PRACTICAL APPLICATION OF THE UNFC to the TURKISH LIGNITE DEPOSITS -  
A CASE STUDY: Yatagan –Eskihisar Mining Area  
Adaption to the Final Version of UNFC  

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Turkish Coal Enterprises, TURKEY  

The First Session of UNECE  
Ad Hoc Group of Experts on Supply of Fossil Fuels  

10-11 November 2004, Geneva
CONTENT

- *Position of Lignites in Turkish Energy Sector*
- Position of TKI in Turkish Lignite Sector
- Position of Yatagan-Eskihisar Mine in TKI
- Classification System Used in Turkey
- UNFC applied to Coal, Uranium & Other Minerals- a comparision with previous version-R70

- Case Study: Yatagan-Eskihisar Mining Area
  - Geological Assessment
  - Feasibility Assessment
  - Economic Viability
  - Comparision of Classification Results

- Conclusion and Recommedations
in 2003
84 MTEP

Lignite : 12%
(12.5% of 13% imported Hardcoal)
TURKISH ENERGY SECTOR - Position of Lignite

Primary Energy Production in Turkey

- **Lignite**: 42%
- **Hardcoal**: 4%

*in 2003*

23.8 MTEP
TURKISH ENERGY SECTOR-
Position of Lignite

Consumption of the Lignites by the Sectors in 2003

- Household: 9%
- Industry: 15%
- Power: 76%

Consumption of lignite mainly for electricity generation

In total electricity generation

Share of domestic lignite in 2003: 17%
CONTENT

- Position of Lignite in Turkish Energy Sector
- **Position of TKI in Turkish Lignite Sector**
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TURKISH LIGNITE SECTOR - Position of TKI

in 2003:
- Total lignite reserve: 8.2 Bt
- Total lignite production: 46.2 Mt

The biggest lignite producer in Turkey
TURKISH LIGNITE SECTOR - Position of TKI

- **in 2003:**
- **Turkey:**
  - Total installed capacity: 35587 MW
  - Share of Lignite Fired Power Plants in Total: 18%

- **TKI:**
  - Power supplied by TKI’s deposits: 4273 MW
  - 64% of total lignite-fired power plant cap.
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ESTABLISHMENTS OF TURKISH COAL ENTERPRISES

1/10 of total prod. of TKI

ELİ  Aegean Lignite Establishment  SOMA / MANİSA
Çan Lignite Production Management  ÇAN / ÇANAKKALE

GELİ  South Aegean Lignite Establishment  YATAĞAN / MUĞLA
Yeniköy Lignite Production Management- MİLAS / MUĞLA

GLİ  West Lignite Establishment  TAVŞANLI / KÜTAHYA
Ilğın Lignite Production Management  ILĞİN / KONYA

SLİ  Seyitömer Lignite Establishment  SEYİTÖMER / KÜTAHYA
Bursa Lignites Production Management- ORHANELİ / BURSA

Doğu Anatolian Control Management  DODURGA / ÇORUM
West Anatolian Control Management  HİMMETOĞLU / BOLU
Silopi Control Management  SİLOPI / ŞİRNAK
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CLASSIFICATION SYSTEM USED in TURKEY

- There is no unique, own system
- There is a terminology chaos for the usage of “reserve” and “resource” terms
- The classification is performed according to geological assessment (G)

Lignite reserves/resources are classified as:
- **Proved reserves**: geologic assurance identified in three dimensions
- **Probable reserves**: geologic assurance identified in two dimensions
- **Possible reserves**: dimensions of geologic evidence undetermined sufficiently
- **Potential resources**: currently not economic but may possibly be so in the future
CLASSIFICATION SYSTEM USED in TURKEY

- There is no generalized, predefined criteria for the cut off values for the depth, thickness, ash, sulphur contents.

