Identify electrical systems in preparation for work

US 10508

Training and Assessment Resource

NCES Level 2

Contents

Introduction to Training Assessment Resource

This Training Assessment Resource (TAR) contains the information that you require to complete the tasks one and three of the assessment pack for this unit standard.

Purpose

People who obtain credit for this unit standard are able to identify:

- Electric line
- Electricity system circuit operation voltages
- Electricity conductors and conductor fittings
- Electricity system structures

Introduction

Activity

Think about the different types of electric lines e.g., communication, distribution, traction and transmission lines. Provide details of what you would look for when identifying the various lines.

The New Zealand electricity supply industry (ESI) can be described through identifying four major areas of operation. These are:

Generation

Where the electricity is produced e.g., the source.

Transmission

How the electricity is ‘transmitted’ from the source to major centres of use (load centres).

Distribution

How the electricity is ‘distributed’ around the load centres.

Utilisation

How the electricity is used.

This unit standard only covers the transmission and distribution areas.

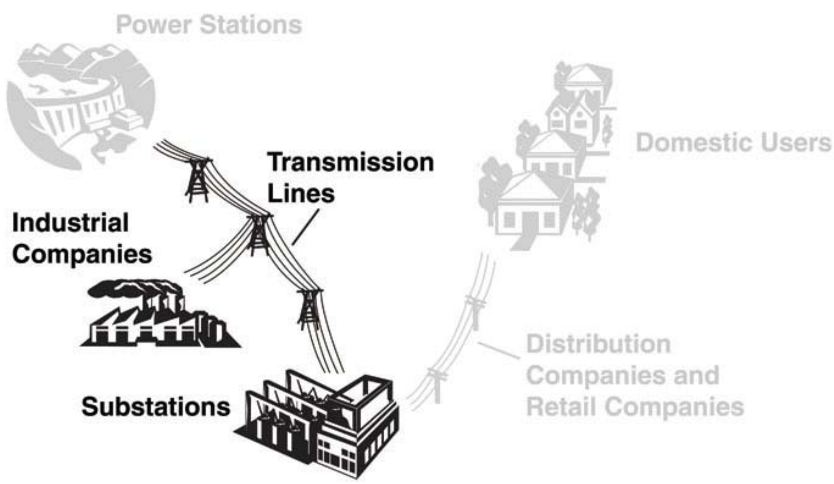
1. Transmission Lines

1.1 Introduction

Transpower is the state-owned enterprise that owns and operates the National Grid - or high voltage transmission network - that carries electricity around the country.

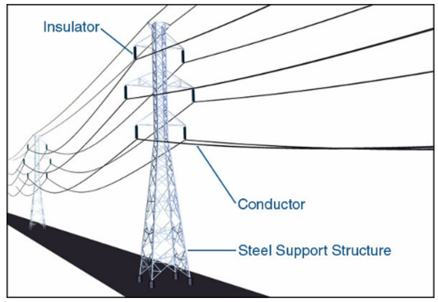
The National Grid is made up of over 12,000 km of high-voltage transmission lines and more than 170 substations. It connects power stations owned by generating companies to substations feeding the local networks that distribute electricity to homes and businesses. Some large industrial users of electricity also receive their power directly from the National Grid.

The New Zealand power system is interconnected between New Zealand's North and South Islands via a High Voltage Direct Current link (HVDC). The capacity of the HVDC link is 1040MW.



Transmission lines.

1.2 Major Components



A transmission line consists of three major components. These are:

Support structures

The support structures are pylons and towers designed with cross arms to support the conductors at a safe distance above the ground. These pylons and towers are made of galvanised steel angle bolted together to form different configurations needed to meet the requirements of the electricity supply industry.

Conductors

Conductors carry the electric current from the generating stations to the area substations. These conductors are usually constructed from steel-reinforced aluminium. The steel (core) is there to take the strain and weight while the aluminium (conductor) is there to carry the load current.

