Results Based Management for Energy in Jordan with Reference to the Use of Oil Shale

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Abstract

Presented herein, is a proposed model for energy in Jordan RBM approach aiming at presenting a *Road Map* for Energy in Jordan with particular emphasis on using Oil shale as an economic source for energy as well as oil production. A complete two-fold seamless system is presented aiming at solving the energy crisis we are facing. The system tackles nearly all previous shortcomings related to cost, environment and the know-how technologies. On one fold, the new technology processes oil shale on site and does not require water in the process. The process is completely contained, with no harmful emissions to the atmosphere. The spent shale may have commercial value when used as a building material. On the other fold, The oil shale is crushed, burned to produce steam to generate electricity as a main source of energy in general and to feed the first fold in particular. Fumes are captured, condensed and used as a fly ash building material as well as in the Cement industry. This approach is sound and realistic provided that new technologies are employed for using oil shale as a promising renewable energy source. This management approach aims at brain storming in which corrective, preventive, predictive and detective management policies are discussed. Improvements in cost, quality, speed, etc. may be achieved by encouraging radical changes of governance and implementation. It is hoped that investors may be convinced to merge in and execute at least a model prototype plant in Jordan

Introduction

Jordan's energy sector will go under major modernization in the coming 10-15 years, with the approval of Jordan's Energy Master Plan by the cabinet, which will inject about $3 billion of public and private sector capital. This plan will cover all the activities of the sector from the exploitations of natural resources to electricity tariff levels, including energy demand, power sector development, gas distribution, oil refining and renewable energy. The plan also covers legislative and regulatory reforms. Under the first phase, Jordan will call for international investment in new power generation, gas distribution business, and the restructuring and reform of refined products sector. The Jordan Petroleum Refining Company was established in 1956 and has a current capacity of 107,000 b/d. Its monopoly concession is due to expire in 2008. A major up-grading project is under sturdy for the refinery with overall cost of $700 millions. One important resource that Jordan has is the oil shale; Jordan has 40-60 billion tones of oil shale, which makes it the third largest reserves in the world.

Jordan currently faces severe imbalances in its energy sector created by very modest local oil and natural gas resources and at a level of consumption, composed mainly of petroleum products, which continues to rise at high rates relative to economic and population growth. Consequently, the economy depends almost entirely on imported crude oil and petroleum products to meet its energy needs. Minimizing the country's reliance on oil and product imports is, therefore, important economically and strategically. Total primary energy consumption is projected to rise imposing a heavy burden on the country's finances. This makes imperative the development of Jordan’s huge proven oil shale reserves.

Until a few years ago the development of Jordan's oil shale reserves would have been economically unviable because of the high extraction and processing costs of shale oil. However, a breakthrough in oil-from-shale technology has made the extraction and processing costs of shale oil competitive with conventional crude oil, particularly when taking into account the cost of exploration for conventional oil. The economic benefits for Jordan's economy and its balance of payments make the development of shale oil worthwhile. This will enable Jordan to, eventually, become self-sufficient in oil and to recoup its investment within an estimated period of 8-10 years. There will also be the added bonus that Jordan could become a net exporter of shale oil. By proper management, this will enhance welfare and prosperity of the people in Jordan as well as Jordan's oil security for generations to come.

Results Based Management of Oil Shale

Results based management (RBM) is an approach that seeks to focus efforts and resources on the expected results of a project, program or organization. RBM builds on traditional management approaches such as management by objectives or activities, but shifts the emphasis from inputs and activities to results. Definition of the terms used in RBM approach is given in Appendix I. Considering energy in Jordan and the utilization of oil shale natural resources and the new technologies of retorting as program or a proposed project where the stakeholders of exchange the know-how and technical services, sustainability and maintaining the on-going momentum, requires the implementation of results-based management approach. In a changing world, the Results Based Management (RBM) has become a powerful tool that dominates all aspects of modern industry. Although perhaps not immediately apparent to some, RBM of the physical assets underpinning today’s industries has changed beyond recognition. We are witnessing occurrence of changes at all levels; from obviously technical shift due to the evolution of new materials, equipment, machines and systems, to strategic transformation in our thinking to develop planned energy activities. [1]

