FACT SHEET

Decentralized energy system

Key points

- ***Decentralized energy systems can be used as a supplementary measure to the existing centralized energy system.***
- ***Decentralized energy systems provide promising opportunities for deploying renewable energy sources locally available as well as for expanding access to clean energy services to remote communities.***

Decentralized energy system explained

A decentralized energy system is characterized by locating of energy production facilities closer to the site of energy consumption. A decentralized energy system allows for more optimal use of renewable energy as well as combined heat and power, reduces fossil fuel use and increases eco-efficiency.

A decentralized energy system is a relatively new approach in the power industry in most countries. Traditionally, the power industry has focused on developing large, central power stations and transmitting generation loads across long transmission and distribution lines to consumers in the region. Decentralized energy systems seek to put power sources closer to the end user. End users are spread across a region, so sourcing energy generation in a similar decentralized manner can reduce the transmission and distribution inefficiencies and related economic and environmental costs.

How it works

Infrastructure components

A decentralized system relies on distributed generation, energy storage and demand response:

Distributed generation: The core component of a decentralized energy system is distributed generation, also known as embedded generation, on-site generation, dispersed generation and decentralized generation. Both heat and electricity can be generated in a decentralized manner. But heat cannot be transported over long distances; thus it has been traditionally generated onsite. Shifting to decentralized power generation allows for coordinating between heat and power generation in combined heat and power plants. Doing that increases the system's efficiency with electricity and heat production because heat is a by-product of many electricity-generating techniques.

Energy storage: An important limitation in the distribution of electricity has been that electrical energy cannot be stored and must be generated as needed. Adding more generation sources in a decentralized system can lead to new difficulties in controlling supply to best match demand. However, such storage techniques as batteries, compressed air and pumped hydro storage can help keep the grid stable by storing energy when supply exceeds demand and feeding it back into the grid during peak hours. Storage is particularly helpful for intermittent renewable energy plants, which often produce at their highest capacities during non-peak hours. As with generation, storage can and should also be decentralized to maximize its efficiency; it can be off-grid or grid-connected.

Demand response: Demand-response technologies provide another tool to manage grid stability when decentralized generation is grid-connected. Conventionally, grid management has focused on supply management. But new technologies, including smart grid and smart metering, allow for real-time monitoring and communication between producers and consumers of electricity to optimize grid usage. In fact, with distributed generation and storage, many consumers of electricity will also at times be producers of energy. Implementing smart grid technologies to facilitate grid management is necessary to building a truly decentralized energy system.

Infrastructure design

Distributed generation facilities may be connected to the grid or simply serve a particular site without feeding potential excess generation into the grid.

Grid connected: Distributed electricity generation can be connected to a central grid, such as in commercial or industrial plants that have their own power production facilities but can sell excess power to the grid or to a mini-grid to serve regions located far from the central grid. As countries further develop their central grid system, mini-grids can be upgraded to form a distribution network that is connected to a larger transmission network. Linking distributed generation resources through a grid system increases their reliability, particularly when using intermittent renewable resources. Additionally, heat generated from CHP can be connected to distribution pipelines to serve a district.

Off-grid: Electricity demand management and energy storage, although at a smaller scale, are still important components of an off-grid decentralized energy system. Even a solar home system for a single housing unit operates most efficiently with battery storage and if the users manage their own loads to best match supply fluctuations.

Heat generated from CHP can also serve a single site, requiring fewer infrastructures to transmit heat to neighbouring buildings.

Opportunities in Asia and the Pacific

Rural electrification: Because grid integration of distributed generation and storage requires major technical upgrades, countries in the region can focus on distributed generation for rural electrification – either through off-grid or mini-grid systems.

Increases in the share of renewable energy: A decentralized energy system is designed to accommodate many energy sources, including the renewable sources with intermittent production, such as wind and solar. Distributed generation, demand management and storage can all facilitate increased inflows of renewable generation.

Strengths in using a decentralized system

Environmental

- The use of CHP, made possible through the decentralizing of electricity production, also increases the overall heat and power system's efficiency and thereby reduces harmful greenhouse gas emissions.

Economic

- Distributed generation sources often have lower capital costs per project, compared to large central power plants.
- In some circumstances, off-grid distributed generation can reduce the need for expensive transmission and distribution network expansion.
- Lower losses through the lengthy transmission of electricity increases eco-efficiency. Reducing losses in transmission and distribution and the incremental addition to capacity through distributed generation can help defer investment in large central power plants.
- Decentralized siting of energy generation facilities requires decentralized businesses to construct, operate and maintain the facilities, creating opportunities for local business and job creation.

Technical
- Distributed generation projects provide planning flexibility due to their small size and short construction lead times, compared to larger central power plants.
- A decentralized energy system may be a boon to energy efficiency measures. Increased information about energy flows from smart meters can make consumers more conscious of their use. Through on-site energy production, consumers of energy become producers and have a greater economic stake in efficient production and consumption.

Social
- A decentralized system, particularly through the use of isolated, off-grid units and mini-grids, are suitable in rural areas where the population density is low. Often much more economically feasible than central grid build-outs, decentralized approaches can achieve rural electrification faster.

Challenges to using a decentralized energy system

Institutional
- State-controlled electricity markets hamper the development of a decentralized energy system because distributed generation encourages myriad actors to become power producers.
- Interconnection presents not only an economic difficulties but also legal and administrative hurdles for project developers.
- Ownership schemes and pricing systems must be developed for off-grid and mini-grid services. Pricing must not only take into account the cost of producing electricity from the unit or system but also the ability and willingness of users to pay.