The Aluminium Core Steel (ACSR) conductors ale always stranded and have no insulation around them. They are bare conductors. It is more economical to use aluminium rather than copper.

Insulators

The insulators are used to insulate live current carrying conductors from the tower steel and from earth. There is usually between six and 33 individual insulators (depending on the level of voltage being transmitted), joined together to make up a full insulator string. There are seven for 110kV and fourteen for 220kV.

The insulators are usually made of glass (clear or light green) or porcelain (brown or light grey).

Some of the more modern insulators are made from fibreglass and special rubber and come in various colours and lengths depending on voltage and location.

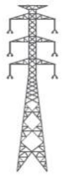
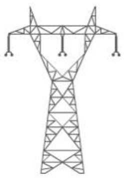
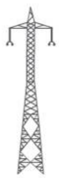
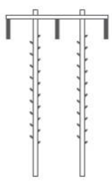
The transmission towers must be designed to be strong enough to safely carry the overall weight of the line, and to withstand ice, snow and high wind loadings depending on the location.

Activity

What does the size of the insulators, the space between conductors, the number of wires and the type of structure tell you about a transmission line?

1.3 Typical Configurations

There are tower configurations to suit a wide range of applications. The diagram below shows some of the typical configurations used in New Zealand.

	Voltage (V)	Number of Circuits	Structure Type
	220,000 V AC	Double circuit, twin conductor	Steel tower
	220,000 V AC	Single circuit	Steel tower
	500,000 V DC	Twin conductor	Steel tower
	110,000 V AC	Double circuit	Steel tower
	110,000 V AC	Single circuit	Wood poles
	110,000 V AC	Single circuit	Wood pole

1.4 High Voltage Direct Current System (HVDC)

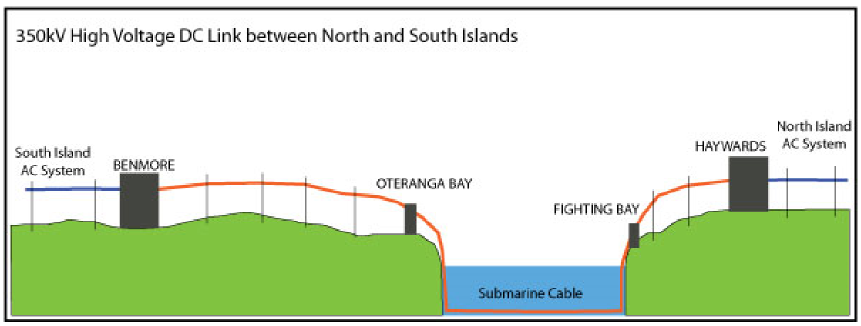
A high-voltage direct current (HVDC) link connects the power systems of New Zealand's North and South Islands.

The capacity of the link is 1040 MW and it operates at voltages of 270 kV and 350 kV.

The link generally sends power from the South Island to the North Island. Power is converted from alternating current (AC) to direct current (DC) at Benmore in the Waitaki Valley, then transmitted over 535km to the shores of Cook Strait, where undersea cables carry the power 40km to the North Island.

At Haywards in the Hutt Valley, the power is converted back from DC to AC and injected into the National Grid.

The HVDC link was commissioned in 1965.

