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SUSTAINABLE ENVIRONMENTAL SANITATION AND WATER SERVICES

Economy of dual water supply systems

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HONG KONG IS one of the very few coastal cities in the world which utilize "dual water supply systems". The dual water supply involves two distribution systems, one fresh water distribution system for potable use and another seawater system for toilet flushing and fire fighting purposes. The details of such dual water supply systems have been given in a paper (Tang, 2000) published in the Proceedings of the 26th WEDC Conference. The objective of this paper is not to repeat what has been described in said paper but to report a comparison of the economy of (1) a single distribution system (fresh water supply only) and (2) the dual water supply systems. In other words, the question addressed in this paper is: would it be more economical for Hong Kong to use a single distribution system instead of the existing dual systems?

Basic assumptions for economy comparison

As is mentioned above, the dual water supply systems are in operation in Hong Kong. In order to have a meaningful comparison, an imaginary single fresh water supply system of similar size to the existing dual systems has to be assumed. The consumption of salt water is assumed to be totally replaced by fresh water. The increase in costs in the procurement of the extra raw fresh water and in treating this amount of raw fresh water must be taken into account. The saving, in this imaginary case, is the cost of the extra distribution system for salt water. In the economic appraisal to be made, it will be assumed that the owner (Hong Kong Government) will invest the whole capital required, that is, the investment will be without a loan (or so called the all-equity case). The reason for doing this can be found in any books on economic feasibility appraisal such as Tang (1996).

The capital investments can be divided into two parts. They are initial capital costs and the renewal costs of the water work facilities. On the top of capital investments, there are running costs, which are recurrent expenditures spent every year by the Hong Kong Government in order to keep the water supply system running smoothly at all times. Besides outgoings, the Hong Kong Government receives incomes every year from the users of the water supply system. The capital investments, the running costs and the revenues (incomes) are to be discussed in more detail in the next section.

Capital investments

For the fresh water supply system, the initial capital includes the construction cost of water work facilities, the cost of purchasing equipment, the land cost and the cost of working capital. In practice, the Government owns the land on which the facilities are built, and therefore we ignore the land cost in our analysis. The water work facilities include storage reservoirs, water treatment plants, E&M equipment, pumping stations, service reservoirs, water mains and tunnels. For the seawater supply system, the facilities include only pumping stations, E&M equipment, service reservoirs, seawater mains and tunnels. There are no storage reservoirs and treatment plants in the sea water supply system.

The renewal costs of the facilities relate to depreciation. The depreciation of the facilities is calculated on a straight line basis to write off the costs of the assets less salvage values over their estimated useful lives. The annual rates of depreciation set are 1% for tunnels and dams, 2% for civil engineering works and fresh water mains, 5% for salt water mains, 4% for E&M items and 10% to 20% for motor vehicles. The depreciation rates indicate the lifetimes of different facilities. However, from the experience of the engineers of WSD (Water Supply Department) of the Hong Kong Government, there is no exact lifetime for water mains, because the mains were usually replaced before the end of their lifetime due to system expansion or work improvement, or were destroyed by the construction of underground utilities or failure of road bases. The same happens to other facilities (eg. E&M items) as well. Nevertheless, on a conservative side, we can assume that the lifetimes of the salt water system and the fresh water system be 20 years and 30 years respectively. Both salt water and fresh water distribution systems, as told by the WSD engineers, use the same type of pipe materials and the mains of the two systems are of the same cost per unit length.

Running costs

Running costs include staff cost and OAE (operation and administration expenses). In 2000/2001, the staff establishment of WSD was 5,688. Of the 5,688 staff, which cost HK$1,734 million (US$1 = HK$7.8) in that year, 363 are of professional grade, 2,180 inspectorate or technical grade and 2,246 general or common grade. The OAE are the costs of light and power, the maintenance costs of buildings,

reservoirs, water mains, treatment plants and pumping stations, the costs of emergency repairs, hiring of services and professional fees, specialist supplies, material and equipment, and general departmental expenses (Leung et al.). The (total) OAE amounted to HK$1,382 million in 2000/2001. The total running costs in that year were therefore equal to HK$3,116 million (WSD Annual Report 2000-2001).

Revenue generated

The revenue of WSD, the only supplier of water in Hong Kong, comes from water charges of users. The method of charging the users by WSD is quite complicated and is not to be discussed in detail in this paper. In 2000/2001, the total water charges amounted to HK$2,572 million (WSD Annual Report 2000-2001).

Economy comparison

The net present value (NPV) method will be used in the analysis for comparing the economy of the imaginary single fresh water supply system and the existing dual water supply systems. The details of the NPV method can be found in books like Lang and Merino (1993), Tang (1996) and Muro (1998), and will not be discussed here. The water supply in Hong Kong is a money losing business, and therefore readers will find shortly that the NPV is a negative value. The alternative with 'less negative' NPV, therefore, will be regarded as financially better. The following shows the calculation of the NPVs.

