TRANSPOWER

A GUIDE TO TRANSPOWER 2009

Keeping the energy flowing

Transpower New Zealand Ltd The National Grid

TRANSPOWER PLANS, BUILDS, MAINTAINS AND OPERATES NEW ZEALAND'S HIGH VOLTAGE ELECTRICITY TRANSMISSION NETWORK – THE NATIONAL GRID.

Contents

INTRODUCTION

This guide is for those who want to learn more about the major transmission assets owned and operated by Transpower New Zealand Limited and the company's role in the New Zealand electricity industry. It also provides the reader with some background information on the nature of electricity and how it is transported from the power station to your home. Further information can be found on the company's website: www.transpower.co.nz.

The material contained in this guide was correct at the time of publication (April 2009) but is subject to change.

Transpower's roles Transpower is the State Owned Enterprise that plans, builds, maintains and operates New Zealand's high voltage electricity transmission network – the National Grid – which links generators to distribution companies and major industrial users. The grid, which extends from Kaitaia in the North Island down to Tiwai in the South Island, transports electricity throughout New Zealand.

Transpower's Operational Assets as at 30 June 2008

LENGTH OF HIGH VOLTAGE ALTERNATING CURRENT (HVAC) AND HIGH VOLTAGE DIRECT CURRENT (HVDC)	11,803 ROUTE-KM
NUMBER OF SUBSTATIONS (INCLUDES CABLE STATIONS)	178
NUMBER OF TOWERS	25,000
NUMBER OF POLES	16,000
POWER TRANSFORMERS	1,116
CIRCUIT BREAKERS	2,267
HVAC TRANSMISSION LINE VOLTAGES – kV	220, 110, 66, 50
HVDC TRANSMISSION LINE VOLTAGES – kV	350, 270
LENGTH OF EACH COOK STRAIT CABLE	40 KM
TOTAL FIXED ASSETS	$ 2.6 BILLION

SYSTEM OPERATOR 24/7

Through its ownership and operation of the grid, Transpower sits at the centre of the New Zealand electricity industry and is responsible for maintaining system security.

In its role as System Operator, Transpower manages the real-time operation of New Zealand's electricity system. The System Operator keeps the right amount of energy flowing – 24 hours a day, seven days a week.

Electricity flow on the National Grid is controlled from Transpower's two control centres located in Wellington and Hamilton. Each centre is capable of running the entire grid in real time, with the other as back up.

The System Operator also manages the wholesale electricity market. Transpower does not own the electricity but provides a co-ordination service to the electricity industry whereby it schedules the production of electricity from all power stations, monitors the entire network and ensures the security of the New Zealand electricity system.

