What are distributed energy resources?

A Distributed Energy Resource (DER) is any resource on the distribution system that produces electricity and is not otherwise included in the formal NERC definition of the Bulk Electric System (BES).
Some examples of DER resources

1) Microturbine

Microturbines are a relatively new Distributed Energy Technology being used for stationary energy generation applications. They are a type of combustion turbine that produces both heat and electricity on a relatively small scale.
2) Combustion Turbines

Conventional combustion turbine (CT) generators typically range in size from about 500 kW up to 25 MW for DER, and up to approximately 250 MW for central power generation. They are fueled by natural gas, oil, or a combination of fuels ("dual fuel"). Modern single-cycle combustion turbine units typically have efficiencies in the range of 20 to 45% at full load.
3) Internal Combustion Engines

A reciprocating, or internal combustion (IC), engine converts the energy contained in a fuel into mechanical power. This mechanical power is used to turn a shaft in the engine. A generator is attached to the IC engine to convert the rotational motion into power. They are available from small sizes (e.g., 5 kW for residential back-up generation) to large generators (e.g., 7 MW). Reciprocating engines use commonly available fuels such as gasoline, natural gas, and diesel fuel.
4) Stirling Engines

Stirling engines are classed as external combustion engines. They are sealed systems with an inert working fluid, usually either helium or hydrogen. They are generally found in small sizes (1–25 kW) and are currently being produced in small quantities for specialized applications in the space and marine industries.
5) Fuel Cells

Fuel cell power systems are quiet, clean, highly efficient on-site electrical generators that use an electrochemical process—not combustion—to convert fuel into electricity. In addition to providing power, they can supply a thermal energy source for water and space heating, or absorption cooling. In demonstration projects, fuel cells have been shown to reduce facility energy service costs by 20% to 40% over conventional energy service.
6) Energy Storage/ UPS System

Energy storage technologies produce no net energy but can provide electric power over short periods of time. They are used to correct voltage sags, flicker, and surges that occur when utilities or customers switch suppliers or loads. They may also be used as an uninterruptible power supply (UPS). As such, energy storage technologies are considered to be a distributed energy resource.
7) Photovoltaic Systems

Photovoltaic (PV) cells, or solar cells, convert sunlight directly into electricity. PV cells are assembled into flat plate systems that can be mounted on rooftops or other sunny areas. They generate electricity with no moving parts, operate quietly with no emissions, and require little maintenance.
8) Wind Systems

Wind turbines use the wind to produce electrical power. A turbine with fan blades is placed at the top of a tall tower. The tower is tall in order to harness the wind at a greater velocity, free of turbulence caused by interference from obstacles such as trees, hills, and buildings. As the turbine rotates in the wind, a generator produces electrical power. A single wind turbine can range in size from a few kW for residential applications to more than 5 MW.
9) Hybrid Systems

Developers and manufacturers of DER are looking for ways to combine technologies to improve performance and efficiency of distributed generation equipment. Several examples of hybrid systems include:

- Solid oxide fuel cell combined with a gas turbine or microturbine
- Stirling engine combined with a solar dish
- Photovoltaic systems with battery storage and diesel backup generators
- Engines (and other prime movers) combined with energy storage devices such as flywheels
Applications of DER

Some of the primary applications for DER include:

- **Premium power**—reduced frequency variations, voltage transients, surges, dips, or other disruptions
- **Back-up power**—used in the event of an outage, as a back-up to the electric grid
- **Peak shaving**—the use of DER during times when electric use and demand charges are high
- **Low-cost energy**—the use of DER as base load or primary power that is less expensive to produce locally than it is to purchase from the electric utility
- **Combined heat and power (cogeneration)**—increases the efficiency of on-site power generation by using the waste heat for existing thermal process

Generally, DER provides the consumer with greater reliability, adequate power quality, and the possibility to participate in competitive electric power markets. DER also have the potential to mitigate overloaded transmission lines, control price fluctuations, strengthen energy security, and provide greater stability to the electricity grid.
Characteristics of DER

