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Renewable Energy in Southeast Asia

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ABSTRACT

USARenewable energy sources, such as solar, wind, and hydropower, offer great promise in the fight against climate change. The use of these clean energy sources can significantly reduce greenhouse gas emissions and help mitigate the impacts of global warming. One of the biggest advantages of renewable energy is that it is sustainable and does not deplete natural resources. Unlike fossil fuels, which are finite and create harmful emissions when burned, renewable energy sources can be replenished naturally and emit little to no greenhouse gasses. This makes them a crucial component in the transition to a low-carbon economy and a sustainable future. Solar energy has great potential in Southeast Asia due to the region's high levels of solar irradiation. Several countries in the region, including Thailand, Malaysia, Vietnam, and the Philippines, have implemented policies and incentives to encourage the deployment of solar energy systems. Hydropower is another significant source of renewable energy in Southeast Asia, particularly in countries with large rivers and mountainous regions such as Laos, Cambodia, and Myanmar. However, the development of large hydropower projects has faced criticism due to their potential environmental and social impacts. Wind energy is less prevalent in Southeast Asia, but there are increasing efforts to develop wind power in some countries, such as Vietnam and the Philippines. However, the region's low wind speeds and limited land availability for wind turbines have limited the potential for large-scale deployment. But what is the status of the uptake of solar, wind, and hydropower energies? This paper focuses on South East Asia and the uptake of renewable energies in the past two decades. We focus on the different laws and policies in place in multiple countries and how those laws have been implemented in the countries, and what remains to be done.

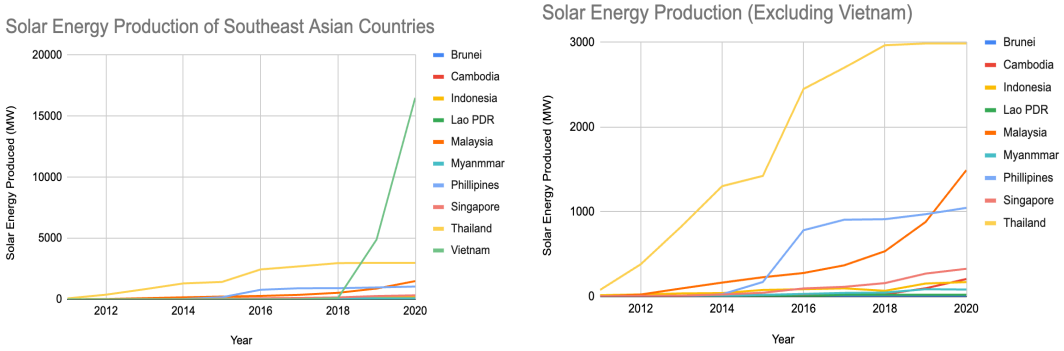
Introduction

Renewable energy sources, such as solar, wind, and hydropower, offer great promise in the fight against climate change. The use of these clean energy sources can significantly reduce greenhouse gas emissions and help mitigate the impacts of global warming. Unlike fossil fuels, which are finite and create harmful emissions when burned, renewable energy sources can be replenished naturally and emit little to no greenhouse gasses. This makes them a crucial component in the transition to a low-carbon economy and a sustainable future.

Despite their numerous advantages, renewable energy sources face numerous challenges and lack economic competitiveness compared to fossil fuels. Not only do they require a large initial capital investment, they are also relatively expensive to maintain, and produce energy inconsistently. To capitalize on the full potential of renewable energy sources, government intervention is a necessity.

Southeast Asia is a region that is currently rapidly developing both economically and in terms of population. This growth inevitably requires large amounts of energy production to back up, and it is during this crucial stage when Southeast Asia's energy market is being structured that renewable energies have the potential and opportunity to be established as a leading source of energy production. This paper investigates the current uptake of renewable energy in Southeast Asia, a region that is developing rapidly. Implementation of renewable energy sources early on in the region's development is crucial to creating a sustainable future.

The Current Proliferation of Solar Energy in South and Southeast Asia



Due to its great size, India produces the most solar energy in South and Southeast Asia at 63146 MW. Vietnam produces the most solar energy per capita in Southeast Asia at 171 MW per person. Vietnam has had a meteoric rise in solar energy production in the past decade; in 2016, its solar energy capacity was at 5 MW while it currently stands at 18474 MW. India and Vietnam are followed by Thailand which produces 3065 MW annually at a distant third[1].

