Project Ladakh – photovoltaic in foreign countries
modular PV-hybrid AC-system for the Himalayan region in India
renewable energies for decentralised energy supply

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A complete infrastructure concept on a basis of renewable energies for a sustainable economy in
decentralised rural regions. An example for a complete supply and disposal system for an
improvement of the extreme living conditions in a little community in 3.500 m over sea level.

1. Introduction
Complete infrastructure systems in foreign countries have achieved new dimensions with today's
development standards. New concepts like project Ladakh have to consider sustainability,
improved eco efficiency and renewable energies, that the independence and the self-respect of the
people will be strengthened.

A lasting economy offers its services in countries with a bad or missing infrastructure as a solution
trial. Engineering and environment technologies can show their best degree of effectiveness and
already avoid made faults.

2. Objective target
A sustainable economy concentrates even in the planning phase on the saving of resources and its
efficient use and the gradual know-how transfer. It is also connected with exporting knowledge,
responsibility and also jobs.

Through this we achieve improvement in the conditions of life through this and we strengthen the
self-responsibility and the peace readiness.

Only the “modular PV hybrid AC system” which is
described below in detail made our complete
infrastructure system possible in the project Ladakh.
The Sunny Island is a real enrichment for
decentralised village power supplies in foreign
countries with his flexibility and his good-natured
robust performance. It will last for years until other
companies based on the idea of Prof. Jürgen Schmid
(given a lecture in Barcelona 1997) once again will
invest so many know-how and thinking work like

SMA with the team around Dr. Burger.

Our description shows the positive experiences, extensibilities, electrification in rural areas, the
international cooperation and the improvement of the living conditions of the target group in a
social centre with 450 inhabitants. Project Ladakh is supported by the BMZ – Bundesministerium
für Zusammenarbeit and the W.P.Schmitz-Stiftung.
3. Ladakh and the Mahabodhi International Meditation Centre - MIMC

Ladakh is situated in the most northern India in the utmost west of the Himalayan mountains in 3,500 m over sea level at the edge of the crises area Jammu-Kashmir. The living conditions in this region are extremely hard. Temperatures of –30°C during winter and impassable passes from September till May make the life in this area, characterized by stones and sand, the survival fight.

The intensive solidarity of the Ladakhies to nature and their thinking with the sun is negatively influenced by the tourism during the summer months. With this project it is tried to strengthen the traditional knowledge about the use of natural resources. This should be possible because the Ladakhies long for winter months when the tourists and traders leave the country and the nature gets the possibility for regeneration.

In 1986 Venerable Bhikkhu Sanghasena established the social centre with friends and on behalf of a Buddhist teacher and is the spiritual leader of it. MIMC is a NGO (non-governmental organisation), on the base of non-profit-making and will be financed mostly by donations and sponsorships. Up to now projects like a school with a girls’ and boys’ hostel, an old age home, a public library, a nunnery, a meditation centre and a hospital free of charge have been established.

The targets of MIMC are:

- Education free of charge for children of poor families.
- The passing of the ecological appreciation of nature.
- To learn dealing under hard conditions of life.
- Care and worry for ill and old people as well as for penniless.
- Education of Buddhist nuns for a life in village and religious sects.

4. Project description

The concept concentrates on the development and the improvement of the infrastructure of the MIMC so that an efficient administration of the complete complex and the communication between the different areas gets possible. A broad room passes straight at this project for the application of renewable energies in an integral solution trial in form of a hybrid system.

