MED-EMIP
Euro-Mediterranean
Energy Market Integration Project

Concept Paper for Creating An International Oil Shale Council For the Nations of Egypt, Jordan, Morocco, Turkey, and Syria

Prepared by Thomas A. Sladek, PhD
Ockham Energy Services
Lakewood, Colorado USA

Draft of 10 January 2010

Part 1: CONCEPT PAPER

A. VISION STATEMENT

The vision of the International Oil Shale Council is an oil shale industry that enhances the health of the planet and the lives of people, especially the people of Egypt, Jordan, Morocco, Turkey, and Syria.

B. MISSION STATEMENT

The mission of the International Oil Shale Council is to facilitate and promote the economical, efficient, and environmentally beneficial utilization of oil shale resources in Egypt, Jordan, Morocco, Turkey, and Syria and thereby to enhance the prosperity and security of those nations and their neighbors. This is to be accomplished by employing regional and international cooperation and by focusing the best available skills and facilities on the unique challenges and opportunities of the Middle East – North Africa (MENA) region.

C. OBJECTIVES

The primary objective of the International Oil Shale Council is to use regional and international cooperation to promote the practical and beneficial development and use of oil shale in Egypt, Jordan, Morocco, Turkey, and Syria.

Other objectives include:

- To create an institution where information, experience, expertise, facilities, and other capabilities can be pooled to address problems and opportunities of mutual interest to the five nations

- To provide an efficient mechanism to procure and manage technical and financial support from entities such as technology developers, energy companies, multilateral institutions, development banks, foundations, and the governments of concerned nations

- To assess the status of the oil shale industry in the MENA region and worldwide and to identify areas where additional work is needed to foster the timely and appropriate utilization of the resources

- To promote, facilitate, or conduct the needed programs and to disseminate the findings to stakeholders such as technologists, potential developers and investors, policymakers and regulators, advocacy groups, and the public

- To create an information base incorporating results of oil shale work in the five nations, with mechanisms in place for updating, expansion, and remote access, and to cooperate with programs to create similar resources in other countries

- To identify areas where local, regional, and international cooperation could reduce the costs and impacts of oil shale development and thereby foster a more beneficial industry

- To conduct conferences and issue professional publications

- To promote and support the training of miners, equipment operators, and other workers in the emerging oil shale industry

- To create and operate laboratories, pilot plants, and other facilities to support exploration and evaluation of oil shale occurrences and the testing, validation, and improvement of extraction and conversion processes and environmental controls, either alone or in cooperation with technology developers, project developers, or other firms and institutions.

D. STAKEHOLDERS

Stakeholders can be identified in four general areas, as follows.

1. Governmental agencies of nations with substantial resources of oil shale or other unconventional fossil fuels, such as heavy oil and oil sands.

- Agencies of Egypt, Jordan, Morocco, Turkey, and Syria
- Agencies of the other nations, such as the United States of America, Brazil, Canada, Venezuela, Australia, Estonia, People's Republic of China, and the Russian Federation

2. Firms that could benefit from the emergence of a viable oil shale industry

- Developers of projects to recover and use energy and materials from oil shale
- Energy companies requiring long-term supplies of petroleum substitutes
- Developers and marketers of proprietary extraction and processing technologies and equipment
- Vendors of mining, mineral processing, refining, transportation, and pollution control equipment
- Providers of engineering, procurement, and construction services
- Investment banks and equity pools
- Specialists in international law, financing, and logistics
- Research universities and institutions

3. Organizations promoting economic development, stability, and security in Egypt, Jordan, Morocco, Turkey, Syria, and other MENA nations

- United Nations
- World Bank Group
- Agencies of the major donor nations – Gulf Cooperation Council, European Union, Japan, UK, USA, Canada …
- Development banks – Islamic, Asian, African, …
- Foundations

4. Non-Governmental Organizations concerned about protection of the environment, cultural values, historical sites, worker health and safety, …

E. SCOPE & SERVICES OF THE COUNCIL

The scope of the Council's activities will be global and may include:

- Procuring, managing, and disseminating information and expertise

- Soliciting and managing technical and financial support

- Providing expert consultation to the member nations and other parties

- Organizing and participating in joint-venture projects with companies, institutions, and governmental agencies.

- Testing and evaluating oil shale resources.

- Testing, evaluating, and developing extraction and control technologies, either alone or in cooperation with technology developers, project developers, or other firms and institutions

The Council will need only office space and a small staff to initiate its work. Projects involving physical or chemical analyses or process testing and development may be contracted to commercial laboratories and research firms. The Council may, in time, choose to develop its own physical facilities to support its mission. These could include:

- A commercial analytical laboratory to support exploration, process evaluation, and product testing

- A remotely accessible library and data base of oil shale information

- A conference center and training facility for oil shale workers and observers

- Facilities to develop and test extraction technologies and environmental controls

The benefits of the Council's work will be widespread. Principal beneficiaries of the services will be five founding nations: Egypt, Jordan, Morocco, Turkey, and Syria.

F. APPROACH

Creation of the Council will proceed through four phases: Design, Development, Implementation, and Operations. The proposed conference in Sharm el Sheikh is an important step in the Design Phase. Participants should concentrate on defining the mission, scope, and feasibility of the Council; designating an organizational structure; assigning responsibilities to the member nations; and committing to the Development Phase. The principal tasks of the Development Phase will be

1. Creating a detailed strategic plan and promotional materials

2. Promoting the Council to the stakeholders identified above (governments, institutions, companies, foundations) to procure commitments of financial and technical support

3. Developing a work plan for the Implementation Phase

4. Reporting the results to the Council members and sponsors

The Implementation Phase will require much legal expertise and a multitude of contracts. The major tasks will be:

- Creating the International Oil Shale Council, complete with charter, bylaws, and other corporate documents, in accordance with the laws of each country in which the Council will operate

- Setting up a main office in one of the member nations and branch offices in the other members

- Selecting and engaging directors, advisors, and workers

- Installing systems for managing personnel, funds and other assets, schedules, and risks

The Operating Phase can begin immediately afterwards, to provide the services described previously. As discussed in Section K, the first projects might consist of a seminar on oil shale needs in the region; short courses on environmental assessment methods, regulatory standards and practices, and economic and financial analysis; and examination of the regulations and regulatory practices in the five nations. These projects would provide immediate visibility for the Council, establish its credibility, build networks in a number of crucial communities, and advance the readiness of the member nations.

G. VISIBILITY STRATEGY

International meetings are excellent forums for disseminating information on the Council's operations and accomplishments to workers in the oil shale industry. The annual symposium at the Colorado School of Mines in Golden, Colorado, USA is held in October. International oil shale conferences have also be conducted in Estonia, Jordan, People's Republic of China, and other locations.

A website and a monthly or bi-monthly newsletter may be the most effective ways to communicate with the other stakeholders. It may be advisable to maintain three or more sites, one in Arabic and the others in, say, English and French.

Papers in professional and commercial journals could also help disseminate information and announce plans and accomplishments. Candidate journals include *Fuel*, *Oil and Gas Journal*, *AIChE Journal*, *Chemical Engineering Progress*, *Mining Journal*, *Engineering and Mining Journa*l, the Estonian journal *Oil Shale*, and the numerous publications of professional societies such as the Society of Petroleum Engineers; American Institute of Mining, Metallurgical, and Petroleum Engineers; American Chemical Society; Canadian Mining Institute, and others. Targeted advertisements in the journals could also be helpful, especially to encourage attendance at conferences sponsored by the Council.

Strategic alliances with professional societies (such as AIME, AIChE, Society of Petroleum Engineers) and institutions (such as Colorado School of Mines, Tallinn University of Technology, universities in the Council's member countries) could greatly enhance visibility among colleagues in the fields of oil shale research and development.

H. FUNDING

The Design Phase, Development Phase, and Implementation Phase might be fundable with grants from donor nations, multilateral banks, development banks, or foundations. Cost of the Operations Phase will depend on the designated scope of the Council's services. If the work plan suggested in Section K is adopted, the Council will need about $800,000 for its first operating year. This funding might also be obtainable from donor nations, banks, or foundations. In the longer term, the Council might become self-sufficient by selling subscriptions to its information base, charging registration fees for conferences, and attaching overhead charges to fees for expert services.

Costs could rise substantially if the Council chooses to construct and operate physical facilities, such as analytical laboratories and pilot plants. Analytical services should be provided under a schedule of fees sufficient to cover operating costs and overhead. Pilot plant projects should be billed to the beneficiaries of such projects, at the cost of operations and overhead. The Council could market the expert services of its staff, associates, and advisors on a contract or consulting basis to others involved in oil shale development and share in the fee income from such activities. (This would have to be managed carefully to avoid conflicts of interest.)

If the Council's work produces enhanced processing or control technologies, these could be licensed to vendors and developers, perhaps including firms involved in industries other than oil shale. Licensing fees could help cover the Council's operating costs for a very long time, even if oil shale's emergence is delayed.

Perhaps the most practical approach, at least initially, may be to defer costly physical facilities, keep the staff small, and sell associate memberships to potential developers, agencies of other governments, and vendors of equipment and development services. This membership approach is fairly common in the trade association industry. Coupled with fees for services, memberships could make the Council self-sufficient very quickly, but only if operating costs are kept low.

I. BUSINESS MODEL

Both non-profit and not-for-profit models have compelling features. Both avoid taxation, if properly managed, which could be important for attracting associate members from firms subject to income tax. The non-profit model looks more like a charity, which could appeal to some potential members. The not-for-profit model allows retention of profits, provided these are reinvested in the organization to promote its mission. The need to register in each member country and each associate country should be confirmed by legal counsel.