Solar power has high potential in South Asia. Its ability to be applied in smaller scales means that it avoids one inherent problem of renewable energy: high initial cost of installation. Currently, there exists an affordable system of small-scale photovoltaic energy harvesters known as Solar Home Systems (SHS) which have successfully been implemented in Bangladesh. However, the problem of atmospheric particulate matter poses a threat to energy production especially in densely settled and polluted areas.

Applications of Solar Home Systems

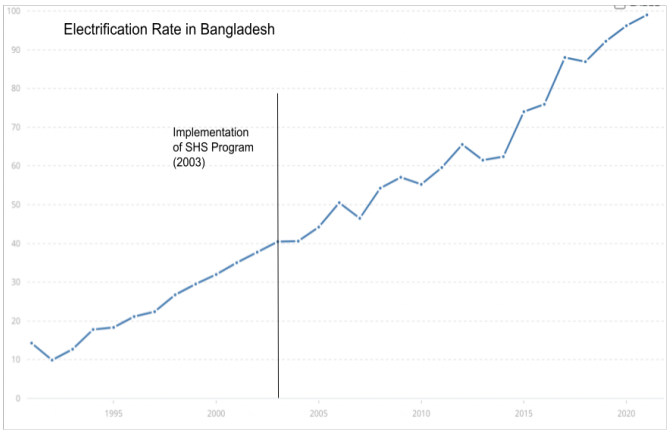
Solar Home Systems (SHS) are stand-alone photovoltaic systems that contribute to the energy production of a household through the harnessing of solar energy.

Bangladesh's SHS program is a primary example of the success of this particular approach to solar energy. The program was launched in January 2003 in a 3-way partnership with the World Bank, Infrastructure Development Company Limited (IDCOL), and the Bangladesh government[2]The initial goal of the program was

[1] Sreenath, S, and Azlin Mohd Azmi. "A Decade of Solar PV Deployment in ASEAN: Policy Landscape and Recommendations." ScienceDirect, June 1, 2022. https://www.sciencedirect.com/science/article/pii/S2352484722010691.

[2] Komatsu, Satoru, Shinji Kaneko, and Partha Pratim Ghosh. "Are Micro-Benefits Negligible? The Implications of the Rapid Expansion of Solar Home Systems (SHS) in Rural Bangladesh for Sustainable Development." Science Direct, December 30, 2010. https://www.sciencedirect.com/science/article/abs/pii/S0301421510008463?casa_token=5t9HP2-vdYQAAAAA%3AaS-Pkt9C7ocxdmJCYF_CymAgsHpGH2onJUODXYeri8jIaTkFUVR23B-hymjl1zi2dvgHrAf5zWUtOg.

to install 50,000 SHS units in off-grid areas in five and a half years, and the goal was reached in 2005, three years earlier than the expected date. Since the start of the program, over 5.5 million units have been installed across the country, replacing an estimated $411 million dollars in fuel. During the 20 years the program has been running, rural electrification in Bangladesh grew from 27% to nearly 98%. Solar energy now accounts for 416MW of the 650 MW of renewable energy produced in Bangladesh[3]. .



The SHS program in Bangladesh is managed under a meticulous structure headed by the Infrastructure Development Company Limited (IDCOL). IDCOL works with numerous partner organizations to create and finance loans for individual households to afford the installation of SHS programs. These payments, which are linked to national banks, are structured in such a way that they are equivalent to the cost of kerosene that would be necessary to produce the same amount of electricity the panel does[4]. Despite widespread poverty in the rural regions of Bangladesh, 88% of the SHS users have been able to repay their loans to have the panels installed. The government also provides additional subsidies and tax breaks for IDCOL and the partner organizations to foster greater participation. In addition, a rigorous system of quality monitoring is in place with certain minimum warranties guaranteed for key components of the system such as the photovoltaic panel and batteries.

[3] Satoru, Kaneko, Ghosh. “Are Micro-Benefits Negligible?”

[4] Satoru, Kaneko, Ghosh. “Are Micro-Benefits Negligible?”

