

RENEWABLE ENERGY

VARIABLE RENEWABLE ENERGY GRID INTEGRATION SUPPORT



Over the past decade, technologies for variable renewable energy (VRE) sources such as wind and solar have undergone dramatic cost reductions in many markets. For many countries, the possibility of achieving high levels of VRE penetration is now within sight. Over 144 countries have set ambitious renewable energy targets, and more than 100 have already enacted policies or measures to promote the use of renewables.

However, the prospect of meeting a sizeable share of electricity demand through variable sources also requires significant expansion and modernization of existing electrical grids. Integration of VRE into electricity systems has become a prominent issue and research focus for utilities, universities, private companies, and international organizations.

Additionally, the new VRE capacity includes both utility-scale projects and distributed generation. Distributed systems, such as rooftop solar systems, offer some advantages compared to centralized generation. The proximity to demand minimizes transmission losses and infrastructure costs, but also creates technical and financial challenges, as well as opportunities, for utilities and system operators.

Long-term integration costs can be reduced considerably if integrated planning strategies and regulatory reforms are adopted to gradually transform power systems into “VRE-friendly” grids. And a recent report by the Energy Sector Management Assistance Program (ESMAP), [Bringing Variable](#)

[Renewable Energy Up to Scale: Options for Grid Integration Using Natural Gas and Storage](#), looks at approaches—policies, strategies, and investments—countries can take to integrate large shares of VRE into their grids without compromising the adequacy, reliability, or affordability of electricity supply.

As the costs of VRE technologies continue to drop and countries continue to diversify their energy mix, the demand for technical assistance on VRE integration is rising substantially. The need is greatest in countries with limited capacity or where the integration challenges are so broad that donor coordination is needed to adequately tackle all of the technical and regulatory concerns. Several multilateral banks and bilateral donors are already supporting country-specific efforts. Additional technical assistance and knowledge, however, is needed to implement operational improvements that can help reduce VRE curtailment in the short term, and carry out integrated power sector planning to shape new policies and inform investments in the mid and long term.

In response, Energy Sector Management Assistance Program (ESMAP) has developed a [VRE Grid Integration Support Program](#) to offer support, including capacity development for long-term grid planning, market design, revision of renewable energy support mechanisms, development of rules of access to electricity grids for VRE, and efforts aimed at strengthening the electricity dispatch and transport infrastructure. The programmatic approach will allow developing countries and Bank teams to benefit from



The Energy Sector Management Assistance Program (ESMAP) is a global knowledge and technical assistance program administered by The World Bank. It provides analytical and advisory services to low- and middle-income countries to increase their know-how and institutional capacity to achieve environmentally sustainable energy solutions for poverty reduction and economic growth. ESMAP is funded by Australia, Austria, Denmark, the European Commission, Finland, France, Germany, Iceland, Japan, Lithuania, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom, as well as The World Bank.

improved procurement practices and supervision of consultancy services, facilitate the co-financing of large studies, and improve the access to planning and operation input data such as resource data from other donors or the validation of power trade assumptions among countries. The program will benefit from contributions provided by

ESMAP's Renewable Energy Resource Mapping Program and Smart Grid Technologies Knowledge Sharing Portal, as well as from the support of the World Bank's Clean Energy and Power Systems Global Solution Groups.

This program aims to increase the capacity of countries to develop new policies and investments, and encourages

adoption of best practices through international exchanges of experience. The program is highly operational and, whenever required, will identify opportunities to scale up VRE integration by the World Bank Group and other multilateral and bilateral financing institutions.

PARTNERSHIPS

ESMAP has partnered with the [Clean Energy Ministerial](#) and the National Renewable Energy Laboratory as part of the 21st Century Power Partnership and

receives in-kind support from the Global Sustainable Electricity Partnership (GSEP). In addition, the program has supported World Bank teams in a num-

ber of countries to obtain funding from the Korea Green Growth Trust Fund and the Small Island Developing States Support Program ([SIDS DOCK](#)).

PROGRAM COMPONENTS

- **Just-in time advisory services** by a network of international experts to solve immediate client concerns on VRE integration
- **Planning and grid integration studies** to support a realistic, affordable, and system-wide plan for scaling up VRE
- **Operational support with a focus on procurement of and capacity**

development for the management tools needed to efficiently manage a VRE-heavy power system, such as:

- ◇ Advanced control technologies, metering, and forecasting systems
- ◇ Optimized operational procedures for the use of existing flexible generation and incorpo-

rate energy storage

- ◇ Upgraded dispatching centers that are able to efficiently manage VRE

- **Support for new regulatory frameworks**, particularly grid codes and VRE procurement strategies, and market design (e.g., to explicitly value flexibility and capacity in national electricity markets)

ACTIVITIES

The program is already supporting engagements various VRE-integration related activities in Bangladesh, Cape

Verde, Costa Rica, Guatemala, Haiti, Honduras, India, Kazakhstan, Mexico, Morocco, Pacific Islands, Philippines,

Senegal, Seychelles, Sri Lanka, Turkey, Ukraine, and Vietnam, with demand from a dozen more countries.