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Royal Scientific Society

Proposal on Upgrade RSS Technical Capability in:

1. Energy Consumption Measurement

&

2. Development of Building Envelope Component Testing Laboratory to support Energy Code Enforcement

Prepared for

USAID

August, 2010

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Upgrade RSS Technical Capability in Energy Consumption Measurement

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1. Introduction

USAID is interested in supporting RSS by providing the necessary testing equipment to start an Energy Labeling program for some locally manufactured and imported household electrical products.

An internationally recognized system of product testing is a key parameter for any country to increase its access to regional and international markets thus the tests provided by RSS are of outmost importance for Jordan's trade position. This project shall further strengthen the Jordanian industry by contributing to enhance the competitiveness of their products versus products of other countries.

Having the testing facilities in Jordan is so important for the success of this program. These facilities will provide the local industry with a new and advanced testing services related to performance evaluation of their products, helping them to develop these products in terms of energy performance, thus make them more competitive and will open a new export opportunities for them. The consumers shall also have the opportunity to compare the energy efficiency of appliances before buying any. The project shall help in reducing the number of low-quality imported products entering the Jordanian market.

The Royal Scientific Society (RSS) has always played the major role in all the technical activities in Jordan, with its long experience in the field of Conformity assessment of products, and with its highly qualified technical staff with their excellent knowledge of the international standards and requirements, RSS can contribute much to the success of this project by establishing and implementing the relevant technical services within its premises.

USAID thankfully is willing to finance the procurement of the testing equipment needed for the testing facilities in RSS. The technical assistance the

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USAID is providing builds on a resource which is already well established, namely; its testing laboratories. The project shall serve to complete and expand accredited laboratory testing which is the most highly requested conformity assessment service for product certification.

2. Aim of project:

To enhance the technical capabilities of RSS by establishing the necessary technical facilities which are capable of performing the required energy efficiency assessment and measurements on the following household products:

- Refrigerating appliances.
- Clothes washing machines
- Lamps
- Air conditioners

Other products can be added in the future in the next phases of the cooperation based on national priorities and enforcing the necessary laws in Jordan.

3. List of equipments need to conduct energy consumption measurements

The testing equipment needed for the testing facilities in RSS with their full specifications are attached, below is a summary of these testing equipment:

A) Refrigerating appliance energy measurement Lab:

Equipments needed are:

- Climatic Chamber
- Adjustable transformer
- Watt-hour meter
- PC-based Data acquisition system
- Test packages

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- Chest freezers

B) Clothes washing machines energy measurements Lab:

Equipments needed are:

- Voltage stabilizers
- Small Climatic chamber
- Digital Balance
- Instruments to measure the water temperature
- Watt-hour meters
- Water pressure gauges
- Temperature recorders
- Reference detergent
- Reference washing machine
- Water Flowmeters
- Reference textile load
- Timer
- PC-based Data Acquisition system

C) Compact and Tubular fluorescent Lamps and incandescent lamps measurement system:

Equipments needed are:

- Light measurement sphere (chamber)
- Spectrometer
- Power meter
- AC/ DC power supplies
- Waveform generator
- Reference Ballast , Lamps and lamp-sockets

D) Air Conditioners Testing Facilities

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4. Specification of equipments

A) Refrigerating appliance

No.	Testing equipment
1	*Climatic chamber (walk-in chamber)* *Quantity : Two chambers* *Specifications:* Dimensions of the climatic chamber: Outside dimensions : Width 2440 mm Depth 2140 mm Height 2800 mm Insulation thickness 80 mm Inside dimensions : Width 2120 mm Depth 1980 mm Height 2200 mm Chamber construction: - Walk-in chamber. - Door: two wings, both sides of stainless steel sheet metal, minimum width of the door (two wings) is 1500 mm - Floor: insulated panels, outer side zinc plated sheet metal, inner side water resistant PVC coated plywood panel. Electric supply : 400 V / 50 Hz , 220 V / 50 Hz Chamber ambient temperature: adjustable from (+18 °C ~ + 45° C) ± 1 °C Relative humidity: adjustable from (50 % ~ 95 %) ± 3 % Regulation of temperature and relative humidity: microprocessor / digital displays. Built in two adjustable safety thermostats for max. and min. temperatures. Chamber shall be equipped with two inlet ports of diameter 40 mm.

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	Ambient temperature sensors shall be shielded from any sources or sinks of radiant heat in the chamber, including conditioning equipment, external windows or other appliances under test. Ambient temperatures shall be kept constant within ±0.5 K both during the periods required for obtaining stable operating conditions and during the tests. The vertical ambient temperature gradient from the platform to a height of (2 m) shall not exceed (1 K/m) measured at the same vertical axis as for the ambient temperature measurement. Air circulation in the test room shall be such that the specified ambient temperatures are obtained within the limits of the specified tolerances. The refrigerating appliance under test shall be shielded from any air currents of velocity above (0.25 m/s).
2	***Adjustable Transformer*** ***Quantity : Three*** Specifications: Primary: Single phase 220 - 230 Volts Secondary : Single phase (0 – 240 Volts) Capacity : 3 kVA A-meter built-in V-meter built-in
3	***Watt-hour meter*** ***Quantity : Four*** Specifications: Electrical ratings: 220 Volts / 50 Hz Watt-hour meters shall be readable to 0,001 kWh and be accurate to within ±1 % of the total energy consumption measured during the test period (i.e. 1 % of reading).