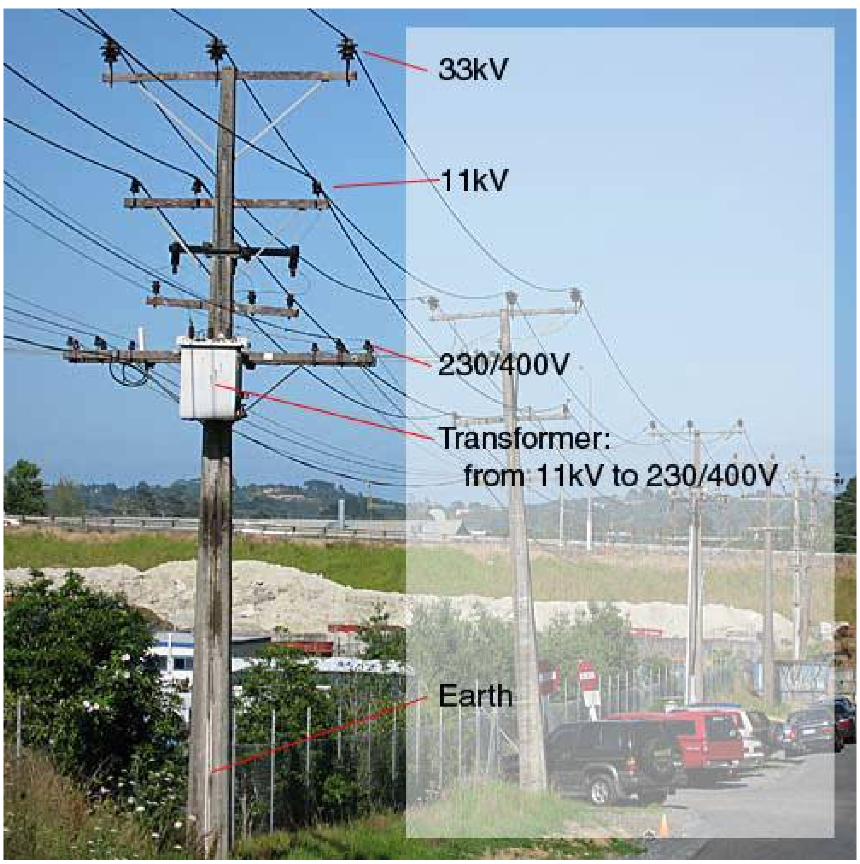


HVDC link.

2. Distribution Lines

The distribution system is the section of the system that takes the large amount of electricity delivered at the load centres (bulk supply) and 'distributes' it to the consumer. The distribution system typically operates at voltages of 33kV, 11kV and finally at 400/230 volt level, three phase four wire systems. Large factories can receive their power at 33kV and 11kV and have their own substations to reduce it to the 400/230 volt levels.

Structures used in the distribution system are usually made of concrete or wood and there is an increasing amount of distribution which is underground cabling.



Distribution lines.

3. Telecommunication Lines

Lines for telephones and cable TV would run under the 400/230 volt distribution lines, they have smaller insulators and have quite different types of terminating boxes where they are run into a building. If the telecommunications cable is fibre optics, it will be labelled accordingly. However, most of these services are on their own poles and increasingly as underground services.

The NZ Electrical Code of Practice #34 (NZECP:34) states strict guidelines for installing telecommunication conductors near power lines. An extract is sited below

"3.4 Conductors Near Telecommunication Lines

"3.4.1 A conductor shall always cross or run above telecommunication lines and the minimum distance at any time between any conductor and a telecommunication line shall not be less than the distances specified in table 3.

"3.4.2 Notwithstanding the requirements of clause 3.4.1, the minimum separation of a bare telecommunication line from a conductor shall not be less than 1.8 metres from a high voltage conductor and 1.2 metres from a low voltage conductor except that conductors insulated to full working voltage and covered telecommunication conductors may have a separation of not less than 300 millimetres.

"3.4.3 Stay wires shall be at a distance of more than 300 millimetres from any uncovered telecommunication line."

4. Traction Lines

Traction lines are used for the supply of electricity to electrical transport equipment such as electric trains, trolley buses and trams which are not widely used in NZ. A history of the electrification of the main railway line from Wellington to Auckland can be found on www.techhistory.co.nz/Electricity/rail_electrification.htm. Freight trains operate on 25,000 Volts AC while the commuter trains are 1500 Volts DC. Trolley buses are still used in Wellington and Christchurch and are operated on 600 Volts DC.

