

Research Paper

Solar energy-based water treatment system applicable to the remote areas: Case of Indonesia

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ABSTRACT

Remote areas usually lack basic clean water services. Considering low population, poor geographical accessibility and lack of electricity, a small-scaled water treatment system capable of producing clean fresh water associated with solar thermal/photovoltaic applications, which is characterized with low capital cost, easy operation and less need of maintenance, is employed in the techno-economic study. Indonesia is one of the countries which owns considerable water resources in their territories but has moderate coverage in basic water services, and is chosen as a case for demonstration. The price of clean water from this system is profitable as compared to that of bottled water, which is an accessible safe water in these areas, but still much higher than that of municipal water.

Key words | developing country, Indonesia, remote area, solar energy, solar thermal, water treatment system

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INTRODUCTION

Fresh water is one of the critical and essential things for human life. Without water, human beings can survive for a few days only (Popkin *et al.* 2010; UN 2018). Only 2.5% of the world's water is fresh water, which is stored in lakes, rivers as well as groundwater and usually cannot be directly used for human life because the conditions of the water are far from the clean water standards (WWAP 2014). It is well known (Reed 2013; WHO 2018) that poor water quality can lead to water-related diseases such as waterborne diseases, malnutrition, diseases related to vector contamination and metal poisoning, which result in 2.2 million people dying globally every year and mostly in developing and underdeveloped countries. Among the waterborne diseases, diarrhoea is one of the major death factors of children less than five years old. It often results from the ingestion of pathogens from faeces that have not been disposed of properly or have been treated

with a lack of hygiene (WHO 2018). It was reported by Patunru (2015) that the odds of getting diarrhoea in a household with unsafe water resources in Indonesia is 12% higher than that with improved water resources. Accordingly, the lack of basic water service, mostly in the developing and underdeveloped countries, has significantly resulted in low life expectancy.

Prevention of diarrhoea can be effectively made through sanitation which requires provision of an improved water supply. Improved water supplies refer to technologies such as piped household water connections, public taps, standpipes, protected dug wells, or rainwater collection (WHO 2019). Improved water supplies can also be achieved by the current available water treatment technologies (Abdelkareem *et al.* 2018).

Throughout the world, 55% of the population lives in urban areas, thus, relatively higher than that in rural areas. However, the population living in rural areas reached as high as 3.4 billion in 2018 and need improvement of basic water services to achieve the Sustainable Development Goals (UN 2019). According to a joint survey carried out by

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doi: 10.2166/washdev.2020.003

WHO & UNICEF (2017), only 55% of the rural population has access to safely managed water services. In particular, only about 12% of populations living in the small-island developing countries of Oceania region have access to fresh water sources free of contamination (WHO & UNICEF 2017).

We have taken Indonesia as an example in this study. It is the largest archipelago country in the world, which consists of 16,056 islands and it has 3,696 remote coastal villages (Ministry of Maritime Affairs & Fisheries Republic of Indonesia 2015; Statistic Indonesia 2018). Indonesia with a population of around 261.8 million is the fourth most populated country in the world. However, about 11.1% of its population, most of whom live in remote villages, still live under the poverty line; and about 5% of the population (around 13 million) lacked access to electricity by 2017 (Ministry of Energy & Mineral Resources Republic of Indonesia 2018; Statistic Indonesia 2018). Here, the remote villages cover not only the coastal villages in islets but also the villages located inland on large islands but isolated from development areas. It is reported (Statistic Indonesia 2018) that the drinking water of 11.7% of households in Indonesia is not from safe water resources while around 35.2% of households buy bottled water as their drinking water. It is also reported by UNICEF & National Development Planning Agency Republic of Indonesia (2018) that coverage of basic drinking water service falls below 80% in most of the provinces in Indonesia. More information on the water situation and need in Indonesia is referred to in Wibowo & Chang (2019).

