

## **ANNEX II**

**To the Agreement Between the Department of Energy and the Department of The Treasury of the United States of America and the King Abdulaziz City for Science and Technology and the Ministry of Finance and National Economy of the Kingdom of Saudi Arabia.**

WHEREAS, the Department of Energy and the Department of the Treasury of the United States of America (hereinafter referred to as "DOE") and the King Abdulaziz City for Science and Technology and the Ministry of Finance and National Economy of the Kingdom of Saudi Arabia (hereinafter referred to as "KACST"), have entered into a Project Agreement for Cooperation in the Field of Renewable Energy Research and Development, signed in Riyadh on February 4, 1987 (hereinafter referred to as the "Agreement").

WHEREAS, DOE and KACST (hereinafter referred to as the "Parties"), recognize that it would be beneficial to both countries to work on a project in Assessment of Solar Radiation Resources in Saudi Arabia (hereinafter referred to as "the Project");

THEREFORE, the Parties agree as follows:

## Article 1

### Scope

The objective of the Project is to improve the assessment of solar radiation resources in Saudi Arabia by upgrading surface measurements and by developing correlations between surface and satellite data.

The Project will be a 48-month R & D effort involving scientists from the Department of Energy's National Renewable Energy Laboratory (NREL), formerly Solar Energy Research Institute (SERI), and KACST.

NREL will provide technology (procedures, models, algorithms and software) that has been developed over the past decade. KACST will provide the facilities and equipment at the Solar Village and the satellite receiving and data processing facility. NREL and KACST scientists will work together to adapt NREL technology to Saudi Arabia and to advance the technology for estimating solar irradiance (at sites lacking measured data from a combination of satellite, meteorological, and solar irradiance data from nearby locations). The roles of NREL scientists will be limited for the most part to those of advisors, consultants, and instructors. After procedures and systems have been established, with the help of NREL scientists, KACST scientists will take over the continuing effort. During the development of procedures and systems, it is expected that KACST and NREL scientists will work side-by-side.

The intent of this Project is to establish a sound program to assess Saudi Arabia's solar radiation resources on a long term, continuing basis. The Project is also designed to produce an initial nationwide assessment (within a four-year period), which will have a greater reliability, accuracy, and spatial resolution than the existing solar atlas for Saudi Arabia.

In order to achieve the best results possible, the approach incorporates all pertinent information, to the extent possible. This includes: 1) solar radiation data from a new, state-of-the-art network to be established during the first and second year; 2) solar radiation data from the existing network operated by the Ministry of Agriculture; 3) satellite data to be acquired by KACST satellite data receiving facility; and 4) meteorological data collected by the Meteorological and Environmental Protection Agency in Saudi Arabia.

## Article 2

### Tasks

- Task 1. Upgrading solar radiation measurements and data bases at KACST. This will include upgrading of KACST calibration facilities and the establishment of a 12-station solar radiation network at sites having different surface albedos, climates, elevations, and terrain characteristics. Direct normal, diffuse horizontal and global horizontal irradiances will be measured with thermopile radiometers.
- Task 2. Assembling a data base of concurrent solar radiation, satellite (METEOSAT), and meteorological data (over a 10-year period, to the extent possible).
- Task 3. Adapting NREL models and other software for use in Saudi Arabia.
- Task 4. Developing procedures, algorithms, and software to estimate solar irradiance at locations and times for which measured solar radiation data are not available. All pertinent, available data will be used, including surface measurements, satellite (METEOSAT) data, and meteorological data.
- Task 5. Preparing a uniformly spaced grid of solar radiation data for use in the preparation of maps and atlases and for estimating solar radiation resources and solar energy system performances at any location in Saudi Arabia.

## Article 3

### Work Plan

- I. The project schedule and milestones are as follows:

#### **3.1 YEAR-ONE ACTIVITIES**

- 1A - DOE and KACST sign the Annex.
- 1B - KACST and NREL principal investigators meet to develop detailed plans for year-one. (Months 1 - 2).
- 1C - Prepare specifications and ordering by NREL and KACST of instruments needed for upgrading KACST radiometer calibration and characterization facilities. (Months 3 - 4).
- 1D - Prepare specifications and ordering by NREL and KACST of equipment needed for a 12-station solar radiation network. (Months 3 - 6).
- 1E - Selection of sites for a 12-station solar radiation network by KACST-NREL. (Months 3 - 6).

