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Review Article

Synergies and potential of hybrid solar photovoltaic for enhanced desalination: A review of selected countries

Dwiprayogo WIBOWO[*1,2], Raldi Hendrotoro SEPUTRO KOESTOER[1]

[1]*School of Environmental Science, Universitas Indonesia, Jl. Salemba Raya Kampus UI Salemba, DKI Jakarta, Indonesia*
[2]*Department of Environmental Engineering, Universitas Muhammadiyah Kendari, Faculty of Engineering, Southeast Sulawesi, Indonesia*

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ABSTRACT

In an effort to construct a desalination pilot plant, a study of several kinds of literature is needed to ensure Indonesia develops advanced and environmentally friendly desalination technology. This research aims to explore several research papers referenced in developing the desalination pilot plant to gain information on environmentally friendly and sustainable desalination technologies in selected countries such as Spain (Burriana), Mexico, Chile, the Philippines, and Iran (Kish Island), including in the Middle East and North Africa (MENA) region on the development of desalination technology for environmentally friendly and sustainable-based communities. This research used a systematic literature review (SLR) approach emphasizing secondary information from several studies based on selected countries to develop desalination technology. Each technology developed is examined for suitability with environmental conditions and desalination technology to be further applied in Indonesia. The main reason for building desalination plants in selected countries is to support sustainable development based on green energy and technology. They are combining desalination technology with photovoltaic (PV) electrical energy, which is a critical factor in promoting green technology through electrodialysis (ED) or reverse osmosis (RO) techniques. The developed desalination pilot plant can achieve 7–14 L/(m^2.h) productivity at approximately 0.36–0.78 USD/m^3. If implemented in Indonesia, it is necessary to prepare financial support to construct, operate, and maintain. Desalination technology in Indonesia should prioritize environmentally friendly technology. Indonesia's topographic region is a golden advantage to supporting sustainable green energy by utilizing PV-RO or PV-ED-RO to create fresh water from seawater.

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INTRODUCTION

Desalination technology in various countries supports the sustainable development goals (SDGs) to reduce the clean water crisis and ensure proper sanitation for communities [1, 2]. In addition, it also commits to developing clean and renewable energy to ensure that it supports sustainable development [3, 4]. Aende et al. [5] reported that desalination plants worldwide have significantly increased to improve the quality and quantity of treated freshwater and anticipate the threat of climate change. In 2020 more than 22,000 desalination plants worldwide

***Corresponding author.**
*E-mail address: dwiprayogo@umkendari.ac.id

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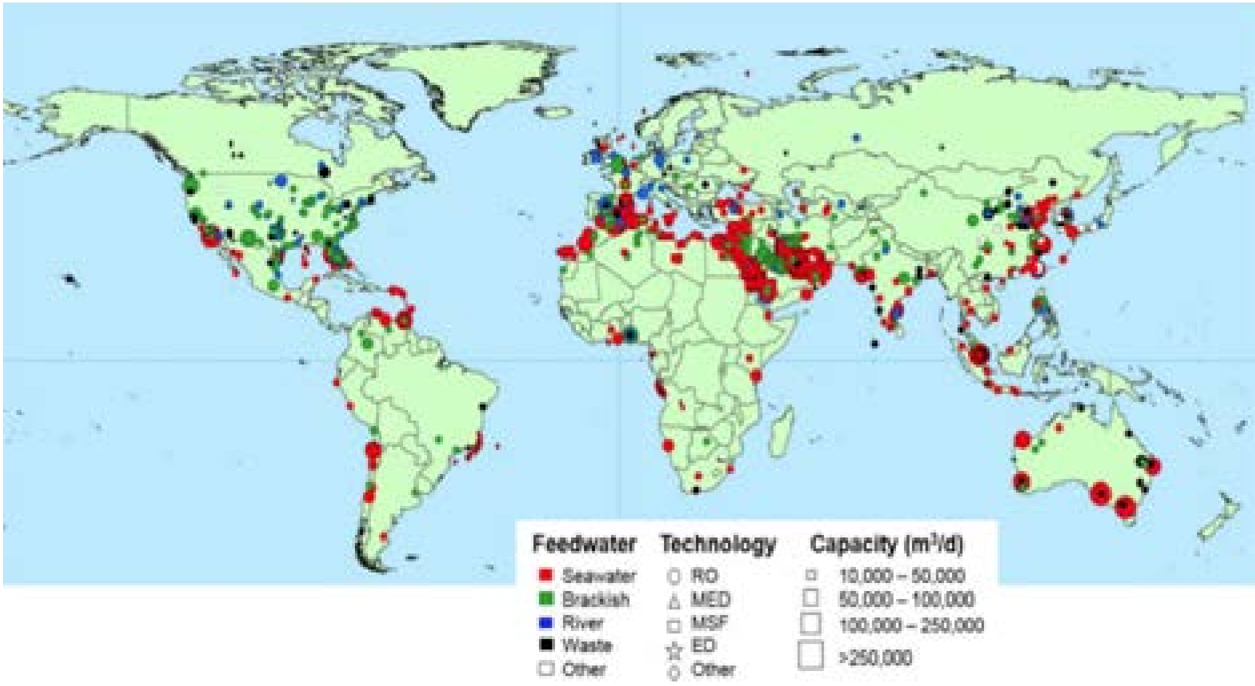

Figure 1. 2020 worldwide desalination plants reviewed by [11, 16].

were constructed and produced around 92 million m^3/day of fresh water, dominated by European and Middle East and North Africa (MENA) countries [6, 7]. These countries have innovated desalination technologies to reduce environmental impacts, such as applying renewable energy, minimizing waste and pollution, using environmentally friendly technologies, and paying attention to environmental sustainability [8, 9].

Environmentally sound desalination technology research from European and MENA countries can provide invaluable lessons for developing countries, particularly in Indonesia. The Indonesian government is also committed to encouraging the construction of desalination plants to build more efficient and environmentally friendly technologies [10, 11]. These will have a significant beneficial impact on taking lessons and some suggestions from desalination technologies developed in selected countries such as Spain (Burriana) [12], Mexico [13], Chile [11], Iran (Kish Island) MENA region [14], and the Philippines [15] to evaluate the feasibility of implementing desalination technologies in Indonesia.