5. Operating Voltages Used In the National Grid

The Electricity Regulations 1997 define the high and low level voltage values:

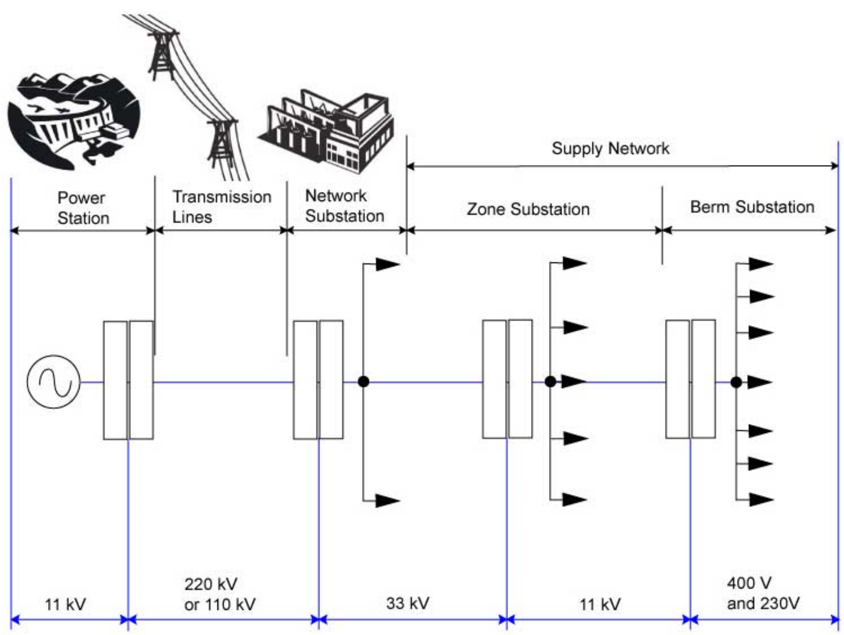
Low voltage

Means any voltage exceeding 50 volts AC or 120 volts ripple-free DC but not exceeding 1,000 volts AC or 1,500 volts DC.

High voltage

Means voltage exceeding 1,000 volts AC or 1,500 volts DC

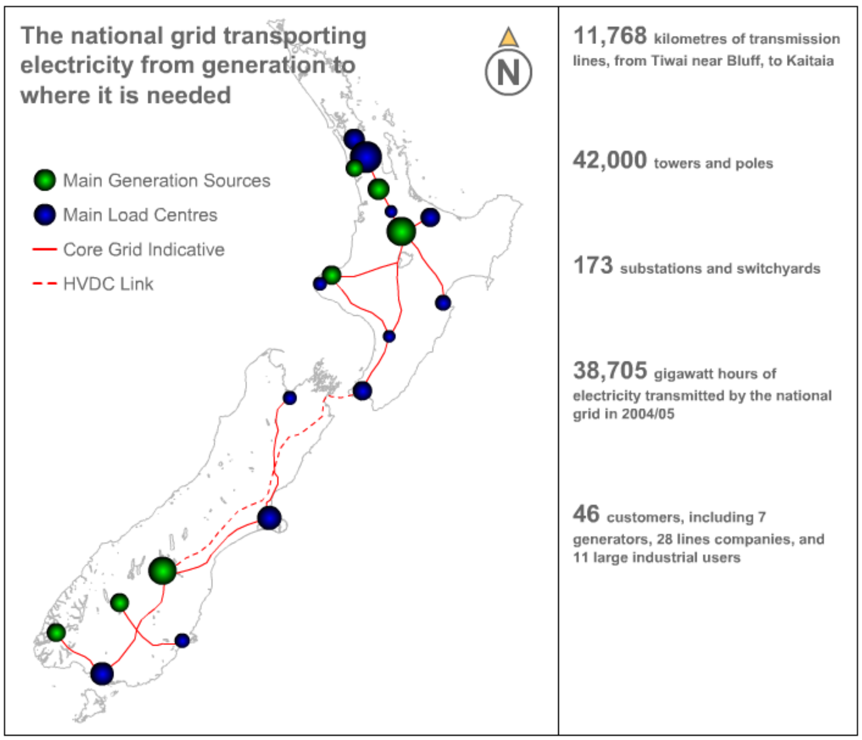
The transmission system is totally at the high voltage levels while the distribution system ranges right through to low voltage levels. The transmission voltages used by Transpower within New Zealand are 220 kV and 110 kV. However these are likely to be increased to 400 kV to provide for increasing power demands in the upper North Island and particularly Auckland. Typical power system voltages used in New Zealand are shown below.



