# Energy Review

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## Adviser's Note

When Tuvalu's Foreign Minister, Mr. Simon Kofe, addressed world leaders at the UN Climate Change Summit COP26 he made a powerful statement. Standing knee-deep in rising sea water, he spoke of the challenges facing small island nations and urged immediate action on climate change. Mr. Kofe is not alone. Leaders throughout the Pacific have been calling for climate change action and demanding that big polluters intensify their carbon cuts for the past few decades. As nations continue to roll out their commitments to net-zero carbon emissions, the spotlight on the renewable energy sector has never been brighter. Through renewable energy we can build energy resilience with the deployment of reliable and cost-effective solutions. We must continue to be steadfast in exploring new technologies and leveraging private sector investment. At the International Solar Alliance, our target is to unlock US$1 trillion in solar investments by 2030. That's a formidable target but one that will bring the world closer to meeting its energy transition needs. In this edition of Energy Review, the three articles explore key trends in the renewable energy sector- obstacles, collaboration and opportunity. These themes will be ever present as we strive to reach our net-zero targets. It will be hard work but it's within our reach, and we have a moral obligation to nations such as Tuvalu to continue.

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## Inside this Issue



## Energy Review Team

# *The Brazilian Energetic Matrix and the Possible "Blackout" Scenario*

**Carine Tondo Alves, Jadiel dos Santos Pereira and Luciano Sergio Hocevar**

Brazil is currently experiencing a moment of energy insecurity, resulting from a crisis scenario that has dragged on for years and is similar to that which occurred in the 2000s. The reduction of rainy periods has been identified as the main factor of this risk due to its influence on the hydroelectric reservoirs, but would this be the key factor for the possible energy "blackout" of energy in Brazil? Is the scenario likely in the current context of the country, if we consider, in addition to technical and economic aspects, the decisions that were taken? This article seeks to explore the aforementioned issue.

According to the Brazilian National Energy Balance (2021), the national supply of electricity is 645,9 TWh, and the Brazilian electricity matrix is composed of 85% renewable energies, among which hydroelectric power is responsible for 65%, biomass and wind power with 9% each and solar photovoltaic with less than 2%.

Renewable energies such as biomass, wind and solar photovoltaic are increasing rapidly with an overall renewable capacity (excluding small hydropower) expected to grow at a compound annual growth rate (CAGR) of 6% by 2030. Renewables are very important for the diversification of the Brazilian electric matrix. However, together those represent less than 20% of the all-generated energy. Hydroelectric generation remains predominant, although its share has decreased from 85% in 1980 to 65% in 2021. Hydroelectric energy is advantageous in terms of generation cost, which is lower compared to the other types of energy generation. However, it is heavily dependent on rainfall, which can make the Brazilian electricity production and transmission system vulnerable, especially in periods of lack of rain, when the volume of reservoirs decreases and the electric energy generation started to be carried out by thermoelectric plants. It is during these periods that the possible "blackout" scenario intensifies, as in 2001 and today at the beginning of 2022.

To better understand what differentiates the two scenarios (2001 and 2021), two twenty-year periods (1980-2000) and (2000-2020) were compared. In 1980, Brazil's installed electricity generation capacity was 33 GW. In 2000, it reached 74 GW and then increased to 175 GW in 2020. The Brazilian population was 121 million in 1980, increased to 175 million in 2000 and reached 213 million in 2020. When these data were compared, it was possible to verify that between 1980 and 2000, the installed capacity increased by 124%, while the population grew by 44%. In the period between 2000 and 2020, the installed capacity increased by 137%, while the population increased by 22%. Therefore, it is clear that there is a growth in electricity supply greater than that of the population. This growth is in line with the national energy balance (2021), where the domestic supply of electricity is 645.9 TWh and the final consumption is 540.2 TWh.

