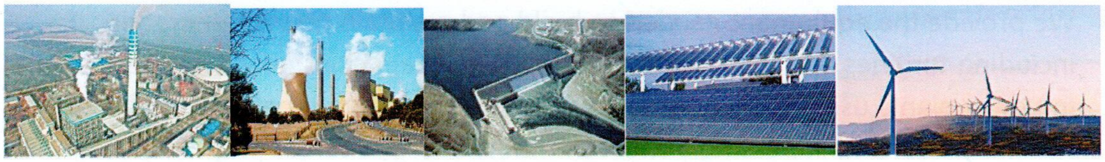
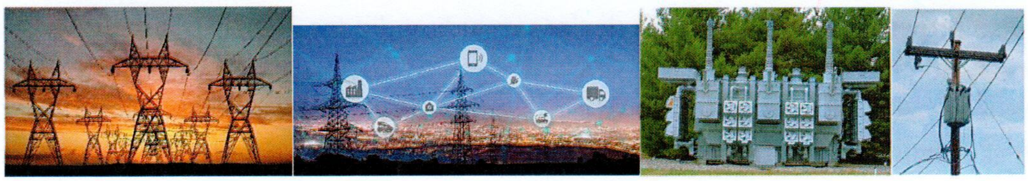
Company profile



Sub/ Power generation, distribution and transmission.



Good Greeting !

Hi-Tech General Trading LLC was born from a group of 27 years of experience in **supplying production and distribution equipment** for the power industry, as well as basic power systems for use in the event of a power outage. We have supplied power equipment for **the oil and gas industries, chemical and petrochemical projects, mining and metallurgy processes** and many more.

And management of Hi-Tech company experts of the group

- It enables it to provide the equipment required for the full range of the energy business, **from power generation using conventional and renewable energy sources**, as well as for **local transmission and distribution**. We have experience in both **start-up projects, new construction, and renewal of old networks**, as well as providing what is required to continue the high-quality spare parts that must be available in all power plants and transmission networks.
- As a company with good experience in the region, we are well aware of the requirements of the old and old power plants that depend on the vast hydrocarbon resources in the region, and we often use oil, gas and coal as the source of energy, but we are also well aware of the region's move to start peaceful nuclear power generation, the important move Extremely towards

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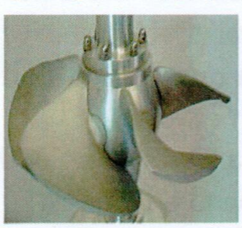
renewable energy sources, with solar energy leading the way in most of the Gulf region, and other energy sources such as wind, hydro-dynamics, and geo Thermal mass and biomass play an increasingly important role as the world moves to a more sustainable future.

- We provide the equipment needed to build and maintain power generation, including turbines and generators of all types and capacities, that can operate in power plants using fossil fuels (including gas and oil), hydroelectric and nuclear power and increasingly with renewable energy sources played by solar energy. Big part.
- We work with several transmission and distribution networks, providing their requirements for towers and shafts, through a wide range of needed transformers, as well as cables and substations, and other requirements such as lubricants and coolants.
- We also provide power electronics devices including diodes, transistors, trios, hybrids and inverters (AC / DC, DC / DC, DC / AC, AC / AC)
- Our supply also includes the range of electric motors needed by the industry, such as rotating magnetic field, rotating induction motor, linear induction motor, synchronous motor, direct current motor, stepper motor and single phase motor.

Looking to the future, we are ready to provide the needs of smart grids and smart network management, as well as the requirements of building smart homes. We are also working to support the increasing shift in the automotive industry away from hydrocarbons to electric cars and hybrid vehicles.

What we supply

A. Generation, transmission and distribution



All power networks regardless of the energy recourse they use, are made up of three distinct systems: generation, transmission and distribution.

1. The **generation system** includes the main parts of the power plants such as turbines and generators. The energy resources used to generate electricity in most power plants

are combustible, nuclear, or hydropower. The burning of fossil fuels or a nuclear reaction generates heat that is converted into mechanical motion by the thermal turbines. In hydroelectric systems, the flow of water through the turbine converts the potential or kinetic energy of the water into rotating mechanical energy.