In the diagram of the National Grid the green dots represent the main generating sources, the blue dots indicate the main load centres, the solid lines show the main transmission grid and the dotted lines the HVDC link.

The diagram gives a graphical presentation on how the National Grid 'transports' the electricity from generation to where it is needed.

There is a high concentration of generation in the Waikato and South Canterbury regions of NZ. It is in these areas that the hydro power generation takes place. Thermal generation is concentrated in Huntly and New Plymouth with geothermal in Wairakei.

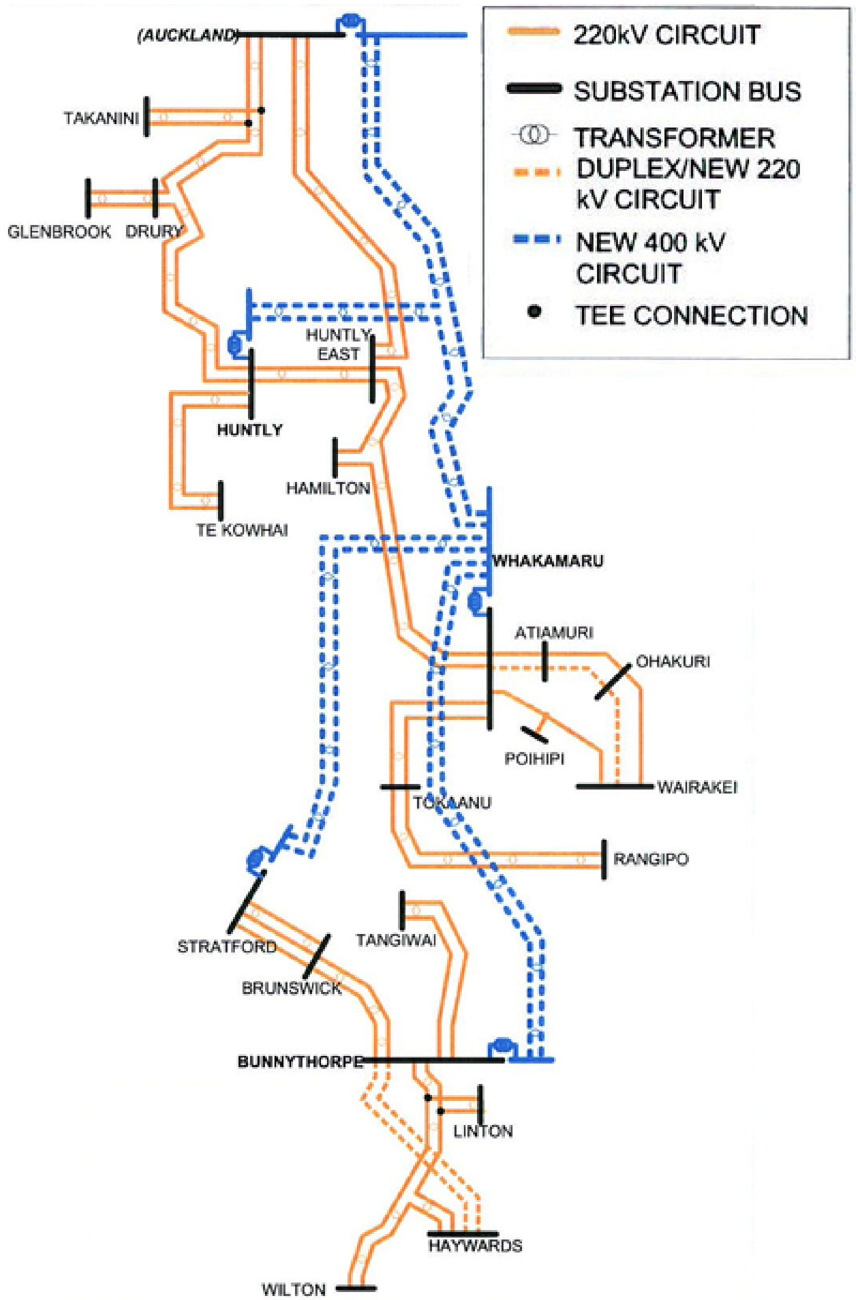


The National Grid.

Important components of the transmission and distribution systems are the transformers. Transformers which change the voltage from 11kV (a typical generation voltage) to 220kV (a typical transmission voltage), are called step-up transformers.

Transformers which change the voltage from 220kV (transmission) to 33kV (distribution voltages) are called step-down transformers.

A possible transmission system being proposed for 2040 is shown below:



6. Conductors and Conductor Fittings Used in the National Grid

6.1 Overhead Vs Underground

There are choices that need to be made when designing a system of electricity supply. These include whether to install the system with overhead lines or underground cables. Some of the factors that may influence those decisions are:

- Environmental
- Economics (cost)
- System voltage and current levels
- Current capacity required and possible increased demand
- Reliability
- Access for maintenance

Features of the two supply systems are shown in the table below:

Factor	Overhead system	Underground system
Environmental/Design	> High voltage overhead lines are not environmental friendly to most people and take up a lot of space. > The corona affect can produce noise and interference. > Pollution reduces the effectiveness of overhead conductors and insulators. > The effect of electromagnetic fields is an issue for some.	Underground cables are usually chosen when environmental factors are most important. Where appearance is critical and land is limited.
