PROJECT BRIEF

1. IDENTIFIERS:

PROJECT NUMBER	
PROJECT NAME	**Global: Solar and Wind Energy Resource Assessment**
DURATION	3 years
IMPLEMENTING AGENCY	UNEP
EXECUTING AGENCY:	UNEP/DTIE in collaboration with: National Renewable Energy Laboratory (NREL - US), Risø National Laboratory (Risø – Denmark), Tata Energy Research Institute (TERI - India), the National Institute for Space Research (INPE – Brazil), German Aerospace Center (DLR-Germany), and national agencies (list in Annex)
REQUESTING COUNTRIES:	Global; China, Bangladesh, Sri Lanka, Nepal, Ghana, Kenya, Cuba, Honduras, El Salvador, Nicaragua, Algeria, India, Brazil, Guatemala
ELIGIBILITY:	All countries have ratified the UNFCCC and are eligible for GEF support
GEF FOCAL AREA	Climate Change
GEF PROGRAMMING FRAMEWORK:	OP#6 - Promoting the adoption of renewable energy by removing barriers and reducing implementation costs

2. SUMMARY:

This project will provide solar and wind resource data and geographic information assessment tools to public and private sector executives who are involved in energy market development. It will demonstrate the use of these instruments in investment and policy decision making and build local capacities for their continuous use. The project will enable private investors and public policy makers to assess the technical, economic and environmental potential for large-scale investments in technologies that enable the exploitation of two increasingly important sources of renewable energy. During this pilot project, tools for analysis and use of resource information will be developed, a global archive and review mechanism will be initiated, regional/national solar and wind resource maps generated and national assessment demonstrations performed. The overall goal is to promote the integration of wind and solar alternatives in national and regional energy planning and sector restructuring as well as related policy making. The project will enable informed decision making and enhance the ability of participating governments to attract increased investor interest in renewable energy.

3. COSTS AND FINANCING (MILLION$ US)

GEF:	Project	6.512
	PDF	0.300
	Sub-total	**6.812**
CO-FINANCING:	Collaborating Agencies	1.515
	National agencies	0.993
	Sub-total	2.508
	Total Project Cost	**9.020**

4. ASSOCIATED FINANCING (MILLION US $):

5. OPERATIONAL FOCAL POINT ENDORSEMENTS:

Mr. Hari P. Regmi, Under Secretary, Ministry of Finance, Nepal - 10/28/99
Mr. Md. Shawkat Ali, Sr. Asst. Secretary, Ministry of Environment and Forest, Bangladesh – 10/13/00
Mr. Jinlin Yang, Operational Focal Point, MOF, China – 8/9/00
Mr. B.M.S. Batagoda, Director, Economics & Global Environmenal Affairs Division, Ministry of Forestry and Environment, Sri Lanka – 10/20/99
Mr. Humberto Arango, Director, International Cooperation Department, Ministerio de Ciencia, Tecnologia Y Medio Ambiente, Cuba – 9/12/00
Ing. Raul Archila, Ministro, Ministerio de Energia y Minas, Guatemala – 6/3/00
Mr. Garcia Cantarero, Asesor Ministro, Ministerio del Ambiente y Recursos Naturales, Nicaragua – 6/8/00
Ms. Ana Maria Majano, Ministro, Ministerio de Medio Ambiente Y Recursos Naturales, San Salvador
Ms. X.G. de Caballero, Ministra de Recursos Naturales y Ambiente, Honduras – 5/31/00
Mr. Sid-Ali Ketrandji, Ambassador, Algeria – 9/18/00
Mr. B.O.K. K' Omudho, Director, National Environment Secretariat, Ministry of Environment and Natural Resources, Kenya – 9/18/00
Dr. Christina Amoako-Nuama, Minister for Lands and Forestry, Ministry of Lands and Forestry – 9/28/00

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List of Acronyms and Abbreviations

CSP	Concentrating Solar Power
CBEE	Brazilian Wind Energy Center, Brazil
CEPEL	Electric Power Research Center, Brazil
CPTEC	Center for Weather Forecasts and Climate Studies, Brazil
DLR	German Aerospace Center, Institute of Technical Thermodynamics
DTIE	UNEP Division for Technology, Industry and Economics
GEF	Global Environment Facility
GIS	Geographic information system
GRID	UNEP Global Resource Information Database
GTZ	German Agency for Technical Cooperation
INPE	National Institute for Space Research, Brazil
LABSOLAR	Laboratory for Solar Energy, Brazil
KAMM	Karlsruhe University Atmospheric Meso-scale Model
LaRC	U.S. NASA Langley Research Center
NASA	U.S. National Aeronautics and Space Administration
NREL	U.S. National Renewable Energy Laboratory
PV	Photovoltaic
Risø	Risø National Laboratory, Denmark (also spelt Risoe)
SWERA	Solar and Wind Energy Resource Assessment
TERI	Tata Energy Research Institute, India
TMY	Typical Meteorological Year
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
WB	World Bank

BACKGROUND AND CONTEXT

1. Slowing and eventually reversing growth in global greenhouse gas emissions will require, amongst other initiatives, the large-scale use of renewable energy technologies for producing thermal energy, electricity, and hydrogen fuel. The Global Environment Facility is committed to supporting the use of renewable energy technologies on an unprecedented scale throughout the world. Over the next several decades large-scale applications of wind electric and solar electric technologies could grow to several hundred thousand megawatts. By 2008 the European Wind Energy Association expects 70,000 MWe of wind electric capacity to be in place globally. The great majority is expected in Europe and the United States, *despite of the enormous and growing potential in the developing world.* Similarly, the potential applications of photovoltaic technologies are expected to continue to grow robustly (>30%/year), with market breakthroughs as installed system prices fall below ca. US$ 4 – 6 per watt over the coming decade. Solar thermal power plants may also achieve large-scale commercial "breakthrough" with the support of IFC/World Bank/GEF initiatives. The KfW, in concert with UNEP/DTIE, is exploring the potentials for decentralized grid-connected PV plants in conjunction with hydro plants in developing countries around the world that could lead to rapid growth in PV applications Taking into account that resource information is often not available in developing country markets resource assessment need to be redirected to developing countries to accelerate these investment opportunities.

2. Investment in wide-scale intensive application of these technologies in developing countries is inhibited by the lack of adequate solar and wind resource data and by the lack of tools to evaluate these data for energy planning. A critical parameter in the costing of solar and wind energy development is the proximity of possible generation locations to load centres and electricity grid stations. The surface topology has a major influence on micro-climate resulting in highly variable wind resources and significantly variable solar resources over small areas. Without reliable resource information, potential investors tend to avoid the risk of wind or solar project development activities. Main stream investors, venture capital firms and independent power producers are not aware of viable renewable options.

3. The project will influence investment decisions by promoting alternate business scenarios beyond those an energy developer might take on his own, working directly with banks and developers to overcome informational barriers in EE/RET financing. Through targeted appraisals of solar and wind technologies the project will increase investors' familiarity with EE/RET investments. Knowledge and perception barriers, once removed, are unlikely to return.

4. Information on the potential for solar and wind energy can also influence policy and national planning. Although long term average costs of solar or wind may be higher than for hydropower, diversification of energy supply will become more important as climate change impacts cause droughts and endanger the availability of hydro resources (as experienced recently in Kenya, Ghana, and other African countries). Security of supply could justify increased buying tariffs for independent power producers. The reliability of the solar and wind energy resources over time, and phase relationship of these resources relative to other fluctuating resources, can therefore be important. Without accessible, high quality information solar and wind energy development opportunities for enhancing supply diversity and security will be missed.

CURRENT BASELINE ACTIVITIES:

5. Availability of reliable and easily useable resource data is essential for government and industry to identify in-country power generation potential from these options and to act on that knowledge. Yet most developing countries lack such reliable, sufficiently detailed and easily used solar and wind energy resource data. This lack is a *primary obstacle to both public-sector and private-sector investments in renewable energy applications in most of the developing world, including renewable energy projects and programs supported by the GEF*. This project addresses that obstacle, in response to Operational Programme #6 – Promoting the Adoption of Renewable Energy by Removing Barriers and Reducing Implementation Costs.

6. The barrier removal opportunity for this project was identified through the experiences of some developing countries in considering the requirements for incorporating *large-scale* use of solar and wind energy systems in national energy development planning. Developing such resources responds to their commitments and interests as parties to the UN Framework Convention on Climate Change (UNFCCC), and to many countries' national interests (and energy development plans) in diversification of their energy mix, expanding domestic energy production, and diminishing the environmental burdens of energy supply. Lack of adequate renewable energy resource information is blunting their efforts to use these resources. When the information becomes available, important new renewable energy development programs can be initiated and existing programs expanded. Examples of assessment projects and their impact are described in Annex G.

7. In the case of solar, very few weather stations make actual pyranometer solar measurements, so solar information has to be derived from human-based cloud cover observations, or simple instruments that record only the number of direct sunshine hours in a day. Available global solar resolution data[1] is lower resolution and can be improved for microclimates. In the case of wind, the measurements can often be blocked by nearby obstacles (encroaching construction and trees), resulting in unrepresentatively low readings. Furthermore, in many countries, areas with the best wind resource have no measurements at all, this leaving with the impression that the total wind resource availability is much lower than is actually the case. The current global low resolution wind map is considered inadequate for energy assessment in most regions of the world.[2] In addition, for both solar and wind measurements, many countries do not have the financial resources to maintain and properly calibrate the measuring equipment, further contributing to the uncertainty of resource assessments using these data. Due to mechanical component deterioration in anemometers, errors in wind speed are systematically biased to under representation of wind speed. Data can be difficult to access and is often not in digitized format. Since meteorological systematic tracking is considered a national baseline responsibility, measurements themselves

1. The U.S. National Aeronautics and Space Administration (NASA), Langley Research Center (LaRC) has developed a world-wide surface solar energy data set as part of its activities with the World Climate Research Program. The data set provides daily and monthly global horizontal solar resource data on 280x280 km cells for a four-year period. The data are completely derived from weather satellite data, although validation studies using ground-based measurements have been conducted. This data set is readily accessible through the Internet, and on CD-ROM available from NASA/LaRC.