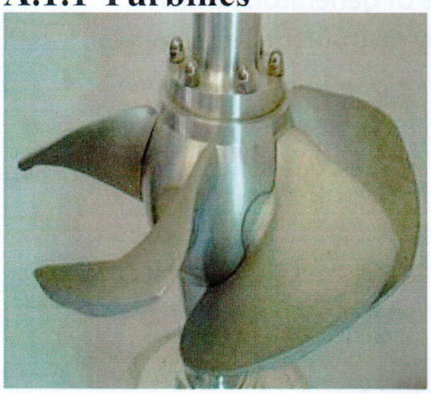
2. The generated electricity is **transmitted** to all customers by a complex network of transmission systems composed mainly of transmission lines, transformers, and protective equipment.
3. At the load centers, the voltage of the transmission lines is reduced by step-down transformers to lower values (15–25 kV) for the **distribution** of power within city limits to the end users. At the consumer sites, the voltage is further reduced to values from 100 to 240 V for household use depending on the standards of the country.

All power plants must have the following main parts, that we can supply, as well as spare parts and accessories. We also supply the equipment to deliver the energy sources to the power plants.

A.1 Generation

The range of our supply includes the equipment for the burners in fossil fuel plants, reactors in nuclear power plants, and dams in hydroelectric plants.
All power plants also need turbines and generators.

A.1.1 Turbines

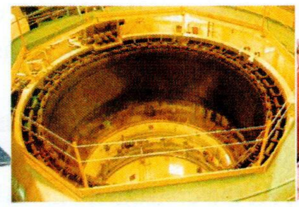


There are two types of turbines in conventional power plants: thermal and hydroelectric. Both use the turbine to rotate the electrical generator by converting the thermal energy of the steam or water into rotating mechanical energy.
In **thermal power plants**, fossil fuels or nuclear reactions are used to produce steam at high temperatures and pressures. The steam is passed through the blades of the thermal turbine and causes the turbine to rotate. The steam flow is controlled by several valves to ensure that the turbine rotates at a precise speed.
Hydroelectric power plants consist of a dam that holds the water upstream higher than the turbine. When electricity is needed, the water is allowed to pass to the turbine blades through pipes called penstocks. The turbine then rotates, and the valve of the penstock regulates the flow of water, thus controlling the speed of the turbine.

We are able to supply all the parts, turbines and accessories that are required for either thermal or hydro-electric power plants.

A.1.2 Electrical generators

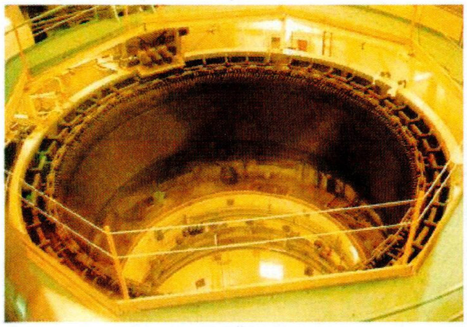





The generator used in power plants is the synchronous machine which has a magnetic field circuit mounted on its rotor and is firmly connected to the turbine. The stationary part of the generator, called a stator, has windings wrapped around the core of the stator. When the turbine rotates, the magnetic field moves inside the machine in a circular motion, which induces voltage across the stator windings.
The output voltage of the generator (5–22 kV) is not high enough for the efficient transmission of power, and higher voltage generators are not practical to build as they require more insulation. Therefore, the output voltage of the generators is increased by using step-up transformers.
Our range of supply includes the generators themselves, as well as the spare parts for annual and regular maintenance. There is heavy usage of generators, which means that all the electrical and mechanical parts, and any instruments, all require regular maintenance and support.

.1.2.1 Synchronous generator

The synchronous generator is the most used machine for generating electricity. All power plants use synchronous generators to convert the mechanical power of the turbine into electrical power. This is because synchronous generators can have enormous capacity; a single generator can be built to produce over 2 GW of electric power. Large synchronous generators are used in nuclear power plants and major hydro plants.
The main components of the synchronous generator are: the **stator** of the synchronous machine which is similar to the stator of the induction motor. It consists of three-phase windings mounted symmetrically inside the stator core. The **stator windings** are also known as armature windings. The winding of the rotor of the synchronous machine is excited by an external DC source through a slip ring system. The **rotor winding**, which is also known as field winding or excitation winding, produces a stationary flux with respect to the rotor; that is, the rotor is an electric magnet. The rotor is assembled inside the stator. Two sets of ball bearings are used on both ends of the rotor to allow the rotor to spin freely inside the stator.



Stator of synchronous generator Rotor of synchronous generator

A.1.2.2 Induction generator

Some new technologies like wind energy and other renewable energy systems do not use synchronous generators, but use induction generators. This is because the machine is simple and less expensive than other types. It is also easier to synchronize with the grid than synchronous generators.