J. STRUCTURE

Directors are likely to be required for any formal organizational structure. These could be organized into a board, with an elected chairman, to oversee and audit the Council's operations. An advisory committee will be essential, and it is important to staff it with representatives of the natural resource, environmental, and energy agencies of each of the five nations. Other advisors can be drawn from academia, NGOs, multilaterals, international law firms, financial counselors, and associations of energy companies, engineering companies, and equipment vendors (but probably not individual companies).

A full set of directors and a full advisory committee will be needed regardless of the initial size of the Council. However the organization chart for the Council's employees will be determined by how many employees are present. An executive director may eventually be needed, but perhaps not initially if the startup staff is small.

K. INITIAL WORK PLAN

Overview

Section F suggests four sequential phases for creation of the Council. The Design Phase is underway and will be the principal topic of discussion during the meeting at Sharm el Sheikh. The Development Phase will create a strategic plan and promotional materials, obtain support commitments from sponsoring stakeholders, and submit a work plan for implementation of the Council. The Implementation Phase will create the Council, set up offices, enlist leaders and workers, and install operating systems. The Operating Phase will conduct the Council's first projects. As initial guesses:

- The Development Phase might take four months; require one full-time professional, a large travel budget, a small support staff, and volunteers in each of the five nations; and should cost no more than $100,000.

- The Implementation Phase might take four more months and require two full-time professionals with limited staff support, part-time professional support and volunteers in each of the five nations, and substantial services from international law firms. The cost might exceed $200,000.

- The Operating Phase will continue for the life of the Council. A small staff – perhaps one manager, one associate, and a clerical employee full-time – should be sufficient during the early years. Expenses will be incurred for directors, the advisory committee, consultants, travel, communications, and office operations. Total costs will depend on whether the professional employees are foreigners but could exceed $1 million per year.

Initial Activities in the Operating Phase

The following three projects are suggested for the Council's first year.

1. Regional Symposium on Oil Shale Research and Development – a gathering of officials, scientists, engineers, and prospective developers from the five countries to share experience and data, to specify promising areas for additional R&D, to design appropriate programs, and to share resources to accomplish those programs.

2. Short Courses. Government personnel, especially in regulatory and finance agencies, will be intensely involved in the creation and operation of an oil shale industry. Diverse knowledge and skills will be required, and these are seldom available. Some of the countries have requested help with personnel training and technical support. A series of customized short courses could fill that need. Topics might include:

- **Management of environmental effects from oil shale development –** Characterization of the unit operations in minerals mining and processing, oil refining and transportation, and the production and distribution of electricity and other utilities. Identification of gross emissions and their implications for the ecosystem and human health and safety. Review of international standards for regulation and bonding. Identification of best control practices and their expected effectiveness with oil shale in the five countries.

- **Environmental impact assessment standards and practices –** Introduction to the internationally accepted methods for assessing environmental and social effects, regulating and offsetting emissions and other impacts, providing long-term protection of environmental resources, and mitigating damage. Methods for protecting groundwater resources are especially important in the MENA states.

- **Cost engineering and economic analysis –** Introduction to methods for estimating the costs of building and operating an oil shale facility and forecasting its economic feasibility. This knowledge is helpful for structuring bonus and royalty requirements, production sharing agreements, performance bonds, and penalties. It is especially useful if the government participates in project financing, either as a partial owner or as a source of capital.

Although all of the topics could be covered in one long week, it might be less disruptive to have three sessions with a two-week break between each. To encourage participation, the courses should be conducted in each of the five countries. To encourage understanding, the courses should be conducted in the business language of each country.

3. Audit for Compliance with Equator Principles. As discussed in Section F of Part 2, the Equator Principles are voluntary guidelines for assessing and managing social and environmental risks associated with financing of projects, specifically in low-income, non-OECD states. The Principles are based on the standards and guidelines of the World Bank Group. They are applicable to any new lending over $10 million, and they have been adopted by 68 financial institutions worldwide, representing around 90% of all project financing. If a project, such as development of an oil shale facility, does not comply with the Equator Principles, the financial institutions will not provide loans.

To avoid delays in the implementation of an oil shale project, it may be appropriate to examine the geographical areas in each of the five countries where development might occur and to specify the standards and guidelines which would apply if development were to proceed. The country's environmental and social regulations and practices could then be audited for compliance with the Principles, and suggestions could be made for any required modifications.

In later years, the Council should also consider participating in **creation of a global oil shale information center** – a computerized data base to provide access to oil-shale related documents in numerous institutions, agencies, and companies worldwide. The goal is to allow investigators to benefit from previous efforts, while avoiding duplication, and to facilitate orderly creation and operation of efficient and beneficial oil shale industries. The Colorado School of Mines and the University of Utah have begun digitizing their substantial oil shale collections and making them available through internet portals. The Council could apply similar techniques to collections in Turkey, Syria, Jordan, Egypt, and Morocco and help expand the scope to collections in Estonia, Germany, the Russian Federation, China, Australia, Canada, Scotland, Brazil, and other countries. Modern software should allow translation of key portions of each document into the business language of each participating country, including Arabic.

And in the longer term, the Council could support or engage in a wide range of **technical research and feasibility studies**. Numerous oil shale R&D programs are underway worldwide, but several topics relevant to the MENA resources would benefit from additional attention. These include the use of spent oil shale as a grouting agent to stabilize in situ retorts, water-conserving technologies for dust control and the safe disposal of mining wastes and retorted oil shale, co-pyrolysis and co-combustion of oil shale with other fossil fuels and waste materials such as plastics, and the use of spent in situ retorts as storage reservoirs for carbon dioxide. Many other region-specific topics could be identified if the intra-regional oil shale symposium, suggested as Project 1, is carried out.

There are also opportunities to reduce the costs and impacts of oil shale development through **cooperative programs with local governments and other industries** (such as water utilities and wastewater treatment systems) and shared processing facilities (such as crude shale oil upgrading plants, refineries, and pipelines). Engineering and economic studies are needed to assess feasibility. The council could organize and manage these programs and arrange funding from outside sources.

Estimated Operating Costs for Year 1

Table 1 shows the estimated costs of the Council's initial operating staff and of the consultants that might be engaged for the three projects described above. The estimates are based on arbitrary but not outlandish assumptions. They should be considered very rough and probably are optimistic. Although the costs of consulting services in particular are near the low end of the international scale, it should be possible to find capable, dedicated people to do the work.

The Council's staff consists of three people – a manager, an associate, and a support person. The total cost of their salaries and benefits (insurance, payroll taxes, paid leave, pension) is $256,250 per year. This is equivalent to a total cost $114 for each hour the office is open. The average for each of the three employees is $38 per hour.

The consultant employs similar people at similar costs but adds 200% of those costs to pay for overhead expenses and profit, for a total charge rate of $708,750 per year. This is equal to $341 per billable hour for the consultant's three employees, or $113 per hour each on average.

Table 2 shows how these costs might be allocated among the three projects, based on their duration and the relative importance of the consulting organization. In addition to costs for staff and consulting labor, the Council incurs expenses for travel and overhead items such as office rent and utilities, supplies, communications, local transportation, and accounting.

The total operating expense for the first year is $786,281, which is allocated as follows:

- **20% ($153,813) for the Regional Symposium** on oil shale research and development needs. Four months are allowed to design the program, select participants, arrange facilities and services, conduct the meeting, and document the results. The budget pays for conference facilities, labor, and some of the travel expenses of the participants. Most of the work is done by the IOSC staff.

- **50% ($400,523) for the Short Courses.** About six months would be needed to plan the sessions, obtain instructors, prepare course materials, conduct the classes, and write a report. Work would be divided equally between IOSC staff and the consultants.

- **20% ($155,656) for the Equator Principles audit.** This relatively short (two month) task might require about ten days of work in each of the five countries, with additional time needed to prepare country reports and document the project. The project would require a consultant familiar with oil shale operations and effects; with internationally accepted environmental standards, regulations, and enforcement practices; and with a working knowledge of the business languages of each country.

- **10% ($76,289) for other activities**, such as back-office operations, liaison with the Council's directors and advisors, advertising and public relations, and professional meetings.

The regional symposium should be conducted first and as soon as possible. The short courses and the Equator Principles audit could be conducted at the same time or in sequence. The other activities would be spread fairly evenly over the year.

Table 1: IOSC & CONSULTANT LABOR RATES, US$

IOSC Staff Costs	Salary $/yr	+ Benefits 35%	= Cost $/yr	= Cost $/hr
Manager	80,000	28,000	108,000	52
Associate	60,000	21,000	81,000	39
Support	35,000	12,250	47,250	23
Total	175,000	61,250	236,250	114

Consultant Costs	Salary $/yr	+ Benefits 35%	= Cost $/yr	+ Overhead 200%	= Charge Rate $/yr	= Charge Rate $/hr
Manager	80,000	28,000	108,000	216,000	324,000	156
Associate	60,000	21,000	81,000	162,000	243,000	117
Support	35,000	12,250	47,250	94,500	141,750	68
Total	175,000	61,250	236,250	472,500	708,750	341

Table 2: ESTIMATED OPERATING COSTS IN YEAR 1, US$

	1. Regional Symposium	2. Short Courses	3. Equator Audit	Other	Total
Duration, months	4	6	2	12	-
IOSC Staff Time	80%	75%	60%	26%	-
Hours	555	780	208	537	2,080
Labor Cost @ $114/hr	63,000	88,594	23,625	61,031	236,250
Share	30%	40%	10%	30%	100%
Consultant Time	25%	75%	100%	0%	-
Hours	173	780	347	0	1,300
Labor Cost @ $341/hr	59,063	265,781	118,125	0	442,969
Share	10%	60%	30%	0%	100%
IOSC & Consultant Labor	122,063	354,375	141,750	61,031	679,219
IOSC Travel*	16,000	24,000	8,000	-	48,000
Other Costs**	15,750	22,148	5,906	15,258	59,063
Total Costs	**153,813**	**400,523**	**155,656**	**76,289**	**786,281**
Share	**20%**	**50%**	**20%**	**10%**	**100%**

*4 trips/month at $1000 = $4,000/mo

**Rent, utilities, supplies, phone, local transport, other: 25% of IOSC Labor Cost

Part 2: SUPPORTING INFORMATION COLLECTION

A. CURRENT OIL SHALE ACTIVITIES

International

United States of America

Most of the oil shale work in the USA is taking place in the Green River Formation, specifically in the Uinta Basin in the state of Utah and the Piceance Basin in the state of Colorado. These areas have been characterized as home to the world's richest hydrocarbon resource, containing far more potential energy than has ever been extracted from the world's petroleum reservoirs. While individuals and private firms (notably energy companies) own large blocks of the oil shale lands, the richest and thickest deposits are owned by the national government and managed by the Bureau of Land Management, a subdivision of the U.S. Department of the Interior. In the 1970s, the BLM leased two tracts of land in Colorado and two in Utah to energy companies, with the intent of creating a prototype oil shale industry. Mines were developed and retorting tests were conducted, but the projects did not survive the collapse of oil prices in the 1980s. The leases were abandoned, and surface facilities were removed. Mine shafts in Colorado were plugged, but the White River oil shale mine in Utah was preserved.