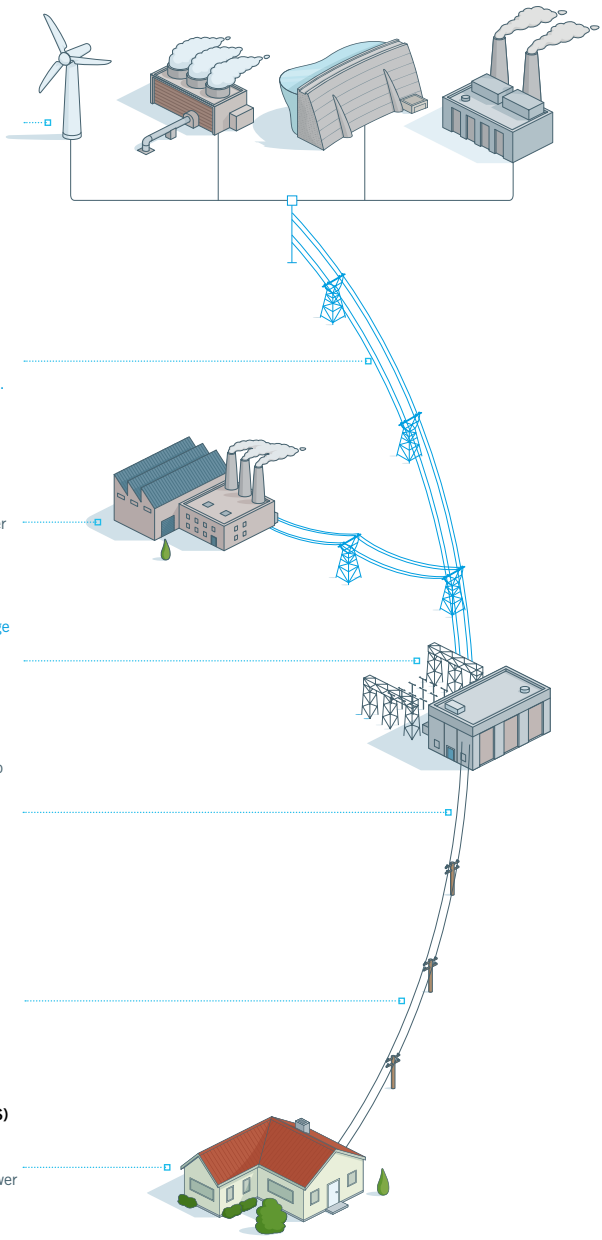
Photograph: Soenke Dwenger

Along with its commercial responsibilities, Transpower has a strong commitment to act as a good corporate citizen. A number of educational, social, environmental and staff initiatives have been developed, with a focus on giving back to the communities that live in close proximity to our transmission assets. Transpower's CommunityCare Fund, established in 2006, assists communities affected by new Transpower works or upgrade plans by funding local projects that add value and benefit to a community. Transpower has also developed a number of partnerships with community organisations such as the New Zealand Landcare Trust.

HOW IT WORKS

How do we get our electricity? Electricity is generated by New Zealand's hydro, thermal (coal and gas), geothermal and wind generation stations. It is then transmitted throughout the country by Transpower on high voltage (high capacity) transmission lines to distribution companies and directly to major industrial companies. Electricity is transmitted at high voltages (110 kV, 220 kV and 350 kV) over the National Grid.

Substations lower voltage to that used by the local electricity distribution network or lines company (typically 66 kV and below) at the point where electricity is delivered to Transpower's customers. Distribution companies' lines are used by the retailers to deliver electricity to their domestic and business customers.



1 GENERATION

Generation companies generate power from:
- wind
- thermal
- hydro
- geothermal.

They sell the power they generate on the electricity market.

2* TRANSMISSION

Transpower transports high voltage power from where it is generated to distribution companies and some large directly connected customers. It also coordinates the power system in real time.

3 INDUSTRIAL COMPANIES

A few major industrial companies receive their power directly from Transpower.

4* SUBSTATIONS

Substations reduce the voltage at the point where electricity is delivered to distribution companies.

5 DISTRIBUTION

The power is transformed into lower voltages at Transpower substations and transported by distribution companies to homes and businesses throughout New Zealand.

6 RETAIL

Retailers buy power on the electricity market, package it together with the other costs of delivering power (transmission and distribution) and on-sell it to consumers.

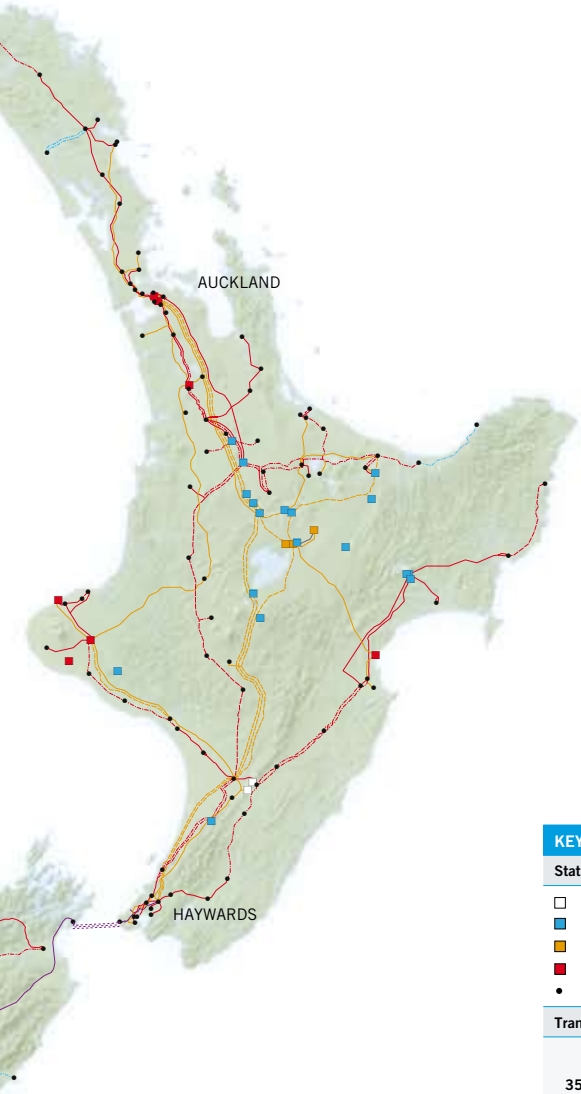
7 DOMESTIC USERS (HOUSES)

