Jordan's Commercial Oil Shale Exploitation Strategy
Part 1
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Presentation Outline

Part One (Eng. Munther Bsieso)
- Energy Situation in Jordan
- Jordan's Oil Shale Resources
- Oil Shale Previous Work
- Current Activities
- The Role of Oil Shale in the Kingdom's Energy Master Plan (The Strategy)

Part Two (Dr. Tom Sladek - Behre Dolbear & IdRC)
(Jordan Oil Shale Technical Assistance Project [JOSTA])
- Technology Assessment
- Economic Modeling
- Evaluation of Environmental Effects and Water Requirements
The world will consume energy over the next 30 years at a faster rate than it has for the previous 125 years.

It is generally agreed that worldwide petroleum supply will eventually reach its productive limit, peak, and begin a long term decline.

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>Reserves, billion B.I.O.E</th>
<th>Period of time (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>1012</td>
<td>44</td>
</tr>
<tr>
<td>Natural gas</td>
<td>750</td>
<td>67</td>
</tr>
<tr>
<td>Coal</td>
<td>3745</td>
<td>223</td>
</tr>
<tr>
<td>Oil shale</td>
<td>1500-3400</td>
<td>-</td>
</tr>
<tr>
<td>Tar sand</td>
<td>1650</td>
<td>-</td>
</tr>
</tbody>
</table>
Cost of oil has risen in a decade from $15 per barrel to $83 at present.

This gives a clear economic interest for Jordan to have the oil shale developed as a possible strategic source of energy.
• High oil prices in international markets will improve economics of shale oil, drive development of technology, and reduce production costs.

Technology readiness and production costs will determine when an oil shale industry will emerge.
A structural trap. Faulting in the earth has caused vertical movement of the rock layers. Gas and oil cannot pass through the fault boundary, and they are trapped.
• Oil Shale Resources
In Jordan
The term *oil shale* generally refers to any sedimentary rock that contains solid bituminous materials that are released as petroleum-like liquids when the rock is heated. To obtain oil from oil shale, the shale must be heated and resultant liquid must be captured. This process is called *retorting*, and the vessel in which retorting takes place is known as a *retort*.
Jordan contains massive amounts of oil held in oil shale, distributed over about 65% of its land.

Recoverable energy from these high-grade deposits may be more than 80 billion barrels of crude oil.
<table>
<thead>
<tr>
<th></th>
<th>Brazil</th>
<th>U.S.A</th>
<th>Europe</th>
<th>China</th>
<th>Estonia</th>
<th>Morocco</th>
<th>Jordan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil (k cal/kg)</td>
<td>1340</td>
<td>1800</td>
<td>1986</td>
<td>1500</td>
<td>2000</td>
<td>1100</td>
<td>1800</td>
</tr>
<tr>
<td>Oil Content (%)</td>
<td>7</td>
<td>9.7</td>
<td>13</td>
<td>7</td>
<td>20</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Organic Carbon (%)</td>
<td>2.6</td>
<td>17.3</td>
<td>20</td>
<td>12</td>
<td>19</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td>H2 (%)</td>
<td>1.9</td>
<td>1.7</td>
<td>2.7</td>
<td>2</td>
<td>2.5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>O2 (%)</td>
<td>2.7</td>
<td>2.1</td>
<td>11.5</td>
<td>7</td>
<td>7.5</td>
<td>9.6</td>
<td>1.8</td>
</tr>
<tr>
<td>N2 (%)</td>
<td>0.6</td>
<td>1.3</td>
<td>0.2</td>
<td>0.38</td>
<td>0.2</td>
<td>_</td>
<td>0.34</td>
</tr>
<tr>
<td>S (%)</td>
<td>0.6</td>
<td>0.65</td>
<td>6</td>
<td>0.3</td>
<td>1.55</td>
<td>1.2</td>
<td>3.2</td>
</tr>
<tr>
<td>H2O (%)</td>
<td>5.3</td>
<td>0.7</td>
<td>12.7</td>
<td>13</td>
<td>11.5</td>
<td>10</td>
<td>2.5</td>
</tr>
<tr>
<td>Ash</td>
<td>79.8</td>
<td>68.3</td>
<td>45</td>
<td>71</td>
<td>44</td>
<td>64</td>
<td>55</td>
</tr>
</tbody>
</table>

![Graph showing oil reserves](image1)

![Image of oil shale](image2)
• Oil Shale covers more than 60% of Jordan’s area

• There are more than 25 surface and near surface occurrences of oil shale
Vast reserves of oil shale.