Therefore, this paper aims to provide an overview of the development of desalination technology that has been implemented by researchers in selected countries so that it can be a lesson for Indonesia to start developing environmentally friendly and sustainable energy-based desalination technology. In line with the review of the progress of desalination technology applied, it can provide understanding for the community to support sanitation and technological advances jointly. Of course, this needs to be based on technological advances that will be developed to support environmental sustainability for the people of Indonesia.

MATERIALS AND METHODS

This research uses a systematic literature review (SLR) method by searching for several recent articles on desalination technology studies in various countries such as Spain (Burriana) [12], Mexico [13], Chile [11], Iran (Kish Island) in the MENA region [14], and the Philippines [15] are building desalination pilot plants. The selected countries as an example for review because they are strongly interested in developing desalination capabilities and addressing water scarcity issues. This is based on their geographical location, which experiences high evaporation rates, leading to increased droughts and clean water crises. They are interested in studying electrical efficiency and advancing desalination technology to gather information on environmentally friendly technologies. We explored several research papers referenced in developing the desalination pilot plant to gain information on environmentally friendly and sustainable desalination technologies. Figure 1 shows the distribution of desalination plants worldwide in 2020, reviewed by Cornejo-ponce et al. [11] and Jones et al. [16] are the main reasons why we studied the selected countries to examine the development of the technology.

Specifically, this SLR research observed and collected quantitative data from selected sources, such as articles, original reviews, and trusted websites. This method relied more on qualitative descriptions as we presented a study on the positive and negative impacts of the desalination technology they developed for implementation in Indonesia. An important factor in building desalination pilot plants in other countries is the model the Indonesian government can learn from to build desalination technology based on a sustainable environment.

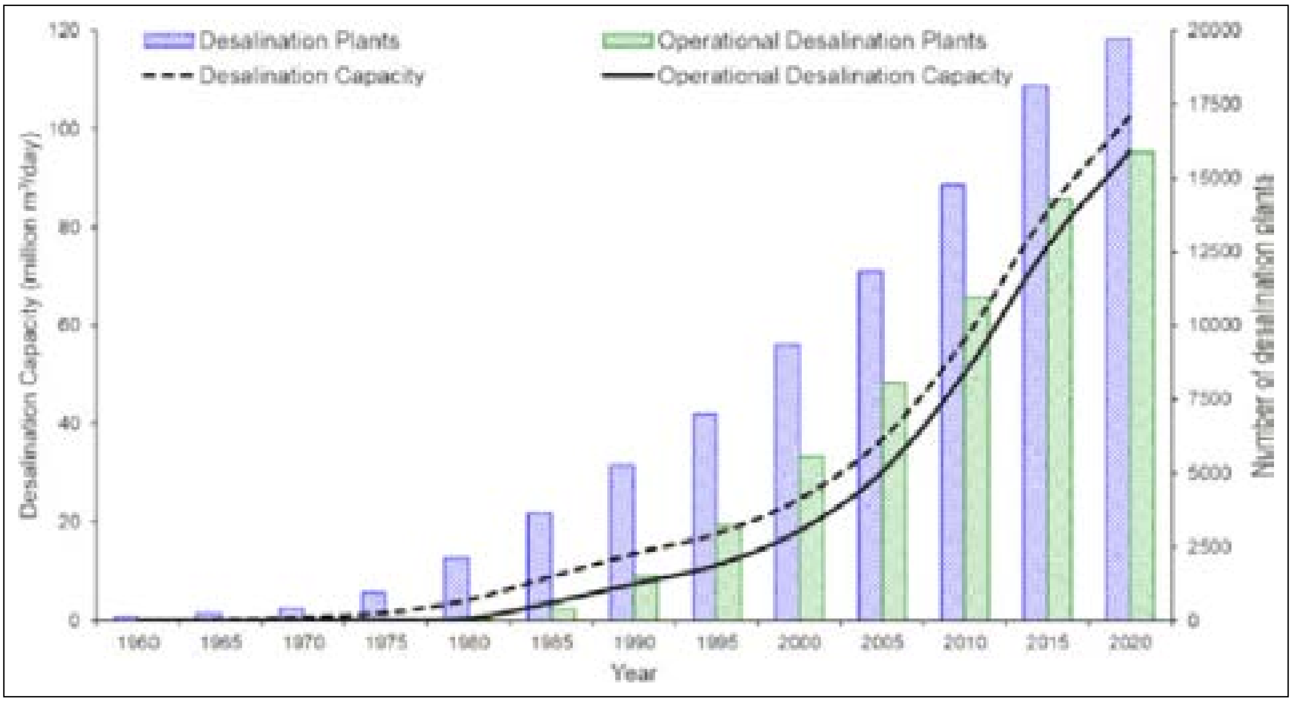

Figure 2. World desalination growth from 1960 to 2020 [5].

