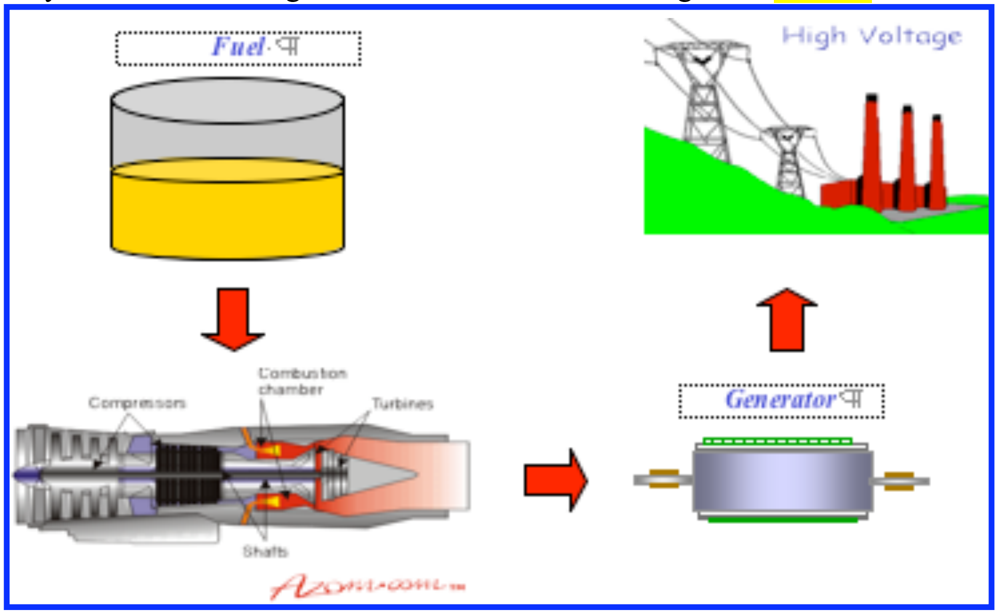
What is an Open Cycle Gas Turbine (OCGT)?

An open cycle gas turbine is a combustion turbine plant fired by liquid fuel to turn a generator rotor that produces electricity. The residual heat is exhausted to atmosphere at about 550 degrees Celsius. The turbine and generators are housed in enclosures designed to reduce noise levels and occupy an area of approximately 75m X 25m per unit. The exhaust stack height is approximately 30m with the height of the intake structure being 20m. **NOTE 1**



A compressor sucks air in from the atmosphere and compresses it through a number of compressor stages. Fuel is pumped into a combustion chamber and mixed with the compressed air. The fuel/air mixture is then ignited to form hot, high velocity gas. This gas is passed through turbine blades that turn the shaft that is attached to the rotor of the generator. The rotor turns inside the stator and electricity is generated. This electricity is then distributed via the high voltage network to where it is needed. **NOTE 2**

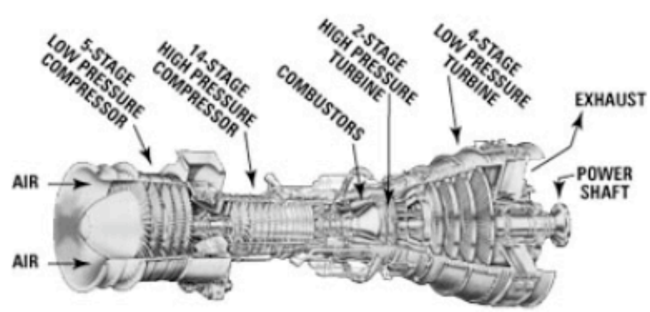


Figure 3. A modern land-based gas turbine used for electrical power production and for mechanical drives. This is a General Electric LM5000 machine with a length of 246 inches (6.2 m) and a weight of about 27,700 pounds (12,500 kg). It produces maximum shaft power of 55.2 MW (74,000 hp) at 3,600 rpm with steam injection. This model shows a direct drive configuration where the l.p. turbine drives both the l.p. compressor and the output shaft. Other models can be made with a power turbine.

