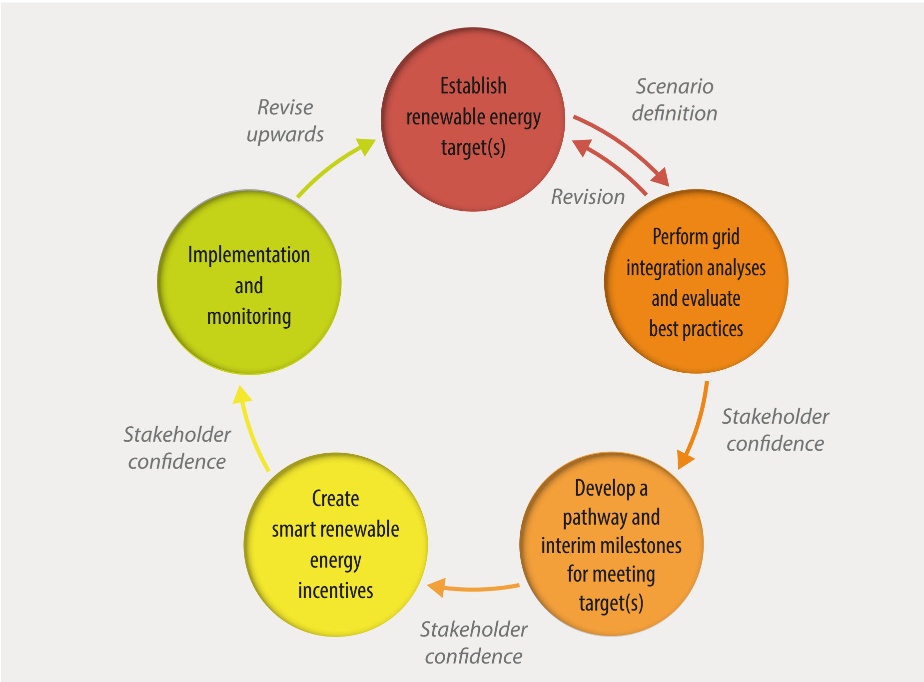
SCALING UP RENEWABLE ENERGY GENERATION: ALIGNING TARGETS AND INCENTIVES WITH GRID INTEGRATION CONSIDERATIONS



An iterative process for target-setting, analysis, and implementation helps power system stakeholders set and meet progressively higher renewable energy targets.

Countries around the world have established ambitious targets for increasing the contribution of renewable energy toward meeting their national energy demand. Over the next decade, India, Indonesia, Kenya, and the Philippines, among others, are aiming to collectively add hundreds of gigawatts of new wind and solar capacity, most of which is likely to be interconnected to the electricity grid [1]. At low penetrations of wind and solar (e.g., below 5%–10% of annual electric demand), impacts to the power system are likely to be minimal. However, as the proportion of variable renewable energy (VRE) connected to the grid increases, power system planners will increasingly need to evaluate and manage the impact of increased variability and uncertainty on system operations. They will also need to ensure that the policy and regulatory environment offers sufficient certainty and revenue streams to encourage investment in new VRE generation. To address these needs, power system planners can take several steps to align targets and incentives with grid integration considerations.

Establish renewable energy target(s). Long-term, aspirational renewable energy targets establish a vision that can drive innovation in the policies and system operations that support clean energy. Renewable energy targets take a variety of forms and can focus on the contribution of renewables toward primary energy supply, electricity production, and/or installed capacity. Mexico, for example, has adopted a generation target to obtain 35% of the country's electricity from renewable sources by 2024 [2]. India on the other hand has announced a capacity target to establish 175 gigawatts (GW) of renewable energy capacity (comprising 100 GW solar, 60 GW wind, 10 GW biomass and 5 GW small hydro) by 2022 [3]. Some jurisdictions, including Australia and many states in the United States, have mandatory renewable electricity targets (often in the form of renewable portfolio standards), though many other countries have developed aspirational policy targets that are not legally binding.

Perform grid integration studies and establish best practices. Experience demonstrates that system operators, when able to evaluate the requirements of power systems with high VRE, have been willing to innovate in discovering new approaches to meeting and

CASE STUDY: ITERATIVE TARGET-SETTING AND INTEGRATION STUDIES IN CALIFORNIA

The U.S. state of California used an iterative process for setting renewable energy targets and conducting grid integration studies to support progressively higher penetrations of wind and solar energy. In 2002, California established a statewide renewable portfolio standard (RPS) that required investor-owned utilities (IOUs) to obtain 20% of electricity supply from renewable sources by 2017. The timeframe for meeting this target was subsequently accelerated to 2010 due to the early progress of the IOUs toward meeting the RPS target. To understand the grid operation and design measures needed to meet the 20% RPS target, California's system operator, regulators, industry experts, renewable energy system owners, and other stakeholders collaborated and developed several grid integration studies [7]. These analyses were extended to examine a 33% RPS scenario, and in 2011, a new RPS target of 33% by 2020 was codified by state law.

