# Technical Assistance Request

**Project title: Kalman Filter Dynamic Estimation for Solar PVs:**

- Achieving real-time situation awareness through dynamic state and grid strength estimation.

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**The proposed solution**

The goal of this project is to achieve real-time situation awareness by providing real-time dynamic state estimation of solar PVs along with the grid characteristics, including but not limited to grid voltage condition and grid strength.

Many of the solar PV's internal states, e.g., phase-locked-loop angle, cannot be directly measured by phasor measurement units (PMUs) installed at the Point of Interconnection. Additionally, the interconnected power grid is a large-scale system, whose condition is very difficult to be described due to the large dimension of the geographic size and numerous electrical states. Therefore, we propose a Kalman filter based on a simplified equivalent solar PV interconnection system's model, to provide real-time dynamic states and grid characteristic estimation. Through fusing the model-based prediction with PMU measurement-based correction, this project will achieve adequat dynamic state and grid characteristic estimation, thereby significantly enhance the real-time situation awareness for grid operators and solar PV power plant operators. Figure 1 illustrates the proposed solution of real-time situation awareness by fully utilizing data stream along with prediction made by a simplified model.

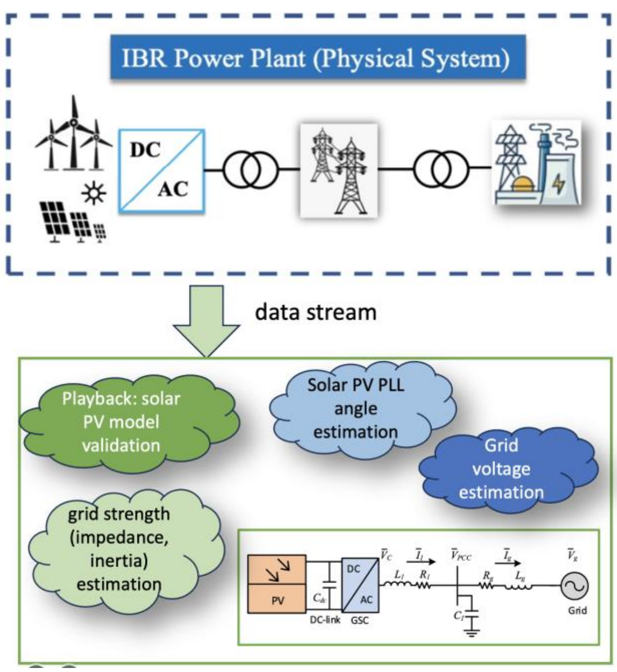


*Figure 1 The proposed solution of real-time situation awareness by fusing data stream with model-based prediction.*

The key technology of the proposed solution, Kalman filter-based dynamic state and grid strength estimation for solar PVs, consists of three critical components: (1) adequate transparent model building, (2) fusing model-based prediction with measurements of different sampling rates, and (3) control hardware-in-the-loop (CHIL) verification of the estimator. Specifically, real-world implementation requires the consideration of fusing the solar PV simulation models with 50 microseconds time step with measurement data of 60-Hz streaming rate; and such implementation requires a CHIL testbed with PMU data stream available for verification.

**Assistance to Realize the Solution**

The project will achieve significant commercial success given assistance provided in the following two aspects.

First, performance of dynamic estimation largely depends on the model built to represent the solar PVs. Since solar PVs are largely black boxes with their converter control as proprietary information, model building requires a large set of field or experiment data to capture essential dynamics that can characterize solar PVs. Grid operators usually have access to data and some dynamic data from PMUs have been posted online. On the other hand, without properly labeling the data and associate data to a one-line diagram of the power grid topology, the data are useless for analysis. It is necessary that a detailed data along with description be provided. Besides field data, experiment data containing rich dynamics generated from controlled experiments on MW level IBRs are also valuable to this project.

Second, assistance is needed for field demonstration. In the lab environment, the physical system is modeled in real-time digital simulation and the PMU is based on such a system. While the key functionality of the proposed solution, including taking in PMU data stream and calibrating dynamic state and grid characteristic at real time, can be verified in the lab environment, field demonstration is necessary to check the robustness of the proposed solution in a different environment.

Existing testbeds built at National Labs can be used for field demonstration. The National Renewable Energy Lab (NREL)’s Flatirons campus has different types of inverter-based resources and allows for testing at the 20-MW level. Such a testbed is suitable for field demonstration of the developed products.