A vision for the 21st century that is directed to using oil shale in Jordan will be manifested by the will of the wise leadership defining the roles of all stakeholders and enhancing international cooperation. RBM may be considered as a powerful tool to realize this vision to make Jordan depending on its natural resources as will be presented herein after. Bearing in mind the simple know-how about oil shale stone as shown in Fig. 1 and the burned stone as shown in Fig. 2. Common products using early operations were kerosene, lamp oil, paraffin, fuel oil, lubricating oil, grease and ammonium sulfate.

With the introduction of the mass production of automobiles and trucks in the early 1900s, the supposed shortage of gasoline encouraged the exploitation of oil shale deposits for transportation fuels. Nowadays oil shale is back in the picture with increasing oil prices and declining crude oil production in most areas, therefore some world countries are taking another look at the huge volume of potentially recoverable hydrocarbons in vast oil shale deposits. Oil shale in great quantities ex-

Figure 1: Oil Shale

Figure 2: Burning oil shale.

ists worldwide: including in Australia, Brazil, Canada, China, Estonia, France, Jordan, Russia, Scotland, South Africa, Spain, Sweden and USA. Many economical and environmental methods has been investigated for utilizing this indigenous natural resource, which, due to its high organic content, is considered a suitable source of energy either by direct burning to generate electricity or by retorting to produce oil and gas. Jordan as one of the richest countries by this treasure; oil shale utilization in Jordan should be pursued because it will result in significant savings in foreign exchange, improve Jordan's energy supply security and create new jobs.

Input: Following the schematic flow diagram of RBM as shown in Figure 3, efforts were directed to scan all available information about this subject from all aspects. Literature survey was made and

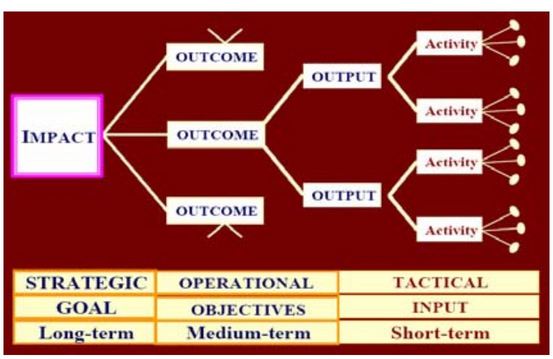

Figure 3: Results Based Management and Planning.

reported [2-7]. As far as the oil shale in Jordan, we cite information available [8,9]. One can easily have this input information in way or another; but the focus will be directed to the new technologies and the applicability of such technologies on Jordanian oil shale resources taking into consideration the environmental aspects and impact, the shortage of water and the lack of energy source on one hand and the needed budget and expenditures on the other hand [10,11].

Oil Shale Technology

Oil shale can be mined using one of two methods: *underground mining* using the room-and-pillar method or *surface mining*. Then it goes through the following major steps:

First step: Oil shale must be drilled and blasted. If it is to be processed other than *in situ*, the blasted rock must be loaded and hauled to the processing plant where it is crushed, and then heated.

Second step: The organic material in oil shale is Kerogen which is the first stage of nature's way of producing oil, but it has not gone through the "oil window" of heat, and therefore, to be changed to an oil-like substance, it must be heated to ≈ 900 °F. By this process the organic material is converted into a liquid, which must be further processed to produce an oil which is said to be better than the lowest grade of oil produced from conventional oil deposits, but of lower quality than the upper grades of conventional oil.

Third step: shale oil is chemically "Kerogen" – not petroleum. An additional hydrogen (H) atom is required to convert Kerogen into a hydrocarbon that can be refined into gasoline and other petroleum products. The missing hydrogen is usually supplied from water (H_2O) and requires a "pre-oil" plant plus large quantities of water. In order to release hydrogen from water, energy must be supplied [8]. These last two steps makes the refining procedure to produce gasoline from oil shale expensive for practical purposes.