[2] A world-wide wind resource map was prepared by the U.S. Pacific Northwest National Laboratory in the early 1980s. The low resolution (100 km by 100 km) of this map prevents it from being useful in identifying regions likely to have commercially significant wind energy resources

are not proposed for GEF funding in this project. Current baseline information availability is discussed in the Technical Information Annex.

8. UNEP operates the Global Resource Information Database (GRID) as a facility for gathering, archiving and making information accessible. Information covers a broad range of environmental issues and carries information from a many of sources. Solar and wind energy assessment information is not currently carried. As solar and wind energy information will be useful for studies phenomena like surface moisture evaporation rates, carrying this data will be consistent with GRID' s long term mandate. This facility combined with UNEP Division for Technology Industry and Economics with focussed efforts on renewable energy and industry support services will provide a sustainable solar and wind energy resource information service.

RATIONALE AND OBJECTIVES

9. The global environmental objective of the pilot project proposed here is to make available and accessible reliable, high resolution solar and wind energy resource information, thereby removing a significant barrier to widespread use of clean solar and wind technologies. The project will transform the ability of developing countries to assess the technical, economic, and environmental potential for broad scale investments in solar and wind facilities, and amplify their ability to attract private and public sector investments. The goal is to support more informed decision-making, science-and-technology based policy, and increased investor interest in renewable energy. UNEP proposes to engage the solar and wind energy communities (industry, investors, researchers, and government agencies) through a low cost network by which information is continuously shared so that solar and wind energy planning decisions can be made progressively and expeditiously.

10. Removing the key information barriers to large scale deployment of solar and wind energy technologies in developing countries can be achieved by improving the quality and accessibility of renewable energy resource data and provision of planning support tools. The value of diversified energy supply and the potential for economic development can not be analysed without sound information. In addition to the assembly of global information, countries will be targeted for pilot demonstration of high-resolution mapping and assessment of national solar and wind energy development potential. National studies using the tools and other information will indicate the policy opportunities and potential investment impact of the assessments and provide a further indicator of the global potential for wind and solar energy.

11. The techniques for mapping offered through this project will be complementary to parallel measurement programs and provide targeting of measurement activities for best results. The overall cost of preinvestment activities are lowered through the techniques offered. Computer mapping of solar and wind potential is an incremental activity to most developing country activities and technology transfer would not generally be cost efficient in the near future. Building on the information provided during project development, the initial technical reviews will focus on how technical transfer can incrementally build the capability to make national contributions to the project goals and leave a sustainable core capacity for further work.

12. Following the STAP recommendation that renewable energy technology assessments be done, the concept paper "Wind Resource Assessment: State-of-the-Art Technology Applications

and Technology Transfer in Latin America and Asia" was submitted and approved for pipeline entry January, 1998. The project will integrate both solar and wind into a consistent GIS data base platform with analysis tools. UNEP will build on its industry and energy clearinghouse function to fill information gaps and also build on UNEP activities in global resource assessments and tool development.

13. The outcomes of SWERA will be:

- Reduced uncertainties associated with investment and development decisions for solar and wind projects. This in turn will decrease uncertainties in the design, cost, and performance of solar and wind systems, and should increase investor confidence, and confidence of key stakeholders, such as government agencies responsible for facilitating clean energy development.
- Increased awareness by key stakeholders and decision makers of the solar and wind resources and the relevance of the resource information to the development and deployment of various solar and wind technologies, (existence of potential resource, inclusion of solar and wind energy technologies in energy planning)
- Consistent, reliable, verifiable, and accessible global data sets for international and in-country investors and other stakeholders
- Increased capacity for making solar and wind energy plans on the local, provincial, national, and regional levels. The availability of the solar and wind resource data and training in the use of the tools to make use of the data will facilitate better planning for solar and/or wind energy development. In some countries, large-area high-resolution wind and solar resource mapping is expected to reveal far larger commercial wind and solar project development potential than currently thought possible. In order to demonstrate the outputs of SWERA, nationally executed assessments of the potential for solar and wind development will be performed.

ACTIVITY COMPONENT 1: SOLAR RESOURCE ASSESSMENT

Activity 1.1 Solar Methodology and Information Review Panel

14. In view of the wide range of capability found among the participating countries of the project, it is expected that a wide range of existing information on solar energy resources and assessment capacity will be available. A solar review committee will be established to review available information and assessment capacity from each participating country. The review committee will include relevant country partner experts, solar experts from SWERA, and independent experts. Existing country data will also serve as validation or comparison data sets and as background reference data.

15. An output of this review activity will be technical reviews of all data sets and the associated methods. These reviews will define how the SWERA activities will add value to existing solar resource information and will be available to support informed selection and use of existing data in the global archive.

Activity 1.2 Gather Relevant Meteorological Data from National or other Archives

16. Country partners will gather relevant in-country data sets to support the solar assessment process. Such data sets include solar validation data and meteorological data used as input to the models (such as surface temperature and relative humidity, aerosol optical depth). Of particular value will be the identification of and access to specialized data sets that are not normally

available as part of routine weather station observations. For example, data collected for research purposes, data available through universities or private parties, and data collected by other government agencies such as agricultural offices can be useful to the solar assessments.

17. An output of this activity will be the compilation of data sets and reports that the country partners can use in conjunction with the SWERA team for the solar assessment work. Country partner roles will also include the reprocessing of selected data sets to be used into the solar assessment methodologies and incorporated into the final data archive (TMY, validation data).

Activity 1.3 Develop Solar Resource Maps

18. A global *coarse resolution* solar resource map is being developed by the NASA/LaRC, and is available to this project. See Annex: Additional Technical Information

19. *Medium resolution* (approx. 40 km x 40 km) climatological solar resource data sets, comprising monthly average daily total global horizontal, direct normal, and diffuse solar resource elements, will be developed for four major regions of the world: Mexico/Central America/Caribbean, South America, Africa, and South and southeast Asia (including China). Tools to calculate the resource for various collector orientations will be included in these databases.

20. *High resolution* (approx. 0.05^{o} to 0.15^{o}, 1-3 hourly) site/time specific solar resource datasets derived from geostationary satellite data will be developed to include targeted countries and regions in each of the four areas defined above.

Activity 1.4 Generate Time-Series Data

21. Typical Meteorological Year datasets will be developed from selected ground based three-hourly observations of cloud cover data collected over a period of 20-years or more for up to 100 sites, representing 6-10 sites in each targeted country. SWERA will work with the regional collaborators and the country partners to build the capacity for the country agencies to perform these calculations themselves.

Activity 1.5 Relate short-term satellite-derived time series to long-term ground-based time series

22. Existing tools and software will be configured and made available within the GIS tools of this project to relate time series data from the shorter-term satellite-derived model datasets, to the longer-term surface-derived data sets, so that TMY data can be adjusted to any grid cell available from the satellite data. These tools will be developed by members of the SWERA team and will work with the country partners to assure each country has the ability to use these tools and data sets.

Activity 1.6 Conduct Cross-Model Comparisons and Validation Studies

23. Cross-model comparisons among the results of the various methodologies identified above will be conducted to establish uncertainty limits for the model results. Validation studies, using existing ground data sets obtained from the country partners, will also be used to validate the various modeling approaches, and establish further information on the uncertainty of the model results. These studies will be enhanced by co-financing from the sponsoring organizations of the participating agencies. For example, a cross-model comparison of NREL' s CSR model and

INPE-LABSOLAR' s BRASIL-SR satellite-derived solar model will be conducted in climatologically specific regions of Brazil South America, so that the results of the two modeling approaches can be used to define the uncertainty limits of their outputs, and to establish the relative performance of BRASIL-SR region-specific model to the global dataset developed from the CSR model. Results of these studies will be posted with the final SWERA data archive. Co-financing from the host organizations for this activity is anticipated.

Expected Results: Solar Resource Assessment

24. At the end of the SWERA pilot project the regional maps with improved solar resource information will be available to over 100 countries. Regional wind maps will also cover more than the participating target countries.

25. All participating countries will have:

- access to enhanced solar resource maps and expanded databases including national validation results and expanded time series information.
- the capacity to use the data in an effective manner to facilitate solar technology investment.
- understanding of how the resource data are developed
- improved ability to undertake measurement programs for further validation data as well as site-specific pre-feasibility studies

Activity Component 2: Wind Resource Assessment

26. This component contains activities to remove information barriers on wind resources, expedite the deployment of wind technologies in the targeted countries. Although the situation varies between countries, the main barrier found in most of the countries is the lack of quality high-resolution wind resource maps and data that can be used to design and deploy a wide variety of wind technologies. Another barrier is that many countries lack the capacity themselves to develop this information. The wind resource products proposed for this project will take advantage of the research and development of sophisticated models, investment in advanced hardware and software technology, and access to expensive meteorological data sets. The per square kilometer cost of model generated maps varies by a factor of 10 with the size of the area mapped due to the high cost of setting up the input data. Mapping of multiple countries is by far most cost effective. Hence, depending on the country capacity, the main barriers found range from either the lack of capacity for developing high-resolution wind resource maps, and/or the lack of capacity for effectively using these data if they were available. The approach to providing or enhancing the information and/or capacity is discussed in the Annex on Technical Information.

Activity 2.1 Review of Existing Wind Surveys and Assessment Methodologies

27. In view of the wide range of capability found among the participating countries of the project, it is expected that a wide range of existing information and assessment capacity on wind energy resources will also be available. In this task, a wind review committee will be established to review available information methods and assessment capacity in each country. The review will include relevant country partner experts, wind experts from SWERA, and independent experts. The purpose of the review is to identify the wind resource, assessment capacity and related information already available to the country or region. This will form a baseline for the

project. A selection from the existing country data will serve as validation data sets and as the reference data for interannual, diurnal and seasonal variability. Areas of interest for additional analysis using a mesoscale model will also be identified.