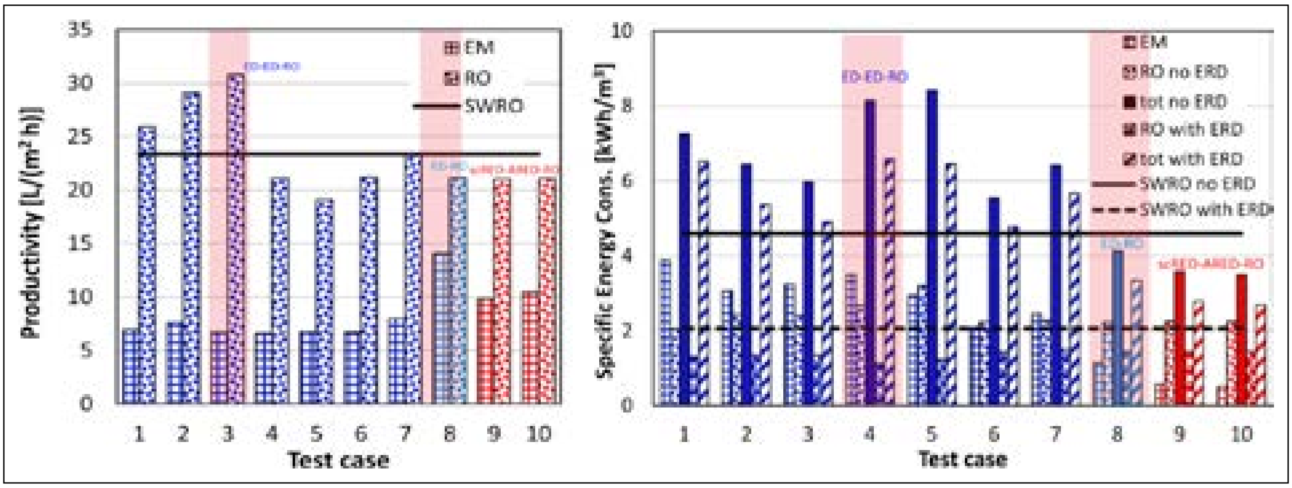

Figure 3. Results of desalination tests in Burriana (Spain) by [12]: (a) ED-ED-RO, (b) ED-RO, (c) scRED-ARED-RO, (a) Productivity comparison, and (b) Energy consumption.

RESULTS AND DISCUSSION

Review of Desalination Technology in Selected Countries

The development of desalination technology worldwide has continued to increase from 1960 to 2020 [5]. Desalination technology development focuses on the operational level, production capacity, and desalination capacity (Fig. 2). Some of the technologies developed depend highly on the type of technology used, the scale of production, and available resources such as energy and seawater used as raw materials [17]. The main objectives in establishing and developing pilot plant desalination technologies are low operational rates, requiring less energy, and having smaller production capacities than other desalination technologies [18]. In our review, the operational level, production capacity, and desalination capacity, the economic desalination technologies reverse osmosis (RO) and electrodialysis (ED) are widely developed because they are considered economical and environmentally friendly.

Technology developed in Spain (Burriana), the study conducted by Gurreri et al. [12] entitled "*Coupling of electromembrane processes with reverse osmosis for seawater desalination: Pilot plant demonstration and testing*" have designed a new innovative technology of seawater desalination pilot plant built inside a container (Fig. 4a) that aims to address the growing problem of freshwater access in the Spanish region. They created the desalination technology by combining ED-RO technology to optimize the process synergistically. In general, the energy consumption of the ED-RO integrated pilot plant is almost comparable to the performance of a seawater reverse osmosis (SWRO) system (Fig. 3a). The developed ED-ED-RO integrated system can produce better quality drinking

Figure 4. Desalination technologies installed and tested in several studies; **(a)** Burriana, Spain [12], and **(b)** Mexico [13].

water of 31 L/m^2.h at a reasonably high energy rate between 3.5–8.4 kWh/m^3. The disadvantage of this system is that ED technology increases electrical energy consumption compared to only the ED-RO system (Fig. 3b). The manuscript suggests that using ED-RO technology is sufficient to solve the water crisis by producing safe and clean drinking water from seawater in a more energy-efficient and affordable way [12]. Desalination water treatment processes are becoming more competitive in terms of consuming less energy and being less harmful to the environment [19]. However, Spain pays more attention to the context of water supply outcomes rather than resource management. Therefore, desalination technology in the Spanish state is constantly being improved to cater to a more excellent water supply.

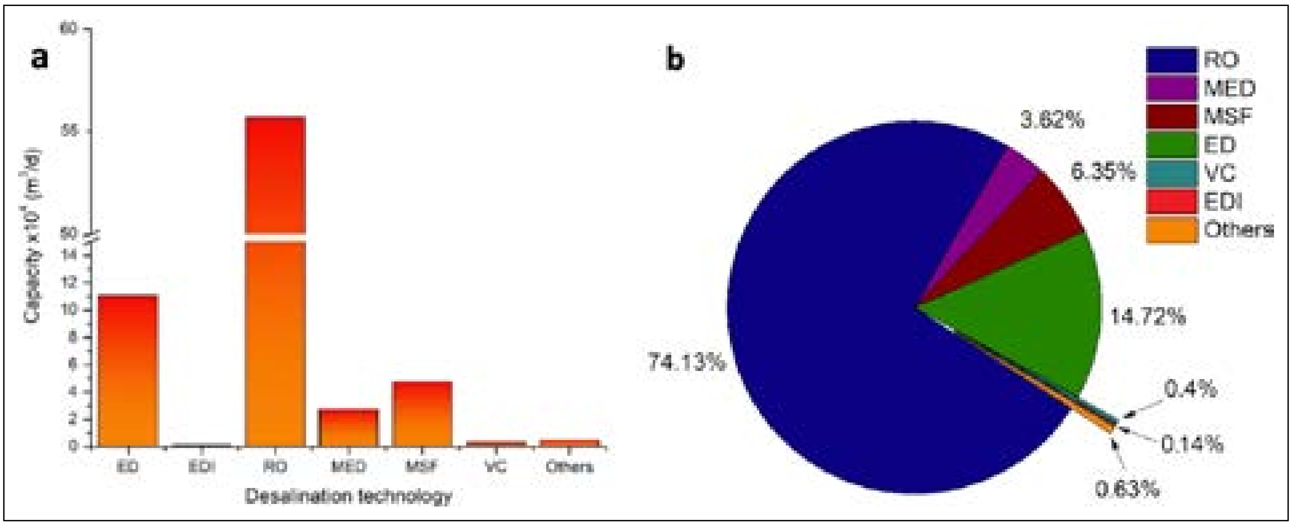

Figure 5. Desalination in Mexico; **(a)** Installed capacity per type in 2022 **(b)** Percentage of installed capacity by technology [23].