- 1F - Acquire 3 new bimetallic actinographs by KACST of the type used by the Ministry of Agriculture that are to be tested at NREL. (Months 2 - 4).
- 1G - Prepare the facilities at KACST (buildings, fencing, platforms for mounting radiometers, power sources, etc.) at the selected solar radiation network sites. (Months 6 - 7).
- 1H - Calibrate and characterize the 3 new bimetallic actinographs at NREL with assistance from KACST scientists. The months of June and July are critical to achieving a wide range of solar zenith angles. KACST's cavity pyr heliometers will be compared with NREL and NOAA cavities, providing traceability to the World Radiation Reference. (Months 6-7).
- 1I - Calibrate and characterize at KACST the 3 new bimetallic actinographs and 6 or more actinographs from the Ministry of Agriculture network. (Months 9 - 12).
- 1J - Calibrate and characterize at KACST the radiometers purchased for the 12-station solar radiation network. (Months 9 - 12).
- 1K - Select and train KACST personnel to operate and maintain equipment at the 12 sites of the solar radiation network. Train a KACST instructor by NREL. (Months 10 - 12).
- 1L - Prepare detailed Management and Financial Plan for year-two. (Months 9 - 12).

### **3.2 YEAR-TWO ACTIVITIES**

- 2A - Install equipment at each of the 12 sites of the solar radiation network and begin continuous collection of data. (Months 13 - 24).
- 2B - Establish procedures and prepare software for routine processing and quality assessing of solar radiation data. Implement processing on a long-term continuous basis. (Months 13 - 24).
- 2C - Initiate continuous collection and route processing of 5 or more METEOSAT images of Saudi Arabia each day. Purchase data from the European Space Agency if necessary to obtain a serially complete data set. (Months 13 - 24).
- 2D - Purchase an erasable optical disk drive and magnetic disk drives as needed for storage and processing of solar radiation and meteorological data. Upgrade other KACST computer facilities as needed to facilitate the processing of large volumes of data. Optical disks will be the media used to exchange software and the large volumes of solar radiation and meteorological data required by this project. (Months 13 - 18).
- 2E - Acquire meteorological data for the existing period-of-record from all active meteorological stations that have collected the data required for a period of 10 years or more. Place the data on optical disks for archival and later use. (Months 13 - 24).

- 2F - Based on the characterization of the bimetallic actinographs, develop procedures and software to upgrade the historical solar radiation data collected by the Ministry of Agriculture. Implement the upgrade of this data, quality assess, and place on optical disks for archive and later use. (Months 13 - 24).

### **3.3 YEAR-THREE ACTIVITIES**

- 3A - Maintain continuous collection, processing, quality assessing, and storing of surface solar radiation data, METEOSAT data, and meteorological data. Recalibrate all radiometers. (Months 25 - 36).
- 3B - Test, modify (if necessary), and validate the use of Maxwell's DISC and METSTAT models in Saudi Arabia. This activity requires the availability of 12-months (or more) of quality assessed solar radiation data from the 12-station network, along with concurrent meteorological and METEOSAT data to determine atmospheric conditions. (Months 25-30).
- 3C - Use the DISC model and/or METSTAT model to estimate direct normal and diffuse horizontal irradiances from upgraded actinograph measurements of global horizontal irradiance. Store on optical discs. (Months 30 - 36).
- 3D - Develop procedures, algorithms, and software for combining surface measurements, satellite (METEOSAT) data, and meteorological data for estimating solar irradiance at locations and times for which measured data are not available. This activity requires the availability of 12 months or more of quality assessed solar radiation data from the 12-station network and concurrent METEOSAT and meteorological data. Some of the algorithms from the METSTAT model will be used for this activity. (Months 25 - 36).
- 3E - Prepare and publish joint (KACST and NREL) technical reports and journal articles on the results of research performed on this project. (Months 30 - 36).

