ANNEX XI

To the Agreement Between the Department of Energy of the United States of America and the Ministry of Energy and Infrastructure of Israel in Energy Research and Development

Fluidized Bed Retorting and Combustion of Israeli Oil Shales

WHEREAS, the Department of Energy of the United States of America (hereinafter referred to as "DOE") and the Ministry of Energy and Infrastructure of Israel (hereinafter referred to as "MOEL") have entered into an agreement in Energy Research and Development signed in Jerusalem, on June 3, 1984, (hereinafter referred to as the "Agreement").

WHEREAS, DOE and MOEI (hereinafter referred to as the "Parties") recognize that it would be beneficial to both countries to work on a project in Development of a Fast-Heating Rate Oil Shale Retorting Process (hereinafter referred to as "the Project");

WHEREAS, the Parties further recognize that the Project is of mutual interest to both countries;

THEREFORE, the Parties agree as follows:

Article 1

Scope

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The DOE has been examining the effects of shale matrix and kerogen chemical composition of selected eastern and western shales upon retorting and combustion behavior in fast-heatup systems, with emphasis on solid-solid heat fransfer and fluidized bed systems. The Ministry of Energy and

Infrastructure (MOEI) researchers at PAMA (Energy Resources Development) Ltd. have also been studying fluidized bed systems for oil shale during the past five years. It will be beneficial to DOE to have access to data on a broader range of shale properties in similar process equipment, as represented by the Israeli shales and laboratory and pilot fluidized bed reactors developed by PAMA.

The Project shall be executed by PAMA on behalf of MOEI. The Project shall comprise modifications of the facility so that it will eventually include:

- a. 5" fluidized bed retort:
- b. 8" fluidized bed combustor;
- c. Retort off gas cooling and oil collection system;
- d. Gas recycling and heating system;
- e. Solids feeding and collecting weighed systems.

It shall also include a series of up to 29 tests, all as detailed in Article 2 - the Tasks.

DOE's participation will be limited to cost-sharing of Task #1 and the first year of work under Task #2.

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<u>Tasks</u>

Task 1: Retorting with Gas Recycling and Ash Injection

Previous studies in PAMA's Research Unit were carried out with methane heating. Before going into a full-blown retort-combustion system, the plant will be modified so as to include a new gas cooling and oil collecting system, gas recycling system including compressor, filters and instrumentation and an ash injection system. Ash will be supplied from an adjacent fluidized bed combustor. It is anticipated that the ash characteristics will be close to those of recirculated ash in a retort-combustor system.

MOEI will undertake to carry out about 9 tests. The objectives of this preliminary series of tests are to verify calculated product yields during previous work, to study any mechanical implications of the large quantity of ash in the retort, and to study the ash-shale mixing in the fluidized bed retort.

A tentative test matrix is presented in Table 1. Analyses of solids, oil, gas and water are listed in Tables 2 through 5 respectively. These analyses will be used in balances and yields evaluation. Balances, yields and process conditions will be calculated and reported for each test. The Parties shall consult each other regarding additional lab procedures and techniques, and DOE shall undertake to assist PAMA in implementing and using these procedures and techniques. DOE's assistance shall be in the form of technical advice, forwarded by DOE's Contracting Officer Technical Representative ("Project Leader" as identified in Article 4) to the MOEI Project Leader; by mail, telex, or telephone as appropriate, in response to questions received from MOEI's Project leader by similar communications. DOE's COTR will have access to DOE's in-house expertise at the Morgantown Energy Technology Center in developing or obtaining such technical information.

Task 2: Fluidized Bed Retorting-Combustion Testing

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After completion of Task 1, estimated to be seven months from Project initiation (See Schedule in Article 3), MOEI shall undertake to add a combustion and ash recirculation system to the Research Unit. A series of about 20 tests will then be carried out in order to achieve the objectives set forth in Article 1. The test matrix shall be prepared after the completion of Task 1. It is anticipated that the range of process parameters will be as follows:

Retort temperature:	500-570°C		
Retort residence time:	bed	•	1-4 min.
Combustor temperature:	free board 700-800 [°] C	•	3-10 sec.
Combustor residence time:	1-5 min.		
Particle size:	0-7 min.		

