Establishment of a Comprehensive Optimization Tool for WWTPs

(Research of FY 2018-2021)

1. PURPOSE

This research aims to establish an optimization study tool for wastewater treatment plants. Optimizing WWTPs involves minimizing energy consumption and greenhouse gas (GHG) emissions while maximizing the utilization of energy generated from sewage. Specifically, the goal is to develop a "Comprehensive Optimization Study Tool" (hereinafter referred to as the "Study Tool") that allows for a simple calculation of potential reductions in energy consumption and greenhouse gas emissions by introducing new, energy-efficient technologies. Additionally, this tool will help assess the amount of energy that can be generated, facilitating a comprehensive optimization approach.

2. Outcomes of This Year

(1) Improvement of the Assessment Tool:

Adding digestion gas power generation technology to the Study Tool enables estimating the amount of energy that can be created.

(2) Implementation of case-study

Table 1: Summary of 2021 survey result

Facility scale	Daily maximum	50,000m³/day		
	Daily average	40,000m³/day		
Wastewater treatment process		Conventional activated sludge process		
Sludge treatment process		Separate thickening – Dewatering (Centrifugal)		
Elemental technology		Hard-to-dewatered sludge adaptable screw-press dehydrating machine (two-coagulant)	Carrier-filled high-speed methane fermentation	Digestion gas generation (Gas engine)
Case 1		✓		
Case 2			✓	
Case 3			✓	✓
Case 4		✓	✓	
Case 5		✓	✓	✓

The study assumed a hypothetical wastewater treatment plant with a conventional activated sludge process and a 50,000 m3/day capacity (maximum daily). Five cases introducing new technologies include retrofitting dewatering machines and new construction of the digestion process, such as digestion gas power generation by a gas engine. Table 1 shows the results of the annual power consumption and GHG emissions calculated for each case. The research examined the most efficient combination of new technology introduction.

The estimation targets the wastewater treatment (primary, reaction, final settling tanks) and the sludge treatment processes.

Figures 1 and 2 outline the calculation results for power consumption and greenhouse gas (GHG) emissions for each case studied.

- Case 1: New technology was introduced exclusively to the dewatering machine, reducing power consumption by 5% and GHG emissions by slightly decreasing.

- Case 2: A new digestion process was implemented, resulting in a 16% increase in power consumption and a corresponding rise in GHG emissions.
- Case 3: Digestion gas generation was added to Case 2, which reduced power consumption by 89% and GHG emissions by 53%.
- Case 4: This case combined elements of Cases 1 and 2. It resulted in a 10% increase in power consumption and a slight rise in GHG emissions.
- Case 5: Digestion gas generation was added to Case 4, achieving a remarkable reduction of 94% in power consumption and a 57% decrease in GHG emissions.

Overall, GHG emissions—specifically N2O and CH4—generated during the wastewater treatment process did not decrease as significantly as power consumption. This case study demonstrates that updating dewatering machines alone can effectively reduce power consumption and GHG emissions. Conversely, implementing a digestion process, which is digestion gas power generation, substantially enhances energy savings. Therefore, Case 5 emerges as the most effective strategy for energy saving and GHG reduction.

