# PROJECT IDENTIFICATION FORM (PIF)

**PROJECT TYPE: Full-sized Project**
**TYPE OF TRUST FUND:GEF Trust Fund**

## PART I: PROJECT IDENTIFICATION

| | | | |
|---|---|---|---|
| Project Title: | **Catalysing the Use of Solar Photovoltaic Energy** | | |
| Country: | Iraq | GEF Project ID: | 5063 |
| GEF Agency: | UNDP | GEF Agency Project ID: | 5137 |
| Other Executing Partners: | Ministry of Environment | Submission Date: | August 28, 2012 |
| GEF Focal Area (s): | Climate Change | Project Duration: | 48 months |
| Name of parent program: For SFM/REDD+ | | Agency Fee: | $222,727 |

### A. FOCAL AREA STRATEGY FRAMEWORK:

| Focal Area Objectives | Expected FA Outcomes | Expected FA Outputs | Trust Fund | Indicative grant amount ($) | Indicative co-financing ($) |
|---|---|---|---|---|---|
| CCM-3 | **Outcome 3.1** Favourable policy and regulatory environment created for renewable energy investments. | **Output 3.1** Renewable energy policy and regulation in place. | GEFTF | 821,273 | 830,000 |
| CCM-3 | **Outcome 3.2** Investment in renewable energy technologies increased. | **Output 3.2** Renewable energy capacity installed. | GEFTF | 1,300,000 | 8,900,000 |
| Sub-total | | | | 2,121,273 | 9,730,000 |
| Project management cost | | | GEFTF | 106,000 | 525,000 |
| **Total project cost** | | | | **2,227,273** | **10,255,000** |

### B. PROJECT FRAMEWORK:

**Project Objective: To reduce GHG emissions in Iraq by demonstrating and catalyzing the application of distributed solar power to meet the energy needs of offices, small businesses, residences and small town services (rooftop solar power systems for air conditioning and water heating; small-scale distributed solar PV power plants).**

| Project Component | Grant type | Expected Outcomes | Expected Outputs | Trust Fund | Financing from relevant TF, ($) | Indicative co-financing, ($) |
|---|---|---|---|---|---|---|
| 1. Investment in solar photovoltaic power technologies for distributed electricity generation for office, residential, small business and small town application. | INV | Concrete evidence of the utility, practicality and competitive advantage of rooftop solar PV AC/water heater systems for office, small business and residential application and the viability of distributed, small-scale (5 MW) solar PV power plants for small town services, leading to replication of the solar PV technology applications that were demonstrated and increased investments in such technologies. | 1.1 Assembly and installation of 2,000 rooftop solar AC/water heater units (1,000 in Baghdad and 1,000 in Najaf; Government offices and staff residences; model town houses; small businesses), based on a review of available solar air conditioner and water heater technologies suitable for Iraq conditions and design of a hybrid concept (technical specifications) for a solar AC/water heater for Iraq conditions. Monitoring data (including costs and energy generation) over one year for energy production/cooling capacity of the units under different operational conditions.<br>1.2 Assessment of small-scale (5 MW) solar PV power plant technology suitable for Iraq conditions, including cost-benefit analysis of a range of configurations.<br>1.3 Site selection (for distributed electricity generation, near Najaf Model Town), design, construction and operation of a small-scale (5 MW) solar PV power plant (with an option for night-time augmentation from a proposed local biogas power plant to which it will be linked, for 24-hour distributed generation capacity) for town services. | GEFTF | 1,300,000 | 8,900,000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 1.4 Monitoring data for operational aspects, power production and distribution, and domestic use of solar power supply. | | | |
| 2. Encouragement of investments in solar power technology in Iraq and consumer uptake of solar appliances through policy reform and financial incentives. | TA | Enhanced private investment in, and consumer uptake of, solar PV technologies (rooftop appliances and distributed solar power plants). | 2.1. Approved and enforced revised policies and regulations, and new financial incentives, to encourage solar power industry development (private sector) and consumer uptake, including removal of import tariffs on components; introduction of subsidies and tax credits to promote investment in, and installation of, solar units; increased taxes on non-solar AC units; development of a renewable energy database containing site-specific data on RE potential to facilitate investment decisions; and clarification of IPP policies, with inducements to accelerate solar PV power plant development throughout Iraq. Examination of inter-connections between distributed power producers and the grid (including feed-in tariffs and net metering options) and support to Government to implement feed-in tariff and/or net-metering schemes. One selected measure to be framed as a NAMA, with corresponding baseline, MRV and institutional systems developed.<br>2.2. Public dissemination of rooftop solar PV AC/water heater options, costs and benefits for air conditioning and water heating (based on Project Component 1). | GEFTF | 600,000 | 590,000 |
| 3. Facilitation of private sector capacity for technology development, innovation, and servicing in the solar power industry, through technical capacity building and domestic market analysis. | TA | Widespread awareness and increased private sector capacity for the supply and servicing of solar PV air conditioners and water heaters and increased Government and private sector capacity for the design, construction and operation of small-scale distributed solar PV power plants, leading to: (1) Increased installed capacity of operational distributed solar PV power plants that are locally designed, engineered, constructed and operated; and (2) increased volume of locally-manufactured solar PV AC/water heater units. | 3.1 Solar power market demand/industry response strategy developed for Iraq, informed by case studies from other countries with developed solar power industries, domestic market analysis, and clarification of Iraqi private sector opportunities for distributed solar PV power production. Iraq private sector and Government agencies exposed to all aspects of the industry (technology development, supply, servicing, financing).<br>3.2 Development and delivery of certified technical training on solar PV technologies (hybridization, supply, service) for emerging private sector companies.<br>3.3 Development and delivery of dissemination sessions on future IPP involvement in the electricity supply network, including relationships with technology firms and Government agencies, feed-in tariffs, and net metering options. | GEFTF | 221,273 | 240,000 |
| Sub-total | | | | | **2,121,273** | **9,730,000** |
| Project management cost | | | | GEFTF | 106,000 | 525,000 |
| **Total project costs** | | | | | **2,227, 273** | **10,255,000** |

## C. INDICATIVE CO-FINANCING FOR THE PROJECT BY SOURCE AND BY NAME IF AVAILABLE, ($)

| Sources of Co-financing | Name of Co-financier[1] | Type of Co-financing | Amount ($) |
|---|---|---|---|
| National Government | Ministry of Environment | Grant | 10,125,000 |
| GEF Agency | UNDP | Grant | 60,000 |
| GEF Agency | UNDP | In-kind | 70,000 |
| **Total Co-financing** | | | **10,255,000** |

## D. GEF/LDCF/SCCF RESOURCES REQUESTED BY AGENCY, FOCAL AREA AND COUNTRY: N.A.

# PART II: PROJECT JUSTIFICATION

### A. DESCRIPTION OF THE CONSISTENCY OF THE PROJECT WITH:

### A.1. THE GEF FOCAL AREA STRATEGIES:

In accordance with Objective 3 of the GEF Climate Change Focal Area Strategy for GEF-5, the project will promote investments in renewable energy. The proposed project focuses on catalyzing the development and use of solar photovoltaic energy in Iraq, taking advantage of an extremely high level of irradiance throughout most of the country, most of the year, and addressing the fact that the country is not yet organized for accelerated growth in solar power service delivery. Although some solar technology development and piloting has been done in various locations in Iraq, a coherent strategy and widespread application of the most beneficial solar power options are now required. This project will therefore set a clear direction for use of the most appropriate solar PV technologies, suitable for Iraqi conditions, and will catalyze consumer awareness of these technologies and facilitate the development of the industry through policy and regulatory inducements.

The project will create a favourable environment for the rapid development of the solar PV power sector in Iraq by adjusting renewable energy policies and regulations (FA Output 3.1) (removing existing barriers) and facilitating ongoing investment (FA Output 3.2) in solar PV power installations and to accelerate the "home-grown" design, assembly and installation of rooftop solar power AC/water heater units. One of these policy measures will be framed as a Government-endorsed Nationally Appropriate Mitigation Action (NAMA) so as to catalyse follow-on climate finance.

