State classification of mineral resources and reserves of Ukraine as an evaluation instrument of investment proposals on energy resources

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Black Sea and Caspian Energy Conference
14 February 2013, London
According to the subsoil legislation of Ukraine, economic-geological evaluation of mineral reserves follows the process of subsoil area use from the beginning of geological study till the full development.

Mineral deposits or subsoil area that are provided for use shall be reassessed every 10 years of their usage, and in case of significant changes in quantity or quality of inventory or technical and economic indexes of effectiveness (more than 20-50%).
State Commission of Ukraine on Mineral Resources carries out economic-geological evaluation (EGE) of mineral resources and reserves as well as scientific and research thematic works on formation and development of methodology for economic-geological evaluation of mineral reserves and resources.

According to actual geological and feasibility study of the productive field, Ukrainian Mineral Resources Classification of State Subsoil Fund presents initial, previous and detailed economic-geological assessments.
The sequence of economic-geological evaluation of subsurface

EGE-3 – initial economic-geological evaluation

EGE-2 – provisional economic-geological evaluation

EGE-1 – detailed economic-geological evaluation
Ukraine was the first that had adapted its Classification of mineral reserves and resources to the United Nations Framework Classification following the UN ECOSOC Resolution No 227/1997, according to which Unites Nations Framework Classification was recommended for practical use by UN member-countries.

Ukrainian Classification of mineral reserves and resources is a framework and can be used for all types of minerals.
## UKRAINIAN MINERAL RESOURCES CLASSIFICATION

<table>
<thead>
<tr>
<th>Economic value</th>
<th>The degree of feasibility study</th>
<th>The degree of geological study</th>
<th>Class Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Balance reserves (1..)</td>
<td>EGE-1 (.1.)</td>
<td>Explored reserves (.1)</td>
<td>111</td>
</tr>
<tr>
<td></td>
<td>EGE-2 (.2.)</td>
<td>Explored reserves (.1)</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Explored reserves (.1)</td>
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<tr>
<td></td>
<td></td>
<td>Probable</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Probable</td>
<td></td>
</tr>
<tr>
<td>2. Conditionally balance and outbalance reserves (2..)</td>
<td>EGE-1 (.1.)</td>
<td>Explored reserves (.1)</td>
<td>211</td>
</tr>
<tr>
<td></td>
<td>EGE-2 (.2.)</td>
<td>Explored reserves (.1)</td>
<td>221</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Explored reserves (.1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Probable</td>
<td>222</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Probable</td>
<td></td>
</tr>
<tr>
<td>3. Mineral reserves or resources, economic value of which is not defined (3..)</td>
<td>EGE-3 (.3.)</td>
<td>Explored reserves (.1)</td>
<td>331</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Probable</td>
<td>332</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Probable</td>
<td>333</td>
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<tr>
<td></td>
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<td>334</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Probable</td>
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</tbody>
</table>
# Categories and Classes of the UNFC-2009 and Classes Used in Ukrainian Classification of Minerals

<table>
<thead>
<tr>
<th>Category</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial projects</td>
<td>111 121 122</td>
<td></td>
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<tr>
<td>Potentially commercial projects</td>
<td>211 221 222</td>
<td></td>
</tr>
<tr>
<td>Non-commercial projects</td>
<td>331 332</td>
<td></td>
</tr>
<tr>
<td>Exploration projects</td>
<td>333 334</td>
<td></td>
</tr>
<tr>
<td>Additional quantities in place</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other combinations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extracted quantities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classes, used in the Ukrainian Classification</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Codification (E1, F2, G3)**

**Black Sea and Caspian Energy**
The given above scheme presents a comparison between Ukrainian Classification of mineral reserves and resources and the UNFC-2009.

From among 40 Classes, which are specified by the UNFC, only 10 are used in Ukrainian Mineral Resources Classification.