Samples will be analyzed according to Tables 2-5 and the results will be used for data evaluation. In addition, the cementing properties shall be analyzed as per Table 6. Mass balances and products yields shall be calculated and presented for each test.

Table 1: Task 1 - Test Matrix

Test No.	Ash Injection	Gas Circulation
1	-	•
2	•	-
3	+	-
4	+	•
5	+	-
6	•	+
- 7	-	+
8	+	+
9	+	+ 1
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Table 2: Solids Analyses

	Raw <u>Shale</u>	Ash (1)	Retorted Shale (2)	Combusted Shale (3)
Particle size distribution	+	. +	+	+
Material balance Fischer Assay	+			
Fischer Assay			+	
Total Carbon	+	+	•	+
Mineral Carbon	+	.	+	+
Organic Carbon	+	+	+	+
Total Sulfur	+	+	+	+
Organic Sulfur	+		+	
Pyritic Sulfur	+		•	
Sulfate Sulfur	+	+	+	+
Total Nitrogen	+	+	+	+
Organic Nitrogen	+		+	
Inorganic Nitrogen	+		+	
Organic Oxygen	+		+	
Total Hydrogen	+	+	+	+
Organic Hydrogen	+		+	
Iron	+	+	+	+
CaO	+	+	+	+
Heating value (bomb calorimeter)	+		+	
Organic matter (oxidation method)	+		+	
Water (free)	• 🔶			
Water (hydrate)	+			

Only for tests with ash injection
 Both bed and cyclone samples

(3) Both bed and cyclone samples

Table 3: Shale Oil Analyses

Specific gravity (pycnometer method) Water and sediment by centrifugation Pour point (ASTH D97) Viscosity at 122 deg.F, 210 deg.F Simulated distillation (ASTM D2887) Bromine number N-Heptane insolubles Toluene insolubles Ash (ASTM D482) Total Carbon Total Hydrogen Total Nitrogen Total Sulfur Total Oxygen

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Table 4: Gas Analyses

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	Retort Offgas	Combustor Flue Gas
C2, C3, C4 Paraffines	+	
C2, C3, C4 Olefins	+	
C5+ Hydrocarbons	+	
Carbon Monoxide	+	
Carbon Dioxide	+	+
Methane	+	•
Hydrogen	+	•
Oxygen	+	+
Nitrogen + Argon	+	+
Hydrogen Sulfide	+	
Ammonia	+	
Sulfur Dioxide		+
Oxides of Nitrogen		+
Water	+	+

Table 5: Water Analyses

Total Carbon Total organic Carbon Total inorganic Carbon Total Kjeldhal Nitrogen Nitrate Nitrogen Sulfates Sulfides Total dissolved solids Total suspended solids

Table 6: Ash Evaluation As Cement

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Compressive strength ASTM C109

Analyses

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CO2 CaOT Org C ST Sulface Al2O3 Fe2O3 MgO CaOF SiO2 Maleic Acid Solubles: SiO2, Al2O3, Fe2O3.

Table 7: Mass Balance

Overall Total Carbon Mineral Carbon Total Sulfur Total Mitrogen Inorganic Nitrogen Organic Nitrogen Total Hydrogen

Table 8: Process Conditions

Retort Feed rate Feed rate Feed size Retorting temperature (bed & freeboard) Solids residence time (bed & freeboard) Solids recycle ratio Recycled solids temperature Gas superficial velocity

<u>Combustor</u> Feed rate Feed temperature Combustion temperature Solids residence time Flue gas oxygen Bed temperature Bed depth Bed pressure Freeboard temperature Gas residence time Gas superficial velocity Supplemental fuel

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Task 3: Process Design of a Commercial Plant

The data collected during the 29 tests of Task 1 and 2 will be used to prepare a process design basis for a retort-combustion system.

Schedule. Milestones and Reporting Requirements

- The schedule and milestones of the Project are presented in Figure 2. At the end of the first year, schedule and milestones shall be reviewed and updated by MOEI and DOE representatives as mutually agreed upon.
- 2. MOEI shall prepare brief quarterly reports that will note the status of the Project with respect to schedules, milestones and budgets. The fourth quarter report shall be a full annual report, including a specific work plan for the following year; this report shall be delivered within thirty days following the end of the project year.

