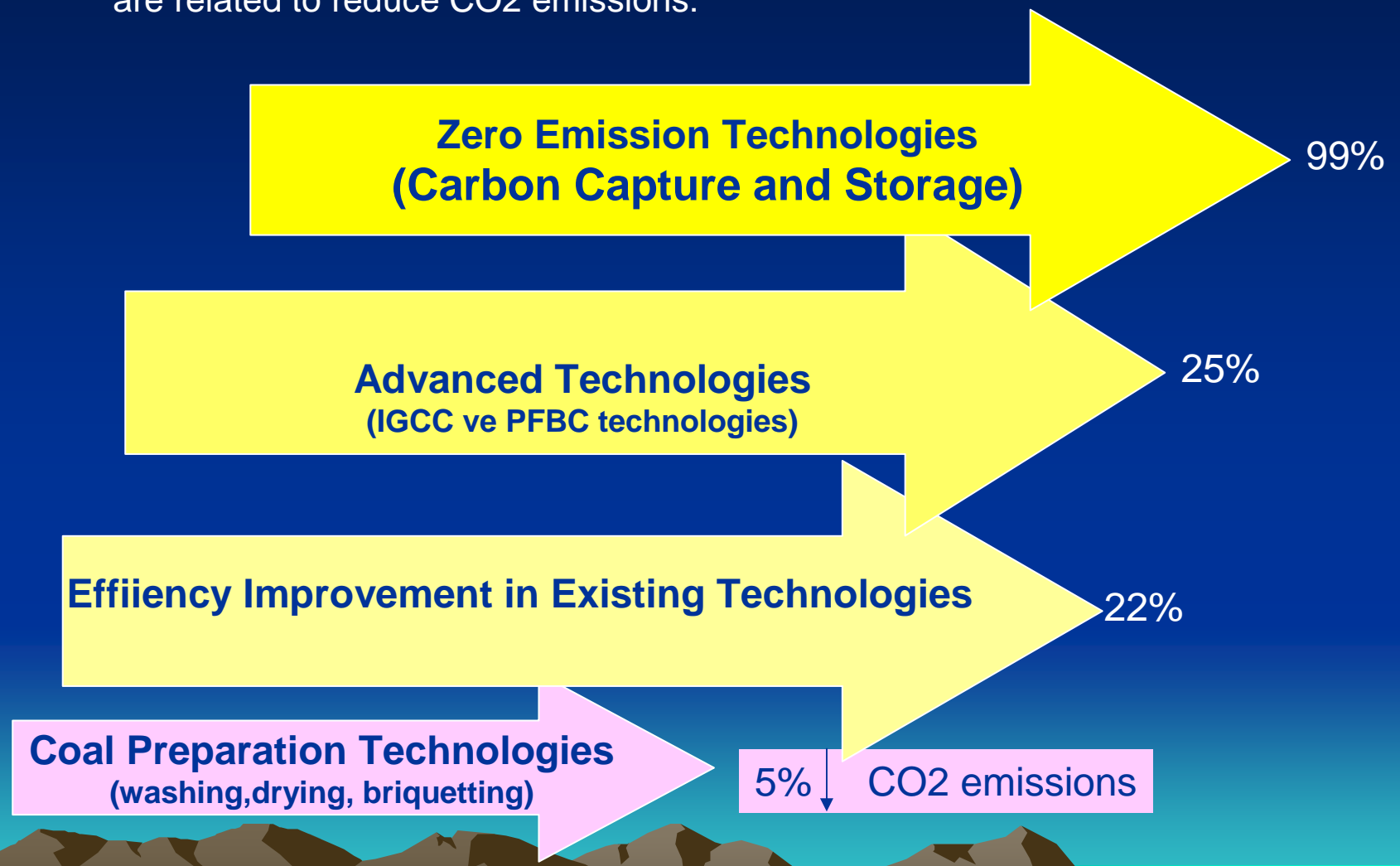
\* Calculated using IPCC Guidelines and EUAS data