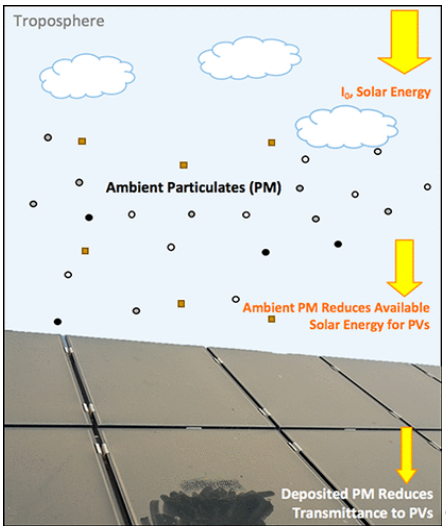
 [5]

The structure of the SHS system implemented in Bangladesh has proven to be extremely effective in both providing electricity in rural areas and increasing the production of energy through renewable sources in Bangladesh. The model's applicability in rural and relatively impoverished areas makes it an example of success.

Effect of Pollution on Solar Energy Harvesting

Atmospheric Particulate Matter (PM) which refers to microscopic particles released as a result of air pollution, significantly reduces the efficiency of photovoltaics to harness solar energy. Two types of particulate matter can affect energy: ambient particulate matter and deposited particulate matter. Ambient Particulate matter refers to particulate matter in the air surrounding the photovoltaic, which can decrease the overall amount of solar irradiation the panel can harness. Deposited particulate matter, on the other hand, refers to the particulate matter that has accumulated on the surface of the panel itself.

[5] The Global Partnership for Results-Based Approaches (GPRBA). "Bangladesh: Solar Home Systems Reach 2 Million Households." Bangladesh: Solar Home Systems Reach 2 Million Households . Accessed July 27, 2023. https://www.gprba.org/news/bangladesh-solar-home-systems-reach-2-million-households.



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Ambient particulate matter, also referred to as aerosol, has significantly altered the amount of solar irradiation that reaches the Earth's surface. Aerosol particulate matter decreases irradiation by directly absorbing and scattering the sun's rays or indirectly by affecting the formation of clouds and in turn the amount of sunlight that is able to penetrate the atmosphere. A study[8] that examined the effect of aerosol particles on the NPP (Net Primary Productivity) of photosynthesizing plants in an area saw a significant decrease in the productivity of plants in heavily polluted areas, up to 15%. Another study[9] found that heavy ambient particulate matter could increase the diffusion of solar irradiance from 15% up to 40%.

[6] Bergen, Mike H. "Large Reductions in Solar Energy Production Due to Dust and Particulate Air Pollution." ACS Publications , June 15, 2017. https://pubs.acs.org/doi/10.1021/acs.estlett.7b00197.

[7] Bergen, "Large Reductions in Solar Energy"

[8]Nahar, N. M., and Jagdish P. Gupta. "Effect of Dust on Transmittance of Glazing Materials for Solar Collectors under Arid Zone Conditions of India." ScienceDirect, March 5, 2003. https://www.sciencedirect.com/science/article/abs/pii/0741983X9090092G.

[9] Bergen, Mike H. "Large Reductions in Solar Energy Production Due to Dust and Particulate Air Pollution." ACS Publications , June 15, 2017. https://pubs.acs.org/doi/10.1021/acs.estlett.7b00197.

Table 1. The output power for different loads resulted from light radiation of 310 W/m². Percentage in bracket shows the reduced of output power relative to clean solar panel.

Testing Loads	Power (W)				
	Clean	Talcum	Dust	Sand	Moss
Short Circuit	0	0	0	0	0
12V Bulb 21/5 W	3.45	2.37 (-31 %)	1.02 (-70%)	0.68 (-80%)	0.66 (-81%)
12V Bulb 10W	8.68	6.65 (-11%)	2.37 (-73%)	1.87 (-78%)	1.44 (-83%)
12 V Festoon Bulb 10W	8.89	7.41 (-17%)	2.83 (-68%)	2.20 (-75%)	1.68 (-81%)
12V Motor 18W	8.15	7.38 (-9%)	3.09 (-62%)	2.37 (-71%)	1.81 (- 78%)
12 V Bulb 8W	3.16	3.01 (-5%)	2.75 (-13%)	3.12 (-1%)	2.65 (-16%)
No Load	0	0	0	0	0

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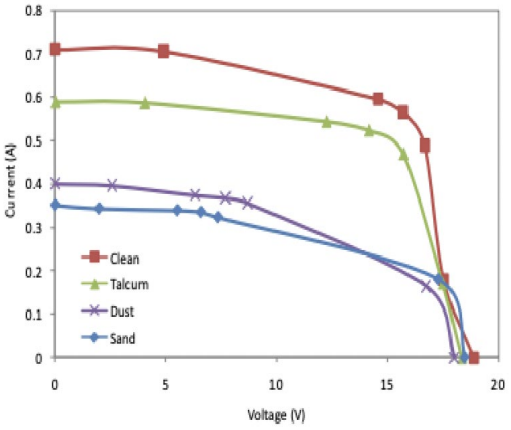

