

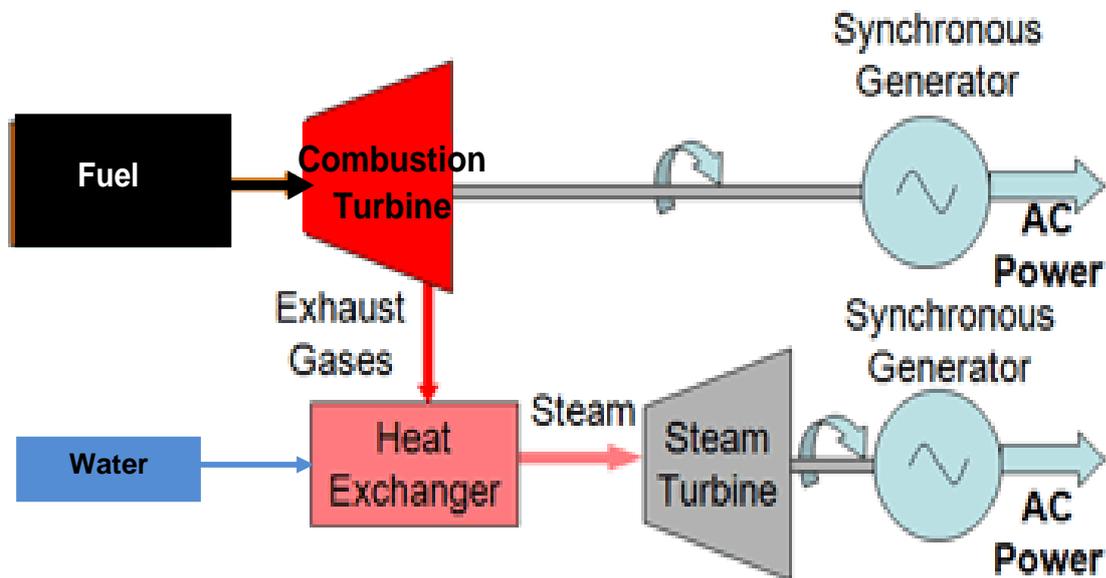
Combined Cycle Diesel Generator

Defining characteristics	Narrative
<i>General</i>	<p>A generator is a device that converts mechanical energy to electrical energy based on the principle of electromagnetic induction. Combined cycle power generation reflects a power optimisation strategy built on converting waste heat from a conventional thermal generator to dispatchable electricity by means of a parallel generating unit. To this effect, a combined cycle diesel plant integrates power production from a diesel generator and steam turbine connected to alternators that produce a synchronised alternating current output from motive forces generated by the diesel engine and steam turbine operating as distinct units. It is perhaps worth noting that the key technical components of this combined cycle power plant (CCPP) were independently developed in the 19th Century, and significantly improved over time through advances in materials science and industrial engineering. Modern generators are designed to operate in a wide range of temperature conditions (IMIA Working Group, 2015).</p>
<i>Siting and land use</i>	<p>Locational decisions concerning implantation of power stations require consideration of multiple qualitative and quantitative economic, technological, environmental and social criteria. Ideally, the site chosen for installation of a combined cycle diesel plant should not cause environmental impacts including disruption of ecosystems on contiguous land in breach of established in legal statues or industry standards. Social costs and acceptability should also be considered and discussed with communities living in close proximity to sites identified for implanting a new CCPP. Alternative land uses forecast over the life span of the plant could be equally important. As a general rule, a combined cycle diesel power plant should be located on land dedicated to medium-size and heavy industries. Using coal-fired power plant as a surrogate, combined cycle diesel power plants may require on average 0.2 ha per MW of electricity generated (Fhenakis and Kim, 2009), plus an additional 0.68 ha per MW electricity for balance of station systems (Pasqualetti and Miller, 1984).</p>
<i>Design (components) and Operation</i>	<p>A CCPP consists of two modular generation sub-systems; one of them converting chemical energy to electricity, and the other, converting thermal energy to electricity. The first sub-system represents a combustion turbine, and the second, a steam turbine, connected to one or separate alternators (IMIA Working Group, 2015)..</p> <p>A combustion turbine is made up of the following key components: 1) diesel engine, and 2) alternator. The major components of the diesel engine are its air intake and exhaust systems, fuel injection system, cylinder mounting, crankshaft, and camshaft. The operation cycle of a diesel engine starts with filtered air being drawn into engine cylinders, then getting heated as a result of compression by controlled movement of pistons inside the cylinder, and causing a calibrated and scheduled amount of fuel injected into the cylinder to ignite spontaneously, creating an explosive force that drives the piston to its lowest position allowing spent gases out of cylinder through exhaust valves. Diesel engines in power plants typically have 6 to 16 cylinders and the force exerted on pistons are transmitted through a crankshaft that attaches to the axis of an alternator that produces an alternating current proportional to the rotational speed of the crankshaft.</p> <p>The steam turbine sub-system derives its energy source from spent/flue gases produced from combustion of fuel oil in diesel engine cylinders. In a first step, exhaust gases are piped through a heat exchanger/boiler system inside which hot flue gases generate superheated steam in an elaborate network of tubes containing water containing water without the two fluids mixing. When high pressure steam flowing through connector pipes from storage drums is directed at rotor blades of the steam turbine, the pressure exerted on rotor blades causes the turbine shaft to rotate and generate electrical energy when connected to an alternator. Condensers are used to liquefy steam from the turbine</p>

