

A Support Tool to Level Transmission Equipment Replacements Considering Supply Reliability Constraints – Development of A Prototype Tool –

Background

The progress of aging of transmission equipments is becoming a crucial issue in Japan, and maintenance and replacement costs are expected to greatly increase in the near future. Appropriate replacement planning methods need to be developed in order to replace a large number of equipments installed up to 1990s in the future, while maintaining supply reliability. One such planning method is to prioritize a number of replacements while taking supply reliability of the whole network and replacement cost into account and to build a replacement plan, which shows which equipments should be replaced and when they should be replaced.

Objectives

The purpose of this study is to develop a prototype planning support tool to build a replacement plan, which levels transmission equipment replacements over a long planning horizon, while maintaining supply reliability and keeping total replacement cost as low as possible.

Principal Results

1. Development of a planning support tool to level transmission equipment replacements

- (1) A planning support tool is developed to build a replacement plan, which assures that the supply reliability of the whole network and replacement cost in each planning period (e.g. 5 years) can be kept below specified level over a long planning horizon (e.g. 30 years or more)
- (2) The developed tool builds a transmission equipment replacements plan, which satisfies reliability constraints of the whole network and cost constraint, considering the condition (namely, failure rate) of equipment in the network based on aging characteristics of the equipments given as input data. The calculation of replacement plan is made in two steps. In the first step, a minimal set of equipments is identified, which must be replaced to satisfy reliability constraints over the planning horizon. Second, based on the results in the first step, leveling of cost is performed with respect to the periods where replacement cost exceeds the maximum acceptable cost. Both these steps can be formulated as optimization problems and they are very simple problems, so that only small amount of computational time is required to obtain the plan.

2. Verification of effectiveness of the developed tool

The developed tool is applied to develop a replacement plan over long term (40 years) of a small model power system (IEEE Reliability Test System). The result shows that the tool can successfully develop a replacement plan which satisfies both reliability constraint and cost constraint, and the developed tool is helpful for leveling transmission equipment replacements over the long term.

Future Developments

Improvements of the developed tool will be made so that the tool is applicable to more realistic problems.

Main Researcher: Masaki Nagata, Ph. D.,

Senior Research Scientist, Power Systems Sector, System Engineering Research Laboratory

Reference

M. Nagata, et al., 2009, "Development of a Support Tool to Level Transmission Equipment Replacements over Long Term", IEEE/PES Power Systems Conference and Exposition 2009