Cost	Aerial cables a more economical to install and maintain.	At 220kV underground cables are approximately 20 times more expensive than overhead conductors
Voltages	Greater distance can be maintained between conductors enabling higher voltage operation.	High cable capacitance makes the operation of long runs of underground cable at high voltages difficult. 750kV is the highest D.C. voltage used in NZ.
Current carrying capacity	Bare aerial cables have a higher current carrying capacity due to the air movement around them providing better cooling.	The operating temperature of cable insulation and the ground limits the current carrying capacity. Higher prospective short circuit currents are present due to the distance between cables and quality of insulation.

Installation	> People and animals must be protected from electromagnetic and electrostatic fields that surround aerial cables. A corridor of vacant land is usually provided for this reason and for maintenance access. > Voltages below 110kV are usually placed at the top of poles with no easement required. > Equipment connected to overhead lines requires extra protection from voltage surges caused by lightning.	> Electric fields are mostly contained within the cable due to screens and the design of underground cables. > The installation of underground cables requires excavation of a trench, the installation of the cable and its mechanical protection, backfilling of the trench and restoration of the surface.
Maintenance	Maintenance and fault finding is simplified because the cables and supports are all visible. Aerial cables are exposed to harsher conditions and require regular maintenance.	Underground cables do not require maintenance unless there is a failure. Some cables do require checking such as oil filled and gas filled cables.

Activity

Provide two reasons why underground cables may be chosen rather than overhead lines.