A.1.2.3 Small generators

Small generators are used in a wide variety of local situations, including many manufacturing sites as well as on project sites. They are also used domestically, particularly in areas where central distribution grids fail on occasion.

Small generators are also increasingly distributed throughout power systems using a very large number of mass-produced very small generators. The demand for small generators is growing rapidly as power systems become more flexible and are increasingly using local intelligent control to manage the generation and distribution of electricity. Such active systems involve routine flow reversal and continued operation under islanded conditions, with generation and load controllers responding to local network conditions, for example reducing the output of relevant generators to cover the period of a circuit outage in an autonomous and unmanned operation.

We supply a wide of different capacity of generators, ranging from 1kva to 2mw. The generators can use both diesel and petrol engines, air or water cooled, and be skid mounted and mobile. We supply the generators from different sources, depending on the customers' requirements. We make a point of supplying the spare parts that are required, and we offer attentive after-sales service.

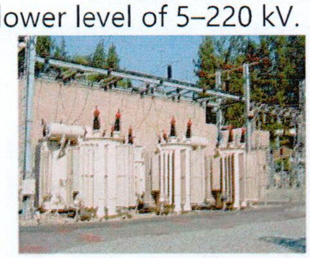
A.2 Transformer



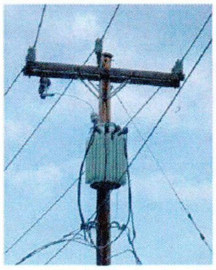
Transformer's function is to increase or decrease the voltage. Transmission starts from the power generation at a high level, and when the electric power is delivered to the load centers, the voltage is reduced for safe distribution over cities. Finally, the voltage is further reduced for household distribution at 100–240 V, depending on the various standards worldwide. The transformers' capability allows the transmission and distribution of massive amounts of power in modern extensive power grids. Transformers can increase of the voltage on the transmission lines so that the current is reduced, and the cross section of the wires are reasonably small and the cost of the transmission line is manageable. There are four main **functions** of transformers:

- **Transmission transformers** are connected to both ends of the transmission line. At the generating power plants, the transformer steps up the voltage of the generators to very high levels (220 kV–1 MV) so that the current can be reduced substantially. At the other end of the transmission line, the transformer steps down the voltage to a lower level suitable for distribution to load centers.

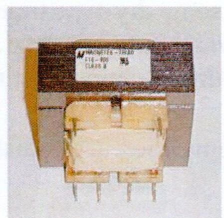
- **Distribution transformers** are installed in distribution substations near the load centers. They reduce the output voltage of the transmission transformers to a lower level of 5–220 kV.



- **Service transformers** are located near customers' loads and lower the distribution voltage to the household level. They are normally mounted on power poles, placed inside vaults, or installed inside large buildings.

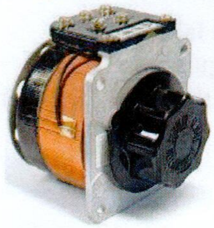


- **Circuit transformers** are small transformers extensively used in power supplies and electronic circuits where the household voltage is stepped down to the circuit voltage level of a few volts. Other applications include impedance matching, filters and electrical isolation.

A.2.1 Transformer types

- **Multi-winding transformers** which can have multiple secondary windings to provide different voltage levels to different loads.
- **Autotransformer** which have its primary and secondary windings connected in series, and can be built to provide adjustable output voltage.

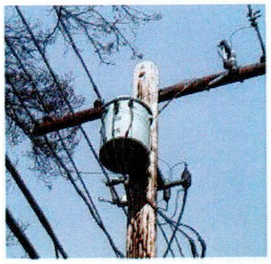
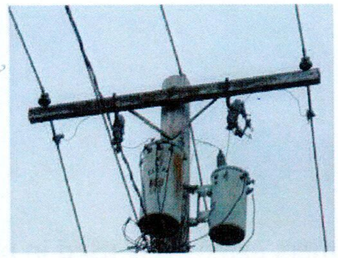
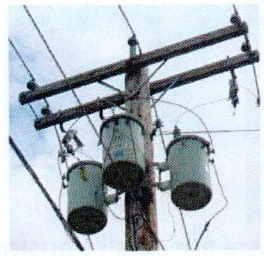


Autotransformer with adjustable voltage

- **Three-Phase Transformer** can be constructed of a three-legged core when the primary and secondary windings of each phase are placed on the same leg of the core. Three-phase transformers can be connected **wye–wye** (Y–Y), or **delta-delta** (Δ–Δ), or **wye-delta** (Y–Δ).

