Berichte aus der Energietechnik

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Development of Sustainable Energy and Water Supply Systems for Off-Grid Remote Communities in Arid Regions

Case Study: New Kalabsha Village in Lake Nasser Region, Egypt

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Abstract

This thesis has an interdisciplinary nature and deals with sustainable rural development in arid regions. The main focus of this work is the improvement of energy and water supply and use and the development of a sustainable energy supply system.

Absence of convenient energy supply and inefficient water supply and use were identified to be the core problems in remote and off-grid rural regions. Accordingly, the objectives of this work were designed to satisfy the energy and water needs by exploiting the local natural resources in sustainable manners, i.e. employing renewable energy resources instead of fossil fuels for power generation and developing adequate techniques for water use. Comparative analysis was employed as a tool for decision-making, e.g. for the selection of the energy supply system, the water transport technique and the energy system components. A new established village (New Kalabsha Village) in the Lake Nasser Region in Upper-Egypt, was selected as a representative case study.

Concepts to transport water for irrigation purposes have been developed in this work based on ensuring the enhancement of energy savings and the reduction of water losses. Consequently, the option of transporting water through optimised open channels from surface water source to the acreage plots has been proved to be more adequate for the target region than transportation by pipes, due to energy and cost saving aspects.

An efficient energy conversion system with a total capacity of 2,184 kWp was planned to satisfy the entire energy needs for village households and water pumping. This system is based solely on photovoltaic (PV) technology with a gensets backup in case of emergency.

In addition to proving the economic competitiveness of the PV system compared to conventional rural energy systems in the arid regions, this work proved that the designed PV energy system has excellent energy yield despite of very high temperatures; the electricity yield per installed capacity of PV per year is about 1,862 $kWh \cdot kW_p^{-1} \cdot a^{-1}$. The proposed energy supply system can provide electricity for 0.13 $€ \cdot kWh^{-1}$, which is cheaper than conventional genset electricity at real prices.

Furthermore, this thesis addresses the planning, the realisation, the implementation, and the operation and maintenance aspects of the energy system. An analysis of potential stakeholders of the energy project was performed and resulted in producing a matrix of representative of organisations and individual experts including their interests. This matrix establishes the institutional framework to regulate the relationships and interactions between the various actors in the project. Additionally, options to finance the energy project and to develop correlated pricing schemes are introduced in the work.