<table>
<thead>
<tr>
<th>Location</th>
<th>Horizontal extent of deposit ($10^6$ m$^2$)</th>
<th>Mean thickness of deposit, (m)</th>
<th>Overburden thickness, (m)</th>
<th>Stripping ratio</th>
<th>Average oil content (by wt. %)</th>
<th>Proven reserves of deposit ($10^6$ tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wadi Maghar</td>
<td>29</td>
<td>40</td>
<td>41</td>
<td>1.02</td>
<td>6.8</td>
<td>31,600</td>
</tr>
<tr>
<td>Wadi Thamad</td>
<td>150</td>
<td>136</td>
<td>60</td>
<td>0.44</td>
<td>10</td>
<td>11,400</td>
</tr>
<tr>
<td>Attarat Um Gadran</td>
<td>226</td>
<td>45</td>
<td>53</td>
<td>1.17</td>
<td>11</td>
<td>11,300</td>
</tr>
<tr>
<td>Jurf Ed Darawish</td>
<td>150</td>
<td>64</td>
<td>48</td>
<td>0.75</td>
<td>6</td>
<td>8,506</td>
</tr>
<tr>
<td>Ellujun</td>
<td>20</td>
<td>30</td>
<td>26</td>
<td>0.87</td>
<td>10.5</td>
<td>1,196</td>
</tr>
<tr>
<td>Sultani</td>
<td>75</td>
<td>31</td>
<td>69</td>
<td>2.18</td>
<td>7.5</td>
<td>989</td>
</tr>
<tr>
<td>Khan Zabib</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>Siwaga</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7</td>
<td>-</td>
</tr>
</tbody>
</table>

**Oil Shale Deposits in Jordan (Bilion Tons)**

- Wadi Mughur: 32
- Althamad: 11.4
- Attarat: 11.3
- Jurf: 8.6
- Lajjun: 1.3
- Sultani: 1
Al-Lajjun Oil Shale Deposit
Sultani Oil Shale Deposit

Chalk
Marl
Chalky marl
Slightly Bituminized Marly Lst
Oil shale
Main Studies
Klockner/Lurgi - German (50,000 b/d)  
300 MW CFB
Bechtel / Pyropower CFB 400MW
+Test Burn in Finland
Combustion Engineering / Lummus Canada CFB 400MW + Test Burn in Germany

- Fuel flexibility
- Capacity to burn low grade fuels
- Multifuel burning capability
- Meets strict emission regulations easily
- No complex chemical cleaning systems
- Proven reliability
- Simple construction
- New plants, rehabilitation or repowering
Sinopec / China - 1000 tons Retorting Test
Enin / Russia – UTT 3000-Galoter

Shale Oil Plant
800 tons oil /day
Suncor Alberta Taciuk Process (ATP)
• Economics of shale oil production in the past have remained behind conventional oil keeping oil shale off nation’s energy agenda.

• When crude oil prices were ~ $12 per barrel (1980s - early 1990s), estimates of selling price needed to make oil shale economic were ~ $20 per barrel.

• Crude oil prices have risen sharply starting in 2004, reaching $80 per barrel that makes oil shale viable and strategic energy source.
Main Results - Technical

- Jordanian oil shale is considered as a good and acceptable fuel to be burned in circulating fluid bed boilers (CFB) cleanly and efficiently.
- Very high combustion efficiency in excess of 98.5% and very low emissions.
- Oil yield is 10% and gas yield is 5% by weight.

### BASIC YIELD STRUCTURE - JORDAN SHALE

<table>
<thead>
<tr>
<th>Kerogen content</th>
<th>NOMINAL GRADE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22.65</td>
</tr>
</tbody>
</table>

| Fischer Assay | 12.0 + 0.8 |

<table>
<thead>
<tr>
<th>Pyrolysis Products</th>
<th>HC SPLIT ON KERGEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil C4+</td>
<td>12.65</td>
</tr>
<tr>
<td>Gas C4- &amp; H2S</td>
<td>2.10</td>
</tr>
<tr>
<td>Coke</td>
<td>7.90</td>
</tr>
<tr>
<td>Retort Water</td>
<td>1.5 (est)</td>
</tr>
<tr>
<td>N2 + CO2</td>
<td>1.9 (est)</td>
</tr>
<tr>
<td>Mineral Residue</td>
<td>73.95</td>
</tr>
<tr>
<td>Free Moisture</td>
<td>3.0</td>
</tr>
<tr>
<td>Total</td>
<td>103.0</td>
</tr>
</tbody>
</table>
### Main Results - Economic