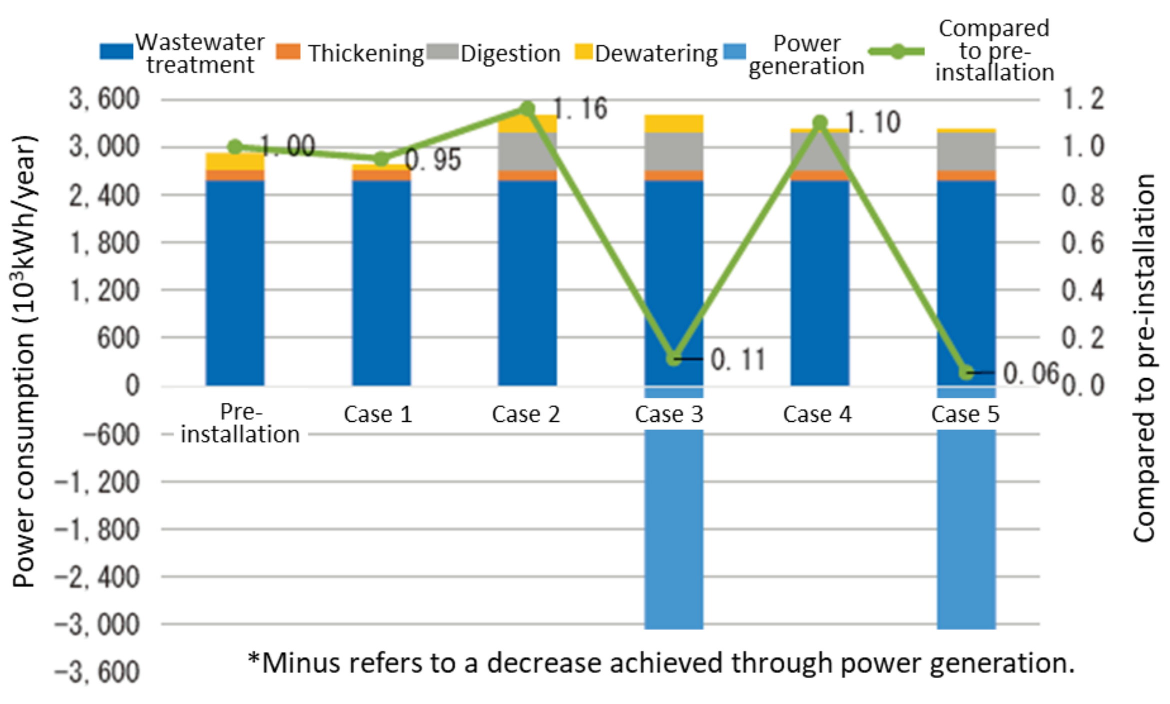

Figure 1: Results of the power consumption trial calculations for each case

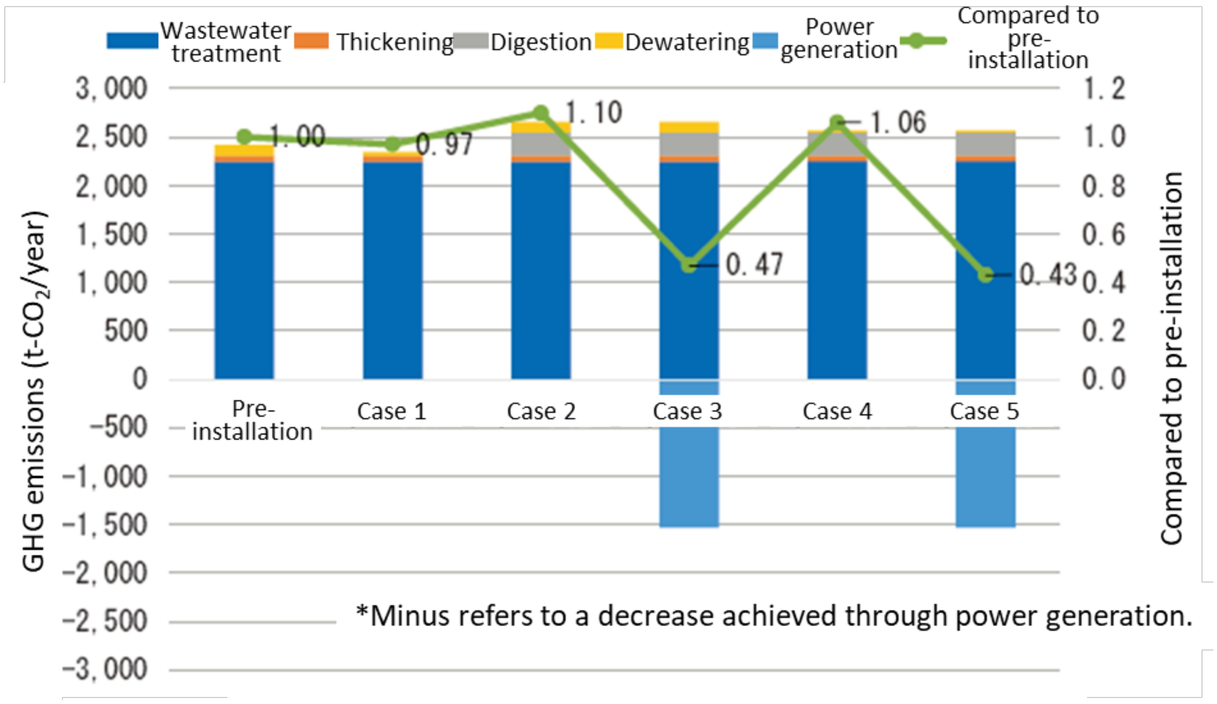

Figure 2: Results of the GHG emissions trial calculations for each case

3. Summary of the 5-year Study

Over five years, research has led to the development of a comprehensive optimization tool for wastewater treatment plants (WWTP).

This tool allows for easy estimation of the benefits gained from various combinations of new technologies with energy-saving capabilities, helping to identify the most effective wastewater and sludge treatment processes.

Keywords: **Comprehensive optimization, Energy saving, Greenhouse gas**