In a review study by Gurreri et al. [12], the ED process can reduce RO membrane fouling, extending RO membrane life and minimizing repair costs. However, Gurreri et al. [12] needed to explain the negative impacts of the developed technology and the strategic location for deploying the developed desalination technology. Although the developed technology is highly efficient and easily mobilization is strategically implemented, the community factor determines the sustainability of the developed desalination technology. Techno-economic factors that affect the reciprocal relationship between technology and the economy must also be explained. A limitation of the technology that has yet to be described is the cost of building a sophisticated desalination technology in a container (Fig. 4[a]). In addition, the source of electrical energy is not widely associated with environmentally friendly technologies [20]. Although the developed technology is excellent in that the average ED-RO productivity is 7–14 L/(m^2.h), it requires specialized space and adequate human resources to operate the desalination pilot plant. In addition, the negative impacts of implementing the desalination technology in Burriana are the high operational costs and space requirements for the location of the desalination plant have also not been considered if it is implemented in coastal areas and its very high maintenance.

In contrast, the desalination technology developed by Cervantes-rend et al. [13], entitled "*Rural Application of a Low-Pressure Reverse Osmosis Desalination System Powered by Solar-Photovoltaic Energy for Mexican Arid Zones*" has built a sustainable desalination energy by combining solar panels and reverse osmosis (PV-RO) that is low-cost and easy to operate (Fig. 4b). The desalination investment costs incurred by the researchers are proportional to the results obtained during one year of productivity. Cervantes-rend et al. [13] also recommended that low-pressure RO desalination systems produce lower energy consumption and higher water recovery rates. These systems can be developed by utilizing PV energy, a clean and renewable energy source abundant in arid zones. PV in desalination systems can be used independently to distribute electrical power and reduce dependence on fossil fuels [21, 22]. The potential desalination model developed by Cervantes-rend et al. [13] involves several steps including PV modules that are firmly installed to withstand the strong winds in the area that can reach 79 km/hour. Then, the PV-RO system is connected to hydraulic and electrical parts to drive the RO technology. The engineered desalination model developed by Cervantes-rend et al. [13] is very feasible to develop at low cost and suitable for coastal islands.

In Mexico, the application of RO technology has achieved an optimal capacity of clean water of 52×104 m^3/s (Fig. 5a) [13]. The Mexican government strongly supports innovations made by Cervantes-rend et al. [13] to continue innovating to reduce atmospheric gas emissions by utilizing PV as a driver for desalination technology. This is one of the main reasons why Mexico continues strengthening ways to get clean water using desalination technology. Some of the technologies used in desalination plants in Mexico (Fig. 5b) include reverse osmosis (RO), multiple effect distillation (MED), multi-stage flash (MSF), electrodialysis (ED), vapor compression (VC), electro-deionization (EDI), and others.

Cornejo-ponce et al. [11] also stated the same condition in their publication "*Small-Scale Solar-Powered Desalination Plants: A Sustainable Alternative Water-Energy Nexus to Obtain Water for Chile's Coastal Areas*" which examines small-scale desalination technology in coastal areas of Chile. Cornejo-ponce et al. [11] suggested increasing sustainable alternative energy to obtain clean water. The technology developed in Chile is more about applying RO technology to obtain fresh water. They also added PV as a source of electrical energy to power the electric pump (Fig. 10). Utilizing solar energy to reduce the impact of fossil energy dependence and the role of the community is also needed to support the sustainability of PV-RO to supply fresh water from seawater [21, 22]. In this context, saltwater becomes one of the essential non-conventional water resources to be developed in Chile. Research conducted by Cornejo-ponce

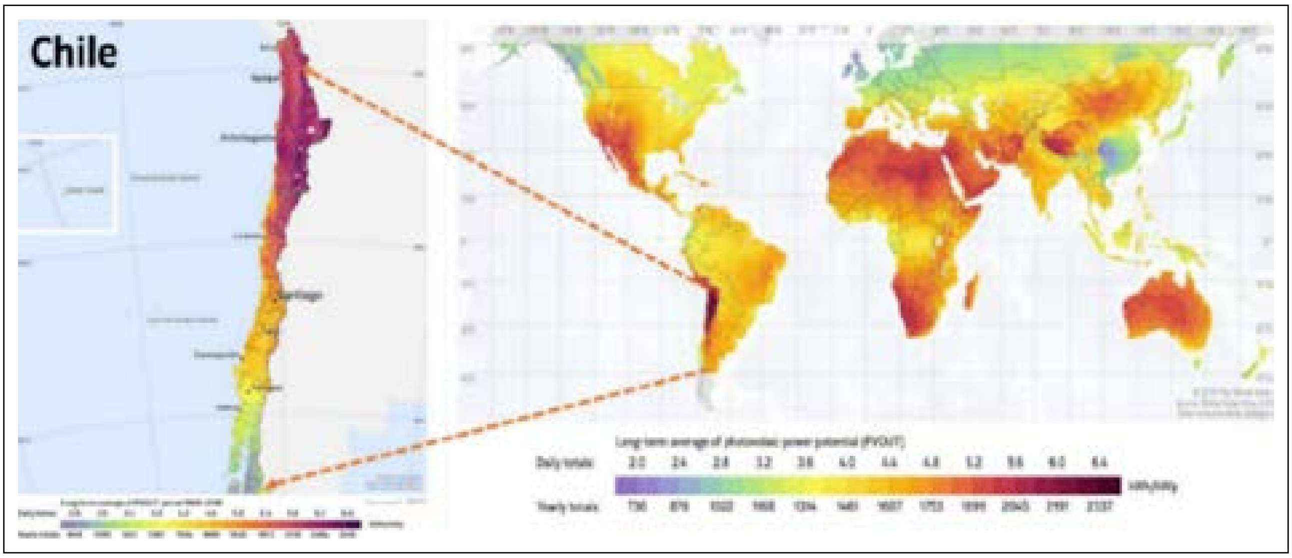

Figure 6. Map of solar photovoltaic resources in the world and Chile [11].

et al. [11] has simulated photovoltaic/desalination energy to harness solar power to build small-scale desalination plants in the coastal areas of Chile (Fig. 6).