Open cycle gas turbine plants, without a steam cycle, are sometimes installed as peaking capacity; their thermal efficiency is much lower. **The high running cost per hour is offset by the low capital cost and the intention to run such units only a few hundred hours per year**.

Byproducts of these power thermal plants' operation need to be considered in both the design and operation. *Waste heat due to the finite efficiency of the power cycle must be released to the atmosphere, using a cooling tower, or river or lake water as a cooling medium*. **NOTE 3.** The flue gas from combustion of the fossil fuels is discharged to the air; this contains carbon dioxide and water vapour, as well as other substances such as nitrogen, nitrogen oxides, sulfur oxides.

Fossil fueled power stations are major emitters of CO_2, the most important greenhouse gas (GHG) which according to the consensus of scientific organisations is a major contributor to the global warming observed over the last 100 years. Carbon capture and storage of emissions are not expected to be available on a commercial economically viable basis until 2025. **NOTE 4.**

An Eskom OCGT Project

Due to the growth in the South African economy, which results in an increased demand for electricity, Eskom's excess electricity generation capacity is being depleted, especially when it comes to supplying electricity during peak demand periods. When government gave Eskom the green light to build new power stations in October 2004, work started in earnest to determine the kind of peaking plant that can be built in a relatively short time, given that it became clear that Eskom would need additional capacity to meet the demand during the winter of 2007.

Based on the following considerations, it was decided to build two OCGT plants:

- The technology has been proven all over the world and has a good track record.
- There are numerous suppliers across the world.
- OCGTs can be built in 3 to 4 years, and if fast tracked, within even shorter project lead times.

The proposed OCGT gas turbine stations will add approximately 1000MW of new generation capacity. It is estimated that an open cycle gas turbine's life span is 25 years. **NOTE 5**.

Background of OCGTs in the Western Cape.

From: BUSINESS DAY, 31 Mar 2010 - Johannesburg: According to industrial and petrochemical consultant Philip Lloyd, peak demand in the Western Cape region is 5300MW. Koeberg provides 1800MW of the peak demand. Gas company Gigajoule wants Eskom to convert the Ankerlig power station to a combined-cycle gas turbine. Eskom says it's infeasible. A reliable supply of natural gas is not available now in required quantities.

Another 3000MW could be supplied by wind farms, says Andrew Marquard of the Energy Research Centre at the Univ. of Cape Town. This is equivalent to only 1000MW of coal power, because wind power, unlike coal, is available only about 1/3 of the time, while coal provides constant base-load power. Thus wind would require standby peaking power when there is demand but no wind. In the case of wind, $2/3^{rds}$ of the time its contribution would have to be supplied by peaker plants such as the open cycle gas turbines. **NOTE 6.**

To illustrate, the Ankerlig power station, an open-cycle gas-turbine plant, has nine units of 150MW each, giving a total of 1350MW. It is a peaking power plant, meaning it is operational for only 6% of the year, and uses diesel to produce power. But open-cycle gas-turbine plants are inefficient, and diesel is an expensive way to produce power. **NOTE 7.** **Lloyd says Eskom's average cost price of electricity is 40c/kWh, compared to R3/kWh for the open-cycle gas-turbine plants run on diesel. The utility uses an average of 40-million litres of diesel a year in these power stations**. **NOTE 8**.

NOTE 1.

By contrast, each LFTR and its gas turbine generator will be co-located 10 meters underground on a one acre (4,047 m^2, or .655 hectares) footprint with its municipal power grid customer(s). LFTR waste heat is exploited on coastal installations with hybrid desalination plants, and on inland installations with airconditioning and / or heat loops. There are no water cooling or cooling towers associated with LFTRs. In addition, there are no large fuel dumps as is the case with diesel fuel depots held in reserve to power open cycle gas turbines. LFTRs are fueled with thorium, a relatively heavy, not-fissile heavy metal, in its natural form, thorium oxide THO_2

NOTE 2.