<table>
<thead>
<tr>
<th>CAPITAL COST</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost Per Estimate = US Dollars</td>
<td>$68,037.0, 99,480.6, 139,965.0</td>
</tr>
<tr>
<td>Capital Cost JD</td>
<td>22,667.4, 34,901.1, 46,000.4</td>
</tr>
<tr>
<td>Interest During Construction</td>
<td>1,980.6, 1,945.5, 2,782.6</td>
</tr>
<tr>
<td>Total Capital Cost = JD</td>
<td>25,040.0, 36,030.0, 50,783.0</td>
</tr>
</tbody>
</table>

### FINANCIAL

| Offshore Mixed Credit | $29,823.7, 27,806.8, 39,845.8 |
| JRA - Equity | 5,216.3, 6,330.7, 10,977.3 |
| Total Financing | 35,040.0, 36,130.0, 50,823.0 |

| PERFORMANCE INDICATORS | 1987 |
| Generating Capacity (MW) | 153,475, 306,950, 613,901 |
| Number of Employees | 95, 190, 148 |

### FINANCIAL INDICATORS

| Annual Productivity (MWh/Ga) | 1720, 3615, 2870, 4148 |
| Installed Capacity (MWh/Ga) | .5, .26, .42, .68 |

| OTHER ECONOMIC INDICATORS | Guideline |
| Rate of Return on Equity * | 8.0, 7.7, 15.6, 18.1 |
| Debt Coverage | 1.5, 2.04, 2.25, 4.9 |
| Debt Equity Ratio | 50/58, 78/21, 77/23, 79/22 |
| Capital Cost per MW | 300, 3000, 721, 966 |
| Present Value JD ** | 5921, 32379, 30991 |
| Present Value per MW | 609, 465, 369 |

* Based on net project cash flow from operations assuming equity is invested as required during construction.

** Discounted at 10%. Based on equity contribution to cover interest during construction and local cost of construction plus debt repayment of interest and principle on a concessional basis to cover all off shore costs.

A comparison with the final results of the updated prefeasibility study shows a required sales revenue of 15.1 $/bl in order to generate an internal rate of return on total investment of 10%. Based on current border prices the weighted mean value of the petroleum products ex El Lajun complex has been calculated to 21.4 $/bl which is more than the required sales revenue. A petroleum product's price of only 15.6 $/bl has to be reached to meet an economic internal rate of return on total investment of 10% (CBA).
Shell Oil thinks it can produce oil from oil shale at $30 per barrel using an in situ process where the shale is cooked without first mining it onto the surface.
Main Results - Environment

- Emissions registered during combustion test of 75 tons of Sultani Oil Shale conducted in Lurgi Facility Germany

- $SO_2$ (ppm) 20-40
- $NO_x$ (ppm) 140 – 200
- CO (ppm) 150
- $CO_2$ (ppm) 14
- Particulate (%) 50
Comparison of Different Emission Levels of Oil Shale, Coal and Fuel Oil Power Stations

<table>
<thead>
<tr>
<th></th>
<th>Oil Shale CFB</th>
<th>Coal</th>
<th>HTPS</th>
<th>ATPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO2 (ppm)</td>
<td>20 - 40</td>
<td>200 - 500</td>
<td>1700</td>
<td>1300</td>
</tr>
<tr>
<td>NOx (ppm)</td>
<td>140 - 200</td>
<td>120 - 650</td>
<td>N.A</td>
<td>170</td>
</tr>
<tr>
<td>CO (ppm)</td>
<td>150</td>
<td>N.A</td>
<td>120</td>
<td>20</td>
</tr>
<tr>
<td>CO2 (%)</td>
<td>14</td>
<td>N.A</td>
<td>15.3</td>
<td>14</td>
</tr>
<tr>
<td>Particulate</td>
<td>50</td>
<td>160 - 180</td>
<td>40</td>
<td>170</td>
</tr>
</tbody>
</table>