The application of PV in Chile provides an average energy increase of 6.4 kWh/kWp per day to supply electrical energy to the desalination plant using solar energy (Fig. 6). This paper has yet to describe the model and long-term negative impacts of using PV for desalination applications on coastal communities. Given that small-scale desalination plants require maintenance and impact on the environment. The arid and hot northern region of Chile needs to review the feasibility study of the durability of the PV used.

Research conducted by Riyahi et al. [14] entitled "*Energy analysis and optimization of a hybrid system of reverse osmosis desalination system and solar power plant (case study: Kish Island)*" identified the integration of solar power plants with RO desalination systems to supply fresh water on Kish Island, Iran. Riyahi et al. [14] identified the energy and production and optimized the performance of a hybrid system compared to a conventional method using diesel-powered electrical energy. The study results explained that the optimal configuration of the developed system includes a solar power plant with a capacity of 2MW and an RO desalination system with a total of 10,000 m^3/day that can meet the water demand with an annual average solar fraction of 72% with a PV-RO construction cost of about $11.6 million, and when compared with the conventional system of diesel-powered electrical energy of $18.4 million. Based on the economic analysis, the hybrid system provides significant cost savings compared to a traditional diesel-powered system. The payback period for the hybrid system is about five years, while the payback period for the conventional method is about nine years. Overall, this study concludes that a combined PV-RO system is a viable and sustainable solution for supplying freshwater to Kish Island, with the potential to be applied in other coastal areas with similar conditions.

Suggestions include energy analysis and optimization by estimating energy requirements for desalination and planning a solar power plant that can provide electrical energy based on solar irradiation data [25]. Kish Island receives about 1900 kWh/m^2 of electrical energy per year from PV panels and it can support electrical power to RO technology (Fig. 7). Then build an RO desalination system with energy efficiency and optimize the PV-RO coupled system to maximize system efficiency and minimize costs. The strategic condition of Kish Island is the reason for the opportunity to develop desalination technology [26]. In addition, Kish Island is located in the Persian Gulf, where temperatures can reach 45°C during summer and water salinity is high. Therefore, the Iranian government supports high capability and determination to become a solid industrialized country; desalination technology has gradually become an important instrument to promote the country's development [27].Developing PV-RO technology is a practical study that integrates renewable energy to be sustainable. PV-RO can be considered as an economical technology where the desalination cost ranges from 0.883–2.14 $.$m^3$. In addition, this technology is also considered competitive for green energy as it does not rely on fossil fuel energy for its electrical energy supply [28].A study in a developing country such as the Philippines by Peter et al. [15] entitled "*A review of desalination technologies and its impact in the Philippines*" explained that the Philippines also started innovating desalination technology development. The beginning of the development of MED system desalination technology from 2012 to 2016 with a target of distributing clean water to 6 million people using simple flotation, filter, aeration, and ultrafiltration technologies. From 2017 until now, the Philippines developed RO and disinfection technology to optimize the need for clean water free of bacteria and harmful chemicals [15]. The study described by Peter et al. [15] the importance of assessing the potential impacts of desalination by discharging brine and other chemicals into the ocean and energy consumption. They explained that the

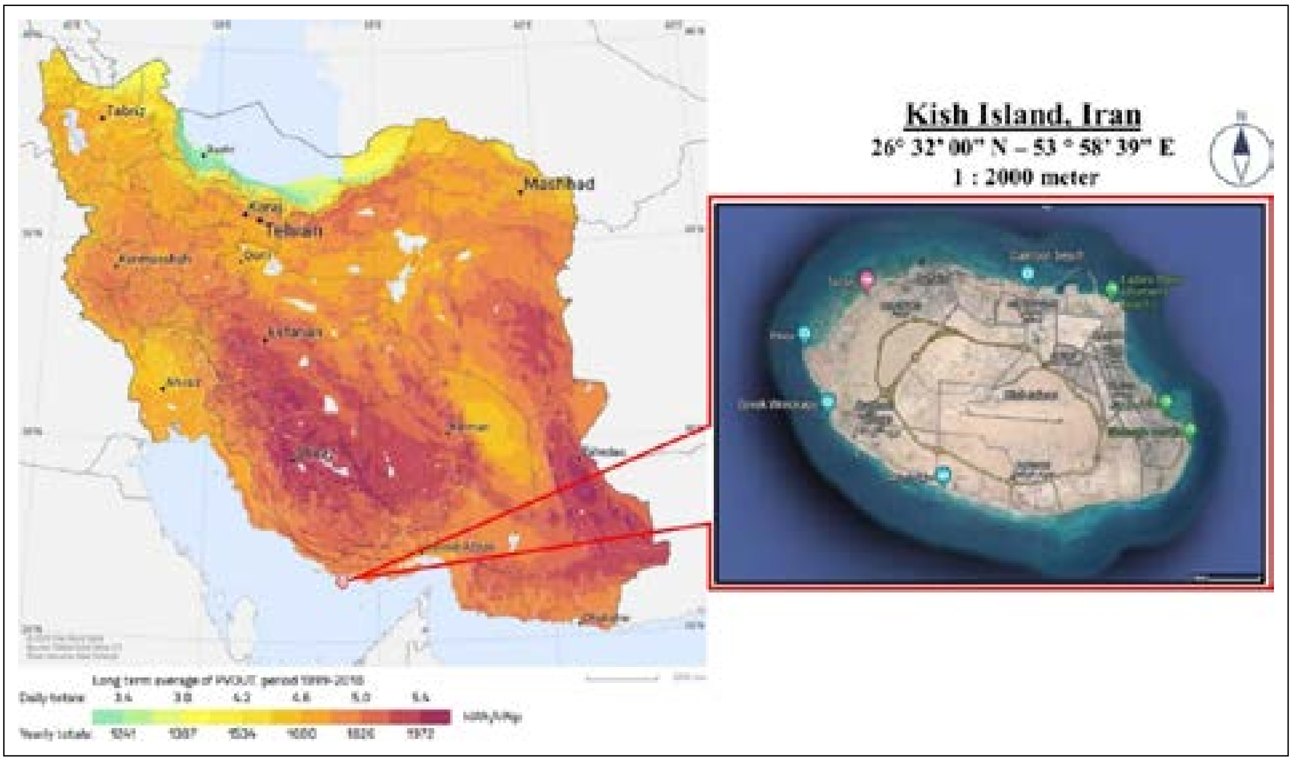

Figure 7. Location and intensity conditions of photovoltaic power potential of Kish Island (Iran) (Modified from [24]).

feasibility study of clean water after the desalination process should be identified physical, chemical, and biological parameters to be safe for use by local communities.