As LFTRs are co-located with their customers, there is no need for R 15 million per mile long distance high-voltage transmission facilities with their six-traffic-lane-wide right of way extending from the power plant to the faraway customers. As OCGTs are to be used as peaking plants, their sparse electricity output (provided 6% of the time) must amortize the cost of the electricity loss (7%) and the construction cost of the long-haul transmission facilities.

NOTE 3.

Whether used as a base load electricity generator, or a peaking power generator, the LFTR's operating costs stay consistent because of its design.

NOTE 4.

The average 1000 MW OCGT will require multiple 30 meter cooling towers, where water is not used. The average coal or nuclear plant generating 1000MW will require 600,000 gallons of river water to cool the power plant or it will evaporate 20,000 gallons per minute to cool the power plant.

The single most volatile aspect of current nuclear reactors is pressurized water. In the 441 LWRs operating worldwide today water serves as both the reactor's coolant and neutron moderator, (with graphite control rods added by regulators for safety "defense in depth"). Fission heat causes water to boil, either directly in the core or in a steam generator that drives a turbine. In the core, water is maintained at a high pressure to raise its boiling temperature. The explosive pressures involved (up to 160 atmospheres) are contained by a highly engineered system of expensive piping and containment vessels collectively named the 'pressure boundary' – the ultimate line of defense. This 'pressure boundary' is a massive, costly containment building surrounding the reactor, designed to withstand any explosive calamity and prevent the out-of-control release of radioactive materials.

The LFTR operates at the same pressure as the earth's atmosphere. The neutral pressure drops the cost and size of the LFTR's structure – there are no billion-dollar containment vessel requirements. There is no pressure explosion possible. A leak in a LFTR transport line will drop the molten salt into the catch basin where it stops reacting, cools off and freezes into a solid (at 450º C). If the LFTR's heat expands its liquid fuel beyond intended levels, the LFTR core's reactivity falls instantly. Also, if the molten salt gets hotter than is intended, the frozen salt plug kept cool by a fan, will melt and the liquid fuel in the core is immediately evacuated, pouring into a sub-critical geometry in a cooled catch basin where it freezes. This is only possible because the fuel is already a molten salt liquid. In the original 8 MW(h) MSRE reactor built and operated from 1965 through 1968, the operators would deliberately melt the freeze plug on Friday evening, causing the evacuation of the fuel salt into the sink basin below where it remained frozen for the weekend. On Monday morning, every week of the four years of the MSRE's operation, they heated up the frozen salt and pumped it back into the core where it resumed operation for the week.

The LFTR uses no water to cool the power plant or to generate electricity or to carry waste heat away from the power generator. Over the course of 30 years, ten 100 MW LFTRs will generate about 1000 kg of fissile isotopes unwanted in the reactor because they steal neutrons used for heat and breeding fuel. These left over isotopes can either be burned in a LFTR or will be buried in steel caskets between 5,000 and 8,000 feet below the surface of the earth in deep bore holes.

NOTE 5.

The lifespan of a LFTR is estimated at 40 years.

NOTE 6.

Those countries that have committed to solar and wind and withdrawing their support. In the UK, The 280ft turbine situated in a business park near the M4 in Reading operated at just 15 per cent of its capacity year, meaning it generated £100,000 of energy, despite attracting subsidies of £130,000 from the Government. Since 2005, when it began producing energy, the turbine has been subsidised with £600,000 of public money but has run at an average of 17 per cent of its capacity. The decrease in wind speeds has been reported widely in the U.K. and some scientists predict they will continue, prompting some biomass developers to question the wind farm strategy and whether biomass could step up and take the renewable energy reins. "I think this reported trend for lower wind levels is very worrying for the U.K. bearing in mind its planned over-reliance on wind as a massive component of its future electricity source," said Chris Moore, director of U.K. biomass power developer MGT Power. The government is currently consulting on its proposals for the Electricity Market Review, he adds, a new program that includes subsidies such as capacity payments. "These capacity payments will be huge if the generated wind power is as low as these scientists are forecasting," he said.