# Policies and Strategies to reduce CO2 emissions

- Policies and strategies for Development of R&D studies to reduce CO2 emissions:
  - 5 years Development Plans of Turkey
  - Vision 2023 document
  - Energy Research Program of Ministry of Energy and National Resources
  - Decisions of Science and Technology High Level Board
- United Nations Framework Convention on Climate Change in Turkey (24 May 2004)
  - First National Declaration has been prepared and submitted.  
(studies done on GHG emission Inventory and GHG emission reduction on energy sector by involvement of 20 organizations and >100 academics)
- Signing Kyoto Protocol is under the agenda of Turkish Ministry of Board since June 2008
- Harmonisation of Turkish regulation with EU coal, electricity and environment related regulation is underway.
- To improve energy efficiency (Energy Efficiency law put into effect)
- To increase share of Renewables (renewables laws)
- To install new power plants with high technology

# Technological Solution for reducing CO2 Emissions: Clean Coal Technologies

- Since most of produced coal is consumed for electricity generation; the most CCTs are related to reduce CO2 emissions:



# STATUS of COAL PREPARATION TECHNOLOGIES in TURKEY

	LIGNITE WASHING PLANT NAME	CAPACITY (ton/h)	CAPACITY (ton/year)
1	ISIKLAR DEREKOY	800	4.800.000
2	SOMA-EYNEZ-IMBAT	500	3.000.000
3	SOMA-GURMIN	200	1.200.000
4	SOMA-DENIS	150	900.000
5	SOMA-DARKALE-UYAR	75	450.000
6	SOMA-HUSTAS	150	900.000
7	SOMA-BURUYAR	50	300.000
8	AYDIN-LINYIT	80	480.000
9	AYDIN-SOKE-SEKERLER	20	120.000
10	MUGLA-MILTEN-YENIKOY	50	300.000
11	MUGLA-ORS	200	1.200.000
12	MUGLA-UNSA	220	1.320.000
13	DENIZLI -KALE	50	300.000
14	KUTAHYA-TUNCBILEK*	700	4.200.000
15	KUTAHYA-OMERLER*	600	3.600.000
16	KUTAHYA-SEYITOMER-PARK	350	2.100.000
17	BURSA-ORHANELI-IVME	150	900.000
18	ANKARA-CAYIRHAN-PARK	600	3.600.000
19	TEKIRDAG-MALKARA	20	120.000
20	YENICELTEK-MERZIFON	150	900.000
21	CORUM-ALPAGUT-CELIKLER	75	450.000
	<b>Toplam</b>	<b>5190</b>	<b>31.140.000</b>

## Lignite washing plants

- Significant increase in lignite washing capacity in last 4 years;

- about 40% of total lignite production capacity is being washed.

(TKI's washing capacity (together with its contractors is 24 million tons/year)

## Hard Coal Washing Plants

Capacity (50-750 t/h) 12 plants to wash all produced hardcoal.

# STATUS of COAL PREPARATION TECHNOLOGIES in TURKEY

- **Some ongoing Projects**
  - Simulation aided design of new washing plants (TKI, Hacettepe University(HU))
  - Optical separation (TKI, HU)
  - Coal preparation by shaking table, multi gravite separator and flotation methods (Scientific and Technological Research Council of Turkey(TUBITAK), General Directorate of Mineral Research Exploration (MTA), TKI)
  - Improvement of TKI's laboratories (Gazi University (GU), Middle East Technical University(METU))
  - Reduction of SO<sub>2</sub> emissions by washing lignite in a suitable solution and Briquetting (TKI, GU).