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4	***PC–based Data Acquisition system*** ***Quantity : Four*** Specifications: - Electrical ratings : 220 V / 50 Hz - No. of channels : 32 - The data acquisition system shall be capable of recording temperature values with measuring intervals not greater than 60 seconds. - Overall uncertainty of temperature measurements not greater than ±0.5 K - The data acquisition system shall be also capable of checking the Nominal Voltage and Frequency, power, etc… - Thermocouples: - Type K (Temperature range: –26 ~ +105 °C) - Length of thermocouple : 3.5 meters - No. of Thermocouples : 32 / system - The sensor of the thermocouples shall be inserted in the centre of solid cylinders made of brass or tin-covered copper having a mass of 25 g and of minimum external area (diameter = height = about 15.2 mm) - Software: - Capable of graphics for every channel and formatting in Excel and calculation min, max, avg , etc…. - Laptops : (Quantity: four) - Colour Printers : (Quantity: four)

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5 ***Test Packages*** ***Quantity :*** ***See Table 1 below***

Specifications:

These are used as the reference load during the test.

Dimensions and chemical composition of the test packages :

The test packages shall be in the form of rectangular parallelepipeds.

Their size, prior to freezing, and their mass, packaging included, shall be in accordance with table 1

Table 1 — Test packages dimensions and mass

Dimensions mm	Tolerance mm	Mass g	Tolerance %	Quantity
25 × 50 × 100 50 × 50 × 100 50 × 100 × 100 25 × 100 × 200 50 × 100 × 200	± 2,0 for dimensions 25 and 50 ± 3,0 for dimensions 100 and 200	125 250 500 500 1000	±2	100 100 300* 300 100

Composition of the test packages:

The packages shall consist of the following:

a) A suitable filling material containing, per 1000 g:

- 230 g of oxyethylmethylcellulose;
- 764,2 g of water;
- 5 g of sodium chloride;
- 0,8 g of 6-chloro-m-cresol.

The freezing point of this material is − 1 °C (its thermal characteristics correspond to those of lean beef).

The following alternative composition of test packages with a freezing point near −5 °C may be used:

- 232 g of oxyethylmethylcellulose;
- 725 g of water;
- 43 g of sodium chloride;
- 0,6 g of 6-chloro-m-cresol

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	c) A wrapper, consisting of a sheet of plastic or any other suitable material of such a nature that exchange of moisture with the ambient medium is negligible. After filling, the wrapping sheet shall be sealed. It is advisable to use a laminated sheet, consisting of layer of high-pressure polyethylene, easily sealable, 120 µm thick, together with an external sheet of polyethyleneterephthalate approximately 12.5 µm thick, the two layers being bonded together. * 500 g packages (50 mm × 100 mm × 100 mm) shall be fitted with thermocouples, which shall be inserted in the geometrical centre of the packages in direct contact with the filling material. (Quantity 20), (10) of composition a) above and (10) of composition b) above.
6	***Electric Chest Freezers*** ***Quantity: Four*** To store the test packages when not in use. Specifications: Electrical ratings: 220 V / 50 Hz Storage temperature : - 18 °C Storage volume : 600 L **Estimated price for the testing equipment is US $ 240 000**

Royal Scientific Society responsibilities:

To provide an appropriate building structure to accommodate the testing equipment.

The building shall be equipped with all Utilities needed: Electrical power, Air conditioning systems, compressed air, water, cooling water, distilled water, hot water, drain, lighting, floor with sufficient weight bearing capacity.

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B) Clothes washing machines

General requirements for the testing Lab: Water supply requirements: A water hardness of (2.5 ± 0.2) mmol/l shall be used during the tests. The temperature of the water supply shall be: - for cold water (15 ± 2) ºC - for hot water temperature indicated by the manufacturer ± 2 ºC, or (60 ± 2) ºC , if no value is given. Ambient temperature of the test room : (+23 ± 2) °C Systems below shall be controlled through data acquisition system with software

No.	Testing equipment
1	**Voltage stabilizers** **Quantity : Four** *Specifications:* Input ratings : 220 ~ 240 Volts / 50 Hz Output ratings : 220 ~ 240 Volts ± 1% , 50 Hz ± 1% Capacity : 2 KVA
2	**Climatic Chamber** **Quantity : One** *Specifications:* Electric supply : 400 V / 50 Hz or 220 V / 50 Hz Chamber ambient temperature: adjustable from (+15 °C ~ + 30 ° C) ± 2 °C Relative humidity: adjustable from (60 % ~ 75 %) ± 5 % Inside dimensions : Width 900 mm Depth 800 mm Height 1000 mm

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3	**Digital Balance** **Quantity: Two** *Specifications:* Electric ratings : 220 V / 50 Hz Capacity : 10 kg Accuracy: ± 0.1% Resolution: 0.1 gram, or better
4	**Instruments to measure the water temperature** **Quantity : Four** *Specifications:* Electric ratings : 220 V / 50 Hz or Battery operated Temperaure range: (+5 ~ + 80 °C) Resolution: 0.2 K Accuracy : ± 0.5 K Display : Digital Liquid type : Water No. of channels : 2 Protection class : IP65 Temperature sensors: PT100 Transducer options: complete set
5	**Watt-hour meter** **Quantity : Four** *Specifications:* Input ratings: 220 V / 50 Hz Watt-hour meters shall be readable to 0,001 kWh and be accurate to within ±1 % of the total energy consumption measured during the test period (i.e. 1 % of reading).

