Evaluation of Small Scale Hydropower Generation Using Agricultural Water Supply Facilities in Long Waterway system

--- Case study on waterway system of Meiji Yosui---

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1 Background Motivated by global warming and rising oil prices, many countries intend to replace the fossil fuels with renewable energies such as wind power generation, hydro electric power, solar and geothermal power. Among them, hydropower is an appealing source of energy because it is cheaper and more convenient especially in its maintenance. Hydropower generation using agricultural water supply facilities have great potential, which relies on long waterway and unused falling height. The total length of waterways in Aichi Prefecture is 2, 467km that ranks third in Japan, while waterway density is the highest. As a result, hydropower generation potential using agricultural water in Aichi Prefecture occupies a high position throughout Japan. This study aims to evaluate the electricity generation potential using overflows and water heads available at the headwork and water diversion works etc in the Meiji Yosui region.

2 Study sites The waterway system of Meiji Yosui is located at the lower reach of the Yahagi River. And Meiji Yosui covers beneficial area of 8,000 ha, including 8 cities and 4 towns in Aichi Prefecture. Meiji Yousui land improvement district operates and manages the headwork, main canal, diversion works. Hydropower generation is divided into four type's modes as follows according to the falling height and discharge. ①Headwork**:** The headwork of Meiji Yosui was built in 1958, located at the center of the Yahagi River, and takes water from the Yahagi River for agriculture and municipal water. Using spill discharge at this head work to generate electricity. The average falling height is about 5.6m. ②Industrial water diversion work**:** Using superfluous falling height in Naka-Isuji main canal to generate electricity. The average falling height is about 4.1m. ③Blowoff at Chuto water division work**:** Using facilities management water to generate electricity, the water flow is 0.2m^3/s and the average falling height is 7.75m. ④Nihongi, Akamatsu, and Higashiyamada water diversion work**:** Using the overflow at these water diversion works to generate electricity. The average falling height is 4.2m, 7.45m and 6.35m, respectively.

3 Research methods Daily flow rate and water level (from 1997 to 2011) of these six sites are provided by the Meiji Yosui Land Improvement District. The potential hydraulic energy available in a body of water is defined as follows:

Table 1 Annual electric power generation at head work of Meiji Yousui

流量	超過確率(%)	90	80	70	60	50	40	30	20	10	0
	m^3/s	2.8	4.6	6.4	9.1	13.5	18.6	25.1	37.5	61.5	1183
定格発電出力	kW	111	182	253	360	534	734	993	1483	2429	46765
最大発電量	MWh/年	970	1596	2215	3153	4676	6428	8698	12994	21274	409658
実発電量	MWh/年	901	1447	1932	2546	3388	4178	4967	6005	7190	9588
設備利用率	%	92.9	90.7	87.2	80.7	72.4	65.0	57.1	46.2	33.8	2.3

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Keywords: hydropower, energy availability factor, Meiji Yosui, eclectric power generation potential

$$P_{in}=\rho gHQ\eta$$

Where: ρ for density of water (1019kg/m^3);g for gravitational constant (9.81m/s^2);H for falling height (m);Q for flow rate (m^3/s). η for generation efficiency (72% assumed).

4 Results and discussion The spill discharge at head work is fluctuated by rainfall event. Tab.1 showed that energy availability factor increases according to the decrease of the rated power output. When the energy availability factor is set at 60%, the spill discharge of headwork is 22.6m^3/s, the rated power output is 894kw, and average of annual generation was 4695MWh (**Tab.1**). In this case, the annual generation is 3137-6345MWh during the past 15 years. The monthly generation has a small variation; the maximum is 535MWh in January and the minimum is 324MWh in October (**Fig.1** (a)). The above results show that the spill discharge at headwork promises the highest and stable electric power generation.

The average of annual actual electric generation at Industrial water diversion work, Blowoff at Chuto water diversion, and Nihongi, Akamatsu and Higashiyamada water diversion works is 424.5, 133.2, 45.2, 137.4, 44.9MWh, respectively. Annual actual electricity generation of Industrial water diversion work and Akamatsu water diversion work is relatively high and stable compared to the other 2 sites. The monthly average electricity generation of these five sites has a small variation that could provide stable power generation all year round (**Fig.1 (b)-(e)**). From these results, there is great electricity generation potential in Meiji Yosui region. Further study is needed to guide the actual operation.

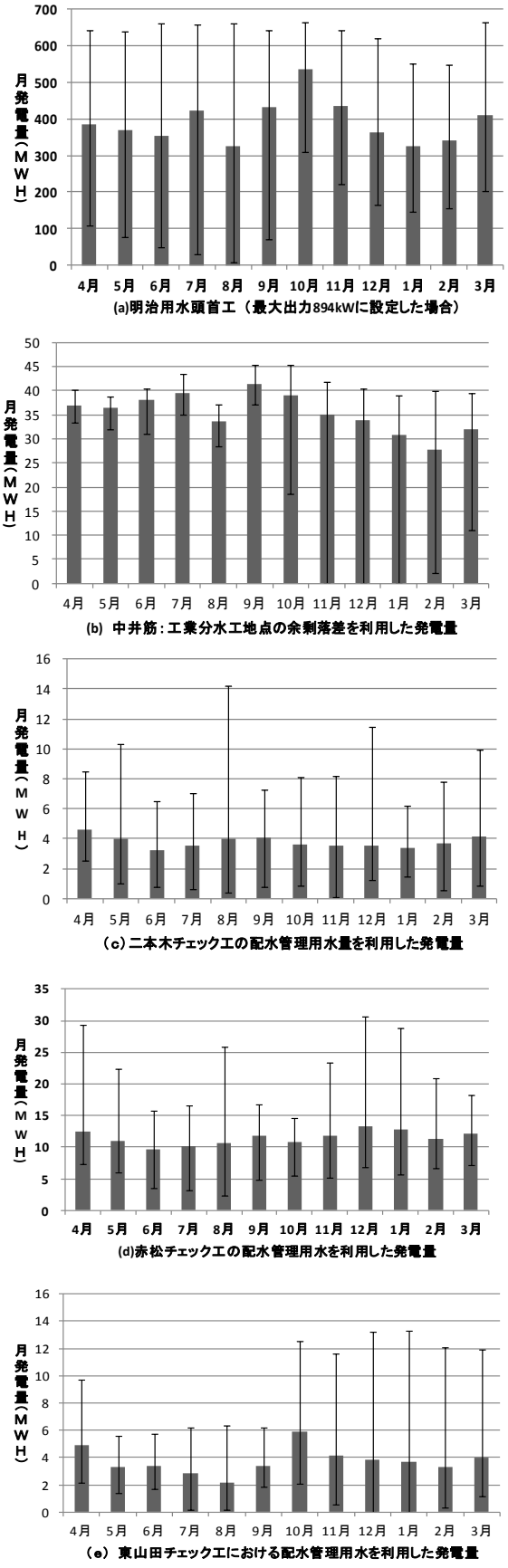

Fig.1 Monthly electric power generation at head work and each water diversion work etc.