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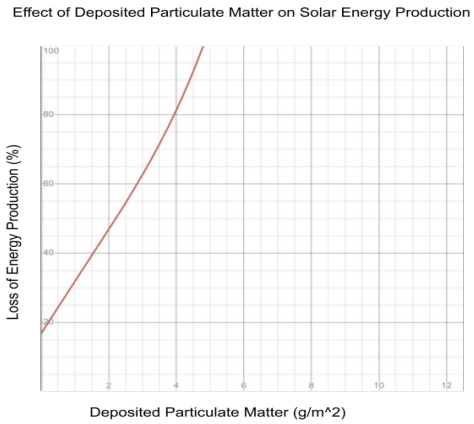
On the other hand, Deposited particulate matter decreases the amount of solar irradiation that the panels are able to convert. A study[12] that compared the efficiency of numerous photovoltaics with different sources of deposited particulate matter found that under a load of 10W of power, dust contaminants can decrease productivity by 68%. Under a range of given circumstances, the contaminated panels decreased in productivity by 1% up to 83%. Another study[13] found that in heavily polluted areas, the decrease in energy produced can be represented by the curve : y=0.0381*x^4-0.0826x^3+15.01*x+16.769 where y represents the percentage loss of energy produced and x represents the dust deposition in g/m^2.

[10] Sulaiman, Shaharin Anwar, Atul Kumar Singh, Mior Maarof Mior Mokhtar, and Mohammed A. Bou-Rabee. "Influence of Dirt Accumulation on Performance of PV Panels." Science Direct, July 24, 2014. https://www.sciencedirect.com/science/article/pii/S1876610214007425.

[11] Sulaiman, "Influence of Dirt Accumulation"

[12] Sulaiman, "Influence of Dirt Accumulation"

[13]Boyle, L., H. Flinchpaugh, and M. P. Hannigan. "Natural Soiling of Photovoltaic Cover Plates and the Impact on Transmission." Science Direct, December 22, 2014.

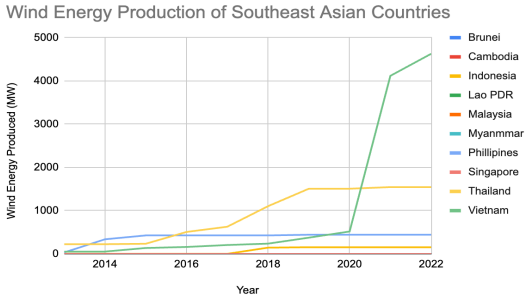


The Current Proliferation of Wind Energy in South and Southeast Asia

Table 1. Estimated levelized cost of new generation by the year 2016 (adapter from [1])

Type of Power Source	Price in kilowatt-hour generation[1] in different currency			
	U.S Cents	Bangladesh (BDT)	Pakistan (RKR)	India (INR)
Conventional Coal	9.48	7.64	8.82	5.26
Advanced Coal	10.94	8.82	10.17	6.07
Advanced Coal with CCS	13.62	10.98	12.67	7.56
Natural Gas-fired				
Combined Cycle (Average)	7.28	5.87	6.77	4.04
Combustion Turbine (Average)	11.4	9.19	10.6	6.327
Advanced Nuclear	11.39	9.18	10.59	6.32
Wind	9.7	7.82	9.02	5.38
Wind Offshore	24.3	19.59	22.6	13.49
Solar PV	21.07	16.98	19.6	11.69
Solar Thermal	31.18	25.13	29	17.3
Geothermal	10.17	8.2	9.46	5.64
Biomass	11.25	9.07	10.46	6.24
Hydro	8.64	6.96	8.04	4.8

[14]



Due to its size, India produces the most wind energy in South and Southeast Asia at 41930 MW. Vietnam produces the most solar energy per capita in Southeast Asia at 49 MW per person. India and Vietnam are followed by Thailand which produces 1545 annually. Interestingly, the top three countries in solar production in Southeast and South Asia are the top three countries in wind energy production in Southeast and South Asia[15].

