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OIL SHALES AND TAR SANDS *

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CONTENT

I - INTRODUCTION

1. The exploitation of oil shales as a fuel and a source of liquid hydrocarbons on a substantial scale extends over a period of nearly 150 years. At the beginning of this century, oil shales industries were established in such countries as UK, France, Sweden, Germany, Spain, USSR and later in South Africa, Australia and China.

2. Many of the oil shales plants were closed due to competition from crude petroleum but in almost all cases, shales oil plants have been built as a result of scarcity of liquid fuel. Currently, the only large scale oil shales operations are those in the USSR and China.

3. Production in the USSR is about 35 million metric tons of shales per annum, the main part of which is produced from the Estonian deposits, Two-thirds of the oil shales is used directly as fuel for electric power generation, the remainder for petro-chemicals and gas.

4. In China, the oil-shales industry has been operating for 50 years mainly on production of shale oil by retorting, and has accumulated much production and technical experience. In Fushun the oil shales overlie coal seams and are surface mined as a by-product of the surface mining of coal. In Maoming, the oil shales are also surface mined. Annual output of crude shale oil from two retort installations in Fushun and one in Maoming amounts to about 300,000 tonnes, with by-product ammonium sulfate obtained from the ammonia in the retorting gas. The economic viability is further assisted by using a part of the spent shales ash for cement. Production cost of Fushun and Maoming crude shale oil is lower than the world natural oil market price.

5. The total production of the oil shales in the world is insignificant when compared to that of petroleum. But it has been estimated that known oil shales resources, recoverable by present day technology and converted into oil, contain a potential of more than 400 billion tonnes, about four times more than often quoted world oil reserves.

6. At present, there is no production of shale oil in Africa.

7. Tar was used early in the history of mankind primarily for caulking boats (ancient Egypt). Two centuries ago Canadian fur traders discovered the Indians were using seeping tar to seal canoes. Furthermore, tar sands have been used as paving material in Europe and in the USA for over 100 years. More recently, tar sands have been used for the same purpose in Zaire. However, only bench-scale and limited field efforts at energy production had been attempted until recently in the world. Large-scale development started in Canada in 1967 with the establishment of Great Canadian Oil Sands (currently Suncor).

II - DEFINITION AND CHARACTERISTICS

A- OIL SHALES

8. Oil-shales deposits were formed from lacustrine and marine sediments laid down under conditions which preserved organic matter (still or very slow-moving water over the sediment). These conditions arose at locations where water was stratified with the deeper water permanently isolated from the atmosphere and can arise in deep water bodies, shallow stratified water bodies, and in offshore troughs and embayments. Many different types of disposition were capable of producing oil shales. Consequently, each deposit has an individual nature, but each tends to be similar within its deposition limits.

9. Oil shales are defined as sedimentary rocks that contain solid, combustible organic matter in a mineral matrix; the organic matter, commonly called kerogen, is largely insoluble in petroleum solvents. Shale oil is obtained by heating the shales to a temperature of about 500°C; the pyrolysis of kerogen achieved during heating is generally called "retorting". Shale oil resembles, but is not identical to crude petroleum.

10. Additional names given to oil shales throughout the world include: algal shales, bituminous shales, black shales, cannel coal, cannel shales, carbonaceous shales, coaly shales, coorongite, gas shales, kerogen shales, kerosine shales, kukersite, lignitic shales, maharahu, organic shales, stellaritetasmanite, and torbanite, and others. All of these materials fit the above definition of oil shales.

11. Oil-shales are usually fine-grained, nonporous, solid, frequently showing bedding rock. The organic matter and the mineral matter are intimately mixed. In virtually all oil shales the mineral matter is most of the rock while the organic matter is usually less than 15 weight percent. The characteristics of the mineral matrix within a deposit can vary greatly with stratigraphy in a deposit and to a lesser degree with linear extent. These variations are one of the chief technical reasons for the site-specific nature of oil-shales development.