28. An output of this review project will be technical reviews of all data sets and methodologies used. These reviews will be available to support informed selection and use of existing data, and to define how the SWERA activities add value to existing information. In an effort to build up analytical and data processing capability in partner countries, models and methodologies used to produce the wind map/atlas will be documented and made available through the SWERA archive.

Activity 2.2 Gather Existing Relevant Wind Data

29. Country partners will work with the SWERA team to assist in gathering relevant in-country data sets to support the wind assessment process. This includes the identification of existing wind data available from meteorological agencies and other sources. The different types of data to be identified include data collected from surface stations (i.e., ground-based measurements), upper-air stations (i.e., weather-balloon measurements), and marine data where available (i.e., ships, buoys). Data identified by in-country partners will be compared to data that are available from SWERA through its global datasets selected in-country data that are supplementary obtained for use in the assessment.

30. An output of this activity will be the compilation of data sets and reports that the country partners can use in conjunction with the SWERA team for the wind assessment work. Country partner roles may also include the reprocessing of data sets (such as supplementary weather balloon data) so that they can be input to the computer wind assessment methodologies.

Activity 2.3 Process Data Sets and Perform Critical Analysis of Data Quality

31. The SWERA team will collaborate with the country partners on the methods to be used for processing and analysing the various model input data sets. The SWERA team will share processed summaries of data from global data sets (e.g. DATSAV2) with country partners who will assist with the analysis of the data quality. Qualified regional or national experts will process their in-country data sets, with guidance from the SWERA team to facilitate the use and integration of these data with the models.

32. The final critical analysis of the data to select the best and most reliable data for developing meteorological inputs to the models will be made by the SWERA team with in country assistance, particularly where qualified experts are available.

Activity 2.4 Adjustment of Surface Observations using WAsP methods

33. Country partners will be trained by SWERA technical support on the use and application of a highly localised method (WAsP) for adjusting ground measurement data and developing time-based information. The training and technical assistance will be through the regional institutions where appropriate. The country partners will apply these methods to selected data for use in verification of computer-generated wind maps and expansion of the assessment information to include variations over time.

Activity 2.5 Generate High-Resolution Wind Maps

34. For countries/regions identified, NREL' s empirical/analytical model will be used to generate high-resolution annual average wind maps at 1-km resolution. It is anticipated that the mapping

will be carried out for 5 to 8 regional blocks and include as many demonstration countries as possible. The KAMM mesoscale model would be run, especially for channeled wind corridors, and the results made available separately and as recombined with the empirical/analytical model data. Other models and methods will be considered where a cost/benefit advantage exists.

Activity 2.6 Prepare Wind Atlas

35. The preparation of the wind atlas document (non-map, meta-data stored information including interpretation of the wind maps and summaries of the salient wind characteristics) will largely be the responsibility of the country partners. Country agencies will provide the data such as the hourly time-series data and with technical support, prepare the summaries, graphical output of the data, and outputs of selected data sets with inter-annual, monthly, and diurnal variations for the meta-data sets in the global archive.

Activitiy 2.7 Conduct Cross-Model Comparisons and Validation Studies

36. For specific areas where feasible, cross-model comparisons among the results of the various methodologies will be conducted to establish uncertainty limits or confidence levels for the model results. For example, the NREL model and KAMM will be compared with the MM5 mesoscale model used by the Brazilian Center for Wind Energy (CBEE). Validation studies, using existing ground data sets obtained from the country partners, will also be used to gain confidence in the modeling approaches, and establish further information on the uncertainty of the model results.

Expected Results: Wind Resource Assessment

37. It is expected that at the end of the project participating countries will have:

- access to high-resolution wind resource maps and databases that will support planning for the deployment of a large range of wind technologies, from large utility-scale to small off-grid applications, water pumping, etc.
- the capacity to use the wind data in an effective manner to facilitate wind technology investment.
- an understanding how the mapped resource data was developed;
- enhanced capacity to undertake wind measurement programs to provide validation data for the assessments as well as site-specific studies for pre-feasibility;
- where mapping in blocks of small countries is done, the information will be made available for all the area in the mapped block although the national activities would not be executed in all countries within the pilot project. Mapping of countries and areas will be optimized within available resources.

Activity Component 3: Integration with Geographic Information System (GIS)

38. A Geographic Information System (GIS) is the combination of hardware, software, data, and expertise used to create, modify, evaluate and analyze spatial or geographically referenced information in digital format. GIS data are comprised of two components: spatial features and attributes. The spatial features are elements that can be shown on a map. They include roads, rivers, population density, electric transmission corridors, meteorological stations, and the wind or solar resource distribution. The attributes are the associated information such as land ownership and use (designations such as forest, agriculture, park, etc), temperature, wind speed and solar radiation values. The combination of both a computerized map and a database within the same system facilitates planning and decision making.

39. This project will contribute to removing information barriers by integrating the solar and wind resource assessment products into a GIS format. Additionally, the SWERA project will provide an easy-to-use GIS Toolkit that supplements these data products, and is targeted specifically to organizations and individuals that lack GIS capability. Despite the growing presence of GIS throughout the world, it is often not used to facilitate renewable energy project deployment. It is noted that the full set of relevant information will include data sets already available from other agencies such as USGS, NASA, and GRID centres. Unless the information has been modified or adjusted, the most effective means of providing access is expected to be through pointers or web site links to the original source.

Activity 3.1 Develop standard GIS datasets

40. Geospatial Database Development. Geospatial datasets will be developed from the results of the solar and wind resource assessment activities. These datasets will be in a standard format, allowing for easy importation into commercial GIS software packages. These datasets will also be included within the GIS Toolkit and project archive sites for distribution. The resolution of these datasets will vary according to the resource assessment methodology used. These datasets will include the spatial representation of the resource and the associated attributes (tabular information).

41. *Metadata Development*. The documentation for the GIS datasets will be comprised of metadata to the International Standardisation Organisation standard. Metadata are "data about data" and include information about the data sets' identification, quality, organization, spatial reference, entity and attributes, distribution and reference. This information facilitates informed use of the data and allows searches to be conducted through a GIS Clearinghouse.

42. *Conversion and Integration of Selected Data Sets into GIS format*. Additional data sets to be included in the archive and GIS Toolkit will support the analytical functions that can be performed within a GIS. These will include terrain, population information, administrative boundaries, and when available in the public domain land use, load centers, transportation and transmission corridors. Finally, the data and associated information from ground based measurements and the qualifying information on data sources and limitations will be integrated with the GIS data.

Activity 3.2 Develop GIS Toolkit

43. A GIS Toolkit will be adapted from currently available GIS technology for widespread distribution. Interested parties will have access to the resource assessment data products in a format that allows for visualization and simple analysis with neither specialized software nor GIS expertise required. The GIS Toolkit will be a standalone product for use on most personal computers. The Toolkit will be distributed via CD-ROM. All toolkits will include the geospatial solar and wind resource data along with selected GIS datasets of topography, population and land use for that area. Additional datasets will be included on a per-country basis, if these databases exist in the proper format, are available in the public domain, and can be obtained at nominal cost. Regional agencies will be able to offer expanded customization services to agencies wanting to pay for additional capabilities or privately held information.

44. *SWERA Graphical User Interface*. A graphical user interface (GUI) will be developed to serve as the "front end" to the GIS Toolkit. This interface will be easy to use, will include on-line help, and will enable the user to access the program and associated data, and create graphical output. The programming environment will take advantage of object-oriented programming capabilities offered by several GIS vendors. A programming environment will be selected after careful evaluation of the options. The evaluation will include a consideration of the common GIS platforms in use throughout the world, the evolutionary nature of GIS programming and technology, and the specific needs of this project. This will ensure compatibility with the other project GIS data products to help ensure the long-term viability of the GIS Toolkit.

45. *Integration of appropriate geospatial databases from the SWERA GIS.* The successful analysis of geographically distributed phenomena requires appropriate geospatial databases. In addition to renewable energy resources and power generation and energy production potential for solar and wind technologies, the toolkit will incorporate existing GIS databases for topography, land use, and population density. Additional public domain data sets may be included at the recommendation of the regional and in-country partners, provided that these datasets exist, are readily available at nominal cost, and that there are no restrictions to their use.

46. *Algorithms and routines for the GIS Toolkit.* A subset of standard geospatial operations that are commonly performed within a GIS will be developed for the tool kit. These will initially be limited to overlay and proximity. Overlay operations will allow examination of resource related information with other factors that share a common geographic area. An example of an overlay operation would be the identification of areas where optimum solar energy resource intersects optimum economic conditions. Proximity operations will allow the user to measure how far apart two or more features are. An example of a proximity operation would be determining the distance from a load center to the nearest useable wind resource area.

47. *User Manual and Training Materials for distribution with the GIS Toolkit*. The success of this project will depend on the proper distribution and usage mechanisms being developed and implemented. Selected individuals within the regional and in-country partner organizations will be trained on the use of the Toolkit. These individuals will then be available for continued or expanded training and user support with additional distributions of the Toolkit.

Activity 3.3 Needs assessment for in-country partners

48. The needs of in-country partners will be assessed based on their ability to implement the GIS component of this project. The amount and type of incremental capacity building with the in-country partners will take into account the environment in which current GIS capability resides, the existence and availability of databases, the capability to provide customer support and training, and finally, GIS infrastructure maintenance and sustainability. A regional collaborative agency will provide any of these services should an in-country partner with adequate capacity not be available. The in-country or regional partner will work in close collaboration with the SWERA Team to perform the necessary GIS related activities. Subject to needs and availability, these activities could include data compilation and integration, establishing a local data archive and dissemination facility, accessing databases for inclusion in the project, or training other national energy, wind and solar specialists.

Activity 3.4 Establish global archive

49. A global archive of solar and wind information with reference data sets and technical reviews supporting informed use will be established. UNEP/GRID facility will design the archive and dissemination activities to be replicated by regional/in-country partners. The standard, public domain products generated by the SWERA project will be freely accessible by international investors, agencies, and developers. The global archive will contain, or link to, existing data sets for world wide low resolution solar irradiance, population density, topography, land use and other wind or solar assessments, as available, from other organizations such as the World Bank, UNDP or GTZ. The products will include the solar and wind resource assessment maps, related data sets, and accompanying documentation. Additional archival locations and dissemination activities will be established during the project by regional or country collaborators to contain more country specific data. More country specific data sets (ie. electricity grid) will be under the control of the participating country, with dissemination activities taking place accordingly.