Indonesia has already set up a policy regarding water supply. As basic drinking water service is a primary need, it is supposed to be supplied by a governmental unit either at municipality or province scale, but this policy cannot cover the whole rural areas as yet. Private sectors are permitted to be involved in this business through the joint operation with governmental units. The latest amendment was issued in 2016 (Ministry of Home Affairs Republic of Indonesia 2016a) and allows the BOT (i.e., build, operate and transfer) scheme for private sectors. A tariff is set with the limitation of, at most, 4% of the standard municipality minimum income at which the water treatment system is installed (Ministry of Home Affairs Republic of Indonesia 2016b).

The problem in Indonesia is not the lack of water resources. Instead, it lacks safe fresh water in most of the remote areas of the country. A small-scaled water treatment system, which is

driven by solar energy and can produce clean fresh water, is suggested to be used in remote areas. However, in consideration of most residents in the remote areas, who are the interest to be addressed here, the issues of economic incentives including low capital cost, easy operation and less maintenance for the water treatment technologies, must be significantly taken into account in the study. A typical remote village in a rural area of Indonesia with the minimum basic water demand listed in Table 1 will be used in the study for demonstration. A simple economic analysis to estimate both cost investment and payback period is next made in the study. The estimated water price will be compared with the consumer price of bottled water, which is the major safe drinking water in the remote areas of Indonesia.

TECHNO-ECONOMIC ANALYSIS

Before the selection of an available small-scaled water treatment system, the fresh water demand and the energy demand for operating the water treatment system will be evaluated based on typical household population and the type of remote village. Once the available water treatment system and its sizing is determined, an economic analysis, which consists of estimating total investment cost, determining water production cost and estimating payback period, is next conducted to examine the feasibility of the system.

Water consumption of household activities in remote areas

For sustainable living, around 50 litres of fresh water is needed for personal daily activities including drinking,

Table 1 | Minimum basic water requirement

Minimum basic water requirement (litre per person per day)			
Drinking water	5	5.5	2
Sanitation	20	12.5	6
Bathing	15	30	20
Food preparation	10	2	18
Total water requirement	50	50	54
Source	Gleick (1996)	Howard & Bartram (2003)	Liu <i>et al.</i> (2018)

food processing, bathing and sanitation (Gleick 1996). The same quantity of fresh water for personal daily activities, but with different contributions in each term from that reported by Gleick (1996) (see Table 1), is found in the paper of Howard & Bartram (2003). A recent study by Liu *et al.* (2018) reported a water demand of around 54 litres per person per day for the generic population in islands (but excluding municipal water and other water demands). Table 1 compares different estimates of the minimum requirement from various references (Gleick 1996; Howard & Bartram 2003; Liu *et al.* 2018).

Remote area is defined as a place isolated from the development areas due to one or more factors including poor transportation accessibility, distance and geographical isolation (Ministry of Public Works & Public Housing Republic of Indonesia 2018). The villages in remote areas usually lack basic clean water services. It is reported (Máñez *et al.* 2012; Ministry of Maritime Affairs & Fisheries Republic of Indonesia 2015) that 47% of the coastal villages in Indonesia have access to sources of fresh water directly from rivers and lakes while the remainder, particularly those in islets (small islands), rely on collection of rainfall or groundwater without any treatment. In contrast, the prevailing methods of water collection in the remote villages located in the inland of Indonesia are mainly rainfall catchment and extraction from groundwater sources (Ayoub & Alward 1996).

Máñez *et al.* (2012) studied water scarcity in Spermonde archipelago, South Sulawesi, Indonesia which is located on the equator. One of the remote villages in this archipelago, Sangkarrang district Baranglombo village, has 1,270 households with an average household size of 3.6 (Sangkarrang 2019). This sizing information of households will be used in the following estimate of water demand and economic analysis.

Estimating water demand in remote villages

As seen from Table 1, different amounts of minimum basic water demand are reported. Here, the water demand per capita (w_n) is estimated by the median value in Table 1. Total water demand (WD_T) is calculated by:

$$WD_T = 365 \times w_n \cdot P_n \quad (1)$$

$$P_n = h \times P_{sv} \quad (2)$$

where h is the household size ($=3.6$), and P_{sv} is the household population per sub-village. Two kinds of remote villages are studied here. The remote villages inland usually have access to raw fresh water resources such as rainfall, rivers and lakes. The main water demand of the residents is for drinking and food preparation. In contrast, the fresh water demand of the residents in coastal villages of islets should cover the additional part for sanitization and bathing because such remote villages on islets almost only have access to seawater.