Oil Shale Retorting: It is the step which comes after mining. The oil shale is transported to a facility for retorting. The vessel in which retorting takes place is known as a ***retort***. The available technologies for retorting are surface retorting and in-situ retorting.

Surface Retorting: While current technologies are adequate for oil shale mining, the technology for surface retorting has not been successfully applied at a commercially viable level although technical viability has been demonstrated.

In Situ Conversion: The in-situ retorting process is also known as *thermally conductive in-situ conversion*. The process involves the drilling of holes from the surface to the oil shale zone. Into these holes are inserted electrical resistance heaters which gradually (over a period of months) heat the oil shale to approximately 650-700 F^o. This heating process converts the Kerogen present in the oil shale into oil and gas, with the heavier compounds being partially converted in lighter end products. From the above mentioned technologies and considering the nature of oil shale resources in Jordan, surface retorting would fit best in most locations. It should be noted however, that other factors should be considered such as the shortages of both water and power. Therefore, improved and new technology which will be presented later would be the one that suits the Jordanian environment.

The Proposed System

Proposed herein is the set-up of two parts as shown in Figures 4 and 5. The unit in Fig. 4 could easily be used to produce oil by direct heating of the oil shale aggregates. The plant in Fig. 5 can be used, if augmented with the unit in Fig.4 to serve both producing oil and generation of steam as a major source of power supply. Description of components for the model shown in Figure 5 is given in Table 1. A new patented technology could replace the proposed unit in Fig. 4. It is ready and cab be used to produce oil in the short term. Detailed description of the retort is presented herein after.

Oil Shale New Technology: Oil-Tech, Inc. has designed, tested and validated a breakthrough method of economically producing oil from shale rock with minimal environmental impact. At last, the well known potential for utilizing the vast deposits of oil shale has been realized. The plant is described in Figures 6 through 9.

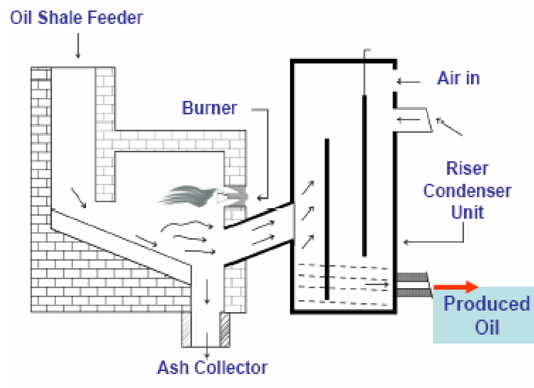

Figure 4: Oil Shale Furnace and Condenser Unit

There is actually no oil in shale rock. It contains organic matter that forms an oil compound only after it is heated and vaporized. The new technology process may be viewed as drastically speeding up the millions of years that nature would require to produce oil from the same geological ingredients. This rock produces 1.4-1.5 barrel of shale oil/m^3.

It was discovered that the linking steps from oil shale to oil could be accomplished by heating the oil shale in the absence of oxygen, a process known as destructive distillation at temperatures in the range of 1,000 F^o. When the organic components encapsulated within the shale oil are vaporized and condensed, the process is called "retorting." The trapped organics that are vaporized and condensed become the raw shale that is the base for further remediation to produce a refinery feedstock of an excellent quality. Apart from making oil, oil shale is an organic raw

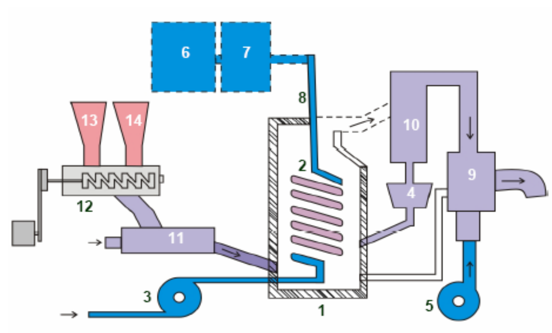

Figure 5: Oil Shale Furnace and Steam Generator.

