An Empirical Study: Kinmen Power System Survived in Extreme Events by the Aid of Energy Storage Systems

(Electric power system laboratory：Wu,Chen-Han　Yen,Jou-AnWang,Yung-Fu　Liao,ching-Jung)

I. Background and Purposes

As an isolated power system, the recorded penetration rates of renewable energies in Kinmen from time to time exceed 30% during certain time periods. High renewable penetrations have negative impact both to the operation of power plants and the stability of power system. Seeing this, Taiwan Power Research Institute (TPRI) embarked on installing energy storage systems (ESSs) by two phases (1st phase the energy-typed NaS ESS, 2nd phase the power-typed Li ESS) in Kinmen, for the following experimental purposes:

(1) Reducing the impacts of renewable energies on Kinmen's power system.
(2) Preparing for higher renewable energy penetration in the future.
(3) Improving Kinmen power system's operation efficiency.
(4) Accumulating ESS dispatch/control experiences.
(5) To serve as a reference for ESS installations in Taiwan .

Fig.1 Illustration of the 1st phase (L) and 2nd phase (R) installations

II. the Functions of the 2nd phase ESS

Since the installation of the 1st phase ESS was delayed by some complex procurement procedures, our discussion will be limited to the 2nd phase. The specification of the 2nd phase ESS is 2MW/1MWh capable to provide the following functions:

(1) smoothing renewable generation,
(2) constant active/reactive power output,
(3) frequency control,
(4) voltage-var control, and
(5) spinning reserve (in the way of Rate of Change of Frequency).

The F-P and V-Q control (acquiring frequency/voltage and automatically supply or absorb active/reactive power) are shown as Fig. 2.

The RoCoF control (to detect frequency deviations caused by generator tripping and to supply active power according to the setting points until the operator aborts this function) are shown as Fig. 3.

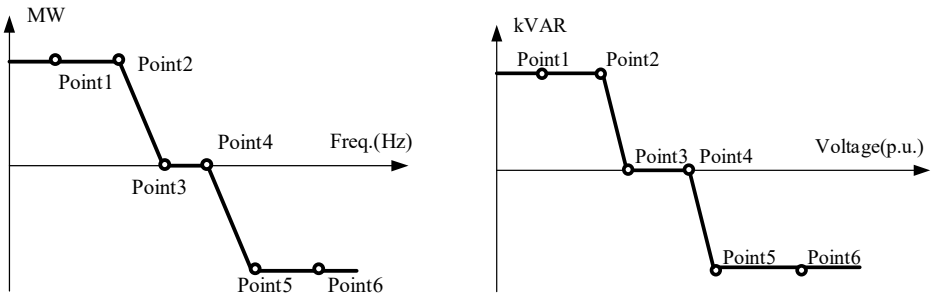

Fig.2 F-P(L) and V-Q(R) control diagrams

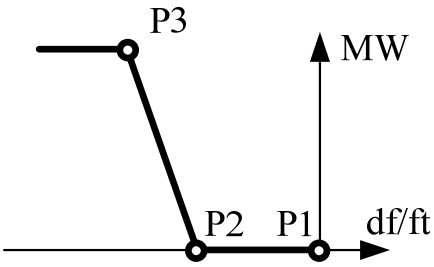

Fig.3 RoCoF control diagram

III. Actual Cases in Kinmen

The 2nd phase ESS started operation in December 2019. Owing to Kinmen power system's embedded conditions, Volt-Var control and spinning reserve mode are interactively switch on and off. For example, constant reactive power control has to be applied in the nighttime to absorb redundant reactive power, and spinning reserve/RoCoF to provide extra power to prevent severe frequency deviation caused by generator trip. Two recent cases in Kinmen are shown as Fig. 4 and Fig. 6.

January 16, 2020, Tansan #9 generator tripped during parallel running test and caused a loss of 22.22% generation output. Thanks to that the load bank trip (4.2MW) was chained to Tansan #9 generator CB and ESS immediately responded (2MW within 166 milliseconds), the system frequency only dropped slightly , shown as Fig. 5.

Fig 4. Tansan #9 trip and ESS response (2020/01/16)

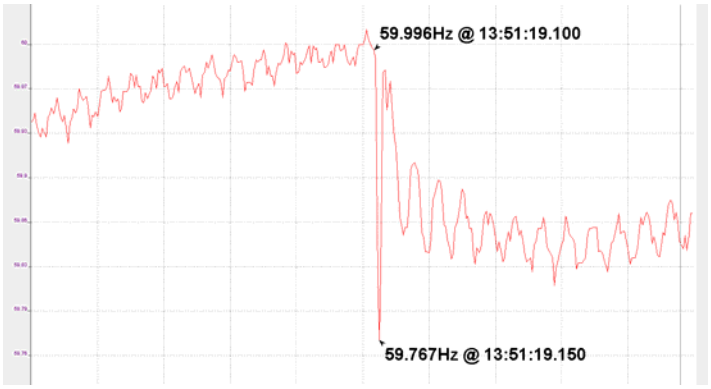

Fig 5. System frequency (2020/01/16)

January 22, 2020, Tansan #9 generator occurred output sag during parallel running test and caused a loss of 7MW (25.74%) generation output. This incident had not triggered load bank trip and severe system frequency deviations, thanks to that the CB of Tansan #9 generator was on and ESS immediately responded (2MW within 234 milliseconds).

From the above events, it is clear that immediate response of ESSs had effectively prevented severe frequency deviations at the occurrences of impromptu generator trips.

Fig 6. Tansan #9 output sag and ESS response (2020/01/22)

Fig 7. System frequency (2020/01/22)