Despite different Class names, the quantities of minerals, which have common socio-economic viability (the E axis), project feasibility (the F axis) and geological knowledge (the G axis), can be identified with one and the same numeric code.

Thus, both classifications UNFC-1997 and UNFC-2009 are comparable.
MAPPING OF UKRAINIAN MINERAL RESOURCES CLASSIFICATION AND THE CRIRSCO TEMPLATE

- 334 EXPLORATION RESULTS
- 333 INFERRED RESOURCES
- 332 INDICATED RESOURCES
- 331 MEASURED RESOURCES

MINERAL RESOURCES

334 - Classes that are used in the Ukrainian Classification

MINERAL RESERVES

121 122 PROBABLE RESERVES
111 PROVED RESERVES

Increasing level of geological knowledge and confidence

Consideration of mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors ("modifying factors")

Black Sea and Caspian Energy
The presented above mapping of Ukrainian Classification to the CRIRSCO Template illustrates that among 10 classes of mineral resources, which belong to Ukrainian Classification, 7 are represented in the CRIRSCO Template.

It is connected with the fact that Balance and Outbalance reserves, which are marked as 221, 222 and 211 Class Codes, can not be applied to the CRIRSCO Template. These Classes are included into the category of “Mineral Resources”.

However, mineral resources that belong to one of the CRIRSCO Template Classes can be identified with one of the Class Codes, specific to Ukrainian mineral resources Classification.
## MAPPING OF UKRAINIAN AND SPE (PRMS) CLASSIFICATIONS

<table>
<thead>
<tr>
<th>Ukrainian Mineral Resources Classification</th>
<th>SPE (PRMS)</th>
<th>Project Maturity Sub-classes</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
<td><strong>Balance</strong></td>
<td><strong>Conditionally balance</strong></td>
<td><strong>Out-balance</strong></td>
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<td>A, B</td>
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<td>221</td>
<td></td>
</tr>
<tr>
<td>A, B</td>
<td>121</td>
<td>221</td>
<td></td>
</tr>
<tr>
<td>C₁</td>
<td>111</td>
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<tr>
<td>C₂</td>
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<td>C₂</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>D₁+D₂</td>
<td>334</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Society of Petroleum Engineers (SPE) estimates the probability of hydrocarbon resources availability and economic efficiency of reserves extraction.

According to the SPE Standards and depending on the total feasibility assessment, all Reserves fall into the “P” Category and all Contingent Resources belong to the “C” Category.

The mentioned above table presents a partial result of comparison between SPE (PRMS) Classification and Ukrainian mineral resources Classification what demonstrates a provisional mapping of the Classifications.
Thus, keeping up the established approaches to the principles of mineral reserves Classification and the existing State balance of Ukrainian mineral reserves, the Classification provides adaptation of mineral resources base and common experience of subsoil use to conditions that are represented in UNECE, CRIRSCO and SPE (PRMS) Classifications;

Accumulation and processing of information on economic-geological evaluation of mineral deposits, along with application of internationally accepted approaches and principles, contribute to: optimum understanding of Ukrainian raw material base and attraction of investments for further project implementation, connected with subsoil use.
OIL AND GAS REGIONS OF UKRAINE

Map symbols

- Fields
- Oil
- Gas
- Gas-condensate
- Oil-gas condensate
Eastern oil and gas region is the largest in Ukraine by potential resources and reserves.

It has 205 fields, 121 of them are being developed (gas – 64, gas condensate – 72, oil – 53).

The degree of the initial potential resources realization – 57%.
Western oil and gas region is the most long-exploited in Ukraine and the smallest by potential resources and reserves. It has 103 fields, 62 of them are being developed (gas – 13, gas condensate – 4, oil – 40)
Southern oil and gas region is the least developed. The degree of initial resources realization – 5%. The largest deposits were discovered within the shelf area: gas condensate fields – Shtormovoe, Shmidtovskoe, Halitsynskoe; oil fields – Subotinskoе (Black Sea); gas fields – Northern- and Eastern-Kazantipskoe (Sea of Azov). The explored offshore reserves – 64 bcm.
Characteristics of reserves and exploration process

68 perspective areas were found at a sea depth of 100m, 23 of them were prepared for exploration drilling with the average resource potential of 1 – 5 million tons of coal equivalent/object.