The 2005 federal Energy Policy Act required leasing of oil shale lands for experimental purposes and the development of rules for commercial leasing. In 2006 BLM issued six leases, each for 160 acres (65 hectares) with an option to expand the leasehold to 5120 acres if development is shown to be feasible and beneficial. The lessees are:

- **Oil Shale Exploration Company**, which will apply aboveground retorting to oil shale near the White River oil shale mine in Utah. OSEC's lease agreements with the national and state governments cover more than 30,000 acres (12,000 hectares) of oil shale property containing up to 4 billion barrels of potential shale oil. In June 2008, OSEC announced investment and development agreements with affiliates of the Brazilian national energy company Petrobras and Japanese investment and trading company Mitsui & Company Ltd. Petrobras will study the feasibility of processing the oil shale in Petrosix retorts. Mitsui will provide management advice. Studies are underway.

- **Chevron USA, Inc.**, which will develop an *in situ* technology. The process consists of drilling two holes into the oil shale formation, linking the bottoms of the holes by fracturing the formation with carbon dioxide gas under pressure, using propellents or explosives to rubble the oil shale above the fracture, and then heating the rubble to retorting temperatures with a heat-carrying fluid, such as additional hot carbon dioxide.

- EGL Resources, Inc., which will develop an *in situ* technology. This one relies on advanced oilfield production techniques to access and heat the oil shale and withdraw the fuel products. Boreholes will be drilled from the surface into the oil shale zone, deviated to the horizontal direction, and then deviated again to return to the surface. A hot fluid will be injected into each hole, passed through the oil shale formation to heat it, and returned to the surface for reheating. Initially, natural gas or propane will supply the heat. After retorting temperatures are reached, gas produced by kerogen decomposition might be used. Oil and gas will be produced through wells drilled vertically from the surface into the production zone.

In January 2008, IDT Corporation acquired a majority interest in EGL Oil Shale and renamed it American Shale Oil, LLC. In March 2009, the French energy firm Total bought half of AMSO. IDT retained the other half and is the operating partner.

- Shell Frontier Oil & Gas, Inc., which will develop its In-situ Conversion Process. The ICP is conceptually similar to the Ljungström process, which was used at Kvarntorp, Sweden, by the Swedish Shale Oil Company from 1940 to 1966. Shell's process involves boring a ring of holes into an oil shale zone, inserting an electrical resistance heater into each hole, and, over a period of many months, heating the entire zone to retorting temperatures. Oil and gas will be drawn to the surface for processing through a centrally located production well.

Shell leased three tracts to work on the ICP. On the first site, Shell will continue the development work begun on its privately owned Mahogany site. On the second, Shell will test combining the ICP with the recovery of nahcolite, a valuable sodium mineral that co-occurs with the oil shale in the Piceance Basin. On the third, Shell will develop advanced heating equipment to use in the ICP.

ExxonMobil Corporation failed to obtain a lease but has proceeded, in laboratories and on its holdings in Colorado, to develop several technologies, including its Electrofrac *in situ* process. In that process, pairs of wells are drilled into the oil shale, and hydraulic fracturing is used to establish communication between each pair. An electrically conductive fluid is injected into the fractures, and it is heated with electrical current. The heat is transferred to the oil shale by conduction. Pyrolysis products are drawn to the surface through production wells.

Other *in situ* developers include the following:

- Mountain West Energy is developing its In-situ Vapour Extraction (IVE) technology to recover fuels from heavy oil deposits and oil shale. Hot gas is forced through a central injection well into fractured oil shale, and crude shale oil is recovered through a ring of extraction wells. Mountain West has proposed to use IVE in a heavy oil field in Wyoming. A license has been issued to use the technology for oil shale in Morocco, as discussed below.

- **Oil Shale Alliance** is an association of three small technology development companies. Phoenix Wyoming Inc. seeks to heat oil shale *in situ* by using microwave generators in boreholes. Petro Probe Inc. will inject hot gas to heat the oil shale and will produce the pyrolysis products through the same borehole. Independent Energy Partners Inc. will heat oil shale electrically, through boreholes, using solid oxide fuel cells to generate the electricity.

- **Raytheon and CF Technology** propose to insert radio-frequency antennae into boreholes in oil shale, use the RF energy to heat the oil shale, and then extract the fluid fuels with supercritical carbon dioxide. In 2008, Raytheon sold its oil shale technology to Schlumberger, an oilfield service company.

Portions of the Piceance Basin oil shale are immersed in ground water. This presents obvious challenges for *in situ* processing, because the temperature of the formation cannot exceed the boiling temperature of water until all the water is gone. That temperature is not sufficient to decompose kerogen. AMSO proposes to avoid the problem by attacking a zone of deeply buried oil shale which is dry. Shell proposes an innovative “freeze-wall” technology to isolate the zone of oil shale that is to be processed. A ring of boreholes is drilled around the zone, and a refrigerated liquid is circulated through the holes. The refrigerant freezes the water between the boreholes and forms a wall that the groundwater cannot penetrate. Water within that wall is pumped out, and heating commences. The freeze wall must be maintained until all the oil shale is retorted.

Other developers of aboveground retorting projects include the following:

- **Millennium Synthetic Fuels Inc.** is developing the Oil-Tech retorting technology, which heats sized oil shale in a vertical shaft kiln with hot gases. Millennium controls 34,000 acres of state oil shale leases in Utah

- **Red Leaf Resources** is developing the EcoShale In-Capsule Process on 16,500 acres of state oil shale leaseholds in Utah. Broken oil shale is placed in a trough made of earth and is covered with earth. Hot gases are passed through the oil shale in pipes, heating the oil shale and decomposing the kerogen. When retorting is completed, the capsule is left in place, with its load of retorted oil shale, and the exposed surface is reclaimed. Low capital cost is an obvious advantage.

- **Syntec Inc.** proposes to gasify coal and use the hot gases to retort oil shale in a rotary kiln.

- Shale Technology International continues to develop the Paraho retorting process at its pilot plant facility near Rifle, Colorado. The Paraho technology shares history with the Petrosix process used by Petrobras. Shale Tech is closely associated with the rebirth of the Stuart oil shale project in Australia.

In October 2009, the Department of the Interior announced its intent to open additional public oil shale lands for a second round of RD&D leases. If a lessee demonstrates feasibility, it will have preference rights to another 480 acres of land to produce the oil.

People's Republic of China

Significant oil shale deposits are found in many of China's provinces, including Liaoning, Jilin, Guangdong, Heilongjiang, and Shandong. Liaoning has the largest deposits, although oil yields are relatively low. Fushun Mining Group, a state-owned mining company headquartered in the city of Fushun in Liaoning Province, has been processing oil shale since 1991 and is now one of the world's largest shale oil producers. FMG's retorting plant comprises 180 Fushun-type retorts with a total annual design capacity of 11 million tonnes of oil shale or 330,000 tonnes of shale oil. The plant was expected to produce 300,000 tonnes of oil in 2008. The plant can also convert oil shale ash into bricks and about 300,000 tonnes per year of cement.

Fushun retorts are vertical shaft processors that convert about 100 tonnes per day each of coarsely-ground oil shale. (Oil shale from Jordan's El Lajjun deposit was tested in Fushun retorts in 1985 by China Petro-Chemical International Company (SINOPEC), FMG's predecessor at the Fushun works). FMG is adding a 250 tonne per hour ATP processor to handle pieces of oil shale smaller than 8 mm. These cannot be converted in the Fushun retorts. The ATP unit has been delivered, and installation is underway. FMG has announced plans to build a "big plant" capable of producing 400,000 tonnes per year of shale oil.

In Huadian in Jilin Province, Jilin Energy & Communication Corporation burns 300,000 tonnes of oil shale per year in three fluidized bed boilers and produces 12 MW of electricity. (Similar technology has been proposed for use in Jordan.) The plant was completed in 2006. Jilin Energy, together with China Power Investment Company, is developing a large integrated project in Huadian that will process 2 million tonnes per year of oil shale in Petrosix retorts and produce 200,000 tonnes per year of shale oil. Two fluidized bed combustion units will convert the retorted shale into 100 MW of electricity. Ash will be used in cement.

Also in Huadian, five companies produce a total of 30,000 tonnes of shale oil per year with Fushun retorts. Environmental effects are not well controlled.

In Wang Qing County in Jilin Province, a private company mines oil shale in an open pit mine and processes it in 10 Fushun retorts. In 2006, 15,000 tonnes of shale oil were produced. Environmental effects are not well controlled.