Water treatment technologies

The water treatment processes are mainly classified into two types (Al-Karaghoulis & Kazmerski 2013; Abdelkareem *et al.* 2018). One type is called distillation, through the evaporation mechanism, which is a physical change in the state of water, including multi-stage flash distillation (MSF), multi-effect distillation (MED), humidification dehumidification (HDH), vapour compression distillation (VC), etc. The other is filtration process associated with membrane technologies such as electro-dialysis (ED), electro-dialysis reversal (EDR), capacitive deionization (CDI), reverse osmosis (RO) and membrane distillation (MD). In addition, there are hybrid techniques which couple solar thermal application as an auxiliary thermal energy source and/or photovoltaic (PV) as an auxiliary power source with the distillation (Al-Karaghoulis & Kazmerski 2013; Sharon & Reddy 2015).

Among the available water treatment technologies, desalination is one of the most developed and widely used (Delyannis & Belessiotis 2010), which separates mineral parts from saline water to produce fresh water. At the end of 2016, the majority of commercial desalination plants were using filtration technologies: 73% membrane-based desalination, while the remainder used thermal desalination technologies (Ahmed *et al.* 2019). However, commercial desalination plants are mostly for large-scale production of clean fresh water which requires high input of thermal energy (for distillation-related processes) or constant replacement of membranes (for filtration-related processes). Since the present interest is focused on remote villages which have less population and poor geographical accessibility, in addition to lacking electricity, small-scaled, stand-alone water treatment systems with solar thermal

application, such as schematically shown in Figure 1, are selected for the following analysis.

The study of Al-Karaghoul *et al.* (2009) showed that frequent replacement of membrane and constant maintenance in the membrane-related water treatment system impacts water cost more than the thermal-related water treatment system. The study of Mnez *et al.* (2012) reported some failed projects using membrane technologies for water treatment in some remote villages due to the lack of spare parts of membrane and maintenance. Thus, the distillation-related water treatment technologies are considered in this study.

Keith & French (2019) studied clean water production using a purification and filtration process powered by solar energy. Nguyen *et al.* (2019) studied desalination of seawater using a hybrid system of the solar still associated with the Fresnel concentration technique and an electrical heating module. Banat & Jwaied (2008), as well as Omara *et al.* (2013), have studied the performance of small-scaled, stand-alone, solar-powered water treatment systems. Mulyanef *et al.* (2018) conducted an experimental study of the desalination process with solar still to produce fresh water in Padang, Sumatera, Indonesia. The study of Manju & Sagar (2017) demonstrated that the small solar energy integrated desalination system can work in areas where the water demand is less than 200 m³/day together with enough input of solar energy. The systems were split into three parts in their studies. The first part is a water treatment plant for processing raw feed water for distillation. The second part is the solar thermal field to gather thermal energy for supplying heat for distillation. The last part is the solar PV field to supply electricity as the auxiliary power for operating the whole system. In the remote areas where electrification ratios are normally low, the PV

system can be used to supply the required electricity (Abdelkareem *et al.* 2018). Figure 1 shows a schematic layout of these solar-driven water treatment systems.

Several kinds of solar collectors, which are responsible for providing thermal energy to the water treatment process, can be used from the available solar thermal technologies, including flat-plate collectors, evacuated-tube collectors, concentrating collectors, salinity-gradient solar ponds, etc. The auxiliary electrical power for operating the water treatment system can be supplied by integrating PV in the system.

Energy demand

Analysis is done with a small-scaled, stand-alone, solar thermal/PV water treatment system which is equipped with a simple distillation device: the solar still. Although the distillation efficiency of the solar still is low, it is a rather cheap water treatment system that is affordable in the remote areas. The solar condition is taken to be the same as that in Manado, Sulawesi Island, Indonesia which is rich in sunshine with an average daily global solar radiation of 4.97 kWh m⁻² (Solargis 2017). According to the study of Al-Karaghoul & Kazmerski (2013), the minimum energy requirement of water desalination for normal seawater of salinity equal to 33,000 ppm at 25 °C, calculated with the van 't Hoff formula, is 0.77 kWh m⁻³. This value will be used in the present analysis no matter what the feed water is, that is, from seawater or raw fresh water in either coastal or inland remote villages.