Table 1. Definition of Model components.

Part Number	Part Name
1	Furnace
2	Heat Exchanger
3	Water Pump
4	Recycling Device
5	Air Fan
6	Steam Turbine
7	Steam Electrical Generation Station
8	Steam Flow
9	Combustion Gasses
10	Gas Collector
11	Feeder + Air
12	Oil Shale Granules Feeder
13	Oil Shale Inlet
14	Fuel Inlet

material used for various chemical products, such as adhesives, resins, cement, building materials, and insulation. Further benefits are outlined when interaction with other industries is realized.

New technology's approach to heating the rock is not only efficient, but it does not introduce combustion byproducts. The oil companies did not develop a process that allowed for cogeneration or recovery of remaining heat in the spent shale to reduce operating costs, or the development of other byproducts that added to the value of the process. New technology is actively pursuing these areas. The New technology process requires minimal water, with no water being used in the retort itself.

Figure 6: The New Technology Retort

The shale rock is mined using mechanized, high-volume mining equipment.

Figure 7: Condensing System Control.

Figure 8: Retort Control Room.

Figure 9: Dust Collector & Rock Processing Equipment

The mined shale, which is approximately 2" minus in size as a result of the mining process, is sent via conveyors to the oil shale processing equipment located near the mine. The rock is then further crushed and fed via conveyor equipment to the top of an 80 foot building contain a heating column, known as a "retort". The retort heats the shale rock until vapors from the organic materials are released. These vapors are then drawn into a condensing unit which consolidates the raw shale oil. The raw shale oil is finally subjected to a standard process that separates the refinery oil from other marketable byproducts [12].

The innovation and efficiency of the new technology process resides primarily in the design and utilization of the heat exchanger/retort system and the manner in which the vapor is heated, captured and condensed. Furthermore, the design has overcome the caking and plugging problems prevalent in previous retort technologies allowing the retort to function productively without the need for frequent downtime in order to remove the caked build up. The refinery feedstock has been shown to be low in sulfur content and is thus viewed as "sweet" or "light". One of the primary factors responsible for the quality of the crude is that the heating process does not use combustion within the retort, thus causing no combustion contamination of the end product or its associated byproducts. Methane and propane, a valuable energy source, is a primary byproduct. The shale oil remediation process also recovers pyridine from the shale oil which is well suited as an asphalt additive. and is also used in vitamins and medicines. By adding the nitrogen based compound from the shale oil to the asphalt "cement" known as AC-20, the life expectancy of the road surface is extended to approximately 20 years instead of 5 years. The spent shale has potential to be used in manufacturing such as drywall-type building materials. European efforts have already shown success in this area. Electricity co-generation is a major byproduct. Most will be used onsite for retort energy and mining, while any surplus would be sold onto the national grid. The potential for other byproducts exist. Many byproducts would not be economically viable if the production was limited to just that byproduct. In conjunction with producing oil, however, the economics of production shift dramatically. The New technology process is very efficient and removes virtually all of the hydrocarbon content from shale rock. The design of the retort specifically addresses the problem of plugging, caking and clogging. Contrast this to prior attempts by others which typically required shutting down the retort to clean the unit after only 24 hours of operation. The system uses electricity to initially heat the rock. After the process has reached "steady state," the electricity requirement for continuous heating drops dramatically. Furthermore, cogeneration capacity should be able to supply the ongoing needs to heat the rock. The resulting spent shale, with a temperature of above 1,000 degrees Fahrenheit, has a large heat value that will be used as a source for heating new shale rock entering the retort. The spent shale also has residual carbon content that may be combusted without producing visible emissions (primarily CO, CO_2 and NO_X) to further produce energy. Finally, the system produces propane, which is the final potential source of energy. New technology is currently designing a cogeneration system that will utilize the heat energy from these components and expects that the electricity generated as result will dramatically lower, if not eliminate, the energy cost linked to our patented process.