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6	**Water pressure gauges** **Quantity : Eight** *Specifications:* Range : 0 ~300 kPa Acccuracy: ± 5%
7	**Temperature Recorders** **Quantity : Two** *Specifications:* Electric ratings : 220 V / 50 Hz or battery operated Temperature range: (+10 °C ~ + 50 ° C) ± 1 °C
8	**Reference Detergent** **Quantity : 20 kg** *Specifications:* *see attached Annex 1*
9	**Reference washing machine** **Quantity: 2** *Specifications:* *see attached Annex 2*
10	**Water Flowmeters** **Quantity: Ten** *Specifications:* *Flow : (0 ~ 5) L / minute* *Accuracy : 1%*

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11	**Reference Textile Load** *Specifications:* Cotton base load textile : See attached Annex 3 Quantity: No. of sheets : 24 No. of pillowcases : 100 No. of hand-towels : 200
12	**Timer Quantity: Two** *Specifications:* Battery operated. Range: (0 - 120) minutes ± 5 sec.
13	**PC–based Data Acquisition system Quantity : Two** *Specifications:* - Electrical ratings : 220 V / 50 Hz - The data acquisition system shall be capable of measuring and recording the electrical parameters, room temperature , room humidity, pressure and temperature of water inside the unit under test with measuring intervals not greater than 60 seconds. - Software: Included - Laptops : (Quantity: Two) - Color Printers : (Quantity: Two) **Estimated price for testing equipment is : US $ 150 000**

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Royal Scientific Society responsibilities:

To provide an appropriate building structure to accommodate the testing equipment.

The building shall be equipped with all Utilities needed: Electrical power, Air conditioning systems, compressed air, water, cooling water, distilled water, hot water, drain, lighting, floor with sufficient weight bearing capacity.

C) Compact and Tubular fluorescent Lamps and incandescent lamps

No.	Testing equipment
	The system measures: Total spectral flux (Watts/nm) Total radiant flux (Watts) Total luminous flux (lumens) Color (CCT) Color Ellipses Spectral purity Color rendering Index (CRI) Chromaticity coordinates Lamp current Lamp voltage Lamp wattage Reference Ballast voltage

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	Basic components of the system: 76-inch light measurement sphere Test: T5, T8, T10, T12, and CFL Internal Lamp Mount for base-up and base-down mounting. Lamp Sockets: Linear and screw base G5, G13, G24Q, E12, E14, E27 and E40 spectrometer Variable Impedance Reference Ballasts Reference calibration lamps Calibration Lamp Power Supply Auxiliary Correction Lamp and Power Supply Photopic Detector and Radiometer Temperature Probe and Monitor Lamp Measurement Software Windows Compatible Computer System AC / DC Power supply for operating Test Lamps Variable Transformer Energy Analyzer for auxiliary and test lamps Power meter Waveform Generator **Specifications:** Sphere diameter 76 in. (1.93 m) Sphere coating spectraflect Reflectance 98% Radiometric range 5,000 W(max)

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	Fluorescent Lamps range	0.08-26,000 lm
	Fluorescent Lamps fixtures	T5, T8, T10, T12, E12, E14, E27, E40, G5, G13, G24Q, CFL
	Spectrometer	
	Detector	TE Cooled 1044 x 64 CCD (back thinned)
	Spectral range	350 - 1050 nm
	Resolution	1.5 FWHM
	Integration time	8 ms – 40 s
	Cooling	10+/- 0.05 C
	TE Temp drift	+/- 1C
	Linearity	+/- 0.5%
	Wavelength accuracy	<+/-0.4 nm
	Focal length	100 mm
	Slit width	2.5 nm
	Spectral sample interval	0.25 nm
	Mechanical shutter	Yes
	Speed	0.1 scans/sec
	Dynamic range	30000:1
	Optical output	600 µm, 3m long
	AD Converter	16 bit
	PC interface	USB
	Power Meter	
	Voltage rms input	0 - 1000 V
	Current	0 - 7 A per element

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	AC power supply	
	Line voltage input	187 - 253 VAC, 47 - 440 Hz
	Voltage ranges	0 - 135 VAC
		0 - 270 VAC
	Frequency range	45 – 5000 Hz
	Current	0 – 7.4 A (on 270 V range)
	Power	1800 VA (on 270 V range)
	DC power supply	
	Line voltage input	200 - 250 VAC, 47 - 63 Hz ,10 A max
	Power output (1.2Kw)	0 – 300 V, 0 – 4 A , 1200 W
	Waveform Generator	
	Frequency	1 µHz – 20 MHz (sinewave)
	Amplitude	10 mVp-p – 10 Vp-p into 60 Ohm circuit
	Line voltage input	100 – 240 VAC, 50/60 Hz
	Electrical ratings	
	Line voltage input	200 – 240 VAC, 50 / 60 Hz
	Reference ballast	L1: 720 V, L2: 180 V, L1+L2:0.75 A maximum
	Estimated price for testing equipment is : US $ 300 000	

Royal Scientific Society responsibilities:

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The building shall be equipped with all Utilities needed: Electrical power, Air conditioning systems, compressed air, water, cooling water, distilled water, hot water, drain, lighting, floor with sufficient weight bearing capacity.

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D) Air Conditioner

No.	Testing equipment
	Capacities & Accuracy Test Unit Capacities: Cooling: 5000 - 36000 Btu/hr. Heating: 5000 - 36000 Btu/hr. Repeatability: Test results shall be repeatable within ± (100 Btu/hr + 2% of Rating) based on identical test conditions for rated test unit capacities 5000-36000 Btu/hr. Heat Balance: Heat balance within 4.0% for test unit cooling capacities of 5000 - 36000 Btu/hr. **Typical Cooling test Conditions** Test Standard ISO 5151