Domestic users receive their electricity directly from retail companies, which deliver power to homes using distribution companies' lines.

* THE TEXT HIGHLIGHTED IN BLUE SHOWS THE AREAS TRANSPOWER IS RESPONSIBLE FOR

How does the power system work? Much of New Zealand's electricity is hydro, generated from lakes and rivers in the South Island, while most of the electricity demand is in the North Island, in particular, the Auckland region. Consequently, large amounts of electricity need to be transmitted long distances between the two islands.

It is more efficient to transmit electricity over long distances by high voltage direct current (HVDC). Transpower operates an HVDC link from Benmore hydro power station in the South Island to Haywards substation near Wellington. The link crosses Cook Strait using submarine cables, allowing large electricity transfers between the two islands.



KEY

Stations

- Wind power station
- Hydro power station
- Geothermal power station
- Thermal power station
- Substation

Transmission lines

350 kV HVDC	Double circuit towers Single circuit towers Double circuit poles Single circuit poles Submarine cable
220 kV AC	Double circuit towers Single circuit towers Double circuit poles Single circuit poles Underground cable
110 kV AC	Double circuit towers Single circuit towers Double circuit poles Single circuit poles Underground cable
50/66 kV AC	Double circuit towers Single circuit towers Double circuit poles Single circuit poles Underground cable

Note: This is construction voltage.

Alternating current is used on the rest of the grid, mainly with four different voltages – 50 kV, 66 kV, 110 kV and 220 kV.

Transpower connects with distribution companies' networks at substations, where voltages are lowered for transmission on the lines companies' networks. Voltages are further reduced by the distribution companies and retailers to supply their domestic and business customers.