Also in Jilin Province, Royal Dutch Shell is working with a local partner to explore the oil shale resources and evaluate the potential of Shell's In-situ Conversion Process.

A SINOPEC subsidiary has proposed to build an oil shale power plant in the city of Maoming in Guangdong province. A retorting plant has been proposed for Zhan County in Heinan Province.

In 2006, China National Petroleum Company (PetroChina), China's largest oil company, established a special department to promote energy production from oil shale, tar sands, and biomass. Oil shale research is being conducted at the company's Langfeng branch. In August 2008, PetroChina began building a plant in Mudanjiang in Heilongjiang Province that will convert 1.2 million tonnes per year of oil shale into 100,000 tonnes of shale oil. Da Qing Oil Company is also engaged in oil shale exploration and production.

China National Coal Company and Harbin Coal Chemical Company have tested fluidized bed retorting of oil shale in a large pilot plant. They have proposed to build a 1000 tonne per day shale oil plant in Heilongjiang Province. Several other minerals companies have proposed oil shale projects, including some involving co-processing of oil shale and coal.

Estonia

Oil shale was discovered in Estonia in the 1700s, and serious development began after World War I. Oil shale use peaked in 1980 at 31.4 million tonnes, dropped rapidly after liberation in 1990, and then rose again. More than 80% of the oil shale was burned in power plants.

Early power plants burned pulverized oil shale in conventional boilers, which had low energy efficiencies and caused serious air pollution, especially emissions of fly ash and sulfur dioxide from the high-sulfur fuel. Air quality improved with the addition of pollution controls and the advent of fluidized bed combustion boilers. The large land areas devastated by disposal of waste shale are being reclaimed.

Firms and factories in Estonia's current oil shale mining and processing industry include Eesti Põlevkivi AS (Estonian Oil Shale Ltd.), Eesti Energia AS (Estonian Energy Ltd.), the Narva Power Station, the Narva Oil Factory, Viru Keemia Grupp AS (Viru Chemistry Group Ltd. or VKG) and others.

Today about 12.2 million tonnes of oil shale is mined per year in Estonia. Shale oil production uses 1.5 million tonnes to manufacture 230,000 tonnes of shale oil. The cement industry uses 200,000 tonnes, and the power generation industry converts 10.5 million tonnes into 6,800 GWh of electricity. The modern retorting plants use Kiviter or Galoter retorts.

Power plants burning oil shale make more than 90% of Estonia's electricity, and retorts produce about 8000 barrels per day of shale oil in three locations. Two of these operations are run by VKG and use Kiviter retorts, each with a capacity of 1,000 tonnes per day. The other plant, the Narva Oil Factory, is run by Eesti Energia AS, the national power utility, and uses two TSK140 retorts. These are descendents of the UTT/Galoter retorts developed when Estonia was part of the Soviet empire. Each processes about 3,000 tonnes per day of oil shale. In 2006, the Narva Oil Factory produced about 130,000 tonnes of shale oil.

In February 2007, VKG began building a new unit that would expand its shale oil capacity by 40%. The plant will use an updated version of the UTT solid heat carrier retort to process up to 3000 tonnes of oil shale per day, or 900,000 tonnes per year. Engineering design was performed by Atomenergoproyect, a Russian industrial design bureau. The plant was undergoing startup testing as of the end of October 2009. It was originally estimated to cost EUR 70 million. VKG has also announced its intent to increase shale oil production by adding an ATP retort.

In November 2007, VKG announced it had obtained a permit to develop approximately 350 million tonnes of oil shale in the Boltõški deposit in Ukraine. The total volume of the Boltõški resource is about 3.8 billion tonnes, but only a small portion is recoverable.

In November 2008, Eesti Energia and Finnish minerals processing company Outotec announced an agreement to form a joint company – Enefit – to develop oil shale processing methods. In May 2009, Eesti Energia announced its intent to add new processing units and upgrading facilities for the crude shale oil and two oil shale-fired electricity generators. The plant will process 2.26 million tonnes of oil shale annually and produce 290,000 tonnes of shale oil and 75 million cubic meters of gaseous fuel for electric power generation. A 35-megawatt steam turbine will use waste process heat to produce electricity. Estimated cost of the retorting complex is EUR 192 million.

In July 2009, Outotec announced that the plant would use the new Enefit fluidized bed retorting technology. The retorted shale will be burned in fluidized bed combustion units to generate electricity. Outotec will receive EUR 110 million for its design, procurement, and construction services. The plant will start up in early 2012.

Eesti Energia is heavily involved in the emerging oil shale industry in Jordan. As discussed later, the company's subsidiary Oil Shale Energy Jordan has agreements with the government to investigate a 36,000 barrel per day retorting plant and a 600 to 900 MW power station.

Brazil

Brazil's deposits of oil shale are second in size only to those in the United States. The Irati formation oil shale is comparable to a medium grade of Colorado shale and has yields similar to the yields from Jordanian oil shale. In 1953, Petrobras, the national oil company, began developing its own retorting technology, which it named Petrosix. In 1970, construction of a demonstration retorting plant began at Sao Mateus do Sul, near the city of Curitiba, in the State of Parana. Petrobras built two large pilot-scale Petrosix retorts. A unit with a 5.5 meter diameter was completed in 1981 and can process 1,600 tonnes per day of oil shale. An 11-meter diameter unit was completed in 1991 and can process 6,200 tonnes per day. The facility's total capacity is 7,800 tonnes per day. It can produce 480 tonnes per day of fuel oil, 90 tonnes per day of industrial naphtha, 120 tonnes per day of fuel gas, 45 tonnes per day of liquefied petroleum gases, and 75 tonnes per day of sulfur, plus solid residues that can be used in asphalt, cement, agriculture, and ceramics. The plant also processes scrapped vehicle tires to recover oil, gas, and sulfur. Since May 2001, more than nine million tires have been processed, at a rate of 1,500 tonnes per month (3.5 million tires per year), equal to about 5% of the oil shale throughput. Gas that is not consumed in the process is piped to a nearby ceramics plant. Heavy fractions of the shale oil are used in asphalt. The naphtha fraction is burned in boilers and or used to make solvents. Sulfur is sold in bulk.

Petrobras has not announced plans to expand its oil shale activities in Brazil. However it is actively engaged in development projects in Jordan (with Total S.A.), in the United States (with Oil Shale Exploration Company and Mitsui & Company Ltd.), in Morocco with Total, and in China (with Jilin Energy and China Power Investment Company).

Australia

Australia has very large oil shale resources, principally in the northeastern state of Queensland. From time to time, between 1865 and 1952, Australia had oil shale industries of substantial size. The Stuart resource near the town of Gladstone in Queensland has received the most attention lately, because of the work by Southern Pacific Petroleum NL (SPP) to develop oil shale using the ATP retorting technology.

The Stuart Project was formed in June 1997 as a joint venture between Suncor Inc. of Canada and the affiliated Australian companies SPP and Central Pacific Minerals (CPM). In April 2001, Suncor sold its interest in Stuart to SPP and CPM and left the project. SPP and CPM later merged their operations into a single entity: SPP. Although the project had many significant accomplishments, it had ongoing technical problems with an undersized dryer. Correcting those problems required substantial capital investment. Servicing the debt created a cash flow problem, and the secured creditor placed the company into receivership. In February 2004, Queensland Energy Resources Ltd. acquired most of SPP's assets. Suspension of the project was announced in July 2004. In August 2008, QERL announced that it was abandoning the ATP technology in favor of the Paraho II technology. The ATP plant was dismantled. QER processed 8,000 tonnes of oil shale from its Australian deposits in the Paraho pilot plants maintained by Shale Technology International in Rifle, Colorado. As of October 2009, QERL was completing a feasibility study and seeking management approval to restart Stuart with Paraho retorts.

Others

Resource surveys and limited field exploration studies are underway in Canada, Thailand, and other places. The Holcim Cement plant in Dotternhausen, Germany, continues to make cement from oil shale. Tests continue on the alum shale in Sweden to determine feasibility of recovering oil, uranium, nickel, molybdenum, and vanadium.

Regional

Turkey

Turkey imports more than 90% of its liquid oil and natural gas. Lignite is the largest resource of fossil energy and is exploited for power generation, despite its low heating value and high sulfur content. Oil shale is the second largest fossil-fuel resource.

Lacustrine oil-shale deposits are widely distributed in middle and western Anatolia in western Turkey. Only a few of the deposits have been investigated, and there are few resource estimates. A 1993 report estimated total resources of in-place shale oil for eight Turkish deposits at 284 million tonnes (about 2.0 billion barrels). In 2006, investigators from Middle East Technical University and Michigan Technological University reviewed data on 13 deposits and estimated the total resource at 2.2 billion tonnes. The largest deposit in terms of proven resources was Beypazari in the Ankara region, which was believed to contain 328 million tonnes of oil shale. The oil content was given as 5.4%, which suggests an in-place shale oil resource of 18 million tonnes. In 2001, Turkey consumed 77 million tonnes of oil-equivalent energy, so the shale oil potential at Beypazari, although large, is not sufficient to displace imported energy for very long. The average sulfur content is 1.4%, and most of the sulfur is inorganic. A shale oil product probably would be high in sulfur.

A better alternative to retorting might be combustion in power boilers, either alone or co-mingled with the domestic lignite. The carbonate minerals in the oil shale could absorb the sulfur dioxide produced during combustion and thereby reduce air pollution. The Himmetoğlu oil shale deposit in the province of Bolu is especially interesting in this regard. The in-place shale oil content averages 43% by weight of the rock, and the potential oil yield is 482 liter per ton (3 barrels per ton). The sulfur content is 2.5%, which is very high, but the minerals are mostly calcite and dolomite, both of which can adsorb sulfur compounds from combustion gases. The oil shale seam lies above and within a lignite zone. The co-development of the two fossil fuels and their co-combustion in power plants could be practical.