### A.2. NATIONAL STRATEGIES AND PLANS OR REPORTS AND ASSESSMENTS UNDER RELEVANT CONVENTIONS:

Iraq ratified the UNFCCC in July 2009. However, Iraq has only just started the process of developing the Initial National Communication and does not as yet have strategies in place for specific elements of climate change mitigation and adaptation. Nonetheless, Iraq has set a clear direction for the energy sector, which accommodates the development of renewable energy technologies, mainly to address the gap between demand and supply and recognizing the huge potential for solar power to do so[2]. This is recognized as ultimately making a significant contribution to reduction of greenhouse gas emissions currently associated with the Iraqi energy sector. This renewable energy direction is further

[1] The Ministry of Electricity, the Ministry of Science & Technology, Anbar University Renewable Energy Research Centre and Najaf Model Town developers have expressed interest in active participation in, and co-financing of, the project. At this stage, their precise roles and amounts of co-financing have not been formalized through the appropriate Government committees (though preparatory discussions have been productive and positive). Although these entities are absent from the table above, their operational participation in, and financial support to, the project is likely to be highly significant and will be formally agreed during the project preparation phase. The Ministry of Electricity and the Model Town developers, especially, are expected to invest up to an additional $12-15 million for the 5 MW solar PV power plant. They will expect a reasonable return on their investment through collection of distributed generation electricity tariffs.

[2] The Ministry of Electricity has a budget for development of solar power in Iraq, and the Ministry of Science and Technology is actively engaged in research on solar power applications.

reinforced in the recent (May 2011) Joint Declaration[3] signed by Iraq and the European Union, in which sustainable energy in Iraq is explicitly mentioned, including generation from low and zero-carbon emission sources.

The Ministry of Electricity Master Plan for 2010-2030[4] indicates that 10,000 MW of fossil-fuelled plants need to be in place by 2013 to meet expected demand and to overcome the current shortfall in supply. Other units to be considered after 2013 will be based on the projected increase in demand, and a combination of Government and private-sector finance will be required. Residual Heavy Fuel Oil (HFO) is expected to be the primary fuel for the initial 10,000 MW, whereas natural gas, distillates and renewables will be brought on stream after 2013.

The current main drivers of the Electricity Master Plan are as follows:

- Lack of adequate power supply (with political, security and stability implications that should be addressed quickly).
- Insufficient natural gas and distillates capacity to meet needs until after 2013 (therefore, use of HFO for new plants until 2013).
- Urgent need to get power plants online (with single cycle gas turbine (SCGT) plants until 2013).

It is very unlikely that a supply-demand balance will be achieved by the target of 2013 (2015 is more likely). Thereafter, the Ministry of Electricity would like to use more efficient combined cycle gas turbines and increase the reliance on renewable energy alternatives: for example, the Ministry intends to build 16 solar power plants in the next five years (whether PV or thermal has yet to be defined), and options for private sector Independent Power Producers – IPPs – have been discussed. While there is certainly private sector interest in the IPP concept, there are a number of constraints, which the GEF project will address. The first such constraint is that IPP discussions to date have focused on power plants dependent on oil or natural gas for fuel, with the IPP assuming all the risk for fuel supply (and this is a very high risk at the moment, with inadequate and sporadic gas supplies, especially, being paramount). The second constraint is the lack of policy clarity about diversified power supply, including renewable energy, given the Government of Iraq's previous preoccupation with oil and gas-fired power plants. Development of progressive IPP policies, which explicitly include renewable energy power plants (within this proposed project), will eliminate the unreliable energy input issue, which, in turn, will be highly conducive to private sector investment.

Given the persistent gap between electricity demand and supply, and its possible protraction into the next 5-year period (rather than just 1-2 years, as originally expected), the Government of Iraq recognizes the need to activate renewable energy options now, with a focus on solar power development. This has the highest potential for addressing electricity demand-supply gaps and also reducing greenhouse gas emissions, which will otherwise continue to increase through reliance on hydrocarbon-based power plants.

Estimates provided by the German Aerospace Center DLR indicate that in some parts of Iraq solar radiation reaches 6 kWh/m$^2$/day, with an annual country average of 2,050 kWh/m$^2$/year for Global Horizontal Irradiance and 2,000 kWh/m$^2$/year for Direct Normal Irradiance (a threshold for economic potential in the medium-term for both photovoltaic and large solar thermal applications)[5]. This high-level of irradiance has been obvious to Iraqis for a long time, evident in the work of the Solar Energy Research Center in the Ministry of Science and Technology (MoST; part of the Iraqi Scientific Research Council), which has been active since 2006, examining solar energy applications that suit Iraqi conditions (for example, experimentation with solar-tracking PV panels, and with various solar-powered air conditioners). MoST is also the Iraq focal point for the International Renewable Energy Agency, IRENA. Furthermore, Dr. Hussein al-Shihrestani, Iraqi Deputy Prime Minister and Minister of Electricity, has explicitly supported the development of renewable energy resources in Iraq, solar in particular. As a result, a national policy on solar power development is to be established over the next two years[6]. This will probably nest within the Iraq Integrated National

[3] Joint Declaration. May 26, 2011, "Ensuring Safe, Secure and Affordable Energy", signed by G.H. Oetingger, EU Commissioner for Energy and H. al-Shahristani, Deputy Prime Minister of Iraq. This also includes provision for technical assistance in promotion of renewable energy in Iraq.

[4] Parsons Brinckerhoff. 2010. Republic of Iraq. Ministry of Electricity. "Iraq Electricity Masterplan - Final Report".

[5] Referenced in: "Towards an Enlightened Future: Workshop Report", Strategies and Recommendations for Iraq's Electricity Sector. 20-22 November 2011. Beirut, Lebanon. Facilitated by UNDP.

[6] A.M.A. Alasady. 2011. "Solar Energy: The Suitable Energy Alternative for Iraq Beyond Oil", 2011 International Conference on Petroleum and Sustainable Development. IPCBEE Vol. 26: 11-15.

Energy Strategy, which is being developed with support from the World Bank[7]. The proposed GEF project will be well-placed to inform the development of the national policy on solar power.

As can be seen from the above, there is a clear recognition in Iraq of the needs and opportunities related to solar power; this is converging with Iraq's parallel activities to clarify its climate change management strategies. The proposed GEF project will create an effective bridge between Iraq's climate change responsibilities and the need to develop renewable energy options.

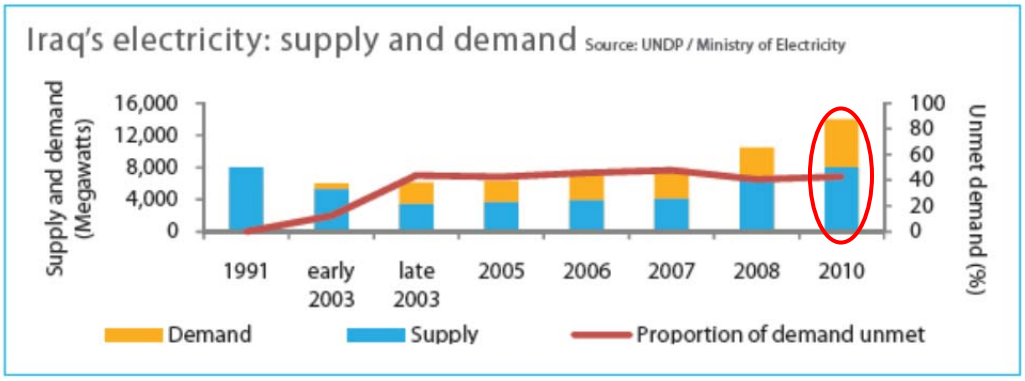
## B. PROJECT OVERVIEW

### B.1. DESCRIBE THE BASELINE PROJECT AND THE PROBLEM THAT IT SEEKS TO ADDRESS:

Background

A recent workshop of Iraq stakeholders (UNDP facilitated; November 2011) indicated that the reliability and capacity of Iraq's electricity supply have fallen since 2002. At that time, electricity supply capacity was 9,300 MW, with peak loads of 5,100 MW. The current electricity supply in operation is about 4,500 MW, with a demand of almost 10,000 MW, which creates a huge challenge: about 6 GW of new power is required in the near-term. Approximately 80% of Iraqis are on-grid, with over 80% of grid-supplied electricity coming from hydrocarbon-fueled power plants. A small amount, less than 20%, comes from hydropower. Iraqis have increased their demand for electricity (through population growth and increased electricity requirements in homes and offices), but the reliability of supply is quite inadequate and load-shedding is a common daily experience (for example, in Baghdad, electricity is supplied for only about 14 hours per day, rolling on-and-off). Many households and businesses therefore rely on diesel-powered generators to fill the demand-supply gap, which increases the cost of electricity significantly. The Ministry of Electricity is bringing gas-turbine power plants into operation (the most recent is a General Electric facility near Baghdad), but there is still a concern that electricity demand will not be met for a while (see Figure 1 below), and the power plant strategy still depends on hydrocarbon supply. About 50% of overall electricity demand is due to air conditioning alone. Iraq is one of the hottest countries in the world (up to 45-50 $^{o}$C), and summer temperatures are steadily increasing (see Figure 2 and Table 1). People in Baghdad, especially, are desperate to buy, and hopefully have enough electricity to use, air conditioners, as noted frequently in local media.