TEST DESCRIPTION	INDOOR DB/WB °F	OUTDOOR DB/WB °F	INDOOR DB/WB °C	OUTDOOR DB/WB °C
Standard Cooling (T1)	80.6 / 66.2	95.0 / 75.2	32 / 23	43 / 26
Standard Cooling (T2)	69.8 / 59.0	80.6 / 66.2	21/ 15	27 / 19
Standard Cooling (T3)	64.2 / 66.2	114.8 / 75.2	29 / 19	46 / 24
Maximum Cooling (T1)	89.6 / 73.4	95.0 / 73.4	32/ 23	43 / 26
Maximum Cooling (T2)	80.6 / 66.2	95.0 / 75.2	27/ 19	35/ 24
Maximum Cooling (T3)	89.6 / 73.4	125.6 / 87.8	32/ 23	52 / 31
Enclosure Sweat Test	80.6 / 75.2	80.6 / 75.2	27/ 24	27 / 24
Freeze Test	69.8 / 59.0	69.8 / -	21 / 15	21/ -

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Typical Heating Test Conditions Test Standard ISO 5151

TEST DESCRIPTION	INDOOR DB/WB °F	OUTDOOR DB/WB °F	INDOOR DB/WB °C	OUTDOOR DB/WB °C
Standard Heating (high)	68.0 / 59.0 max	44.6 / 42.8	20 / 15 max	7 / 6
Maximum Operating Conditions Heating	80.6 / -	75.2 / 64.4	27 / -	24 / 18

Operating conditions:

Indoor and Outdoor Maximum Temperatures = 52.0 °C duration not to exceed 4 hours.

Indoor and Outdoor Minimum Temperatures = 7.0 °C

Design Description

Insulated Test Rooms

Test rooms are prefabricated insulated rooms consisting of 4" R34 urethane foam. Room is divided by an integral barrier wall creating two adjacent test rooms, one being the indoor side compartment and the other outdoor side compartment. Floor will be galvanized steel and have a load bearing capacity of 200 Lbs./Sq. Ft. Test room is completely sealed with both gaskets and additionally with Silicone RTV when installed. Access Doors are provided in each test room and include an observation window.

Test Room Reconditioning Equipment

To enhance the range and accuracy, each test room shall use water for cooling.

Water provides the most predictable heat transfer characteristics and allows very precise calculation of heat removal. This is critical to proper capacity measurement when used as a Calorimeter. Test facility shall be configured to perform both Cooling and Standard rating tests in the Calorimeter configuration.

Test facility shall be configured to perform both Cooling and Standard rating tests in the Calorimeter configuration.

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	Controlled Air Space (CAS) The test room shall be enclosed in a temperature controlled guard space to minimize heat loss or gain from the test room. Walls, doors and windows for this guard space shall be supplied. Test facility support structure, walkways shall be supplied. Thermocouple grids A thermocouple grid arrangement shall be constructed for the indoor compartment and outdoor compartment. This grid when interfaced with the data acquisition unit provides the means to accurately balance and measures the heat flow through the calorimeter walls by properly adjusting temperature of the controlled air space. The grid arrangement shall insure proper balancing of the walls, floor and ceiling. Barrier Wall A thermocouple grid arrangement shall also be constructed for the barrier wall between the indoor compartment and outdoor compartment. This grid when interfaced with the data acquisition unit shall provide the means to accurately measure the heat flow through the barrier wall by measuring heat gain directly from the thermocouple grid. Control and Power Panels Control and power panels shall be located within each test room so total energy supplied to the test rooms can be measured. Power shall be supplied to each room by a measured three-phase power line. Machinery Room The machinery room shall contain the air handling equipment, chiller equipment, and control and power panels required for conditioning the guard space and providing chilled water to the test rooms.

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Indoor Compartment

Air Reconditioning and Distribution System

Indoor side air reconditioning shall be designed to circulate and condition the air inside the test room and provide an even discharge of low velocity air as close to the test unit inlet as possible without influencing normal operation of the test unit. Also included are:

- Main blower
- Air mixer
- Cooling and dehumidifying coils
- Auxiliary multi-staged heaters
- Dry bulb and Wet bulb control valves
- Auxiliary multi-stage steam generator
- Auxiliary cooling coils and blowers

Steam Generation

The design for steam generation shall guarantee a very efficient, highly accurate, repeatable, and shall offer a wide range of capacity control. The design shall also allow for easier cleaning, maintenance, and continuous

Measurement of consumption. Steam generation shall be controlled by direct control of heat input to an aluminum plate. A unique two-stage system for water level control shall be used to provide a constant supply of water with resolution better than ±5 grams. Heat shall be supplied by fixed and variable stages for complete control over entire range of capacity. This method will allow for precise control of moisture added to the test room.

- Accuracy better than 1%.
- Capacity up to 20 Lbs./Hr (9 Kg/Hr)

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	Air Temperature Sampling System Air sampling system shall be configured to maintain approximately 1000 FPM in the Psychrometric box. Platinum 4-wire Dry bulb and Wet bulb RTD thermometers shall be included and interfaced with the data acquisition equipment. Control of dry bulb and wet bulb conditions shall be enhanced by the use of fast responding %RH transducers and thermocouples. Single stainless steel sampling tree and hose connections shall be included. Controlled Air Space (CAS) Air space temperature shall be fully controlled and includes an air-handling unit to condition the air around the test room. This will allow heat loss in the test room to be accurately balanced and maintained. Air-cooled or water-cooled condensing units can be specified for the controlled air space cooling equipment. • Variable capacity heating/cooling system. Auxiliary Cooling (For Heating Test Conditions only) Cooling shall be performed using chilled water coils. Thermocouples A T-type thermocouple panel shall be located inside the test room. Twenty thermocouples shall be installed. These will typically be used to measure refrigerant temperatures, inlet and outlet air temperatures and other parameters for unit evaluation. Test Unit Supply Power A multiple outlet power panel shall be installed in the test room. This is the single-phase source of power for test units. Various outlets shall be included. To provide proper voltage control and measurement the voltage shall be measured inside this panel.