- After classification performed based on geological assessment (G),
  - Economic viability (E) of the deposits is estimated
    - from mining reports for the active mines
    - from the feasibility studies for the deposits that will be mined in the near future

- Preliminary evaluation of the economic viability is done
  - by application cut off values from comparable mining operations
Lignite reserves/ resources base on National System by 2004:

- Proved reserves: 6,909 Mt
- Probable reserves: 830 Mt
- Possible reserves: 152 Mt
- TOTAL RESERVES: 7,891 Mt
- Potential resource: 308 Mt
- GENERAL TOTAL: 8,199 Mt
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- Conclusion and Recommendations
Since UNFC for solid fuels and minerals in application worldwide by about 60 countries since 1997, no big changes have been done on this version.

All category & axes names, figures kept same as the previous version.

Joint UN/CMMI definitions for mineral reserve and resource classes (agreed upon in 1999) were replaced with the definitions in the R.70 Document.
UNFC Applied to Coal, Uranium & Other Minerals - a comparison with the previous version - R70

Classification criteria

- Economic Viability
- Feasibility Assessment
- Geological Assessment
UNFC Applied to Coal, Uranium & Other Minerals
- a comparison with the previous version - R70

R.70

- No sub-category codes

- Final UNFC version

Appendix I:

for E1
- E1.1 as needed
- E1.2 codes for
- E2.1 sub-categories
- E2.2 will be added

for F1
- F1.1
- F1.3

e.g. 1.1;1;1 → E1.1, F1 and G1
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**Case Study: Yatagan-Eskihisar Mining Area**
- Geological Assessment
- Feasibility Assessment
- Economic Viability
- Comparison of Classification Results

- Conclusion and Recommendations
By beginning of 2004 TKİ 55 lignite deposits 13 of them in operation

**CASE STUDY:**

**Yatagan-Eskihisar Mining Area, TKI**

- Eskihisar lignite deposit
- Y.Bagcilar lignite deposit
- Turgut lignite deposit

in operation since 1979 with the capacity of 3.500.000 t/y
CONTENT

■ Position of Lignite in Turkish Energy Sector
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  ■ Comparision of Classification Results

■ Conclusion and Recommndations
First studies were initiated in 1956
Detailed geological, geophysical, geotechnical, hydrogeological studies were done

**Coal seam**
- Unique
- Average thickness: 11.7 m
- Uniform thickness
- Middle miocene age
- Jointed & laminated
- Low inclination
- inclination increases at boundary of the basin

**Stratigraphical section**

<table>
<thead>
<tr>
<th>Stratigraphical section</th>
</tr>
</thead>
<tbody>
<tr>
<td>CENOZOIC</td>
</tr>
<tr>
<td>MUGLA GROUP</td>
</tr>
<tr>
<td>Yatagan</td>
</tr>
<tr>
<td>LITHOLOGY</td>
</tr>
<tr>
<td>MAX. THICKNESS (m)</td>
</tr>
<tr>
<td>DEFINITION</td>
</tr>
<tr>
<td>~ 50</td>
</tr>
<tr>
<td>SANDSTONE (with conglomerate lenses)</td>
</tr>
<tr>
<td>~ 60</td>
</tr>
<tr>
<td>LIMESTONE and CONGLOMERATE</td>
</tr>
<tr>
<td>~ 25</td>
</tr>
<tr>
<td>CLAY, CLAYEY SILT</td>
</tr>
<tr>
<td>~ 90</td>
</tr>
<tr>
<td>CLAYSTONE, LIMESTONE, MARL(above)</td>
</tr>
<tr>
<td>~ 20</td>
</tr>
<tr>
<td>LIGNITE</td>
</tr>
<tr>
<td>~ &gt;180</td>
</tr>
<tr>
<td>CLAY, SILT</td>
</tr>
<tr>
<td>?</td>
</tr>
<tr>
<td>MARBLE</td>
</tr>
<tr>
<td>?</td>
</tr>
<tr>
<td>SCHIST</td>
</tr>
</tbody>
</table>
Exploration - Drillhole locations

Yatagan-Eskihisar Mining Areas
- **170** drillholes up to initiating operation (250 m spacing)
- **130** more drillholes during operation (50-100 m spacing)

DETAILED EXPLORATION

Turgut-2 Deposit
- **6** drillholes (400-600 m spacing)