Figure 1: Recent Iraq electricity supply and demand trends.




[7] T.A. Ghadhban. Chairman of the Advisory Commission. Office of the Prime Minister. "Iraq's Energy Strategy: A Mid- and Long-Term View", Keynote Speech. Iraq Petroleum 2010 – CWC, London.

Figure 2: Trend in average July temperatures in Iraq's major cities
(Awadh and Ahmad, 2010)

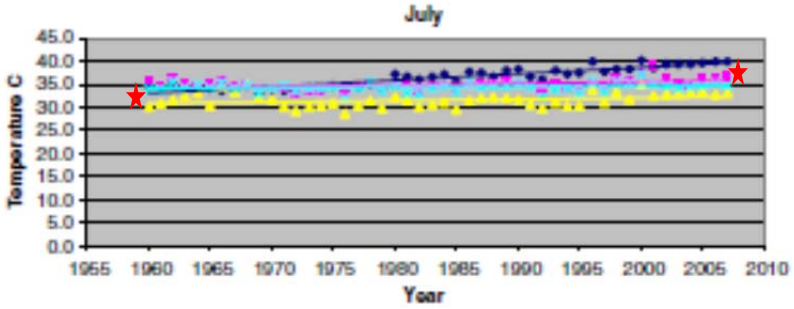



Table 1: Climate data for Baghdad

**Climate Data for Baghdad**

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average high °C (°F) | 15.5 (59.9) | 18.5 (65.3) | 23.6 (74.5) | 29.9 (85.8) | 36.5 (97.7) | 41.3 (106.3) | 44.0 (111.2) | 43.5 (110.3) | 40.2 (104.4) | 33.4 (92.1) | 23.7 (74.7) | 17.2 (63.0) | 30.6 (87.1) |
| Average low °C (°F) | 3.8 (38.8) | 5.5 (41.9) | 9.6 (49.3) | 15.2 (59.4) | 20.1 (68.2) | 23.3 (73.9) | 25.5 (77.9) | 24.5 (76.1) | 20.7 (69.3) | 15.9 (60.6) | 9.2 (48.6) | 5.1 (41.2) | 14.9 (58.8) |
| Rainfall mm (inches) | 26 (1.02) | 28 (1.1) | 28 (1.1) | 17 (0.67) | 7 (0.28) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 3 (0.12) | 21 (0.83) | 26 (1.02) | 156 (6.14) |
| % humidity | 71 | 61 | 53 | 43 | 30 | 21 | 22 | 22 | 26 | 34 | 54 | 71 | 42.3 |
| Avg. rainy days (≥ 0.1 mm) | 5 | 6 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 6 | 29 |
| Mean monthly sunshine hours | 192.2 | 203.3 | 244.9 | 255.0 | 300.7 | 348.0 | 347.2 | 353.4 | 315.0 | 272.8 | 213.0 | 195.3 | 3,240.8 |

*Source:* World Meteorological Organisation, WMO.

The most compelling renewable energy source in Iraq (at this time) appears to be solar, mostly reflecting the pervasive nature of this energy source (in time and space) and the opportunity to develop distributed generation systems with minimal dependencies on existing infrastructure and institutional processes, but also with a significant potential to feed back into the electricity grid during peak load periods. In addition, there is significant opportunity for private sector deployment in the solar power sector, especially given the expected increasing consumer demand for solar-powered appliances (air conditioners in particular, and water heaters) and given the construction of "model" towns (for example, near Najaf, south of Baghdad), where the intention of developers is to remain non-reliant on the grid, ensure a reliable supply of clean electricity, and develop cost recovery mechanisms that will support the initial investments (including selling electricity back to the grid).

Iraq has made some initial ventures into solar power use. A number of cities in Iraq have installed solar-powered street lights and solar water heaters, but these cases have not been well-documented and there is anecdotal information that some of the street lighting is ineffective. Extreme high temperatures and increasingly frequent dust storms present some additional challenges for solar PV panels. Careful comparative research into options and some innovation in creating cooling flows to panels and self-cleaning functions are required. In addition, provision of air conditioning at night is still a key requirement, and some element of grid connectivity or hybridization of traditional compressor technology and absorption cooling, in combination with PV panel support to such a unit, may be required. Some comparative work on various solar power air conditioner technologies has already been done by the Ministry of Science and Technology (MoST). MoST has devoted considerable efforts to exploring a range of hybrid rooftop units that utilize PV and also solar thermal energy; the PV-generated electricity can be used for household consumption and/or to provide electrical supply to run (where applicable) a unit's fans and/or pumps and/or cooling loop-vent to reduce the surface temperature of the PV panels themselves (thereby increasing their efficiency in very hot conditions). While various technology comparisons and assessments have been undertaken, there is as yet no strategic approach which focuses on the highest critical electricity consumption appliances (air conditioners) and the need for reliable distributed electricity supply in new residential development areas. The proposed GEF intervention addresses these deficiencies in the baseline project (see below).

Baseline Project

The baseline project comprises four loosely connected ongoing and planned elements, which collectively constitute the baseline project. These elements need to be threaded together and catalyzed for broad application in Iraq (which is the intention of the proposed GEF project), as follows:

a. *Initial technology comparisons, experimentation with hybridization of roof-top solar-powered appliances (water heaters and air conditioners/chillers), pilot trials with these units (and with street lighting, as well as building heaters), and development of solar-tracking PV panels (undertaken by the Solar Energy Research Centre (SERC) at MoST and at Anbar University).* While these are significant "technical" mobilizations by the Iraqi Government, these all need to be rationalized, coordinated and launched in a strategic manner that offers maximum social and economic benefits for the most important household and business/Government building needs, as well as maximizing the resultant reductions in greenhouse gas emissions. Solar-powered rooftop air conditioners have received consistent attention over the last few years, given the persistent consumer demand for such appliances (the conventional form). SERC has examined at least eight solar air conditioner configurations and is still trying to optimize/hybridize various options that have minimal power requirements for maximum cooling capacity, as well as trying to address cooling requirements at night (whether through power storage, or reverting to grid-supplied electricity, or alternative power sources). There has always been an intention to pilot and monitor the optimized hybrid air conditioner/water heater arrangement (still to be more clearly defined) in Government buildings, although progress has been slow. The Ministry of Environment buildings were identified last year as the location of the first pilots for rooftop solar PV AC/water heater units in Baghdad. The proposed GEF project will activate this pilot (and others as well); will provide a vehicle for concerted, 'joined up' Government action; and will mobilize additional (incremental) private sector involvement that is not anticipated in the baseline. Specifically, 1,000 Government-funded units planned for Baghdad will be augmented by 1,000 private-sector funded units in the Najaf area.

b. *Government "institutional" positioning for solar power development (the Solar Energy Research Centre at MoST, the development of the Renewable Energy Research Center at Anbar University, the Ministry of Electricity budgeting for 16 solar power plants, and the Joint Declaration with the EU which includes development of sustainable energy in Iraq).* These entities now need to be synchronized and working together, so that the most pressing electricity supply gaps can be filled effectively with solar power applications. The proposed piloting of solar-powered air conditioners/water heaters and the design and piloting of a small (5 MW) solar PV power plant can take the design concepts currently in the hands of these various institutions and lever them through the pilots to very wide application throughout Iraq, meeting the single highest electricity demand (air conditioners) and potentially servicing at least 20% of the population which is not connected to the electricity grid, and an additional 50% of the population which receives less than half-time electricity, with power from solar power plants. The GEF project will provide the momentum required for rapid piloting and institutional coordination, as well as creating the enabling policy, institutional and financial frameworks to facilitate and remove barriers to the implementation of the selected design concepts.

c. *Government intentions for renewable energy policy definition, including the introduction of the Independent Power Producer (IPP) concept (for both conventional and renewable energy).* These have been articulated in the Strategic Energy Partnership with the EU, and in explicit statements from both the Ministry of Electricity and the Ministry of Science and Technology. These policy priorities are itemized below[8]:

- Establishing a National Renewable Energy Policy that will coordinate the action of different Government ministries.
- Nested within that, the creation of a knowledge base for renewable energy in Iraq that will facilitate incorporation of renewable energy into future projects.
- Promoting efficient use of energy through building codes and equipment standards, in coordination with other agencies.
- Research and development in the field of solar energy, especially that which is suitable for broad application in Iraq under different conditions.
- Following from the above, research and technology development for solving dust and heat effects on solar panels.
- Renewable energy systems for domestic use.