Syria

According to the Energy Information Administration of the U.S. Department of Energy, Syria produces and consumes modest quantities of oil and natural gas but occupies a strategic location in terms of regional security and prospective energy transit routes. Syria is the only significant oil producer and exporter in the Eastern Mediterranean region. Production has been in decline since the mid-1990s while domestic demand has been increasing. Syria's demand for electricity is also growing rapidly. Syria plans to accelerate development of its natural gas resources and to become a hub for natural gas transport through a regional pipeline system. Development of Syria's oil shale resources – to produce oil, fuel gas, or electricity – may be consistent with these plans.

A 1984 report described an occurrence of oil shale in the Wadi Yarmouk Basin near Syria's southern border with Jordan. The deposit is probably an extension of the Yarmouk deposit found in northern Jordan. The strata are marine limestones that are common in the Mediterranean area. The mineral components of the oil shales are 78% to 96% calcite and other carbonates. The sulfur content is 0.7 to 2.9 percent. Oil yields by Fischer assay are 7% to 12% by weight, which may be rich enough for commercial exploitation if a large number of other factors are favorable.

In January 2009, Syria's oil minister announced the discovery of large quantities of oil shale in the northern part of the country near Aleppo. The deposits are near surface and extend over a large area. Preliminary estimates place the resource at 2.5 billion tonnes.

In October 2009, representatives of Syria and Jordan agreed to exchange expertise in the use of oil shale to generate electricity, which is a priority activity in Jordan's efforts to develop an oil shale industry.

Jordan

Jordan's people consume about 107,000 barrels of liquid fuels per day. Electricity demand peaks at about 2 gigawatts. Except for a small amount of natural gas, all of the primary energy resources are imported. Oil and oil products are trucked from the port at Aqaba. Natural gas comes in a pipeline from Egypt. Energy imports have become very expensive, and the government of Jordan has renewed its efforts to exploit the Kingdom's large resources of oil shale.

Oil shale deposits underlie more than 60% of Jordan and are estimated to contain up to 70 billion tonnes of oil shale. There are at least 26 deposits. The Yarmouk deposit in the north may be very extensive, possibly underlying several hundred square kilometers and reaching 400 meters in thickness. The four best-known deposits - El Lajjun, Sultani, Jurf Ed-Darawish, and Attarat Umm Ghudran - are much smaller but still contain about 35 billion tonnes of oil shale. They are located in west central Jordan, 100 to 150 km south of Amman and 20 to 75 km east of the Dead Sea, near the towns of Karak and Qatrana.

The resources are typically at shallow depths, in essentially horizontal beds. Up to 90% of the oil shale should be amenable to surface mining. At the average oil yield of 7.5% (roughly 19 gallons per short ton) the potential shale oil in place is 17 billion barrels, which could satisfy Jordan's liquid fuel and electricity needs for centuries. There are limitations, however. Although the rock could be mined at low cost, the sulfur level is high and the ash yield is about four times that of a medium grade of bituminous coal with similar sulfur content. This makes the rock a difficult and expensive solid fuel. The liquid product is also difficult. Shale oil from El Lajjun contains 14 to 17 times as much sulfur as shale oil from Colorado's Piceance Basin.

Recovery of sulfur from shale oil and gas could provide a small but very helpful revenue stream for an oil shale project. Sulfur is needed by Jordan's fertilizer manufacturers, and its availability from a local source would help the industry and the Kingdom. On the other hand, the high sulfur content of the crude shale oil is a very serious concern, because it makes the oil corrosive and unstable, increases the cost of refining, and makes it difficult for the finished products to meet modern quality standards. Sulfur also inhibits the potential use of the crude shale oil as a fuel for industrial or utility applications. The mineral matrix could be helpful in this regard, because the carbonates could adsorb the sulfur gases as they are formed.

When the crude oil is distilled, the sulfur distributes itself through all of the fractions produced. Refining would be easier if the sulfur preferred one end of a distillation column or the other, because then the other fractions could be refined with relative ease. Similar problems can be anticipated for the similar oil shale resources in other MENA nations.

Surface water is scarce in Jordan, and ground water will need to be tapped for oil shale operations. The shallow aquifer that underlies the best-known oil shale deposits provides fresh water to cities in central Jordan. It lacks capacity to also supply an oil shale industry. There are other opportunities for obtaining water for oil shale, but these need careful study and planning.

The government of Jordan has executed memoranda of understanding with several potential oil shale developers, as follows:

- November 2005: MOU allowing Jordan Cement Factories Company to manufacture cement from El Lajjun oil shale.

- June 2006: MOU with Royal Dutch Shell to evaluate applying Shell's In-Situ Conversion Process to deeply buried oil shale in central and southern Jordan. In December 2008 an agreement was signed for up to $25 billion in additional investment, subject to demonstration of technical and economic feasibility. The first oil could be produced within 12 years of the agreement's execution.

- November 2006: MOU with the Estonian energy company Eesti Energia to recover fuels from the El Lajjun deposit using the Galoter retorting technology. The project was later relocated to the Attarat Umm Ghudran deposit because of concerns about the shallow aquifer that underlies El Lajjun. In April 2008, Eesti Energia submitted a feasibility study for a 36,000 barrel per day retorting complex to be completed in 2015. That same month the government gave Eesti Energia exclusive rights to build a large power plant using oil shale as fuel. That plant is to have a capacity of 600 to 900 megawatts and is also to be operational by 2015.

- November 2006: MOU with Jordan Energy and Mining Ltd. to investigate use of the Alberta Taciuk Process to retort El Lajjun oil shale. JEML processed 86 tons of El Lajjun oil shale at the ATP pilot plant in Alberta, Canada, and completed a preliminary feasibility study in May 2007. The MOU was revised to provide access to oil shale in the Attarat region. In 2010, JEML plans to begin front-end engineering and design for the first production module and to proceed with financing. A concession agreement with the government is pending.

- November 2006: MOU with the International Corporation for Oil Shale Investment (INCOSIN) to evaluate an aboveground retorting project in the El

Lajjun area. The company proposed to use both Estonian Galoter retorts (which process fine oil shale particles) and Russian Kiviter retorts (which process coarse particles).

- March 2007: MOU with Brazil's national oil company Petrobras to examine the application of its Petrosix retorting technology to part of the Attarat Umm Ghudran deposit. The global energy company Total S.A. is participating.

- October 2008: MOU with the International Company for Oil Shale Investment under which INCOSIN.BVI Ltd. will evaluate development of oil shale in the Attarat Umm Ghudran area.

The agreements cover both *in situ* retorting and aboveground processing in a diverse selection of retorts, with a range of potential production capacities, in several of Jordan's oil shale areas. One agreement could produce a major power generating facility capable of meeting most of Jordan's electrical demand, and one agreement provides for recovery of a valuable byproduct – Portland cement. With these agreements, Jordan is well positioned to become a major producer of shale oil. However there are restraints.

In addition to the usual issue areas – economic feasibility, land disturbance, waste management, water requirements, and environmental, social, and cultural concerns – Jordan has a special problem with competition for other minerals contained in and around the oil shale deposits. The problem arises because Jordan wishes to develop nuclear power facilities fueled with Jordan's own uranium, and some of the Kingdom's uranium resources overlap some of the Kingdom's oil shale resources. In November 2008, Jordan's Natural Resources Authority announced its intent to stop all oil shale activity for eighteen months while conflicts with the uranium program are sorted out.

Egypt

In 2008, John Dyni of the U.S. Geological Survey reported that oil shale has been found in two areas in Egypt – the Safago-Quseir deposit (containing estimated in-place resources of 644 million tonnes of oil shale and 4.5 billion barrels of shale oil) and Abu Tartur (172 million tonnes and 1.2 billion barrels). His source was a 1984 German report by geoscientist Uwe Troger of Berlin Technical University. Troger also reported Fischer assay yields of 20 to 45 gallons of crude shale oil per ton (0.5 to 1.1 barrels per ton) and up to 5.7% by weight of gas.

Interest in Egyptian oil shale has risen in recent years. A 2007 paper by investigators from Al-Azhar University and the Egyptian Geological Survey provided some details about the major resource areas and suggested that the "black shales" could be an important energy resource for Egypt.

In February 2007, Centurion Petroleum Company announced an agreement with the Egyptian Mineral Resources Authority to quantify the resources of oil shale in Egypt and to evaluate the feasibility of commercial exploitation. The goal is to diversify Egypt's energy supplies and thereby to conserve some of the country's economically important oil and natural gas.

Morocco

Morocco's Tangier oil shale deposit was discovered in the 1930s, and two other large deposits – Timahdit and Tarfaya – were discovered in the late 1960s. Tangier is in extreme northern Morocco, close to the Straits of Gibraltar. Timahdit is about 250 km due south of the Tangier deposit, and Tarfaya is on the Atlantic coast in southern Morocco. At least seven other deposits have been discovered. The total shale oil resource is estimated at 50 billion barrels, which could satisfy Morocco's oil demand for nearly 800 years.

The Tangier deposit is relatively small and thin, and oil yields are low. The more attractive Timahdit and Tarfaya deposits have been intensely studied, including preparation of technical and economic feasibility studies. The oil shale is similar to the marine shales of Egypt, Israel, and Jordan. Oil yields are not high (60 to 70 liters per ton, on average) but the deposits are large, thick, and fairly close to the surface. Both deposits could be developed by open pit mining. Sulfur is present in the rock, and the shale oil contains nearly 7% sulfur by weight. The carbonate minerals calcite and dolomite are found in significant concentrations, which could help control air pollution if the oil shale is burned. Phosphate rock and uranium are also found in the oil shale, so recovery of valuable byproducts is a possibility.