HTPS: Hussein Thermal Power Station (fuel oil)
ATPS: Aqaba Thermal Power Station (fuel oil)
N.A: Not Available
<table>
<thead>
<tr>
<th></th>
<th>PC Boilers</th>
<th>CFB Boilers</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO\textsubscript{2} bounded</td>
<td>80 %</td>
<td>almost 100 %</td>
</tr>
<tr>
<td>Fly Ash Emissions</td>
<td>&lt; 200 mg/Nm\textsuperscript{3}</td>
<td>&lt; 30 mg/Nm\textsuperscript{3}</td>
</tr>
<tr>
<td>\text{SO}_2 emissions</td>
<td>2000 mg/Nm\textsuperscript{3}</td>
<td>0 - 20 mg/Nm\textsuperscript{3}</td>
</tr>
<tr>
<td>NO\textsubscript{x} emissions, mg/Nm\textsuperscript{3}</td>
<td>300 mg/Nm\textsuperscript{3}</td>
<td>90 - 170 mg/Nm\textsuperscript{3}</td>
</tr>
</tbody>
</table>
Current Activities
Three Directions

- In-Situ Process
- Surface Mining
- Circulating Fluidized Bed
Mining and Surface Retorting Is the Traditional Method for Processing Oil Shale

Mining & Crushing → Retorting → Oil Upgrading → Oil to Refinery

On-Site Disposal of Spent Shale → Reclamation
Oil Shale Above Ground Retorting Technologies

<table>
<thead>
<tr>
<th>Country</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>ATP (Stuart Project)</td>
</tr>
<tr>
<td>Brazil</td>
<td>Petrosix</td>
</tr>
<tr>
<td>Canada</td>
<td>Water extraction/coking</td>
</tr>
<tr>
<td>China</td>
<td>Vertical Retort</td>
</tr>
<tr>
<td>Estonia</td>
<td>Galitor &amp; Kiviter</td>
</tr>
<tr>
<td>Israel</td>
<td>Vertical Retort – R&amp;D</td>
</tr>
<tr>
<td>Jordan</td>
<td>Active R&amp;D Program</td>
</tr>
<tr>
<td>Mongolia</td>
<td>Active R&amp;D Program</td>
</tr>
<tr>
<td>Morocco</td>
<td>Active R&amp;D Program</td>
</tr>
<tr>
<td>Russia</td>
<td>Vertical Retort</td>
</tr>
<tr>
<td>Turkey</td>
<td>Active R&amp;D</td>
</tr>
<tr>
<td>USA</td>
<td>Shell Exploration &amp; Production Insitu</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Retorting type</th>
<th>Oil (tpa)</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fushun</td>
<td>103000</td>
<td>China</td>
</tr>
<tr>
<td>Galoter, kiviter, Generator</td>
<td>300000</td>
<td>Estonia</td>
</tr>
<tr>
<td>Generator</td>
<td>202000</td>
<td>Russia</td>
</tr>
<tr>
<td>Petrosix</td>
<td>160000</td>
<td>Brazil</td>
</tr>
<tr>
<td>Taciuk (ATP)</td>
<td>200000</td>
<td>Australia</td>
</tr>
</tbody>
</table>
In June 2006, the government signed an MOU with Royal Dutch Shell to test extraction of deep oil shale resources using Shell’s in-situ conversion process in the Azraq and Al-Jafr blocks of central Jordan.
• The Government of Jordan (GOJ) is currently negotiating with Shell to utilize the new extraction technique to reach an agreement and go ahead with the project.

• The project study will take about ten years and shall consist of the following main Phases:
  1. Negotiation of the Commercial Agreement and GOJ Approval - (one year)
  2. Exploration and Assessment of Oil Shale Resources - (2 years)
  3. Appraisal of Selected Prospects - (2-3 years)
  4. Localization of Demo Project - (2-5 years)
  5. Project Definition and Final Commercial Investment - (4-5 years)

• Consequently, at least 10 and possibly more years will elapse before oil shale development will reach the production growth phase
Recovery Methods

- **In-situ retorting**
  - Heat shale slowly to 650 to 700 degrees F
  - Recover 1/3 gas and 2/3 light oil
  - Potential for 1 acre to yield 1 million barrels of oil

**Advantages:**
- Much less land disturbance
- No tailings
- Better recovery efficiency
- Allows access to deeper oil shale reserves
- Higher-quality product

