COAL AND COAL BED METHANE STUDIES IN TURKEY

Hasan Hüseyin ERDOĞAN

Head of Department
Presidency of Strategic Development
Ministry of Energy and Natural Resources
TURKEY

October 22, 2015  Geneva
OUTLINE

• Introduction
• Structure of the Turkish Coal Sector
• Coal Potential
• Production & Consumption
• Coal in Electricity Generation
• Major CBM developments in Coal Sector
OUTLINE

• Introduction
• Structure of the Turkish Coal Sector
• Coal Potential
• Production & Consumption
• Coal in Electricity Generation
• Major CBM developments in Coal Sector
Coal;
• supplying 30% of global primary energy needs
• generating 41% of the world's electricity
• Providing more than 7 million jobs and
• investing in developing countries (>US$7 billion in 2010)

plays a significant role as an energy source and in sustainable development,

According to the IEA scenarios, coal will continue to be a dominant resource in the future (overtake oil in the Current Policy Scenario)
The Republic of TURKEY

TPES by sources (Projection)

The same can be said also for Turkey
OUTLINE

• Introduction

• Structure of the Turkish Coal Sector

• Coal Potential

• Production & Consumption

• Coal in Electricity Generation

• Major CBM developments in Coal Sector
State-owned companies operating in the sector:
- TTK Turkish Hard Coal Enterprise
- TKI Turkish Coal Enterprises
- EUAS Electricity Generation Company
- MTA Mineral Research and Exploration Company

TTK was the only company dealing with hard coal production till 2004 but a royalty system was put into practice to increase production. Currently some of the hard coal production in the area is done by private sector.

TKİ produces about half of all lignite production (app, 49% in 2012)

EUAS produces lignite for its power plants (app, 462 in 2012)

MTA carry on exploration studies

Private companies produce around 9% of total lignite production and currently around 35% of total hard coal production.
OUTLINE

• Introduction
• Structure of the Turkish Coal Sector
• Coal Potential
• Production & Consumption
• Coal in Electricity Generation
• Major CBM developments in Coal Sector
• Coal potential has been studied in addition to the existing reserves especially for lignite,

• By exploration studies starting from the year 2005 additional lignite reserves have been found through the country,

• By the addition of these reserves, total lignite reserve reaches to 14.7 billion tonnes,
LIGNITE - HARD COAL FIELDS and RESERVES of TURKEY

LIGNITE RESERVES (Before 2005): 8,3 billion tons
NEW EXPLORED FIELDS and ADDED RESERVES by MTA (Between 2005 - 2014) : 6,93 billion tons

- MTA Pirahmet Field 100 million tons
- EÜAŞ Çerkezköy Field 495 million tons
- MTA Amasya Field 4.2 million tons
- EÜAŞ Elbistan license 515 million tons
- EÜAŞ Afşinlicense 1.3 billion tons
- MTA Eskişehir Field 1.453 million tons
- MTA Konya-Ilıç Field 30.5 million tons
- MTA Aydon-Dinar Field 941 million tons
- MTA Malatya Field 17 million tons
- EÜAŞ Karapınar Field 1.832 billion tons
- TKI Soma Field 205 million tons

EXPLANATIONS
- Lignite and sub bituminous coal
- Hard Coal
- Uranium
- Thorium
- Bituminous shale
- Asphalite
- Coal-Fired Power Plant
- Lignite fields, suitable for new power plants

The Republic of TURKEY
### Lignite Reserves (million Ton)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Possible</td>
<td>28</td>
</tr>
<tr>
<td>Probable</td>
<td>726</td>
</tr>
<tr>
<td>Proven</td>
<td>13,968</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14,723</strong></td>
</tr>
</tbody>
</table>

The calorific value of lignite reserves varies between 1000 kcal/kg and 4200 kcal/kg.

### Hard Coal Reserves (1000 Ton)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Possible</td>
<td>368,447</td>
</tr>
<tr>
<td>Probable</td>
<td>424,955</td>
</tr>
<tr>
<td>Proven</td>
<td>520,114</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,313,516</strong></td>
</tr>
</tbody>
</table>

The calorific value of hard coal reserve varies between 6200 kcal/kg and 7200 kcal/kg.
## Distribution of Lignite Reserves

<table>
<thead>
<tr>
<th>ESTABLISHMENT</th>
<th>PROVEN</th>
<th>PROBABLE</th>
<th>POSSIBLE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>EÜAŞ</td>
<td>7,872,278</td>
<td>133,706</td>
<td>2,964</td>
<td>8,008,948</td>
</tr>
<tr>
<td>TKİ</td>
<td>1,910,759</td>
<td>184,005</td>
<td>25,030</td>
<td>2,119,794</td>
</tr>
<tr>
<td>MTA</td>
<td>1,974,905</td>
<td>408,350</td>
<td></td>
<td>2,383,255</td>
</tr>
<tr>
<td>Private Sector</td>
<td>2,210,552</td>
<td></td>
<td></td>
<td>2,210,552</td>
</tr>
<tr>
<td><strong>TOPLAM</strong></td>
<td><strong>13,968,494</strong></td>
<td><strong>726,061</strong></td>
<td><strong>27,994</strong></td>
<td><strong>14,722,549</strong></td>
</tr>
</tbody>
</table>
The Republic of TURKEY