12. The characteristics of the organic matter (kerogen) within a deposit are generally uniform; however, the composition of the organic matter varies from deposit to deposit and is influenced by the depositional conditions and the nature of the organic debris.

13. In addition to carbon and hydrogen, kerogen contains varying amounts of sulfur, oxygen, and nitrogen. The concentration of these elements also affects the percentage of organic carbon recovered as oil during retorting.

B- TAR SANDS

14. Tar sands are defined as being any material such as unconsolidated sand, sandstone, limestone or other sedimentary rock, containing an oil with a viscosity greater than perhaps 10,000 centipoises under its underground conditions. As a result of this character, the in-place oil has a very low mobility, and no significant primary production can be obtained from such deposits. The density of such oil is usually 1.0 g/cm^3 or more (API gravity about 10 degrees or less). Tar sands differ from oil shales by the fact that the organic matter is essentially soluble in petroleum solvents. They differ from heavy oil reservoirs by the lack of fluidity of the reservoir oil.

15. Development of the oil resources from tar sands is dependent upon technology and economic conditions. New technology along with favorable economic conditions for production of oil from tar sands (brought about by higher product prices) may encourage tar-sands development.

16. Large tar-sand deposits have one common factor: their occurrence in deltaic or very near shore environments. Most tar sands deposits are found in fluvial sandstones with the exception of the Siligir deposit in the USSR which has a Cambrian carbonate host rock. Another significant feature common to many deposits is the presence of a regional cap rock.

17. The setting for large tar-sands accumulation to be formed is a large deltaic sediment with organic-rich source beds, regional cap rock to force the fluid to flow laterally, a homocline with up-dip stratigraphic convergence and bacterial degradation and meteoric water washing to turn a medium gravity oil into a heavy tar. The majority of the world's known large tar deposits are in rocks of Cretaceous and early Tertiary Age. Over 90 per cent of the very large tar deposits are found in sands of Cretaceous Age and younger.

III- PROCESSING REQUIREMENTS

A- OIL SHALES

18. Heat must be applied to the total rock to convert the kerogen to oil and drive this oil from the rock (retorting process). There are some 2,500 patents (worldwide) relating to retorting oil shales, and they all produce oil from oil shales. Most patents indicate only minor variation from one to another, and they all use heat to convert the kerogen to oil.

19. For surface processing of oil shales, a second requirement is that the shales must be delivered to the retort at the proper size. This requires mining, crushing, and screening. Spent shales disposal is also required. For in-situ processing a second requirement is that communication within the formation must be established. This requires some kind of breaking of the shales, or removal of a part of it, or both fracturing and removing.

B - TAR SANDS

20. Bitumen must be extracted or separated from the host rock or from sand consolidated only by the bitumen. The porous host rock or unconsolidated sand is inert to many treatments but must be heated with the bitumen in thermal applications. The rock is porous and generally permeable. However, the pores contain the bitumen which is immobile. Bitumen is soluble in some hydrocarbon solvents and is combustible. Viscosity of the bitumen will normally decrease markedly with increased temperature.

IV- TECHNOLOGIES LIKELY TO BE SIGNIFICANT IN THE NEXT 10 TO 20 YEARS

A- OIL SHALES

21. Oil shales and tar sands may play a significant role in four application areas: large-scale synthetic crude oil production from oil shales; direct combustion of oil shales for electric power generators; small-scale liquid fuel production from oil shales for local consumption; and large-scale crude oil production from tar sands.

22. Both oil-shales and tar-sands technologies require substantial development time and field experimentation to reach production capability. This limits the significant technologies to those currently in existence or those ready for field testing. Field testing will be necessary to adapt each technology to the site-specific nature of the deposits.

a) Large-scale synthetic crude oil production from oil shales

(i) Surface retorting

23. Surface processing requires heating the oil-shales in retorts. Because even the best of the oil shales is a lean ore, the surface processes are usually planned to treat large volumes of raw shales. Table 1 lists eight significant processes, divided into direct-heated and indirect-heated categories.