[8] From the interview with Dr. Samir Salam al-Atar, Deputy Minister of Science and Technology. Iraqi American Chamber of Commerce and Industry. January 19, 2012. Reconfirmed in meetings with UNDP, MoST, and the Ministry of Environment in Baghdad in May 2012 and in Amman in June 2012.

The IPP concept has been discussed for the past few years. The National Investment Commission (NIC) recently announced plans for two IPPs to support major residential developments at Bismaya (100,000 apartments in a new suburb of Baghdad) and 65,000 units in Taji (30 km north of Baghdad)[9]. With the Government intention of providing one million new housing units in the near-term, there is wide scope for many IPPs, which could at this stage incorporate either conventional power plants (although gas supply is a critical constraint at the moment), or solar power, which is likely to have fewer input constraints, once the technology has been properly tested for Iraqi conditions (a key activity within this proposed GEF project). There are no plans for the Government to be involved in subsidizing the power to the end-user, which is a constructive step and a new policy direction, allowing market demand-supply equilibrium to be reached based on much more reliable supply of electricity. As a result, residents in the new developments may end up paying more for electricity, compared to now, but will avoid the daily blackouts in electricity supply. The expectation is that residents in new development areas served by IPPs will be willing to pay a premium for guaranteed continuous electricity supply, which solar PV plants (or solar thermal, for that matter) can likely supply. One aspect of a solar power plant IPP that will be appealing to the private sector is the relatively low risk associated with the inputs (availability of solar irradiance), whereas the conventional gas-fired power plant IPP is a concern for private developers, as they will have to assume all the risk for fuel supply (as discussed previously. This has been a key factor in the lack of IPP uptake; the proposed project will clarify IPP policy that relates specifically to solar power and other forms of renewable energy).

d. *Related to the renewable energy policy intentions and the IPP concept described above (c.), and well-positioned to apply the solar technology developments (a. and b. above) expected with the baseline project, is the ongoing model town development near Najaf (south of Baghdad).* Najaf Governorate has managed to effectively plan for residential expansion and implement proposed developments quite quickly (compared with other parts of Iraq) and developers have started construction of residences. One in particular has designed in a methane power plant, which is to be fed by municipal and agriculture waste from the Najaf environs. The intention is to remain non-reliant on the grid (with distributed power sources) and operate as a "municipal" IPP, with electricity tariffs set to allow recovery of the investment and, as well, the ongoing operational and maintenance costs associated with the methane power plant. Given the somewhat unpredictable feedstock supply for methane generation, and the need for 24-hour/day electricity supply in the model town (a feature which is expected to attract residents), the current concept is to link up the proposed methane power generation with a 5MW solar PV power plant, with the solar covering daytime electricity needs (and possibly with excess power being sold back to the electricity grid), and the methane-generated electricity addressing night-time electricity requirements. The progressive developers in the Najaf area require the proposed GEF project to sharpen the technical specifications of both the solar PV power plant and the rooftop solar AC-water heater units that can be provided with every new residence (since the developers lack prior experience with solar technologies), and to identify and define the required policies to facilitate IPP implementation with solar technologies and to spur consumer awareness of, and demand for, solar air conditioners/water heaters in particular – items with the highest consumer interest, but the current conventional versions of which also consume more electricity than any other single appliance-type.

**B. 2. INCREMENTAL COST REASONING AND THE ASSOCIATED GLOBAL ENVIRONMENTAL BENEFITS:**

The proposed GEF project will advance on the work done to date in Iraq with regard to solar power technologies and currently in progress with the various elements of the baseline project. It will clarify the most practical and affordable combination of solar power air conditioning/water heating options that can meet the operational conditions in Iraq, addressing the most critical electricity demands in houses, offices and small businesses throughout Iraq. The project is required to organize the comparative technology assessments completed to date, and to catalyze the actual procurement and assembly of parts (or complete units), install them in a manner that allows further monitoring for effectiveness, and at the same time bring benefits to the users, which will help with the eventual replication of installations and spur Iraqi industrial development in this area. The same philosophy is expected with the design and construction / operation of a 5MW solar PV power plant (there are none in Iraq at the moment, although, as noted previously, the Ministry of Electricity would like to build 16 larger-scale solar power plants over the next five years).

[9] Salar Ameen, Vice-Chairman of the National Investment Commission. At MEED's Iraq Utilities Conference in Istanbul, June 7, 2012.

The proposed project will advance the baseline project in three ways:

1. By designing, piloting and monitoring selected solar photovoltaic technologies for distributed generation applications. In the case of Government-funded activities (e.g. the design assessment work led by the Ministry of Science and Technology, and Baghdad-based pilots led by the Ministry of Environment), the project incrementality arises from the GEF's catalytic role in initiating and accelerating plans that have been 'on paper' for some time. In the case of private sector involvement in installing 1,000 rooftop-based solar PV AC/water heater units in the Najaf area, the incrementality arises from the fact that these units would not be installed without GEF involvement (in the form of the preliminary project discussions with private sector developers that inspired the idea in the first place and through the provision of GEF technical and policy support during project implementation).

2. By stimulating investments in solar power technology and increasing consumer uptake of such technologies through new policies, tools and financial incentives.

3. By facilitating private sector capacity for solar technology development and servicing, through awareness-raising, training and dissemination sessions on the IPP concept.

These three prongs are expected to work in synergy, organizing and enhancing the baseline project so as to promote global environmental benefits (enhanced climate change mitigation) and making the transition from loosely connected concepts and exploratory solar power technical and institutional initiatives to coherent and targeted piloting, which in turn will encourage uptake and replication that will ultimately anchor solar power as a fundamental part of the national energy strategy in Iraq. Details on the three project components are provided below.

Component 1: Investment in solar photovoltaic power technologies for distributed electricity generation for office, small business, residential and small town application. Expected Outcome: concrete evidence of the utility, practicality and competitive advantage of rooftop solar PV AC/water heater systems for office, small business and residential application and the viability of distributed, small-scale (5 MW) solar PV power plants for small town services, leading to replication of the solar PV technology applications that were demonstrated and increased investments in such technologies.

The principal aim of this component of the GEF project is to consolidate the solar power technical work undertaken to date and move it to application to meet the highest electricity demand in Iraq (50% due to air conditioners). The proposal is to assemble and install 2,000 rooftop solar AC/water heater units (1,000 in Baghdad and 1,000 in Najaf; in Government offices and staff residences in Baghdad[10], and small businesses and model town houses in Najaf). These installations will provide excellent opportunities for monitoring operational aspects of the selected units, while at the same time bringing benefits to thousands of residents and office workers during the project period. With successful replication of installations over the next 10-15 years, most of the population of Iraq, about 33 million people, could benefit from solar AC/water heater units. Experience in other jurisdictions indicates that ongoing technology development and refinements, and eventual mass marketing, inevitably lead to eventual reduction in unit costs, especially for items that are in high demand[11]. The initiative will be based on a review of available solar air conditioner technologies suitable for Iraqi conditions and the design of a hybrid concept (technical specifications) for a solar AC/water heater for Iraq conditions (addressing extreme heat and frequent dust storms). There are many compelling examples of technology development with solar-powered air conditioners, which also provide auxiliary functions,

[10] The focus of installations in Baghdad on Government offices and staff residences has been suggested to facilitate the access of scientific monitors to these sites and to maintain weekly logs. Monitoring in private residences and in poorer districts in Baghdad would present logistical and security issues. Protocols will be established for monitoring in the Najaf Model Town (working through the developer). With expected future uptake of the solar AC/water heater units, it will be important to allow all income classes and social groups to have fair access to the technology, which will require a discussion of subsidies. Such a structured discussion with all relevant stakeholders will be supported by the project.

[11] For example, see Ramez Naam, March 16, 2011, Scientific American blog, www.ScientificAmerican.com: "Smaller, cheaper, faster: does Moore's Law apply to solar cells?". In the past 30 years, the cost of capturing solar energy has dropped exponentially. For instance, the National Renewable Energy Laboratory of the U.S. Department of Energy has tracked the price per Watt of solar modules (not counting installation) as they have dropped from $22 dollars in 1980 to under $3 today. In 2010 alone, there was a 30% reduction in the cost of solar photovoltaic cells. These trends in turn encourage increased demand, as solar PV technologies become more competitive. There has been 80% per annum growth in recent demand for solar PV panels (Energy Outlook, November 17, 2011).

which need to be examined (for example: PV power supply to conventional condensers; lithium bromide absorption coolers; and Maisotsenko thermodynamic cycle heat and mass exchanger units, with cooled air also venting to the solar panels, for extreme heat environments, so that they do not experience decreased efficiency; these work very well in low-humidity environments, such as Iraq; there are many others, which need evaluation).