Rank of Lignite Reserves

- <1499: 0.05%
- 1500-1999: 0.13%
- 2000-2499: 4.96%
- 2500-2999: 3.79%
- 3000-3499: 16.08%
- 3500-3999: 3.58%
- 4000+: 71.41%
OUTLINE

• Introduction
• Structure of the Turkish Coal Sector
• Coal Potential
• Production & Consumption
• Coal in Electricity Generation
• Major developments in Coal Sector
Lignite Production (1000 tonnes)

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>TKI</td>
<td>29,359</td>
<td>31,074</td>
<td>30,526</td>
<td>36,697</td>
<td>32,451</td>
<td>29,713</td>
<td>33,401</td>
<td>33,270</td>
</tr>
<tr>
<td>EUAS</td>
<td>24,844</td>
<td>27,243</td>
<td>34,871</td>
<td>36,658</td>
<td>36,267</td>
<td>32,009</td>
<td>31,102</td>
<td>28,507</td>
</tr>
<tr>
<td>PRIVATE</td>
<td>3,505</td>
<td>3,706</td>
<td>6,724</td>
<td>2,816</td>
<td>6,858</td>
<td>7,976</td>
<td>8,047</td>
<td>6,348</td>
</tr>
<tr>
<td>TOTAL</td>
<td>57,708</td>
<td>62,023</td>
<td>72,121</td>
<td>76,171</td>
<td>75,576</td>
<td>69,698</td>
<td>72,550</td>
<td>68,125</td>
</tr>
</tbody>
</table>

The Republic of TURKEY
Hard Coal Production (1000 tonnes)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TTK</td>
<td>1,665</td>
<td>1,522</td>
<td>1,675</td>
<td>1,586</td>
<td>1,880</td>
<td>1,457</td>
<td>1,612</td>
</tr>
<tr>
<td>PRIVATE</td>
<td>505</td>
<td>796</td>
<td>787</td>
<td>1,043</td>
<td>983</td>
<td>835</td>
<td>916</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,170</td>
<td>2,318</td>
<td>2,462</td>
<td>2,629</td>
<td>2,863</td>
<td>2,292</td>
<td>2,528</td>
</tr>
</tbody>
</table>

The Republic of TURKEY
Lignite consumption by sectors (1000 ton)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Generation</td>
<td>48,319</td>
<td>62,894</td>
<td>55,436</td>
<td>60,271</td>
<td>55,742</td>
</tr>
<tr>
<td>Space Heating</td>
<td>4,807</td>
<td>6,530</td>
<td>5,983</td>
<td>6,976</td>
<td>6,637</td>
</tr>
<tr>
<td>Industry</td>
<td>3,202</td>
<td>6,142</td>
<td>7,753</td>
<td>6,634</td>
<td>5,894</td>
</tr>
<tr>
<td><strong>Gross Consumption</strong></td>
<td>56,571</td>
<td>75,641</td>
<td>69,239</td>
<td>73,933</td>
<td>68,461</td>
</tr>
</tbody>
</table>

The Republic of TURKEY
# Hard Coal consumption by sectors (1000 ton)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Generation</td>
<td>5,259</td>
<td>6,361</td>
<td>7,582</td>
<td>10,116</td>
<td>11,854</td>
</tr>
<tr>
<td>Coke Ovens</td>
<td>4,218</td>
<td>4,900</td>
<td>5,322</td>
<td>5,201</td>
<td>5,392</td>
</tr>
<tr>
<td>Space Heating</td>
<td>935</td>
<td>7,340</td>
<td>7,527</td>
<td>6,773</td>
<td>10,022</td>
</tr>
<tr>
<td>Industry</td>
<td>8,970</td>
<td>4,918</td>
<td>5,090</td>
<td>4,105</td>
<td>4,141</td>
</tr>
<tr>
<td><strong>Gross Consumption</strong></td>
<td><strong>19,421</strong></td>
<td><strong>23,698</strong></td>
<td><strong>25,568</strong></td>
<td><strong>26,228</strong></td>
<td><strong>31,460</strong></td>
</tr>
</tbody>
</table>

![Bar chart showing the consumption of hard coal by sectors from 2005 to 2012](chart.png)
OUTLINE