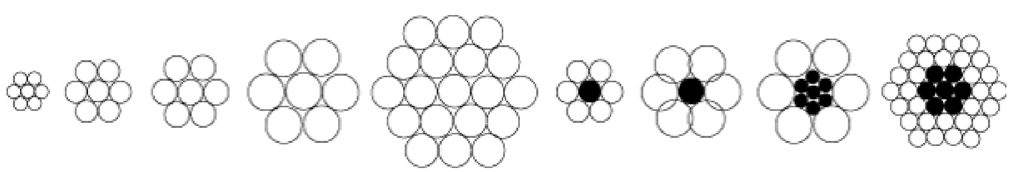
6.2 Line Conductors

The conductors used on supply system lines come in a range of sizes and configurations. Conductors used in high tension supply systems are always stranded and un-insulated. Most of the high voltage conductors used in New Zealand are Aluminium Conductor Steel Reinforced (ACSR) conductors because they are more cost effective and are lighter than copper.

The conductors may be a single conductor or on larger capacity lines they are often formed in sets of two to increase loading. Around the cities four conductors can be used to increase the overall conductor circumference to reduce the corona effect. The corona effect causes radio and TV interference.

Typical conductors used are:

Code name	Cross sectional area (mm2)	Number of strands and diameter	
Namu	20	7/2.11 Aluminium	
Kutu	40	7/3.00 Aluminium	
Rango	50	7/3.66 Aluminium	
Weke	100	7/4.72 Aluminium	
Butterfly	300	19/4.65 Aluminium	
Ferret	40	6/4.72 Aluminium	1/3.00 Steel
Mink	60	6/4.72 Aluminium	1/3.66 Steel
Dog	100	6/4.72 Aluminium	7/1.57 Steel
Wolf	150	30/2.59 Aluminium	7/2.59 Steel



Some examples of ASCR conductors.

Specific cable books will give you the overall cross sectional area (c.s.a.) and the current carrying capacity of conductors and cables. These can be obtained from manufactures and suppliers.

Other factors which must be taken into account when selecting conductors is the wind velocity, changes in temperatures and snow loadings.

Activity

When would four conductors be likely to be used, and why?

6.3 Insulators

Insulators serve to support and anchor the conductors and to insulate them from contact with earth. Insulators are usually made of porcelain, but glass and other synthetic insulating materials are used.

Insulators must be of a very high resistance to prevent the flow of current (leakage current) through them and must be sufficiently thick to prevent breakdown under high voltage stresses. To increase the distance that current would have to flow (leakage current), the insulators are moulded with a wave like shape. They must also be strong enough to withstand the mechanical stresses due to the weight of conductors and other forces.

There are two main types of insulators:

Suspension Insulators

For voltages above 70kV suspension type insulators are used, joined together by a cap and pin made of galvanised steel. The number of insulators depends on the voltage level.

Pin Insulators

The pin insulator has several porcelain skirts (folds) and the conductor is fixed at the top. A steel pin screws into the insulator so that it can be bolted to a support. The higher the voltage the larger the insulator to provide increased resistance and mechanical strength.

7. Transmission Structures Used in the National Grid

7.1 Transmission Towers

The main functions of transmission towers are:

> Support the overhead line
> Ensure a safe distance is maintained between conductor and ground
> Maintain distance between conductors to prevent flashover in all conditions
> Minimise the chance of a short circuit
> Minimise the effect of capacitance between the lines]

For rural distribution lines up to 33kV, with spans around 150 metres, wooden poles are initially cheaper than concrete and steel supports. The life of a wooden pole is however uncertain and therefore reinforced concrete poles, even though slightly more expensive, are gradually replacing the wooden poles.

Over 33kV, galvanised steel towers are used because of the higher mechanical stresses and the larger clearances required between conductors and earth.

Activity

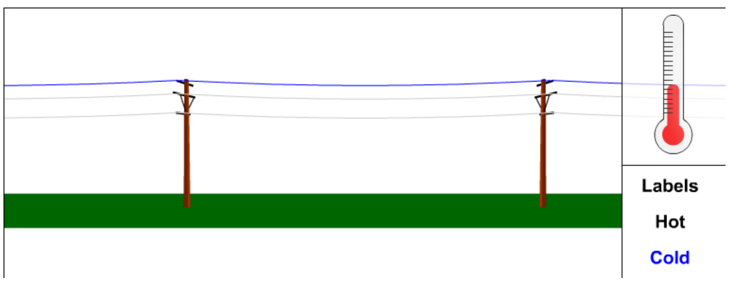
Why are concrete poles generally replacing the wooden poles?