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Outdoor Compartment

Air Reconditioning and Distribution System

Outdoor air reconditioning shall be designed to circulate and condition the air inside the test room and provide an even discharge of low velocity air as close to the test unit inlet as possible without influencing normal operation of the test unit. Also included are:

- Main blower
- Air mixer
- Cooling and dehumidifying coils
- Auxiliary multi-staged heaters
- Dry bulb and Wet bulb control valves
- Auxiliary multi-stage steam generator

Steam Generation

Similar to indoor side an auxiliary steam generator shall be located in the outdoor room. Auxiliary steam shall be supplied for testing split units where a wet bulb temperature is desired and the unit under test does not reject moisture to the air.

Heat shall be supplied by fixed stages. Variable control shall be maintained by an effective method for wet bulb control using a “Wet” coil and heat exchanger.

- Accuracy better than 1%.
- Capacity up to 9 Kg/Hr

Air Temperature Sampling System

Air sampling system shall be configured to maintain approximately 1000 FPM in the Psychrometric box. Platinum 4-wire Dry bulb and Wet bulb RTD thermometers shall be included and interfaced with the data acquisition equipment. Control of dry bulb and wet bulb conditions are further enhanced by the use of fast responding %RH transducers and thermocouples. Single stainless steel sampling tree and hose connections shall be included.

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	Chilled Water System • Outdoor room shall use a chilled water loop to cool, dehumidify and measure the energy removed from the room during testing. This approach will provide a very accurate, repeatable method for measuring outdoor capacity. Water is a stable media for heat exchange and provides the highest possible accuracy in measurement of capacity. • Other cooling methods such as those using direct expansion refrigerant coils shall not be used as they can be difficult to measure and unstable. • A system incorporating separate control valves and a heat exchanger for Wet and Dry bulb control shall be used. The chiller system design shall include a primary/secondary multistage pumping arrangement, which provides stable water supply temperature, flow rate control and complete capacity control from no load to full load conditions. • It shall be possible that Water chiller set point can be varied over a wide range for various test conditions. Precision RTD's measure temperature difference and a high accuracy mass flow meter shall be used to measure water quantity. • All chiller functions shall be fully automated and integrated with the test software. Test Unit Air Leakage Balancing/Air Flow Measuring Apparatus Air leakage balancing and adjustment shall be accomplished by using a variable speed blower and nozzle arrangement. Pressure differential shall be measured between the two test rooms and the proper blower shall run to balance the pressure between the rooms. Two complete assemblies shall be provided so leakage can be balanced in either direction. Two nozzles shall be included in each assembly and have a range of 2-10 SCFM. Balancing shall be performed automatically or manually.

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	Air flow Measuring Apparatus (CODE TESTER for Psychrometric Tests only) A precision airflow measuring apparatus shall be installed in the outdoor room. This room will be used to simulate indoor heating test conditions for heating capacity tests. All necessary transducers shall be supplied to measure nozzle pressures. An air sampling system similar to that used in the test rooms shall be included for measuring discharge air properties. Blower speed control and data acquisition shall be fully automated by the computer. The software shall assist the operator in proper nozzle selection prior to starting a test. Calculations for airflow and capacity shall be performed continuously. Controlled Air Space (CAS) Air space temperature shall be fully controlled and shall include an air-handling unit to condition the air around the test room. This will allow heat loss in the test room to be accurately balanced and maintained. Air-cooled or water-cooled condensing units shall be specified for the controlled air space cooling equipment. • Variable capacity heating/cooling system. • Auxiliary DX coil included for Calorimeter Heating conditions Thermocouples A T-type thermocouple panel shall be located inside the test room. Twenty thermocouples shall be installed as standard configuration. These will typically be used to measure refrigerant temperatures and inlet and outlet air temperatures for unit evaluation. Test Unit Supply Power A multiple outlet power panel shall be installed in the test room. This is the single-phase source of power for the test units. Various outlets shall be included. To provide proper voltage control and measurement the voltage shall be measured inside this panel.

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	Data Acquisition and Control System A computerized Data Acquisition/Control System shall be designed specifically for use with the test facility. The system shall include a computer with all necessary I/O hardware, printer, software, analog data acquisition, transducers, control system electronics, automated test unit power system, and the required documentation, schematics, etc. Computer System The computer shall be a typical business application PC compatible computer. Commercially available electronics items may be added to this computer to help accomplish data acquisition and control functions. Also shall be included in the system is a suitable amount of system ram memory, hard disk drive and a CD-RW to provide data and program storage. A high quality laser printer shall also be provided. System Software The operating system shall be Windows XP. Applications software for data acquisition, facility control and report generation shall be supplied with the system. Software to be installed on the system's hard disk by the manufacturer at the time of facility installation. Analog Data Acquisition This system that is used as a “data logger” shall contain a high accuracy 60-channel analog input front end, which communicates with, and is remotely programmed through the test system computer. Measurements include RTD’s, Thermocouples, and DC Volts. Transducer Packages Shall be included in both the room-side compartment and the outdoor-side compartment which are precision watt/watt-hour transducers for measuring power consumption in the two compartments. The test unit power system shall also contain a package consisting of precision transducers for measurement of voltage, current and watt/watt hour information.