**Environmental concerns:**
- Groundwater contamination
- Energy consumption
Petrobras (Petrosix™ technology)

- March 2007 Jordan signed MOU with Petrobras for
  - exploration of Attarat oil shale
  - technical and economical feasibility study for use of Petrosix™ for production of oil from oil shale
• MOU is for 24 months
  – If the project is economically viable, the Jordanian government will award Petrobras a concession for the exploitation of oil shale in part of al-Attarat area
Oil Shale Energy of Jordan (Galoter Technology)

- November 5th 2006, Jordan signed MOU with Oil Shale Energy of Jordan to
  - carry out feasibility studies on surface oil shale deposits in 1/3 of the Al-Lajjun block
  - investigate retorting oil shale as source for liquid & gaseous fuel
  - employing Galoter Technology
Jordan Energy & Mining (ATP technology)

• November 5th 2006, Jordan signed MOU with Jordan Energy & Mining to
  – carry out feasibility studies on surface oil shale deposits in 1/3 of the Al-Lajjun block
  – investigate retorting the oil shale as a source for liquid and gaseous fuel
  – employing the AOSTRA-Taciuk Process (ATP)
Engineering and economical analysis shows that this is a viable process.

Test program with a Canadian Company “Suncor” for retorting Jordanian oil shale was carried out in 1998.
November 5th 2006, Jordan signed MOU with the International Corporation for Oil Shale Investment, to:

- Carry out feasibility studies on surface oil shale deposits in 1/3 of the Al-Lajjun block
- Investigate retorting oil shale as a source for liquid and gaseous fuel
- Employing Kiviter technology
Since the Kiviter retort cannot accept fines below 2.5 cm and the Galoter retort requires fines of <2.5 cm, the two retorts complement each other for full resource utilization.
Estonian experience in 2000 suggests that oil shale for power generation is viable at coal import prices above $40/t and natural gas import prices above $3.50/MBTU. The production of shale oil is competitive at crude oil prices above $25/bbl and at heavy fuel imports above $95/t.
Estonia

Electricity:

- More than 90% of power is produced in Narva Power Plants by using domestic fossil fuel oil-shale,

Structure of primary fuels 2000 (199,1 PJ)

- Renovation of oil shale power plants by introduction of new CFB (circulating fluidized bed) technology,
Development of power and heat production from oil shale in Estonia

<table>
<thead>
<tr>
<th>Construction date</th>
<th>Plant</th>
<th>MW electricity</th>
<th>MW heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1930s</td>
<td>Tallinn</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>1949–1967</td>
<td>Kohtla-Järve</td>
<td>39</td>
<td>534</td>
</tr>
<tr>
<td>1952–1957</td>
<td>Ahtme</td>
<td>20</td>
<td>338</td>
</tr>
<tr>
<td>1959–1971</td>
<td>Balti</td>
<td>1624 inc. 4 blocks at 200 MWe and 8 blocks at 100 MWe pulverized firing boilers</td>
<td>686</td>
</tr>
<tr>
<td>1969–1973</td>
<td>Eesti</td>
<td>1610 inc. 8 blocks at 200 MWe pulverized firing boilers</td>
<td>84</td>
</tr>
<tr>
<td>1995</td>
<td>renovation of turbines, extra repairs of boilers, new electrostatic precipitators, demolition of old blocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>two 215 MW Circulated Fluidized Bed (CFB) units commissioned in Balti and Eesti Power Plant</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusion:

- Excellent coordination & Team work (NRA-JCF), very good support from MOE, MOA, MOW & Kerak Governorate to make Jordanian dream (Utilizing Oil Shale) is more closer to reality.
- Without using Pet-Coke installations (15 MJD) in Fuhais & Rashadiya, this industrial test wouldn’t be possible.
- A successful substitution of 12% of fuel (60 tpd) is possible. Reaching the 25% target is still to be checked.
- Impact on Environment, Safety & Quality is insignificant. Impact on Process at more than 14% is questionable (To be checked).
- Saving compared to Normal fuel is clear but with Gas is narrow.
- Calorific value of used OS in the Industrial test is (1600 kcal/kg). Hope to have better calorific value in the new quarry location.
- Oil Shale Ash is a very good additive to Cement (potential for lowering CO₂).