Past efforts used water to transport shale oil slurry through pipelines to a central processing center. The New technology retort technology processes oil shale on site and does not require water in the process. There is a secondary remediation on site to separate the refinery feedstock from the asphalt additive, and water is not required in this process. Water is required for personnel and safety use (showers, potable water, fire suppression), and for mining operations, most of which is recyclable. The need for water in the New technology plan is so minimal that it will be trucked to the site. The New technology process is completely contained, with no harmful emissions to the atmosphere. All products from the process are utilized within the sealed system.

Even the leftover spent shale has the qualities of desiccated charcoal which is used in many ways to absorb pollutants. Propane/methane gas, the cleanest burning gas known to the energy industry, is a byproduct of the process that may either be flared off or used to support the cogeneration efforts. Current tests on the spent shale indicate a very high efficiency in removing hydrocarbon content, leaving a byproduct material that has the characteristics of activated charcoal. This material is known to actually absorb industrial spills and pollutants. The spent shale will be delivered to a specific area on the lease via conveyor, with ground/earth moving equipment used to smooth out the area to allow for maximum storage over time. The spent shale may have commercial value when used, for example, as an ingredient in drywall type materials as is being pioneered in Europe. Due to the sealed nature of the retort and the method used to heat the rock, there is virtually no smell associated with the process. A faint smell can be detected when within a couple of feet of the retort. The early attempts by others required heavy capital expenditures on huge facilities based on the alleged benefits of economies of scale. The New technology process reverses that trend and uses smaller, easily replicated and fabricated modular units. These may be easily transported. Any operational/service problems do not disrupt production by more than a minimal percentage.

The Retort Cost: The first four 1,000 barrel/day retort cluster will cost approximately $6.5-$7.0 million. Subsequent units will be less expensive as a result of amortizing tooling and fabrication costs and via volume purchasing of component parts. The largest cost by far is the mining operation. Additional capital costs include such aspects as buildings, cogeneration equipment, and site development. The total requirement for a 20,000 barrel/day operation will be between $50 million and $150 million, depending primarily on mining equipment and mining development costs. Even the $150 million capital expenditure would be recovered in less than one year. Based on a 20,000 barrel/day mine, we estimate a cost range of $12-28/barrel depending upon mining methodology, cogeneration and other processing factors. The New technology process has been validated to produce shale oil with a very low energy cost. The system can also be upgraded by utilizing cogeneration and a variety of BTU recovery technologies that drastically reduce the need for external power for any site operations.

Action Plan

Some assumption and developments must exist to ensure proper planning at all levels considering the available resources and the sincere will of serving. Having that in mind, the expected results that will lead to proper utilization of oil shale as a reliable source of energy on hand and using the spent shale for other industries on the other could be accomplished within a decade. A schematic flow to attain this is shown in Figure 10. The vision for 21st century that will make Jordan enjoy prosperity is illustrated in Figure 11.

Goal: The major goal is to utilize the oil shale using the proper technology hoping to contribute with other energy and industrial projects, if that is feasible, to produce sufficient energy for use in Jordan. The long term expected result will be an impact that could be noticed on having high standards of living, rise in the national income. Energy is the backbone of all industries. This will improve the well-being of people. It ends with a healthier economy. The impact can be monitored by either qualitative and/or quantitative indicators. To achieve such a goal, energy consumption will be a major indicator. Assumptions must be defined to manage all activities where the long term results will

Figure 10: RBM Chain of input towards results.

Figure 11: Vision for the Use Oil Shale in Jordan.

lead to the prosperity of the nation.