A.2.2 Transformer bank

A transformer bank is two or three single-phase transformers connected as a three-phase transformer. These transformer banks are often used in distribution systems. If a power pole with one single-phase transformer cannot cope with the load, additional single-phase transformers can be installed.

Transformer banks: Single-phase transformer; Two transformer bank; Three transformer bank.

Power transformers require **cooling** for their core and coils, as the internal power loss is dissipated in ambient air to keep the temperature rise within the allowable limit set by the insulation material used in the construction.

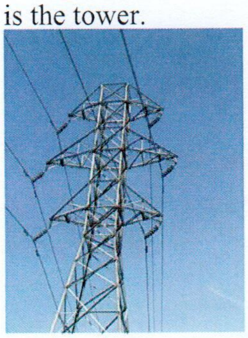
The temperature rise can be as high as 180° in some dry-type transformers used indoors and as low as 55°C in oil-immersed transformers widely used on land. In the increasing order of better cooling and compact size for the same kilovolt-ampere rating, the oil-filled transformer cooling classes are as follows:

- OA oil–air self-cooled by natural convection and radiation
- FA forced air cooled by fans
- FOA forced oil–air cooled by oil pumps
- OW oil–water cooled by water tubes or hollow conductors

A.3 Transmission lines, high-voltage tower

Power lines (conductors) deliver electrical energy from the generating plant to customers. The bulk power of the generating plant is transmitted to load centers over **long distance lines called transmission lines**. The lines that distribute the power within **city limits are called distribution lines**

The transmission lines are high-voltage wires (220–1200 kV) mounted on tall **towers** to prevent them from touching the ground, humans, animals, buildings, or equipment. High-voltage towers are normally 25–45 m in height. The higher the voltage of the wire, the taller is the tower.



High-voltage towers are normally made of galvanized steel to achieve the strength and durability needed in harsh environments. Since steel is electrically conductive, high-voltage wires cannot be attached directly to the steel tower. Instead, insulators made of nonconductive material mounted on the tower are used to hold the conductors away from the tower structure.

The choice of cable design primarily requires the review of the cable's size with required ampacity at the operating temperature that will also meet the voltage drop limitation over the feeder length under steady-state current and the motor starting inrush current.
In addition, many high-speed networks open to new technologies, use **fiber optic cables**. These have the advantage of being lighter and narrower in gauge, which makes them easier to manage when laying the cable lines even though fiber optic cables are more fragile than metal-core cables.
All these kinds of cables can be used **overhead** or **underground**. Before supplying the cable, it is important to know this so that the right specifications of cable can be delivered to the customer, since insulation and prevention of corrosion varies widely depending on the cables' situation.
We supply all kinds of cables – high voltage and low voltage, single and three phase, along with all **accessories**.

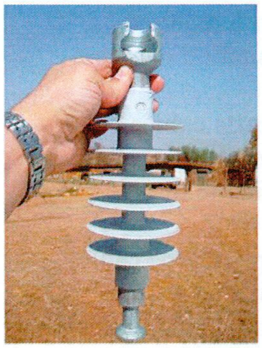
A.5.1 Bundled cable (conductor)

Very-high-voltage transmission lines have their cables split into sub-cables which are bonded together electrically, but are separated from each other by cable spacers which are repeated every few meters. Such bundled cables are designed to reduce the corona effect, which is produced by the high electric field which ionizes the air around the cable.
This ionization is a form of leakage current and is called "corona". Corona is a problem because it:

- Damages the cable and creates spotted burns on the surface of the cable
- Produces electromagnetic fields with wide frequency spectrum that interferes with wired and wireless communications
- Is a form of leakage current that causes energy loss?

A.5.2 Static (shield) wire

Most transmission lines need protection from lightening and build-up of static electricity, which is done by one or two thin wires installed at the top of the towers, known as static, shield wire, or overhead ground wire (OHGW).
The term static is used because the static shield wire does not carry current and is grounded along the transmission line and at the substations. The term shield is used because it protects the transmission line against lightning strikes. Any lightning strike would go to the highest point, and the static shield wire dissipate the energy and so protect the towers. The static wire is bonded to all metal tower structures and at substations.