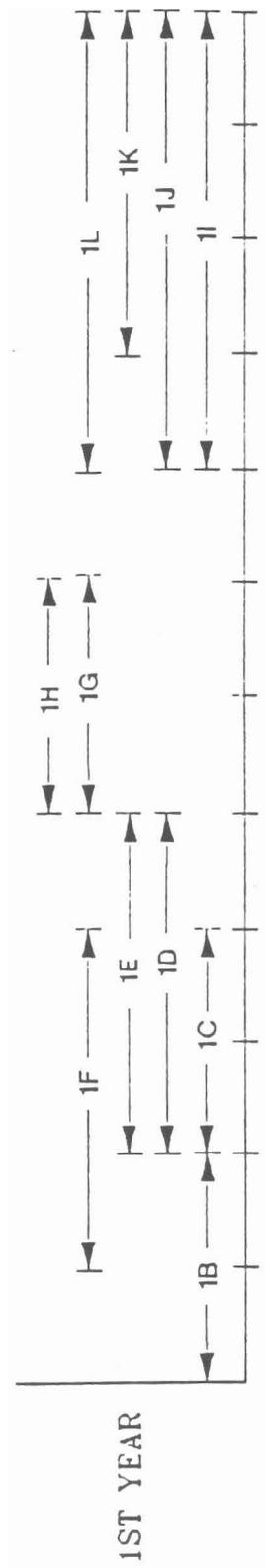
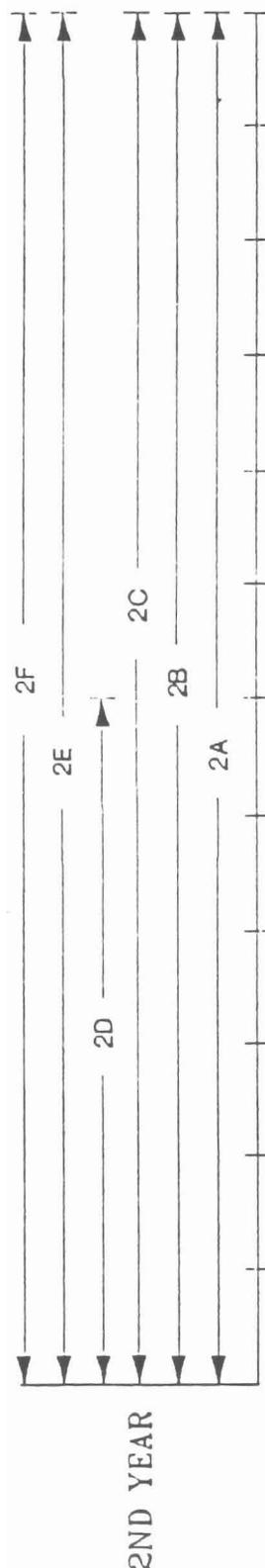
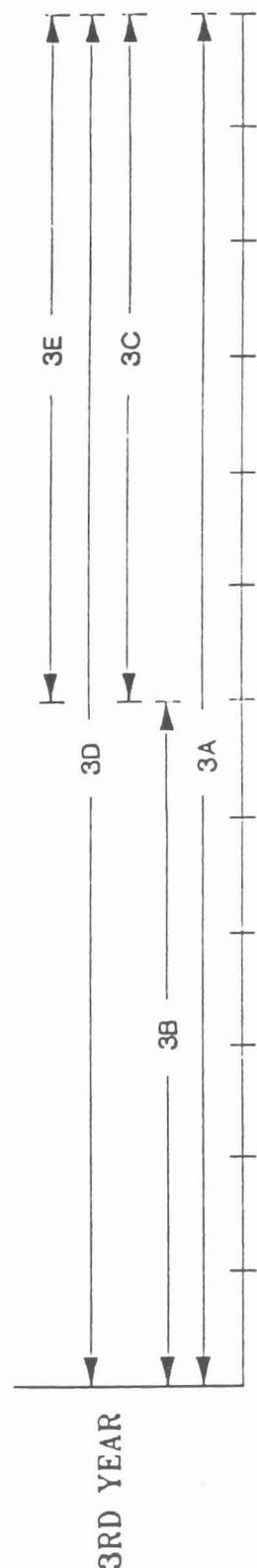
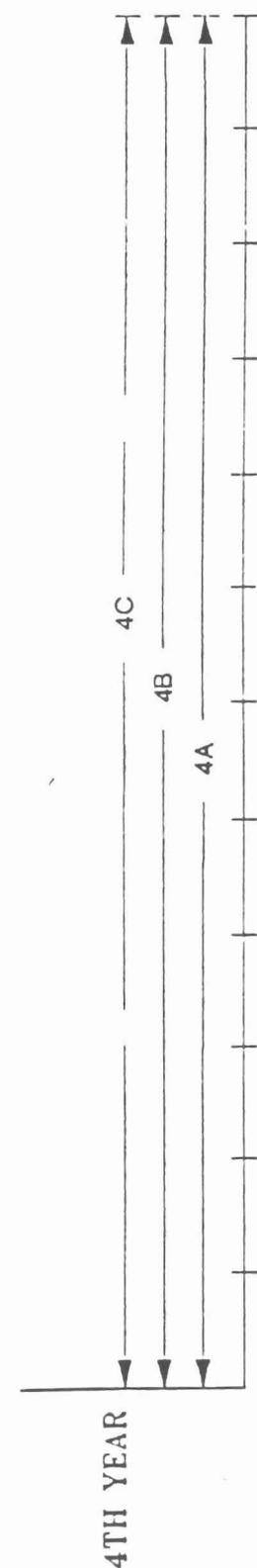
### **3.4 YEAR-FOUR ACTIVITIES**