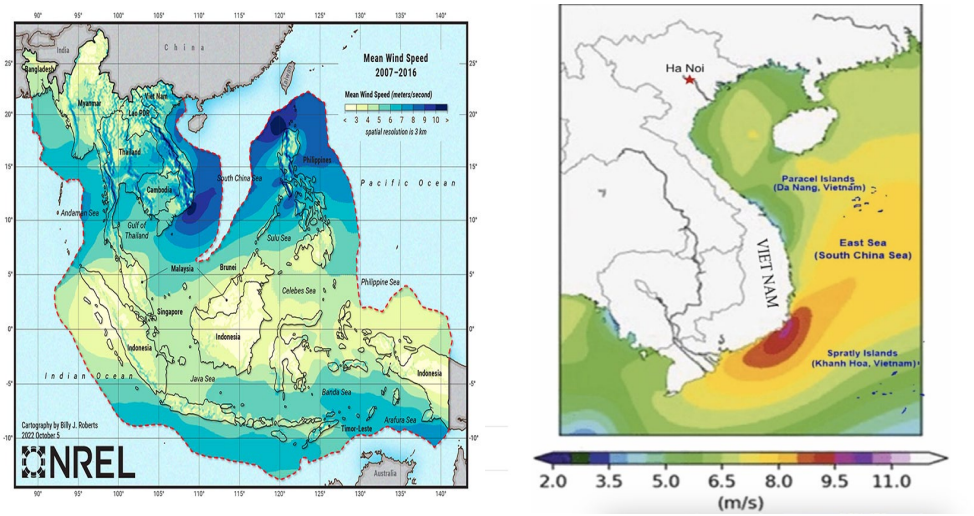
Wind power is still in nascent development in Southeast Asia. Although there is great promise in certain regions such as offshore generators in windy areas such as the shores of Vietnam, wind energy is still underdeveloped in many countries. Not only do six of the ten countries surveyed have no capacity to harness wind energy (compared with zero out of ten countries for solar energy) the average production of wind energy per country is also a quarter of solar energy's amount.

Logistical Challenges for Offshore Wind Energy

For smaller scale turbines, the ideal wind speed is at least 4 meters per second, while the ideal wind speed for larger, industrial turbines is at least 5.8 meters per second. Most of the Vietnam coast is, on average, above the

[14] IRENA. "Renewable Capacity Statistics 2023." IRENA, March 1, 2023. https://www.irena.org/Publications/2023/Mar/Renewable-capacity-statistics-2023.
[15] IRENA. "Renewable Capacity Statistics 2023."

threshold for smaller scale turbines while its southern coast, and waters near Ho Chi Minh City shows exceptional promise with wind speeds up to 9 meters per second[16]. Although the prerequisite of fast wind speeds are met in Vietnam's southern coast, and plans for construction are underway, the problem of inefficient government procedures, as well as the high cost of energy must be addressed before Vietnam is able to fully capitalize on its fast wind speeds.



Currently, for an offshore wind farm to be authorized in Vietnam, private companies must follow a nine-step procedure with no set administrative timeline. Estimates place the process at a time frame of five years. Combined with the time needed for the installation of the wind turbines themselves, in which the fact that the turbines are offshore greatly slows down the process, other sources of renewable energy, such as photovoltaics or onshore wind farms can be placed into operation at a much faster rate.

The high cost of energy must also be addressed in order to make wind energy economically competitive with other renewable or nonrenewable sources of energy. Despite the average price of household energy per kilowatt hour (kWh) being 2.5 times cheaper than that of the United States, Vietnam's government regulations currently allow companies to sell energy harnessed in offshore wind energy for 98 dollars per megawatt hour (mWh), which is nearly double to quadruple the price of wind energy in the United States.

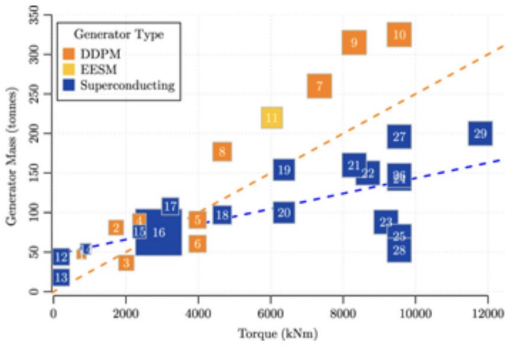
To capitalize on the true potential of Offshore Wind energy in Vietnam, government procedures must be expedited and the cost of energy must be lowered in order for it to become a competitive source of energy.