• Introduction
• Structure of the Turkish Coal Sector
• Coal Potential
• Production & Consumption
• Coal in Electricity Generation
• Major CBM developments in Coal Sector
Installed Capacity by Fuel Type (2000-2013)
Installed Capacity and Generation by Fuel Type in 2013

Installed Capacity (MW) in 2013:
- Natural Gas: 27%
- Coal: 20%
- Oil: 1%
- Multi-Fueled: 12%
- Other Renewables: 5%

Generation (GWh) in 2013:
- Hydro: 25%
- N. Gas: 44%
- Coal: 26%
- Other Renewables: 4%
- Oil: 1%
OUTLINE

• Introduction
• Structure of the Turkish Coal Sector
• Coal Potential
• Production & Consumption
• Coal in Electricity Generation
• Major CBM developments in Coal Sector
The Zonguldak Coal field is situated on the Western Black Sea coastal region of Turkey which is the principal hard coal field. The coalfield is operated by state company of TTK.

The Zonguldak coalfield is characterised by mountanious surface terrain and highly complex geology of the coal measures which are heavily folded, with seam continuity being adversely affected by severe faulting and unconformities.

The coal measures of the Zonguldak coalfield is comprised primarily of sandstones, shales, conglomeratic sandstones, silstones and coals, occurring in a series of rhythmic or cyclic sequences.
There are five deep mines in the field.
Coal seams contain high level of methane gasses in Zonguldak coal field. It is necessary to drain methane during production and to utilize produced methane.
CBM Exploration and Utilization Project-TTK

• Starting from the year 1972, the studies for coal bed methane have been carried out. However, studies were mostly related with safety concerns to be able to get rid of accidents (methane drainage).

• In 1972, METU found that the average methane content was 28.73 m\(^3\)/ton in Kozlu District of Zonguldak Basin.
• The methane drainage system constructed in Kozlu TIM was worked for about 3.5 years but didn’t kept out due to high investment costs.

• Later, Novacorp and Canteck Consultants carried out a series of tests in underground conditions by drilling short holes in 1987 and 1988. The calculated gas content found to be between 5-16 m\(^3\)/ton by standard desorption methods.
CBM Exploration and Utilization Project-TTK

• In 1991, The study carried out by TUBİTAK (The Scientific and Technological Research Council of Turkey) pointed out the existing around 600 bcm of CBM in the region.

• In these early phases, surface drilling activities were done through the mid-1970’s. A total of 431 holes and 305,000 meters were drilled through 1993. The majority of all drilling was completed with rotary drill rigs. Drilling with core rigs didn’t begin until 1987’s and this method offered vast improvements in sample collection and coal seam correlation.

• In 08,03,2005 a contract has been signed by TTK and HEMA Cooperation, By this agreement the region is contracted to the company by 15 years including 2 years exploration studies,

• The studies within the context of the agreement have been carried out by the company in the region, Recently, it is assumeded that there exist around 60 bcm of CBM potential which 10 bcm of it can be recoverable,
In order to explore and produce Coal Bed Methane (CBM), TTK tendered two blocks within its boundaries. At the moment, Hema Natural Energy Resources A.S. has got operational right of Coal Bed Methane in the first area.
The studies within the context of the agreement have been carried out by the company in the region. Recently, it is assumed that there exist around 60 bcm of CBM potential which 10 bcm of it can be recoverable.
CBM Exploration and Utilization Project - TTK
The ability to access and develop well sites in some of the lease areas is hampered by the fact that some of the lease areas are populated, leaving limited area for drilling.

To minimize the drilling footprint, we plan to drill multiple, directional wells from a single pad. This technique will also allow us to access some of the offshore CBM resources.
<table>
<thead>
<tr>
<th>Location</th>
<th>Prospective CBM Area</th>
<th>Gas In Place (Bcm)</th>
<th>Gas In Place (Bcm/km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>hectares</td>
<td>km²</td>
<td>Low</td>
</tr>
<tr>
<td>Armuctuk Core</td>
<td>2,116</td>
<td>21</td>
<td>0.41</td>
</tr>
<tr>
<td>Armuctuk Prospective</td>
<td>3,221</td>
<td>32</td>
<td>0.30</td>
</tr>
<tr>
<td>Amasra Core</td>
<td>8,377</td>
<td>84</td>
<td>4.45</td>
</tr>
<tr>
<td>Amasra Prospective</td>
<td>26,037</td>
<td>260</td>
<td>9.17</td>
</tr>
<tr>
<td>Amasra Extension</td>
<td>50,322</td>
<td>503</td>
<td>31.51</td>
</tr>
<tr>
<td>Zonguldak Core</td>
<td>10,395</td>
<td>104</td>
<td>1.84</td>
</tr>
<tr>
<td>Zonguldak Perspective</td>
<td>11,565</td>
<td>116</td>
<td>2.23</td>
</tr>
</tbody>
</table>

*Prospective CBM has been discounted for areas without coal accumulation and geologic uncertainty based on well lithology and geological structure*
CBM Exploration and Utilization Project-TTK
TKI owns the property

U-type ventilation

142-m face width, 2000 tones/day

Coal is produced from various longwalls

Depth ~350 from surface.