After watching Spain and France pile up huge deficits without generating any energy with their "feed-in tariffs," Holland has dumped the whole renewables strategy and announced it will go nuclear.

"In a radical change of policy, the Netherlands is reducing its targets for renewable energy and slashing the subsidies for wind and solar power," reports The Register, a British newspaper. "It's also given the green light for the country's first new nuclear power plants for almost 40 years."

The Financial Times Deutschland edition reports the Dutch will slash wind and solar subsidies from $4 billion euros annually to $1.5 billion. The decision is not surprising after Electricitie de France found itself losing $1 billion euro a year on a similar program.

A critically important factor affecting the true *value* of the capacity of any generating unit is how much of the unit's "rated" or "nameplate" capacity can definitely be counted on to be available to generate electricity and how much it can definitely be counted to produce *at the time of peak electricity demand in the control area*. This measure is referred to in the electric industry as the unit's "capacity value."

In fact, regardless of their "rated" or "nameplate" capacity, wind turbines can't be counted on to produce any electricity at the time it is most needed; i.e., when electricity demand reaches peak levels. Therefore, wind turbines really have little or no real "capacity value," as that term is used in the electric industry.

Because wind turbines have little or no real "capacity value," electric grid managers responsible for assuring the reliability of electric service must, instead, look to other generating units – i.e., those that are reliable and dispatchable for the capacity that is needed at the time of peak electricity demand. In most areas of the US, peak electricity demand is likely to occur in late afternoon on hot, weekdays in July or August.

When attempting to compare either the *cost* or *value* of electricity from wind turbines, it is important to recognize that the fact that wind turbines produce little or no electricity most of the time means that their "rated" or "nameplate" capacity is not comparable in value to the "rated" or "nameplate" capacity of a reliable generating unit. (A clear example of the "crabapple to orange" analogy.)

The true value of a kilowatt-hour (kWh) of electricity *depends on when it is produced*. Specifically, a kWh of electricity produced during periods of high or peak electricity demand has much higher value than a kWh produced when demand is low (e.g., during nighttime hours in most areas of the US).

NOTE 7.

The delicate balance of generation and load on an electricity grid continuously fluctuates, often significantly, and on varying timescales as industrial and household demands ebb and flow throughout a day, a week, or a season. Generation must adapt where and when required. Every power grid requires load following, peaking power, and base load power. Nuclear and coal plants are typically relied on to meet a grid's continuous energy demand, producing electricity at a constant rate. The grid adds additional generation to available base load to meet moment-to-moment demand in the grid – load following with peaker plants.

LWRs' responsiveness to load is disrupted by the build up of neutron poisons, like ^{135}Xenon, a powerful neutron absorber that captures neutrons needed for heat generation and breeding new fuel. Adding or subtracting nuclear reactivity required by many load following scenarios accelerates LWR Xenon production, as does varying its reactor power.

By contrast, load following is straightforward for LFTRs. The heat energy is simply drawn out of the heat exchanger. The returning fluid fuel is thus colder and slightly denser, so power goes up automatically to match its absence of heat – due to the strong negative temperature coefficient of the LFTR's fluid fuel. If the LFTR's heat exchangers don't draw out enough heat the returning fluid fuel is hotter and the LFTR reactivity goes down. If the fuel rises past a threshold temperature, the LFTR simply shuts off reactivity altogether. Load following by the LFTR is an automatic, 'hands-off' process

NOTE 8.

In 2013 / 14 when these OCGTs come on line, the RSA Eskom mandated price (because of interest service on new coal plants) will be more than R 1.20 per kWh. Also, the R 3 per kWh for diesel-running OCGTs will go up because of the price of oil which is already 20% higher in February '11 than it was in March 2010 when Mr. Lloyd made his statement.

By contrast, the LFTR will be able to make a profit selling its electricity at $ 0.65 per kWh in 2015 when it becomes available for power generation.