- 4A - Maintain continuous collection, processing, quality assessing, and storing of surface solar radiation data, METEOSAT data, and meteorological data. Recalibrate all radiometers. (Months 37 - 48).
- 4B - Use the procedures and algorithms developed during the third year and data collected and assembled during the second, third, and fourth years to prepare monthly and annual statistics of solar irradiance (direct normal, diffuse horizontal, global horizontal) for a uniformly spaced grid (e.g., 100 km by 100 km) covering all of Saudi Arabia. The monthly and annual statistics will include:

Statistical moments  
Cumulative frequency distributions  
Extreme values  
Diurnal patterns

Long-term trends  
(Months 37 - 48)

- 4C - Continue to prepare and publish joint technical reports and journal articles. (Months 37 - 48).
- II. The Project plans will be reviewed at the interim Project meeting and will be revised as necessary.
- III. The results and products that will be forthcoming from this Project include the following:
- 1 - A first class solar radiometry capability and baseline solar radiation monitoring network, capable of continuous operation for the foreseeable future.
  - 2 - A significant upgrade of solar radiation data collected by the Ministry of Agriculture, in the past, present, and future.
  - 3 - An improved capability for combining surface measurements of solar radiation, satellite data, and meteorological data, which can be used at any time in the future to upgrade and update the assessment of solar radiation resources in Saudi Arabia.
  - 4 - A current evaluation of solar radiation resources on a uniformly spaced grid of locations covering all of Saudi Arabia. This product can be used to estimate resources for any location within the Kingdom.
  - 5 - Reports and journal articles on the results of the research conducted under this project.
- IV. Activities 1H, 3B, and 3D shall be carried out at NREL with the assistance of KACST scientists. Two KACST scientists shall travel to NREL for 6 weeks during activity 1H. One scientist shall have knowledge and experience in solar radiometry and the other shall be skilled in computer analysis of data.
- V. KACST shall have one scientist in residence at NREL during the entire third year to work on activities 3B and 3D. This scientist shall have a fundamental understanding of the physics of solar radiation, atmospheric interactions, remote sensing, and computer analysis of data.



JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

#### Article 4

##### Management

1. DOE and KACST shall be responsible for the development, coordination, and implementation of the activities under this Annex.
2. DOE and KACST shall each designate one official to supervise jointly the selection, authorization, and execution of cooperative activities under this Annex.