# STATUS of EFFICIENCY IMPROVEMENT in EXISTING TECHNOLOGIES in TURKEY

## EXISTING COAL-FIRED POWER PLANTS

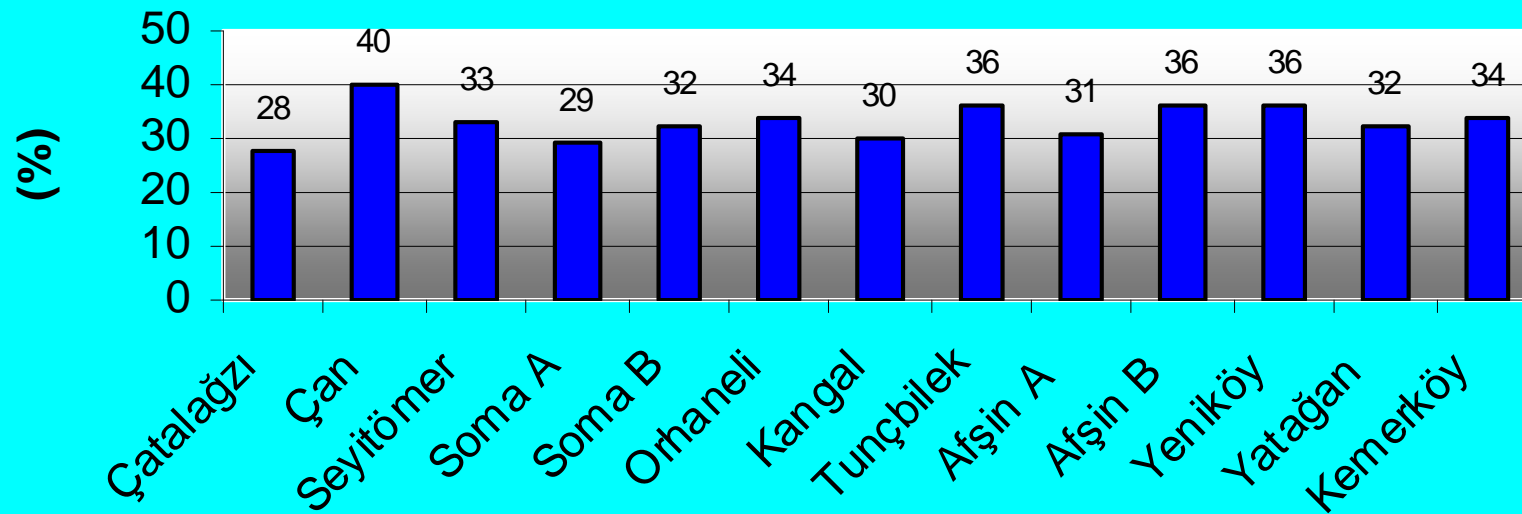
Feeding	Source	Installed Capacity (MW)	Technology	Owner	Status
Lignite	Domestic	7839	Conventional	State	in operation
Lignite	Domestic	320	FBC	State	in operation
<b>Total lignite</b>		<b>8159</b>			
Hard Coal	Domestic	300	Conventional	State	in operation
Hard Coal	Imported	1320	Conventional	Private Sector	in operation
<b>Total hard coal</b>		<b>1620</b>			
<b>Total "in operation"</b>		<b>9779</b>			

Requirement for improvement of efficiency and reduction of emissions in the existing power plants which mainly have pulverized burning technology

use of high technology for the new power plants

# STATUS of EFFICIENCY IMPROVEMENT in EXISTING TECHNOLOGIES in TURKEY

## Thermal Efficiencies of Turkish Coal-Fired Power Stations in 2007\*



\* EUAS Power stations

- rehabilitation studies at some power plants are being carried out by EUAS
- \*installation of Çan power plant with FBC tech. (42% efficiency)

Source: EÜAŞ

# STATUS of EFFICIENCY IMPROVEMENT in EXISTING TECHNOLOGIES in TURKEY

**SOX Control Tekn.**

**FGD Plants** (Çayırhan I-II, Kemerköy, Orhaneli, Yatağan Yeniköy)

After 1986 FGD plant is compulsory (Kangal III, Çayırhan III-IV, Elbistan B)

**Particulate Matter**

**ESP** –all existing power plants

**CO<sub>2</sub> ↓**

High efficiency technology

**-Atmospheric Fluidized Bed Combustion**

**-Çan 18 Mart Power Plant (42%)**

**Harmonisation of Turkish environmental legislation with EU legislation is underway. Costly and lengthy process.**

# INITIAL STAGE PROJECTS RELATED WITH CCS

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# INITIATIVES on CCS TECHNOLOGIES in TURKEY