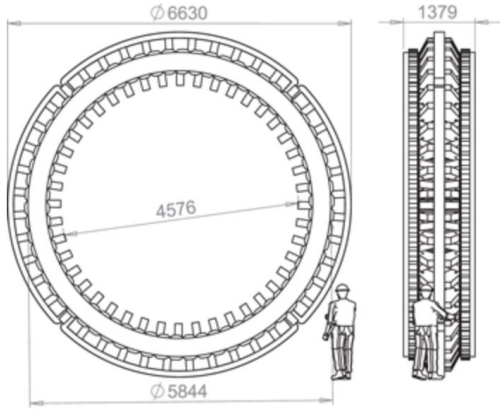
Technical Challenges for Offshore Wind Energy

A relatively straightforward and intuitive process to make offshore wind turbines more productive and cost-effective is to increase the energy output per turbine. Although advancements in technology have allowed for theoretical improvements in wind energy production, from 2 MW turbines to 20 MW turbines in the last decade, a prominent problem that emerges is the exceedingly heavy weight of the turbines. For a theoretical 10 MW turbine, the blades of the turbine weigh nearly 760 tons alone, which creates stress on the system and is exponentially more expensive. Therefore, research has been done in order to create a more efficient design that is lighter and capable of withstanding harsh and volatile weather conditions.

[16] Do, Thang Nam, Paul J Burke, Llewelyn Hughes, and Ta Dinh Thi. "Policy Options for Offshore Wind Power in Vietnam." ScienceDirect, May 20, 2022. https://www.sciencedirect.com/science/article/pii/S0308597X22001270.

A possible solution to decrease the weight of turbines is to install a superconducting generator within the turbine. According to a study[17] investigating the possibility of superconducting generators on offshore wind turbines, it found that "superconducting generators have higher magnetic loading than conventional generators, which increases the power density of the machine. In air-cored superconducting machines the air-gap flux density can go up to several teslas. In fully superconducting machines, it is possible to increase the magnetic and electric loadings of the machine at the same time." By employing a superconducting generator within a turbine, a theoretical 10 MW turbine would weigh only 52.5 tons in total, a sharp decrease from the 790 tons of a standard turbine.





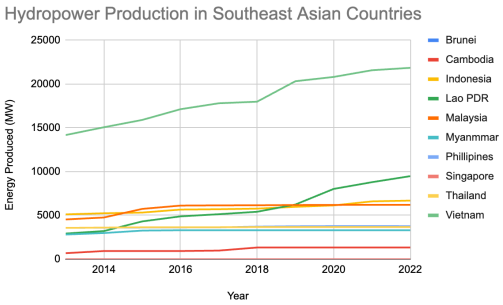
[18]

However, superconducting generators are not without flaws. Although their relatively low weight allows them to be a viable alternative structurally, the generators themselves still have a high cost of manufacturing. The generators require large amounts of wire which increases the price significantly. They also require frequent maintenance, which not only decreases the overall energy output, but is also difficult given that the wind turbines are offshore.

The Current Proliferation of Hydropower in South and Southeast Asia

[17] Keysan, Ozan, and Markus Mueller . "A Modular and Cost-Effective Superconducting Generator Design for Offshore Wind Turbines." Superconductor Science and Technology, February 5, 2015. https://iopscience.iop.org/article/10.1088/0953-2048/28/3/034004.

[18] Keysan, Ozan, and Markus Mueller . "A Modular and Cost-Effective Superconducting Generator Design for Offshore Wind Turbines." Superconductor Science and Technology, February 5, 2015. https://iopscience.iop.org/article/10.1088/0953-2048/28/3/034004.



Due to its great size, India produces the most hydropower energy in South and Southeast Asia at 63146 MW. Vietnam produces the most solar energy per capita in Southeast Asia at 170 MW per person. Vietnam's hydropower capacity has continued to grow at a constant rate, and is cementing itself as a renewable energy hub. India and Vietnam are followed by Pakistan which produces 10002 MW annually at a distant third with 42 W per person[19].

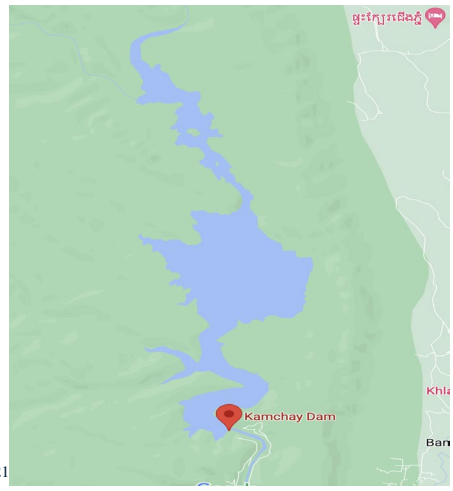
Hydropower is the most developed source of renewable energy in Southeast Asia of the three discussed in this study. Not only does it hold great potential with Southeast Asia being home to numerous major river drainage systems such as the Mekong River Delta, many countries have already begun to capitalize on the rich resource. There is also potential for marine or wave energy development. Although Hydropower in Southeast Asia is heavily dependent upon international funding, it is still leading the renewable energy transition underway.