Ash has shown good ability for grinding which assist in increasing the earlier strengthening for cement.
Cyclohexane+benzene by mixing 28 %
Carbon disulfide 24 %

Ethanol 0 %
Cyclohexane+benzene 6.5 %
Toluene 6.4 %
Dichloromethane 6.74 %
Petroleum spirit 9.09 %
Trichlorofloromethane 9.87 %
Carbon tetrachloride 11.7 %
Perchloroethylene 12.34 %
Xylene 13 %
Chloroform 13.2 %
• Kerogenous-organic-matter did not dissolve during Soxhlet Extraction Technique; bitumen is the only dissolved organic matter.

• The extraction yield and composition of the extracts are quite different in the case of different solvents.

• Solvent Extraction in an agitating medium enhanced organic solvent efficiency.

• Solvent Extraction Technique remains unproven technology in Oil Shale Exploitation.
The Role of Oil Shale in the Kingdom's Energy Master Plan (The Strategy)
As a result of H.M. King Abdullah’s great attention to the energy sector, a Royal Committee was formed to overlook and foster oil shale projects aiming at securing the country's needs for energy and facilitating local and foreign investment in this field. Therefore, oil shale will occupy a very prominent position in the national energy agenda.
• The GOJ has decided to start preparing for an integrated technical and economic feasibility study to determine the optimal utilization of this strategic source of oil shale.

• The GOJ has evaluated various options and considered oil shale as the most appropriate option that suits Jordan’s economy in the near future.
Why Oil Shale Strategy?

- Jordan is a non-oil producing country
- Energy imports create a financial burden on the national economy, representing 23% of GDP
- Jordan ranks third in oil shale reserves and has become one of the most attractive investment and operational acreage holders to oil shale development
- Implementation of the oil shale strategy will open up the market to competition and create several investment opportunities
• The current oil shale policy will lead to a multi-purpose process consisting of:
  – electricity generation,
  – thermal retorting,
  – cement production
  – mineral extraction

• to achieve high utilization factors for oil shale's chemical and energy potentials

• The strategy is proposed to make Jordan the first country to have a diversified and comprehensive oil shale implementation program that will present oil shale processing technology in commercial application
Consultancy Services

The GOJ has appointed two international Consultancy Companies:

1. Charles River International-England
2. Behre and Dolbear - through a grant from the United States Trade and Development Agency (USTDA)
Purpose of Consultancy Services

- Provide a clear vision along with a short and long-term strategy
- Provide competent advice and assistance in the form of technical, financial, economical and legal aspects
- Evaluate and identify critical issues, such as environmental protection, resource access, and infrastructure constraints
- Develop a detailed and well determined Negotiation Strategy leading to successful commercial agreements and project closure
- Review the terms of draft Commercial Agreements and advise the GOJ during the course of negotiations on terms and conditions that lead to successful negotiations
- Analyze current shale oil extraction recovery technology and examine their suitability for use in Jordan
- Apply the best international expertise to the development of an oil shale industry in Jordan
• Facilitate the implementation of near-term actions (Road Map) leading to the commercial production of shale oil
• Provide recommendations and advice for royalties and suggest best revenue sharing arrangements
• Ensure that any project shall follow local and international standards regarding equipment, environment and water consumption
• Identify key environmentally acceptable oil shale waste disposal practices
• Increase understanding of engineering issues concerning the design and scale-up of oil shale extraction and utilization
Essential Measures Taken by the GOJ to Encourage Foreign Investments in Oil Shale Processing and Utilization

- Keep the door open for any company who is interested to invest in the oil shale development
- Provide all available related data free of charge, as most of the information relevant to oil shale development was generated 20–30 years ago
- Grant exploration and mining rights for areas with adequate deposits
- Sign long term purchase agreements of the energy products of any oil shale project
- Facilitate all the logistics needed for oil shale utilization
Development Strategy

The strategy is being implemented in two phases and is designed to achieve the following objectives:

- To encourage development of oil shale through direct burning, surface and deep-mining retorting
- To license a small portion of resources to allow companies to develop their technology and capabilities
- To award acreage in the future to successful companies
## Oil Shale Known Retorting Technologies

<table>
<thead>
<tr>
<th>Retorting type</th>
<th>Oil (tpa)</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fushun</td>
<td>103000</td>
<td>China</td>
</tr>
<tr>
<td>Galotier, kiviter, Generator</td>
<td>300000</td>
<td>Estonia</td>
</tr>
<tr>
<td>Generator</td>
<td>202000</td>
<td>Russia</td>
</tr>
<tr>
<td>Petrosix</td>
<td>160000</td>
<td>Brazil</td>
</tr>
<tr>
<td>Taciuk (ATP)</td>
<td>200000</td>
<td>Australia</td>
</tr>
</tbody>
</table>
Exploitation Appraisal