- **3 Linked Projects**

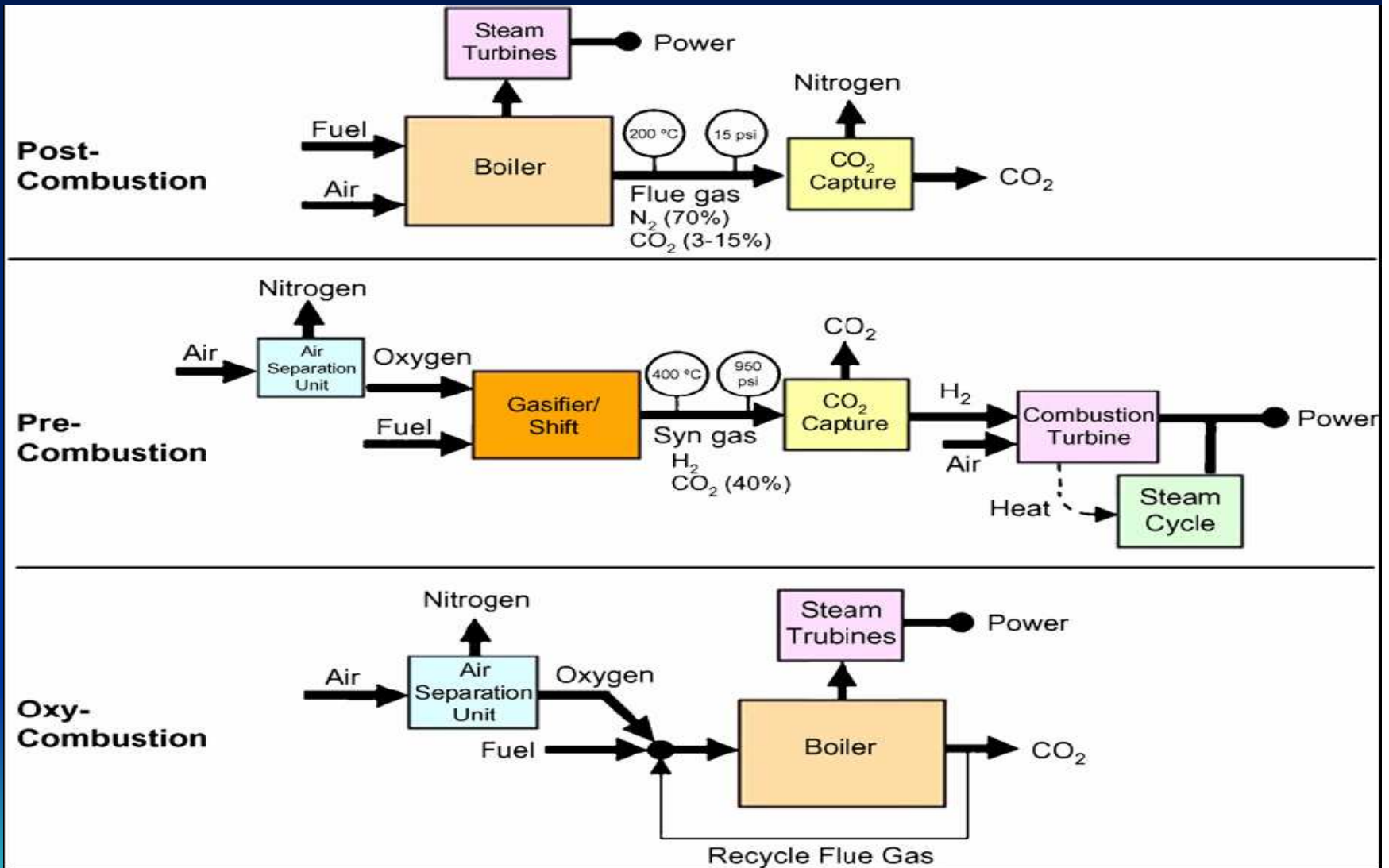
- **Lignite Expolaration Project (2005-2010)**

- Exploration studies in 20 regions including Soma Area.