Over the twenty years that separate these two events, many assertive decisions were taken, such as investments to increase the installed capacity and diversification of the energy matrix, including wind and solar photovoltaic generation. Management and planning tools were developed and improved, such as the precipitation databases from the National Institute for Space Research (INPE), electricity generation and demand from the National Electric System Operator (ONS) and the National Interconnected System (SIN).

In the possible scenario of blackout in 2022, these databases and software are available for energy planning and its information. Reservoir storage data and rainfall history were already known and were available in 2020 with reports indicating the possibility of water shortages. Therefore, the decision to activate the thermoelectric plants could have been taken before the situation became critical with high operating costs. Historical data from 1981 to 2020 show that between April and October, the monthly rainfall index is low, indicating that the level of reservoirs may decrease, recommending the use of thermoelectric plants.

These data have been important for energy planning without serious problems for twenty years, even with the economy demanding more energy. Therefore, the planning at those times was well executed. Some decisions since the "blackout" in 2001 can be questioned, such as the permission for the increase of deforested and burnt areas, which, in addition to interfering with the flow of rivers, reduced the carbon capture credits in that area. According to the INPE, the Amazon has lost 729,000 $km^2$ to deforestation so far, which means 17% of its entire biome of 300,000 $km^2$ since 2001.

This affects the sources of rivers and alters the rainfall regime. Rivers still suffer from gigantic irrigation projects that benefit few and bring negative environmental consequences for everyone. Some large rivers are dying and the country needs to recognize that this scenario will be bad for its population, as water is good for everyone, not a raw material for a few people who change location, or country, when it is scarce. Furthermore, with the predominance of the hydroelectric model, the electric power generation capacity will be severely affected.

Due to the economic crisis that the country is going through, it is unlikely that a "blackout" will occur and that the energy demand will increase in the short term. Based on this, there is time to correct what is necessary. However, it is possible to observe our total dependence on hydroelectric power and rainfall, as well as on fossil fuels that fuel thermoelectric plants.

The increased production of renewable energy will solve only a small part of the problem of electric generation in Brazil. This country is extensive, populous, with unequal distribution of consumption, different sources of energy generation, storage, dispatch, different intermittence and seasonality, at the moment and in the quantity demanded, and that is why this equation is complex to be solved. Energy planning was, is and will continue to be important, as well as the decisions taken from it, fundamental for the country's energy supply and for the technical, economic and managerial aspects that must always be analyzed together.

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# *Energy Potential from Ocean Swells and its Directional Characteristics relevant for the Indian Ocean in a Changing Climate*

**Prasad K. Bhaskaran**

Increasing energy demands across many locations of the nation, pressure on developmental activities, and rapid deterioration of air quality index in urban locations have led to investigating various renewable sources of energy for sustainable use. The oceans comprise about 71% of the Earth's surface and cover an area of about 361 million km$^2$, and the various possible sources of marine energy can result from the tidal stream, tidal variations, waves, offshore wind, ocean thermal gradients, ocean currents, river runoff and salinity gradients. In the context of the North Indian Ocean region, preliminary investigation as well the identification of potential locations for harvesting ocean wave energy started in 1988, and the first pilot wave energy plant was set up in 1990. Though considerable research works were carried out on renewable marine energy extraction, limited studies are conducted so far on ocean wave energy and its potential that has wide implications for coastal and island locations in terms of energy demands. During the financial year 2019-2020, the renewable energy sector contributed only 21.2% against the total power consumption, and the contribution from marine energy was negligible. Estimates signify that the contribution from the ocean and tidal currents comprises about 5 TW of energy and about 1-10 TW of wave energy. It is interesting to note that ocean waves can provide about 20 times more available energy per square meter compared to wind and solar energy.

