SOLAR PV AND WIND TURBINES IN YEMEN

TECHNOLOGY DESCRIPTION

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Solar photovoltaic technology, which converts solar radiation directly into electricity through semiconductor materials, offers a highly modular and scalable solution with minimal maintenance requirements. The technology's selection was driven by its low operational costs, declining installation expenses, and zero direct emissions during operation. Solar PV systems provide immediate electricity availability during daylight hours and can be deployed in both grid-connected and off-grid applications, making them particularly suitable for Yemen's diverse geographical context.

Wind energy technology, which harnesses wind's kinetic energy through turbine generators to produce electrical power, complements solar PV in Yemen's renewable energy portfolio. The technology's competitive levelized cost of electricity and substantial emission reduction potential made it a compelling choice for further development. Wind energy systems are available in various sizes and can operate in both distributed and centralized generation modes, offering flexibility in deployment. The technology's ability to generate power during different times of day and seasons makes it particularly valuable when integrated with solar PV systems.

CURRENT TECHNOLOGY READINESS LEVEL OR COMMERCIAL READINESS INDEX

Solar PV: The **TRL** for Solar PV in Yemen is **7-8**, as the technology has limited but functional installations in the country, primarily in urban areas. This reflects its readiness for large-scale deployment despite infrastructural and operational challenges. The **CRI** for Solar PV is **5-6**, as it shows moderate commercial viability driven by declining costs and abundant solar resources, yet limited adoption and an underdeveloped market restrict its full commercialization.

Wind Turbines: The **TRL** for Wind Turbines in Yemen is **6-7**, as the technology has only been piloted locally despite being globally established. This indicates Yemen's early operational phase for wind energy projects. The **CRI** for Wind Turbines is **4-5**, as the market remains in its infancy with no significant commercial projects, although favorable wind conditions and government targets provide strong potential for future development.

CLIMATE RATIONALE OF THE TECHNOLOGY

According to the latest GHG inventory in 2010, the energy sector contributed approximately 22,038 Gg CO_2-eq, representing 65% of national emissions. The sector's emissions are primarily generated through the combustion of fossil fuels including petroleum oil, diesel, mazut, and natural gas for power generation. Most power generation plants are operating well beyond their expected lifespan, with total production sometimes falling below 100 MW due to fuel shortages and maintenance issues.

The energy sector plays a vital role in Yemen's socio-economic development while being the largest contributor to greenhouse gas emissions. This sector faces significant challenges due to ongoing conflicts and infrastructure damage, resulting in a substantial energy deficit exceeding 2,000 MW. This shortfall severely impacts social and economic development across the country.

Yemen's energy infrastructure is heavily reliant on fossil fuels, with a gas power plant of 340-380 MW capacity and thermal power plants contributing approximately 1,100 MW. Renewable energy installations remain minimal, with just

1.5 MW from small solar PV projects, while aging transmission and distribution networks and isolated grid systems hinder efficiency and expansion. Transitioning to renewables presents a critical opportunity to modernize the energy sector, reduce dependency on fossil fuels, and mitigate the impacts of climate change, fostering a more sustainable and resilient energy future.

AMBITION OF THE TECHNOLOGY

SCALE FOR IMPLEMENTATION AND TIMELINE

Aden's loads in all sectors (except the industrial and commercial sectors) are over 600 MW. Since most power generation plants are old and have exceeded their expected lifespan, their total production sometimes falls to less than 100 megawatts due to the lack of fuel.

Solar PV technology, which currently has limited installations primarily in urban areas. The national target for Solar PV by 2030 is to achieve a total capacity of 400 MW, with 250 MW through off-grid systems and 150 MW through on-grid systems.

Wind Energy, which currently has minimal uptake with only pilot projects in place. The national target for Wind Energy is to achieve 200 MW of capacity by 2030 through a combination of on-grid and off-grid systems. These targets are aimed at meeting the energy needs of households and government institutions, including ministries, water institutions, hospitals, schools, and universities. The implementation of these technologies is supported by Yemen's abundant renewable resources, with solar radiation ranging from 5.21-7.23 kWh/m^2 per day and average wind speeds exceeding 8 m/s in coastal areas.

This will cover the needs of households and all government institutions, including ministries, water institutions, hospitals, schools, universities, etc.

AMBITION FOR TECHNOLOGY READINESS LEVEL OR COMMERCIAL READINESS INDEX

Solar PV: The ambition for Solar PV is to achieve a TRL of 9, reflecting widespread and fully operational deployment across Yemen in both on-grid and off-grid applications. The CRI ambition is to reach 7, indicating a commercially mature market with large-scale installations, accessible financing, and strong policy frameworks. This aligns with the national target of achieving 400 MW capacity by 2030 and addressing energy deficits through a scalable and sustainable solution.

Wind Turbines: The ambition for Wind Turbines is to achieve a TRL of 8-9, ensuring robust deployment beyond pilot projects and operational readiness for both on-grid and off-grid systems. The CRI ambition is to reach 6-7, signifying a competitive and commercially viable wind energy sector capable of attracting investment and scaling to meet the national target of 200 MW by 2030. This requires utilizing Yemen's high wind speeds and integrating wind energy into the renewable energy mix.

IMPACTS OF THE TECHNOLOGY

Solar PV and wind turbine technologies can contribute to the global transition towards renewable energy while reaping the benefits of clean, affordable, and sustainable power generation.

The expected benefits could be:

- Increased renewable energy deployment to the overall energy mix in Yemen.
- Enhanced energy accessibility.
- Job creation and economic development.

- Reduce dependence on fossil fuels, leading to a decrease in greenhouse gas emissions and environmental degradation.
- Increase awareness and knowledge about the benefits of renewable energy and fostering a culture of sustainability

POLICY ACTIONS FOR TECHNOLOGY IMPLEMENTATION

EXISTING POLICIES IN RELATION TO THE TECHNOLOGY

Key energy sector policies and legal frameworks are :

1-National Strategy for Renewable Energy and Energy Efficiency (NSREEE)-2009-Under revision- which sets RE targets and implementation framework and Promotes energy efficiency measures

2-Public Electricity Law-2009-which Regulates the electricity sector and establishes the institutional framework

3-Investment Law-2010, which provides incentives for RE investments and aprivate sector participation framework

PROPOSED POLICIES TO ENHANCE TECHNOLOGY IMPLEMENTATION

- Implemented financial incentives to RE to attract potential investors and industry stakeholders to invest in RE.
- Establish national RE policies, plans, and regulations, administrative challenges.
- Policies promoting hybrid systems combining solar PV and wind energy.

USEFUL INFORMATION

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LINKS TO TNA REPORTS

https://tech-action.unepccc.org/country/yemen/