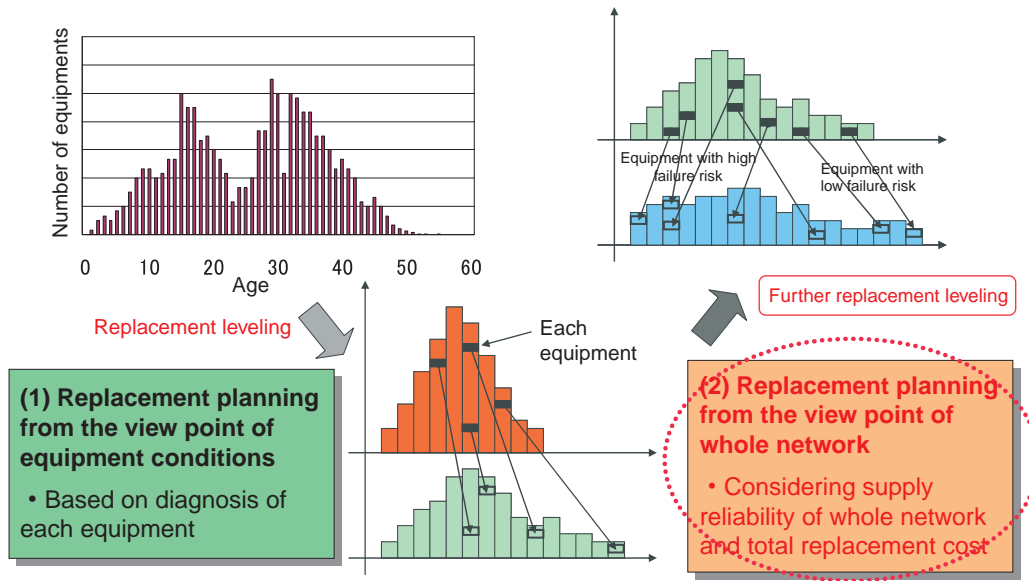


Fig.1 Criteria of replacement leveling

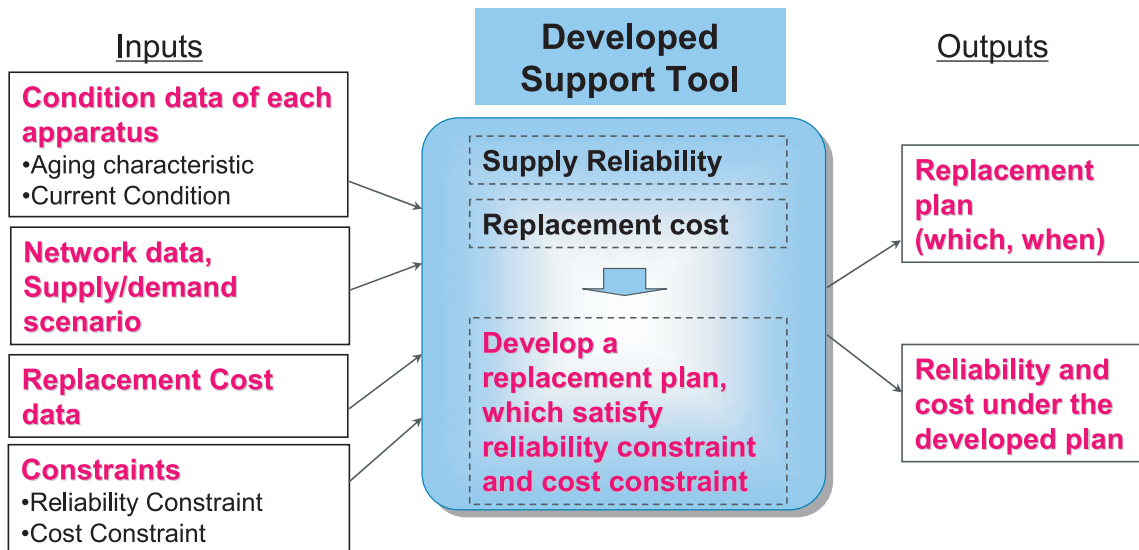
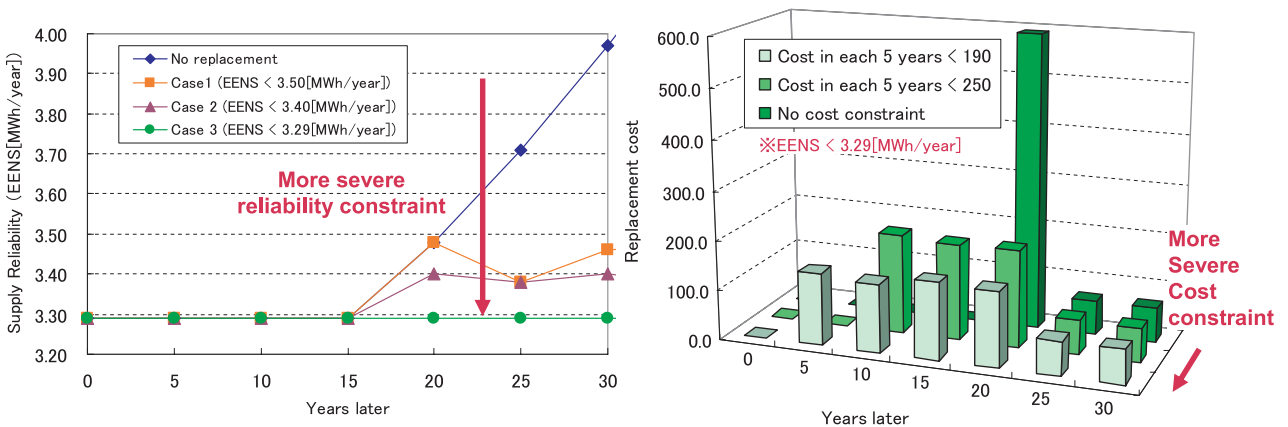


Fig.2 Inputs and outputs of the developed tool



(1) Reliability under various reliability constraints

(2) Replacement costs in Case 3

Fig.3 Numerical examples