- **CBM Project** (Determination of Coal Distribution by Integrated Seismic Methods and the Investigation of Coal Gas Potential in Tertiary Soma Basin)

- **SOMALOX Project- Retrofitting a pulverized lignite power plant for oxy-fuel combustion for FP7 ENERGY 2008-2**

# INITIATIVES on CCS TECHNOLOGIES in TURKEY



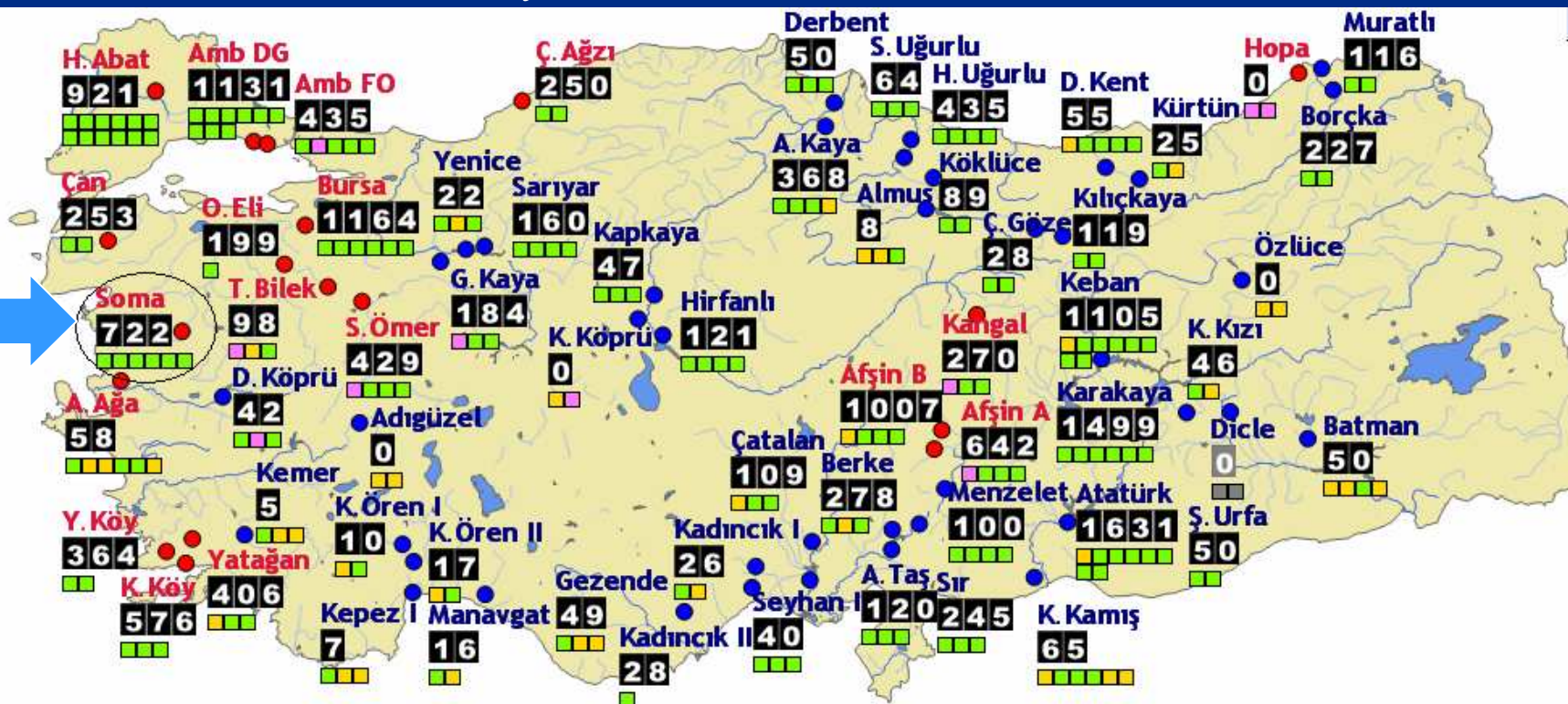
## Pre-combustion

- Pilot-scaled lignite gasification projects initiated in cooperation with TKI, Institutes and Universities including
  - assessment of possibility of CO<sub>2</sub> capture and
  - Assessment of usage of syngas for power generation with IGCC technologies as well as producing liquid fuel, H<sub>2</sub>, chemicals.

