ANNEX III STAP ROSTER TECHNICAL REVIEW

Renewable Energy Based Rural Electrification in Peru

Technical Review

1) **Overall impression.** This is an excellent project, completely in line with overall GEF operational strategy and entirely consistent with the guidelines and objectives of Operational Program No. 6: *Promoting the adoption of renewable energy by removing barriers and reducing implementation costs.*

2) **Relevance and priority.** Renewable energy technologies, when cost effective, are attractive alternatives for reducing greenhouse gas emissions. Providing electricity to rural areas is an important development objective in permitting the use of high quality electric lighting and possibly other electrical appliances. In dispersed rural populations, grid expansion is a capital-intensive alternative for providing electricity. In many cases where the solar resource is excellent, as in large parts of Peru, solar photovoltaics (PV) is the least-cost alternative. Currently the cost of solar PV systems in Peru is high because the market size is small. The high cost in turn reduces market penetration. The proposed GEF project would cut through this vicious circle by creating a significant market, reducing costs and permitting rural electrification using solar PV to be a sustainable, commercial alternative for rural electrification in the medium term (5 - 10 years). See "Cost analysis of solar PV systems", below.Thus the project addresses both climate change priorities and development objectives.

3) **Background and justification.** The background information and data are clearly presented to justify the proposed project. Besides climate change and development, the Project Document identifies linkages with past and ongoing projects, training and capacity building necessary to make PV systems sustainable.

4) **Scientific and technical soundness.** The project approach is sound. See, however, "Delivery mechanisms ...", below.

5) **Objectives.** The objectives are clearly expressed. A minor observation follows: Para. 38 mentions growth of "GHG" emissions caused by electricity generation from 2.69 million tonnes (1990) to 19.18 million tonnes (2010). Since GHG emissions can be expressed in different ways — Carbon equivalent, carbon dioxide equivalent, etc.— the document should specify the units used. The increase represents a growth rate of 8% per year, equivalent to population growth of 2% a year and per capacity electricity consumption growing at 6% a year, which are reasonable baseline assumptions.

6) **Activities.** The reviewer believes that a couple of activities could be added. This can be accomplished by modifying some of the proposed activities without increasing financial resources. The suggestions are listed in order below:
Activity 1. Development of renewable energy data and databases. Solar energy has far less geographical variation than wind, hydro, and geothermal resources. Consequently, a solar atlas for Peru may be prepared from existing data with relatively little effort. A more

relevant Geographic Information System (GIS) would characterize the *potential market* for PV and other renewable alternatives. This database could incorporate census and other demographic and socioeconomic data, the location of existing transmission and distribution lines, which define future access to grid-based electricity. The GIS would include solar radiation and other renewable energy resource data relevant to this and other renewable energy projects in rural Peru. Argentina has such a GIS developed and operating for those provinces where PV is most attractive for decentralized electrification. This know-how could be transferred to Peru through appropriate training programs.
Activity 2. Standards for PV systems and its installation and certification. Product standards should include not only the PV components —as proposed— but lighting equipment as well. Relatively small changes (± 20%) in the efficacy of fluorescent lamp systems mean significant differences in the cost of the PV system (costing around $900 in Peru) to meet the demand. Also, fluorescent tube lamps, ballasts, and starters have large differences in quality, affecting both performance and lifetime. While these are problems in urban settings as well, equipment failure may be highly counterproductive in the proposed project whose aim includes demonstrating that solar PV systems (and associated equipment) are an excellent alternative for dispersed rural areas.
Activity 3. Establishment of model rural electricity concessions and local companies. Paras. 47 and 63 suggest that PV electric service would be provided by companies at the community level. This is not the only option. See "Delivery mechanisms ...", below.
Activity 5. Installation of PV systems. Para. 67 sets forth criteria for the pre-selection of communities. These may not be the best criteria. For instance, solar PV is most cost effective compared to other alternatives for dispersed rural populations far from existing or proposed grids ("far" in distance or because of natural barriers, such as streams, mountains, forests, etc.). The market survey mentioned in Activity 1 would help identify potential locations. The distance between houses is not relevant if the solar systems are at the individual house level (as is most common). The criterion that the number of potential users be "relatively high, at least 50" is reasonable to achieve scale economics if the service is provided by a community-level company, but less relevant if service is provided by a company covering a larger area. Indeed, a community of 50 houses relatively close to each other, represents a potential electricity demand that could be met at lower cost using other renewable technologies (such as wind, hydro or biomass) where unit investment requirements ($/kW) have strong economies of scale compared to PV systems which are modular in nature.