	<p>outlet. Water is subsequently re-circulated to the heat exchanger/boiler system. In line with environmental regulations, CO, SO₂ and other pollutants are removed from flue gases before release through stacks.</p> <p>An alternator or synchronous generator has two major components: 1) a rotor, and 2) armature coils. In general, armature coils are stationary whilst the rotor, driven by a prime mover, rotates and produces a changing magnetic field around the armature inducing an alternating current in the armature coils, in the process.⁷² Key variables of the alternating current generated such as voltage and frequency are related to the strength of the magnetic field, armature design and rotor speed. Transformers boost voltage output up to 400,000 volts to facilitate transmission over the grid.</p>
<i>Costs</i>	<p>Investment and operating costs for combined cycle diesel power plants depend on a multitude of variables including rated power output of plant, its technical configuration, fuel costs, flue gas cleaning technology, and balance of station systems. That said, cost information relating to small scale CCPPs is sparse. Investment costs range from USD676/kW for a conventional combustion turbine (85MW) to USD1,023/kW for an advanced CCGT plant (400MW), with corresponding fixed operation and maintenance (O&M) costs of USD7.04/kW.yr and USD13.17/kW.yr, respectively (SAIC, 2013), not discounting regional cost adjustments (SAIC, 2013). Over long distances, or in larger countries, or even smaller ones with contrasting landscape, geographical differences in price of specific project inputs could be significant (Njie, 2008; Mouyelo-Katoula and Nshimyumuremyi, 2007).</p>
<i>Supporting infrastructure</i>	<p>Roads Power house (sound-attenuated enclosure, control room, internal switchgear room) Office Workshops and storage External switchgear room Tank farm (storage and buffer tanks, perimeter bunds) Purifier and pumphouse Fire protection system Pipework and cable connections Transformer</p>
<i>Advantages</i>	<p>High load bearing capacity Can accommodate base load, peaking, emergency or standby power applications (Aabakken, 2006) Highly reliable Moderate O&M costs Can achieve 50%-200% gains in efficiency relative to setup with conventional combustion turbine (IMIA Working Group, 2015) Does not require much land as renewable energy conversion technologies (Fhenakis and Kim, 2009)</p>
<i>Disadvantages /Challenges</i>	<p>Atmospheric emissions (CO₂, SO_x, NO_x) Land and water pollution (wet deposition) Occupational health hazards Noise pollution Hazardous waste residues</p>
<i>Abatement potential</i>	<p>Uncertainties surrounding abatement potential of a combined cycle diesel power plant rests on efficiency gains and quality of fuel used in its combustion turbine. Assuming plant efficiency gains of 50 to 200% (IMIA Working Group, 2015) on a fuel with specific carbon dioxide emission lying between values associated fuel oil and lignite, a combined cycle diesel power plant can be expected to offset between 0.0731gCO₂/kWh and 0.31gCO₂/kWh of electricity produced.</p>

⁷² Based on Faraday's law of electromagnetic induction

<i>Level of penetration</i>	The Gambian public utility company, NAWEC operates one generator working on same principles
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Adapted from:

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Further readings

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