The paper emphasizes the need to carefully plan and manage desalination projects to minimize environmental impacts [15]. In 2021, the finalized desalination technology was developed in the Philippines and produced 1000 L/day using seawater. The suggested technologies utilized include thermal distillation and membrane processes. Thermal distillation involves boiling seawater and collecting the condensed vapor, while membrane processes use semipermeable membranes to filter out salts and other minerals [22, 29]. Even though desalination technology in the Philippines has yet to fulfill the need for clean water fully, it is a promising solution for communities experiencing water shortages and poor water quality. It is essential to carefully consider desalination's environmental, economic, and social implications to maximize its benefits and minimize its potential negative impacts.

Economic Feasibility and Mitigation Practices

Economic feasibility based on solar-powered desalination systems can be improved through several strategies. The PV modules combined desalination technology-based RO process performed well compared to other techniques. To improve the economic feasibility, firstly, reducing the cost of PV modules to provide an attractive option for renewable energy use in water treatment under simple desalination technology. When solar photovoltaic systems power RO desalination facilities, they can reduce the specific energy consumption from fossil energy by about 10%, reducing the total water cost [30]. Secondly, prospering site analysis, including the water storage or salinity issue, available resources (electricity, membranes, gas reservoirs, solar energy), and the requirement of desalination plants (small or large), should be performed in the area that needs fresh water [31, 32]. This will allow the introduction of area-specific efficient, and cost-effective desalination methods. Several of the largest desalination plants in the MENA region studied by Maftouh et al. [33] explore that the RO process has exhibited exemplary performance with low-cost efficiency for seawater as feedwater, with a daily production capacity of 540,000 m^3 and costs of \$0.585/m^3. In addition, studies conducted by Cai et al. [17] explain that the RO cost is relatively low due to small investment in RO equipment and low energy consumption (4–6 kWh/m^3). The cost of freshwater production for RO is about US \$0.45–1.72/m^3 [34]. This is lower than other methods, such as Multi-Stage Flash (MSF) and Low-Temperature Multi-Effect Distillation (LT-MED), mainly due to the small investment in RO equipment and relatively low energy consumption (e.g., 4–6 kW h/m^3). The large amount of electricity consumption in the desalination system is the main reason for the high cost. Therefore, to control the production costs of RO desalination, there is a need to reduce the cost of materials, increase the rate of water harvesting and freshwater production, and replace obsolete RO equipment promptly.

The other challenge is minimizing desalination's negative impacts and the prospect of sustainable and eco-friendly desalination. Current desalination approaches have moderate and non-negative environmental impacts. However, with proper mitigation and utilization of modern technol-

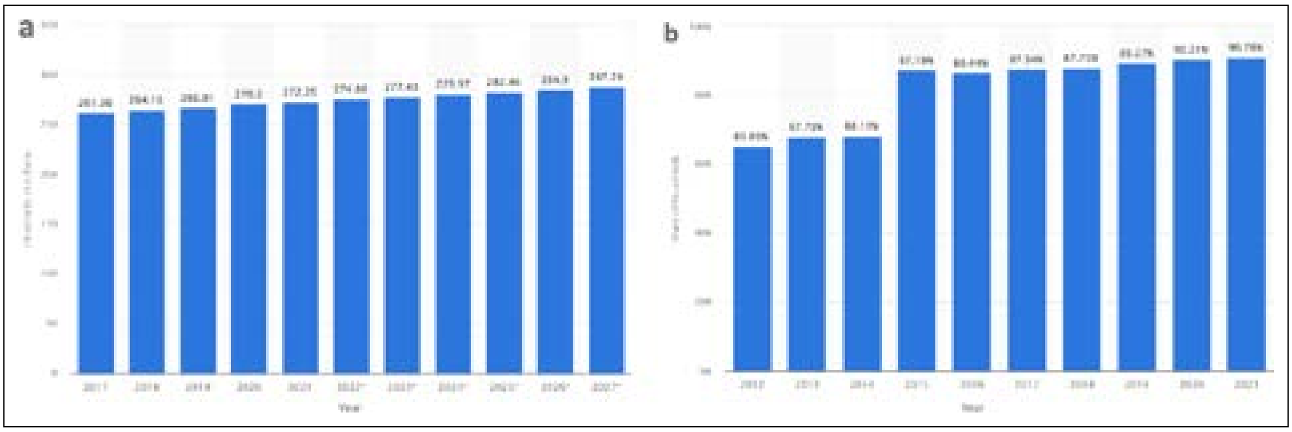

Figure 8. **(a)** Predicted population of Indonesia from 2017 to 2027, and **(b)** Drinking water consumption in Indonesia from 2012 to 2021 [37].