Since the salt water system is assumed to have a lifetime of 20 years and the fresh water system 30 years, we have to make a comparison based on a time horizon of 60 years. The renewal of the salt water system will be at year 20 and year 40, and that of the fresh water system will be at year 30. All prices are adjusted to the money value of Year 2000 by the use of Consumers' Price Indices published by the Hong Kong Government, so that the comparison can be made on a 'constant base year prices' basis, and hence the NPV calculated will be 'real' (Tang, 1996, Chapter 4). For example, the revenue is no more HK$2,572 million as given above after adjustment to Year 2000 money value but is HK$2,668 million.

Existing dual water supply systems

Capital cost (fresh water storage reservoirs, fresh water mains and pumping stations, fresh water treatment plants, E&M equipment, fresh water service reservoirs, salt water mains and pumping stations, salt water service reservoirs)= HK$137,317 million[1]Renewal cost of fresh water mains and E&M items (a life of 30 years)= HK$31,640 millionRenewal cost of salt water mains and E&M items (a life of 20 years)= HK$8,010 millionRunning cost (staff cost and OAE)= HK$2,669 million per year. Revenue (water charges)= HK$2,668 million per year. It should be noted that the above running cost and revenue figures are those averaged from the past ten years' data.

Imaginary single fresh water supply system

Capital cost (storage reservoirs: require more storage reservoirs than the dual systems, water mains and pumping stations: one distribution system instead of two but of larger pipe sizes, water treatment plants: require more water treatment plants, E&M equipment, service reservoirs)= HK$151,118 million[2]

Renewal cost of water mains and E&M items (life of 30 years)= HK$37,547 million

Running cost= HK$2,764 million per yearRevenue= HK$2,720 million per year

The NPV calculated, using a discount rate, i, of 5% p.a. for the dual water supply systems is –HK$137,753million[3]. If we spread this amount over 60 years with the same discount rate, that is 5%, the net annual gain is –HK$3,532 million per year[4], or we can say that the annual loss is HK$3,532 million per year. The NPV calculated for the single fresh water supply system, using the same method, is -HK$148,901 million. This is equivalent to an annual loss of HK$3,818 million per year. Therefore, the single system is about 8% more expensive than the dual systems.A sensitivity analysis is also carried out for finding out the effect of change of discount rate on the annual losses. The result is shown below.

	Annual Loss (in million HK$)	
	Single System	Dual System
i = 3%	4,101	3,839
i = 4%	3,944	3,668
i = 5%	3,818	3,532
i = 6%	3,715	3,423
i = 7%	3,628	3,332

Conclusion

The engineering economy of the single fresh water supply system and the dual water supply systems (fresh water + seawater) has been compared for the Hong Kong situation. The single system is found to be about 8% more expensive than the dual systems. For the past fifty years, Hong Kong has been using the dual water supply systems. Technically, the dual systems are no more difficult to construct, operate and maintain than any other reticulation systems. The result of this work further justifies the use of dual water supply in Hong Kong, as it has been found that it is financially better to adopt such an alternative. The consequence of dual water supply is the creation of mixed (fresh + salt) wastewater. The issue of mixed wastewater treatment has been addressed in another paper (Tang and Lee, 2002) presented in this very same conference. Readers who are interested in the said issue can refer to that paper published in the Proceedings of the 28th WEDC Conference.The cost of treating mixed wastewater is nearly the same as treating fresh wastewater. The difference is negligible for a comparison of the systems of that sort of scale.In conclusion, the authors of this paper feel that the

concept of dual water supply is something that should be promoted for application in coastal towns or cities, particularly when fresh potable water is such a scarce and valuable commodity in the world nowadays.

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Notes

1. The total capital cost of the existing dual systems is expressed as a figure in Year 2000 money value. Different facilities may be provided at different times in the past. The cost of each facility provided is adjusted to Year 2000 price using the Consumers' Price Indices (CPI) published by the Hong Kong Government. Summing up of adjusted prices for all the facilities will arrive at that figure.
2. The total capital cost of the imaginary single fresh water system is obtained by firstly deducting the capital cost of salt water components from all existing dual system facilities, and then multiplying that figure by (912 + 170)/912 where 912 million cubic meter is the average annual fresh water consumption and 170 million cubic meter is the average annual seawater consumption in Hong Kong for the past 10 years.
3. $NPV = F_0 + F_1/(1+i)^1 + F_2/(1+i)^2 + \ldots + F_{60}/(1+i)^{60}$ where F_n = (revenue – expenditure) in Year n and expenditure includes, besides running cost for each year (n = 1, 2, … , 60), the capital cost when n = 0 and the renewal cost when n = 30 for the fresh water system and when n = 20 and 40 for the salt water system.
4. Net annual gain = $NPV \times [i(1+i)^{60}] / [(1+i)^{60}-1]$

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