➢ Aesthetics
  ➢ Improves sightlines and views with off-the-grid systems, which eliminate the need for overhead power lines
  ➢ Gives more choice in energy supply options; allows customers to choose the best solution for an individual location

➢ Cost-Effective
  ➢ Enables cost savings by reducing the peak demand at a facility, therefore lowering demand charges
  ➢ Provides greater predictability of energy costs (lower financial risk) with renewable energy systems

➢ Productive
  ➢ Some DER equipment provides high quality power for sensitive applications
  ➢ Responds faster to new power demands—as capacity additions can be made more quickly
  ➢ Facilitates less capital tied up in unproductive assets—as the modular nature of distributed generators means capacity additions and reductions can be made in small increments, closely matched with demand, instead of constructing central power plants sized to meet estimated future (rather than current) demand
  ➢ Back-up power decreases downtime, enabling employees to resume working
Functional
➢ Provides better power reliability and quality, especially for those in areas where brownouts, surges, etc. are common or utility power is less dependable
➢ Provides power to remote applications where traditional transmission and distribution lines are not an option. Locations such as cellular towers, small remote towns, or drilling platforms in the ocean are outside the electric grid and benefit from DER as a primary power source
➢ Reduces upstream overload of transmission lines
➢ Optimizes utilization of existing grid assets—including potential to free up transmission assets for increased wheeling capacity
➢ Improves grid reliability
➢ Facilitates faster permitting than transmission line upgrades

Secure/Safe
➢ Strengthens energy security
➢ Back-up power provides quick recovery after an event

Sustainable
➢ Provides cleaner, quieter operation, and reduces emissions for some technologies (e.g., solar, wind, fuel cells)
➢ Reduces or defers infrastructure (line and substation) upgrades
➢ Possesses higher energy conversion efficiencies than central generation
➢ Enables more effective energy and load management
Looking at DER’s like a problem?
Rooftop PV Installation overview

Site Plan
Penetrations and Hardwares

sealant/M1
Electrical Wiring and J-box
PV Array with LI-ION BATTERY
## Challenges of Economic PV Grid Integration and the Need for Flexibility

### Table 1. Characteristics of PV Electricity Generation and Associated Integration Challenges

<table>
<thead>
<tr>
<th>Solar Characteristic</th>
<th>Potential Economic Challenge to Integration</th>
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<tbody>
<tr>
<td></td>
<td>Energy Value &amp; Curtailment</td>
</tr>
<tr>
<td><strong>Variability</strong></td>
<td>PV output can vary as underlying resource fluctuates.</td>
</tr>
<tr>
<td><strong>Uncertainty</strong></td>
<td>PV output cannot be predicted with perfect accuracy.</td>
</tr>
<tr>
<td><strong>Non-synchronous generation</strong></td>
<td>PV does not currently help maintain system frequency.</td>
</tr>
</tbody>
</table>
### Types of Grid Flexibility

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator flexibility</td>
<td>Ability of conventional generation to vary output over various time scales</td>
</tr>
<tr>
<td>Storage flexibility</td>
<td>Ability to store energy during periods of low demand and release that energy during periods of high demand</td>
</tr>
<tr>
<td>Geographic flexibility</td>
<td>Ability to use transmission to share energy and capacity across multiple regions</td>
</tr>
<tr>
<td>Load flexibility</td>
<td>Ability to vary electricity demand in response to grid conditions</td>
</tr>
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Impacts of PV on Net Load and the Problem of Overgeneration

Figure 1. The CAISO duck chart
Source: CAISO 2013
Modeling PV Generation and Curtailment with Limited Grid Flexibility

Figure 2. Net load profiles for California on March 29 in a scenario with increasing penetration of solar, assuming no curtailment (penetrations are based on annual potential)
References

- “Distributed energy resources (DER)” https://www.wbdg.org/resources/distributed-energy-resources-der
- Images from https://pixabay.com
- “Achieving the potential of DER” https://www.youtube.com/watch?v=P2YiWFASZqs
- What are distributed energy resources and how do they work https://arena.gov.au/blog/distributed-energy-resources/
Thank You!

Any Questions?