Bachelor on Science Thesis Proposal on Adaptive Control of Energy Storage (*adaptation to a Master on Science Thesis is possible*)

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Background

The global photovoltaic (PV) market has had a tremendous development the last 10 years. In many countries, there are bidding schemes where the Government open up for international bids for building and long-term operation of larger PV systems. Different kinds of additional conditions together with the lowest bid price normally win the bid.

From the technical point of view, monitoring and control of PV systems are also required for systems cost effective operation since the initial investment for the installation and maintenance is high and for reliable functioning and maximum output solar power. Monitoring systems can provide information such as system efficiency, performance and energy produced hence return of investment of the installation that the users mostly require knowing [1]. According to Bartle [2], system monitoring provides information that will be useful in ([3]): system condition analysing, getting experience from one system and using it in another one for proactive control, etc.

As for the optimization of the operation of PV parks, due to the fact that the output power of photovoltaic solar cell has non-linear characteristics, up to know different kinds of control algorithms have been proposed ([4]), e.g. maximum power point tracking (MPPT), PID, etc. However, the optimization of the operation of the PV depends strongly on the control parameters which can have a good performance on one solar park might not be good for the other. One main reason for this is that the existent control methods do not take into account the historical response of the system behaviour in contrast to the issues that will affect the annual production of PV systems, such as energy consumption variations, irradiation, ambient temperature, degradation of modules, etc.

In this research, we propose to develop an adaptive control system for PV systems that adapts after changing conditions. In particular, we aim to incorporate and develop the concept intelligent control conventionally implemented for highly dynamic systems to enable the application in smart energy systems. Due to its complexity of the proposed research, in a previous work, we have proposed an experimental methodology to analyse the effect of the thickness of the snow on a PV regulator response based on the analysis of power electronics control parameters without extra sensors in a simple PV solar cell module [5]. On the other hand, we proposed the simplification of the complexity of an experimental model based on machine learning (Long Short-Term Memory model) for the forecasting of the electric energy consumption from a cooperative house , as it is shown in Fig. 1 ([6]). Moreover, in order preliminary research was carried out to understand each setting for energy storage system and calculate cost for each business model to optimize parameter setting [7].

In this proposed thesis work, the focus will be given to propose a suitable control strategy in order to integrate the forecasting of the electric energy consumption output to the control parameters of the battery management system from a cooperative house.

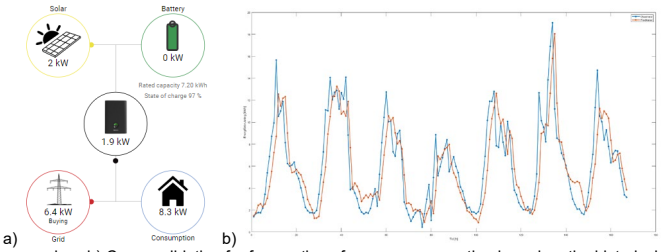

Figure 1. a) System overview, b) Cross-validation for forecasting of energy consumption based on the historical data over 1 month.

Objectives:

The objective are:

- Proposed a control strategy to adapt the battery control parameters based on the forecasting output from the LSTM model
- Perform basic tests to determine the effectiveness of the proposed control strategy
- [Optional] Propose possible improvements for the existent LSTM to better detect the energy consumption peaks and Implement and test the improved LSTM model

Tasks and tools

The thesis work should comprise the following tasks:

- Literature study on PV systems, Machine Learning and Control
- Propose a methodology to map the forecasting output to the battery control parameters
- Perform tests to verify the performance of the proposed control strategy
- [Optional] Propose improvements for the existent LSTM model to better detect the energy consumption peaks and implement the proposed improvements of the algorithm in Matlab
- Write thesis report describing the work and results

Requirements

One or two students in Bachelor of Science in Electrical Engineering or Mechanical Engineering (Otherwise, it is possible to adapt the thesis content for on Master of Science student in Mechanical Engineering or Energy and Environmental Science or Physics Engineering or similar is suited for this job). Candidate should have a basic background in electrical engineering, modelling, control and programming. Good programming skills is desired. It is also important that the applicant have good writing and communication skills. Please attach a list of courses with marks and a CV in your application.

References

[1] M. Anwari, M.M. Dom, M.I.M. Rashid, Small scale PV monitoring system software design, in: Energy Procedia, The Proceedings of International Conference on Smart Grid and Clean Energy Technologies, 2011, pp. 586–592.
[2] P. Bartle, Handbook of Monitoring, Available online: http://cec.vcn.bc.ca/cmp/hemon.htm (accessed on 25 September 2019)
[3] G.T. Yeneneh, Testing of Apis System Platform in Grid-Connected Photovoltaic System and Comparison with Metrum for Fault Detection and Diagnosis, Master Thesis, Darlana University, 2016, pp. 6-8.
[4] S. Yang, Solar energy control system design, Master Thesis, Royal Institute of Technology, 2013, pp. 13-25.
[5] Solis, J., Hamanee, S., Nilsson, M., Analysing the effect of snow on the PV regulator response in a simple PV system. 35th European PV Solar Energy Conference, 2018, pp. 1948-1987
[6] Solis, J., Tomohiro, O., Ericsson, J., Nilsson, M. (2019) Forecasting of Electric Energy Consumption for Housing Cooperative with a Grid Connected PV System, International Conference on Smart Grid, pp. 118-125.
[7] Solis, J., Kato, C., Ericson, J., Nilsson, M. (2020). Cost benefit analysis for business model in a grid connected PV system with energy storage, 36th European PV Solar Energy Conference and Exhibition.

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