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Ayda Esfandyari  
*Dublin Institute of Technology*, ayda.esfandyari@dit.ie

Agata Świerc  
*Silesian University of Technology*, agata.swierc@polsl.pl

Brian Norton  
*Dublin Institute of Technology*, president@dit.ie

Michael Conlon  
*Dublin Institute of Technology*, Michael.Conlon@dit.ie

Sarah McCormack  
*Trinity College Dublin*, mccorms1@tcd.ie

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Campus Energy Testbed: Battery Energy Storage System (BESS) Based Photovoltaic Charging Station (PV-CS) For A Green University Transportation

Ayda Esfandyari, Agata Świercz, Brian Norton, Michael Conlon, Sarah J. McCormack
1 Dublin Energy Lab, Grangegorman, Dublin 7, Ireland
2 Department of Civil, Structural & Environmental Engineering, Trinity College Dublin, Dublin 2, Ireland
3 Department of Heating, Ventilation and Dust Removal Technology, Silesian University of Technology, Gliwice, Poland
4 Department of Electrical Engineering, University of Washington, Seattle, WA, USA

ABSTRACT
With the trends encouraged by governments and political parties to increase the adoption of Renewable Energy Sources (RES); solar energy, and in particular photovoltaics (PV), is poised as an excellent candidate to offset the energy requirements of charging stations (PV-CS) for Electric Vehicles (BEV). This work presents a 10.5 kW Transient System Simulation (TRNSYS) model of a university campus PV-CS to determine sizing as well as to determine the best operating strategies for a Battery Energy Storage System (BESS). The economical optimization model is formulated via theoretical approach adopting the Simple Payback Period (SPP) indicator. The optimization takes into account the campus transportation load profile while BESS is used to attain the shortest SPP gain. The results, from both theoretical as well as simulation approach, reveal that leveraging the campus BEVs charging via BESS based PV-CS scheme has the potential to reduce the energy demand from the grid, and to maximize self-consumption efficiency.

OBJECTIVE
- Develop a 10.5 kW Transient System Simulation (TRNSYS) model of a university campus PV-CS
- Determine the size and the best operating strategies for a Battery Energy Storage System (BESS)
- Perform economical optimization via theoretical approach adopting the Simple Payback Period (SPP) indicator
- Give recommendations for the real system components

MODELLING PROCEDURE
The PV-CS model was developed to replicate the experimentally proposed model in [1].

- The model was created in TRNSYS through the connection of selected components, called TYPES, (Table 1) and their input-output mapping.
- The flow diagram for the model and utilised components are shown in Figure 1.
- Furthermore, completed PV-CS TRNSYS model with all inbuilt components (TYPES) is illustrated in Figure 2.

ENERGY MANAGEMENT
- The energy flow parameters were calculated according to the steps summarised in Figure 3.
- To assess the feasibility of investment, parameters are further monetised using the economic model hence, adopting the system capital cost along with time variant energy tariff rates.
- It was assumed that the excess energy is fed back into the grid, and exploited for other campus loads.
- The energy balancing optimization adopted the Simple Payback Period (SPP) method in order to investigate the acquired positive gain by BESS unit. The SPP time for regaining project investment was expressed in years.
- The key variables for tuning the BESS capacity were load profile and size of BESS. This was selected accordingly to the specification of newly launched Lithium-Ion Tesla Powerwall batteries (Table 2).

RESULTS
- The SPP for all analysed BESS/load configurations is gathered in Table 3

DISCUSSION
- Leveraging the campus BEVs charging via BESS based PV-CS scheme has the potential to reduce the emission levels at the generation point.
- To embrace the full potential of PV-CS green generation, it would be beneficial to incorporate additional auxiliary campus loads as part of the overall system demand.
- This could potentially lead to increase in system self-consumption and reduction of energy procurement from the grid.

FUTURE WORK
- Clarification of energy flow and control management
- System monitoring: charge/discharge cycles, electrical/thermal characteristics

REFERENCES
Esfandyari, A. et al., The Battery Energy Storage System (BESS) Design Option for On-Campus Photovoltaic Charging Station (PV-CS), City of Washington Conference (CWC), 2015, Denver, Colorado.