GENERAL EXPLORATION
**CASE STUDY: Yatagan-Eskihisar Mining Area**

**Geological Assessment**

**Reserve Estimation**
- Polygon method was used
- Geological coefficient factor \(0.8 - 1.0\)
- **Criteria:**
  - Coal bearing clay and silt were included into coal seam having thickness \(\leq 1.0\) m and \(\leq 0.8\) m respectively
  - Specific gravity were taken 1.5 t/m³
  - Intermediate rock were included into coal seam having thickness \(\leq 0.5\) m

**Yatagan Mining Area:**
- 118 Mt Proved reserve
- 106 Mt Extractable reserve

**Turgut –2 Deposit**
- 4.2 Mt Proved Reserve
- 3.8 Mt Extractable Res

Stripping ratio: 4.1 m³/t
# CASE STUDY: Yatagan-Eskihisar Mining Area
## Geological Assessment

### Remaining Reserves Quantities:

<table>
<thead>
<tr>
<th><strong>Yatagan-Eskihisar Mining Area</strong></th>
<th>Proved</th>
<th>Extractable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eskihisar deposit:</td>
<td>37.3 Mt</td>
<td>33.6</td>
</tr>
<tr>
<td>Y.Bagcilar deposit:</td>
<td>8.1 Mt</td>
<td>7.3</td>
</tr>
<tr>
<td>Turgut deposit:</td>
<td>1.3 Mt</td>
<td>1.2</td>
</tr>
<tr>
<td><strong>Total in operation:</strong></td>
<td>46.7 Mt</td>
<td>42.1</td>
</tr>
<tr>
<td>Pillars:</td>
<td>8.3 Mt</td>
<td></td>
</tr>
</tbody>
</table>

| **Turgut-2 Deposit:**             | 4.2 Mt | 3.8         |
| **GENERAL TOTAL:**                | 59.2 Mt| 45.9        |
## CASE STUDY: Yatagan-Eskihisar Mining Area

### Geological Assessment

**Quality**

571 samples

<table>
<thead>
<tr>
<th></th>
<th>Yatagan-Eskihisar Mining Area</th>
<th>Turgut-2 Deposit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave. Calorific Value (kcal/kg)</td>
<td>2100</td>
<td>2310</td>
</tr>
<tr>
<td>Ave. Moisture Content (%)</td>
<td>36</td>
<td>-</td>
</tr>
<tr>
<td>Ave. Dry Ash Content (%)</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Ave. Total Sulphur Content (%)</td>
<td>1.9</td>
<td>-</td>
</tr>
</tbody>
</table>
CASE STUDY: Yatagan-Eskihisar Mining Area

Geological Assessment

Archeological Studies

- **200 graves** were exposed in ancient city Stratonikeia by doing detailed geophysical studies by TKI.

Other Studies, Test, Analyses

- Chemical, elementary, physical, mineralogical and ash analyses, washability, carbonization, grindability test, combustion of coal in boilers and stoves, ASTM classification, uranium analysis, briquetting, utilization of marl as a raw material of cement
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Case Study: Yatagan-Eskihisar Mining Area
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Conclusion and Recommendations
**CASE STUDY: Yatagan-Eskihisar Mining Area**

**Feasibility Assessment**

<table>
<thead>
<tr>
<th>Yatagan-Eskihisar Mining Area:</th>
<th>Turgut-2 Deposit:</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>(in operation)</em></td>
<td><em>(not in operation)</em></td>
</tr>
</tbody>
</table>

Base on **MINING REPORTS**

*(have feasibility study)*

Production cap.: 3,500,000 t/y

*Yatagan Power Station: 3,300,000 t/y*

*Household: 200,000 t/y*

Base on **GEOLOGIC STUDY**

No prefeasibility & feasibility study
Since 1979 in operation

- **Open pit Mining System** (Dragline-Excavator-Truck)
  - **Production:** 59.3 Mt lignite
    - 95% of total sales to Yatagan Power station
    - 5% of them to household
  - **Stripping ratio:** 4.1 m³/ton
  - **Calorific Value:** 2000-2100 kcal/kg
  - **Recultivation:** 600,000 trees on 341 hectare land
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CASE STUDY: Yatagan-Eskahisar Mining Area
Economic Viability

