NAME : Hayato SATOH
COUNTRY : JAPAN
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**Key Consideration of Under-Frequency Load Shedding Schemes for Ensuring Future Frequency Stability**

**Summary (Slide 2)**

- **Large-scale integration of renewable energy sources (RESs)** could **decrease system inertia**, eventually **increasing the RoCoF** following the loss of large-scale generation, causing **significant large-scale self-disconnection of RESs** and the **risk of large-scale power outages** due to frequency drops. Therefore, special protection schemes can flexibly and quickly respond to events in which deteriorated frequency stability is needed.
- In the case of the large-scale self-disconnection of RESs or the loss of generation exceeding the scale of contingencies, **under-frequency load shedding (UFLS) schemes as a backup become important to ensuring frequency stability**. In Japan, the RoCoF relays are expected to contribute to faster load shedding as one of the countermeasures for enhancing UFLS.
- However, it can be difficult to cope with these issues using conventional emergency frequency control schemes based on UFLS schemes in which the UF relay setting is fixed. Therefore, in Japan, the idea of **adjusting the control settings of UFLS using information and communication technology effectively according to the system status** has been proposed as a new approach for enhancing UFLS in future systems. Based on this approach, the authors have developed **a new UFLS scheme using the RoCoF relay to cope with RES self-disconnection**. The following are important considerations to ensure the sufficient effect of the proposed UFLS scheme.
  - **Use the RoCoF relay with the appropriate RoCoF calculation method and UF relay to ensure fast response and accuracy.**
  - **Adjust relay settings according to system status (using information and communication technology) to maintain an accurate amount of load shedding.**
  - **Construct systems of UFLS scheme using IEC 61850 to ensure high interoperability to cope with future power system changes flexibility.**

**Investgate and share information**

**Proposed Control Method for enhancing UFLS in future systems (slide 3)**

- In the proposed control method, **a load shedding function based on RoCoF considering the characteristics of RES self-disconnection, characterized primarily by anti-islanding protection relay,** is added to UFLS.
- Furthermore, **the amount of load shedding is adjusted by changing the RoCoF relay settings** in real-time according to the RES output, estimated self-disconnection, etc. Adjustment of the relay setting is conducted in the following flow.
  1) Estimate the output of RESs.
  2) Estimate the amount of RES self-disconnection (≒load shedding) vs. RoCoF.
  3) Adjust the settings of each RoCoF relay (use or non-use, threshold level, and time delay as necessary).
  4) Send setting change command to each RoCoF relay.
- In step 2) above, key consideration is as follows.
  - It is important to **use the RoCoF calculation method equivalent to the anti-islanding RES protection relay for the RoCoF relay** to ensure both accuracy and fast-response of the RoCoF relay that detects RES self-disconnection.
  - It is also important to adjust the RoCoF relay setting appropriately according to the system status, to maintain the accurate amount of the load shedding for RES self-disconnection. For this purpose, it is important to **thoroughly keep track of or share information on the characteristics of each RES anti-islanding relay**.

**Configuration of Proposed Control System for ensuring high interoperability (slide 4)**

- In the proposed control method, it is necessary to change the RoCoF relay settings in an appropriate cycle (on the order of minutes) to adjust the amount of load shedding appropriately in real-time according to the RES outputs. It is important to avoid requiring a large amount of information to change the control settings.
- Therefore, **applying the proposed control scheme is preferable not to the entire grid but rather to a certain scale or unit, such as a distribution substation**.
- **Two systems** are needed in each substation to apply the proposed control method to distribution substations.

- A "**load shedding system**" using the RoCoF relays considering the characteristics of the RES anti-islanding protection relay.
- A "**relay setting control system**" to adjust the amount of load shedding appropriately according to the system status.
- Here, it is considered that the system can be constructed at **a lower cost and with higher scalability** than before **by using a configuration compliant with IEC 61850**, which is being introduced in monitoring control systems and protection relay systems.

**Conclusion**

- It is important to **use the appropriate RoCoF calculation method for the RoCoF relay** and **adjust the RoCoF relay setting based on the appropriate information** (on the characteristics of each RES anti-islanding relay etc.)**,** to ensure the sufficient effect of the proposed UFLS scheme.
- In addition, it is important to **construct systems of proposed UFLS schemes using IEC 61850** to ensure high interoperability to cope with future power system changes flexibility.