50. The technical review services are described elsewhere in this document. The reports generated by the technical review will be incorporated into the global archive. The global archive will include:

- Standard GIS data sets representing wind resources with supporting documentation
- Standard GIS data sets representing solar resources with supporting documentation
- Accompanying meta-data and data sets for wind and solar including TMY' s, time series, etc
- Standard set of GIS data sets for topography, land use and population density
- Reports detailing technical review activities and findings
- Links to web sites that are pertinent to this project, such as the international, regional and country sites, GEF focal points or their designated agencies, the GIS Toolkit, and other UNEP/GRID sites

51. UNEP/GRID will develop an Internet world-wide-web site. This site will house the archive, act as a clearinghouse for searches, and disseminate products across the Internet. All inquiries and special data or service requests will be automatically directed to the SWERA team websites for processing. Regional and country centers will distribute products by offering CD-ROMs, Internet distribution, or other means. The regional and national partners will work in close collaboration with the SWERA team to perform the necessary integration, conversion, and dissemination activities.

Activity Component 4: National Application of the SWERA tools and information

52. Case studies in the utilization of SWERA tools in energy planning will demonstrate the potential for support to planning and development. The advantages of the information and tools leading to better targeted and more effective preinvestment resources, more accurate techno-economical analysis leading to realistic cost-benefit projections, framing specific policies and financial incentives to attract private sector investment, and energy development policies. This activity will enhance existing activities by other agencies where they are operating and the tools further delivered through the UNEP Sustainable Technology Advisory Network.

53. These products (and data) can be effectively used in national energy planning case studies exercises in the estimation of exploitable wind/solar resource potential under various scenarios, identification of potential regions of interest within the country and matching of resource availability with needs of population centres. The estimation of share of unserved energy demands that could be met by wind/solar energy in energy deficit pockets/regions can also be made. Other relevant analyses depending on available national data for electric grid lines, roads, etc. would also be included. The information can be marketed directly to investors who may not otherwise be reached.

Activity 4.1 Alternative business development scenarios in energy supply

54. This activity will demonstrate the outcomes of SWERA by developing and presenting solar and wind energy investment opportunities to investors. Marketing and outreach activity will require special efforts to reach investment decision-makers in venture capital companies, independent power producers, and utilities.

55. To create the business scenarios, information from other sources will need to be assembled. Drawing on existing national activities and GHG inventories, a number of demand growth scenarios would be selected. These will include national development plans. The work will consist of a review of available projections and selection of a few representative scenarios as opposed to a full mitigation analysis study. A nationally oriented technology mix will be identified that is a marketable to potential investors. This will include efficiency factors, nominal line loss characteristics, new load assumptions as required to convert the solar and wind energy resource data into usable potentials. Benchmark technologies will also be used for comparison purposes.

56. For participating countries, national stakeholders and particularly energy planners will use the energy demand projections, solar and wind resource data, and engineering estimates of potential solar and wind based energy production as input to development of long term solar and wind development scenarios. These alternate business development scenarios can demonstrate the long term strategic potential of renewables, and serve as a basis for estimating GHG emission reduction potentials. Insights gathered from such exercises can stimulate policy initiatives designed to attract public and private investment in renewable energy projects.

Activity 4.2 Marketing and presentation of the alternative energy development projections to investors

57. The project will influence investment decisions by promoting alternative scenarios to business-as-usual investment especially in fossil fuel power plant. SWERA will present these scenarios directly to banks, financiers and developers to overcome informational barriers in solar and wind projects development for financing.

58. The various dissemination formats will include, limited hardcopy maps and reports, web-based access to information, CDROM information only, and CDROM information with user friendly tools. The core solar and wind information will be housed in the global archive (described in Activity Component 4), however, the collaborating agencies, with backup from INPE, TERI will be able to customise and modify the auxiliary data (electric grid lines etc) and provide customised services and products to regional clients. Confidentiality of auxiliary data

will be negotiated in respect of national requirements and proprietary rights. New web technology, such as ArcIMS and ArcSDE, is changing how data is archived and shared, and how disseminators interact with expert users and regional centers, particularly those with access to high speed internet. The new technologies will significantly assist the regional agencies and commercial investor' s ability to do value-added marketing based on the core data. Within the limited funds of this pilot project, the SWERA products will be promoted to investors and policy-makers.

59. Expected results are:
- a demonstration of the value of the assessment activities
- an indication of the potential for increased estimates of the global potential for solar and wind energy utilisation.
- investment and policy changes

ACTIVITY COMPONENT 5. MANAGEMENT AND COORDINATION

Activity 5.1 Coordination of project activities

60. UNEP/DTIE will coordinate the project with regional assistance from INPE and TERI as required. The Steering Committee will include WB, UNDP and other cofinanciers as appropriate to coordinate activities.

61. During the pilot project, TERI and INPE will provide services to countries in their regions as needed. Where appropriate, they can coordinate the activities among national partners and develop the technical capability; after SWERA to ensure that SWERA products are effectively and efficiently utilized to achieve accelerated and continued deployment of solar and wind energy systems.

62. Various tasks and responsibilities of the regional agencies can be summarized in the following manner:
- Coordination between SWERA team and national partners of the region so that activities and schedules are maintained.
- Assistance to national partners in data quality assessment & refinement.
- Work closely with NREL & Risø in the development of maps and receive incremental capacity building in assessment techniques including modeling.
- Provide capacity building to national organizations in use of resource maps and SWERA tools for energy planning.
- Dissemination of SWERA products and outreach to investors.

Activity 5.2 Meetings

63. Regional meetings will be held during project startup and during the development of the final report on the project. National assessments, regional mapping efforts, and integration/ extrapolation of global significance of the assessment will be developed through this exercise and recommendations made for further improvements in assessment methodologies and coverage. Sharing of information through common training exercises, sharing experiences and validation approaches during the assessment activities will enhance the quality of the assessments

STAKEHOLDER PARTICIPATION AND IMPLEMENTATION ARRANGEMENTS

64. A global network of international and national agencies with various technical interests and support services in solar and wind energy resource information and assessment will be established. Stakeholders will be the European, American and other wind energy associations and the American, International and other Solar Energy Societies. Other International Agencies like the World Solar Program of UNESCO, UNDP/GEF will also be integrated. These stakeholders will assist with the development of the facilities and represent the solar and wind technology providers and some investors.

65. UNEP/DTIE, will be the executing agency for the project. The executing agency manages the project and is accountable for the effective use of the resources. A Project Manager will be established within UNEP to implement the project on a full time basis. The Project Manager will provide guidance to both project holders and governments during the period of execution. Project execution will be by UNEP in collaboration with NREL, Risø, TERI, INPE, DLR and national agencies in all pilot demonstration countries (list in Annex).

66. Regional meetings were held in Nairobi, Delhi, and São Paulo. Participants included industry, assessment experts, energy officials from governments and non governmental organisations. Meeting reports are available on request. Further stakeholder participation will be encouraged through world wide web based information exchange during the project.

67. A Steering Committee will provide guidance to the project activities, monitor and guide the implementation of the work plan, review the budget and address significant implementation problems. The Steering Committee will consist of members from UNEP/DTIE, NREL, Risø, TERI, INPE, UNEP/ GRID, and DLR. The World Bank and UNDP will be invited to participate especially for the coordination of country activities.

68. The SWERA team consists of technical resource assessment and GIS experts from NREL, Risø, TERI, INPE, DLR, and UNEP. This team is responsible for actual execution of the mapping, database development, and GIS technical support activities.

69. TERI and INPE will act as Regional Agencies during the pilot project based on their ability to sustain activity in these areas. Their services will be concentrated on their immediate regions but they may supply similar services elsewhere. In China, CRED will work directly with the SWERA team. In Africa the support services will be shared by UNEP and the SWERA team.

RISKS AND SUSTAINABILITY

70. SWERA can only be successful if governments of participating countries show strong and continuous commitment to the project. The interest and support of the wind energy associations, the solar industry associations, investors and governments will be needed. Based on interest so far, this is likely.

71. Replicability has been addressed through the selection of two regional agencies that will be able to carry on assessment services after SWERA Pilot Project. The global archive will be maintained by UNEP/GRID.

72. This project, in and of itself, may not directly stimulate accelerated investments in renewable energy projects. Other barriers, such as policy or economic barriers, may also need to be overcome in certain countries before expanded investment occurs. However, in absence of reliable and precise resource data, solar and wind energy projects/programs will not take off, even if all other barriers are removed.

INCREMENTAL COSTS AND PROJECT FINANCING

73. Baseline meteorological measurement programs do not provide sufficient information for solar and wind energy assessment as they are designed for other purposes and measurements are only funded by GEF or when they lead to actual investment. Mapping of the potential resources and their integration into a GIS format provides incremental activity to the baseline in most countries. Information of the resource potential will trigger the follow-on investmant activities. The baseline meteorological measurements are still needed for agricultural and transport purposes. Assessment and mapping model development has taken place in the technical supporting agencies that can be capitalised on by the GEF and will set up a sustainable activity area for further regional assessment projects.

74. A letter of cooperation has been received from GTZ offering to support SWERA through the TERNA Wind Measurement Program. The monetary value is estimated based on similar past TERNA projects and cannot be determined until additional constraints of the TERNA program are satisfied within each country. The funding is shown against National Alternative Development Scenarios.

Incremental Capacity Building within Collaborating Agencies is discussed in a separate Annex.

75. The SWERA project focuses on removal of information barriers through satellite and computer modeling techniques, and building the capacity in the national collaborating agencies to use this information and contribute to the output of the project. Capacity building is therefore limited in scope and extensive follow on activities will be needed. Capacity will be increased incrementally from each country' s baseline where they can become sustainable.