The starting point for this initiative will be a review of solar AC technology evaluations undertaken to date by MoST and Anbar University, and then adding assessments of other technologies not covered to date. The assessment will involve a combination of literature review and in-laboratory and *in situ* measurements of power production, PV panel integrity and cooling capacity under different light and air quality conditions. Prototypes, which include the optimal combinations of solar AC/water heater elements, will then be assembled and further monitored in a rooftop application. With final confirmation of technical specifications for the pilot installations, 2,000 units will be assembled (with off-the-shelf components). Installations will then be established on rooftops in Baghdad and in Najaf, as noted previously. Detailed monitoring data will then be collected over one year for selected units, to determine energy production/cooling capacity of the units under different operational conditions. All units will be observed by the Government staff and residents, with provision of simple weekly written assessments that will include notes on external conditions and cooling effectiveness and water heating capacity of the units. Monitoring data will be collated and operational trends plotted on a monthly basis throughout the year to determine any operational effectiveness correlations with dust storms, cloud cover and maximum and minimum temperatures. Required technical modifications can then be defined (such as panel angle to reduce dust accumulation, panel tilt cleaning and cool venting of the panels to address extreme temperature situations). Careful attention will also be paid to the cost of assembly and installation of the rooftop units, so that larger-volume production costs and rates of return, measured in displaced electricity costs and the "value" of cooled buildings in terms of human productivity, can be determined. This information will then inform the potential private sector entities which will take over the supply and servicing of solar rooftop units.

Component 1 will include assessment of small-scale (5 MW) solar PV power plant technology suitable for Iraqi conditions, as well as cost-benefit analysis of a range of configurations. This will lead to the design of a 5 MW solar PV power plant. Given the existing private sector developer interest in the Najaf area, a specific site will be selected that will accommodate a distributed solar PV power plant that can serve about 1,500 – 2,000 houses in a Najaf model town (some of these, Government offices and selected small businesses in Najaf, will also be outfitted with the rooftop solar AC/water heater units). As noted previously, the solar PV power plant will be coupled with a biogas power plant for night-time power augmentation, to ensure 24-hour distributed generation capacity for town, small business and residential services. The solar power plant, and linkages and switch-overs with the biogas power plant, will be monitored for operational efficiency, power production and distribution, domestic use of solar power supply, and capital and operational costs, which will then inform the future replication of solar PV power plants throughout Iraq (either by Government or the private sector, through IPPs).

The GEF funding will cover the incremental costs of the technology assessments and the operational monitoring of both the rooftop solar AC/water heater units and the solar PV power plant, whereas the 2,000 units and the 1 MW solar power plant (and the biogas plant) will be funded through Iraqi co-financing.

Component 2: Encouragement of investments in solar power technology in Iraq and consumer uptake of solar appliances through policy reform, tools and financial incentives. Expected Outcome: Enhanced private investment in, and consumer uptake of, solar PV technologies (rooftop appliances and distributed solar PV power plants)

The principal aim of this component is to catalyze private sector investments in solar PV power technology in Iraq, and, at the same time, to stimulate consumer demand for such technologies, to create an adequate and growing demand-side that will continue to encourage solar PV technology investment. The main "marketing" principle here is to fill the electricity supply gap, in particular areas not connected to the grid (spatial gaps) and addressing the frequent blackouts (time gaps). The current Government interest in the IPP concept (which is included in the Electricity Regulatory Law currently being drafted, and which is expected to be further informed by this project) is a good context in which the necessary policy reforms and financial incentives can be defined to spur both consumer demand and private sector investment response in provision of solar PV technologies. Furthermore, there is a significant opportunity to develop distributed generation systems with minimal dependencies on existing infrastructure and institutional processes. At the same time, there is a significant opportunity for policy development which will encourage IPPs to sell excess solar power back to the electricity grid (especially during peak load periods experienced in the daytime), which will encourage further investment and address the issue of load shedding. This sub-component

will involve examination of feed-in tariffs and net-metering in other jurisdictions to determine fair solar electricity pricing schemes in Iraq that reflect both the investment in hardware and installation, the value of reliability of supply, and time-of-supply reconciled to load demands on the grid, whether set at retail electricity rates or as enhanced rates to induce IPPs (and potentially home owners and small businesses) to invest in the technology and sell excess electricity back to the grid. The project will work with the Government to implement feed-in tariff and/or net-metering schemes, potentially initially at pilot-scale level but with the intention of national scale-up.

The current policy and regulatory environment is somewhat confusing, as it does not specifically address the technology needs of solar power development. For example, there has been confusion about new import duties on air conditioners (conventional types). These had been expected to increase significantly, but now there is a delay in their implementation as the implications for affordability and development of domestic industry capacity are being examined. The proposed project will analyse and clarify the "pros and cons" of such policy and regulatory options, and will work with the Government to introduce, implement and enforce a sensible and clear policy/regulatory re-direction that will spur solar power technology development and servicing in Iraq.

Low electricity tariffs and low collection rates (about 40%) might be considered a counterforce to development and installation of solar power technologies but, in fact, in areas where grid electricity is not supplied and in areas where the electricity supply is unreliable, the expense considerations relate to private electricity generation, if that is even an option for consumers. For those who can afford a generator, the costs include the initial investment in the generator, then about US$50/month for 10 kWh/day. This is a significant expense that can be precluded with investments in rooftop solar PV AC/water heater units. In addition, for those who can afford conventional air conditioners, individual unit costs range from $300 to $500 (or more), and these may not be effective in some conditions. The financial context for the AC consumer therefore needs careful analysis, to determine where financial incentives, such as tax breaks or subsidies, might be introduced to spur consumer demand (once awareness of solar PV technologies is disseminated).

In case the unit cost of the selected hybrid solar PV AC/water heater unit appears to still be too high for widespread uptake by Iraqi consumers, the project will examine the possibility of exported oil revenue "transfer" subsidies, in which case the general oil revenue benefit to Iraqis (national income to general revenues, which is currently re-distributed in many subsidized services and in financial transfers to the Governorates) will have a small component dedicated to family and small business procurement of the solar PV AC/water heater units. This possible subsidy will be subjected to a cost-benefit analysis (see below), which would be expected to show a net economic benefit, due mostly to the displacement of oil-fired electricity generation (much of which goes to air conditioner electricity load in any case, as noted previously) and the cost of transmission infrastructure, as well as the significantly increased productivity of households and small businesses due to cooler buildings. While this may initially create a distortion of the actual price of solar PC AC/ water heater units, over time, with the expected rapid consumer uptake of the technology and local fabrication/assembly of such units, individual unit costs would be expected to decline, and the oil revenue subsidy could be phased out according to need and family incomes (so that the poorest families with solar power needs are not excluded from the solar power consumer market).[12]

The project will examine solar electricity policies and financial incentives (for private sector investment, as well as encouragement of consumer demand) in other jurisdictions, in the region (such as Lebanon and Jordan), and globally. It will be very important to undertake cost-benefit analyses of both the solar PV power plant design and the rooftop solar PV AC/water heaters (as noted above), for different volumes of production and installation and different scales of end-users, to allow policy and financial incentive targeting that will reduce the cost side of developing these two technologies. Consideration will be given to developing various incremental (i.e. beyond the baseline) financing instruments, such as local bank loan schemes (0% loans and long payback periods), reduction of import duties on PV equipment, related tax breaks and tax increases on conventional air conditioners. The experiences of other countries will be valuable in informing this process. A public-access renewable energy database will also be developed in conjunction with Anbar University Renewable Energy Centre (and coordinated with the International Renewable Energy Agency's ongoing solar data collation activities) so as to provide site-specific data on renewable energy potential, thereby gradually building up a resource that can facilitate private (and, indeed, public) sector investment decisions. Private sector investment in solar PV power plants will initially focus on distributed generation facilities. However, the project will also examine the establishment of grid feed-in tariffs to create further opportunity and

[12] Other countries, such as Canada, have created an ongoing subsidy system for poor families with base heating and electricity needs. Such systems could be examined in the proposed project.

demand for solar PV power plants, which will, in turn, likely induce further private sector investment (especially if the IPP policy can be finalized at the same time). The establishment of one of the financing instruments to spur demand for rooftop solar AC/water heater units will be framed as a Nationally Appropriate Mitigation Action (NAMA), with attendant baseline, mitigation methodology and MRV frameworks, and will be formally submitted to the UNFCCC by the Government of Iraq so as to mobilise additional climate finance.