Ocean waves result from the manifestation of energy transfer at the air-sea interface. Swells are long period surface gravity waves generated by wind action at the air-sea interface in a conducive growing environment having sufficient fetch and duration. Physical mechanisms associated with swell wave propagation and its characteristics have immense practical applications ranging from off-shore activities, coastal protection, beach restoration, design of wave energy converters, ocean wave prediction, wind-wave climate studies, and many more. Propagation characteristics of long period swells is indeed challenging due to its complexity and spatial variability. It is interesting to note that energy propagation from swells can reach distant locations travelling thousands of km in the open ocean reaching various destinations along the coast. Energy loss in the course of swell propagation due to inner friction, and viscosity, effects are very small. For any given region the wind-wave climate is characterized by the combined effect resulting from mutual interaction between multiple wave systems. The propagation characteristics of swells and the associated physical mechanisms have emerged as a great interest for many researchers because of their huge potential in wave energy.

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC-AR5) highlights the importance of waves and their active feedback in improving the existing climate models. The swell wave system plays an important role in redistributing the wave energy during their trail of propagation to long distances thereby determining the wind-wave climate across the global oceans. A comprehensive understanding of the regional-wise wave characteristics has immense importance in context to climate change and estimation of wave energy potential. Remotely forced swells can modulate and modify the locally generated wind-waves of a given region. Hence, a proper understanding of the long-term variability of swell wave parameters is very essential for determining the potential of ocean wave energy.

A recent study conducted by our team at IIT Kharagpur has divided the entire Indian Ocean into six sub-domains classified into zones covering the Arabian Sea, Bay of Bengal, South China Sea, Tropical South Indian Ocean, Western extra-tropical South Indian Ocean and the Southern Ocean, and the Eastern extra-tropical South Indian Ocean and the Southern Ocean. A detailed study was carried out to investigate the monthly, seasonal, intra-seasonal, and inter-annual variability of wind waves in the Indian Ocean region. Further, the study had analysed the regional-wise characteristics, spatio-temporal distribution, and variability of high threshold significant wave heights in the region. A methodology was developed to identify the potential regions of swell wave variability, their trends, and maxima to understand the influence and role of various climate indices affecting the variability and trends of wind seas and swells. The study has led to identifying the variability of extreme swell wave climate, wave power density, and directionality for the Indian Ocean and coastal regions in a changing climate scenario. In addition, a methodology was developed to assess the changes in seasonal directionality of swell wave propagation and extreme swell energy flux for selected regions along the Indian coast.

Multi-platform calibrated satellite altimeter wave data was used to emphasize the climatological trend and patterns in the wave energy distribution. A comprehensive analysis was performed for the six sub-domains listed above providing details on the monthly and seasonal wave climatology, annual cycle, and pentad-scale trends. Interesting observations from the study signify that for the extra-tropical South Indian Ocean, the 99th, 95th, and 90th percentile values for waves are active for more than six months in a year highlighting the potential source and generation area of wave energy. Lower percentile significant wave heights are also significant exhibiting a pentad scale oscillation over this region and a decadal variability over the North Indian Ocean and tropical South Indian Ocean regions. Swells that propagate from the western sector of the extratropical South Indian Ocean are the primary source of swell wave power in the tropical and subtropical Indian Ocean, reaching different locations of peninsular India with an average travel time of 7-8 days. The study points out that there is no significant trend in the swell wave energy flux over the north Bay of Bengal; and in addition, a strong La Niña epoch can decrease the directional swell wave energy flux. Other climate indices such as Indian Ocean Dipole, and El Niño-Southern Oscillation have a significant correlation with a directional spread in the tropical Indian Ocean, especially in the nearshore regions. The study is expected to have wide potential in the planning of renewable energy resources from ocean waves in the deep and nearshore locations of the Indian coast. By pointing out the potential of ocean swells, this article thus places the importance of further research in this area.

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# The Road to Energy Transition and Cooperation between Israel and Jordan

**Shivani Choudhary**

Renewable energy, energy security, and importance for energy efficiency and energy sufficiency are significant ongoing themes for discussions in the contemporary world, especially in regions like West Asia, that has been at the forefront of oil and gas resources. Regardless of that, some other countries have been historically poor in energy resources. Unlike their oil-rich neighbors, Israel and Jordan are currently reliant on imported fossil fuels to meet their energy demands. Expanding renewable energy production offers these countries a possible path to greater energy independence and security.