Table 1. Surface oil-shales retorting processes

Process	Type	Operating Rate Demonstrated by Pilot or Production retort, tonnes oil shales per day
Directly Heated		
NTU (USA)	Vertical kiln (Batch)	—
Paraho (USA)	Vertical kiln	225
Superior Oil (USA)	Traveling Grate	225
Fushun (China) 1/	Vertical kiln	200
Kiviter (USSR) 1/	Vertical kiln	350
Indirectly Heated		
Petrosix (Brazil)	Vertical kiln	2200
Union Oil-B (USA)	Vertical kiln	1200
Union Oil SGR-3 (USA)	Vertical kiln	3
TOSCO II (USA)	Rotary kiln	1000
Lurgi Ruhgas (FRG)	Screw Mixer	12
Galoter (USSR) 1/	Rotary kiln	500

1/ Production retort operating on oil shales.

24. Economics is the important problem of oil-shales development. In general, the production costs of shale oil from oil shales have been higher than that of natural crude oil. Therefore shale oil has been of limited importance until now. Rising world market prices for natural crude oil increase the possibility for development of the shale-oil industry. The production costs of shale oil may now be lower than the market price of petroleum, depending upon local conditions, selection of proper technologies, and rational use of products and by-products.

(ii) <u>In-situ retorting</u>

25. In-situ retorting produces oil from oil shales without mining much of the rock. No commercial in-situ development exists and only the USA is conducting in-situ production experiments. Four technologies are being investigated. One is a vertical modified in-situ process (VMIS), two are horizontal modified in-situ processes (HMIS), and one is a solution-mining in-situ process. Of the four, only two are thought to be sufficiently advanced to be significant over the next 20 years: the Occidental VMIS and the Geokinetics HMIS processes.

26. The VMIS process (Occidental Petroleum Corporation) is the most publicized of the in-situ processes. In this process a part of a thick (more than 100 m.) oil-shales bed is mined out, and the resulting void space distributed through the balance of the bed by explosive treatment. Oil-shales rubble in the resulting chamber is burned. Pilot-plant development began at the Laramie Energy Technology Center (LETC) in 1965, and Occidental began field development work in 1972 (still continuing).

27. The most advanced horizontal modified in situ process (HMIS) is the one being field tested by Geokinetics, Inc. The process is applicable to shallow oil shales (less than 30 meters in total depth), made permeable by explosive treatment. Burning in the retort and production of gases and liquids is horizontal.

28. There are good prospects for these two in-situ methods for delivering synthetic crude oil at competitive prices in the next 20 years.

b) <u>Direct Combustion</u>

29. Technologies for the direct combustion of oil-shales for electric power generation already exist. Some of these technologies have been in existence for quite a time (fixed-bed furnaces) while more modern fluid bed combusters are in experimental use. The most advanced method for direct cumbustion involves use of a fluidized bed. The minimum organic carbon content of the oil shales for direct combustion operations appears to be around 6-7 percent. Because of large transportation costs resulting from the low heating value of the oil-shales fuel, the combustion operation must be near the mine. Because of transmission investment costs and transmission line losses, a market for electric power must also be nearby.

30. Only the USSR has ongoing large-scale oil-shales operations involving direct combustion to produce electric power. Both surface and underground-mined oil shales are used for steam production in large power stations (to 1600 MW) in the Baltic region. Approximately 35 million tonnes of oil shales are mined annually, with 70 percent burned directly for electric power and heat. The balance is used for petrochemical feedstocks. Ash is used as a raw material in the cement industry and for reduction of soil acidity in agriculture.

c) Small-scale production of liquid fuel from oil shales for local consumption

31. In some cases, especially in developing countries, a possibility exists to develop small-scale, decentralized, low-cost, labor-intensive retorts producing a liquid fuel suitable for cooking purposes, lighting, etc. The technology for this small-scale retorting is available and the components are suitable for local manufacture in developing countries.

