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COUNTRY :	Japan	PREF. SUBJECT :3
REGISTRATION NUMBER : 7300		QUESTION N° : 1

Q PS3.1: What are the benefits of digital solutions like IoT-sensors, machine learning, artificial intelligence, drones, robots etc. for substation life cycle from planning to maintenance? Which measures are necessary to increase the acceptance of intelligent IoT-based power equipment in substations?

Case study about cost-Effectiveness of investment for sensors in existing substation equipment

1. Introduction

Future challenges of the electric power business include increased blackout risk caused by aging of equipment and decreased numbers of qualified maintenance personnel caused in part by low birth rate and an aging population.

As one potential solution, TEPCO Power Grid aims to reduce the frequency of patrol inspections by upgrading to condition based maintenance (CBM) using rapidly advancing digital technology. With the use of data analysis, CBM also reduces blackout risk and facility down time during maintenance.

Digitalization of new equipment can be achieved relatively with sensors installed during manufacture. In contrast, digitalization of existing equipment may require de-energization and/or rebuild, which may cost more than when it was newly installed. Therefore, existing equipment is somewhat more difficult to digitalize compared to new installations, but existing equipment is also more likely to cause problems, so the need for its digitalization is high.

Due to the number of variables, a cost-benefit simulation is performed based on assumptions for the investment cost to install sensors onto the existing equipment and the obtained benefit.

2. Expectations of sensor installation

Table I shows the monitoring items and sensors implemented into GIS and OIT. When introducing smart equipment, maintenance tasks such as patrols, actual equipment maintenance work and past failures are reviewed. Monitoring items and sensors useful for abnormality and degradation diagnosis, life assessment, and maintenance efficiency improvements are then determined.

Table I monitoring items and sensors implemented into GIS and OIT

Equipment	Monitoring items	Sensor	Purpose		
			Degradation diagnosis	Life assessment	Efficiency of maintenance
GIS Overall	Gas pressure Slow leak	Gas pressure sensor Temperature sensor	✓		
GCB	Operating characteristics	DC clamp CT Travel sensor Auxiliary switch	✓	✓	✓
GCB	Operation mechanism energy storage	DC/AC clamp CT Oil pressure sensor	✓	✓	
GCB	Contact consumption	AC clamp CT	✓	✓	
DS/ES	Operating characteristics	DC clamp CT Operation check switch Temperature sensor	✓	✓	✓
OIT	Oil temperature	Temperature sensor	✓	✓	
OIT	Oil level	Level sensor			✓
OIT	Dissolved gas	Dissolved gas analysis unit	✓	✓	✓
Bushing	Partial discharge	PD sensor	✓	✓	
LTC	Driving torque	Torque sensor	✓	✓	✓

3. Cost-Effectiveness of investment based on estimation conditions

The cost-benefit analysis assumptions are:

- Mounting of sensors to equipment aged over 30 years
- Sensor repaired in 15 years and updated in 30 years
- An additional 10 years of service life prior to replacement (e.g., 60 to 70 years)
- Depreciation expense for 10 years included in the analysis
- Cost of data transmission is reflected
- Influence on societal benefits such as the avoidance of power outages is reflected

The analysis result is shown in Figure 1. In this case, the break-even point is 24 years after sensor installation and the return on investment accelerates significantly after 30 years of sensor installation.

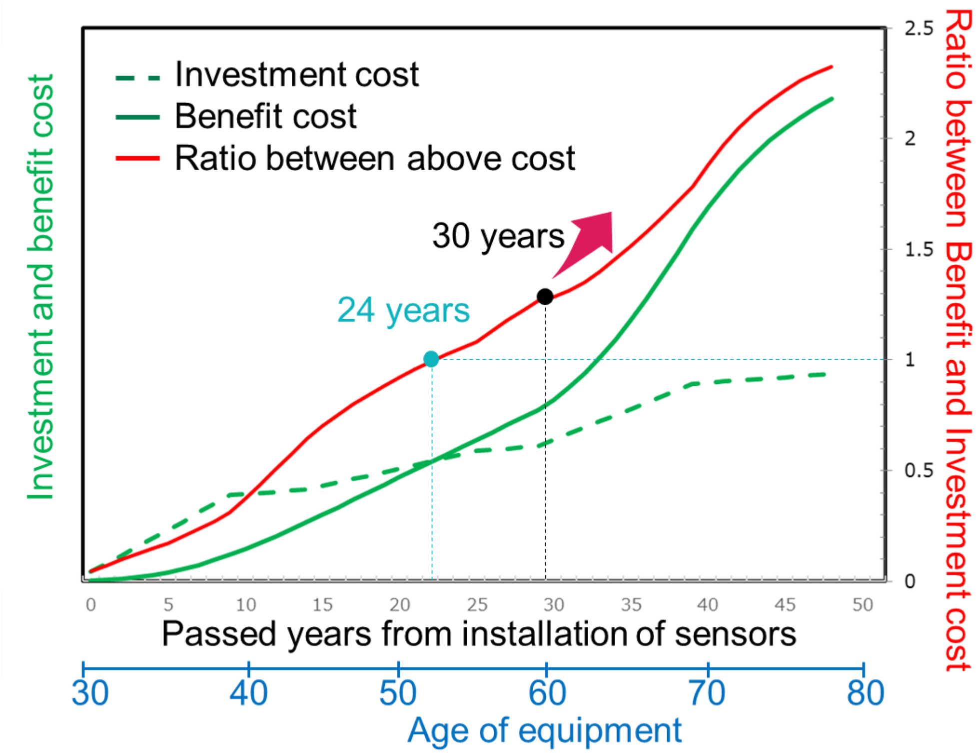

Figure 1 Estimation results based on the assumed scenario

4. Conclusions and future work

A case study of the cost effectiveness for investment that introduce CBM sensors into existing facilities is presented.

As a result of this analysis, the break-even point is 24 years from the installation of the sensors and the return on investment accelerates significantly after 30 years.

In the future, the break-even point may occur even earlier by reduction of the investment cost via the use of general-purpose sensors and components to the greatest extent possible.