When oil prices soared in the 1970s and 1980s, energy companies from North America and Europe explored the deposits and conducted mining and processing studies. More than 2200 tonnes of Timahdit and Tarfaya oil shale were processed in pilot plants in the USA, Europe, Canada, and Japan. Most of the advanced retorting processes were employed, plus the T^3 retort, a technology developed especially for Morocco. An 80 tonne per day T^3 pilot plant was built in Morocco and operated from 1983 to 1986, processing more than 2500 tonnes of Timahdit oil shale. This experience was used to complete a feasibility study for a 25,000 tonne per day processing plant. A study was also completed for a 50,000 barrel per day project using modified *in situ* technology. Pilot plant testing of Tarfaya oil shale was used to complete feasibility studies for 53,800 and 60,000 barrel per day plants using aboveground retorts.

The commercialization programs were discontinued after oil prices collapsed in the middle 1980s. High oil prices after 2004 revived interest in oil shale, and the Office National des Hydrocarbures et des Mines (ONHYM) is pursuing a new development strategy aimed at reducing the Kingdom's high dependence on imported energy. ONHYM identifies the major challenges as:

- Economic – Oil shale plants require major investments and must operate for long times to achieve profitability. Volatility of crude oil prices makes these investments risky.

- Technological – Treatment technologies need more work, which must be completed quickly.

- Environmental – Developers must invest in environmental protection.

The challenges are being attacked on several fronts. Fiscal laws and regulations are being revised to encourage private investment. Expertise and capacity to manage oil shale R&D projects is being emphasized. Exploration programs and analytical studies have resumed. Partnerships have been established with energy companies, developers of processing technologies, operators of oil shale plants, universities, and research centers. The industrial partnerships cover both oil production and generation of electricity.

In June 2009, ONHYM executed an MOU with Brazil's national oil company Petrobras and with Total to explore both the Tarfaya deposit and the Timhadit deposit. The goals are to confirm the findings of the feasibility studies undertaken in the 1980s and to determine if the retorting technology owned by Petrobras could recover fuels economically. Another MOU was signed with San Leon Energy Plc to apply In-situ Vapour Extraction (IVE) technology to a 6000 km^2 segment of the Tarfaya deposit. San Leon Energy licensed the technology from Mountain West Energy, a Utah firm. IVE is an *in situ* technology that forces hot gas through a central injection well into fractured oil shale. Crude shale oil is recovered through extraction wells spaced around the injection well. IVE has been proposed to enhance heavy oil production in the Tea Pot Dome Field in Wyoming.

Synopsis

Internationally:

- In the **USA**, numerous *in situ* and aboveground retorting processes are being developed in Colorado and Utah, including some that are backed by global energy companies and some that, in the long run, could obtain access to the rich, thick oil shale resources controlled by the national government. Shell's ICP technology is also being evaluated in Jordan and China. The IVE *in situ* technology developed in the USA is being evaluated in Morocco. The OSEC project is supported by Petrobras, which is also active in Jordan and Morocco.

- The oil shale industry in **China** is expanding very rapidly, with large power plants and retorting facilities expected to emerge over the next few years. The power plants will use fluidized bed combustion units, as proposed by Eesti Energia for Jordan. An ATP retort (proposed by JEML for Jordan) is being installed at the Fushun works. Petrosix retorts (proposed by Petrobras and Total for Jordan) will be used in Jilin Province. Shell is seeking places in Jilin to use its ICP technology.

- In **Estonia**, VKG is completing a major expansion of its shale oil plant. Eesti Energia has formed a strategic alliance with Outotec and plans major upgrades to its retorting plant and power plant. Work on both power and retorting are relevant to Eesti Energia's work in Jordan.

- **Brazil** is not expanding its domestic oil shale industry, but the national energy company Petrobras is actively involved in projects in Jordan, the USA, Morocco, and China.

- **Australia** seems to be getting back into the oil shale business, probably in Queensland, possibly with Paraho retorts.

Regionally:

- Turkey imports nearly all of its oil and gas, and a domestic source of those fuels would be very helpful. Unfortunately Turkey's oil shale deposits are relatively small, and the best use for the oil shale may be as solid fuel in electricity generating stations, probably co-mingled with domestic lignite.

- Syria is a net exporter of oil and imports only a small quantity of natural gas. Syria's has large reserves of natural gas, and the gas could become an important export commodity. Syria may wish to develop its oil shale to conserve the natural gas resources. The recently discovered deposits in the north might be developed using surface mining and aboveground retorting. And it may be practical to use *in situ* technology to develop the very large Yarmouk deposit along the border with Jordan. A cooperative program with Jordan could help both countries.

- Jordan imports all of its oil and more than 90% of its gas. Jordan is trying to relieve this situation by developing the Kingdom's oil shale. The goal is to produce both fluid fuels and electricity. Several leading aboveground retorting processes are being evaluated, along with the *in situ* technology owned by Royal Dutch Shell. The deep, thick Yarmouk deposit in north Jordan may be the most suitable for *in situ* processing, perhaps in cooperation with Syria.

- Egypt, like Syria, is a net energy exporter. Exportation of natural gas from Egypt's substantial reserves is an important source of foreign exchange. Development of Egypt's oil shale could help conserve those reserves.

- Morocco, like Jordan, is almost totally dependent on imported oil and gas. Domestic reserves of conventional oil and gas are very small, but resources of oil shale are very large. Development of those resources appears to be the only way to reduce the Kingdom's absolute reliance on energy imports.

Except for the lacustrine oil shales in Turkey, the typical resources in these countries are characterized by an abundance of the carbonate minerals calcite and dolomite, medium yields of crude shale oil, substantial sulfur concentrations in the raw shale, and very high levels of sulfur in the crude oil. These characteristics produce some interesting opportunities and challenges, which could be productively addressed by an international oil shale council.

B. RESEARCH NEEDS & ACTIVITIES

Research Needs

Oil shale research has been conducted by universities, private firms, and governmental laboratories for many decades. Much of the early research was technological in nature and was a response to the need to locate oil shale resources with economic potential and to produce oil from those resources at a cost competitive with the cost of more conventional liquid fuels, such as fat from whales and other animals, coal oil, and the refined derivatives of natural petroleum. Both governmental agencies and private firms participated in technology development; sometimes cooperatively, sometimes in competition. Conversion efficiency, investment costs, and operating costs were the important considerations. Impacts on the physical and social environments did not receive much attention.

The growth of environmental regulation after 1970 introduced a host of new needs. Some of these were technological in nature. For example:

- Devices for measuring and monitoring environmental conditions and emissions were needed.
- Industrial pollution controls had to be improved and new ones developed.
- New methods were required for restoring disturbed lands and ensuring safe disposal of mining and processing wastes.
- Sophisticated forecasting tools (atmospheric dispersion models, models of groundwater hydrology …) had to be constructed or adapted for the affected regions.

Planning and public policy needs also emerged. Studies were required to forecast the adequacy of infrastructure such as utilities and transportation systems to support development or to predict the effects of various levels of development on local or regional populations, airsheds, or water systems. Models of energy supply and demand and price elasticity were also needed, on a global scale, to forecast when prices of conventional fuels might be high enough to allow oil shale projects to flourish. More recently, the need to address climate change concerns has led to both policy studies (to estimate net emissions of greenhouse gases from oil shale development, for example) and technical investigations (of carbon capture or offsetting technologies, for example). In addition, the unfavorable image of oil shale mining and aboveground disposal of the mining and processing wastes, combined with a desire to access deeply buried resources, has renewed interest in *in situ* processing. This technology has many research needs.

Research Activities

Much of the current research is focused on topics of local concern, such as describing occurrences of oil shale with some commercial potential; evaluating the adequacy of infrastructure such as utilities and transportation systems to support development; or forecasting the effects of development on local or regional populations, airsheds, or water systems. Even some of the ostensibly basic research, such as studies of reaction kinetics, is likely to have a regional bias since it is influenced by the chemical and physical characteristics of the resource being studied.

In the United States, major research programs are conducted at the Colorado School of Mines, the University of Utah, the U.S. Geological Survey (a subdivision of the U.S. Department of the Interior), and several national laboratories controlled by the U.S. Department of Energy, including Los Alamos National Laboratory and Idaho National Laboratory. In June 2009, the Office of Naval Petroleum and Oil Shale Reserves of the U.S. Department of Energy published a report entitled *Oil Shale Research in the United States -- Profiles of Oil Shale Research and Development Activities in Universities, National Laboratories, and Public Agencies* which summarizes the numerous studies under way at those institutions. Here is a list of the research topics.

Colorado School of Mines: Center for Oil Shale Technology and Research

Geomechanical behavior of oil shale
Geochemical properties and analytical methods for oil shale production
Oil shale information office

Colorado School of Mines: GIS-based Water Resource Geospatial Infrastructure

Web-based geoinfrastructure and data dissemination
Energy resource development systems models
Surface water and groundwater modeling
Transfer technology

Idaho National Laboratory

Dynamic impact model / information system to support unconventional fuels development
Dynamic system modeling of regional influences from energy resource development
Generation and expulsion of hydrocarbons from oil shale
Modeling deformation and fracturing of oil shale rock during *in-situ* retorting
Near field impacts of *in-situ* oil shale development on water quality
Nuclear pathways to energy security
Western Energy Corridor initiative
Carbon and water resources impacts from unconventional fuel development in the Western Energy Corridor

Los Alamos National Laboratory
Common data repository and water resource assessment for the Piceance Basin
United States Geological Survey
Oil shale assessment
Analysis of environmental, legal, socioeconomic, and policy issues critical to the development of oil shale leasing on public lands in Colorado, Utah, and Wyoming under the mandates of the Energy Policy Act 2005
University of Utah
Basin-wide characterization of oil shale resource in Utah and examination of *in-situ* production models
CO_2 emissions
Effect of oil shale processing on water compositions
Kerogen/asphaltenes atomistic modeling
Market assessment of heavy oil, oil sands, and oil shale resources
Multiscale thermal processing of oil shale
New approaches to treat produced water and perform water availability impact assessments
Oxy-gas combustion for CO_2 capture in thermal processing / upgrading
Policy analysis of water availability/use issues in context of domestic oil shale/sands development
Pore scale analysis of oil shale pyrolysis by X-ray micro CT and LB simulation
Repository of data, information, and software related to oil shale and oil sands
Utah oil shale resource evaluation
Utah Geological Survey
Evaluation of the Birds Nest aquifer and its relationship to Utah's oil-shale resource

The results of most of these studies are unlikely to help a MENA nation develop its oil shale. However the methodologies might be transferable and could be very helpful to MENA investigators. One possible contribution of an International Oil Shale Council would be to examine the research conducted worldwide and assess its relevance to the council's member countries.