32. A small-scale retort might have a 200 tonnes capacity operating at approximately one batch each month, for an annual throughput of 2400 tonnes of shales and a production of 240 tonnes of shale oil. The retort would have a height of about 15m. and might cost on the order of $200,000. This price is an indicated order of magnitude cost and must not be taken as absolute. Several retorts might be operated in conjunction with one labor-intensive mining operation and requiring one or two technical and supervisory personnel for the operation. The retorts require air compressors for combustion and blowers for cooling. The shale oil can be used directly without upgrading for cooking, lighting, and heating in equipment with specially designed burners. It may be feasible to operate batch retorts efficiently at smaller scales than this.

B- TAR SANDS

a) Surface mining

33. Only commercial tar-sands operations employ variations of strip mining technology to remove overburden and mine the tar sands. The Clark hot-water process is used to separate the tar from the sand. This process is simple, but it requires approximately equal volumes of water and tar sand as feed materials. It functions well only if the bitumen saturation exceeds 10 percent by weight and only if the sands are water wet. Large tailing ponds are required in order to deposite fine clays before any water may be recycled. Upgrading (coking) facilities are employed on-site to convert the viscous bitumen (as extracted) into a pipelineable crude. Electrical generation facilities are also located on-site. Modest improvements could be made in mining efficiency and several other extraction methods are being tested, including:

- Oil agglomeration, with wet screening of agglomerates;
- High temperature retorting, with residual coke combustion in sand, a method which requires no water and is probably economic if heat can be recovered from the used sand;
- Combined water/solvent treatment with the solvent dissolving the bitumen so reducing viscosity and increasing the density differential with respect to water;
- Solvent extraction (no water) treatment with the solvent dissolving the bitumen.

b) <u>In-situ recovery</u>

34. The bulk of tar-sands deposits throughout the world are located at depths that require in-situ methods of extraction. Various techniques have been tested through pilot-scale operations most of them attempting to lower the oil viscosity by raising its temperature. The problem is to contact a sufficient volume of the essentially immobile deposit to obtain adequate production and it could be overcome by utilizing pressures higher than overburden pressure and thereby fracturing the deposit.

35. In-situ recovery techniques are applicable only within certain limits pertaining to reservoir depth and thickness and to formation properties (porosity, permeability, oil properties). For instance, thermal techniques are not adapted to deep reservoirs in the present stage of technology. Due to the unique nature of most deposits, it is presently necessary to carry out a field pilot test or tests before any commercial scale development can be contemplated.

36. The most widely tested method of obtaining in-situ recovery of tar snads, is cyclic steam injection, whereby steam is injected in slugs alternating with periods allowing the flowback of condensed steam and oil. An advantage of cyclic steam injection is that it can be utilized wit a lower capital investment, the limiting case being a one-well test.

37. Drive technologies that endeavor to force oil from injection toward production wells offer the potential for higher recovery rates. Continuous steam displacement of oil can be attempted in a tar sand following a number of cycles sufficient to enable communication between injection and production wells. Alternatively, air can be injected to sustain combustion in the deposit. Water also may be injected to scavenge heat and thereby improve thermal efficiency.

38. In certain instances, a method of decreasing oil viscosity is to utilize solvents. Such a method could be used to generate permeable paths between wells.

39. About fifteen in-situ pilot tests are in progress in the Alberta tar sands, most of them being operated in the Cold Lake area. The largest test is the Leming pilot in Cold Lake which involves cyclic steam injection; the production from the Leming pilot is presently close to 300,000 tonnes/year. Expansion to a commercial-scale operation is being contemplated. Other large pilots are ongoing in Peace River (steam injection into a bottom-water zone) and in Athabasca (in situ combustion). Several thermal in-situ recovery pilots are in operation or under development in the Orinoco deposit.