WHAT WE CALL THINGS

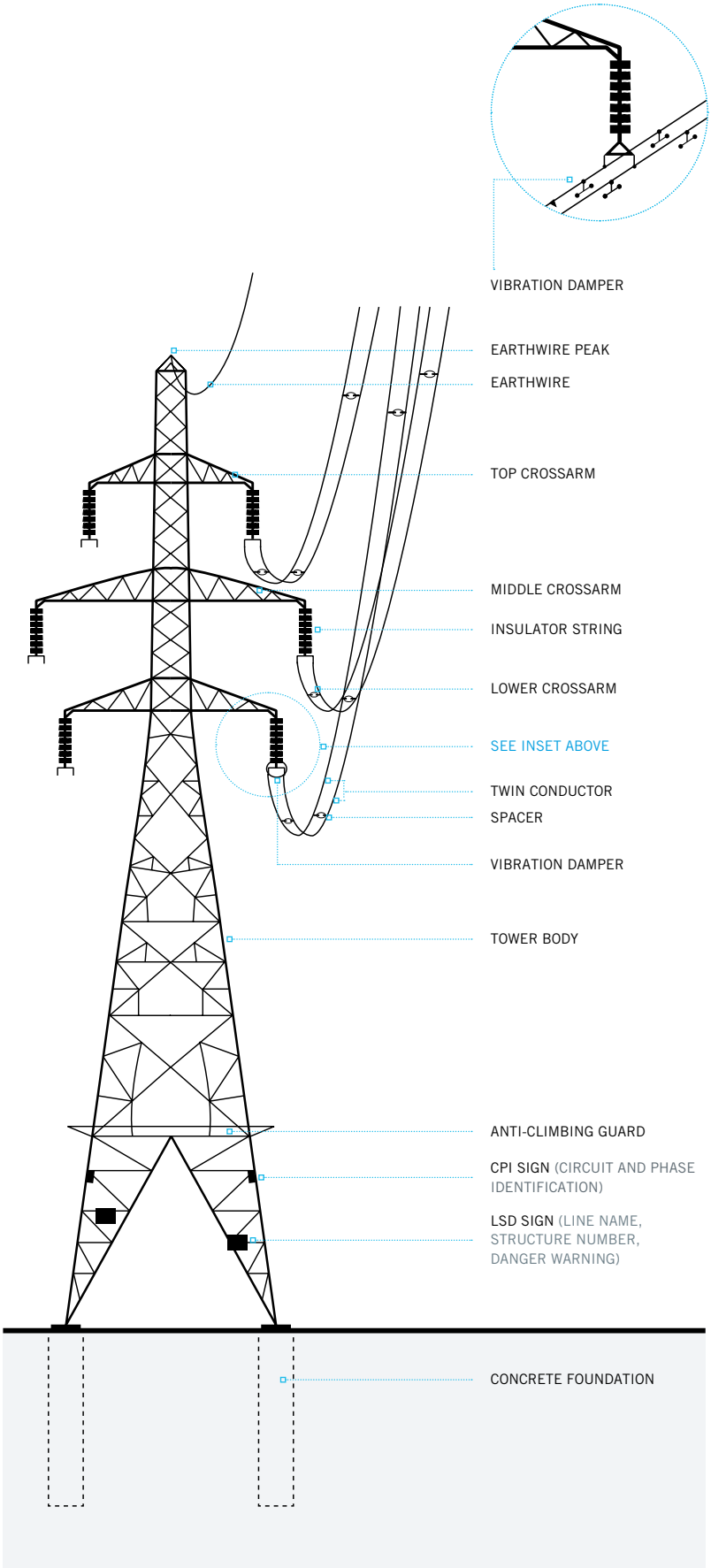
Transmission terminology **Circuit** (transmission circuit) Each transmission line typically carries one or two transmission circuits. Each circuit normally comprises a set of three conductors or phases, coded red, yellow and blue (R Y B). Each circuit is an electrical connection between two substations, and each circuit can be independently switched in or out of service.

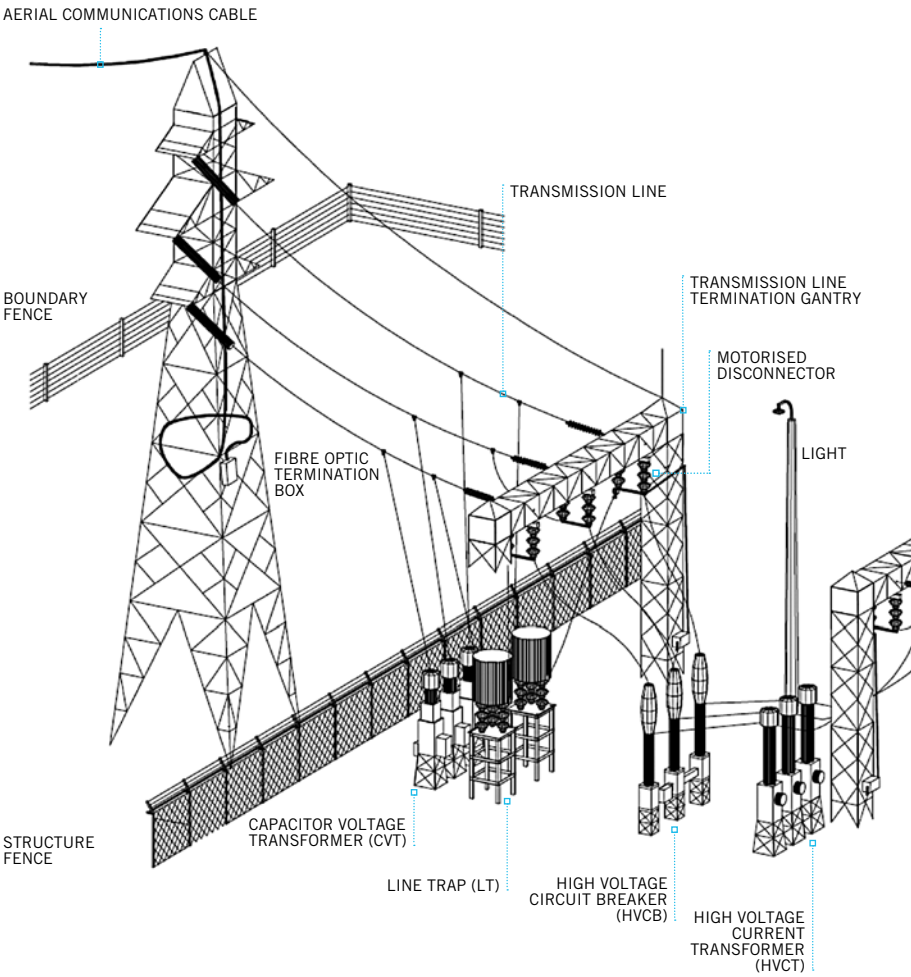
Transmission line A line of poles or towers carrying a high voltage transmission circuit between two substations. Transmission lines normally consist of either three conductors (these make up a single electrical circuit) or six conductors (forming two circuits, or a double circuit).