Substantial oil shale research is also carried out in the MENA nations. The government of **Morocco**, for example, has conducted a large number of investigations of Morocco's two main deposits since they were discovered in the 1960s. These studies accelerated after the 1973 oil crisis and have continued until the present day, with some time off after oil prices collapsed in the 1980s. Projects have included exploration and analysis programs, processing tests, and feasibility studies, some in cooperation with foreign firms and universities.

In **Egypt**, the Egyptian Petroleum Research Institute has conducted a range of retorting tests and analytical studies on Egyptian oil shale, including some directed towards recovering byproducts, such as grease and chemicals. Since 1992, EPRI has published the Egyptian Journal of Petroleum, a peer-reviewed journal that features original research papers on petroleum, natural gas, and unconventional fuel resources such as biomass, tar sands, and oil shale.

A significant research project was conducted between 1994 and 1998 and culminated in the publication of a report *Availability of Oil Shale in Egypt and its Potential Use in Power Generation*. The project concluded that Egyptian oil shale is a feasible but expensive fuel for power production, and development would have to await high prices for oil and coal. An experimental 20 MW oil shale power plant near Quseir was recommended.

Although oil shale resources in **Turkey** are relatively small, they have been fairly intensely studied. Research into their utilization began in 1928 and has been continuous, although sometimes at a low level, since the 1970s. Special emphasis has been placed on co-retorting and co-combustion with other materials, such as heavy oils, lignites, and waste plastics such as polyethylene. Professor Ekrem Ekinci, of the Department of Chemical Engineering at Istanbul Technical University, provided an excellent summary of Turkish research at the International Conference on Oil Shale in Amman in November 2006. Co-processing studies conducted in the 1990s may be significant for oil shale development in other MENA nations. When oil shale was retorted with waste polyethylene, for example, the product oil was lighter than oil obtained from oil shale alone, suggesting the possibility of a hydrogen-donor mechanism. Other tests showed that carbon prepared from oil shale was 2.5 times more efficient at adsorbing hydrogen sulfide pollutants than standard commercial carbon. Both findings suggest productive pathways for future oil shale research.

In **Jordan**, oil shale and all other minerals are considered property of the state. The body charged with regulating the exploitation of minerals is the Natural Resources Authority (NRA) of the Ministry of Energy and Mineral Resources. NRA establishes development policies, grants permits, and monitors operations to ensure compliance with the regulations. NRA also conducts, sponsors, and participates in research programs as they relate to minerals characterization, extraction, and use. In January 2007, NRA published a compact disc containing a huge collection of information on the resources and the previous attempts to commercialize them. Research programs are also ongoing, in NRA as well as in the Kingdom's universities and research institutions. The National Energy Research Center, an arm of the Higher Council for Science and Technology, has conducted a series of technical and policy studies related to Jordan's energy situation and the potential roles of conventional fuels and alternate energy resources, such as oil shale. Tafila Technical University maintains the Energy and Oil Shale Research Center, the primary function of which is to conduct research on oil shale development and the consequences of shale oil production, including carbon management and impacts on water resources. The center supports an oil shale information office which receives and disseminates information about oil shale and coordinates its collection with repositories in governmental agencies such as NRA and with international repositories of oil shale information. Al Balqa Applied University has an active oil shale program and has published many reports and papers on the potential role of oil shale in Jordan's energy future and how oil shale development could affect water availability and environmental and cultural resources. Technical research projects include experiments with advanced retorting techniques and the development of processes to recover associated minerals, such as uranium and rare earths, from the oil shale. Many other schools have programs dedicated to oil shale.

Implications for the Council

Many oil shale research projects are underway in many places. The results may not be directly transferable to the MENA nations because the research was conducted with different types of oil shale deposits in different economic and social circumstances. However the methodologies employed by the researchers could be very relevant. The International Oil Shale Council should consider, as an ongoing function, reviewing R&D programs in other countries and assessing their relevance to work in the Council's member states.

Processing of oil shale mixed with other materials (such as coal, lignite, biomass, plastic) may have important implications for oil shale development in the MENA nations. Turkey is already considering co-combustion of oil shale with lignite in power plants, to reduce the release of acidic gases and other air pollutants. Jordan and Syria might consider mixing oil shale with similar solid fuels, or with high-sulfur fuel oil, which is relatively cheap because few power plants can use it without causing unacceptable levels of air pollution. Morocco might consider burning a mixture of oil shale and coal in its large power plants, such as Jorf Lasfar and Mohamedia, which together consume 4 million tons per year of coal. Oil shale could displace some of this imported coal and might allow Morocco to source higher-sulfur (and therefore cheaper) coal. Egypt could consider adding oil shale to low-value residual fuel from its refineries and burning that mixture for power production, thus conserving some of the important oil and gas reserves. Similar opportunities are presented by waste plastics, which are troublesome for nearly all countries. Co-processing with oil shale could relieve the plastics disposal problem and produce higher quality oil and gas. Co-processing, both retorting and combustion, is a ripe area of involvement for the International Oil Shale Council.

C. BENEFICIARIES OF OIL SHALE DEVELOPMENT

The principal beneficiaries of oil shale development will be the developers, owners, and operators of the oil shale processing facilities, the governments that obtain leasing and royalty revenues, and the populations those governments serve.

Secondary beneficiaries will include providers of oil shale processing technology, mine development and plant construction consulting, drillers, cranes, shovels, excavators, draglines, continuous miners, haulage systems, conveyors, crushers, compressors, specialty plates and pipe, earthmovers, concrete, fuels, fellerboom bunchers, knuckleboom loaders, power equipment consulting, suspension boilers, fluidized bed boilers, power turbines, generators, switchgear and power transmission equipment, emergency power supplies, distributed control systems, air separation plants, specialty gases, coatings, fasteners, catalysts and specialty chemicals, water treatment and wastewater management equipment and supplies, and pollution control equipment and chemicals; plus lawyers, engineers, accountants, librarians, elected officials, clerks, medical personnel, brokers, marketers, business executives, plumbers, psychologists, messengers, pipefitters, botanists, lobbyists, bankers, electricians, regulators, computer programmers, information managers, millwrights, welders, technical writers, janitors, grocers, caterers, drivers, operators of waste collection services and sanitary landfills, mechanics, security staff; and specialists in environmental protection, solid waste management, dispersion modeling, archeological reconnaissance, permitting, transportation, water development, economic feasibility studies, powerplant construction and maintenance, construction management, technology licensing, oil refinery operations, corporate and project finance, and engineering, design, and construction services; and others.

D. PLAYERS

Eminent experts, researchers, and business executives in the field of oil shale extraction and utilization are identified in the attached four documents:

- **DOE R&D in the Public Sector Profiles 2009.pdf**, which is the document *Oil Shale Research in the United States -- Profiles of Oil Shale Research and Development Activities in Universities, National Laboratories, and Public Agencies in the United States*, which was published by the Office of Naval Petroleum and Oil Shale Reserves of the U.S. Department of Energy in June 2009. It describes the major research programs underway at the Colorado School of Mines, the University of Utah, the U.S. Geological Survey, Los Alamos National Laboratory, Idaho National Laboratory, and the Utah Geological Survey. Contact information is included for each project.

- **DOE Secure Fuels Report Oil Shale Tar Sands Company Profiles 2009.pdf,** which is the document *Secure Fuels from Domestic Resources - The Continuing Evolution of America's Oil Shale and Tar Sands Industries: Profiles of Companies Engaged in Domestic Oil Shale and Tar Sands Resource and Technology Development*, which was published by the Office of Naval Petroleum and Oil Shale Reserves of the U.S. Department of Energy in September 2009. This third edition includes profiles for some 35 companies engaged in oil shale development in the United States. Each profile includes contact information for a spokesperson.

- **Oil Shale Symposium 2009 Registrants. pdf**, which is the list of registrants for the 29th Oil Shale Symposium, held at the Colorado School of Mines in October 2009.

- **Oil Shale Counterparts(2).xls**, which contains names, titles, phone numbers, and email addresses for the members of the MED-EMIP advisory committee.

E. NEEDS ANALYSIS

Table 3 summarizes the energy economies of five MENA nations - the five prospective members of the International Oil Shale Council - plus Germany for comparison.

Three of the MENA nations import nearly all of their oil and oil products: Turkey 95%, Jordan 100%, and Morocco 95%. Syria is a substantial oil exporter, and Egypt is essentially neutral.

The same three nations import nearly all of their natural gas: Turkey 98%, Jordan 92%, and Morocco 89%. Syria imports about 2% of its gas. Egypt exports substantially, including supplies to Jordan and Syria.

All five countries appear to be self-sufficient in electricity, but the statistics for Turkey, Jordan, and Morocco are misleading because much of their electricity is generated using imported fuels.