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	Control System Electronics All of the necessary control electronics and their sensors shall be provided for use in the control loops. Relays, valves, power controllers shall be included. Where possible each automated output shall include a manual over-ride in the software to allow the device to be controlled manually. Optically isolated control modules shall be used in the control system to control outputs automatically using an RS-422 interface. Inputs shall also be provided for all data required to fully automate the tests. Automated Single Phase Test Unit Power System This system shall include a variable single-phase voltage source, operating under computer control, capable of delivering the required test unit power per normal room air conditioner specifications. This system shall automatically regulate and control test unit power during the course of the test. • This test unit power system will control and regulate 50 or 60 Hz power from a supplied Electronic Power Source. • Other test unit power options shall also be available such as secondary power supplies to allow engineering evaluation of individual components on the air conditioner under test. Automated Three Phase Test Unit Power System This system shall include a variable three-phase voltage source, operating under computer control, capable of delivering the required test unit power per normal room air conditioner specifications. This system shall automatically regulate and control test unit power during the course of the test. •This test unit power system will control and regulate 50 or 60 Hz power from a supplied Electronic Power Source. • Other test unit power options shall also be available such as secondary power supplies to allow engineering evaluation of individual components on the air conditioner under test.

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	Test Console The operator test console workstation shall consist of a freestanding desktop workstation and a cabinet, which will contain the Data Acquisition Unit. • Computer, keyboard • Data Acquisition Unit • Printer • 19" LCD Monitor • DAC Cabinet **Major components Range and Accuracy** **Single Phase Test unit power source** An Electronic Variable voltage and frequency power supply 5 KVA shall be provided. Measurement Measurement of single phase supply power shall be achieved using a power analyzer configured to measure 3 individual single phase loads. Test Unit interface shall be configured for the following: 10 Amp circuit 20 Amp Circuit 30 Amp Circuit **Three Phase Test Unit power source** An Electronic Variable voltage and frequency power supply 5 KVA shall be provided. Measurement Measurement of three phase supply power shall be achieved using a power analyzer configured to measure one 3 phase 4-wire load. Test Unit interface will be configured for the following: 15 Amp circuit

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Room Power Transducers

• Indoor Room: 3 Phase 4 Wire 15 Amp 240 V Watt-Watt-hour transducer - Remote voltage sensing Accuracy 0.25% of reading from 10% to 150% of ful scale.

• Outdoor Room: 3 Phase 4 Wire 15 Amp 240 V Watt-Watt-hour transducer - Remote voltage sensing Accuracy 0.25% of reading from 10% to 150% of ful scale.

Chilled Water Flow Meter

A high accuracy Mass-flow meter shall be supplied to measure water quantity in the indoor and outdoor rooms. This meter shall be integrated with the data acquisition and control system and also will control the flow rate supplied to the test room.

- Range 0-15 GPM
- Accuracy 0.25% full scale

Temperature Measurement

High precession RTD's shall be supplied and calibrated for use in measuring all dry bulb and wet bulb temperature conditions. Outdoor chilled water supply and discharge temperatures shall also be measured using these high accuracy devices.

RTD's shall be integrated with the data acquisition and control system for full automation.

- Calibrated Accuracy: +/- 0.1 °C
- Ten individually calibrated precision platinum RTD's
- Indoor room dry bulb temperature
- Indoor room wet bulb temperature
- Outdoor room wet bulb temperature
- Outdoor room dry bulb temperature
- Airflow measuring apparatus dry bulb temperature
- Airflow measuring apparatus wet bulb temperature
- Chilled water indoor room inlet & outlet temperature
- Chilled water outdoor room inlet & outlet temperature
- Chilled water outdoor room outlet temperature

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Pressure Measurement

High quality electronic pressure transducers shall be supplied for measuring all pressures.

Test room pressures

- Barometric Pressure 800 hpa – 1060 hpa range, ±0.25 %
- Room pressure differential ± 0.1" H2O transducers, ±0.5%
- Leakage nozzle pressure differential 0-5" H2O transducers, ±0.5%

Code Tester (Psychrometric Tests)

- Nozzle pressure differential 0-4" H2O transducer ±0.25%
- Test unit discharge pressure ± 1.0" H2O transducers, ±0.25%
- Before Nozzle static pressure 0-5" H2O transducers, ±0.5%

Computer Data Acquisition System

- Computer
  - IBM PC Compatible including:
  - Hard disk drive
  - Serial/parallel ports
  - VGA color graphics interface
  - 19" LCD color monitor
  - Laser Printer
  - RS-422 interface card
  - CD - RW
  - Software, installed:
  - Windows Operating System
  - Room air conditioner test and control software

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	Air Flow Measureing Apparatus An Airflow measuring apparatus shall be installed in the larger test room to be used for measuring indoor airflow for the purpose of determining indoor cooling and heating capacity. Flow meter assembly shall be completed with air temperature sampling system, mixer, inlet plenum, diffusion baffle, nozzle plate assembly, pressure taps, discharge plenum, diffusion baffle, and exhaust blower. Access doors shall be provided for RTD access, and nozzle access. System shall be fully integrated with data acquisition and control system for full automatic control. Small nozzles shall be included for leakage testing and very low airflow measurements when required. Measurement Range: 10 to 1350 SCFM Air Flow Control: Variable speed exhaust blower Accuracy: 1% Test Facility Utility Requirements Electrical Power: 380/220 VAC ± 6%, 3 phase, 4 wire, 50 Hz. 150 amps, Drift of less than 1 volt per minute **Estimated price for testing equipment is : US $ 1 000 000**

Royal Scientific Society responsibilities:

To provide an appropriate building structure to accommodate the testing equipment. The overall dimensions including support equipment and access in front and around the test facility would be: 14 meters wide x 12 meters deep x 5 meters high.

The building shall be equipped with all Utilities needed: Electrical power, Air conditioning systems, compressed air, water, cooling water, distilled water, hot water, drain, lighting, floor with sufficient weight bearing capacity.

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5. References

- BS EN 60456: 2005 Clothes washing machines for household use - Methods for measuring the performance.

