Increasing energy efficiency at the Charles Darwin Research Station on the Galapagos Islands

Identification of electricity saving potentials and recommendation of energy efficiency measures

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THE COMPANY: *short information*

I conducted my second study project at the Charles Darwin Station in Puerto Ayora in Galapaogs, a world-wide known international scientific non-profit research facility for biological and evolutionary research. The organization was founded 1959 under Belgian Law with the help of IUCN, UNESCO and a team of worldwide conservationists. The CDF's research station in Puerto Ayora on the island of Santa Cruz was opened in 1965. Through scientific research, the organization provides knowledge and assistance to the government in order to ensure conservation of the environment and biodiversity in the archipelago. The research at the station aims at generating a deeper understanding of the unique ecosystem and the environmental impacts from humans as well as the interactions of endemic species with humans or invasive species in order to understand how the ecosystem can be protected best. For fifty years, the CDF has worked closely with the Galapagos National Park Directorate responsible for the protection of the islands' natural resources and for providing results of scientific research. Over one hundred scientists, educators, research assistants, support staff and volunteers from all over the world are working at the station to take part in this effort.

INTRODUCTION: *motivation and aims of the project*

The Charles Darwin Station with its numerous research facilities represents with an electricity consumption around 28.000 kWh per year one of the biggest energy consumers on the Galapagos islands. As generation of electricity is currently dominated by diesel, electricity consumption poses a threat to the islands' environment due to climate change and fuel spill risks. In this context, the station aims for decreasing its electricity needs by appropriate energy efficiency measures as well as for increasing its share in renewable energy production. Therefore, the purpose of this project is to identify electricity saving potentials and to propose suitable energy efficiency measures based on these findings. The project also requires knowledge about the climatic conditions on-site in order to be able to perform a sound evaluation of the proposed solutions regarding their feasibility and effectiveness. The project therefore consisted of two parts: (1) the main focus of the project was on the generation of fundamental information needed for the evaluation and the proposal of appropriate efficiency measures. Those information included the categorical electricity consumption for the individual buildings as well as the climate data on-site including radiation, temperature, humidity and wind information. (2) The second part of the project was aiming to give sound proposals of energy efficiency measures based on analysis of the information gained in the first part of the project. Due to the short time available for the complex project, calculation of savings and profitability of proposed measures make up a small part of the project. Altogether, this project provides the basic information needed for future investigations focusing on profitability calculations of the proposed solutions.

CONTEXT: *calculation of energy consumption*

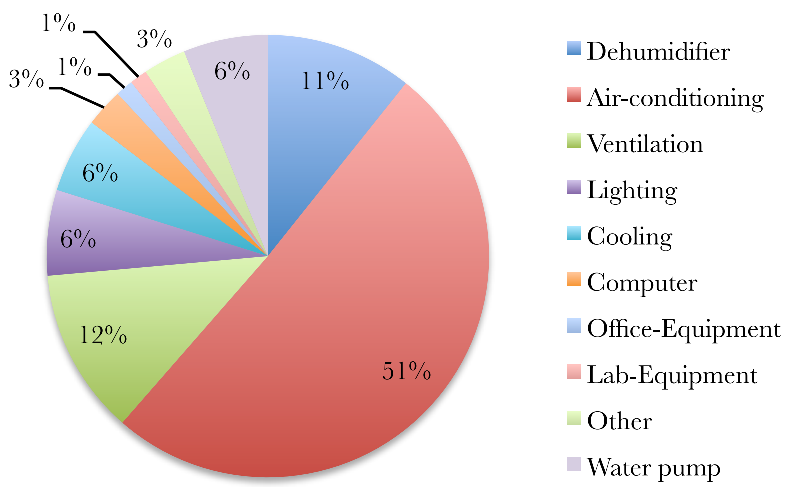
The devices' energy consumption is normally measured with an energy meter, which is able to measure consumption over a certain period of time, for example over a day or a week. As no such energy meter device was available on the islands and the import from abroad would have taken too much time, the electricity consumption of the individual electric devices had to be obtained by either reading the annual or monthly energy consumption values from energy labels located on the device, or by calculating power consumption with the technical information written on the nameplate by multiplying the apparent power S of the device with its running hours H_d, its running days D_{yr} and the number of devices N with the same function, power and use pattern as described in the Equation below.