40. Most of the tests carried out so far concerned sandstones or silica sands. Specific problems would arise in carbonate rocks, due to the physical properties of the material and to its possible thermal decomposition. Hydraulic mining for surface processing is a new approach which is presently being considered. For in-situ recovery of tar sands, some of the alternate technologies that have been studied or suggested include combination of steam with additives such as gases or surfactant solutions, injection of carbon dioxide which may decrease oil viscosity, electrical heating, radiofrequency heating and microorganism treatment. Horizontal drilling through the deposit may improve the contact between an injected fluid and the tar sand. Combining some mining work with deviated wells from the galleries into the formation is claimed to be capable of leading to good recoveries.

41. No major cost reductions in production of energy from tar sands are apparent from the developing or research technologies.

c) Refining

42. The bitumen extracted from tar sands has limited acceptability for refining into the lighter liquid fuels most in demand today. As extracted, the bitumen is also difficult to transport by pipeline because of its relatively high viscosity. Upgrading of bitumen could range from simple visbreaking to produce a viscosity adjusment, through deasphalting, to a complete cooking or hydro-cracking operation. In the more severe operations all of the heavier ends are removed as a residue or converted to process fuels. The residue tends to be high in sulphur and may be difficult to dispose of. The naphtha and gas oil streams that result from upgrading operations are usually blended to form synthetic crude oil suitable as feedstock in most existing refineries. This sythetic crude oil tends to be high in middle distillates and somewhat lower in gasoline yields than natural crude oils and is accordingly not perfectly substitutable in obtaining a particular petroleum byproduct.

43. Possibilities exist for the separate use of the two types of streams from upgraded bitumen; naphtha as a petrochemical feedstock, and gas-oil as diesel-type fuel. Bitumen also has direct-use possibilities as a heavy fuel-oil and for asphalt-related uses. By-products that could also be marketed are sulfur and possibly, silicates and coke. The silicates could be used in the glass-making industry.

V- OIL SHALES AND TAR SANDS RESOURCES IN AFRICA

44. African resources in terms of oil shales and tar sands are far from being fully known. Resources in African known oil shales and tar sands deposits are estimated at nearly 19 billions tonnes of oil of which some 2 billions tonnes may be considered as recoverable under present conditions.

45. A rough breackdown by country is as follows:

Angola	- 50 millions tonnes
Ivory Coast	- 0.5 million tonnes
Madagascar	- 3,000 million tonnes
Mali	- 40 million tonnes
Morocco	- 700 million tonnes
Zaire	- 15,000 million tonnes
South Africa	- 19 million tonnes
Total	19,319.5 million tonnes of oil

46. When compared to the world resources (25,000 billion of tonnes) African reserves are very small and this is probably due to the fact that many deposits have not yet been discovered.

47. In addition to the above mentioned list, oil shales deposits are known in Egypt Gabon, Niger, Somalia, Tanzania, Tunisia, Uganda and Zambia. None of them have been explored in details and there is no doubt that deposits of significant value may also exist in Sudan, Algeria, Libya, Senegal, etc.

48. As far as tar sands are concerned deposits are known to exist in Gabon, Ghana, Ivory Coast, Madagascar, Nigeria, Somalia and Zaire. The later has some 300 million tons of tar sands with 11 to 20 per cent of recoverable bitumen equal to some 3 million tonnes of recoverable oil. Until 1958, Zaire produced 67,313 tonnes of tar sands mainly used for roads and Mwanda airport runway.

49. The only known major tar sands deposit in Africa is the Bemolange deposit. It consists of 420 sq,km of impregnated sandstones with 2 to 9 per cent content of bitumen. It contains some 3 billions of recoverable bitumen and is currently under exploration.

50. Coming back to oil shales, the first place in Africa is detained by Zaire with some 15 billion tonnes of oil content. The country initiated a project to develop and utilize a part of its resources with a view to obtaining some 170,000 cubic metres of by-products such as gas- oil , gazoline and kerosene but no concrete activities have been undertaken yet to implement the project.