- JS 1749: 2007 Household refrigerating appliances - Characteristics and test methods

-ISO 5151 : Non-ducted Air Conditioners and heat pumps- Testing and rating for performance

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Annexes

Annex 1: Reference detergent

Annex 2: Description of the reference washing machine and methods of use

Annex3: Specification for base loads

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Royal Scientific Society

Upgrade RSS Technical Capability in Development of Building Envelope Component Testing Laboratory to support Energy Code Enforcement

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Aim of Project:

The aim of this project is to establish a state of art optical & thermal testing laboratory for testing energy performance of building envelope materials which will help to create database of certified construction material. It will help implement codes in unified manner and provide unbiased to information on the performance of the building envelope material or products.

Description of Project:

The project objective is to establish a pilot Regional Energy Efficiency Center with an established building envelope components testing laboratory having capabilities to provide energy performance testing services to the building sector in a unified manner.

The project will be the first step in developing a building envelope component certification program to be the nationally accepted benchmark for the design, construction and operation of high performance energy efficient buildings. This will help establish the minimum level of energy efficiency for the proposed building envelope component namely fenestration, roof and wall roof systems. The certification program will provide products energy performance level which will be listed on the label. Energy rated and labeled products will provide building inspectors a means to verify compliance of the Jordan's new Energy Efficient Building Code.

The new Energy Efficient Building Code specifies the requirements that need to be adhered to by the building envelope components in terms of various performance requirements (SHGC, Light Transmittance, U-factor and Air Leakage, Surface Reflectance, Surface emissivity and R-value).

As part of the implementation program of the energy efficient building code, the RSS is interested in developing a certification institution which will be capable of

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providing accurate independent certifications on the Building component performance parameters.

The establishment of an energy performance-testing laboratory at RSS will provide certification services and be recognized as one of its independent laboratory.

Goals of Project:

- Establishment of state of art testing laboratory which will help creates a unified database of certified materials and products. This will help manufacturers use products with know performance in the buildings.
- Unified product performance information will help to identify and respond to the range of barriers that limit the implementation to the use energy efficient products and technologies.
- Data will help use of standardized building envelope component performance information in computer simulation tool for analyzing the building component performance. This will help better simulation and real life results agreements.
- The public data base will provide base performance information of energy efficient products available in the marketplace which will encourage competition, research and development of newer more efficient products.
- Testing laboratory is critical to support development and implementation of building envelope component rating (fenestration, insulation and roofs). The testing lab, simulation and quality check in a ratings program helps support unbiased analysis and verification.
- Helps develop and enhance standards development

Train RSS technicians on proper use of the requested equipment by providing

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actual training and information on conduction calibrations, testing, round robins and quality control checks.

Project Deliverables:

Building envelope component energy labeling system:

- To set up a state of art building envelope component testing laboratory at Royal Scientific Society (RSS).
- The laboratory will have required capabilities to test 1) Thermal transmittance 2) Solar Gain 3) Spectral optical measurements of glazing, 4) Air Leakage 5) Surface reflectance and emissivity of building envelope components as applicable.
- Provide technical know including design drawings, operation manual, calibration and quality control guidelines.
- Help procure correct testing equipments.
- Hold experts and professionals workshop to discuss and address technical issues during implementation process.
- Help develop database for certified material and products which will have public and stake holder access.
- RSS will provide the location ,space and the required civil work in coordination with the provider abiding with the required specifications .
- The provider shall install ,operate and conduct proper training at RSS premises to the RSS technicians during commissioning .
- Calibration, operation and commissioning of testing laboratory are the provider responsibility, within the period of the project.

Warranty, spare parts, manuals ,names of local suppliers shall be submitted by the provider.

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List and Specification of Equipment needed:

(Note: This equipment is to be build to specifications and not available in the market place, The power supply in Jordan is 220 volts):

No.	Testing equipment
1	**Thermal Transmittance testing Chamber (Guarded Hot Box)**: Is used for the Measurement of the thermal transmittance (U-factor) and thermal resistance (R – Value) of fenestration and building walls assembly/ components. Guarded hot box test method is used for establishing the thermal performance of building assemblies when exposed to controlled environmental conditions (surface heat transfer coefficients at temperature conditions representative of their use). This test method is used for large homogeneous or non-homogeneous specimens. Smaller flat homogeneous specimen can be tested using Heat Flow Meter. This test method may be applied to building structures or composite assemblies of building elements for which it is possible to build a representative specimen appropriate for the test apparatus. *Specifications:* **Components in Guarded Hot Box:** • Room Side Metering Chamber • Environment Side Room Chamber • Guard Chamber • Surround Panel for installing test specimen **Room Side Metering Chamber:** • Heater • Fans to circulate air in the metering room within natural convection flow requirements. • Baffle • Heaters for Baffle • Humidity control

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	• Temperature controlled ON/OFF switch • Thermocouple wire, Type T 30 gauge. **Environment Side Room Chamber:** • Refrigeration System • Heater • Fan System to generate required film coefficient • Thermocouple wire, Type T 30 gauge. • Baffle **Guard Chamber:** • Fans to circulate air • Split system to maintain the required temperature in the guarded area • Surround Panel: • Foam of at least 4” thickness for installation of products. **Controls:** • PID controller system for control of environmental conditions in the chambers. • Data acquisition System unit to read thermocouple readings, heat energy and etc. • Inverter, to control environmental chamber fan speed. **Calibrations:** • Calibration transfer standard • Thermocouple calibrator • Computer with program(s) to be connected to the data acquisition unit to read and calculate the data and that would be able to hold required controller cards. **Reference Documents:** ISO 8990, ISO 12567, ASTM C 1363, C1199, and E1423, NFRC 100 and 102