Political turmoil and instability hinder the energy supply and demand in the region. Since the oil embargo of 1973, there have been numerous occasions where the energy sector had dire impacts due to political turmoil. For instance, in 2011, Egypt cut off the supply of a natural gas pipeline to Israel.

In November 2021, Jordan and Israel came together to develop renewable energy with support from the US and UAE and had signed the biggest energy and water deal in November 2021. Both countries have opened the doors for new transnational renewable energy projects by signing a cooperation agreement on energy and water, a long-standing issue in the region. The agreement can be seen as a big transformative step towards the region facing some of the worst consequences of climate change and scarcity of water. Jordan, which is considered the second most water-scarce country globally, will receive cooperation from Israel under this project. The following project will address one of the environmental criticisms of desalinating seawater in Jordan. The pact entails the potential construction of a desalination plant by Israel for Jordan, and on the other hand, Jordan will work to generate electricity through solar energy, and an energy storage plant from which Israel will benefit. The following pact also includes the two interrelated programs known as Project Prosperity and Green-Blue Deal, i.e., the Green Prosperity Programme.

Jordan, one of the topmost leading states in the West Asian region in the energy transition, will set the stage for constructing a solar photovoltaic (PV) plant in Jordan, with 600 MW of capacity. All this power would be exported to Israel by Jordan. Blue Prosperity Programme - Prosperity Blue involves a water desalination program by Israel, to supply and complete the demand for water in Jordan. The plant would provide 200 million cubic meters of water to Jordan under the deal, doubling the amount of water it promised to sell to Jordan.

The agreement benefits both countries by addressing climate change issues - electricity in Israel and water in Jordan. John Kerry, the US special climate envoy, noted that “the Middle East is on the frontline of the climate crisis. Only by working together can countries in the region rise to the scale of the challenge. Today’s initiative is a welcome example of how cooperation can accelerate the energy transition and build greater resilience to the impacts of climate change. The United States is impressed by the courageous and creative steps by the parties that made this declaration possible, and looks forward to working with the parties, as well as with others in the region and around the world, to turn our shared climate challenge into an opportunity to build a more prosperous future.”

West Asia is at the forefront of being affected by climate crises, which can only be solved through collective responsibility, cooperation, and joint action. Therefore, not only through coming together and by signing the deal but both the countries have also decided to invest in clean energies in their homeland. Both the countries decided to move towards renewable energies. Israel targeted to generate 30% of its power from renewables by 2030. The state has also announced to reduce carbon emission to net-zero by 2050. Israel's National Energy Efficiency Plan also seeks to reduce energy intensity across the economy by 18% from 2015 levels by 2030 as another key strategic step by the Israeli state to reduce Green House Gas (GHG) emissions. The state has also decided to build green infrastructure and use an environmental method and technology to help meet the goals.

Similarly, Jordan has decided to reduce GHG emissions in 2030 by 31%. Jordan is suitable for constructing big photovoltaic powerhouses due to the vast sun-drenched deserts land, also chose to develop renewable energy to sell it to the Israeli state and the entire region. The West Asian countries that are already on the verge of the climate crisis have realized the need for green politics and effective climate-oriented policies. The region is full of political turmoil and disturbance has also decided to keep their disbelief and enmity aside while working on the economic and environmental front with each other.

On a concluding note, while transitioning to renewable energy is essential to decarbonize the economy, it is also crucial for energy security in the West Asian region. The governments' recent shift toward regional integration offers some hope, but investors and developers will need a clearer vision and substantial progress to emerge. The potential for renewable energy development in Israel and Jordan presents a pathway to future energy independence and security in the region and the world. The region is in dire need of collectively responding and addressing the destabilizing consequences of climate change. Both sides should reset their relations and focus on the larger picture of human existence. It is essential to focus on renewable energy, water, electricity, and green energy for generations to come, reduce the risk of future violence, and establish a regional cooperation model for a better green and sustainable world.

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