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Task	Month	010203040506070809101112131415161718192021222324			
Task 1 Task 2 Task 3		**************************************			
Milestones					
Completion of Task 1 Modified Plant Commissionin Completion of Test Pr Annual Report Final Report	g ogram	`1 1 1	t	1	

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Management

- Overall responsibility for annual approval of the Project's technical content and budget shall rest with the Parties.
- Each party shall appoint a Project Leader for the detailed management of the Project. The Project Leaders shall be responsible to their respective Project Coordinators (appointed pursuant to Article 3.3 of the Agreement) for the working contracts between Parties.

Article 5

Funding

- The total cost estimated for the MOEI-planned Project is at \$660,000.
 DOE shall provide \$155,000 for the first year. MOEI shall provide at least \$155,000 toward first year costs.
- The cost of meetings shall be borne by the Party that incurs them, and visits and assignment of personnel shall be borne by the Party sending the personnel, both in accordance with normal procedures of each Party.
- 3. DOE funds provided for the Project that are to be expended in Israel shall be deposited with an authorized depository of MOEI in an account, in the first year within thirty days from the signing of this Annex. Subject to established fiscal controls of MOEI, the Israeli Project Coordinator shall cause said funds to be distributed as is necessary and convenient to carry out the activities authorized herein.

4. MOEI shall maintain appropriate financial records of this Project that clearly account for all funds expended on this Project, including funds transferred from DOE pursuant to paragraph 3 above. MOEI shall, within three months following the end of DOE's fiscal year, following signing of this agreement, provide DOE with a certification common, at its agency, of the amount and use of funds provided by the DOE which were utilized in the Project.

Article 6

Information and Intellectual Property

- Each Party shall be free to use and disseminate all information emanating from the Project. It is intended that the results of this Project shall be published in the scientific literature.
- 2. Copyrights shall be accorded treatment consistent with internationally recognized standards of protection. Any material which may be the subject of copyright developed under this Project may be copyrighted. A Party securing a copyright or rights thereto shall grant a royalty-free non-exclusive license to the other Party to reproduce, publish, distribute, duplicate, use the copyrighted material and to authorize others to do so.

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3. Each Party shall, without prejudice to any right of inventors or authors under its national laws, take all necessary steps to provide the cooperation of its authors and inventors required to carry out the provisions of this Article 6. Each Party shall assume the responsibility to pay awards or compensation required to be paid to its employees according to the laws of its country.

- 4. A Party possessing information arising in the course of or under this Project ('arising information') regarding inventions on which patent protection is to be obtained shall notify the other Party and thereafter such information shall not be published or publicly disclosed until a patent application has been filed, provided, however, that this restriction on publication or disclosure shall not exceed beyond six months from the date of notice to the other Party under this paragraph. Such information shall be appropriately marked to restrict publication or disclosure.
- 5. Inventions made or conceived in the course of or under this Project ('arising inventions') will be owned by MOEI in Israel and third countries and by DOE in the United States. Each Party, its Government and the nationals of its country designated by it, shall receive a royalty-free, non-exclusive license in the countries where the invention is owned by the other Party.

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Other Agreements

The provisions of this Annex shall not affect the rights or duties of the Parties under other agreements or arrangements. This Annex also in no way precludes commercial firms or other legally constituted enterprises in each of the two countries from engaging in commercial dealings in accordance with the applicable laws of each country; nor does it preclude the Parties from engaging in activities with other governments or persons.

Article 8

Laws and Regulations

Activities under this Annex shall be in accordance with laws and regulations of the countries of the Parties. All questions related to this Annex shall be settled by the Parties by mutual agreement.

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Appropriated Funds

It is understood that the ability of the Parties to carry out their obligations under this Annex is subject to the availability of funds.

- a. This Annex shall enter into force upon signature and shall continue in force for a one-year period, and may be amended or extended by mutual written agreement of the farties.
- b. In the event that, during the period of this Annex, the nature of either Party's energy programs should change substantially, either Party shall have the right to request revisions in the scope and/or terms of this Annex.
- c. This Agreement may be terminated at any time at the discretion of either Party, upon six months advance motification in writing by the Party seeking to terminate the Annex. Any such termination shall be without prejudice to the rights which have accrued under this Annex to either Party up to the date of such termination.

Weshing estember 1987. Done day of Stephen Logan Contracting Officer For the Mini For the Department of Energy of and the United States of America Infrastructu