Integrally should not be seen here only as a headword. Also the complete infrastructure must be coordinated with each other and overlap an optimum to reach to environmental efficiency. This approach creates the appreciation from view of an old tradition for the use of natural resources how it also is justified in the religion of the Buddhism. And just here Petra Schweitzer-Ries showed that projects in this way are doomed to failure without a socio-economic master control program. But the owner must also be willing to learn how to deal with this system. Therefore native assistants are trained to operate the systems.
The project includes:

- Installation of an electric supply, consisting of photovoltaic and the use of energy saving consumers, as far as they are available in the country.
- Installation of solar collector systems for the supply of the buildings with warm water and heating for bedrooms and living rooms with simplified wall heating systems.
- Improvement of the insulation of the buildings with material of the region, as well as the use of the passive sun warmth of glass facade set in simple form.
- Installation of pump stations to improve the water supply, installation of an artificial irrigation for the re-cultivated areas and for the reforestation as soil- and erosion protection, as well as a future source of income for roof beams and roof covers.
- Water analysis and sustained cleaning of the water supply plants to improve the quality of drinking water and reduction of the harmful ingredients.
- Training of local workers for the distribution of renewable energies in the region.
- Improvement of the communication system and installation of a monitoring system for the fast and effective remedying of disturbance by local craftsmen.

5. Initial situation
5.1 climatic initial situation
The complete energy concept is based on the high solar irradiation and the extreme height of the Himalayas in 3,500 m. Ladakh has only 5 rainy days per year and the offered solar energy is 50 % therefore higher than in Europe, a very famous place to realise projects with renewable energies.
- Temperatures between +35°C in summer and –30°C in winter
- 115 mm rain and snow per year and approx. 360 sunny days
- 1.550 kWh/m².year solar irradiation but only 3 % disposability of wind/year
- Impassable passes from September till May

5.2 Situation of the public energy supply
The present situation of the energy supply by the public grid is completely insufficient. The availability of the public grid decreased from 24,8 % in 1998 to 12 % in 2001 and picked back up to 16 % in 2002. During the winter month the energy supply decreases to nearly zero. If energy is available or not, the customer still has to pay a fixed flat rate.

The reasons for the insufficient energy supply are:
- The Indus water power plant works only during the summer month and only every second year. In winter the Indus is frozen and every second summer the 50 km long canal has to be cleaned from mud, sand and other contaminations. The running costs for this are too high.
- A degree of effectiveness loss in diesel generators of more than 30 % results for the height in 3,500 m. The air pollution is approx. 50 % worse, the running costs are higher and the life expectancy of diesel generators is shorter than in lower situated regions.
- The whole demand of diesel for the diesel power plants in Ladakh is delivered from the south of India and causes high transport costs. Inclusive an Indian support of the Diesel price the energy costs for diesel generators are 70,-- Rs/kWh resp. 1,50 Euro/kWh.
6. Supply concept and scientific innovations

6.1 Electric supply concept

The heart of the systems is the bi-directional inverter Sunny Island from SMA with an energy management. The inverter works according to the principle of a modular PV-hybrid AC-system with special parameters for the electrification in rural regions. Important for the photovoltaic system is also the cooperation of RWE SCHOTT Solar with the Indian company TITAN – Energy Systems-Ltd. Because of this cooperation it is possible to get Indian modules with European standard.

Difficulties which have to be considered in the concept:
- The input voltage of the energy sources (public grid, diesel generator of the hospital, etc.) ranges from 180 to 260 VAC
- The frequency of the energy sources ranges between 43 and 56 Hz.
- Over voltages up to 400 VAC are possible. Selective over-voltage protectors are installed to protect the consumers against the bad quality of the public grid.
- In our first winter we have experienced, that above ground lying pipes were dismantled and therefore there was no connection to the earthing points for the over voltage protectors. So we lost many over voltage protectors till this unexpected fault was found.
- The Sunny Island, which was connected to the grid, copes with all these different situations. In case of an over voltage of 400 VAC the Sunny Island switches off and protects in this way the connected consumers.

6.2 The modular PV hybrid AC system with SMA-Sunny Island

The electricity supply of decentral consumers, who cannot be connected to an existing electrical grid or for where only an instable grid is available, is essential allover the world.

The decentral energy supply systems based on renewable energies consist of modular elements and provide a wide range of possible combinations. Reliable decentral energy supply systems can easily be designed and maintained by means of modular AC supply units. The necessary components (PV-plant, wind and water generators, battery bank etc.) can be integrated in form of modules and allow numerous variation possibilities with our standard components, such as Sunny Island, Sunny Boy and Sunny Boy Control. This results in an energy supply system that exactly fits your individual requirements.