8 fields were opened within the Black Sea offshore and 5 fields – within the Sea of Azov offshore. Among these, 6 fields are under development, 4 – are prepared for pilot commercial development (PCD), 2 – are under exploration, 1 – is in conservation.

Balance reserves of proven offshore fields amount to 44 million tons of coal equivalent.
Resource potential – is a third of the undiscovered natural gas resources and a fifth of the undiscovered oil resources, belongs to water area of Black Sea and Sea of Azov (remaining undiscovered mineral resources, which are basic for the mining industry development, amount 4979 million tons of coal equivalent, including: oil and condensate – 1148 million tons and gas – 3831 billion m³. The development degree of resource potential of the shelf – up to 5%).

The most perspective for the search of significant deposits is a deep part of the Black Sea.

Its potential recoverable resources reach more than 1000 million tons of coal equivalent (54% of the total Black Sea resources).
Sea depth up to 70–140 m.
The available technical potential in Ukraine:
  • the average cost of 1 well drilling – 20 million US dollars;
  • the average cost of 1 deposit developing and equipment – 0.5 billion US dollars;
  • the average cost of 1 connection pipeline – 100–200 million US dollars.

Sea depth over 140 m.
The technologies of world leading companies:
  • the average cost of 1 deposit developing and equipment – 1.5–2 billion US dollars;
  • the average cost of 1 connection pipeline – 300–500 million US dollars.

Current state: advanced conditions for the creation of joint ventures.
In order to increase production from the shallow shelf, the financing of operations on geological exploration must be increased up to 100 – 200 million USD/year); and in several times (up to 0.5 – 1 billion USD/year) on buildup of production that totals up to 2–5 million tons of coal equivalent/year.

**INVESTMENT**

To create the conditions so that major oil companies could obtain license blocks or set up joint ventures in order to carry out the work programs on deepwater resources development.

Expected investment in exploration for each of the units – up to 0.5 billion US dollars.

Investment appraisal of the deposits development – up to 1.5 – 2 billion US dollars.
Ukraine ranks the 9th place in the world by the total reserves of coal-bed methane

12 – 13 trillion m³ – general resources of coal-bed methane in Ukraine (coal + sandstones);

1.2 trillion m³ – calculated according to the State Committee on Science and Technology (SCST) program, 1989 methane resources in the Donbas coal-bed of proved and prospective areas;

3 – 3.5 trillion m³ – real methane resources that can be extracted from coal-beds and rocks;

314 billion m³ – methane reserves of 186 mines and sites, including 95 operating mines accounted for the State balance of Ukraine as of 01.01.2010;

8 – 12 billion m³/year – estimated potential of methane production per year;

1.4 billion m³/2009 – amount of gas that was released in the process of coal mining (72.2 million tons); the recycled amount – 70 million m³ (5%).
Prospective Zones of Unconventional Gas Production

Black Sea and Caspian Energy

Lublin basin

Dnieper-Donets basin

Lvov-Volyn coal basin

Shale gas reserves in Ukraine according to Ukraine Gosgeonereda
7 trillion cu m

General resources of coalbed methane in Ukraine (coal + sandstones)
12–13 trillion cu m

Lvov, Lutsk, Rovno, Zhitomir, Khmelnytskyi, Cherkassy, Poltava, Kharkov, Lugansk, Donetsk, Donetsk coal basin,
The most perspective objects:

**Dnieper-Donets depression**
Black shale of Devonian and Carboniferous strata:
- area — approx. 100 ths. km²
- thickness — more than 1000 m
- depth of occurrence — up to 2000-4000 m