To estimate the electrical (auxiliary) power through use of PV for operating a water treatment system, several operating parameters should be set beforehand, which include 300 operating days per year, 8 hours' operation per day, and

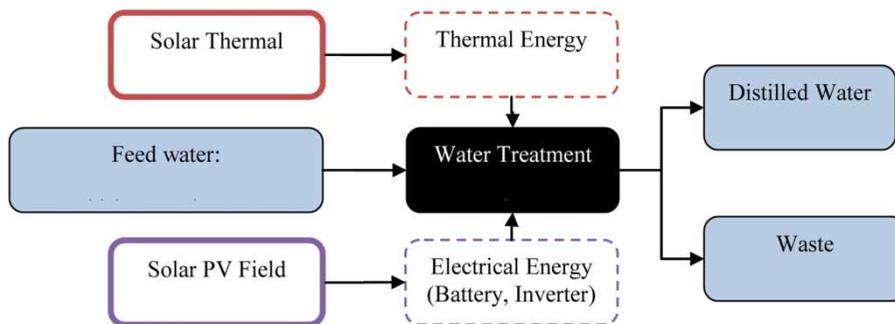


Figure 1 | Schematics of stand-alone small-scaled thermal/photovoltaic water treatment system.

clean water output of $2.74 \text{ m}^3 \text{ h}^{-1}$ and $9.13 \text{ m}^3 \text{ h}^{-1}$ for inland and coastal villages, respectively. In addition, the specification for the power requirement of a solar-powered pump with the capacity of $1.8 \text{ m}^3 \text{ h}^{-1}$, suggested by Chandel *et al.* (2015), is used in the calculation.

According to the results of Omara *et al.* (2013), the usual commercial solar thermal collector can yield a distillation flow rate of $3.3 \text{ litre hour}^{-1} \text{ m}^{-2}$. In addition, it is reported by Solargis (2017), that a typical crystalline silicon PV (with a nominal peak power of 1 kW), fixed at optimum slope angle, has the daily averaged conversion efficiency of $3.80 \text{ kWh kWp}^{-1}$.

Cost estimate

To evaluate accurately the cost for a water treatment system, many factors need to be taken into account, including the plant capacity, required equipment, feed water quality, pre-treatment, energy cost, system life cycle, investment amortization, etc. The major cost elements for the investigated water treatment system are cast into the capital and operating costs. The capital cost ($C_{capital}$) covers the purchasing cost of major and auxiliary equipment, land and installation charges. Since the present study is addressed at the remote areas, the land can be reasonably assumed as free charge. Thus, the capital cost is calculated with:

$$C_{capital} = C_{equipment} + C_{installation} \quad (3)$$

The annual total cost (AC_{total}) is calculated with the total yearly cost of owning ($AC_{capital}$) and the annual operating and maintenance cost ($AC_{O\&M}$) as:

$$AC_{total} = AC_{capital} + AC_{O\&M} \quad (4)$$

The analysis of the capital cost is made with the following conditions and information taken from other research which is recent and generic for the current study of desalination technology or engineering market in Indonesia:

1. The PV-module price is US\$5 per watt-peak (Banat & Jwaied 2008).
2. The solar still price is US\$100 per square metre.
3. The solar collector price per 6-m^2 of solar still is US\$450 (Omara *et al.* 2013).

4. The pump price is US\$1.054 per watt (Allouhi *et al.* 2019).
5. The installation cost is an estimated 25% of the purchased equipment costs.
6. Tax is 10% of total cost, as stated by the Indonesian government.
7. The market penetration, which indicates the proportion of the residents willing to use the clean fresh water generated by the suggested water treatment system, is estimated to be 80%.
8. Zero land cost, that is, free charge for using user-owned or government-owned land.

Among them, Assumption 7 is made ourselves, while Assumption 8 is reasonable in the remote areas.