76. Use of the information is the most critical barrier. Proficiency in the use of the information and tools in activities 3 and 4 are therefore the most important. For advanced countries and especially for the regional agencies, access to the complete GIS data sets will permit more sophisticated GIS applications.

77. Knowledge of wind measurement is also crucial to the national capacity. Since only a core capacity will be established during the national activities, additional funding for pre-feasibility studies and expanded training will be necessary before investment. The firm understanding of the wind data by national collaborating agencies will be able to support further development of national policies and plans. Knowledge of solar measurements will also be beneficial.

78. Where countries/regional agencies already have measurement capacity and assessment capability the incremental effort will be redirected to allow them to increase their assessment capacity. INPE-Labsolar will perform a significant portion of the Latin American mapping activities. CBEE will work with NREL and Risø to refine their 30km resolution wind map in

Brazil. TERI can perform wind measurements and assist with training and has used GIS tools effectively for assessment activities. The Indian - Centre for Wind Energy Technology - meteorologists expertise will be used to reanalyse additional upper air weather data for input to the models. Existing expertise in solar measurements will also contribute significantly to the solar resource assessments and validation activities. During project initiation, the ability of agencies to perform additional assessment tasks will be investigated. The technical review activities in solar, wind and GIS will allow formulation of detailed responsibilities for assessment activities that meet the information barrier removal goals within the prescribed incremental budgets for the pilot project and build on the existing capacities in developing countries. One fifth of the total budget will be used through the national collaborating agencies and is expected to be matched by in-kind baseline activity. The activities executed by national agencies in each pilot country in support of the assessment and demonstration will require 50 to 100 k$. These activities will be targeted during project initiation and not conflict with associated projects.

INCREMENTAL COSTS

	Baseline	Alternate	Increment
Global Environmental Benefits	Lack of solar and wind energy resource data leads to continued dependence on fossil fuels. High emissions of GHG from conventional energy systems that use fossil fuels. Lack of integrated use of geo-spatial, solar and wind energy resource data in energy planning.	Solar and wind investment accelerated through solar and wind energy resource information dissemination and GIS tools and applications. GHG emissions reductions through improved project design and increased investments in solar and wind energy projects.	Significant GHG emissions reductions through improved engineering and targeted investments in solar and wind energy projects. Incremental cost and energy savings due to proper system sizing from more accurate and reliable solar and wind energy data.
Domestic Benefits	Least cost energy planning that continues to deploy conventional fossil fuel-based energy systems.	New investment in solar and wind supports rural development and grid supplies Solar and wind energy systems reduces local pollution and reliance on imported fuels	Diversified energy supply, lower local pollution, and reduced energy imports resulting in economic savings in many cases. More robust energy plans and

		Inclusion of solar and wind energy in the national energy system will diversify the energy supply.	identification of opportunities for local and global environmental pollution.
Total Costs:	Total Baseline Costs: US$ $2,408,000	Total Project Costs:$9,020,000 GEF: $6,512,000 Cofinance:$2,508,000	Incremental Costs: $6,612,000 GEF: $6,512,000 GTZ: $100,000

PROJECT FINANCING

Activities	GEF	Cofinancing	Total
1 Solar Assessment activities			
1.1 Method and Info review	58	26	84
1.2 Gather data	262	249	511
1.3 Develop Resource Maps	0	0	0
South America region	375	156	531
Central America region	142	158	300
African , Middle East	384	286	670
Asian subregion	414	120	534
1.4 Generate Time Series Data	100	100	200
1.5 Relate satellite and Ground series	60	60	120
1.6 Solar Comparison and Validation	194	159	353
Subtotal	1989	1314	3303
2 Wind Assessment			
2.1 Review Surveys and methods	64	39	103
2.2 Gather existing data	206	296	502
2.3 Preprocess data	200	0	200
2.4 Adjustment of surface measurements	41	41	82
2.5 Generate high res maps			
Latin America subregions	660	75	735
African subregion	385	0	385
Asian subregions	295	0	295
Small Islands	240	0	240
2.6 Prepare atlas info	124	69	193
2.7 Wind Comparison and validation	109	69	178
Subtotal	2324	589	2913
3 Integration with GIS			
3.1 Develop Standard Data sets	100	0	100
3.2 GIS Tool kit development	380	300	680
3.3 National GIS activities	183	43	226

3.4 Establish Global Archive	320	0	320
Subtotal	983	343	1326
4 National Applications of SWERA			
4.1 Alternate Development Scenarios	216	240	456
4.2 Marketing	150	0	150
subtotal	366	240	606
1 Networking and coordination			
1.1 Coordination	450	0	450
1.2 Coordination and meetings	400	22	422
Subtotal	850	22	872
Total	6512	2508	9020

Annex A Incremental Cost Matrix

Activity	Baseline	Alternative	Increment
1. Solar Resource Assessment	NASA low resolution global horizontal data set. Varying levels of information and quality in numerous studies primarily for meteorological and agricultural purpose.	High resolution (approx. 0.05° to 0.15°) and medium resolution (approx. 40 km x 40 km) solar resource (global, diffuse and direct radiation) maps and data sets will be developed for large regions of the world. Greater awareness of solar resource potential to meet energy requirements. Increased deployment of solar energy projects from use of more precise solar resource data.	Solar components and higher resolution information accelerates solar investment broadening applications at the margin of premium markets and supporting large-scale strategic investments in solar thermal electric, solar photovoltaic and other solar applications.
Costs	Total 1314 k$ National Agencies, DLR, NASA, NREL, INPE	Total 3303 k$	GEF 1989
2. Wind Resource Assessment	Global map from the 1980s is composed of misleading measurement and interpolated data. Sparsely scattered, non-energy related ground measurements continue to be taken in many but not all countries. Some resource assessment capacity in medium-income developing countries.	High resolution wind resource maps (1 km x 1 km) for selected regions will be generated. More accurate knowledge of wind energy potential. Better information on good wind energy sites. Accelerated deployment of wind energy projects.	High resolution maps are incremental to national baseline activities in all countries considered. The increment will be additional to the current baseline so as to accelerate investment in wind energy development.
Costs	National Agencies 589 k$	Total 2913	GEF 2324
3. Integration with Geographical Information Systems (GIS)	Sophisticated GIS tools that are too cumbersome for the target audience.	Broader awareness and confidence in solar and wind energy resources.	Accelerated information dissemination and effective use.

Activity	Baseline	Alternative	Increment
	Energy planning without the benefit of easy to use geo-spatial information and accurate solar and wind energy resource data.	Broadly accessible and usable solar and wind energy information.	
Costs:	NREL and National Agencies 343k$	Total: 1326k$	GEF 983 k$
4. National Application of SWERA Tools and Information	Low penetration of GIS in energy planning. Lack of accurate solar and wind energy resource data.	Use of simply GIS tools and high quality solar and wind energy resource data in energy planning.	Wider use of GIS planning tools and integration of solar and wind energy resource data in national energy planning.
Costs:	National Agencies: 140 k$	Total: 606 k$	Total: 466 k$ GEF: 366k$ GTZ: 100 k$ (est.)
5. Coordination	International networks exist but none comprehensively focused on solar and wind resource data.	Through links to other agencies and a global resource assessment centre, broader awareness and confidence in solar and wind energy resources is established leading to broadly accessible and easily usable solar and wind energy information.	An international network of regional centres and international technical institutions will provide technical support and information dissemination on the effective use of high-resolution solar and wind energy resource data. Startup costs and project coordination costs.
Costs:	National Agencies: 22 k$	Total: 872 k$	GEF: 850 k$
Global Environment Benefits	Lack of solar and wind energy resource data leads to continued dependence on fossil fuels. High emissions of GHG from conventional energy systems that use fossil fuels.	Solar and wind investment accelerated through solar and wind energy resource information dissemination and GIS tools and applications. GHG emissions reductions through improved project design and increased investments in solar and wind energy projects.	Significant GHG emissions reductions through improved engineering and targeted investments in solar and wind energy projects. Incremental cost and energy savings due to proper system sizing from more accurate and reliable solar and wind energy data.