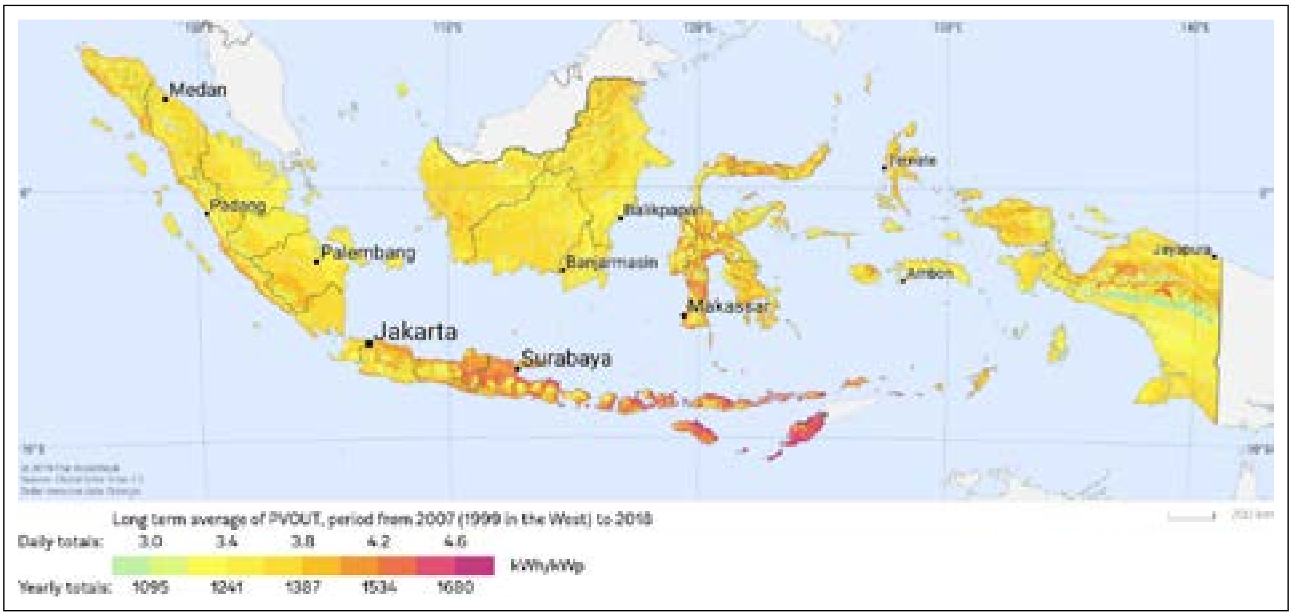

Figure 9. Potential for solar-powered in Indonesia [42].

ogies, these impacts can be reduced by using various beneficial techniques while reducing adverse impacts [35]. Recent advancements in desalination technology have also offered many alternative approaches that provide avenues to adapt to more environmentally friendly desalination. Based on the study results, Ihsanullah et al. [35] explained that the primary concern of SWRO is several environmental challenges that need to be considered, such as its potential impact on marine ecosystems and the disposal of saltwater waste. In addition, the effect of solid waste, such as corrosion and cleaning process chemicals, can also affect environmental pollution. Several mitigation measures and best practices can be implemented to address the ecological impacts of SWRO desalination, such as proper site selection, brine management, environmental monitoring, research, and innovation. High salinity brine discharge can be utilized for salt crystal production to open opportunities in national salt production into a sustainable circular economy study.

Lessons for Indonesia

Currently, desalination technology in Indonesia is similar to the Philippines. Indonesia focuses on providing fresh water for visiting tourists, where the background of desalination development is the same as Kish Island, which prioritizes tourists. Several desalination pilot plants in Indonesia have been built in Ancol (North Jakarta) and Labuan Bajo Island as tourist destinations for tourists visiting Indonesia [36]. Some of the roles of the Indonesian government in providing financial support and incentives for sustainable desalination projects contribute best to the availability of clean water in some remote islands. But this time, the Indonesian government has not 100% allocated financial support to build desalination projects due to the high cost, intensive maintenance, and unprepared human resources. The government only provides regulatory and administrative support to accelerate equitable development and welfare in some small islands. In Indonesia, many desalination projects are developed by private companies to support industrial develop-

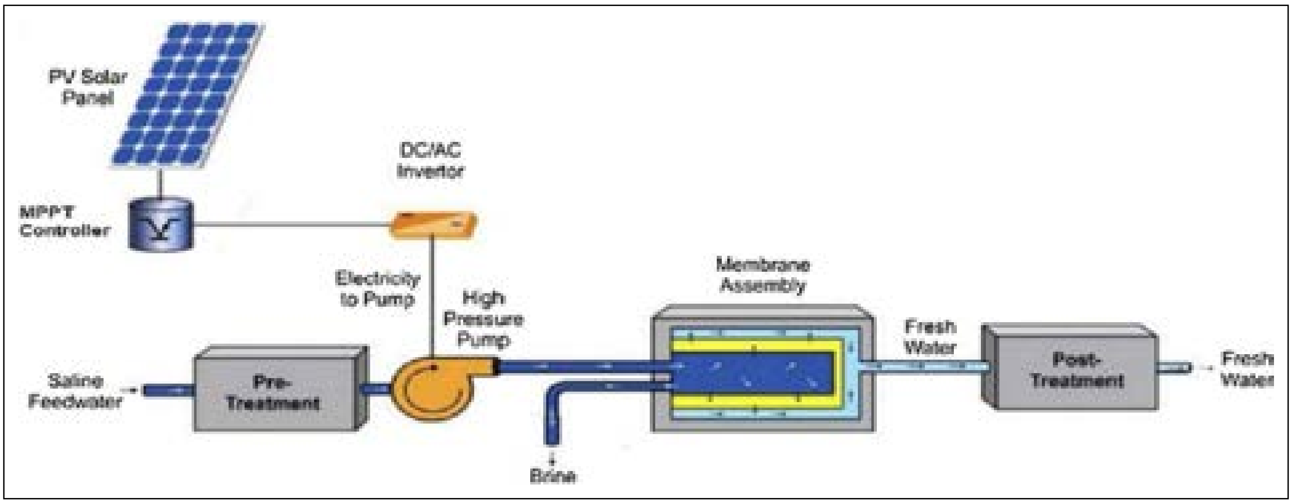

Figure 10. Schematic of reverse osmosis-direct photovoltaic connection system [14].

ment such as mining, logistics, and tourism. The last option is to provide clean water services to the community around the company as a form of corporate social responsibility.