The following values of common economic parameters are used in the estimate, based on generic information for the current study of desalination technology or the financial market in Indonesia:

1. The system life cycle, $n = 15$ year; which is same as the household's solar water heater.
2. The interest rate, $i = 8\%$.
3. The operating and maintenance costs are estimated to be 20% of the equipment cost.
4. Zero pre-treatment cost of raw water, that is, directly from nearby water sources.

Supposing that the required capital cost has to be lent by a bank, there will be an interest charge in the estimated capital cost. Amortization factor (a) is calculated with:

$$a = \frac{i(1+i)^n}{(1+i)^n - 1} \quad (5)$$

which implies the a value decreases along with the elapse year and is set to be zero at the end of the amortization period. By taking into account this factor, the total yearly costs of owning, and the annual operating and maintenance costs in Equation (4) are calculated as:

$$AC_{capital} = a \times (C_{capital}) \quad (6)$$

$$C_{O\&M} = 20\% \times C_{equipment} \quad (7)$$

$$AC_{O\&M} = a \times (20\% \times C_{equipment}) \quad (8)$$

It indicates that the salvage value of the system yearly decreases and finally drops to zero at the end of the amortization period.

The water cost (WC) is defined as the ratio of the total annual cost to the annual production of clean fresh water (annual plant capacity):

$$\text{Water Cost (WC)} = \frac{AC_{total}}{\text{Annual Plant Capacity}} \quad (9)$$

Note the above formulae and the given conditions/parameters are all in a linear relationship. The calculated annual total cost and annual plant capacity are proportional to the water demand. It results in the water cost defined in Equation (9) being independent of the water demand in the present study.

Estimate payback period

The information of payback period is a key factor to justify whether an investment is profitable or not. The payback period (PB) is calculated by:

$$PB = \frac{\sum_{k=1}^n C_{capital} + (C_{O\&M})_k}{\sum_{k=1}^n (\text{expected annual net cash flow})_k} \quad (10)$$

The expected annual net cash flows can be evaluated with the price of substituted clean fresh water such as bottled water and non-potable (municipal) water. However, it is agreed that the remote areas almost lack safely managed water services. Thus, bottled water is the only accessible clean fresh water which the residents living in remote

villages can purchase. Taking the bottled water price as the comparison basis, the payback period of the investigated water treatment system can be evaluated. Two conditions of the governmental policy are considered: with and without tax exemption in the following analysis.

RESULTS AND DISCUSSION

Water demand

Water demand is calculated with Equation (2) by taking $P_{sv} = 300$ (one sub-village consists of 300 households, taking Sangkarrang district Baranglombo village, Spermonde archipelago, Indonesia as the example in this study) and $h = 3.6$. Table 2 summarizes minimum water demands for the two kinds of remote village (either inland or islets). Note that the water demands estimated in the study are considered for the residents only and not for tourists.

System sizing

Taking into account the requirements for thermal energy and electricity, as previously specified, together with the information in Table 2, the energy demands are presented in Table 3. The sizes and capacities of the investigated water treatment system as schematically shown in Figure 1 are then calculated and recorded in Table 3 too.

System cost

Table 4 summarizes the calculated results of Equations (5)–(9) with the above conditions. It shows that the cost of

Table 2 | Water demand

Activities	Inland remote village (m ³)			Islet remote village (m ³)		
	Per capita (daily)	Per household (daily)	Per sub-village (annually)	Per capita (daily)	Per household (daily)	Per sub-village (annually)
Drinking water	0.005	0.018	1,971	0.005	0.018	1,971
Food preparation	0.010	0.036	3,942	0.010	0.036	3,942
Sanitation				0.020	0.072	7,884
Bathing				0.015	0.054	5,913
Total water requirement	0.015	0.054	5,913	0.050	0.180	19,710

Table 3 | Summary of the energy demand, sizing and capacity values used to estimate the cost