Being an energy importer isn't necessarily bad of itself. Germany also imports more than 80% of its oil and gas. However Germany has the world's sixth largest economy and can afford to pay for its fuels. Security of Germany's fuel supply is a concern, however, as was demonstrated in January of 2006 when Russia curtailed its shipments of natural gas through Ukraine to Europe. Turkey, Jordan, and Morocco must deal with the same security concerns, plus they are much less able to pay for imported oil. When crude prices soared in 2008, Jordan spent 20% of its GDP on imported oil.

The potential strategic importance of oil shale deposits in Jordan and Morocco is obvious. Turkey's resources are much smaller, especially relative to Turkey's oil consumption, but they nevertheless represent a potentially valuable asset. Syria and Egypt are energy exporters, although Syria's oil reserves are diminishing. The main benefit of oil shale development in those countries may be the ability to displace their conventional oil and gas, which could be sold for export credits. In any case, there is much to be gained from regional cooperation, and oil shale may be a good place to start.

F. ENVIRONMENTAL ISSUES & SOLUTIONS

Oil shale development faces a host of environmental and social challenges. These are associated with all aspects of a project, from making land available for development to long-term care of restored production sites and waste disposal areas. There are also concerns about the quantities of water required for mining and processing and the need to protect groundwater resources, especially in the areas that will be affected by *in situ* processing, mining and aboveground retorting, and waste disposal. Also, it appears likely that concerns about emission of greenhouse gases from synthetic fuel facilities, such as oil shale plants, will only increase in importance as time passes.

These concerns are not unique to potential oil shale developments in the MENA nations. Early operations in Brazil and Estonia caused serious environmental damage, which is only now being remediated. Much has been learned about how to control emissions from oil shale retorts and power plants and how to protect land, water, and air from residues and wastes and how to restore land disturbed by mining. This experience is directly transferable, although it will have to be customized for the peculiar circumstances in each development area.

The need for water may present the most serious challenges. Although oil shale plants produce water (from mine drainage, drying, mineral dehydration, and combustion in retorts and heaters), they also consume water (for dust control, cooling, power production, land reclamation, and municipal uses). Overall, a plant will be a net consumer of water, and the required water supplies may be difficult to secure, especially in arid countries such as Jordan and Morocco. The impacts of such consumption can be minimized by using water-conserving technologies (such as drying cooling in power plants), by using non-potable groundwater or treated wastewater where practical, and by cooperating with other developers and other water users in the procurement and use of water supplies. It may be very appropriate for the International Oil Shale Council to support development of water-conserving technologies and to foster cooperation in the use of regional and local water supplies.

Another environmental concern is the adequacy of environmental regulations and the capacity for enforcing those regulations. The Equator Principles may provide helpful guidance in this area.

The Equator Principles are voluntary guidelines for the evaluation of social and environmental risks associated with the financing of natural resources development projects. The Principles are based on the general standards and guidelines of the World Bank and its International Finance Corporation (IFC). They were adopted initially in June 2003 by ten leading financial institutions from seven countries. They were revised in July 2006 and, as of May 2007, have been adopted by the following 51 global banks and financial institutions, which currently comprise the Equator Principles Financial Institutions:

ABN-AMRO, N.V.	ANZ	Banco Bradesco
Banco do Brazil	Banco Galicia	Banco Itaú
Bank of America	BMO Financial Group	BTMU
Barclays plc	BBVA Spain	BES Group
Calyon	Caja Navarra	CIBC
CIFI	Citigroup Inc.	Credit Suisse Group
Dexia Group	Dresdner Bank	E + Co
EKF Denmark	FMO	Fortis
HBOS	HSBC Group	HypoVereinsbank
ING Group	Intesa Sanpoalo	JP Morgan Chase
KBC	La Caixa	Manulife
MCC	Mizuho Corporate Bank	Millenium bcp
Nordea	Nedbank Group	Rabobank Group
Royal Bank of Canada	Scotiabank	SEB
Standard Chartered Bank	SMBC	TD Bank Financial Group
Royal Bank of Scotland	Unibanco Brazil	Wachovia
Wells Fargo	West LB AG	Westpac Banking Corp

The revised Principles embrace many areas of concern. For an emerging project, the most important considerations are:

1. Assessment of baseline social and environmental conditions
2. Consideration of feasible environmentally and socially preferable alternatives
3. Requirements under host country laws and regulations and applicable international treaties and agreements
4. Protection of human rights and community health, safety, and security; of cultural properties and heritage; and of biodiversity, including endangered species and sensitive ecosystems
5. Sustainable development and renewable natural resources
6. Use of dangerous substances

7. Major hazards
8. Labor issues and occupational health and safety
9. Fire prevention and life safety
10. Socio-economic impacts
11. Land acquisition and involuntary resettlement
12. Impacts on indigenous peoples and affected communities
13. Cumulative impacts of existing projects, the proposed project, and anticipated future projects
14. Participation of affected parties in the design, review, and implementation of the project
15. Efficient production, delivery, and use of energy
16. Pollution prevention and waste minimization, pollution controls, and solid and chemical waste management

The revised principles also emphasize several new areas:

- Project financings with total project capital costs of $10 million or more (versus $50 million previously) must have the Principles applied.
- A social and environmental assessment is required relevant to the level of expected impacts. This would constitute combining the past Environmental Impact Assessment and Social Impact Assessment reports, using the common jargon.
- IFC Performance Standards and Industry-Specific Environmental Health and Safety Guidelines apply to World Bank Indicator Non-OECD countries and to OECD countries not designated as High Income. (Prospective members of the IOSC are not High Income countries and are, therefore, included.)
- For projects with moderate to major potential impacts, an Environmental Monitoring or Management Plan is required. It must describe mitigation commitments, funding, monitoring, reporting, and corrective actions.
- More formal consultation with affected parties, disclosure, and grievance mechanisms is specified.
- Independent consultant review of the reports and process is also specified, as well as independent expert monitoring and reporting over the life of the loan.

These requirements must be addressed, under the basic tenets of the Principles and in the context of the business of the project. This is accomplished through environmental assessments, project permits, studies, and reports. To check on compliance, several of the Equator Principles Financial Institutions have commissioned qualitative (and to some extent, quantitative) compliance reviews over the past few years before issuing a loan.

The implication for an oil shale initiative that is deemed to be not in compliance with the Equator Principles is clear: ***The Equator Principles Financial Institutions will not finance a project if they believe compliance is lacking.***

The 51 Institutions comprise approximately 90% of the private global project finance capacity for natural resources projects (about $28 billion in 2006). The investment pool for oil shale projects is much reduced if these Institutions cannot participate.

It may be very appropriate for the International Oil Shale Council to help their members to obtain compliance with the Equator Principles, by auditing the national standards and recommending changes to codes and compliance practices.

G. CARRYING CAPACITY & INFRASTRUCTURE

Oil shale processing plants and power plants will cost billions of dollars and will require a broad spectrum of expertise and capabilities. Each of the five countries has a history of natural resource development (Turkey with coal, chromite, copper, boron; Syria with phosphate rock, cement, petroleum; Jordan with fertilizers, potash, phosphate, cement, inorganic chemicals; Egypt with petroleum, chemicals, cement; Morocco with phosphate rock), so mining and minerals processing are familiar technologies. Four of the countries have oil refineries, and Syria is building one.

So there is some familiarity with parts of an oil shale project, but not with the whole. Very specialized expertise will be required to design, build, and operate an oil shale facility, and this will have to be procured from vendors in other countries. Local firms and institutions should be able to handle the planning, construction, and operation of the ancillary roads, pipelines, towns, utility corridors, and training facilities which will also have to be added.

Table 3 - ENERGY ECONOMIES OF THE COUNCIL MEMBERS & GERMANY

		Turkey	Syria	Jordan	Egypt	Morocco	Germany
Area	sq km	783,562	185,180	89,342	1,001,450	446,550	357,022
Rank		37	88	111	30	57	62
Like US state		TX +	ND +	IN -	NM x 3	CA +	MT -
Population (Jul 09)	millions	77	20	6	83	35	82
Rank		17	57	104	15	35	16
Growth rate		1.3%	2.1%	2.3%	1.6%	1.5%	-0.1%
Median age	Years	28	22	24	25	25	44
GDP (2008)	billion $	$729	$99	$20	$444	$86	$2,918
Per capita		$11,900	$5,000	$5,100	$5,400	$4,000	$35,400
Rank		92	142	139	135	153	34
Growth rate		1.1%	5.1%	5.6%	7.2%	5.4%	1.0%
Electricity (2007)	billion kWh						
Produced		182	37	12	118	22	593
Consumed		154	27	10	104	21	547
Rank		21	61	82	29	67	7
Exports		1.1	0	0.2	0.8	0	62
Imports		0.8	1.4	0.2	0.3	3.5	42
Oil (2008)	1000 bbl/d						
Produced		46	426	0	631	4	151
Consumed (A)		676	256	108	697	187	2,569
Rank		27	50	74	26	58	7
Exports		142	155	0	155	17	583
Imports		784	59	108	146	196	2,800
Net imports		642	-96	108	-9	178	2,217
Share of A		95%	-38%	100%	-1%	95%	86%
Reserves	million bbl	300	2,500	1	3,700	0.75	276
Natural gas (2008)	billion cu m/yr						
Produced		1.0	6.0	0.3	48.3	0.1	16.3
Consumed (A)		37.2	6.2	3.0	31.4	0.6	95.8
Rank		23	56	73	28	94	7
Exports		0	0	0	17	0	13
Imports		37	0	3	0	1	92
Net imports		36	0	3	-17	1	79
Share of A		98%	2%	92%	-54%	89%	83%
Reserves	billion cu m	8.5	241	6.0	1,656	1.5	176