Thick lignite seam (KM-2). Upper 2-m was produced.
Underground coal resources of Soma-Eynez are produced from several longwalls. Due to spontaneous combustion propensity of the coal, the rate of ventilation air provided to the mine during coal extraction is kept limited without compromising methane concentration, which is usually less than 1 percent, in the mine.

However, the experience in mining of Panel A had been quiet different. Mine personnel measured unusual methane concentrations in roadway development, as well as in mining of the upper bench of the coal seam.

High methane concentrations experienced at the working depths of Panel A led to the expectation of having even higher methane levels at deeper sections.

Therefore:

- Mining operations were suspended in the panel and the roadways were sealed with stoppings to isolate the panel from rest of the mine.
- GreenGas DPB was contracted for a feasibility study for Panel A and its vicinity for sampling coal and gas, for evaluating gas conditions and for assessing methane drainage options.
Panel A, which had been closed due to high methane readings, was studied for feasibility for degasification.

A borehole was drilled into the gob that resulted from extraction of the 2-m section of KM-2 seam. It encountered high amount of methane 20-30 m above the roof of the seam. Field personnel reported 11000 m³ of methane (100% equivalent) was produced at 30%-40% quality in three weeks.

It is known that the strata and the coal seam is water bearing. No information if water stayed in gob.
ANALYSES:

- Gas analyses
  - Gas sample taken from a surface exploration borehole drilled into Panel A
  - Chromatographic and isotopic analyses
- Desorption and flow tests for gas content and emission measurements
  - Samples were taken from the in-mine holes drilled into the coal at different lengths
  - Average gas content from all locations were determined as 0.23 m³/ton
  - Gas rate measured from coal seam 1.25 liter/min.
- Modelling of gob formation of Panel A
  - Potentially existing gob of Panel A as a result of the upper 2-m bench of the KM-2 seam was modelled
Model results shows that as a result of mining the 2-m upper bench KM-2 seam, Panel A may currently have a gob extending to a height of 110 m from the KM-2 seam.

If methane exists from continued mining or from upper strata, it may travel within the volume up to this height.
**PANEL DESIGASIFICATION OPTIONS**

- Based on observations and measurements, gob gas ventholes seem to be one of the likely options to consider to remove the gas and for its abatement. These boreholes can be placed at return margin of Panel A (and subsequent panels with similar problems) and can be drilled to ~25 m from the top of the KM-2 coal.
- Underground gas drainage using cross-measure boreholes.
  - 2200 m holes (100 m each) with 30° azimuth, 35° dip and 45° azimuth, 30° dip.
## COST OF ALTERNATIVES

<table>
<thead>
<tr>
<th>Surface Drainage</th>
<th>Price in Euro</th>
<th>No. of units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SURFACE GAS DRAINAGE STATION</td>
<td>230,000</td>
<td></td>
</tr>
<tr>
<td>Mobile pump unit</td>
<td></td>
<td>3 containers</td>
</tr>
<tr>
<td>Roots blower for 110 to 500 m3/hour capacity as per attachment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attachments to well head</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel generator, mobile</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Underground Drainage

<table>
<thead>
<tr>
<th>Underground Drainage</th>
<th>Price in Euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRILLING EQUIPMENT</td>
<td>300,000</td>
</tr>
<tr>
<td>METERING EQUIPMENT</td>
<td>12,000</td>
</tr>
<tr>
<td>GAS DRAINAGE PIPELINE</td>
<td>178,663</td>
</tr>
<tr>
<td>PIPELINE EQUIPMENT</td>
<td>26,800</td>
</tr>
<tr>
<td>SURFACE GAS DRAINAGE STATION</td>
<td>400,000</td>
</tr>
</tbody>
</table>
• In underground mines, methane concentrations must be maintained well below the lower explosive limit, so ventilation air exhausts carry only very dilute concentrations of methane (typically less than 1 percent and often less than 0.5 percent)

• Ventilation air methane (VAM) constitutes the largest source of methane emissions at most mines.

• Some technologies for beneficially using the energy content of ventilation air exhausts are currently available, while others are in the development and demonstration phase. One existing approach is quite straightforward and entails using VAM as combustion air, thereby supplying ancillary fuel to internal combustion (IC) engines, turbines, or industrial and utility boilers.

• The five coal districts of TTK have 7 major ventilation fans for production purposes. In 2011, TTK tendered the utilisation of mine ventilation air. The successive bidders was Metanox company. Unfortunately, after two years of research and development period the company could not develop commercial installation. The contract therefore ended in 2014.
THANK YOU FOR YOUR ATTENTION