

# THERMAL

## WHAT IS THERMAL GENERATION?

Thermal generation is the process of generating electricity from heat. Heat is a form of energy. Heat energy that is turned into electricity can be made in many ways. It can be produced by burning fuels such as coal, oil, gas or wood. It can also be taken from steam from a geothermal field, or created by nuclear reactions.

In this factsheet you will learn about the burning of fossil fuels (coal, oil, gas), wood (biomass) and geothermal energy. For more information about nuclear power, see the 'Nuclear Energy' factsheet.

Fossil fuels, such as gas, oil and coal, were created millions of years ago from animal and plant matter that was compressed and compacted inside layers of rock.

When coal is burnt to produce heat energy, this heat energy can be used to create steam. The steam drives the steam turbine, which is connected to a generator. The energy produced by the generator is passed through a transformer into the National Grid transmission line. This is the system that delivers electricity to all of New Zealand.

Biomass means a fuel that is made from living things. The most common example of this is wood waste, which comes from wood processing plants and related industries; for example, pulp and paper mills. Often the wood waste is disposed of, but in some situations it can be burned to produce heat energy, which can be used in different ways to generate electrical energy.

Geothermal energy is the heat that flows continuously from the hot interior of the Earth to the cooler surface. In most places in the world, there is not enough of this heat to use for generating electricity. New Zealand is one of just a few countries in the world that have geothermal fields where hot rocks are close enough to the surface to be useful. Wells are drilled deep into the ground and a mixture of hot water and steam is taken out at high pressure. This steam is separated and piped to the power station, where it is used to drive a turbine and generator in the same way as at other power stations. The water is usually put back into the ground, so that the geothermal reservoir isn't depleted.

## HOW DO STEAM AND GAS TURBINES WORK?

In New Zealand, three types of turbines are used to drive the electrical generators of power stations:

### Conventional steam turbine

The fuel is burnt in a boiler to heat water into steam under high pressure. A conventional steam turbine uses the pressure of the expanding steam to turn a turbine. The turbine drives a generator. The whole process converts heat energy to rotational kinetic energy, which is then converted into electrical energy.

### Open-cycle gas turbine

An open-cycle gas turbine is very similar to a jet engine on an aircraft and is the most basic thermal energy turbine. Air is passed through a compressor and is then mixed with fuel gas in a combustion chamber. It is then burnt and



the hot expanding gases create thrust that turns the gas turbine. The shaft of the gas turbine is connected to a generator which generates electricity.

### **Combined-cycle gas turbine**

Combined-cycle gas turbines first combust the gas in a gas turbine, which produces electricity as above. The exhaust heat is then passed through a boiler to create steam which turns a steam turbine. The steam turbine produces further electricity, and so improves the overall efficiency of the operation.

### **WHAT ARE THE ADVANTAGES OF THERMAL ENERGY?**

The main benefit of thermal energy is that it can provide continuous, reliable energy that is not dependent on the weather.

### **Coal**

Coal has been a useful fuel for generating electricity for many decades because it is relatively cheap and available. Coal is in plentiful supply worldwide which generally makes its price and availability reliable. New Zealand has abundant reserves of coal: near Huntly in the North Island, and on the West Coast and in Southland in the South Island.

### **Natural gas**

Efficient combined-cycle gas turbines produce a lot more electricity and less pollution than coal, meaning they put out much less carbon dioxide into the atmosphere for the same output of electrical energy.

### **Wood waste**

Wood waste is generally sourced from a pulp and paper mill which needs electricity and steam. Therefore the waste of the mill can be used to provide steam and energy for the mill. This reduces transportation cost. New Zealand has huge forests of exotic (non-native) trees.

The processing of these trees into paper or milled timber results in a large amount of bark and wood waste, which can be burnt in a boiler to create steam for manufacturing and/or electricity generation. This is a good example of co-generation, and is discussed further in the separate factsheet on co-generation.

### **Geothermal**

Geothermal energy is the only renewable thermal energy available in the world. Using geothermal energy is a cleaner, greener way to produce thermal energy, compared to using fossil fuels, and is not dependent on the weather or mining.

### **WHAT ARE THE DISADVANTAGES OF THERMAL ENERGY?**

All thermal power stations produce steam which once used to drive the turbine is still too hot to discharge directly. Resource consents stipulate how waste steam must be cooled before it can be discharged to the environment.

Other disadvantages are specific to particular fuels.

### **Coal**

Coal is a non-renewable resource and is only available in a few areas of New Zealand. Burning coal creates carbon dioxide emissions which contribute to greenhouse gases.

### **Natural gas**

Natural gas is a non-renewable resource and, in New Zealand, is only produced in the Taranaki region. Natural gas, once burned, also creates carbon dioxide emissions.

### **Wood waste**

A renewable resource, wood waste creates carbon dioxide emissions once burned, although this is largely offset by growing new trees. However, the supply is limited and dependent on what is available.



## Geothermal

Even though geothermal energy is technically renewable, this is dependent on the careful management of geothermal fields, for example by re-injection of water into the underground reservoir rocks. It is also relatively expensive to build a geo-thermal plant. Compared with large fossil fuel-burning thermal power stations, geothermal stations have relatively smaller generating capacities.

### HOW IS THERMAL ENERGY USED IN NEW ZEALAND?

Thermal energy plays a key role in supplying New Zealand's electricity.

Genesis Energy's Huntly Power Station is the country's largest power station. It has six separate generating units: four conventional boiler and turbine units that can burn coal or gas and that each generate 250 MW of power, one gas-fired turbine generating 48 MW and a 385 MW combined cycle gas turbine (a 250 MW gas turbine plus a 135 MW steam turbine) – a total capacity of 1433 MW. Huntly is capable of producing nearly 13 TWhr (13 million MWhr) of energy each year – about 20% of New Zealand's electricity requirements.

Other fossil-fuel burning power stations are located in Auckland, Taranaki and Hawke's Bay. New Zealand is a pioneer in the use of geothermal energy. Wairakei is the oldest operational geothermal power station in the world. New Zealand's other geothermal power stations are all in the Taupo Volcanic Zone and the Northland geothermal field.

In total they account for 635 MW or nearly 7% of our generating capacity.

## ACTIVITIES

### ACTIVITY ONE

Research project: What are carbon-dioxide emissions and why are they bad for the environment?

### ACTIVITY TWO

Divide the class into seven groups. Assign each group one of the following energy sources:

- Co-generation
- Wind
- Hydro
- Thermal
- Nuclear
- Ocean
- Solar

Each group presents a case for why their energy source is the best to the class.

## SUPPORTING RESOURCES

- New Zealand Geothermal Association: [www.nzgeothermal.org.nz](http://www.nzgeothermal.org.nz)
- Energy Efficiency and Conservation Authority: [www.eeca.govt.nz](http://www.eeca.govt.nz)
- Ministry of Economic Development: [www.med.govt.nz](http://www.med.govt.nz)
- Wikipedia: [http://en.wikipedia.org/wiki/Electricity\\_sector\\_in\\_New\\_Zealand](http://en.wikipedia.org/wiki/Electricity_sector_in_New_Zealand)