Photovoltaic (PV) power generation is growing as the best clean renewable and sustainable source of energy and is predicted to be the main source of electricity by 2050. However, in order to improve the performance of photovoltaic solar systems in terms of efficiency and reliability, further advancements are essential in many areas, such as in energy storage as well as fault detection and localization systems, for PV to be a truly safe and sustainable energy source. To date, there are no reliable and efficient methods for fault detection and localization in solar panels.

In this work, a new approach for fault detection and localization in photovoltaic systems is presented. The proposed system is based on using a network of current and voltage sensors to continuously monitor the solar system under normal operation conditions and issuing an alert of fault and accurate location information when predetermined normal conditions are violated. The proposed system requires resources and time monitoring especially when the system is composed of large scale arrays. An enhanced system is proposed to optimize sensors distribution in the network which will allow for the detection of faulty spots without global search. Time tracking is also embedded in the system to allow the opportunity for fault analysis with respect to time of the day and thus associate it with other parameters and events including load variations.

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To validate the proposed model, MATLAB/Simulink software was used to simulate two different arrays with 24 and 32 PV modules arranged in series-parallel configurations. Simulations included worst-case-scenario faults such as when all branches are faulty simultaneously. Simulation results are at 100% accuracy in detecting and localizing the most common faults that are known to occur in PV systems. The model presented in this dissertation is robust and, due to smart sensor placements, optimizes efficiency, cost, and sustainability.