The exploitation appraisal is expected to cover the full lifecycle of all activities necessary to exploit oil shale includes:

- Construction, development and ownership
- Operation and expansion of production facilities
- Mining operation
- Processing and storage facilities
- Power generation
- Transport and distribution infrastructure
- The wholesale and retail of finished products either to the domestic market or for export
- Sales or safe disposal of by-products
- Plant and mine decommissioning, land remediation activities
Phase 1

- In March 2006 the government decided to issue a Call for Proposals to 14 companies for developing a surface retorting oil shale facility in Jordan.

- The intention of the call for proposals was to:
  - Identify those companies ready to move quickly towards a real project
  - Allocate different areas other than that defined for the Shell concessions to different companies
The bidding process completed with only seven proposals from qualified companies.

The proposals were evaluated based on a series of clearly defined and well-focused criteria.

Companies were selected through two key measures - capability and strategic interest.

The capability assessment was based on: track record, technology assessment, project management, and financial capabilities.

Strategic interest was based on the level of interest in Jordan, regional focus, and whether investment in Jordan would provide an opportunity for the companies to develop and prove the capabilities of their technology.
• Phase one gave the companies the opportunity to demonstrate their competencies and for the GOJ to award companies with increased resources should the BFS demonstrate a viable project.

• This will be followed by good faith negotiations on concluding legally binding concession agreements to allow for the actual exploration and the commercial exploitation of oil shale.
The following five companies have signed MOU's and currently involved in techno-economical studies:

– Shell, using In-Situ Conversion Process (ICP)
– Petrobras, using Petrosix technology
– Oil Shale Energy of Jordan (OSEJ), using Gallotere technology
– Jordan Energy & Mining (JEM), using ATP technology
– International Corporation for Oil Shale Investment (INCOSIN), using Kiviter technology
Phase 2

- To attract interest from high capability companies to invest in oil shale development in Jordan
- To develop and execute a further licensing round
- Some of the other companies which participated in Phase 1 were deemed not qualified and instead it was decided to offer them the opportunity to participate in Phase 2 at a later stage, such that they have more time to develop their capabilities
• Prior to awarding any acreage to interested companies, the GOJ will wish to ensure that the companies have the capabilities to develop oil shale and that the acreage they are awarded be suitable in size and scale to the capabilities of the company.

• It is planned that a tender process be used for license award. This will require the companies to submit proposals and if successful to be awarded defined acreage rights.
Conclusion

• Oil Shale is one of the most abundant and accessible energy resource in the country

• There is a clear economic interest for Jordan to have oil shale developed and used as a strategic energy source

• Jordan is developing competition for access to its oil shale resources and has encouraged private sector involvement in this field so that Jordan is at this stage well placed in terms of implementing its strategy

• Jordan has become one of the top most attractive investment and operational acreage holders in regards to oil shale development
• Investment in oil shale is now open in Jordan on the basis of 
production sharing agreement and/or any agreement which suits Jordan.

• We are rapidly approaching a critical juncture for oil shale development.

• In the short and medium term, oil shale will dominate the world’s energy supply system.

• Oil shale is seen as a viable option at today’s oil prices so that oil shale utilization will result in significant savings in foreign exchange, improves Jordan’s energy supply and security and create new jobs.
Oil Shale More Profitable than Gold

One ton of oil shale produces one barrel of oil. When oil is selling for $50 per barrel, that's $50 per ton of rock.

Profitable gold-ore has about $12 worth of gold per ton. So, when oil is selling at $66 per barrel, like it is right now, oil shale is 5½-times more profitable than gold.

It's no wonder oil shale is called the richest fossil fuel on earth.
Oil shale will be on the energy policy agenda of both U.S.A and Jordan and more attention has been directed at technology and energy market developments that might change the commercial prospects for oil shale.
Energy Policy Act H.R.6 Sec 369

• Declaration of Policy – Congress declares that it is the policy of the United States that

  United States oil shale, tar sands, and other unconventional fuels are strategically important domestic resources that should be developed to reduce the growing dependence of the United States on politically and economically unstable sources of foreign oil imports.

Under high growth assumptions, an oil shale production level of 1 million barrels per day is probably more than 20 years in the future, and 3 million barrels per day is probably more than 30 years into the future.
Thank You For Your Attention

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