#### Article 5

##### Funding

1. All travel expenses, all equipment purchases, and all NREL labor directed exclusively to the benefit of KACST will be funded by KACST. Activities that fall into this category include 1C, 1D, 1E, 1F, 1G, 1I, 1J, 1K, 2A, 2B, 2C, 2D, 2E, 2F, 3A, 3C, 4A, and 4B.
2. NREL labor costs for activities involving technological advancements, consistent with DOE near-term objectives, shall be partially supported from the DOE Solar Radiation Resource Assessment Project (SRRAP). Activities that fall into this category include 1H, 3B, 3D, 3E, and 4C. Activity 3D is the key R & D effort of this four-year Project. Planning activities shall be partially supported from SRRAP funds.
3. The NREL budget for each year is broken down into NREL costs (to be paid out of SRRAP funds) and KACST cost.
4. NREL shall budget \$337,000 for this Annex. Saudi Arabia shall budget \$3,821,343 for this Annex, of which \$1,158,343 shall be budgeted through the Joint Economic Commission Office in Riyadh (JECOR), and \$2,663,000 shall be budgeted directly by KACST.

## 5.1 YEAR-ONE FUNDING

<u>Labor Costs (fully burdened)</u>		<u>NREL Cost</u>	<u>KACST Cost</u>
NREL - Project Leader	35%	\$26,000	\$45,000
Instrumentation Specialist	70%	8,000	97,000
Data Analyst	36%	8,000	37,000
	TOTAL	<u>\$42,000</u>	<u>\$179,000</u>
KACST - Project Leader	50%	--	\$100,000
Instrumentation Specialist	100%	--	139,000
Data Analyst	25%	--	25,000
	TOTAL	<u>--</u>	<u>\$264,000</u>

<u>Travel Costs</u>		<u>KACST Cost</u>
One week planning meeting in Europe - Activity 1B		
2 NREL Project Personnel		\$7,248
2 KACST Project Personnel		6,982
Two KACST engineers at NREL - Activities 1H and 1K - 6 weeks		21,986
Three NREL scientists at KACST - Activities 1I, 1J, & 1L - 4 weeks		24,372
Visits to the solar radiation network stations - activity 1J		
2 NREL Scientists		
2 KACST Scientists		4,860
	TOTAL	<u>\$65,448</u>

<u>Other Direct Costs</u>	<u>NREL Cost</u>	<u>KACST Cost</u>
Operating Expense	\$15,000	--
Computer Support	--	\$3,000
Metrology Lab	--	9,000
Graphics and Publications	--	3,000
Telephone	--	16,000
	TOTAL	<u>\$31,000</u>

<u>Equipment Purchases</u>	<u>KACST Cost</u>
Upgrade KACST Radiometer Calibration Equipment	\$20,000
Three Bimetallic Actinographs	6,000
Equipment for 12-Station Network (with spares) -	
14 Data loggers @ \$2,000	28,000
16 Pyrheliometers @ \$2,000	32,000
32 Pyranometers @ \$2,000	64,000
14 Shadowbands @ \$2,000	28,000
14 Solar Trackers @ \$7,500	105,000
Freight	5,000
TOTAL	<u>\$288,000</u>

<u>Equipment Installation</u>	<u>KACST Cost</u>
Preparation of buildings, fencing, platforms for mounting radiometers, power sources, etc. at the selected solar radiation network sites	\$64,000
Travel of KACST engineers to sites during construction and installation	46,000
TOTAL	<u>\$110,000</u>

<u>Total Funds from KACST to NREL</u>	<u>KACST Cost</u>
1) Labor	\$179,000
2) Travel	31,620
3) Other Direct Costs	15,000
4) Material Handling (5% of 2 and 3)	2,331
5) Base and Award Fee (5.1% of 1,2,3 and 4)	11,626
TOTAL	<u>\$239,577</u>

<u>Total Cost</u>	
KACST	\$949,074*
NREL	57,000
TOTAL COST	<u>\$1,006,074</u>

\*The amount \$575,074 will be budgeted through JECOR and the amount \$374,000 will be budgeted by KACST for payment of KACST Labor Cost and Equipment Installation.