7) **Participatory aspects.** While community participation and support are important for the adaptation and correct use of solar PV systems, this does not necessarily require "community cohesion" (para.67) or that each community establish a local company to provide the service (para. 84 and elsewhere).

8) **Global benefits.** Estimates of global benefits in terms of CO_2 emissions reduction (Sec. A.1.7) from the 12,500 PV systems to be installed during the project are correct. Indeed, successful completion of the project will result in the creation of a sustainable market for solar PV systems of around 50,000 units per year (much higher than the 1000 to 2000 systems per year identified in para. 80). The GEF participation to catalyze such a market is an excellent investment towards the global environment (approx. $1.07 per tonne of CO_2 avoided).

9) **GEF strategies and plan.** See Item 1 of review.

10) **Replicability.** The approach of this project is applicable to electrification in any developing country with a large rural population and good solar resource where a solar PV infrastructure has not yet been developed.

11) **Capacity building.** This element is an essential component in reducing the barriers to successful adoption of solar PV technologies.

12) **Project funding.** Proposed funding levels is appropriate, and the estimates are adequately justified.

13) **Time frame.** The proposed rime frame is appropriate to the objectives and activities.

14) **Secondary issues.**

   a) This project has no significant links to other GEF focal areas (biodiversity and international waters).
   b) The proposed project is related to other efforts at rural electrification using solar PV systems in Bolivia, Chile, Argentina, etc., and would benefit from sharing information and experience with programs in these and other countries.
   c) Insofar as the project tests and compares alternative delivery mechanisms for providing rural electrification using solar PV systems, it would be innovative.

15) **Additional comments.**
See Sections that follow: "Cost analysis of solar PV systems" and "Delivery mechanisms for rural electrification".

Cost analysis of solar PV systems
According to the project document (Annex 1), the cost of PV lighting systems in Peru is currently around $900. With a mature market, and not including cost reductions in manufacturing, the prices (excluding VAT and customs duty) might be as follows:

Solar panel 50W_p module with charge regulator	$ 300
Battery	85
3 compact fluorescent lamps	45
Total	**$ 430**

Considering a lifetime of 20 years for the solar panel, and 7 years for the battery and lamps, and a discount rate of 12% (the same assumptions as in the project document), we estimate the annualized life-cycle cost of buying and operating the system to be $69 per year. The users are currently paying $77 per year for fuels and batteries, *not including the cost of lighting equipment.*

Lighting levels with the solar PV system would be considerably higher. Considering a kerosene consumption of 6 kg/month, and an efficacy of 0.2 lumen/W for kerosene wick lamps, the light output is equivalent to 15,000 lumen-hours per month. With three 16-watt compact fluorescent lamps (efficacy 56 lm/W) operating 4 hours a day, the light output would be 323,000 lumen-hours per month.

Thus a switch from kerosene wick lamps to the solar PV system would increase light output 20-fold while costing no more (in a mature market). If the project can bring about the cost reductions assumed here, and remove other barriers, it is clear that it would be commercially sustainable in the long run, with significant global environmental and development benefits.

Delivery mechanisms for rural electrification

The delivery mechanism for the installation, maintenance and financing of solar PV systems is key to successful project implementation.

Para. 63 of the project document suggests that PV electric service would be provided by companies at the community level. This is not the only option, as service could be offered at larger scales, e.g. covering a number of communities or even an entire *Departamento*. While solar PV hardware is modular in nature, there are institutional economies of scale, through the bulk purchase of equipment, sharing installation and maintenance infrastructure across a larger number of users, etc. Both Chile and Argentina have given concessions over large areas to companies to provide electrification to dispersed populations in rural areas. In the Argentine case it is at the level of the province, which would be roughly equivalent to the Peruvian *Departamento*.

I propose that the past experience in PV system delivery mechanisms, both in Peru and elsewhere be studied in terms of costs to users, problems of maintenance, quality of service, recycling of lead-acid batteries, and other considerations. On the basis of this experience, several different mechanisms should de selected. These delivery mechanisms should be market tested in different areas during the first two years of the project, so that the most successful models may be developed and promoted in subsequent years. This is likely to lead to a least-cost, sustainable delivery mechanism after project completion.