The battery inverter Sunny Island is the central component of such a modular energy supply. Due to the Sunny Island with a power of 4.5 kW and its excellent product features a robust and reliable device for a variety of applications is available. The modular design of this island component and the connection of further components, such as PV inverters or generators on the AC voltage side, allows a simple and uncomplicated upgradeability with low costs.

The advanced battery inverter Sunny Island is the grid master of a modular power supply system and enables small scale island utilities for remote areas. Island grids based on the Sunny Island are uncomplicated to plan and to install and allow a very flexible operation.
Figure 1: Main component of a PV Hybrid AC System, battery inverter Sunny Island 4500

The device includes an intelligent island management which is able to supply different consumers and feed power from different generators. Such generators are e.g. PV-String Inverters for grid supply, small wind energy plants or diesel units, making the battery inverter operate in all four quadrants.

The system management handles battery management, enables a simple load management and provides communication interfaces for optional system management units. The required operating modes and parallel switching of current converters can be realized. A simple single-phase island grid can be established by a battery inverter and a lead acid battery.

The new power of the battery inverter Sunny Island 4500 in detail:

- Bidirectional topology with electrical separation of DC and AC voltage side
- Battery voltage for 48 V and 60 V DC
- Increased continuous AC output power (4500 W at 25°C, P30)
- Can be connected on parallel in 1 - and 3 phases, up to practically every system size
- Genuine parallel operation with generator and grid (power of generator and Sunny Island are additionally available in case of overload)
- Three-phase overload management, starting of critical loads by soft start (decrease of AC voltage)
- Load-dependent switching of generator and relay contacts (load management)
- Energy-saving mode in case of reduced states of charge (disconnection of Sunny Island is configurable)
- Team concept in case of Sunny Islands connected in parallel (much better efficiency in case of partial load and decreased idle losses)
- Synchronized connection and disconnection of generator and/or grid (uninterrupted)
- Virtual uninterrupted supply of loads even in the case of grid or generator failure (short interruption < 20 ms)
- Load management with up to 8 freely configurable relay output ports
- Use of the relay contacts also in the case of the slaves (battery state dependent)
- Timer display for generator control
- Interface for 3-phase operation, communication and service
- Display of the state of charge with a measuring error < 10%
Sunny Island System Kit
With the new Sunny Island System Kit we offer customized complete solutions for your application.

Figure 2: Photovoltaic Off-Grid Electricity Supply with Sunny Island System Kit (1-phase)

Figure 3: Photovoltaic Hybrid Electricity Supply with Sunny Island System Kit (3-phase)
We assembled four basic packages with different upgrade possibilities in order to support you with simple and reliable planning and design of off-grid supply systems. Each package has a modular design and contains a battery bank and/or a generator, where applicable.

The components are tested and selected for a reliable and long-lasting use. An installation guide with all schematics and wiring instructions and the factory preset configuration results in a fast “plug & play” installation on your site.

One important advantage of the modular island grid is that the basic packages can be upgraded, remotely controlled and monitored all depending on the requirements. This makes your system a reliable electricity supply for the future. Based on our experience resulting from many years right on the field of de-central energy supply, we can offer you an easy entry into the electricity supply for off-grid applications with durable solutions since 1981.

Your Advantages if using System Kits are:

**Planning and commissioning**
- Simple design and planning with AC components (grid products)
- Simple connection of additional suppliers due to the AC coupling
- Modular design allows simple and affordable upgrades

**Operation**
- Renewable energy is primarily used directly
- Load dependent connection and disconnection of generators
- Generator support by Sunny Island (additional power)
- Connection of grid-forming elements (1-phase, 3-phase), such as generators or the public utility (utility backup function)
- Power derating of Sunny Boys in case of fully charged battery (battery protection)
- Power increase by “parallel operation” of 1-phase or 3-phase Island grids
- Connection of loads depending on the detected battery state
- Integrated battery, energy and load management for reliable operation and protection of battery
- Energy saving mode in case of low battery states