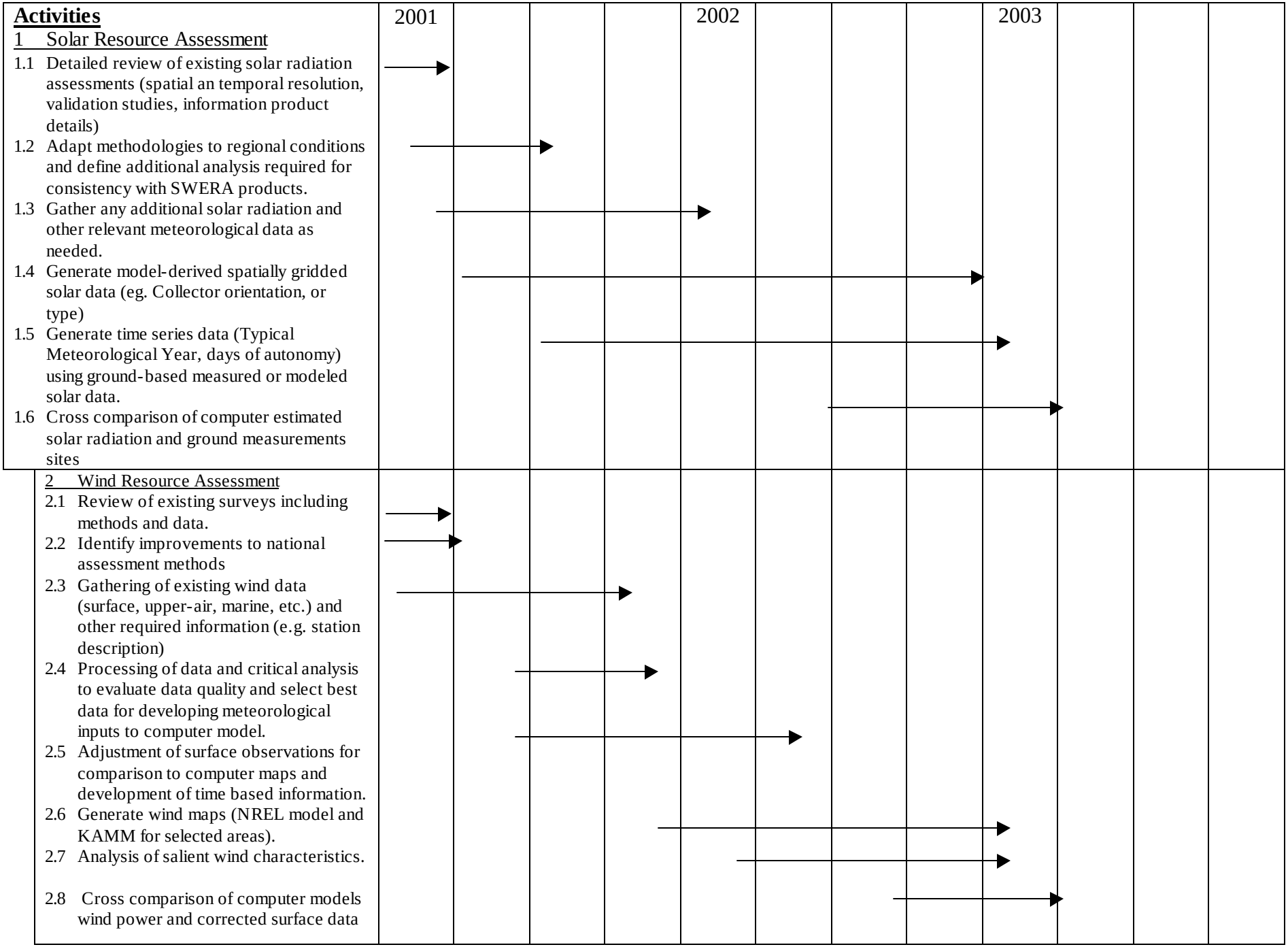
Activity	Baseline	Alternative	Increment
	Lack of integrated use of geo-spatial, solar and wind energy resource data in energy planning.		
Domestic Benefits	Least cost energy planning that continues to deploy conventional fossil fuel-based energy systems. Consumption of fossil energy produces high local pollution Importing of fossil fuels increases energy security risk	New investment in solar and wind supports rural development and grid supplies Solar and wind energy systems reduces local pollution and reliance on imported fuels Inclusion of solar and wind energy in the national energy system will diversify the energy supply.	Diversified energy supply, lower local pollution, and reduced energy imports resulting in economic savings in many cases. More robust energy plans and identification of opportunities for local and reduction of global environmental pollution.
Costs	Total Baseline Costs: US$ $2,408,000	Total Project Costs: $9,020,000 GEF: $6,512,000 Cofinance: $2,508,000	Incremental Costs: $6,612,000 GEF: $6,512,000 GTZ: $100,000

Annex - Logical Framework/Project Planning Matrix

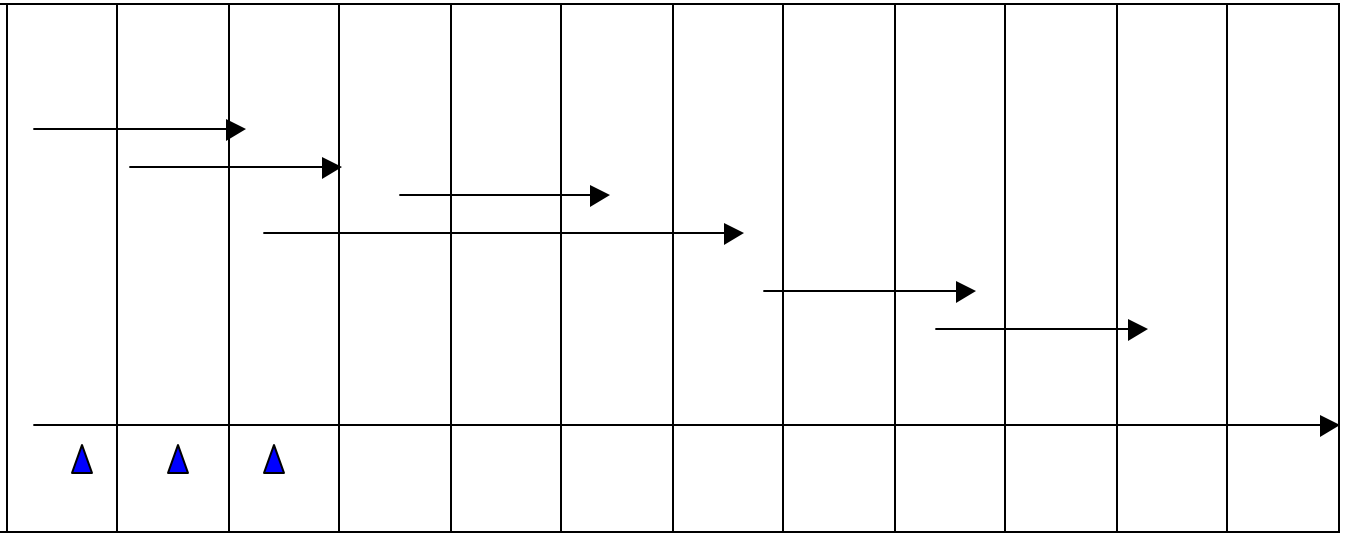
Project Strategy	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Operational Programme 6 Promotion of the adoption of renewable energy by removing barriers and reducing implementation costs. National development, energy diversification, reduced domestic pollution	(1) total capacity installed (2) technology costs (3) involvement and activities of national and/or multinational corporations (4) overall portfolios/activities of national and/or international private financiers, MDBs and bilateral aid agencies (5) national policies (6) awareness and understanding among national and international agencies and NGOs (7) energy consumption and fuel use patterns	*Market surveys* The market scope affected by this work will be large investors in wind and solar energy as well as smaller dispersed investors in rural energy Establish baselines for international market and measure trends over time. Solar energy societies and wind energy associations	*Replication.* Replication occurs across countries and from national markets to international market. *Relevance.* The most appropriate technologies, markets and countries have been included in the GEF portfolio. *GHG emissions.* Changes in market indicators correlate with reductions in greenhouse gas emissions over time.
Outcome Increased adoption and reduced cost of solar and wind energy development by providing higher spatial and temporal resolution resource information in a geographic information system planning tool enabling countries to remove information barriers and, as well, reduce implementation costs by prescreening locations of higher resource potential	Pre-investment measurement activities make use of the high-resolution maps and target the high potential areas. Availability of resource data stimulates policy reform that promotes use of solar and wind technologies for major development. Geo-spatial energy planning takes place. Solar and wind energy investment is accelerated.	The effect in pilot/demo countries is measured by counting follow-on investments, new measurement surveys, policy and planning and projects entering the pipeline.	Opportunity to displace fossil fuel use, good solar resource likely, good policy environment expected, especially in reducing use of high CO_2-emitting fuels, rising energy demand, interested investors.
Outputs Improved awareness of wind and solar resources	Adoption and reference in bidding documents	Count CDROMs sold, web-site hits, people/agencies using maps	Opportunity to displace fossil fuel use, good solar resource

Improved information quality and confidence New resources identified Reduced cost and time of pre-investment work Improved capacity for planning	Increased estimates of potential Estimated time and cost savings Acceptance of the development projections and adoption of the method for further planning and policy work	and tools; incremental increase in the number of projects entering the pipeline over baseline projections Survey of wind/solar engineering firms doing preinvestment studies	likely, good policy environment expected, rising energy demand, interested investors.
Activities 1 Solar Assessment activities 1.1 Method and Info review 1.2 Gather data 1.3 Develop Resource Maps South America region Central America region African , Middle East Asian subregion 1.4 Generate Time Series Data 1.5 Relate satellite and Ground series 1.6 Solar Comparison and Validation 2 Wind Assessment 2.1 Review Surveys and methods 2.2 Gather existing data 2.3 Preprocess data 2.4 Adjustment of surface measurements 2.5 Generate high res maps Latin America subregions African subregion Asian subregions Small Islands 2.6 Prepare atlas info 2.7 Wind Comparison and validation	**Deliverables** Technical reviews will be attached to the information in the database and available to support informed selection and use. In the case of existing or externally funded assessments, activity may end here. Data to be gathered and used Gridded solar radiation data combined with standard TMY data files Data sets and reports TMY data sets based on Ground measurement data, or data modeled from ground meteorological stations An estimate of the confidence limits for local conditions. Technical reviews will be attached to the information in the database and available to support informed selection and use. In the case of existing maps externally funded, activity may end here. Status of existing information and plan for using it. List of data sets and information available for analysis. Results of data analysis and graphical output of selected data sets with inter-annual, monthly, and diurnal variations. High-resolution (1-km) annual average wind power maps and smaller area 5km wind maps with additional information. Report including summaries of salient wind characteristics (seasonal/monthly, diurnal, wind direction frequency, etc.) Summary of cross comparison in specific areas and modeling of channeled flow in some types of terrain		**Assumptions & Prerequisites** Availability of reliable ground data Availability of reliable ground data

1 Wind Resource Assessment 1.1 Review of existing surveys, methods and data. 1.2 Gathering of existing wind data (surface, upper-air, marine, etc.) and other required information (e.g. station description) 1.3 Processing of data and critical analysis to evaluate data quality and select best data for developing meteorological inputs to computer model. 1.4 Adjustment of surface observations for comparison to computer maps and development of time based information. 1.5 Generate wind maps (NREL model and KAMM for selected areas). 1.6 Prepare atlas information wind characteristics. 1.7 Cross comparison of computer models wind power and corrected surface data.	Technical reviews will be attached to the information in the database and available to support informed selection and use. In the case of existing maps externally funded, activity may end here. Status of existing information and plan for using it. List of data sets and information available for analysis. Results of data analysis and graphical output of selected data sets with inter-annual, monthly, and diurnal variations. High-resolution (1-km) annual average wind power maps and smaller area 5km wind maps with additional information. Report including summaries of salient wind characteristics (seasonal/monthly, diurnal, wind direction frequency, etc.) Summary of cross comparison in specific areas and modeling of channeled flow in some types of terrain	
Activities 3 Geographical Information System (GIS) 3.1 Develop Standard Data sets 3.2 GIS Tool kit development 3.3 National/ regional GIS activities 3.4 Establish Global Archive 4 National Applications of SWERA 4.1 Alternative development scenarios 4.2 Marketing and presentation 5 Management and coordination 5.1 Coordination 5.2 Meetings	***Deliverables*** A user-friendly geo-spatial analysis tool developed for broad use. Existing GIS information on communities, roads, electricity grids, load centres, and other geo-spatial land use digital data is identified that can be incorporated A multi layer GIS data set in ESRI Arc/Info software format Development scenarios, GHG emissions impacts A demonstration of the ability of the GIS tools in the national context. Report on global status of assessment and energy potential Communication and information exchange facilities will be set up through UNEP, INPE, and TERI These will include use of internet and regional meetings Combined training, information transfer and feedback meetings will be held	**Assumptions & Prerequisites** Availability of country-specific geospatial data that is suitable for GIS tools Information is readily available without significant effort.