Consideration will also be given to ancillary policies and instruments, which will support investment in solar power technologies and consumer uptake of solar appliances. These include development of appropriate building codes for improved energy efficiency (these could apply to new buildings in the Najaf area, in particular) and streamlined planning permission for installing solar PV AC/water heater units on roofs, both of which will facilitate the installation and operational efficiency of solar units. There will also be a requirement to establish quality control of the products and services that will eventually be available in the market. To support the effort to increase consumer demand for rooftop PV AC/water heater units, there will be broad public dissemination of rooftop solar PV options for air conditioning and water heating (based on Project Component 1), as well as information about the associated costs and benefits.

Component 3: Facilitation of private sector capacity for technology development, innovation and servicing in the solar power industry, through technical capacity building and domestic market analysis. Expected Outcome: Widespread awareness and increased private sector capacity for the supply and servicing of solar PV air conditioners and water heaters; and increased Government and private sector capacity for the design, construction and operation of small-scale, distributed solar PV power plants leading to: (1) increased installed capacity of operational distributed solar PV power plants that are locally designed, engineered, constructed and operated; and (2) increased volume of locally-manufactured solar PV AC/water heater units.

The principal aim of this component is to remove the current barriers to private sector direct engagement in the solar power technology industry in Iraq through increasing private-sector actors' understanding of the sector and their technical capacity to engage with it. At the moment, the Government dominates local industrial production capacity. There is a need to loosen the reins on local production of goods and services, to allow a "home-grown" solar power technology industry to flourish and effectively meet consumer demand throughout the country (which the Government cannot do at the moment). Whereas Component 2 will set the stage for overall development of solar power technology in Iraq and consumer demand for it, through appropriate policy development and financial incentives, Component 3 will focus on technical capacity development and certification schemes to lever private business into the installation and servicing of rooftop solar PV AC/water heater units and the components for solar PV power plants, thereby eventually reducing the costs associated with importing both the components and technical services required in the solar power sector.

The overall approach for this component will be development of a solar power market demand/industry response strategy for Iraq, informed by case studies from other countries with developed solar power industries. The Iraqi private sector and Government agencies will be exposed to all aspects of the industry (technology development, supply, servicing, financing), through technical assistance, exposure to specific industries in other countries (and subsequent mentoring in Iraq), and roundtable discussions of the most appropriate mechanisms for developing Iraqi capacity in this area. There will be an effort to match up private sector capability throughout Iraq with the expected demand in all parts of the country (which may be variable). This effort will be supported by development and delivery of certified technical training on solar PV technologies (hybridization, supply, service) for emerging private sector companies that express interest in the developing solar power industry. Mechanisms for monitoring the quality of both installations and servicing will be established, to give strength to eventual certifications and guarantees required in the industry.

There will be a similar effort related to solar PV power plants, which will require a more sophisticated understanding of the potential industry. This will involve technology review and cost-benefit analysis of small-scale (5 MW) solar power plant options for Iraq (coming from Component 1). There will then be a definition of private sector opportunities for distributed solar PV power production in Iraq, based on case studies from other countries, and the expressed interest from private sector entities in Iraq. These will then have to be formatted to be consistent with the developing IPP concept, which will be articulated in the Electricity Regulatory Law. Component 3 will also include development and delivery of dissemination sessions on future IPP involvement in the electricity supply network, including relationships with technology firms and Government agencies, feed-in tariffs, and net metering options.

It is expected that both of the proposed solar PV technologies (hybrid AC/water heaters and solar PV power plants) can be developed and expanded without any particular initial technical dependence or conditionality on the existing electrical grid. However, it is recognized that there is great future potential to feed excess supply back into the electricity grid during peak load periods, which in turn is expected to create a very large demand and market for future solar power facility investments. This scenario is certain to appeal to private developers and individual households and businesses, as they can then make the initial investments, recover their costs (where this service is provided to house owners or tenants), and ensure a reliability of electricity supply for key appliances that does not exist at the moment. The proposed GEF project is therefore expected to be a significant enhancement of the current baseline situation, in which the basic knowledge of solar power exists in the user/consumer community but awareness of specific technical options, access to actual units and subsequent installation and servicing are all still very obscure or even constrained by existing policies and financial disincentives.

The project will significantly enhance this general level of awareness and sub-optimal policy environment, by demonstrating the utility of solar power AC/water heaters and small-scale (5 MW) solar PV power stations, stimulating private sector capacity in the supply and servicing of such units (by providing relevant certified training to the emerging solar power service industry), and shifting existing policy and regulatory controls to catalyze a "take-off" in the solar power industry in Iraq. These important increments will then facilitate consumer demand for, and access to, such technology, and this will then encourage more investment in both the solar power industry as well as perhaps larger-scale installation of rooftop solar AC/water heater units and replication of distributed solar power plants. The operative principle of the project is to *catalyze* all these required actions, which at the moment remain somewhat vague and conceptual.

A key point to be made here is that there is apparent "pent-up" demand in Iraq, especially in areas where new residential and office construction is planned, or underway. Such areas are not currently well-served by the electricity grid. The owners/occupiers will likely have the financial resources to afford the acquisition and operation of most required appliances, including solar-power options, but do not have sufficient knowledge of the most practical options, nor how to actually procure and install solar AC/water heater rooftop units. Developers are very willing to make the investments (and they expect good cost recovery in the process): they simply need to know what is most suitable for Iraq's conditions and then procure accordingly. This project will clarify all the important aspects required for sound private sector investment in solar PV power in Iraq, including – on the supply side – support for local manufacturing of the components used in selected solar PV technologies, clarification of the expected location of solar power demand in the future, as well as examination of, and support for, the range of options for selling electricity back to the grid.

### B.3. SOCIOECONOMIC BENEFITS TO BE DELIVERED BY THE PROJECT INCLUDING GENDER DIMENSIONS:

The main principle of the proposed project is to aim for the highest impact (most beneficiaries and greatest reduction in GHGs) for the modest investments that are expected in the initial stage of solar power development in Iraq. The examination of technology options and the current expected demand for both specific appliances (AC and water heaters) and electricity in general has led to the conclusion that household or small town solar power (PV), either as rooftop units for air conditioning/water heating or distributed solar PV power plants, could eventually address about half of the electricity demand in the country, with good technology development and roll-out. The proposed small-scale approach, with a concentrated effort to address the required policy changes and market incentives, is the most straightforward and offers the highest impact for the initial investments. Furthermore, there are now significant opportunities in Iraq for private development of solar power (to be encouraged by a progressive IPP policy), with construction of "model" towns (for example, near Najaf, south of Baghdad), where the intention is to remain non-reliant on the electricity grid initially, while still having the option in the future to sell back to the grid, ensure a reliable supply of clean electricity, and develop cost-recovery mechanisms (including appropriate grid feed-in tariffs) that will support the initial investments.

More specifically, Iraq is one of the hottest countries in the world and has a very unreliable electricity supply in many parts of the country (as noted previously). Even where air conditioners are installed, they may not be operable during the hottest times of the day due to load shedding. This has a crippling effect on human productivity, especially for women and children who are disproportionately confined to houses throughout the day. The cost to the economy of Iraq has not been calculated, but even if there were some improved access to air conditioning and reliable operation in

one million homes and small office buildings, with a multiplier of 4-5 persons for each unit, this would improve the comfort and productivity of about 20% of the Iraqi population, which would undoubtedly have a positive effective on the economy of the country.

Even considering the cost of procurement and installation of rooftop solar AC/water heater units (possibly $1,000 per unit, including possible maintenance costs over 25 years), the net saving per family that would otherwise use a diesel generator, over 25 years, could be $15,000, based on current fuel costs (with no future discounting). This translates into $15 billion saved over 25 years, even considering just 20% of the Iraqi population taking up the use of solar PV AC/water heaters. Clearly, there is scope to increase this, pushing into other parts of the population and also considering population growth over 25 years.