**Configuration**
- User-friendly and comfortable menu system for configuration
- Display of plant status and energy flow
- Simple adjustment of the system parameters according to the plant conditions

**Plant Control**
- Use of data logger Sunny Boy Control and software Sunny Data Control for the display of system values and plant monitoring
- Comfortable diagnosis for maintenance and remote access

**Service**
- Support concerning plant design and selection of components
- Preparation of planning and commissioning instructions
- Assembly of complete island solutions
- Pre-configuration of Sunny Island for customized plants
- Training of planners and electricians
- World-wide exchange service directly by SMA
6.3 Concept of thermal energy
For the heating system thermal collectors, storage tanks, heat exchangers and wall heating systems have been installed, which have increased the temperature in the rooms from 0°C to 13°C in Winter 2001/2002. With the people in MIMC the room temperature of 13°C in the bedrooms and living rooms of the buildings has been agreed, as this will be a very comfortable room temperature for the Ladakhies referring of an outside temperature of −30°C in the coldest winter month.

- In India radiators for heating systems are unknown, due to the fact that in the southern parts of India heating systems are not necessary. Indian heating systems work as an open system which is not suitable for the winter time in Ladakh.
- Therefore the idea was created to install simplified wall heating systems in Ladakh which have been developed in Europe. One of the first steps of our training of the assistants was to produce wall heating systems. This training has been realised successfully. Ladakhie companies have already ordered wall heating elements from our assistants.
- The production of these systems is possible with simple tools and can be done without difficulties. The wall heating system will be plastered with a loam layer and are therefore like a modern biological low temperature heating.

- In the district capital of Ladakh we also supported a steel construction company with the production of steel storage tanks and showed them a very simple system to test the tanks for leaks.
- The result - one 6.000 l and seven 1.500 l storage tanks were ready, tested and installed in the different buildings of the social centre of MIMC.
- A positive side-effect is, that the tank producer will take over our testing system for all oil tanks and because of that oil losses and environmental pollution would be avoided.

6.4 Drinking water supply
The water from the drill wholes and pipes have been analysed since summer 2002 periodically. The water quality in the drill wholes is looking good, at the taps the water is polluted with E.coli bacteria, pseudomonads (pathogen bacteria) and fungis. As an immediate measure the tanks have to be cleaned regularly, so that an effective improvement of the drinking water quality can be obtained. The analysis have been discussed with the persons in charge.

6.4 Adaption of buildings
- In Ladakh roofs have a construction of poplar steams and of a netting of twigs. These are insulated with yak grass and sealed with loam. This roof construction can not be weighted and therefore concrete straps calculated statically had to be poured above the load-bearing walls.
- The large span width between the concrete straps is bridged with a flexible mounting system which was developed especially with fischer fixing systems, Tumlingen, for projects in foreign countries.
- The SamonTec-System can be used for photovoltaic systems, for thermal collector systems as well as for mounting of system components.

7. Next building steps
50 % of the project was done in the year 2001 and 2002. But there was a delay in time due to the conflict India-Pakistan. The future tasks for the project will be the installation of a waste water treatment and a waste disposal.