Over-Reliance on International Funding

Cambodia has one of the lowest rural electrification rates in the world, at 18%. This is despite its urban electrification rate standing at 97%[20]. Partially in attempts to increase electricity access in rural areas and also to invest in more sustainable energy sources, Cambodia embarked on the momentous task of building the Kamchay dam, which by itself, has a capacity of 194 MW. The dam was Cambodia's first dam, and it is currently responsible for almost 15% of all hydropower that is generated in Cambodia. Despite the dam's high power generating capacity, there has been great controversy due to the dam's ecological and social impacts on the surrounding areas as well as an over reliance on foreign investment.

[19] IRENA. "Renewable Capacity Statistics 2023."

[20] Ejolt. "Kamchay Dam, Kampot Province, Cambodia: Ejatlas." Environmental Justice Atlas, May 15, 2018. https://ejatlas.org/conflict/kamchay-dam-kampot-province-cambodia.



[21]

The Kamchay dam was built and funded almost exclusively by Sinohydro, a company that is owned and run by the Chinese Communist Party. In exchange for the building of the dam, the Cambodian government granted Sinohydro a 44 year lease of the property.

There have been great ramifications due to the building of the dam. The dam created a massive reservoir over an area that used to be a primary source for locals to gather bamboo. Not only has the local people's main source of bamboo been flooded, Sinohydro has also banned the collection of bamboo in many areas near the dam. The dam has also disrupted the local's access to fish, as Sinohydro is able to artificially control the flow. However, the greatest problem the dam poses is that many of the local residents, whom the dam was made for, can't afford the electricity. As Sinohydro has rights for 44 years for the electricity produced by the dam, much of the electricity is sold for a higher price to urban areas, sometimes internationally.

Conclusion

Although all sources of renewable energy showed promise in Southeast Asia, each has their strengths and weaknesses. Solar energy has great potential to be implemented in smaller scales to boost rural electrification. Wind energy, despite being the least developed of the three sources of renewable energy, shows great promise through the form of offshore renewable energy farms. Despite hydropower being the most proliferated and widespread form of renewable energy in Southeast and South Asia, there still are structural and social problems that must be addressed to best exploit the sustainable natural resource. All in all, despite much progress to be made, there is great promise for a carbon-neutral and sustainable energy future in the region.

Acknowledgments

I would like to thank my advisor for the valuable insight provided to me on this topic.

References

[21] Ejolt. "Kamchay Dam, Kampot Province, Cambodia: Ejatlas."

Abrahamsen, A. B., N. Magnusson, B. B. Jensen , and M. Runde. “Large Superconducting Wind Turbine Generators.” Science Direct, August 10, 2012. https://www.sciencedirect.com/science/article/pii/S1876610212011277.

“Access to Electricity (% of Population) Bangaldesh.” World Bank Open Data, 2022. https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS.

Bergen, Mike H. “Large Reductions in Solar Energy Production Due to Dust and Particulate Air Pollution.” ACS Publications , June 15, 2017. https://pubs.acs.org/doi/10.1021/acs.estlett.7b00197.

Boyle, L., H. Flinchpaugh, and M. P. Hannigan. “Natural Soiling of Photovoltaic Cover Plates and the Impact on Transmission.” Science Direct, December 22, 2014. https://www.sciencedirect.com/science/article/abs/pii/S0960148114008325?casa_token=MZ295HdBadIAAAAA%3A3UbB-SukIqTV3YMH9OkfTzEuMXg1laHnJSsxHosgNuBXz_wbz8f53N9RaF2f4qn2uTWmztsFEOL7lg.
Darrow , Holly. “Southeast Asia Wind Resource Data Set Released through the Renewable Energy Data Explorer.” NREL.gov, March 27, 2023. https://www.nrel.gov/news/program/2023/southeast-asia-wind-resource-data-set-released-through-the-renewable-energy-data-explorer.html.