The exact cost of the selected solar PV AC/water heater unit cannot be predicted at this point (and some of these units in other countries are quite expensive[13]), but even expensive units are expected to have a high rate of return in Iraq. For example, the displacement of diesel fuel costs (most AC units in Iraq are run off independent generators) would still be significant, even if the cost of each solar PV AC/water heater unit were $3,000-$4,000 (even in this case, $10,000 per unit could still be saved over 25 years). As noted previously, it might be possible to maintain an artificially low price for Iraqis, with a subsidy on solar PV AC/water heater units financed through exported oil revenue transfers, until such time that unit costs come down due to high volume sales. The most important point to consider here is that 50% of electricity demand in Iraq is due to air conditioners, and with a current shortfall of almost 6 GW (requiring hundreds of millions of dollars in new infrastructure investment, and still with transmission losses expected), even expensive solar power AC/water heaters may prove to be significantly less expensive than the future electricity power and transmission investments required to meet existing and future conventional air conditioner requirements.

There is also strong potential through this project to develop a solar PV technology industry in Iraq (design, innovation, supply and service), especially assuming successful demonstration of appliances for which there is significant pent-up demand. This will lead to new jobs in a growth industry, which is sorely needed in Iraq where private sector diversification and engagement in the economy is required but still lagging.

If this project were to go ahead with 2,000 rooftop solar PV AC/water heater units, assuming that an average air conditioner in Baghdad would run for at least 12 hours a day (if electricity were reliably provided) at least six months per year[14], then each unit currently running off the grid or diesel generator would consume about 3,000 kWh/year, equivalent to about two tonnes of $CO_2$eq/year (0.688 tonnes$CO_2$/MWh). Installation and operation of 2,000 units would eliminate 4,000 tonnes of $CO_2$eq per year. Over 25 years, this would reduce $CO_2$ emissions by 100,000 tonnes. If the air conditioning needs of all of Baghdad, alone, could eventually be addressed (assuming one air conditioner for every six people, and a current Baghdad population of 7.2 million people, and that these might actually run off grid-supplied electricity or off diesel generators), then 1.2 million conventional air conditioners could be replaced, eliminating more than 2.4 million tonnes of $CO_2$eq per year, or 60 million tonnes of $CO_2$ over 25 years, which is an extremely high benefit.

The installation and operation of a 5 MW solar PV power plant would lead to a further reduction of 375,000 tonnes of $CO_2$eq over 25 years (a 5 MW solar PV power plant eliminates about 15,000 tonnes $CO_2$/year). Given the degree of irradiance in Iraq and the opportunity to replicate in many locations due to demand (20-30 solar PV power plants could be built within ten years), then a cumulative positive global impact of these solar power plants could be a further $CO_2$ emission reduction of as much as 450,000 t$CO_2$eq/year, equivalent to 11.25 million tonnes over 25 years, which is very significant. The combined multiplied effect of both the solar PV air conditioner/water heater units and the solar PV power plants, replicated as described above, could be about 2.85 million tonnes of $CO_2$eq per year or 71.25 million tonnes of $CO_2$eq over 25 years.

[13] Commercial units (in the US) can range from $1,000 - $4,000 for 1-2 tonne capacity solar AC units, which might cool up to 186m$^2$. In discussions with MoST, the assumption is that mass assembly of 2,000 units (some kind of hybrid) in Iraq should be less expensive, due to low labour costs, with $1,000 being a reasonable starting estimate). This will be further explored, and the need for subsidies carefully examined. Night-time AC capacity and possible requirements for power storage, or alternative power sources, will also be cost factors to be considered.

[14] This is a conservative number for the sake of $CO_2$ calculations. The 12 hours represent the duration of daily "sun-period", during which electricity from the grid might not be required. Furthermore, AC units may run year-round, rather than just during the six hottest months of the year (May to October). Therefore, $CO_2$ reductions are likely to be higher than the numbers mentioned here.

With the GEF funds and the leveraged co-financing, the GEF$ cost per tonne of $CO_2$ direct reduction (475,000 tonnes) in 25 years of operation of the 2,000 units and the 5 MW solar power plant (after 3-4 years of testing and installation) is GEF$4.69/t$CO_2$. Obviously, the replication and scaling-up described above would bring the GEF cost of indirect $CO_2$ reductions to a much lower level.

### B.4. INDICATE RISKS, INCLUDING CLIMATE CHANGE RISKS AND MEASURES THAT ADDRESS THESE RISKS:

| Risk | Level | Mitigation |
|---|---|---|
| Hybrid AC/water heater units require significant adjustment for Iraqi conditions; difficult to find requisite parts. It takes time to assess the various technology options and develop prototypes for Iraqi conditions. | M | Solar technology options for very hot, dry conditions already exist: these need to be thoroughly reviewed, including technical specifications, cooling cycles, absorption media, cooling vents for PV panels, etc. There is an extensive technical literature on solar air conditioners that needs to be very carefully reviewed to select a few options that can then be further tested and adjusted in Iraq. The previous and ongoing research by the Ministry of Science and Technology (MoST) needs to be examined to determine lessons learned to date and ensure a sound platform for further comparative testing of at least 7-8 types of solar ACs. The practicality of obtaining and duplicating requisite parts will be a key risk management principle in hybridizing units for Iraq conditions. Research scientists at both MoST and Anbar University will be exposed to AC engineers in other countries in order to avoid pitfalls in developing a hybrid solar AC/water heater for Iraq. |
| Feedback time from monitoring of rooftop units to adjustment of solar units is too long for replication, assembly and marketing to start before end of project. | L | Four years have been allowed for the project. Assuming one year to select and test AC units in the laboratory and under controlled conditions, and another year to assemble the required units for testing on rooftops, then two years will remain for installation and monitoring, which should allow technical specifications for the optimal units to be developed and disseminated to the solar power industry for their uptake. |
| Iraqi developers are reluctant to adopt new technologies in their "model" (new) town projects. | M | The costs and risks associated with both the solar PV power plant (established technology in other countries, so minimal technical risks) and the rooftop solar AC/water heater units (perhaps slightly riskier) will be shared between the project, the Government and the private developers who are expected to engage with, and invest in, this project. Careful monitoring of unit performance will precede the assembly of the 2,000 solar AC units to be deployed by the project; these results will be carefully vetted and disseminated to the developers who wish to engage with the project. They will then be taking well-informed and partially-hedged risks. |
| Iraqi private sector is slow to take up solar power business opportunities. | M | This will require good communication of all project results and careful benefit/cost analysis of different levels of production and servicing of the solar AC units, and the solar PV power plants. Sound estimates of consumer demand, practicality of installation in different parts of Iraq and the rates of return will be developed in consultation with technical and business specialists. Experiences in other countries will help to inform this analysis. |
| Ministries of Electricity and Finance are slow to adapt policies and financial incentives to spur the solar power industry in Iraq. | M | This may reflect the current generally slow pace of policy reform and decision-making in Iraq. It is believed that as consumers and the private sector show increasing interest in solar PV technologies, growing pressure will spur policy reform. The involvement of several well-financed developers in the project, and their exposure to the opportunities presented by the project results, will also help significantly. |
| Low public awareness of solar power options regarding rooftop units. | L | This requires constant attention to the needs and demands of the Iraqi public with regard to solar power opportunities. A communication strategy will be developed early in the project to ensure that clear, relevant information is widely disseminated. The Iraqi media are increasingly capable of picking up technology trends and relating them to the needs of the Iraqi public. |
| Climate risk | L | Climate change is not expected to dramatically alter the output from solar installations. Ever-warmer summers are, however, expected to increase the demand for air conditioning (and hence electricity loads), emphasizing the importance of deploying an energy source – solar – that is plentiful and whose supply corresponds closely with peak demand. In the design and installation of solar systems, adequate emphasis needs to be placed on the systems' ability to survive extreme weather conditions (such as temperature and dust storms) at a level that may have not been typically observed before. Such thinking will be incorporated into all stages of project design and implementation. |

### B.5. KEY STAKEHOLDERS INVOLVED IN THE PROJECT:

UNDP is the implementing agency for this project and will be accountable for the GEF grant. Other key stakeholders and co-financiers in the project are described below.