Sub-system	Inland remote village	Islet remote village
Energy (thermal) demand for desalination per day	15.2 kWh	50.6 kWh
Energy (electrical) demand for auxiliary per hour	2.04 kWh	6.8 kWh
Plant capacity (average) per day	19.7 m ³	65.7 m ³
Area of solar collectors	138.3 m ²	460.9 m ²
Area of solar still	829.6 m ²	2,766 m ²
PV-module	5.7 kWhp	19.2 kWhp

Table 4 | Calculated cost data of the water treatment system

Cost item	Inland remote village	Islet remote village
C _{capital} (US\$)	196,649	655,498
Amortization (yr ⁻¹)	0.11683	0.1168
AC _{capital} (US\$)	22,975	76,582
AC _{O&M} (US\$)	3,342	11,139
Total annual cost AC _{total} (US\$)	26,317	87,721
Water cost (US\$ m ⁻³)	4.45	4.45

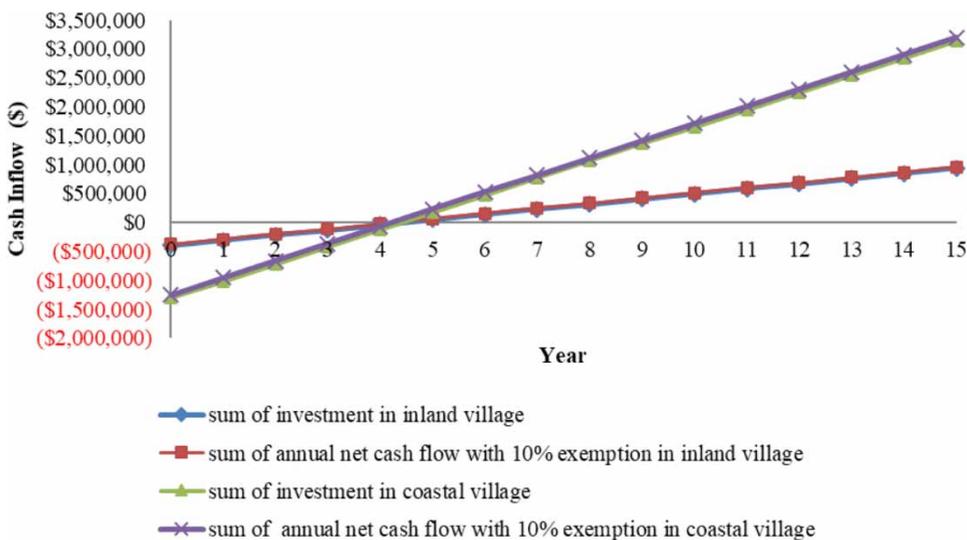
clean fresh water produced by the employed water treatment system is US\$4.45 per m³ for both the cases of inland remote village and coastal remote village. However,

the required investment in the case for the coastal remote village is remarkably higher (a multiple of 3.3) than that for the inland remote village (see Table 4) due to the higher demand for clean fresh water as shown in Table 2.

Survey of the current price of the refilled bottled water in the remote areas of Indonesia is around US\$19 per m³ (Ministry of Maritime Affairs & Fisheries Republic of Indonesia 2015) and US\$0.4 per m³ for municipal water (Makassar 2019). Evidently, the water cost which is evaluated from the investigated water treatment systems (Table 4) is remarkably higher than that of the municipal water but lower than that of bottled water. It is noted that the price of refilled bottled water would become higher, along with greater remoteness extent, than the average one surveyed by the government due to poorer transportation accessibility. It implies that the water cost with the suggested water treatment system would become more competitive than the price of bottled water in the significantly remote areas.

Payback period

The distributions of cash flows within the life cycle of the water treatment system (i.e., 15 years) for both the cases of remote villages in either inland or islet and each with and without considering tax exemption are presented in Figure 2. The payback period calculated from Equation (10) for each case is determined from the interception of the cash-inflows