Although Indonesia has abundant natural resources, the community still needs to meet fully the clean water condition. The Central Bureau of Statistics reports that the achievement of clean water access in Indonesia has only reached 72.55%, below the SDG's target of 100% [38]. The demand for clean water increases every year and is proportional to the increase in population (Fig. 8a). Currently, the estimated population of Indonesia is 277.43 million people, with a demand for clean water in 2020 of 90.21% and 2021 of 90.78%, resulting in an annual increase of 0.57% (Fig. 8b). In fact, Indonesia and the Philippines still rely on surface water and groundwater, resulting in land subsidence. Semarang and Jakarta are categorized as coastal cities experiencing land subsidence, one of which is caused by groundwater exploitation [39].Based on reviews from several researchers from other countries to reduce the use of fossil-fueled electrical energy to power desalination instrumentation, Indonesia should be able to utilize PV for renewable energy. Although, regulations in Indonesia have been stated in Government Regulation No. 79 of 2014 on National Energy Policy and Law No. 17 of 2007 on National Long-Term Plan 2005–2025 to support national energy growth. Indonesia has committed to supporting renewable energy at more than 23% of total energy consumption and reducing fossil fuels to less than 25% [40].

While desalination technology can solve water scarcity in Indonesia, its implementation should be sensitive to the social and cultural contexts of local communities and indigenous populations. Government Regulation under the Ministry of Marine and Fisheries of the Republic of Indonesia No. 1/PERMEN-KP/2020 also has committed to supporting the freshwater facilities in small islands that do not have clean water reserves to fulfill their daily needs. Desalination is a potential technology for helpful water scary by transforming seawater or brackish water into fresh water [31]. The potential impacts on local communities and indigenous populations might require land acquisition, changing the cultural habits, livelihoods, and ecology [41]. Moreover, to successfully implement decentralized desalination systems in rural and remote areas, a holistic approach is required including technical feasibility assessments, community engagement, capacity building, financial support, and considerations for long-term sustainability. Collaborative efforts involving local governments, non-governmental organizations (NGOs), technical experts, and communities are essential to navigate these challenges and unlock the potential benefits of decentralized desalination systems.

PV-RO technology developed in areas that have a high amount of light energy such as Indonesia has the potential to support sustainable desalination technology. Based on the intensity of sunlight to improve PV performance (Fig. 9), the total average daily photovoltaic power in Indonesia reaches 3.8 kWh/kWp. This condition can clearly drive desalination instrumentation with a daily requirement of 3.5–8.4 kWh, as researched by Gurreri et al. [12]. Schematic model of PV-RO installation as reviewed by Riyahi et al. [14] (Fig. 10), PV contributes electrical energy to drive the high-pressure pump in the RO system. The utilization of PV supports sustainable energy and technologies that do not expect fossil energy as a source of electrical energy.

Regarding desalination in Indonesia, Dewita et al. [40] also made a nuclear desalination concept that is very effective for driving desalination technology. Nuclear plays a role in increasing the temperature of seawater to start the evaporation process and stored in freshwater tanks. Unfortunately, nuclear-based energy is still debated by some people regarding the safety factor of nuclear reactors. Indonesia is a region that often experiences earthquakes, which can easily cause accidents and damage nuclear reactors. In addition, they also suggested that renewable energy for RO desalination technology could use wind energy or PV as a power source to drive the RO pump. The role of Indonesian government should take steps in preparing policies and budgets to start implementing desalination technology to provide improved sanitation and quality of life, especial-

Table 1. Summary of desalination technology recommendations from selected countries as lessons for Indonesia

No.	Selected country recommendations	Lessons for Indonesia
1	Need to increase environmental conservation efforts; desalination technology should prioritize ecological sustainability to reduce emissions.	Indonesia should slowly start developing desalination technology to achieve 23% of total energy consumption and reduce fossil fuels to less than 25% by 2025–2030.
2	Fossil-dependent electrical energy supply is slowly being replaced with PV to utilize solar energy as an environmentally friendly sustainable energy source.	In 2025–2030 Indonesia seeks to utilize energy from PV to power desalination instrumentation with a daily requirement of 3.5–8.4 kWh according to the intensity of PV sunlight.
3	The topographic region is critical in implementing sustainable energy as a renewable electrical power source. Sufficient sunlight irradiation can improve the high-performance of PV instruments.	Indonesia has a strategic topographic area between the equator with a 40–52% solar irradiation intensity, making it very suitable for PV electrical energy to be applied for desalination development.
4	The choice of desalination technology also affects the resulting freshwater product. In general, some countries apply ED, RO, and distillation technologies.	Desalination technology should be built in Indonesia, considering that 70% of Indonesia is an ocean. The selection of technology that can be applied in Indonesia using ED-RO technology is deemed to have low costs and easy operations.
5	They recommend that the government prioritize socio-economic issues in building desalination technology pilot plants. These include the community and the low cost of building a desalination plant.	The Indonesian government should be able to build a low-cost desalination plant that is applied to the community to improve clean water services by the Directorate General of Marine Spatial Management Regulation on Technical Guidelines for Distributing Government Assistance in the form of Seawater Desalination Facilities in 2017.
6	The development of large-scale desalination technology had a good impact on society to improve the quality of life.	The development of large or small-scale desalination technologies should consider the beneficial impacts to support sanitation and clean water sources for the community.

ly for people who need fresh water. Based on a review of desalination technologies developed in selected countries, the lessons learned for Indonesia if it wants to start and establish desalination technology are summarised in Table 1.

CONCLUSIONS

This paper presents a review of the current situation regarding the challenges of desalination technology development that has been developed by selected countries in the hope that it can serve as a basis for action for Indonesia to develop an environmentally sound and sustainable pilot desalination plant. Based on the reviewed articles, several countries have different backgrounds in developing desalination technology.

The main reasons for developing desalination technology are climate change conditions, population growth, depletion of surface and groundwater sources, and pollution of water resources due to mining and wastewater activities. The main challenges that must be considered to develop desalination technology are the cost of desalination technology construction, location of technology application, maintenance of desalination equipment, and sustainability of desalination technology.

The decisive factor in improving environmentally sound and sustainable desalination technology must consider PV-based electrical energy supply and allow it to be very suitable to be applied in Indonesia because PV can optimally absorb the intensity of solar energy with a power of ~3.8 kWh/kWp. The existence of an electrical energy source from PV makes it possible to build an efficient desalination technology based on ED and RO that is easy to implement in Indonesia.

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DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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