Including consolidated collectors in the rocks of Mid- and Lower Carboniferous age:
- area — approx. 18.5 ths. km²
- thickness — more than 1000 m
- depth of occurrence — up to 3000-5000 m

**Lviv Paleozoic downfold**
Ludlow layer of the Silurian strata:
- area — tens of thousands km²
- thickness — 400-600 m
- depth of occurrence — 2000-3000 m
### Prognostic variants of shale gas production

<table>
<thead>
<tr>
<th>Index</th>
<th>Oleska field</th>
<th>Yuzovska field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pessimistic scenario</td>
<td>3 – 5 bcm/year</td>
<td>10 bcm/year and more</td>
</tr>
<tr>
<td>Baseline scenario</td>
<td>approx. 10 bcm/year</td>
<td>approx. 15 – 20 bcm/year</td>
</tr>
<tr>
<td>Optimistic scenario</td>
<td>15 – 20 bcm/year</td>
<td>30 – 40 bcm/year</td>
</tr>
<tr>
<td>Possible unconventional gas resources</td>
<td>1 – 2 trillion. m³</td>
<td>1 – 3 trillion. m³</td>
</tr>
</tbody>
</table>
Gas in consolidated rocks

- Penetrates the consolidated sandstones
- Low porosity – small space between the grains of rock
- Low permeability – gas can’t freely migrate through the rock

Shale gas

- Located between shale streaks
- Low porosity and ultra-low permeability
- Hydraulic fracturing is needed to release gas

Coalbed methane

- Natural gas in coal layers
- Low permeability
- Mining due to natural fracturing of coal
- Low production rate

Black Sea and Caspian Energy
HYDRAULIC FRACTURING

- Proven technology
- Use of liquid to form cracks in rock so that gas could flux into the well
- Composition – 99% of water and sand; and 1% of chemical impurities
- The particles of sand-proppant keep the rock opened after HF

Hydraulic fracturing is used to:
- Increase the production rate
- Increase the volume of extracted gas
Layers that contain gas of consolidated rocks occur several thousand metres deeper than freshwater-bearing horizons. Kilometres of various subsurface formations lie between these horizons and fissures, which were formed after fracturing. Best experience in water management lies in water use reducing, maximizing of water reuse and purification according to Ukrainian laws and international standards.

Water reuse reduces water management by 50%. This allows to optimize liquid waste volume and withdrawal for hydraulic fracturing.
FIRST EXPLORATION WELL – BELIAEVSKAYA-400

- Drilling site – 300 x 220 m
- Concreted road laid to the site – 3700 m
- Project drilling depth – 5250 m
- Expected time of drilling – 6 months.
- Best international standards for safety and environmental protection
1. Currently Ukraine implements economic-geological evaluation of mineral deposits on the basis of the United Nations Framework Classification 1997 and applies it at the legislative level. At present the works on comparison between Ukrainian Classification of mineral reserves and resources (UNFC-1997) and UNFC-2009 as also CRIRSCO and SPE (PRMS) Classifications.

Ukrainian Classification of mineral reserves and resources is fully comparable with the CRIRSCO Classification (solid minerals) and preliminary with SPE-PRMS (hydrocarbons) Classification. This will allow to transform the reserves of mineral deposits from national classification system of Ukraine into the world's most common Classification systems of multinational companies.
2. Ukraine has major deficits in energy products, what determines a considerable proportion of their imports. At the same time Ukraine has prospective territories for hydrocarbon upgrading, what determines the potential for profitable investment in new fields discoveries, as well as opportunities of additional hydrocarbon extraction within abandoned deposits in virtue of modern technologies use.

3. Ukraine has significant coal-bed methane reserves that are accounted for the State balance. The problem is the lack of modern technological methods of its recovery and use.

4. Ukraine has significant gas reserves in shale formations and in consolidated rocks, what determines the desirability of corresponding investment projects development on favorable terms for an investor.
THANK YOU FOR YOUR ATTENTION