Technical
- If not properly planned, large-scale deployment in distributed generation may result in the instability of the voltage profile.
- Emerging technologies, such as smart grid, renewable energy and energy storage, will require the operation criteria of the whole power system to be redesigned and modified.
- Demand response technology requires constant, reliable Internet connections, making it an unsuitable option for much of Asia and the Pacific currently.

Financial
- Distributed generation sources often have higher capital cost per kW, compared to large central plants and particularly due to the interconnection transaction costs.
- The high capital costs and long life cycle of existing transmission and distribution infrastructure make it difficult to upgrade to more efficient infrastructure.
- Due to system stability issues, integration with transmission and distribution systems are considered when adding grid-connected distributed generation sources. This integration can be costly for distributed generation and grid operators.

Implementing strategies

Transform the market: Increasing the number of sites of electricity generation requires a degree of energy market diversification. In countries with fully or heavily state-controlled energy markets, institutions and policies must be overhauled to support the participation of local governments, community cooperatives and private businesses in electricity production and distribution.

Provide incentives: Promote distributed generation by establishing differentiated feed-in tariffs for grid-connected renewable energy sources to ensure that utilities will accept excess power from distributed generators and make it available to the local network.

Set standards: Standardize interconnection requirements to reduce technical and legal difficulties associated with feeding electricity to the grid. This will make entering the energy market more enticing to private entities and cooperatives.

Build up capacities and skills: Focus on capacity building to create a skilled labour force to service and operate decentralized generation, storage and distribution systems.

BOX 1: Off-grid renewable distributed generation solutions

There are a number of off-grid solutions based on renewable energy for providing electricity and heat. Such off-grid solutions are often applied in remote areas with low load needs. For instance, populations in small rural villages are often too small or too dispersed for electrification by mini-grid. In those circumstances, stand-alone solar home systems can provide electricity for lighting, television, radio and mobile phone charging. For instance, whether for agricultural drying, water heating or cooking, small solar concentrators can harness the sun's heat and serve a number of household and agricultural or industrial needs without conversion to electricity. Direct applications of geothermal heat resources, primarily for bathing, show another promising example. A small wind turbine can provide power for such services to an individual home at approximately the same cost (US$550 capital investment for 20 years of operation).[1] Off-grid renewable energy systems have a high level of flexibility and can be tailored to a site's resources and needs, as illustrated by myriad examples, including:

- **PV-diesel hybrid systems:** Many schools in Malaysian Borneo are not grid-connected. They either were not electrified or relied on diesel gensets for electric power. However, fuel and fuel delivery costs were high. The Malaysian Ministry of Education funded the capital costs of providing PV panels for PV-diesel hybrid systems to 63 schools on the island. With more reliable electricity access, the schools can provide l ighting, computer use and Internet access.[2]

- **Urban installations:** Functional off-grid installations are not limited to rural regions. Solar lanterns and more versatile solar home systems can provide lighting to urban poor households that are affected by electricity shortages due to mismanagement or pilferage. SELCO (Solar Electric Light Company) partnered with SEWA Bank (Self-Employed Women's Association) to provide affordable solar and biogas-based lighting and cooking devices to home-based workers, such as vegetable vendors in urban areas across Gujarat, India.[3]

- **Water pumping:** The Punjab area of north-western India is dry and arid but has abundant solar insolation. Around 1,400 solar-powered water pumps have been installed in the region, each capable of pumping enough water to irrigate 1.5–2.3 ha of land. Pumps are offered under a lease-finance scheme with soft loans from the Indian Renewable Energy Development Agency. By avoiding diesel fuel costs, farmers save an estimated US$800–$1,000 per year.[4]

[1] Global Environment Facility and United Nation Development Progamme, *Household-size Wind Turbines, Sri Lanka*, Paper for Small Grants Programme (New York, 2003). Available from http://sgp.undp.org/download/SGP_SriLanka1.pdf (accessed 10 February 2012).

[2] Alliance for Rural Electrification, *Best Practices of the Alliance for Rural Electrification: What Renewable Energy Can Achieve in Developing Countries* (Brussels, 2009). Available from http://www.ruralelec.org/fileadmin/DATA/Documents/06_Publications/Position_papers/ARE_Publication_-_Case_studies_for_renewable energy_in_Developing_countries.pdf (accessed 10 February 2012).

[3] Intellectual Capital Advisory Services Pvt. Ltd. and the Rockefeller Foundation, *Opportunities for Private Sector Engagement in Urban Climate Change Resilience Building* (Bangkok and Mumbai, 2010). Available from www.rockefellerfoundation.org/uploads/files/2ad3aea5-525b-4a9b-991c-a024a59a3762-private.pdf (accessed 29 November 2011).

[4] Global Network on Energy for Sustainable Development, *Poverty Reduction: Can Renewable Energy Make a Real Contribution?* (Roskilde, Denmark, 2006). Available from www.gnesd.org/downloadables/povertyreductionspm.pdf (accessed 4 November 2011).

Further reading

Co-generation and Renewable Energy (Paris, IEA and OECD, 2010).

Decentralized Energy Systems (Brussels, European Parliament's Committee on Industry, Research and Energy, 2010).

"Distributed generation: Definition, benefits and issues" by G. Pepermans and others, in *Energy Policy* (2005), vol. 33, pp. 787-798.

"The implications of an increasingly decentralized energy system" by P. Wolfe, in *Energy Policy* (2008), vol. 36, pp. 4509–4513.