**Figure 2** | Cash flows of proposed system versus year.

curve and the horizontal line of \$0.0 (representing zero net present value). Due to the linear dependence of either the annual total cost or annual production flow rate of clean fresh water with water demand, both investigated cases of remote village would have the same result for the payback period. In this study the payback periods determined, respectively, with the two tax conditions, that is, under the normal investment condition (without tax exemption) and an incentive condition with 10% tax exemption from the government, are calculated. The normal investment condition results in a payback period of 4.74 years. In contrast, the condition with 10% tax exemption applied to this water treatment system yields a slightly shorter payback period, 4.54 years. This discloses that the incentive of 10% tax exemption is less attractive to encourage the instalment of such water treatment system in the remote areas. It must be borne in mind that the total investment for the water treatment system in the coastal case is around three-fold of that in the inland case owing to higher water demand. One may argue that the water demands for bathing and sanitation do not need to be as high as the standards of fresh water for drinking and food preparation. If this concern is taken into account, the water demand for a safely managed service in the coastal remote villages becomes exactly the same as that in the inland remote villages.

As shown in Equation (10), the payback period is inversely proportional to the sum of the expected annual net cash flow, which is directly proportional to the price of bottled water. If the local price of bottled water (sold in the place where the suggested water treatment system was installed) was 10% higher than that adopted in the present study (US \$19 per m³) due to higher transportation cost (i.e., higher remoteness extent), the payback period could be shortened by 10%; in other words, it can be reduced from 4.54 years (with the case of 10% tax exemption) to 4.09 years.

The results of Table 4 and Figure 2 were calculated with the given assumptions. If the assumption for the system life cycle, for example, could last from 15 years to 20 years due to the better system quality and maintenance, the water cost would drop from US\$4.45 per m³ to US\$3.38 per m³. Consequently, the payback period could be shortened from 4.74/4.54 years (shown in Figure 2) to 4.42/4.22 years without/with considering 10% tax exemption. Furthermore, if the market penetration was decreased 10% more from the

current assumption (80%), the payback period would become 5.67/5.44 years without/with considering 10% tax exemption. Through these two examples, the sensitivity of the given assumptions on the predicted results in the study can be shown.

CONCLUSIONS

To ensure a hygienic living environment for residents in the remote areas, availability of clean fresh water is one of the primary needs. The clean water demand of the residents in the remote villages for drinking and food preparation is estimated at around 15 litres per person per day. In contrast, the fresh water demand of residents in the coastal villages of islets is estimated as around 50 litres per person per day because it should cover additional needs for sanitation and bathing in addition to those for drinking and food preparation.

In consideration of residents in the remote areas living mostly under the poverty line with poor geographical accessibility and lack of electricity, the criteria of low capital investment, easy operation and less need of maintenance must be taken into account in searching for a water treatment system. A small-scaled solar thermal/PV water treatment system which employs a simple distillation process of solar still is, thus, selected for the study. The household data and the solar resources in Spermonde archipelago, South Sulawesi, Indonesia are used as a case for the economic analysis in the study. It shows that the production price of clean fresh water through the use of the water treatment system is US\$4.45 per m³ for either the inland or coastal village with an assumption of a 15-year life cycle. This cost lies in between the water production costs, made with the solar still desalination, of US\$1.3 and US\$6.5 per m³, as reported by Al-Karaghoul & Kazmerski (2013) and Abdelkareem *et al.* (2018), respectively. Although the water production cost is significantly higher than that of the municipal water (US\$0.4 per m³, in Indonesia), it is competitive with the consumer price of bottled water (US\$19 per m³), which is the most accessible safe drinking water in the remote areas of Indonesia. Taking the price of bottled water as the comparison basis and with the assumptions made in the study, the payback periods fall below five years, as shown in Figure 2, for the investigated cases of

remote villages considered with and without tax exemption. If the consumer price of bottled water was further increased due to the extent of greater remoteness (in other words, poorer transportation accessibility), the suggested small-scaled water treatment system powered by solar energy would be more competitive than the present analysis.

The study reveals that the incentive of 10% tax exemption is less attractive to encourage such investment of water treatment system in the remote areas since the residents mostly live under the poverty line. More attractive incentives such as a subsidy scheme could be considered to promote the suggested idea in the remote areas of Indonesia in the future. However, the suggested idea in the study is limited to the remote areas with a richness of sunshine and not lacking in water sources, no matter what they (sea water or dirty raw fresh water) are.

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First received 22 December 2019; accepted in revised form 20 March 2020. Available online 4 May 2020