7.2 Construction of a Line

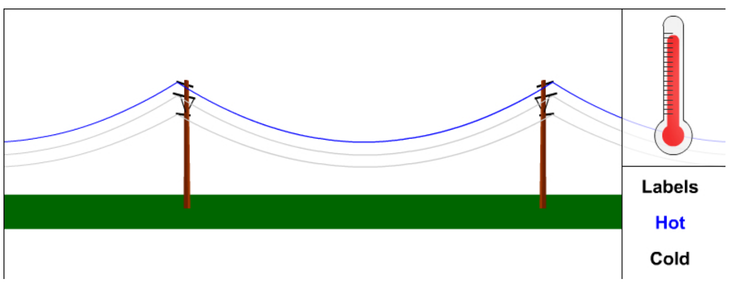
Once the conductor size, the height of the poles and the distance required between poles (span) is known, they can be designed and installed and the conductors 'strung' between them. Stringing of conductors requires some specialised plant and equipment as the cables can be very heavy to string between poles or towers.

Span and sag of line

A wire supported between two points does not remain horizontal, but loops down at the middle. The vertical distance between the straight line joining the two points of the support and the lowest point of the conductor is call sag. The tighter the wire the smaller the sag. When undertaking the actual construction of a line, it is important to calculate the permissible sag and the corresponding mechanical pull stress. Temperature has an effect on this too because the length of the conductor can vary due to temperature. The variation between summer and winter temperatures is a factor.



If the line is strung in the winter the sag must not be too great, otherwise the wire will stretch even more during the summer temperatures and the clearance between conductor and ground may be insufficient.



If the line is installed in the summer then consideration must be given to the sag, otherwise it may be make the wire too tight when the winter temperatures cause it to contract. Wind and snow can also add more strain and in some conditions aerial conductors can break.

Activity

What would you need to take into account when constructing a line in summer to allow for the correct sag?

Select the correct type of electric line(s) to fit the description in the table below:

Electric Line(s)	Features
	Commonly carries direct current
	Commonly carries 25,000 V AC, 600 V DC
	Commonly carries low voltage

Model Answers to Activity Questions

Activity (page 4)

Think about the different types of electric lines e.g., communication, distribution, traction and transmission lines. Provide details of what you would look for when identifying the various lines.

Look for physical construction and configuration of the lines, height, size of insulators, conductors, cables used. This would be me an idea what type of line it is.

Activity (page 6)

What does the size of the insulators, the space between conductors, the number of wires and the type of structure tell you about a transmission line?

It would tell me the voltage that the line is designed to operate at and if it is a single or dual circuit.

Activity (page 17)

Provide two reasons why underground cables may be chosen rather than overhead lines.

Answer could be any of the following:

- Environment factors
- Economics (cost)
- System voltage and current levels
- Current capacity required and possible increased demand or access or maintenance

Activity (page 19)

When would four conductors be likely to be used, and why?

To increase loading and reduce the corona effect and where a three phase, four wire system is required (e.g., 400/230 V distribution system)

Activity (page 20)

Why are concrete poles generally replacing the wooden poles?

Concrete poles will last longer in the long run.

Activity (page 22)

What would you need to take into account when constructing a line in summer to allow for the correct sag?

The ambient temperature.

Select the correct type of electric line(s) to fit the description in the table below:

Electric Line(s)	Features
HVDC transmission	Commonly carries direct current
Traction lines	Commonly carries 25,000 V AC, 600 V DC
Distribution lines	Commonly carries low voltage