| Key stakeholder | Role in the project: |
|---|---|
| Ministry of Environment | The Ministry of Environment is the Focal Point for the UNFCCC and, as such, has an active interest in promoting both climate change adaptation and mitigation initiatives. The Ministry is in the process of writing the Initial National Communication, but in the meantime has identified renewable energy |

| | |
|---|---|
| | as the focus for mitigation efforts. The Ministry will be the executing partner for this project and will be responsible for collecting the monitoring data from the various project pilots and packaging that information for public dissemination. The Ministry will be involved in public awareness campaigns regarding the benefits of solar power. The Ministry will also help with discussions and coordination for the required policy and regulatory reforms to spur the development and growth of the solar power industry in Iraq. With development of the NAMA component, the Ministry of Environment will assume the role of lead agency. |
| Ministry of Electricity | The Ministry of Electricity already has a policy for development and installation of solar power plants in Iraq (16 planned so far), but now seeks to be actively engaged in the evaluation of various technologies, the selection of the site for the proposed solar PV power plant (near Najaf), and assist with the installation and monitoring protocol for the pilots with both the solar PV power plant and the rooftop units. The Ministry will also help with engagement of the private sector (growing the solar power industry) by developing standards for certification of solar power suppliers and designing the required training programmes. The Ministry of Electricity will also be involved in refinement of policies and regulations to help spur the solar power industry. |
| Ministry of Science and Technology | The MoST has already undertaken research on solar power ACs and will continue to be involved in the comparative assessment of AC/water heater technologies and definition of the testing and installation protocols for the solar AC units and the solar PV power plant. The MoST will also facilitate the dialogue on policy and regulatory adjustments, and the identification of those segments of the industry that are likely to take up the supply and servicing of solar power AC units. |
| Anbar University Renewable Energy Research Centre | Anbar University, with UNDP support, is developing its capability for renewable energy research, including development of solar power options. In collaboration with MoST, the University will help with the comparative assessment of solar AC technologies and the monitoring protocol for the rooftop installations, as well as design and installation of the solar PV power plant and its operational monitoring. |
| Najaf Model Town Developers | A number of developers in the Najaf area have expressed their interest in incorporating renewable energy into their new town developments. They are willing to make the investment, with adequate information on the most appropriate technologies for the needs and operational conditions in the area, and expect to implement cost recovery through tariffs for distributed electricity supply. |

**B.6. OUTLINE THE COORDINATION WITH OTHER RELATED INITIATIVES:**

The proposed project is a new venture in Iraq, with a unique focus on solar power technology testing and wide dissemination throughout Iraq. Previous projects in the energy sector have focused on rehabilitation of the electricity supply system and master-planning related to that. More recently, UNDP has been supporting the examination of options for renewable energy development in Iraq by supporting the dialogue between various energy stakeholders in Iraq. These previous initiatives form a platform for this project. The project will coordinate closely with the UNDP-supported initiative with Anbar University (Anbar University will be a partner in this project). The Anbar University project is establishing a Renewable Energy Research Centre at Anbar University (under the auspices of the Ministry of Higher Education and Scientific Research) as a pilot initiative for the development of sustainable energy resources. The University is providing space, facilities, and personnel to support the Research Centre, and UNDP is providing technical assistance and equipment (solar and wind testing equipment to date, as well as reference materials). The proposed GEF project will provide a solid opportunity for Anbar University's research capability to be applied to solar power appliances and facilities that will have broad utility and appeal throughout Iraq.

Similarly, the current solar power research work at the Ministry of Science and Technology (experimentation with solar-tracking PV panels and various solar-powered appliances and lighting) will be given a sharp focus with the testing of various solar-powered air conditioners/water heaters, to develop hybrid configurations that suit Iraqi conditions. In addition to linkages to these renewable energy initiatives, the proposed project will also converge with the current concept of Independent Power Producers (IPPs), in which public-private partnerships are to be established to address some of the critical electricity supply gaps in parts of the country, aiming to make up 2,750 MW capacity. The proposed solar/methane-generation power facility in the Najaf area, which is of great interest to the private sector town developers, will be consistent with the IPP concept.

A Project Steering Committee will be established to ensure that the perspectives of all partners are aired and understood, and their respective roles in the project clarified and maintained.

## C. DESCRIBE THE GEF AGENCY'S COMPARATIVE ADVANTAGE TO IMPLEMENT THIS PROJECT:

UNDP has been providing support to the Government of Iraq as the country has assumed its obligations under the UNFCCC (ratified in July 2009), in particular working with the Ministry of Environment to develop focus areas for initiatives that will be defined in the Initial National Communication (UNDP and UNEP are collaborating on this; UNDP has a Country Office in Iraq whereas UNEP does not). UNDP has also provided support to various Government of Iraq energy initiatives, with the following recent and ongoing projects:

- Emergency Supply of Equipment to Electricity Sector in Iraq and Support to Essential Humanitarian Services (providing electricity to sensitive sectors: for example, hospitals).
- Support to the Iraqi Electricity and Health Sectors in the Emergency and Long-Term (with promotion of energy efficiency measures as one component).
- Al-Muthanna Governorate Electricity Network Reinforcement Programme.
- Electricity Sector Reconstruction Project in the Kurdistan Region.
- Review of Environmental Regulations, Standards and Processes Relating to Electricity Generation, Transmission and Distribution.
- Support to Establish a Renewable Energy Research Center in Anbar University.
- Assistance to Finalize the Energy Master Plans for Basra and Anbar Governorates.
- Preparatory Assistance for Formulating Comprehensive Strategies to Address Limitations in Iraq's Energy Sector.

UNDP-Iraq has a dedicated Environment and Energy Cluster, and four individuals in UNDP-Iraq have long experience working with Government of Iraq partners on the various energy initiatives noted above. UNDP has the largest UN presence in Iraq, with frequent communication with all relevant ministries maintained on at least a two-weekly basis as various projects and programmes proceed.

## C.1. INDICATE THE CO-FINANCING AMOUNT THE GEF AGENCY IS BRINGING TO THE PROJECT:

UNDP's role, under its environment finance service line, is to assist countries to identify, combine, access and sequence funding to meet their environmental finance needs (this is also consistent with UNDP's mandate as the head of the UN Development Group). In this case, UNDP has worked with stakeholders to broker US$10.3 million in co-finance. This includes US$130,000 in co-finance from UNDP. Moreover, UNDP will provide support through its broader environment portfolio and through the range of technical staff working on energy and environment issues.

## C.2. HOW DOES THE PROJECT FIT INTO THE GEF AGENCY'S PROGRAM (REFLECTED IN DOCUMENTS SUCH AS UNDAF, CAS, ETC.) AND STAFF CAPACITY IN THE COUNTRY TO FOLLOW UP PROJECT IMPLEMENTATION:

The United Nations Development Assistance Framework (UNDAF) for Iraq (2011-2014) has five pillars, at least two of which provide clear direction for the proposed project. These are: environmental management and compliance with ratified international environmental treaties and obligations; and increased access to quality essential services. This project is completely consistent with several themes within the UNDP Country Programme Document (CPD), which highlights environmentally sound development of the energy sector (with a specific focus on renewable energy and reduction of greenhouse gas emissions), assistance to Iraq as it takes on its UNFCCC obligations, and increasing the role of the private sector in the economic diversification of the country, which is also intended to allow for private sector delivery of services where needed (including water and electricity supply, the latter already being explored through the IPP approach).

UNDP has identified climate change mitigation and adaptation (along with inclusive growth, gender equality and MDG attainment) as one of four priority areas of synergy with the Iraq National Development Programme and the UNDAF; specifically, UNDP is to assist with the definition and attainment of clean energy targets, which the proposed project is focusing on. In addition, UNDP is taking the lead on Private Sector Development and Public Sector Modernization, both of which provide entry points to development of alternative energy sources and systems, including solar power. There are four UNDP Iraq staff members who have well-established working relationships with Iraqi partners in both the environment and energy sectors in Iraq. In addition, there is a team of staff and advisors who focus on private sector

development and who can contribute to the strategies to engage the Iraq private sector in the development of the solar power industry in Iraq.

## PART III: APPROVAL/ENDORSEMENT BY GEF OPERATIONAL FOCAL POINT(S) AND GEF AGENCY(IES)

### A. RECORD OF ENDORSEMENT OF GEF OPERATIONAL FOCAL POINT (S) ON BEHALF OF THE GOVERNMENT(S):

(Please attach the Operational Focal Point endorsement letter(s) with this template).

| NAME | POSITION | MINISTRY | DATE *(MM/DD/YYYY)* |
|---|---|---|---|
| Dr. Ali Al-Lami | GEF OFP / Ministry Advisor | Ministry of Environment | 08/07/2012 |

### B. GEF AGENCY(IES) CERTIFICATION

This request has been prepared in accordance with GEF policies and procedures and meets the GEF criteria for project identification and preparation.

| Agency Coordinator | Signature | Date | Project Contact | Telephone | Email Address |
|---|---|---|---|---|---|
| Yannick Glemarec UNDP/GEF Executive Coordinator |  | August 28, 2012 | Robert Kelly, Regional Technical Advisor, EITT | +421 915 725 069 | Robert.kelly@undp.org |