# INITIATIVES on CCS TECHNOLOGIES in TURKEY

SOMALOX Project (10 countries, 17 partners (5 of them from Turkey))

- **Retrofitting a pulverized lignite power plant for oxy-fuel combustion for FP7 ENERGY 2008-2**
- A proposal for FP7 ENERGY TREN 2008 to demonstrate retrofitting the SOMA A pulverized lignite power plant (22 MW) to oxy-fuel combustion has been submitted to EC by 8 th October 2008.



# INITIATIVES on CCS TECHNOLOGIES in TURKEY

## Objectives of the project:

- Demonstrate efficient burning of lignite in oxygen-CO<sub>2</sub> gas mixtures
- Demonstrate efficient and cost effective retrofitting of a pulverised lignite thermal plant to oxy-fuel burning



**Demonstrate efficient CO<sub>2</sub> capture possibilities for the retrofitted plant**



**Demonstrate the potential of CO<sub>2</sub> storage (in situ underground, ex-situ, for EOR and enhanced coal bed methane recovery) in the power plant vicinity**

- Demonstrate the scalability potential of the retrofitting to oxy-fuel burning for larger power thermal plants
- Demonstrate the global economic and environmental feasibility of the retrofitting

# INITIATIVES on CCS TECHNOLOGIES in TURKEY

## Expected output and Result:

- Improvement of the plant efficiency resulting in a significant increase in energy production per unit of consumed lignite
- Reduction of emissions, particularly NO<sub>x</sub> emission from the Soma A-Power Plant and improvement of the living conditions of the inhabitants in the surrounding cities.
- Demonstrating the oxy-fuel combustion technology in a small scale power plant (22 MW) and establishing the scaling up potential of the technology
- **Demonstrate the CO<sub>2</sub> capture potential of the retrofitted plant**

# CBM Project-

to determine potential suitable underground stratas for  
CO2 storage

**Project Title:** Determination of Coal Distribution by Integrated Seismic Methods and the Investigation of Coal Gas Potential in Tertiary Soma Basin

## Project Management:

- Customer Organisation: Turkish Coal Enterprises (TKI)
- Project Manager: The Scientific and Technological Research Council of Turkey (TUBITAK) –Marmara Research Center (TUBITAK-MAM)

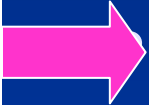
**Project Partners:** Turkish Petroleum Company (TPAO),  
Universities

# CBM Project-

to investigate for determination of suitable underground stratas for CO2 storage

## Outcomes of the Project:

- is to produce clean energy (gas) from low quality lignite (high sulphur content),
- is to decrease in possibility of mine gas (methane) explosion at the underground mines depending on methane production
- is to obtain required energy for drying lignite before briquetting lignite for TKI

 **is to investigate for determination of suitable underground stratas for CO2 storage (will be linked with SOMALOX Project)**

- is to decrease number of heavy drilling activities for lignite exploration by regularly usage of seismic technic
- efficient usage of domestic resources
- distribution of obtained results to the similar lignite regions

- **ON-GOING PROJECT on INVESTIGATION of CO2 STORAGE at U/G GEOLOGICAL STRATAS**

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# PROJECT on INVESTIGATION of CO<sub>2</sub> STORAGE at U/G GEOLOGICAL STRATAS

Project Owner: Ministry of Energy and National Resources of Turkey

Project Management: METU-Petroleum Research Laboratory-(PAL), Turkish Petroleum Company(TPAO),