Do, Thang Nam, Paul J Burke, Llewelyn Hughes, and Ta Dinh Thi. “Policy Options for Offshore Wind Power in Vietnam.” ScienceDirect, May 20, 2022. https://www.sciencedirect.com/science/article/pii/S0308597X22001270.

Ejolt. “Kamchay Dam, Kampot Province, Cambodia: Ejatlas.” Environmental Justice Atlas, May 15, 2018. https://ejatlas.org/conflict/kamchay-dam-kampot-province-cambodia.

IDCOL. “IDCOL SHS Installation under RE Program.” IDCOL Bangladesh Map. Accessed July 27, 2023. http://www.idcol.org/old/bd-map/bangladesh_map/index.php.

IRENA. “Renewable Capacity Statistics 2023.” IRENA, March 1, 2023. https://www.irena.org/Publications/2023/Mar/Renewable-capacity-statistics-2023.

Keysan, Ozan, and Markus Mueller . “A Modular and Cost-Effective Superconducting Generator Design for Offshore Wind Turbines.” Superconductor Science and Technology, February 5, 2015. https://iopscience.iop.org/article/10.1088/0953-2048/28/3/034004.

Khasru, Syed Munir. “Syed Munir Khasru - ICSD.” Renewable Energy Empowerment at the Grassroots: The Success Story of Solar Home System (SHS) in Bangladesh . Accessed July 27, 2023. https://ic-sd.org/wp-content/uploads/2020/11/Syed-Munir-Khasru.pdf.

Komatsu, Satoru, Shinji Kaneko, and Partha Pratim Ghosh. “Are Micro-Benefits Negligible? The Implications of the Rapid Expansion of Solar Home Systems (SHS) in Rural Bangladesh for Sustainable Development.” Science Direct, December 30, 2010. https://www.sciencedirect.com/science/article/abs/pii/S0301421510008463?casa_token=5t9HP2-vdYQAAAAA%3AaS-Pkt9C7ocxdmJCYF_CymAgsHpGH2onJUODXYeri8jIaTkFUVR23B-hymjl1zi2dvgHrAf5zWUtOg.

Nahar, N. M., and Jagdish P. Gupta. “Effect of Dust on Transmittance of Glazing Materials for Solar Collectors under Arid Zone Conditions of India.” ScienceDirect, March 5, 2003. https://www.sciencedirect.com/science/article/abs/pii/0741983X9090092G.

The Global Partnership for Results-Based Approaches (GPRBA). “Bangladesh: Solar Home Systems Reach 2 Million Households.” Bangladesh: Solar Home Systems Reach 2 Million Households . Accessed July 27, 2023. https://www.gprba.org/news/bangladesh-solar-home-systems-reach-2-million-households.

SciDev. “Air Pollution Dims India’s Solar Energy Potential.” Phys.org, March 31, 2022. https://phys.org/news/2022-03-air-pollution-dims-india-solar.html.

Siciliano, Giuseppina, Frauke Urban, Sour Kim, and Pich Dara Lonn. “Hydropower, Social Priorities and the Rural–Urban Development Divide: The Case of Large Dams in Cambodia.” Energy Policy, July 24, 2015. https://www.sciencedirect.com/science/article/abs/pii/S0301421515300215?casa_token=zhUadiyWu9kAAAAA%3AXPL4lwDj4h6vxHAepbJ9_uN5hjJeelbXMiRQx8vgZCntjL1egKB89FIaiq5SrHmNYJ3Z700I-w.

Sreenath, S, and Azlin Mohd Azmi. “A Decade of Solar PV Deployment in ASEAN: Policy Landscape and Recommendations.” ScienceDirect, June 1, 2022. https://www.sciencedirect.com/science/article/pii/S2352484722010691.

Sulaiman, Shaharin Anwar, Atul Kumar Singh, Mior Maarof Mior Mokhtar, and Mohammed A. Bou-Rabee. “Influence of Dirt Accumulation on Performance of PV Panels.” Science Direct, July 24, 2014. https://www.sciencedirect.com/science/article/pii/S1876610214007425.

World Bank Group. “A Game-Changer in Bangladesh’s Growth Story: Solar Home Systems.” World Bank, April 21, 2021. https://www.worldbank.org/en/news/feature/2021/04/08/a-game-changer-in-bangladesh-growth-story-solar-home-systems.

World Bank Group. “Urgent Action Needed in South Asia to Curb Deadly Air Pollution.” World Bank, December 15, 2022. https://www.worldbank.org/en/news/press-release/2022/12/14/urgent-action-needed-in-south-asia-to-curb-deadly-air-pollution.