- The waste, especially the one of the hospital is a great danger for the water reservoirs of the social centre.
- The waste which will be produced by western packing material and by tourists is a lot of overload capacity and an optical pollution for the residential areas.
- To refuse disposal, a little incineration plant will be installed in 2004, which will burn the waste of the hospital without danger. At the same time the waste caused by the tourists will be reduced and changed into warmth.
- 2003 is also the date where the „green house“ will be build. In this building the biological waste water treatment and the composting will be placed. With this the basis for re-cultivation will be created. All systems of the green house will be done in that way, so that composting and waste water cleaning is also possible during the winter month.
- The composting uses the passive solar irradiation and is the basis for a further refinement of the gained soil in hill patches with branches. The hill patch will be used at the same time as bio filters for the exhaust air from the sewage plant. The biological degradation phase is attached to the Ramolhaus (Tyrol) with the experiences from a 5-year test operation in 3,000 m of sea height for 3 years.
- The hill patches in the upper floor allow a vegetable gardening during the extreme winter month. The compost will be mixed with top soil and therefore refined. After one year the compost can be deployed.
- The buffer- and aeration tanks for the biological waste water treatment are integrated to the foundations of the green house and are thermal insulated. 80 % of the system can be done by the constructors on-site. Only the ventilating aggregates are parts of supply. 50 % of the tank will not be used during winter and will serve for an energy storage in this time. Therefore it is warranted that the necessary climate for the micro organism can be hold up with tempered air.
- The plant cleaning system which is integrated in the green house serves as a final sedimentation before the cleaned water will be used for irrigation of the afforested areas.

8. Training program

- Two assistants are trained over four years. After the third year the two assistants will have to do an exam, in the fourth year their knowledge will be deepened.
- The target of the training is, that the assistants will be able to install little photovoltaic systems and thermal collector systems in Ladakh after their training. So in this way the running costs for the complete infrastructure system can be earned.
The success with the training of the first two years as an apprentice are quite respectable. The assistants already are able to install little solar home systems with photovoltaic and to produce wall heating elements for thermal collector systems, which earned a great approval outside of MIMC.

9. Basic approach for a socio economic bey master control program

- Different views and opinions have not always been solved in discussions. We have noticed considerable weak points. As a remedy we tried to develop a socio economic bey master control program, which makes a support service during the whole year possible. The former president of the association „Projekt Ladakh“, Bahwani Shanker, made it possible, that young people who would like to spend their 14-month alternative service abroad can do it in the social centre of MIMC. They have been integrated in the support service. Both – Verena and Oswald – were godsend and should be honoured in a special way for their help in this project. The success of the project is connected directly with the socio-economic master control program. Although this task is so important for technical projects, the costs of these programs can hardly be cashed up with the projects. The solution with the civilian servants was a great help here.

- Additional to their main tasks – care for children, old and ill people – the management of the MIMC charged them to supervise the solar systems.

- The untiring helpers trained the assistants during the whole year according to an agreed course of instruction. They can also adapt the program anytime to the demands and weak points in the basis training.

- But also very important is the self-sacrifice of these highly motivated people for the inhabitants of the social centre. Over the whole year the inhabitants have had the possibility to ask for the optimal handling with the new infrastructure and the new energies. As a main focus in 2004 the training for all inhabitants and members of the administration will be prepared.

- These brownies (Oswald and Verena) will help the MIMC the whole year, also during the extremely hard winter time. They are in contact with the planning office and depict the circumstances of life also in extreme situations, which can only be realised from the planning office after the end of project by the monitoring system. New aspects in planning will flow into the project.

- Besides deep human impressions from the loving tradition of the Ladakhies, the young people take out a new knowledge about renewable energies, recycling management, lasting use of natural resources and education experiences for their further life.
10. Conclusion
During the summer 2001 and 2002 in the month July and August the first steps have been carried out to realise the project. In this time we collected a lot of experiences in India and learned to deal with the special characteristics of this country. In principle, a positive balance can be drawn after these first installation steps. Delivery problems have not been solved, but we found ways to improve the situation. Simple methods for a modern technique and tests have been innovated. Most parts of the material can be delivered by Indian companies. For further steps more improvements can be reached. The training is successful and hope that in the future more improvements can be reached.

As a consequence of the practical use of the modular PV hybrid AC system in foreign countries we can see, that planning, installation, operating and maintenance of these systems will be more simple and cheaper. The system ensures flexibility and allows many applications.

Project Ladakh with all its' creative ideas shows, that environmental systems are possible in extreme high mountain regions as well as in other parts of the world. They are helpful for better living conditions, for improving the quality of life and protecting of nature.

Technical data
Electric energy from photovoltaic

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Thermal energy from collectors

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