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2	**Solar Calorimeter** (Note: This equipment is to be build to specifications and not available in the market place, The power supply in Jordan is 220 volts): Solar heat gain property measurements are made using solar calorimeters exposed to solar radiation under clear sky conditions (outdoors) or using artificial solar radiation (indoors). The test sample is illuminated with either direct beam radiation only, or with direct beam plus diffuse sky and ground reflected radiation. This test method applies to all fenestration systems, glazed apertures, building envelope components in buildings intended for the controlled admission of solar radiation. This includes windows, glazed doors, translucent panels, skylights, and glazing systems. **Components for Indoor Solar Calorimeter:** • Room Side Metering Chamber • Guard Chamber • Surround Panel for installing test specimen • Artificial Solar Energy source **Equipment:** • Heater • Fans to circulate air in the metering room within natural convection flow requirements. • Absorptance Plate • Water flow system to absorb incident and gain solar energy. • Tracking system • Thermocouple wire, Type T 30 gauge. • Sample Plane Pyranometer: WMO Class 1 instruments, a pyranometer to measure the incident irradiance on a plane parallel to the test aperture. • Horizontal Pyranometer - WMO Class 1 instruments, a horizontal pyranometer shall be used to measure the global horizontal (beam plus diffuse) irradiance. • Wind Velocity meter • Chiller system

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	Controls: • PID controller system for control of environmental conditions in the chambers. • Data acquisition System to read thermocouple readings, heat energy and etc. **Calibrations:** • Calibration transfer standard • Thermocouple calibrator • Computer: **Reference Documents:** ISO 8990, ISO 12567, ASTM C 1363, C1199, and E1423, Design of Thermal Chamber technical paper University of Massachusetts, NFRC 200, 201 and 300.
3	**Spectrophotometer and Integrating Sphere:** These Instruments are used for determining the solar optical properties of glazing materials relevant to energy transfer in flat specular glazing materials. The Solar Absorptance, Reflectance, and Transmittance of Materials are determined using Spectrophotometer and Integrating Spheres. This data is is fundamental for simulation program WINDOW and THERM to analyse the fenestration energy performance. **Equipment:** • Lambda 1050 and The Optica model FTIR from Perkin Elmer are specially designed for optical and radiometric accuracy. ***Note***: These instruments are available commercially in the USA. Perkin Elmer (203-925-4600 Toll Free (USA Only) or 800-762-4000), CVI (phone # 860-928-5834) and Labsphere are the manufacturers of (603-927-4266) **Reference Document:** NFRC 300, ASTM E903

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4	**Air Infiltration testing Chamber:** (Note: This equipment is to be build to specifications and not available in the market place): The equipment is used to determine the air-leakage rates, water leakage and structural test of Windows, doors and Curtain wall. **Components for the equipment:** • Room Side Metering Chamber (Fabricated acrylic and steel wall) • Surround Panel for installing test specimen and calibrations **Equipment:** • Fabricated acrylic and steel wall - Room Side Metering Chamber: • Blower • Pressure, Mass Flow, deflection measurement instruments • Laminar flow device • Water spray rack, with specified nozzles • Reservoir water tank (fabricated locally), and water pump • Temperature and barometric pressure measurement device • Clamping accessories • Calibration plates **Controls:** • Data acquisition System to read measurement of pressure readings, flow rate and etc. • Controls for controlling flow rate and pressure • Computer able to be connected to the data acquisition unit. **Reference Document:** ASTM E 283, E330, E331, E547,AAMA 101

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5	**Heat Flow Meter:** The heat flow meter apparatus establishes steady state one-dimensional heat flux through a test specimen between two parallel plates at constant but different temperatures. By appropriate calibration of the heat flux transducer(s) with calibration standards and by measurement of the plate temperatures and plate separation. Fourier's law of heat conduction is used to calculate thermal conductivity, and thermal resistivity or thermal resistance and thermal conductance. Two instruments are typically used for measuring low and high conductive materials. **Equipment:** • LaserComp Fox 600 and Laser Comp Fox 304. ***Note***: These instruments are available commercially in the USA. (LaserComp tel # 781-233-1717). **Reference Document:** ASTM C 518, 1045
6	**Reflectometer:** Solar reflectometer helps determining the solar reflectance of flat opaque materials in a laboratory or in the field. The purpose of the test is to provide solar reflectance data required to evaluate temperatures and heat flows across surfaces exposed to solar radiation. **Equipment:** • Reflectometer meeting ASTM C1549 ***Note***: These instruments are available commercially in the USA. **Reference Document:** ASTM C1549

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7	**Pyranometer:** The pyranometer measures the solar reflectance of various horizontal and low-sloped surfaces and materials in the field. The test method is intended for use when the sun angle to the normal from a surface is less than 45. **Equipment:** • Pyranometer meeting ASTM E1918 ***Note***: These instruments are available commercially in the USA. **Reference Document:** ASTM E1918
8	**Emissometer:** The portable differential thermopile emissometer covers a technique for determination of the emittance of typical materials. The purpose of the test method is to provide a comparative means of quantifying the emittance of opaque, highly thermally conductive materials near room temperature as a parameter in evaluating temperatures, heat flows, and derived thermal resistances of materials. **Equipment:** • portable differential thermopile emissometer meeting ASTM C1371 ***Note***: These instruments are available commercially in the USA. **Reference Document:** ASTM C1371 **Estimated price for testing equipment is : US $ 1 150 000**

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Summary of equipment cost:

1- Energy Consumption Measurement Equipment cost is US $ 1 840 000 as follows:
   - Refrigerating Equipment US $ 240 000
   - Clothes Washing Machines Equipment US $ 150 000
   - Fluorescent Lamps and incandescent Lambs Equipment US $ 300 000
   - Air Conditioner Equipment US $ 1 000 000
2- Building Envelope Component Equipment cost is US $ 1 150 000

Over all estimated cost is US $ 2 840 000

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