Through the process of performing grid integration studies, California's power system stakeholders developed a systematic understanding of and confidence in a pathway to meet the initial 20% as well as the subsequent 33% RPS targets. More recent studies are examining the impacts of larger penetrations of VRE (40% and 50%), and the state legislature is exploring a higher RPS target [8].

even exceeding ambitious renewable energy targets (see sidebar on page 1). A grid integration study is an analysis of a set of scenarios and sensitivities that seeks to inform stakeholders on the ability and needs of a power system to accommodate significant VRE. Grid integration studies both inform and are informed by targets for renewable energy generation. Targets frame the specific scenarios to be modeled and analyzed, while the outputs of integration studies define the system-specific characteristics and limitations that will need to be addressed to meet targets. Iteration between renewable energy target setting and studies of operational feasibility builds confidence among power system stakeholders and investors in the ability of a power system to meet a target.

Develop a pathway and interim milestones for meeting targets. Grid integration studies can identify specific needs (and associated costs) that must be addressed for a power system to meet its renewable energy targets. These studies can also help planners identify interim milestones for meeting targets (for example, Mexico has a 2018 interim target of supplying 5% of its electricity with renewable sources [4]). Planners can use insights from grid integration studies to define a system-specific pathway for achieving their targets. Such a pathway also may include cost-effective actions that can be undertaken without a robust grid integration study (e.g., institutional and market reforms). Emerging best practices from around the world can inform the articulation of priority investments to be included in a pathway for meeting renewable energy targets.

Create smart renewable energy incentives. Many pathways for meeting renewable energy targets will include changes to the policy and regulatory environment to encourage VRE deployment. Power system planners can draw upon a variety of near-term "grid-aware"[1] policies and incentives that encourage VRE generators to provide grid-support services. Grid-aware incentives include [5]:

- Incentives for grid support capabilities
- Incentives and planning processes to address congestion
- Incentives for aligning generation with demand
- Incentives for the provision of forecasting data
- Incentives for integration with dispatch optimization
- Incentives for dispatchable renewable resources.

Incentive Option	Description	Examples
Incentives for grid support capabilities	Link price supports to the requirement that generators use technologies that contribute to grid stability and reliability.	Spain
Incentives for addressing congestion and variability	Reward the development of new distributed generation in locations that relieve grid congestion and/or defer transmission and distribution upgrades.	Minnesota; New York; Germany
Incentives for aligning generation with demand	Compensate generators for implementing a sub-optimal system design that better aligns generation with demand (for example, by producing electricity during peak demand).	Minnesota; California
Incentives for the provision of forecasting data	Combine price supports, interconnection and power purchase agreements, and/or grid codes with the stipulation that generators provide data that can be used by centralized grid operators to forecast future generation.	Germany; Spain
Incentives for integration with dispatch optimization	Provide price support for integrating VRE generation into the centralized power market for optimization with other generation.	Germany; NordPool; U.S. Midwest [6]
Incentives for dispatchable resources	Provide different subsidies based on the extent to which renewable energy generation is dispatchable, recognizing that resources such as biomass, geothermal, and hydro can balance base load in a more predictable way than variable wind and solar energy.	California

Power systems can implement a variety of incentives that link price supports to requirements that renewable energy generators provide grid support services [5].

Policymakers can also combine incentives to encourage investment in new VRE generation (for instance, coupling price support mechanisms such as net metering, feed-in tariffs, and tax incentives with requirements that generators implement technologies that contribute to grid stability). The appropriate mix of policies depends on the unique institutional and regulatory environment in a given power system.

Implementation and monitoring. Monitoring is critical to understanding successes and roadblocks throughout the implementation of policies, incentives, and actions to encourage higher utilization of VRE. Capturing these insights and systematically tracking progress toward meeting interim milestones and targets will help planners identify and scale up interventions that are particularly effective within a given system. This iterative process also informs the revision of pathways and targets over time.

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[1] See [5] for additional policy mechanisms, including "cost-aware" and "market-aware" policies.

Greening the Grid provides technical assistance to energy system planners, regulators, and grid operators to overcome challenges associated with integrating variable renewable energy into the grid.

FOR MORE INFORMATION

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