Between 2003 and 2012, weather-related outages are estimated to have cost the U.S. economy an inflation-adjusted annual average of $18 billion to $33 billion. Continued investment in grid modernization and resilience will mitigate the costs of weather-related outages over time. These investments may include installing smart grid technology such as smart meters, outage management systems, synchrophasors, and advanced control capabilities [1].

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Arrangement and functional concept of a gas-fired power plant

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Gas is a major source of electricity generation. Approximately 21% of the world’s electricity production is based on natural gas. The global gas-fired generation capacity amounts to 1168 GW_e (2007). The combustion (gas) turbines being installed in many of today's natural-gas-fueled power plants are complex machines, but they basically involve three main sections:

- **The compressor**, which draws air into the engine, pressurizes it, and feeds it to the combustion chamber at speeds of hundreds of miles per hour.
- **The combustion system**, typically made up of a ring of fuel injectors that inject a steady stream of fuel into combustion chambers where it mixes with the air. The mixture is burned at temperatures of more than 2000 degrees F. The combustion produces a high temperature, high pressure gas stream that enters and expands through the turbine section.
- **The turbine** is an intricate array of alternate stationary and rotating aerofoil-section blades. As hot combustion gas expands through the turbine, it spins the rotating blades. The rotating blades perform a dual function: they drive the compressor to draw more pressurized air into the combustion section, and they spin a generator to produce electricity.

There are two types of gas-fired power plants, viz. open-cycle gas turbine (OCGT) plants and combined-cycle gas turbine (CCGT) plants. Open-cycle gas turbines (OCGT) for electricity generation were introduced decades ago for peak-load service. Simple OCGT plants consist basically of an air compressor and a gas turbine aligned on a single shaft connected to an electricity generator. Filtered air is compressed by the compressor and used to fire natural gas in the combustion chamber of the gas turbine that drives both the compressor and the electricity generator. Almost two-thirds of the gross power output of gas turbine is needed to compress air, and remaining one-third drives the electricity generator. OCGT generators have relatively low electrical efficiency ranging between 35% and 42% (lower heating value, LHV). Aero-derivative gas-turbines provide efficiency of 41-42% but their size is limited to 40-50 MW_e.

Since theearly 1990s, combined-cycle gas turbines (CCGT) have become the technology of choice for new gas-fired power plants. CCGT plants consist of compressor/gas-turbine groups – the same as OCGT plants – but the hot gas-tubine exhaust is not discharged into the atmosphere. Instead it is re-used in a heat recovery steam generator (HRSG) to generate steam that drives a steam-turbine generator and produces additional power. Gas-turbine exhausts then leave the HRSG at about 90˚C and are discharged into the atmosphere. CCGT plants commonly consist of one gas turbine and one steam turbine. Approximately two-thirds of the total power is generated by gas turbine and one-third by the steam turbine. Large CCGT power plants may have more than one gas-turbine.

State-of-art CCGTs have electric efficiency of between 52% and 60% (lower heating value, LHV) at full load. Combined-cycle gas turbine is mature technology. It is one of the dominant options for both intermediate load (2000 to 5000 hrs/yr) and base load (>5000 hrs/yr) electricity generation. In the last decade, many CCGT plants have been built in North America, Europe, Asia, and the Middle East. These plants have become the workhorses of independent power producers all over the world. With individual heavy-frame gas turbines available in unit sizes of up to 300 MW_e CCGT plants offer modular flexibility and adaptability to the electricity demand and grid requirements. In general, gas-turbines can burn not only natural gas but also heavy/crude oil, distillate and other liquid and gaseous fuels. Obviously, large heavy-duty gas-turbines with big combustion chambers are more suitable for burning heavy fuels, while small, aero-derivate gas-turbines, with several little burners or combustion chambers, are more sensitive to changes of combustion parameters. In general, CCGT plants are designed to respond relatively fast to changes in electricity demand and service. They may be operated between 40% and 100% of nominal capacity with moderate efficiency drop (58-59% at full load to 50-52% of the full load). Due to the high efficiency and the use of natural gas, the best available CCGT power plants emit approximately 50% less CO_2 and up to nine times less NO_x per kWh than modern coal-fired power plants.

One key to a turbine's fuel-to-power efficiency is the temperature at which it operates. Higher temperatures generally mean higher efficiencies, which in turn, can lead to more economical operation. Gas flowing through a typical power plant turbine can be as hot as 2300 degrees F, but some of the critical metals in the turbine can withstand temperatures only as hot as 1500 to 1700 degrees F. Therefore, air from the compressor might be used for cooling key turbine components, reducing ultimate thermal efficiency.

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Power converters

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Power converters are devices designed to convert electric energy parameters (voltage, frequency, number of phases, waveform). Power converters are used in electrical engineer-