Purpose: The purpose or objective of managing oil shale resources and latest technology is to enhance the proper use of shale rocks as a promising source of energy whether by direct burning and/or by harvesting oil through heating and cooling. Emphasis on the spent shale by-products is also considered as materials for use in construction, cement industry, asphaltic cement, chemical and medical use.

Expected results: they are termed as the outcome during the medium range that is assumed to be a decade through which oil production will be fully operational. The project can start producing oil using the patented retorts immediately after installation. Performance of such outcome is monitored and measured by the volume of produced oil and the volume of utilized spent shale for other industrial products.

Assumptions and Risk: The risk level is associated with the assumptions considered in the management system and the level of planning. Should the decision maker at the strategic level is convinced, then implementation of such a decision will then shifted to the operational level where the sincerity and ethic and professional performance will be counted on. Usually the risk level is high at the strategic level of planning; medium at the operational level and low at the tactical level and its associated activities.

Interaction with Other Industries: The spent oil shale should be not be disposed but to be used in chemical and construction industries. The Jordan Fertilizers company which became part of the Jordan Phosphate Mining Co. produces huge amount of unused phospho-gypsum as byproduct of the production of phosphoric acid. Traditionally, Lime (Calcium Oxide) is produced near *Saal;* a village in the north of Jordan. It was used as a building material when the cement was not known at that time. Since the production of lime from oil shale is possible, particularly when modern techniques are used, the production of lime can be combined with the production of oil where the residue of oil shale after distillation of oil, is burnt at 750 C° and the hot gases of combustion are used to distill the oil. By raising the temperature to around 1000 C°, the calcium carbonate content in the oil shale residue changes into lime (calcium oxide) and carbon dioxide. The latter is also produced from the combustion of carbon in the oil shale residue and from the decomposition of calcium carbonate at high temperature. Calcium oxide and carbon dioxide can be utilized in the production of soda ash (sodium carbonate), ammonium sulfate and potassium sulfate. This process is patented to the 2nd author. Due to space limitations, details of this process could not be housed in this paper. The insoluble calcium carbonate and the high soluble ammonium sulfate when produced could easily be separated by filtration. The residue of retorted oil shale can be burnt to give the required carbon dioxide. The ammonium sulfate solution can be used to produce potassium sulfate or to produce solid ammonium sulfate by evaporation of water. Because of the low solubility of potassium sulfate in ammonium chloride solution, we can get around 90% of the content of potassium sulfate by crystallization from ammonium chloride solution and 98%, if the solution is saturated by ammonia. Ammonium chloride is a by-product, which can be recycled to produce ammonia gas required in the ammonium sulfate production. The chemical reaction between ammonium chloride and lime is common in the production of soda ash and potassium sulfate. The purification of carbon dioxide is common in the production of soda ash and ammonium sulfate, which will reduce capital cost and production cost. It is believed that the production of oil from oil shale will be more feasible, if its production is combined with the manufacture of other products like those mentioned above.

Jordan oil shale ash is highly alkaline and requires no limestone to be added for sulfur removal. The pilot test results indicate excellent sulfur capture by the calcium present in oil shale. It is believed that this high calcium ash is suitable for manufacturing a wide range of products such as:

1. Construction materials including bricks, tiles and light weight aggregates and cement mixtures for concrete products.
2. Construction of road bases, and for use as filler in asphalt mixtures.
3. Soil stabilizer and fertilizer for liming acid soils.
4. Foundry cores.
5. Supplement to animal food.
6. Cement manufacturing development. It has a good grinding ability which assists in increasing the earlier cement strengthening. The cement containing some ash will exhibit strength acceleration after 3-7 days.

Salient Points: Since the project will mainly be executed in the southern part of Jordan and other projects may be under consideration, the following points deserve some attention:

1. The proposed new system of oil shale surface retorting requires power supply for heating the oil shale aggregates as well as for cooling and condensation. So the cited retorts could be further developed to use either direct heating by burned oil shale and/or heating by the produced gas.
2. Since Jordan has very limited water resources, the system could be used to generate steam that feeds turbines to produce electricity which in turn could be used for desalination of sea water.
3. It is advisable to know how this project is linked to two seas canal if executed with the time horizon as planned for this project.