Other partners:EUAS and Ministry of Environment and Forestry of Turkey

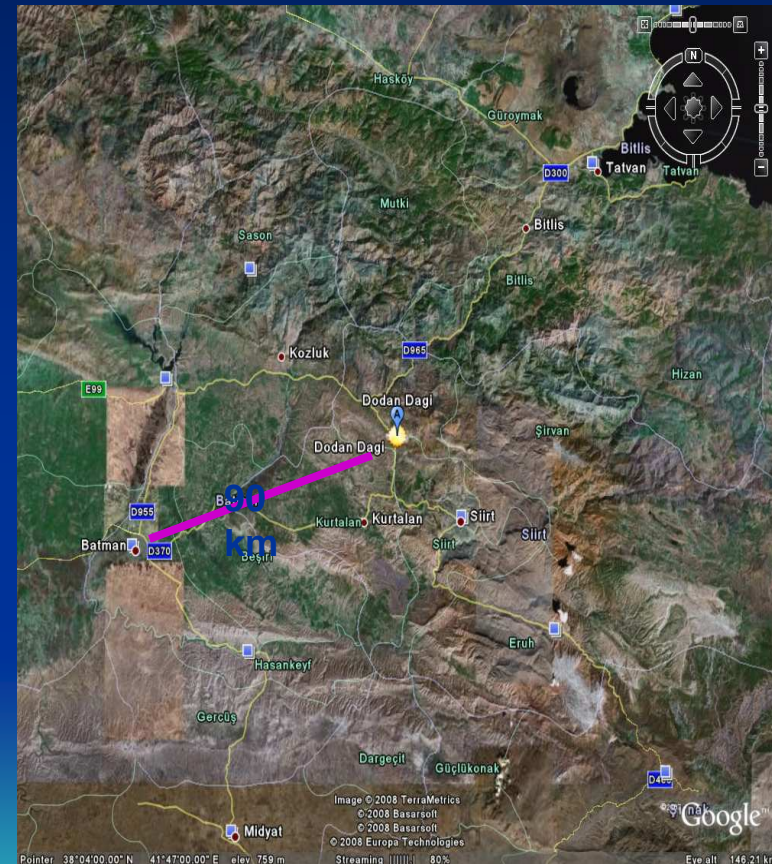
## **Objective of the Project:**

- Investigation of CO<sub>2</sub> emissions at the selected industrial plants,
- Determination of geological storage capacities in the light of obtained information
- determination of additional oil production amount and CO<sub>2</sub> storage capacity in case of EOR
- Investigtaiion of applicability of the project

Source: Ender Okandan, Gasification Workshop, Nov 2008

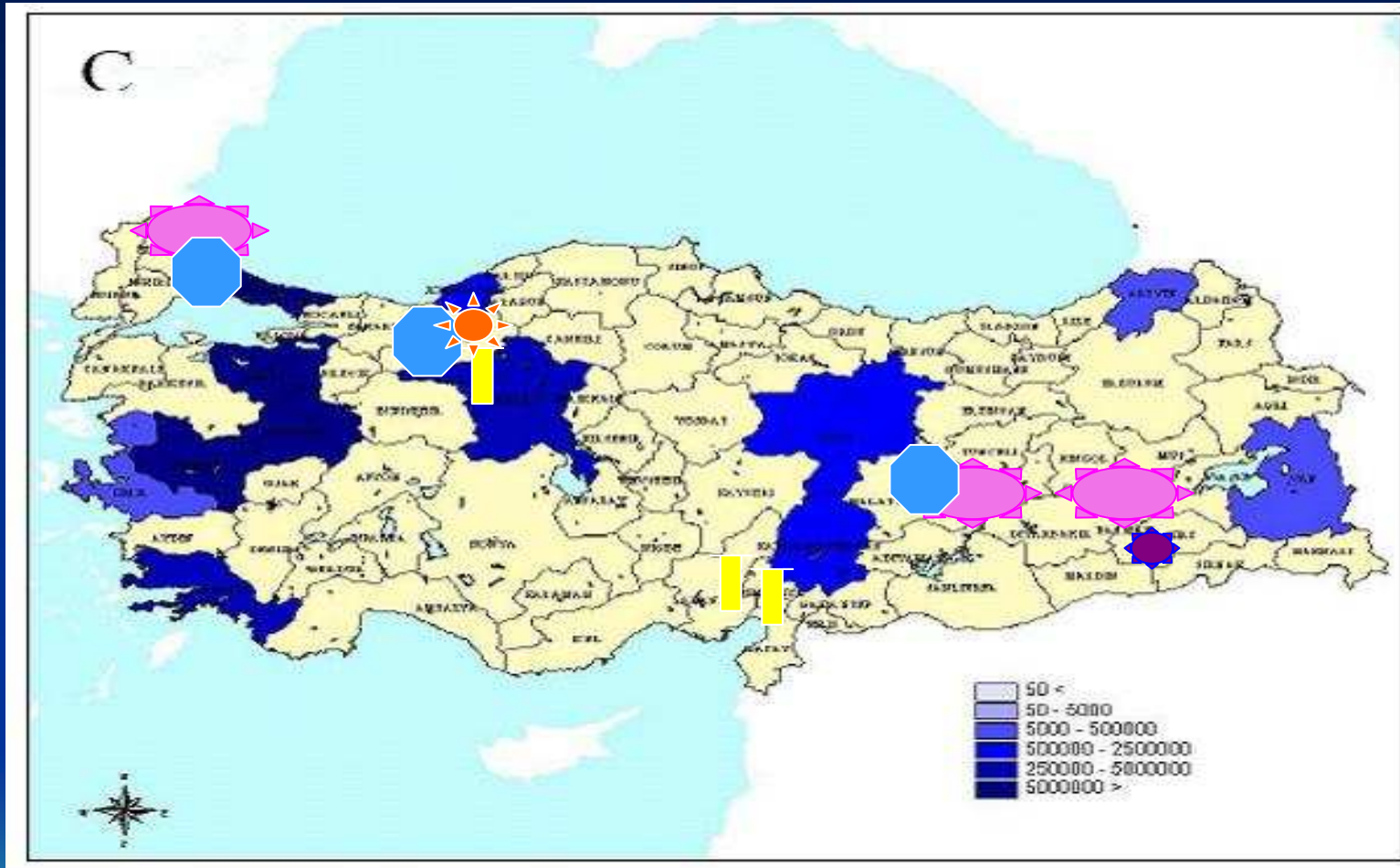
# Current status EOR- TPAO Research & Exploration Activities

