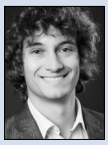

Patrice Mattes

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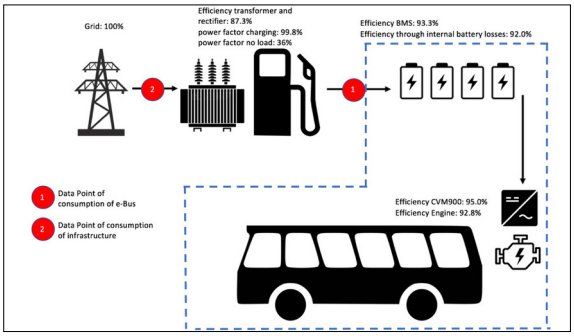
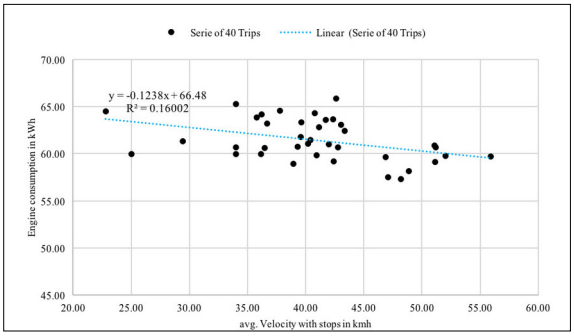
Examiner	Prof. Dr. Andreas Häberle
Co-Examiner	Dr. Elimar Frank, Frank Energy, Rapperswil SG, SG
Subject Area	General environmental technology
Project Partner	Federal University of Santa Catarina - UFSC, Brasil, Florianopolis, Brasil, Santa Catarina

Performance of a Solar powered electric Bus & its environmental impact

e-Bus at the 75kW charging Station of Sapiens Parque with its four battery packs with a total capacity of 128kWh



Efficiency of e-Bus charging process



Engine consumption compared to avg. travel speed

Introduction: The Bachelor thesis was carried out in Florianopolis, Brazil, in partnership with the Universidad Federal Santa Catharina (UFSC). The research object was a solar powered electric bus, which runs exclusively on PV and started regular operation in March 2017. The e-Bus is running on a daily basis and connects the research facility with UFSC with up to 5 daily trips. In December 2017, the e-Bus reached a mileage of 47'000km and a total grid consumption of 45MWh. The existing monitoring of the e-Bus consisted only of the data on the start and ending point of each single trip. Monitoring data of single components and several parameters from the engine were not accomplished yet.

Objective: The aim of the thesis was to participate in the monitoring and li-ion battery evaluation of the solar powered e-Bus under different working conditions. Energy consumption of the different parts was analysed and compared to the energy production by the regenerative breaks. The evaluated results were analysed against the seasonality in PV production and the general sizing of PV systems, that will be necessary to generate enough energy to run an e-Bus in Florianopolis, Brasil. The analysed data should be then compared to the irradiation data in Rapperswil and a conclusion about the autonomy of the e-Bus when getting powered by a PV power plant in Switzerland should be made.

Result: The analysis of the e-Bus consumption showed, that the major part of 85% is used by the engine. The calculated fuel economy of the e-Bus is 1.13kWh/km, when considering the efficiency of the charging process, the fuel economy rises to 1.27kWh/km. Round trips with the use of air conditioning are using on avg. 6.5% more energy than the trips without. During the researched period of March to December, an availability of 89% was calculated. The share of recovered energy during a round trip compared to the consumption of the engine is 20%, when considering efficiency losses of inverter and batteries. Slow avg. speed caused through traffic or many "stops and goes" during the round trip rises the consumption. Number of passenger did not affect the fuel economy, nor did the different drivers. The consumption of 45MWh over the researched period (March to December), could be covered trough the generation of the 66kWp PV power plant at Sapiens Parque. A simulation of the charges and discharges of a PV power plant with a power wall (with a capacity of 400kWh) showed, that a high percentage of 88% of autonomy can be reached. 1kWp of PV can provide 45-121km/month, depending on the seasonality in PV production. For this calculation a production of 57-153kWh/kWp was evaluated with the provided data at Sapiens Parque.
When comparing the global irradiation data from Switzerland to the efficiency of the 66kWp PV power plant at Sapiens Parque and assume higher fuel economy of 1.5kWh/km, we get lower autonomy. The higher consumption in Switzerland is mainly caused trough heating in winter time and could be verified in the literature research. 1kWp of PV can provide 14-101km/month, depending on the seasonality in PV production. For this calculation a production of 17-129kWh/kWp was evaluated with the irradiation data from Rapperswil, Switzerland.