Activities
2001
2002
2003
1 Solar Resource Assessment
1.1 Detailed review of existing solar radiation assessments (spatial an temporal resolution, validation studies, information product details)
1.2 Adapt methodologies to regional conditions and define additional analysis required for consistency with SWERA products.
1.3 Gather any additional solar radiation and other relevant meteorological data as needed.
1.4 Generate model-derived spatially gridded solar data (eg. Collector orientation, or type)
1.5 Generate time series data (Typical Meteorological Year, days of autonomy) using ground-based measured or modeled solar data.
1.6 Cross comparison of computer estimated solar radiation and ground measurements sites
2 Wind Resource Assessment
2.1 Review of existing surveys including methods and data.
2.2 Identify improvements to national assessment methods
2.3 Gathering of existing wind data (surface, upper-air, marine, etc.) and other required information (e.g. station description)
2.4 Processing of data and critical analysis to evaluate data quality and select best data for developing meteorological inputs to computer model.
2.5 Adjustment of surface observations for comparison to computer maps and development of time based information.
2.6 Generate wind maps (NREL model and KAMM for selected areas).
2.7 Analysis of salient wind characteristics.
2.8 Cross comparison of computer models wind power and corrected surface data

Activities	
3 Geographical Information System (GIS)	
3.1 Develop Standard Data sets	
3.2 GIS Tool kit development	
3.3 National/ regional GIS activities	
3.4 Establish Global Archive	
3 National SWERA Application for development potentials	
3.1 Alternative Ddevelopment scenarios	
3.2 Marketing and presentation	
4 Coordination and Management	
4.1 Coordination of project activities	
4.2 Meetings	



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September 4, 2000

Review and Evaluation of

Division for Technology, Industry and Economics (DTIE)
UNEP
GEF Solar and Wind Energy Resource Assessment (SWERA) Project

Project Summary and Evaluation Overview:

This is an ambitious project, designed to increase the knowledge base, and analytic and managerial capacity of both the international community and local governments to plan, implement, support, and evaluate the resources and cost effectiveness of the large-scale use of renewable energy systems. There are significant conceptual merits to this project, including: developing an international resource for renewable energy planning (and, critically, a standardized solar and wind data base); developing standardized assessment methods and project procedures; and expanding the range of trained national and international renewable energy experts.

The implementation of this plan as described in the current proposal, however, is less certain to benefit local and the international market for sustainable renewable energy technologies. In an ideal world, much of the plan and ideas presented in the project brief (SWERA PB8.doc & related documents) are promising and should be completed. Specifically, there is an obvious need and role for a global archive of wind and solar resources as well as system design software. This should be developed. The wider use of that information in developing local capacity (and international support) for renewable energy projects, however, requires additional planning, coordination, and – critically – international as well as local agreement and input.

The experience of the GEF and other national and international efforts in a number of areas needs to be strengthened. The use of software tools to facilitate local decision-making (as a historical example, the LEAP software) needs to be designed with an expanded round of inputs

from prospective users, and recipients of the resulting planning decisions. A range of management options and resources for hardware and vendor/installer certification programs would benefit from expanded levels of local input to avoid some of the mistakes of the past (see, e.g. Foley, 1995; Maboyi, 1995; and Kammen, 1999). That does not mean that with continuing evolution and self-examination that they can not improve, but that the degree of critical review of past projects has not *as yet*, been sufficient to suggest that this project will be of maximum benefit the intended beneficiaries. A variety of study, testing, and local consulting and partnership components are needed first.

In the body of this review I will highlight and comment on these strengths and weaknesses, and illustrate the actions that could be taken to build the foundation of national and international renewable energy infrastructure so that this sort of project would significantly develop and support emerging clean energy industries. In summary, I recommend a process that will involve added, and more diverse, input from the emerging private sector that will implement many of the renewable energy industries, and greater voice and direct involvement of intended recipient groups. These features could be institutionalized to foster added channels and mechanism for local input and response can be developed. It is important not to move forward unless the need for expanded local capacity and input can be addressed. Documents such as the GEF report, the *Thematic Review of the GEF Solar PV Portfolio: Emerging Experience and Lessons*, by Eric Martinot, Ramesh Ramankutty and Frank Rittner, illustrate the need for this wider process of external input, review, and management of the mapping and policy planning process. In light of these concerns, the Annex on ***Incremental Capacity Building*** is insufficient.

As one of many interested observers of the process of support and development of multinational renewable energy projects, I would be willing to draft a more complete plan for the sort of local-global dialog that is needed for greater responsiveness to meet specific development challenges with clean energy systems.

General Comments:

A particularly promising aspect of this project is both the range of nations and the number of program offices and organizations that will be consulted and involved in project planning. While this can become operationally challenging, it remains a key aspect of developing sustainable institutions to support renewable energy industries.

The comments in this review include, but are not limited to the specifics of the solar and wind energy resource assessment, evaluation, and analysis. This is a necessary analysis of the broader context for such a project. The motivation for this is stated in the project brief (Paragraph 3), which notes that the commitment of resources and planning activities surrounding energy resource assessment can influence policy and national planning.

A number of specific recommendations for action prior to implementation of the SWERA project include:

Further analysis and input regarding the benefits, and concerns, surrounding, international programs such as the Photovoltaic Market Transformation Initiative (PVMTI) as a means to

build local market capacity. While the basic mechanism of market transformation remains a critical tool in the development of local clean energy markets (Duke and Kammen, 1999), unanswered concerns regarding both local implementation and the involvement of local businesses do exist. An analysis of the best ways to support local market development would be an appropriate first step. This should include both a commissioned report and an open series of discussions that involve diverse groups (public and private sector, and aspects of civil society, such as Non-Governmental Organizations and local village cooperatives) interested in renewable energy markets and technologies.

Evaluation of the mix of grid, stand-alone, and non-electric resources that would most benefit local development should be undertaken. Software tools, such as HOMER, can be invaluable in assessing local energy resources and the cost-effectiveness of various energy systems. At the same time, many such tools place a particularly strong emphasis on single-mode (electrification) planning. There are wide range of energy applications – such as mechanical water pumping, solar thermal applications – that can cost-effectively serve local needs. Models such as HOMER need to include these options for energy and financial resource allocation to best serve local needs.

The project brief calls for efforts to build investor interest in renewable energy industries, which is critical for long-term market development. This needs to be supported by sufficient levels of local training and review of both the technical and social/managerial systems to benefit end users. One means to accomplish this is to develop independent review and advising networks and organizations that can comment on the SWERA projects, and on the changes that will likely take place in local energy markets. One example of this has been the review of the evolution of the Kenyan photovoltaic market. In that work an interdisciplinary group looked at both equipment issues (in particular the use of amorphous versus crystalline photovoltaic panels, as well as battery performance) and the interaction of vendors and end users (Duke and Kammen, 2000; Duke, *et al*, 2000; Jacobson , *et al*, 2000a,b).

Too much of the technical analysis, mapping, and resource evaluation to take place in this project appears to be scheduled for completion by the international partners, notably NREL and Risø. While the expertise of both organizations is important in model development and use, a far higher percentage of project resources (both human and financial) could and should be devoted to developing and training, and transferring, these capacities to local groups beyond the government partners identified for each national team. These organizations – both governmental and non-governmental, could then take a lead role in performing the analysis.

The budget, incremental cost annex, and budget particulars are satisfactory given the contents of Project Draft 8. As outlined in this review, however, a great deal of further refinement of this projects is recommended, which will greatly alter this budget.

Specific Comments:

Page 1:
Developing these resource assessment and implementation capacities in Cuba is an excellent goal, and should be supported.

Paragraph 4:
There is no question that the development of reliable and freely accessible renewable energy resource maps are a key resource for project planning and evaluation. Construction of this data-base can address both local development issues, national energy concerns, and global environmental concerns. This aspect of the project should take place. At the same time, it is important to evaluate and incorporate a greater range of local perspectives and inputs on what sort of systems would prove useful to meet local energy and development concerns.

Paragraph 6 – 12 and ff:
While it is true that very few pyranometer and other official solar and wind resource stations exist in developing nations, a growing number of non-governmental organizations are able to perform these measurements and make use of the results (Kammen, 1999). A useful step would be to support the growth of such a resource monitoring *and evaluation* network. There are obvious benefits to doing this in terms of supporting local capacity development. The GIS capacity is also one that can be diversified, which will benefit both the growth of the global data base, and the involvement of local organizations. The network of agencies discussed at the end of Paragraph 12 for this networking, for example, is excessively focused on official institutions.

Paragraph 13:
The proposed Steering Committee, is excessively focused on official organizations that often agree in advance on priority that various tasks should receive. This body needs to be diversified.