## 5.2 YEAR-TWO FUNDING

<u>Labor Costs (fully burdened)</u>		<u>NREL Cost</u>	<u>KACST Cost</u>
NREL - Project Leader	25%	\$14,000	\$39,000
Instrumentation Specialist	25%	--	39,000
Data Analyst	50%	18,000	62,000
	<b>TOTAL</b>	<u>\$32,000</u>	<u>\$140,000</u>
KACST - Project Leader	100%	--	\$200,000
Instrumentation Specialist	100%	--	139,000
Data Analyst	100%	--	100,000
Satellite Receiving Station	100%	--	139,000
Network Station Operator	100%	--	139,000
	<b>TOTAL</b>		<u>\$717,000</u>

<u>Travel Costs</u>		<u>KACST Cost</u>
Three NREL scientists at KACST - Activities 2A, 2B, 2F - 4 weeks		\$33,760
	<b>TOTAL</b>	<u>\$33,760</u>

<u>Other Direct Costs</u>	<u>NREL Cost</u>	<u>KACST Cost</u>
Operating Expense	\$15,000	
Computer Support	--	\$3,000
Graphics and Publication		2,000
Travel of KACST engineers to sites to collect data	--	46,000
Telephone	--	16,000
	<b>TOTAL</b>	<u>\$67,000</u>

<u>Equipment Purchases</u>		<u>KACST Cost</u>
Erasable Optical Disk Drive		\$10,000
Magnetic Disk Drives		15,000
Upgrades of KACST Computers		20,000
	TOTAL	<u>\$45,000</u>

<u>Total Funds from KACST to NREL</u>		<u>KACST Cost</u>
1) Labor		\$140,000
2) Travel	33,760	
3) Other Direct Costs		5,000
4) Material Handling (5% of 2 and 3)		1,938
5) Base and Award Fee (5.1% of 1,2,3 and 4)		9,215
	TOTAL	<u>\$189,913</u>

<u>Total Cost</u>		
KACST		\$1,013,913*
NREL		47,000
	TOTAL COST	<u>\$1,060,913</u>

\*The amount \$250,913 will be budgeted through JECOR and the amount \$763,000 will be budgeted by KACST.

### 5.3 YEAR-THREE FUNDING

<u>Labor Costs (fully burdened)</u>		<u>NREL Cost</u>	<u>KACST Cost</u>
NREL - Project Leader	50%	\$50,000	\$52,000
Instrumentation Specialist	10%	8,000	8,000
Data Analyst	100%	85,000	80,000
	TOTAL	<u>\$153,000</u>	<u>\$140,000</u>
KACST - Project Leader	100%	--	\$200,000
Instrumentation Specialist	100%	--	139,000
Data Analyst	100%	--	100,000
Satellite Receiving Station	100%	--	139,000
Network Stations Operation	100%	--	139,000
	TOTAL	<u>--</u>	<u>\$717,000</u>

<u>Travel Costs</u>		<u>KACST Cost</u>
One KACST scientist at NREL - Activities 3B and 3D - 50 weeks		\$43,300

<u>Other Direct Costs</u>	TOTAL	<u>NREL Cost</u>	<u>KACST Cost</u>
Operating Expense		\$15,000	--
Computer Support		5,000	\$5,000
Graphics and Publication		3,000	3,000
Travel of KACST engineers to sites to collect data			46,000
Telephone			16,000
	TOTAL	<u>\$23,000</u>	<u>\$70,000</u>

<u>Total Funds from KACST to NREL</u>		<u>KACST Cost</u>
1) Labor		\$140,000
2) Travel		
3) Other Direct Costs		8,000
4) Material Handling (5% of 2 and 3)		400
5) Base and Award Fee (5.1% of 1,2,3 and 4)		7,568
	TOTAL	<u>\$155,968</u>

#### Total Cost

KACST		\$978,268*
NREL		176,000
	TOTAL COST	<u>\$1,154,268</u>

\*The amount \$215,268 will be budgeted through JECOR and the amount \$763,000 will be budgeted by KACST.

#### 5.4 YEAR-FOUR FUNDING

<u>Labor Costs (fully burdened)</u>		<u>NREL Cost</u>	<u>KACST Cost</u>
NREL - Project Leader	25%	\$25,000	\$37,000
Instrumentation Specialist	10%	--	17,000
Data Analyst	25%	18,000	27,000
	TOTAL	<u>\$43,000</u>	<u>\$81,000</u>

KACST - Project Leader	100%	--	\$200,000
Instrumentation Specialist	100%	--	139,000
Data Analyst	100%	--	100,000
Satellite Receiving Station	100%	--	139,000
Network Stations Operation	100%	--	139,000
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	TOTAL	--	<u>\$717,000</u>