■ Factors mainly affecting the economic viability

■ Stripping ratio
■ Competing prices of the other energy sources
■ Expropriation cost
Stripping Ratio
- Unmined part of the Mining Area

Ave. Stripping Ratio: 4.1 m³/ton

Low Production Cost
CASE STUDY: Yatagan-Eskihisar Mining Area

Economic Viability - Competing prices of the other energy sources

- Mine is profitable except last three years (the loss depends on Transfer Pricing Policy)
- Price of lignite given to the power station is not determined in the competitive market
- In comparision to the other fuel sources at the same calorific value base, the established coal prices are quite low
Turgut Deposit

Between the Y.Bagcilar and Turgut deposits, there is a corridor shaped deposit owned by private sector.

High Expropriation Cost

POTENTIALLY ECONOMIC
**CASE STUDY**: Yatagan-Eskihisar Mining Area

**Economic Viability**

- **Yatagan-Eskihisar Mining Area:**
  - Eskihisar Deposit: ECONOMIC
  - Y.Bagcilar Deposit: ECONOMIC
  - Turgut Deposit: POTENTIALLY ECONOMIC

- **Turgut-2 Deposit:**
  - Preliminary Economic Viability may be estimated from the comparable mining operations
  - INTRISICALLY ECONOMIC
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## CASE STUDY: Yatagan-Eskihisar Mining Area

### Comparision of Classification Results

Classification of the Deposits According to Turkish Classification System

<table>
<thead>
<tr>
<th>OL *</th>
<th>Deposit</th>
<th>Proved</th>
<th>Probable</th>
<th>Possible</th>
<th>Developed</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eskihisar</td>
<td>36,918</td>
<td>-</td>
<td>-</td>
<td>404</td>
<td>37,322</td>
</tr>
<tr>
<td></td>
<td>Y.Bagcilar</td>
<td>8,107</td>
<td>(7,296)</td>
<td>-</td>
<td>-</td>
<td>8,107</td>
</tr>
<tr>
<td></td>
<td>Turgut</td>
<td>1,327</td>
<td>(1,194)</td>
<td>-</td>
<td>-</td>
<td>1,327</td>
</tr>
<tr>
<td></td>
<td><strong>Total (in operation)</strong></td>
<td>46,352</td>
<td>(41,717)</td>
<td>-</td>
<td>404</td>
<td>46,756</td>
</tr>
<tr>
<td></td>
<td>Pillars**</td>
<td>8,266</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>8,266</td>
</tr>
<tr>
<td>Turgut-2</td>
<td>3303</td>
<td>4,222</td>
<td>(3,800)</td>
<td>-</td>
<td>-</td>
<td>4,222</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>58,840</td>
<td>(45,517)</td>
<td>-</td>
<td>404</td>
<td>59,244</td>
</tr>
</tbody>
</table>

* Operating Licence numbers
** Pillars left for ancient city, landslide and Milas highway
*** ( ) Extractable reserve
## Classification of the Deposits Based on UNFC

<table>
<thead>
<tr>
<th>Deposit</th>
<th>Code</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yatagan Eskihisar Mining Area</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yatagan+ Y.Bagcilar Deposits</td>
<td>111</td>
<td>Proved Mineral Reserve</td>
</tr>
<tr>
<td>Turgut Deposit</td>
<td>2:1;1;1</td>
<td>Feasible Mineral Resource</td>
</tr>
<tr>
<td><strong>Pillars</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Turgut-2 Deposit</strong></td>
<td>311</td>
<td>Abandoned Mineral Resource</td>
</tr>
<tr>
<td></td>
<td>3;3;2</td>
<td>Indicated Mineral Resource</td>
</tr>
</tbody>
</table>

### Extractable Reserve

111<sub>e</sub>

“Exploration During Exploitation” term was added.
### Classification of the Deposits Based on UNFC