Conductors (wires) The conductors are the wires that carry electricity along the transmission line and are made of copper or steel-reinforced aluminium.

Poles and towers Support structures that have crossarms to hold the conductors clear of the ground. These structures and their foundations are designed to be strong enough to safely carry the weight of the conductors and withstand storm forces or wind.

Transmission tower



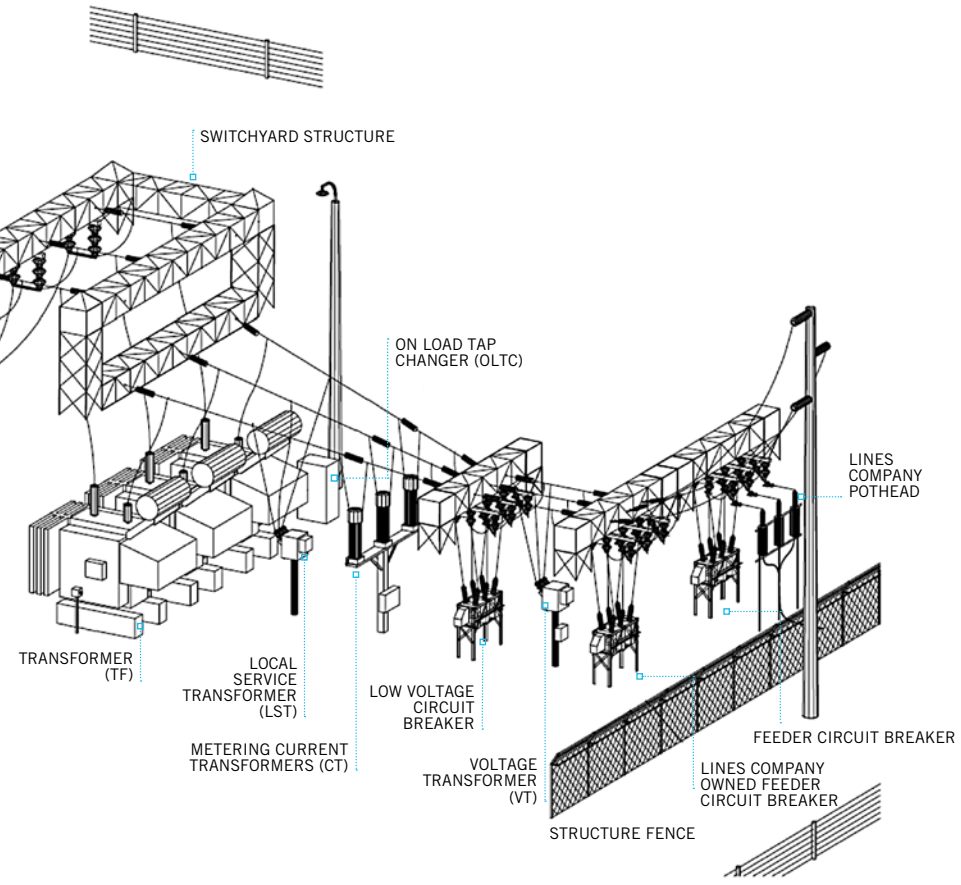


Outdoor substation

FOR CLARITY, NOTE THAT STRUCTURES HAVE BEEN PARTIALLY SHOWN

What is a substation? A substation contains electrical equipment that enables the high voltage transmission lines to be connected and disconnected as required. There may also be other equipment, such as transformers, that change (i.e. 'transform') the voltage and current of the electricity.