- TPAO, Turkey has 25 years experience on EOR,
- CO<sub>2</sub> produced from Dodan field is injected to West Raman Field and oil recovery enhanced.
- Similar applications are done at the West Kozluca and Çamurlu Oil Fields.



Source: TPAO and Okandan, 2008

## Regional Distribution of CO<sub>2</sub> emissions(2005) and Potential Geological Storage Areas



Source: Ender Okandan, Gasification Workshop, Nov 2008



Oil and Gas  
Fields



Deep  
Aquifers



Soda  
caves



Dodan CO<sub>2</sub>  
field



Hard  
Coal

# PROJECT on INVESTIGATION of CO<sub>2</sub> STORAGE at U/G GEOLOGICAL STRATAS

- It is decided to investigate CO<sub>2</sub> emissions originated from thermal power plants and the closest oil fields for storing them
- Elbistan Power plants have the highest Co<sub>2</sub> emissions and most of oil fields are located at the same region, South –East Anatolia Region.
- Possible storage areas in this region:
  - Oil field which has less production life,
  - Dodan CO<sub>2</sub> field
  - Deep Aquifers

Source: Ender Okandan, Gasification Workshop, Nov 2008

# PROJECT on INVESTIGATION of CO<sub>2</sub> STORAGE at U/G GEOLOGICAL STRATAS

- Caylarbasi field has been selected
- Geological and geophysical studies have been completed
- Modelling studies have been initiated. Geological modelling of the field has been done.
- Project shows that there exist potential geological CO<sub>2</sub> storage, net figures on capacity require detailed studies.



Source: Ender Okandan, Gasification Workshop, Nov 2008

## CONCLUSION

- Increasing of energy demand and dependency to foreign energy resources are the main issues of Turkey.
- Coal is the the most important energy resource in Turkey,
- usage of domestic coal, particularly for electricity generation, have to be increased
- however its quality is quite low, requires promotion of more efficient, clean coal technologies
- CCS studies is very initial stage in Turkey. However awareness is increasing by the time.
- More importance are given to R&D Projects in cooperation with national and international Research Institutions and Universities,
  - Framework programme, Turkey Research Area, DPT funds are important tools