<table>
<thead>
<tr>
<th>UN FRAMEWORK CLASSIFICATION</th>
<th>Detail Exploration/Exploration During Exploitation</th>
<th>General Exploration</th>
<th>Prospeksiyon</th>
<th>Ön Arama</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ULUSAL SİSTEM</strong></td>
<td>Detay Arama/İşletme Dönemi Aramaları</td>
<td>Genel Arama</td>
<td>Prospeksiyon</td>
<td>Ön Arama</td>
</tr>
<tr>
<td>Feasibility Study and/or Mining Report</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fizibilite Çalışması ve/veya Madencilik Raporu</strong></td>
<td>1</td>
<td>45,429 (111)*</td>
<td>40,886 (111e)**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1,327 (211)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>8,266 (311)****</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prefeasibility Study</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ön Fizibilite Çalışması</strong></td>
<td>1</td>
<td>(121)</td>
<td>+ (122)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>(221)</td>
<td>+ (222)</td>
<td></td>
</tr>
<tr>
<td>Geologic Report</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Jeolojik Rapor</strong></td>
<td>(1-2) (331)</td>
<td>(1-2) 4,222</td>
<td>(1-2) (333)</td>
<td>(1-2) (334)</td>
</tr>
</tbody>
</table>

**Economic Viability Categories:**
1: Economic
2: Potentially Economic
1-2: Economic to Potentially Economic (Intrinsically Economic)

* Eskihisar and Y. Bagcilar Deposits
** Extractable reserve of Eskihisar and Y. Bagcilar deposits
*** Turgut Deposit
**** Pillars left for ancient city, landslide and Milas highway
***** Turgut-2 deposit

Date: July 2003
Main difference btw National System and UNFC;

- National system bases on geological assessment (G)
- UNFC bases on economic viability (E), feasibility assessment (F) and geological assessment (G).
**CASE STUDY:** Yatagan-Eskihisar Mining Area

**Comparision of Classification Results**

<table>
<thead>
<tr>
<th>Deposit</th>
<th>NATIONAL SYSTEM</th>
<th>UNFC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Term</td>
<td>Quantity (Mt)</td>
</tr>
<tr>
<td>Y.Eskihisar Mining Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eskihisar Deposit</td>
<td>Proved Reserve</td>
<td>37.3</td>
</tr>
<tr>
<td>Y.Bagcilar Deposit</td>
<td>Proved Reserve</td>
<td>8.1</td>
</tr>
<tr>
<td>Turgut Deposit</td>
<td>Proved Reserve</td>
<td>1.3</td>
</tr>
<tr>
<td>Pillars</td>
<td>Proved Reserve</td>
<td>8.3</td>
</tr>
<tr>
<td>Turgut-2 Deposit</td>
<td>Proved Reserve</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Extractable Reserve 45.9 Extractable Min.Reserve 40.9

13.8 Mt difference in Proved Mineral Reserve
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- Conclusion and Recommedations
CONCLUSION and RECOMMENDATIONS

- UNFC can be well adapted to Turkish lignite deposits

- Main difference btw National System and UNFC;
  - National system bases on geological assessment (G)
  - UNFC bases on economic viability, geological & feasibility assessment.

- UNFC provides a guideline in preventing terminology chaos
CONCLUSION and RECOMMENDATIONS

Benefits gained by the study:

- All related data were collected, analysed and put into an order in the form of geological & feasibility assessment, and economic viability.

- Consistency of the reserves/resources figures among the operation management and TKI Headquarter was provided by re-estimation and evaluation of the deposits.

- Operation management will carry out its planning studies for the future base on more reliable information.

- This study will be taken as a model for the classification of the other basins.
Recommendations for the future studies:

- The most commonly used cut off values in the reserve/resource estimation should be complied countrywide. Hence they should be used as a generalized or predefined criteria for reserves/resources estimations.

- All information derived should be stored into a shared database for easily updating the classification due to change in the conditions.

- Extensive, systematic training program should be initiated countrywide.
PRACTICAL APPLICATION OF THE UNFC to the TURKISH LIGNITE DEPOSITS-
A CASE STUDY: Yatagan –Eskihisar Mining Area
Adaption to the Final Version of UNFC

Thank You For Your Attention
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