51. Morocco has significant oil shales resources and recently embarked on their development and utilization. During the past years, it has been experimenting with small-scale installations for production of fuel for local consumption. The results have been very encouraging and complement its programme for large-scale synthetic crude oil manufacture and direct combustion for electric power. Expectations are that in early 1990's energy from oil-shale will be providing approximately 40 percent of Morocco's total energy needs. This promises to be an outstanding example of the integrated development of an oil-shales resources to meet a substantial part of a country's needs for fuel oil, electric power and for rural energy, and will have major employment potential.

Recently the country concluded a contract for a technico-economic study and the construction of a first unit of 200-250 MW as part of a power station of 1000 MW (5 units of 200 MW or 4 units of 250 MW) based on direct combustion of oil shales.

52. In Somalia, the reports show that oil shales occur mainly in the Northern part of the country. The available overburden above the oil-shales beds (710-1400 m) makes it impossible to economically utilize these oil shales. But, fortunately, through faultings of great magnitude, the Jurassic beds (and with them the organic matter in the - shale formation) are in some areas, to a great extent brought to the surface. The estimated reserves of the oil shales are more than 45 billion tonnes. Part of these oil shales, about 2 billion tonnes is amenable to surface mining method. The other part can be mined by edits driven in the shale at the floor of the valley.

52. Many other African countries have theoretical potential for oil shales deposits. Under this category are Cameroun, Ethiopia, Kenya, Libya, Rwanda and Tchad.

VI – CONSTRAINTS LIMITING OIL SHALES AND TAR SANDS DEVELOPMENT IN AFRICA

53. Among the constraints discussed below, three are outstanding :

A. Information flows concerning resources

B. Financing

C. Research and development and technology transfer

A. Information flows

a) Resource information

54. The limited resource knowledge in oil shales and tar sands is a most important constraint, particulary for developing countries of Africa.

55. Pratically all, oil shales and tar sands deposits have not been actively explored. Their presence has become known as a result of general geologic investigations or by accident. Consequently it is entirely possible that potentially exploitable deposits may exist undetected in many areas of the Continent.

56. A good deal of exploratory activities is necessary to delineate the physical extent of a deposit and obtain some preliminary indications whether or not it could be economically developed.

b) Technical information

57. The lack of access in developing countries of Africa to technical information is a serious constraint to the development of oil shales and tar sands. There is a need for various information activities possibly including news letters, symposia, study tours, etc.

B. Financing

58. Large-scale development of oil shales and tar sands requires very large amounts of capital investment. In general these capital requirements are many times larger than those for conventional crude-oil production on shore. However, small-scale developments using non-sophisticated technology would be less capital-intensive and probably within the reach of developing countries. In order to acquire financing, a developing country must be able to present a comprehensive development plan to a banker or other financing source. This must include demonstration of knowledge of the resource including its characteristics and adequacy, a detailed development proposal demonstrating a viable approach to production, and an economic evaluation of how products obtained from the proposed development will turn into money to pay back the financer.

C. Research and development and technology transfer

a) Research and development

59. There may by sufficient technology available in the world to apply to production of energy from oil shales and tar sands in developing countries. However, these technologies must be adapted for application to specific resources. An ongoing research program evaluating resources and determining potential development methods is necessary to develop required information and to provide manpower who know how to use it.

b) Accessing technology

60. In case of large-scale production of synthetic crude oil from oil shales and tar sands most of the technology is in the possession of major national and transnational corporations. However, simple small-scale oil-shales retorting technology and direct combustion technology may be more readily accessible. Measures should be undertaken to facilitate transfer of simple technologies.

D. Education and training

61. For the developing countries the constraints to oil-shales and tar-sands development under this category include the whole spectrum: decision makers, managers, professionals, technicians and laborers. In fact, because there are few large-scale developments in the world, the same will be true of using these commodities in developed countries, but to a lesser extent. Direct experience after appropriate training is an invaluable asset not readily available to developing countries.