Transpower has 178 substations across New Zealand. The primary purpose of a substation is to 'transform' the generator voltage (typically around 11,000 volts or 11 kV) at generating stations up to the transmission voltage (typically 110,000 volts or 220,000 volts) and down again at substations, usually located in towns and cities, to a level that allows it to be used by a distribution company (typically at 33,000 volts or 11,000 volts). The diagram below shows an outdoor substation.



What is a transformer?

What is a capacitor?

What is a bus?

What is a circuit breaker?

What is a current transformer?

What is a switching station?

Transformers are installed in substations to ‘transform’ high voltages (e.g. 220,000 volts or 220 kV) to lower voltages (like 33,000 volts or 33 kV) and vice versa.

Capacitors are installed in substations to help maintain voltage in the transmission system.

A transmission line connects to an interface at the substation known as a bus. For example, a substation’s 220 kV bus is the physical part of the substation that connects the incoming and outgoing 220 kV circuits. A substation may have a number of different voltage buses depending on how many circuits terminate/originate there.

A circuit breaker is a switching device capable of making, carrying and breaking currents under normal circuit conditions and also making, carrying for a specified time and breaking currents under specified abnormal conditions such as a short circuit.

A current transformer is used for obtaining measurements of currents flowing in high voltage circuits. The current measurement output is at a low level, suitable for metering and/or protection purposes.

A switching station is like a substation but with no transformers. The purpose of a switching station is to connect a number of lines together.

UNDERSTANDING MORE ABOUT ELECTRICITY

Measuring electricity

Electricity A flow of electrons through a wire. It is similar to water flowing through a garden hose.

Current The movement of electricity, or flow of electrons, through a conductor. Current is measured in **amperes** or **amps** for short.

Voltage Like pressure in a garden hose that causes current to flow, and the unit for electrical pressure is **volt** (V). Electricity requires high pressure to travel long distances.

To determine the **power** flowing in the wire you need to know:

- the rate at which electrons flow through the wire (amps)
- the force (pressure) needed to make the electrons move (volts).

Power (watts) = voltage (volts) x current (amps).

Watt (W) The most common unit of electrical power measurement.

One watt is a very small amount of power (e.g. a typical light bulb is 100 W or 0.1 kW). The more commonly used measurement is the kilowatt (kW), representing 1,000 watts (roughly equivalent to a one-bar heater). The higher the watt or kilowatt rating of a particular electrical device, the more electricity it requires.

The power output of a large electricity generator is typically expressed in units of megawatts (MW) (millions of watts). The generation capacity of Manapouri hydro power station is 840 MW or 840,000 kW.

Kilowatt hours (kWh) The amount of electrical energy a power plant generates or a customer uses **over a period of time**, so a customer using a 1,000 watt one bar heater for one hour uses one kilowatt hour of energy.

Although electricity use varies widely depending on the season and the region of the country, a typical household consumes between 8,000 kWh to 10,000 kWh/year or 8 MWh to 10 MWh.

Moving electricity

Electricity appears in two forms – alternating current (AC) and direct current (DC). The difference between DC and AC electricity is the way the electrons travel in the wire.

Alternating current (AC) – In AC, the direction of current flowing in a circuit is constantly being reversed back and forth very rapidly.

The rate of changing direction is called the **frequency** of the AC and is measured in **hertz** (Hz), which is the number of forwards-backwards **cycles** per second

The voltage and frequency of AC electricity varies between countries. New Zealand uses 230 V with 50 cycles per second (50 Hz).

The National Grid carries AC from the power generators to the consumers because it is easier to change (i.e. step up or step down) the voltage with a transformer. In other words, a transformer can take a low voltage current and make it a high voltage current, and vice versa.

Electricity is generally transmitted at high voltages (110 kV or above) to reduce the energy lost in transmission from one point to another.

Direct current (DC) – DC always flow in the same direction. High voltage direct current systems are used for bulk transmission of energy from distant generating stations.

The advantages of HVDC over HVAC systems for bulk transmission include higher power ratings for a given line (important since installing new lines and even upgrading old ones is extremely expensive) and better control of power flows.

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