The logical framework analysis for RBM Oil Shale Technology is summarized in Appendix II.

Conclusions

The following conclusions may be drawn from this study:

1. Surface retorting would be more appropriate the oil shale in Jordan.
2. The proposed system could easily implemented and tested within a very short period of time.
3. Within the foreseen future and considering the oil prices escalation, the proposed system is certainly pioneering as well as promising.
4. The spent shale can be used as an additive to asphalt for paving roads, streets and highways.
5. The spent shale could also be used to produce lime and construction material for concrete products.
6. The spent shale and lime could be used in the chemical industries.
7. The Results based management approach could be adapted for planning strategic projects such as the utilization of oil shale resources in Jordan.

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APPENDIX I: Terminology and definition of terms

RBM	Results-based Management is a management approach that seeks to focus efforts and resources on the expected results of a project, program or organization.
Result	The actual consequence of a cause effect relationship.
Results Chain	A progression of development results linked to each other by virtue of their cause effect relationships.
Inputs	The human, organizational and physical resources contributed directly or indirectly by the stakeholders.
Activities	Actions to be undertaken within the scope.
Output	Short-term developmental results.
Outcome	Medium-term developmental results.
Impact	Long-term developmental results.
Goal	Aim to be reached.
Purpose	The project objective or "statement of intent" to be achieved with the life of the project and which can be attributed to activities, outputs and outcomes.
Baseline data	The information starting point (quantitative or qualitative) from which progress towards result is measured.
Assumptions	Conditions that influence the achievement of or lack thereof result. Assumptions are issues over which the project planners and managers have generally little control. Yet, assumptions are necessary conditions for the project to perform. They represent the major risks and uncertainties.
Indicators	An indicator is " a pointer, measurement, a number, a fact, and opinion, or a perception that points at a specific condition or situation and measures changes in that condition or situation over time .Indicators may be either quantitative or qualitative in nature and seek to measure progress towards achieving results.
Risks	Risks indicate the probability that the assumptions will not hold true. Risk analysis seeks to monitor closely the inherent risks of a project throughout its cycle.
Sustainability	The capacity to maintain or reproduce development results for an extended period of time after the termination of the supply of external resources.
Efficiency	The correlation between all development results achieved and the total resources invested.
Effectiveness	The correlation between the development results achieved and the established project objectives, norms or standards.
Gender	Socially constructed roles of men and women, which vary according time and place. Gender roles are distinguished form sex roles, which are biologically determined and unchangeable. Gender is culturally based and learned behaviors which can change over time and is influenced by a wide range of socioeconomic and culture factors.

APPENDIX II: The Logical Framework Analysis for RBM Oil Shale Technology

<table>
<tr><th>Summary</th><th>Results</th><th>Indicators</th><th>Assumptions</th></tr>
<tr><td>Goal
Prosperity</td><td>Impact
Higher standard of living</td><td>Indicators
Improved economy</td><td rowspan="3">1. Political will
2. Investors readiness
3. Support of research
4. International cooperation
5. Technology transfer
6. Pollution control
7. New technologies
8. Know-how
9. Breakthroughs
10. New materials
11. Oil Shale web site
12. Training
13. Conferences
14. RBM application</td></tr>
<tr><td>Purpose
Extract oil
Cement development
Construction material
Chemical usage
Medical usage</td><td>Outcome
More oil production
New cements
New concrete products
Fertilizers
Cosmetics</td><td>Indicators
New refineries
Cement factories
Roads & buildings
Agricultural products
New industries</td></tr>
<tr><td>Resources
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New Oil Technology
Investors
Decisionmakers</td><td>Output
Pilot retort
Oil production
Cement filler
Work plan</td><td>Indicators
No. of retorts
No. of barrels
Energy saving
Rate of progress</td></tr>
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