The call for the Regional Agency (Paragraph 15) to support local capacity building needs to both reflect the wider set of stakeholders (as discussed above), and to explicitly support capacity building in groups that extend *beyond* federal and state organizations. There is a consistent theme, and worry, that the processes involved in building this resource mapping capacity will remain focused on the set of goals enumerated by the international team (e.g. NREL and Risø), and their partner organizations and individuals within the local governments. A crucial example of the interplay between resource mapping activities, and renewable energy planning appears in Paragraph 17 (**ACTIVITY COMPONENT 2: SOLAR RESOURCE ASSESSMENT**). Little distinction appears between resource mapping and project planning activities. While many of the individuals involved in one phase will be involved in the other (see, for example, the Annex for Technical Information), critical questions of development priorities, local needs versus state and international interests, should at this point benefit from a far wider form of public, private, and state involvement, interaction, and evaluation.

Paragraph 17:
After Paragraph 17 the numbering system jumps from 17 to 31, and then paragraphs are interspersed out of clear order thereafter.

Paragraph 52:
Access to the solar and wind resources is ambiguous. The project results, as they are developed, should be placed on open access www sites. This data should not be limited in release for either government offices, or for participating nations alone. Large-scale growth in clean energy

markets can be supported by making this material easily and freely available. As written in the project draft, the control of access to this information is both highly limited and highly troubling.

Paragraph 58 ff (Activity 4.2):
Again, the need for greater local involvement, *and control* over the development of technical tools is apparent. This process needs to be one designed to both transfer expertise, and to support local technical and managerial capacity and control. At present, the document suggests too great a degree of project design, and implementation by the international organizations that while well skilled to develop the software and other project components, can not themselves build sustainable local energy industries. Greater, earlier, input and buy-in by not only governmental organizations but also the private sector and civil society in the recipient nations is needed.

Paragraph 67-68:
Design, planning, and implementation of the case studies should be determined and implemented by local organizations.

Paragraphs 72 – 75:
The level of local control over the project is left unclear. Certainly governmental involvement from at least some of the host countries is specified (e.g. China). A wider process of meaningful participation and control is needed. No indication exists that the problems of the Zimbabwe GEF project, or the PVMTI process, will not be present in the current project.

Paragraph 78
'of' is repeated in line 1.

Paragraph 80:
The Annex on ***Incremental Capacity Building*** is insufficient.

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Annex C1 Response to STAP Roster Review

The reviewer correctly identifies the broader capacity building and stakeholder consultations that are needed to achieve wider spread adoption of energy planning tools.

This project only proposes to develop resource information that will be needed and as well build and exercise the core tools for energy analysis. Output to a standardised data format will allow the expansion of tool development that will ultimately see the achievement of broadly utilised science based decision making. The specfic project outputs do not promise broad applicability.

The project will provide a simple spreadsheet output facility that can be adapted or converted to appropriate inputs to common software such as HOMER or RETScreen.

Response to Specific Comments

Paragraph 4:

Local stakeholder meetings will be included in the nationally executed activities to achieve local consensus on development needs.

Paragraph 6-12 and ff

Local non-governmental institutions will be included in the local networks especially where they have data and skills to offer.

Steering Committee:
The steering committee is intended to function by conference calls and through electronic media. The project will include of additional country representatives.

Para 15

According to upstream guidance from the GEF the project will seek associated projects and opportunities through the UNEP/DTIE technology transfer clearing house to accomplish broader capacity building and stakeholder involvement.

PROJECT REVIEW SHEET

WORK PROGRAM INCLUSION - UNEP CLIMATE CHANGE

Project Title: " **Solar and Wind Energy Resource Assessment** "
DATE: SEPTEMBER 5, 2000

	Work Program Inclusion per criteria	*Reference Paragraphs and Explanatory Notes:*
1. Country Ownership		
• Country Eligibility		• Countries are eligible under paragraph 9b of the GEF Instrument and have all ratified the UNFCCC.
• Country Drivenness	Clear description of Project' s fit within: • National reports/communications to Conventions • National or sector development plans. • Recommendations of appropriate regional intergovernmental meetings or agreements.	OP6 removing barriers and promoting the use of renewable energy See SWERA baselines document
• Endorsement	• Endorsement by national operational focal points	• Endorsements for China, Nepal, Bangladesh, Sri Lanka, and Ghana are attached • Letters of endorsement from officials other than FPs have been received for Nicaragua, Guatemala, Honduras, and El Salvador are also attached and endorsement is anticipated. • Letter indicating probable endorsement attached from Brazil • The others are expected to endorse based on other interaction. The final Project Brief has been forwarded to these countries.
2. Program & Policy Conformity		
• Program Designation & Conformity	Describe how project objectives are consistent with Operational Program objectives or operational criteria	• Baseline Activities para 4, 5. • Log Frame Annex

	Work Program Inclusion per criteria	*Reference Paragraphs and Explanatory Notes:*
• Project Design	Describe: • Sector issues, root causes, threats, barriers etc affecting global environment • Project logical framework, including a consistent strategy, goals, objectives, outputs inputs/activities, measurable performance indicators, risks and assumptions • Detailed description of goals, objectives, outputs and related assumptions, risks and performance indicators • Brief description of project activities, including an explanation how the activities would result in project outputs (in no more than 2 pages) • Global environmental benefits of the project. • Incremental cost estimation based on the project logical framework • Describe project outputs (and related activities & costs) that result in global environmental benefits • Describe project outputs (and related activities & costs) that result in national environmental benefits • Describe the process used to jointly estimate incremental cost with in-country project partner • Present the incremental cost estimate. If presented as a range, then a brief explanation of the challenges and constraints and how these would be addressed by the time of CEO endorsement.	• A detailed logical framework is included as Annex B. • Activities are described in paras 13 to 71 • Expected results are shown with each activity. • Rationale and objectives para 8-12 for golas,objectives, outputs • Risks and assumptions are in Para 76-79 • Annex SWERA benefits provides an incremental cost of GHG emissions from resource assessment • Logical Framework shows outputs leading to broader outcomes as indicated by external actions. • National preparedness for shorter term climate fluctuations • Bottom up analysis of typical facilities and office space that would be expected in developing country agencies • Para 74 – regarding discussion of incremental costs • Note that some of the activities of the collaborating agencies are being diverted to support the objectives of this project. This parallel financing is considered part of the alternative and not the baseline as the impact in developing countries would not exist without the project.
• Sustainability (including financial sustainability)	Describe proposed approach to address factors influencing sustainability, within and/or outside the project to deal with these factors	Incremental Capacity building in assessment is discussed in para 84 and an Annex.
• Replicability	Describe the proposed approach to replication (for e.g. dissemination of lessons, training workshops, information exchange, national and regional forum etc.) (could be within project description)	Information exchange and the establishment of national regional agencies with assessment skills will provide replicability. Not withstanding this, brad scale capacity building and technical assistance for specific site investments is not part of this project. Para 64, 77
• Stakeholder Involvement	• Describe how stakeholders have been involved in project development • Describe the approach for stakeholder	• Three regional meetings were held to discuss the project with potential national collaborators para 73., and available meeting reports

	Work Program Inclusion per criteria	*Reference Paragraphs and Explanatory Notes:*
	involvement in further project development and implementation	• Web based information exchange and meetings are planned to support further interaction.
• Monitoring & Evaluation	• Describe how project design has incorporated lessons from similar projects in the past • Describe approach for project M&E system, based on the project logical framework, including the following elements: • Specifications of indicators for objectives and outputs, including alternate benchmarks, and means of measurement. • Outline organisational arrangement for implementing M&E • Indicative total cost of M&E (may be reflected in total project cost).	• The project does not propose to support baseline meteorological measurement activities nor execute preinvestment activities for individual sites, rather the project seeks to complement and accelerate these activities by offering maps generated using upper air and satellite data and validated with existing ground measurements where possible • Ongoing project management will be accomplished by a project manager and supplemented by the technical collaborating agencies and the regional agencies in South Asia and Latin America. • Stakeholder and Implementation Arrangements para 72-76 • Executing agency costs are included in the Project Management • An increment of 36,000 is requested in the fee. M&E is a major task of the executing agencies.
3. Financing		
• Financing Plan	• Estimate total project cost. • Estimate contribution by financing partners. • Propose type of financing instrument	• Total project cost: 9.020 see cover page and financing section • Cofinancing: 2.508 • Grant
Implementing Agency Fees	Propose IA fee	• 504,367 including additional effort in Global project development (three regional meetings and 53 countries) and increased costs in monitoring and evaluating 10-13 countries in 6 regions.
• Cost-effectiveness	• Estimate cost effectiveness, if feasible • Describe alternate project approaches considered and discarded	• Subject to the risk that countries will not form effective regional links, regional agencies assisting smaller countries is expected to be highly cost effective • While maintaining the information barrier removal objective during the project timeframe and using the steering committee' s advice, developing country capacity building will be maximised as in the diversion of solar mapping activities to INPE and TERI.
4. Institutional Coordination & Support		
IA Coordination and Support • Core commitments & Linkages	Describe how the proposed project is located within the IA' s • Country regional/global/sector programs • GEF activities with potential influence on the proposed project (design & implementation)	• UNEP' s role in global assessments and tool developmentStakeholder and Implementation Arrangements •
• Consultation, Coordination and Collaboration between IAs, and IAs and EAs, if appropriate.	• Describe how the proposed project relates to activities of other IAs and 4 RDBs in the country/region. • Describe planned/agreed coordination, collaboration between IAs in project implementation.	• The Ias and RDBs were invited to the regional meetings and to the project start off meeting in Washington. Although some interest was expressed in the project, no commitment to particpate was established. UNDP and the WB will be invited to participate in the steering committee. Para 13

	Work Program Inclusion per criteria	*Reference Paragraphs and Explanatory Notes:*
5. Response to Reviews		
Council	Respond to Council comments at pipeline entry	
Convention Secretariat	Respond to comments from Convention Secretariat.	
GEF Secretariat	Respond to comments from GEFSEC on draft project brief.	
Other IAs and 4 RDBs	Respond to comments from other IAs, 4RDBss on draft project brief.	
STAP	Respond to comments by STAP at work program inclusion.	
Review by expert from STAP Roster	Respond to review by expert from STAP roster	