Basic Technology Subjects

System Engineering Research Laboratory

Brief Overview

The System Engineering Research Laboratory (SERL) conducts research on the planning, operation, control of, as well as analysis methods for, electric power transmission, distribution systems, and information/communication systems, in order to facilitate the secure supply of electricity generated by large-scale and distributed power sources. The laboratory also pursues research on development, testing, and assessment of customer service technologies to achieve more efficient use of electricity.

Achievements by Research Theme

Electric Power Systems

We develop the fundamental techniques of transmission system analysis and evaluations, control and protection for economic and stable operation of the system. Also, using these fundamental techniques, solutions for recent technical issues surrounding the increase in renewable energy introduction, wide-area interconnection and so on are developed.

- To deal with aging transmission equipment, a coordination method of individually determined maintenance/replacement plans is necessary, to make a consistent and efficient plan for the whole system. Therefore, a method to adjust maintenance/replacement plans was developed, which minimizes an objective function composed of five factors concerning difference from initial plans, cost and outage risk (Fig. 1) (R13021).
- Modular multilevel converter (MMC) is a new type of converter and its introduction will continue to spread due to its superior characteristics. However, the calculation cost of simulation for MMC is expensive as the MMC arm has hundreds of cells. We developed a novel MMC model on which all cells to a voltage source and resistor. The developed model can calculate at a speed of 15.2 times faster than a detailed model in a test circuit (R13027).
- A novel high voltage dc transmission system applying dc boost converters has been studied in our laboratory. A control method has been developed for the system to realize its continuous operation under grid faults. A series of simulation results demonstrate its effectiveness under the grid faults. It is applicable for large scale offshore wind power generations to deliver the power over long distance submarine cable (R13017).

Customer Systems

We develop elemental techniques and tools to support promotion of energy savings by customers. To maintain and enhance power quality of distribution lines, we also develop elemental techniques for supporting estimation and measurement of harmonics generated by customers.

- The ventilation design for commercial kitchens based on the conventional ventilation design standard does not take into account the tendency of cooking appliances to generate heat and moisture. Therefore, the conventional ventilation rate of exhaust hoods for multiple cooking appliances must be excessive. We elucidated ventilation requirements of exhaust hoods for multiple cooking appliances by conducting experiments. The ventilation requirements for multiple cooking appliances are lower than the sum of the individual ventilation rates of exhaust hoods for each cooking appliance, and they are also lower than ventilation requirements based on the conventional ventilation standards (R13015).
- In regards to supporting promotion of energy saving, we developed a heat source characteristic model for room air conditioners up until 2012 by which the electric power consumption during heating and cooling can be estimated. In 2013, we improved the model so that the electric power consumption and heat load under unsteady states can be calculated. Validity of the new model was evaluated by conducting experiments (R13016).
- Thus far, we made clear that the fifth harmonic current (amplitude and phase angle) could be classified two groups of the middle voltage three phase load group and the other group. Applying the characteristics, a method to estimate fifth harmonic current of each customer in the distribution line was devised. The method is applicable even if measurement condition were limiting, such as only one measurement place in a distribution substation feeder. The results of numerical experiments using a seven node distribution network model indicated that proper estimation could be obtained by the method (R13004) (R13028).

Communications Systems

In order to secure high reliability of communications networks for power utilities required for operations and control of power systems, we develop disaster tolerance improvement technologies for communication systems, construction technologies for communication systems to assist restoration at damaged power systems and security technologies for SCADA systems.

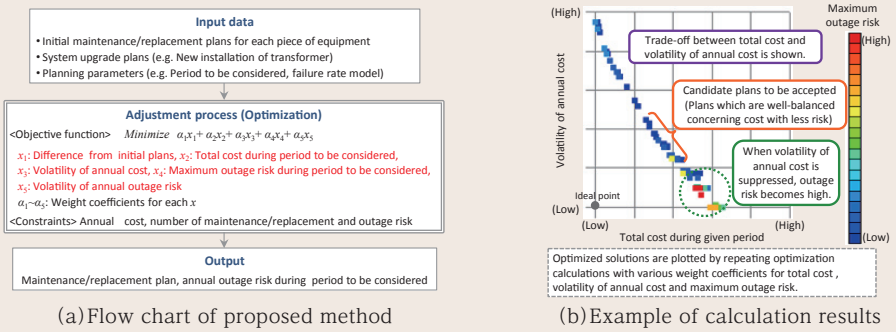
■In microwave radio communication systems, lightning surge current through waveguide can damage communication equipment. To reduce this problem we have proposed utilization of optical fibers as an alternative to waveguide. We confirmed the communication characteristics of radio signal in receiving systems worked by optical fiber power supply. We also evaluated the total communication quality by connecting radio transmitting and receiving systems and confirmed that communication quality was satisfactory. Additionally, output power of radio transmitter was prospected to be close to feasible level by improving output efficiency (R13008). In the future, we will improve the output enhancement method for practical use.

■To make a design guidance of long distance multi-hop wireless LAN for rapid construction of temporary communication channels upon occurrence of a disaster, we estimated characteristics of multi-hop and communication in long span and low height above ground that is supposedly used at a disaster area. As a result, transmission loss estimation in situ is prospected by the type of obstruction (building, forest, steel tower, etc.) and the area of obstruction on the transmission path. Moreover, by measuring multi-hop communication characteristics at varying distances of a section, we confirmed that the total throughput is dependent on that of the longer section (R13009).

Mathematical Informatics

To achieve accurate diagnosis during maintenance and inspection of electric power equipment, we develop diagnosis methods based on high performance machine learning and image processing techniques. We also develop optimization methods for complex large-scale systems.

■To address the issues associated with high penetration of renewable energy sources, such as output fluctuation and surplus power, we proposed a basic framework for a tool to simulate demand and supply operations of power generation units and power storage facilities under the uncertainty of renewable energy sources. As the first step of simulator development, for photovoltaic power output with no uncertainty, we developed a prototype of the planning module which generates the demand and supply operation plan for one month efficiently, passing data to a daily plan from a monthly plan (R13013).



(a) Flow chart of proposed method (b) Example of calculation results

Fig 1: Adjustment of maintenance/replacement plans based on multi-evaluation

Weighted combination of the factors is used as the objective function in the adjustment process, and by applying adequate weights, a plan which is consistent with planner's policy can be obtained. Calculations with various weight coefficients will show relation among factors such as trade-off and significantly help to develop a more efficient and accountable plan.

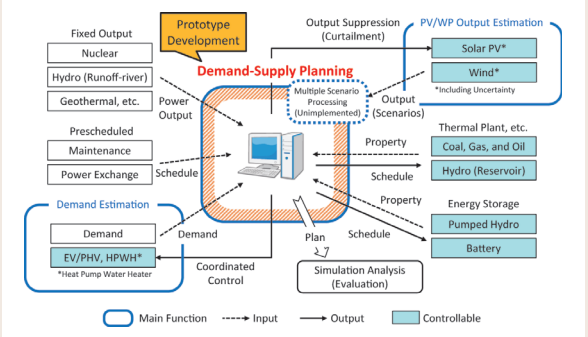


Fig. 2: A basic framework for a demand and supply operation simulator

The planning module, which is the main function of the simulation tool, can generate a demand and supply operation plan in a realistic time by omitting some constraints or simplifying a fuel cost function according to a planning period or desired accuracy.