Area: 8. PV Systems Including BOS Components

DEVELOPMENT OF AN AUTOMATIC FAILURE DETECTION ALGORITHM FOR RESIDENTIAL PV SYSTEM BY USING OPI METHOD

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Recently, remote diagnosis of residential PV systems are being introduced. In the case of using remote diagnosis, it was a problem to judge a decrease in PV output due to shading as a failure. Therefore, we developed Operating Performance Index (OPI) method and we have remotely diagnosed residential PV systems. By using OPI method, it became possible to distinguish output reduction due to a malfunction or shading. In the previous study, we succeeded in detecting a failed PV system. However, since we aim to diagnose a large number of PV systems, it is necessary to identify the failed PV systems from a lot of PV systems automatically. In this paper, we propose an algorithm for remote failure detection of numerous PV systems using OPI method.

$OPI(t)$ is defined as $E_M(t)$ divided by $E_{EST}(t)$ and is calculated in 5 minutes intervals. Where, $E_M(t)$ is measurement power generation at time t [kW], $E_{EST}(t)$ is estimated power generation at time t [kW] , $E_{EST}(t)$ is calculated based on PV system configuration, air temperature, and horizontal global irradiation which is estimated using satellite data of Himawari 8. If $OPI(t)$ is around 1.0, PV system generates electricity normally. On the other hand, if $OPI(t)$ is decreasing, PV system output is decreased due to a failure or shading. We have five PV systems data, these PV systems were analyzed every day using $OPI(t)$ data of past 30 days. All $OPI(t)$ was converted into $OPI(\psi,h)$ based on solar azimuth ψ[deg.] and solar height h[deg.]. $OPI(\psi,h)$ was stored in each sector of the celestial sphere divided into solar azimuth Ψ = 5[deg.] intervals and solar height H = 5[deg.] intervals. $OPI_p(\Psi,H)$ was calculated as the local maximum value of the frequency of the $OPI(\psi,h)$ in each area. OPI_{Pp} which indicating power generation performance index of PV is calculated as the local maximum value of the frequency of the $OPI_p(\Psi,H)$. Since OPI_{Pp} varies depending on the analysis date, OPI_{MA} is calculated using the moving average of OPI_{Pp} by using the past 14 days OPI_{Pp} excluding the maximum value and the minimum value. An examples of calculation results of OPI_{Pp} and OPI_{MA} of the analyzed PV systems are shown in Fig.1 and Fig.2. The PV system in Fig.1 was a system that was caused artificial failure on 9th September, 2016 and it could be confirmed that the OPI_{MA} value in Fig.1 had been decreasing since October, 2016. OPI_{MA} value of the PV system that is normally generating power is shown in Fig.2 and it was confirmed that OPI_{MA} continued to show a constant value.

As a preliminary study of the automatic diagnosis, the minimum value of the OPI_{MA} in the past 45 to 60 days before the analysis date is calculated, and it is compared with OPI_{MA} of the analysis date. When the OPI_{MA} on the analysis date is lower than the minimum value of the past OPI_{MA} and the difference is larger than 0.06, the corresponding PV system is suspected of failure. Also, PV system which has suspected of failure over 20 days in the most recent 30 days is judged as a failure. As a result of the automatic diagnosis, it was judged that the one failed system was as a failure and it was judged as normal for the four normal systems. Therefore, by using this algorithm it can be said that all 5 systems could be judged correctly. In future, we are planning to diagnose many PV systems and improve the accuracy of automatic diagnosis. This research is supported by NEDO.

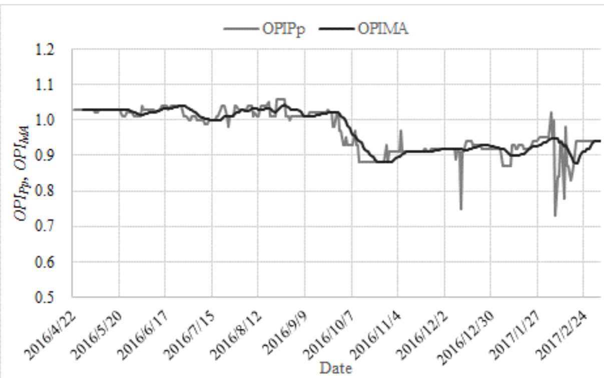

Figure 1: OPI_{MA} transition of a failed system

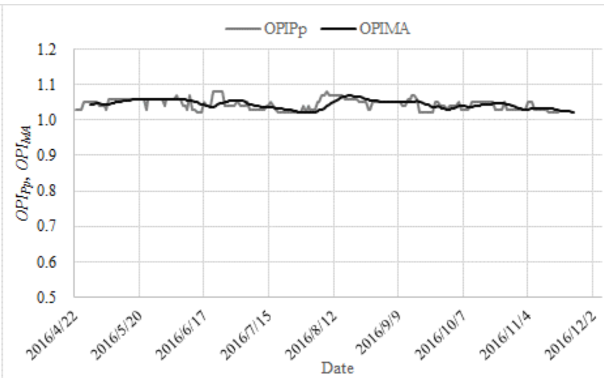

Figure 2: OPI_{MA} transition of normal PV system