$$E_{yr} = S \cdot H_d \cdot D_{yr} \cdot N \tag{1}$$

the technical data written on the nameplate only represent maximum power, with the device running under full load conditions (100%), which is in general not the case. In order to obtain data which are as realistic as possible, calculated electricity consumption values had to be adjusted accordingly. Running hours and running days of the devices were obtained by questioning employees about the use patterns of their electric devices.

CLIMATE: *data and conclusions*
Solar radiation is very high throughout the year with a high share of direct radiation, resulting in high temperatures throughout the year. This allows very good use of solar radiation for electricity generation by solar panels and thermal application, but eliminates geothermal applications due to high subsurface temperatures. Furthermore, requires high cooling efforts are required for collection rooms, laboratories and archives. As air-conditioning devices consume a great amount of energy during operation, those devices can be assumed to account for the greatest part to electricity consumption of the station. Relative and absolute humidity values are high during all the year, which requires high dehumidification efforts in order to protect valuable samples and documents from the influence of humid air. Wind analysis shows that wind velocities may be too low for wind power applications.

ENERGY CONSUMPTION: *share of categorical end-user categories*
The station consumes 320 MWh per year for all buildings except for apartments of volunteers, visiting scientist and permanent employees. This value also includes the water pump, which cannot be allocated to a single building. The figure below shows the calculated share of the different end-consumer categories of the total electricity consumption of the station. It can be shown that total electricity consumption is mainly dominated by air-conditioning purposes with a share of 51%, followed by ventilation with 12% and dehumidification with 11%. Lighting, cooling and water pump were calculated to account for 6% each. Computer, office and laboratory equipment and other were found to be minor contributors to total electricity consumption.
Four buildings could be identified as the greatest electricity consumers of the station, with annual electricity consumption values above 40 MWh. Those are: the right Tomas Fischer building with 72.59 MWh, the Exhibition Hall with 46.46 MWh, the left Tomas Fischer building with 46.33 MWh and Biomar with 40.43 MWh per year. In total, those buildings consume 205.81 MWh per year, which accounts for 64% of the total buildings' electricity consumption.



ENERGY EFFICIENCY MEASURES: *proposal of appropriate energy saving measures*

Energy efficiency measures were described in relation to the different end-user categories. The extent and detail of the described energy efficiency measures was thereby adjusted to the relevance of the different end-user categories.

Reduction of air-conditioning demand could be achieved by a combination of passive cooling methods such as night ventilation, greening of roofs, walls and facades, building envelope insulation, optimization of windows, solar cooling technologies as absorption cooling, desiccant cooling and chilled ceiling combined with desiccant cooling. The latter method can be used for low energy cooling and dehumidification of buildings at the same time. The efficiency measures for this category resulted in the highest financial savings up to 11,930 USD per year by insulation of the building envelope.

Proposals for energy saving in the lighting category mainly included the replacement of light bulbs by energy saving LED, which resulted in annual savings up 1,077 USD for replacement of all lights of the station.

Improvements for the cooling category were limited to the purchase of new and more energy efficient products for future purchases. Slight improvements could be made by appropriate loading and placement of the fridges and freezers.

For computers and monitors, it was proposed to purchase less energy consuming computers and monitors and to raise awareness among employees for turning off those devices during non-working time.

For office equipment, it could be shown that replacement of the numerous printers in the Administration building by one central printer could save up to 50 USD per year.

Energy efficiency measures therefore not only can help to reduce financial expenses for electric devices, but they can also help to protect the unique environment of the Galapagos from the environmental consequences of fossil fuel consumption used for electricity generation.