<u>Travel Costs</u>			<u>KACST Cost</u>
Two NREL scientists at KACST - Activity 4B - 2 weeks			\$12,460
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	TOTAL		<u>\$12,460</u>

<u>Other Direct Costs</u>	<u>NREL Cost</u>	<u>KACST Cost</u>
Operating Expense	\$12,000	
Computer Support	--	--
Graphics and Publication	2,000	2,000
Travel of KACST engineers to sites to collect data	--	46,000
Telephone	--	16,000
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	TOTAL	<u>\$64,000</u>

<u>Total Funds from KACST to NREL</u>	<u>KACST Cost</u>
1) Labor	\$81,000
2) Travel	12,460
3) Other Direct Costs	2,000
4) Material Handling (5% of 2 and 3)	723
5) Base and Award Fee (5.1% of 1,2,3 and 4)	4,905
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	TOTAL
	<u>\$101,088</u>

<u>Total Cost</u>	
KACST	\$880,088*
NREL	57,000
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TOTAL COST	<u>\$937,088</u>

\*The amount \$117,088 will be budgeted through JECOR and the amount \$763,000 will be budgeted by KACST.

## Article 6

### Information and Intellectual Property

1. The Parties support the widest possible dissemination of information provided, exchanged, or arising under this Annex, subject to the need to protect preexisting proprietary information and copyright restrictions.
2. Information transmitted by one Party to another Party under this Annex shall be accurate to the best knowledge and belief of the transmitting Party, but the transmitting Party does not warrant the suitability of the information transmitted for any particular use or application by the receiving Party or by any third Party. Information developed jointly by the Parties shall be accurate to the best knowledge and belief of both Parties. Neither Party warrants the accuracy of the jointly developed information or its suitability for any particular use or application by either Party or by any third Party.
3. Subject only to copyright restriction, the Parties shall have the right to publish all information provided to or arising from the Annex except preexisting proprietary information.
4. The Parties shall take all necessary measures in accordance with this paragraph, the laws of their respective countries, and international law to protect preexisting proprietary information provided under this Annex. Proprietary information shall mean information of a confidential nature, such as trade secrets and know-how (for example, computer programs, design procedures and techniques, chemical composition of materials, or manufacturing methods, processes, or treatments), which is appropriately marked, provided such information:
  - a. Is not generally known or publicly available from other sources;
  - b. Has not previously been made available by the owner to others without obligation concerning its confidentiality; and
  - c. Is not already in the possession of the recipient Party without obligation concerning its confidentiality.

It shall be the responsibility of either Party supplying preexisting proprietary information to identify the information as such and to ensure that it is appropriately marked.

5. The Parties may take appropriate measures necessary to protect copyrightable material generated under this Annex. Either Party may reproduce and distribute such material, but neither Party shall publish such material with a view to profit.
6. Inventions made or conceived in the course of or under this Annex (arising inventions) shall be owned by DOE in the United States and by KACST in Saudi Arabia. Ownership in third countries shall be by agreement between DOE and KACST on an equitable basis.

## Article 7

### 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. It is understood that the ability of the Parties to carry out their obligations under this Annex shall be subject to the availability of appropriated funds. All questions related to this Annex shall be settled by the Parties by mutual agreement.

## Article 9

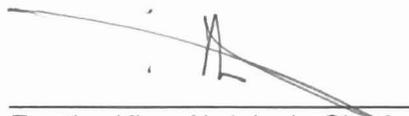
### Entry Into Force and Termination

1. This Annex shall enter into force upon signature by both Parties and shall continue in force for a four-year period unless terminated either in accordance with paragraph three (3) of this Article or through termination of the Agreement provided, however, that all joint efforts and experiments initiated but not yet completed at the termination of this Annex shall be continued until their completion under the terms of this Annex and of the Agreement. This Annex may be amended or extended by mutual written agreement of the Parties.
2. 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.
3. This Annex may be terminated at any time at the discretion of either Party, upon six months advance notification 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.

Done at Washington DC and Riyadh this 21st day of July, 1993.



For the Department of Energy of  
the United States of America



For the King Abdulaziz City for  
Science and Technology, Kingdom of  
Saudi Arabia