E. Infrastructure and institutional

62. In general, the developing countries of Africa lack indigenous facilities: manpower, skilled and semi-skilled services, both professional and technical; equipment manufacture and supplies; and installations necessary to establish and support oil-shales and tar-sand industries. Remoteness of deposits, lack of water, adverse weather, lack of land availability, and shortage of transportation facilities also impose infrastructure constraints.

63. The lack of adequate legislation is considered another constraint and could easily affect the financing of oil- shales and tar-sand development. Financial institutions may hesitate to support a development that could later be hindered by new regulations. Development of oil shales and tar sands may require regulations ranging from land and water availability to import duties or regulations on technical equipment.

VII - RECOMMENDATIONS

A. Resources Inventory

64. Oil-shales and tar-sands resource inventory should be undertaken as soon as possible. To assist developing countries the geological and mineral exploration literature should be reviewed and possible occurences indexed.

B. Standardization of Resource Evaluation Procedures

65. There is a need to standardize resource evaluation and measurement procedures. Geologic evaluation and correlation data should also be treated in a standardized way. This calls for international collaboration.

C. National Oil-Shale/Tar-Sands Centres

66. Countries having some prospects for oil-shale/tar-sands development should establish a national centre for policy making, planning and implementation of projects related to development of oil shales and tar sands deposits.

D. Small-scale Retorting of Oil Shale for Domestic Energy Needs

67. Small-scale retorting of oil shales for domestic energy needs is technically and may be economically feasible in rural areas of some countries having a resource base. The attention of governments is drawn to this possibility.

E. Oil-Shale/Tar-Sand Centers

68. International assistance should be made available for countries wishing to create national centers for oil shales and tar sands. These national centers would perform the following functions :

a) Materials and know-how suppliers

69. The Center could identify the existing sources of equipment and services required to establish shale-oil and tar-sand industries. Through use of these sources and by utilizing personnel who have been properly trained and educated, the necessary facilities and installations can be constructed, operated and maintained.

b) Technology requirements information

70. The Center could assist in choosing a technology that would best accomodate the infrastructure of a developing country. For instance, an economic-analysis comparison of ten technologies may show that for the USA a sophisticated, capital-equipment-intensive technology is superior to a simple, labor-intensive one. However, when the infrastructure and social requirements of a developing country are considered, a simple, labor-intensive system may be more suitable.

c) Education and training

71. The Center should identify the institutions that are suitable for education and training of decision makers, managers, professionals, and technicians that will be required to establish and to operate oil-shales and tar-sands industries. This should be followed by liaison activities to assure that the best training possible is being made available to the best qualified personnel. Scholarship availability might be exploited to facilitate this training.

d) Research and development

72. In addition, the Center could also assist in establishing cooperative research and development programs. An example is the cooperative oil-shale

research program that is being carried out between the Laramie Energy Technology Center and Morocco.

e) Resource evaluation seminars

73. The Center should sponsor seminars presenting resource evaluation procedures in detail to the people who will be conducting resource evaluations. This transfer of basic information and know-how to countries interested in initiating resource evaluation programs could save developing countries invaluable time and funds. The seminars should be aimed primarily at geologists, mining engineers, chemists, and technicians, but should on occasion include managers to enhance understanding and support of the evaluation processes.

f) Technology information

74. The Center should accumulate, index, and maintain descriptions of available production technologies. This should include descriptions of their resource requirements and their performance variables. Incorporated in this should be cost estimates for operating the processes on suitable resources.

g) Study Tours

75. Study tours of ongoing commercial ventures, demonstration projects, pilot-plant experiments, and research and development facilities can be used to stimulate interest and educate personnel at all levels. This may also be used to arouse interest in development.

F. Financing

76. International financial organizations should be made aware of the favorable prospects for oil-shales and tar-sand developments, especially for small-scale oil-shale retorting to supply rural energy needs.

G. International technical assistance

77. It is recognized the urgent need of developing countries for technical assistance in all aspects of oil-shale/tar-sands development, and it is recommended that international arrangements for organizing and financing such assistance be strengthened.

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