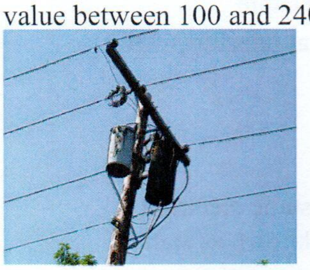


A.4 Distribution lines, low-voltage towers and poles

The conductors of the distribution lines are lower in voltage and are either buried underground or mounted on **poles** or **towers**. Since the voltage of the distribution lines is much lower than that for the transmission lines, the distribution towers are shorter and their insulators are smaller. The distribution towers are often made of steel, wood, concrete, or composite materials.

Most of the commercial and industrial plants have direct access to the distribution network, and they use their own transformers to step down the voltage to the levels needed by their various equipment.

In residential areas, utilities install transformers to reduce the distribution line voltage to any value between 100 and 240 V, depending on the standard of the country.

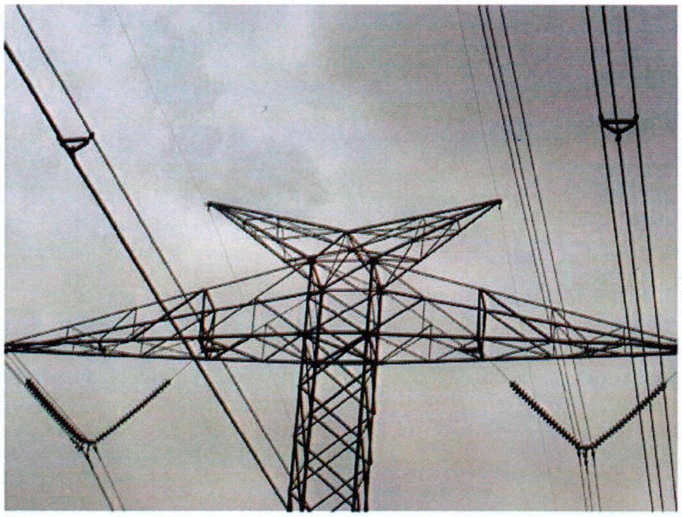


A.5 Power cables (conductors), fiber-optic cables and accessories

Although transmission line conductors used to be made of copper, they are no made of aluminum because 1. it is much cheaper, and 2. it is lighter than copper, which allows the use of longer spans between towers.

The power industry uses several types of cables; the most common ones are:

- All **aluminum conductors** (AAC): This conductor has one or more strands of aluminum alloy without reinforcement strands. AAC is used when the span between towers is short (urban areas). In coastal areas, where corrosion is a problem, AAC conductors are used.
- **Aluminum conductors steel reinforced** (ACSR): To increase the strength of the aluminum conductors, the ACSR has steel strands at its core surrounded by one or more layers of aluminum strands. The steel of the core is often galvanized steel (zinc coated). The ACSR are used when the span between towers is long. Even though the steel is galvanized, it can still be corroded over a period of time, especially in coastal areas.
- All **aluminum alloy conductors** (AAAC): This is an alloy conductor made of aluminum, magnesium, and silicon.



Picture caption: The two thin wires, suspended from the top of the tower, between the more visible bundled lines, are the static shield wires.

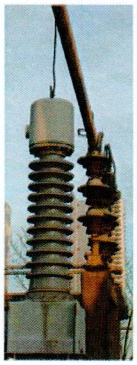
A.6 Substations

The substation is where the voltage is adjusted, circuits are switched, system is monitored, and equipment is protected. A typical substation includes

- Transformers
- Switching equipment
- Protection equipment
- Measuring devices
- Control systems

A substation steps up or steps down the voltage of the incoming power. A substation includes

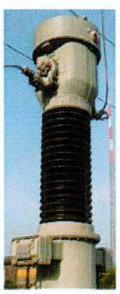
- Potential transformer – to measure the incoming current



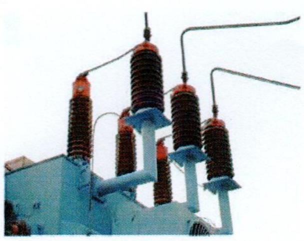
- Disconnecting switch - to isolate a section of the substation when needed

- Circuit breaker - to open the circuit when faults occur

- Current transformer - to measure the line current of the high-voltage side

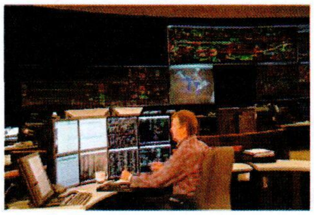


- Surge arrester - to dissipate any lightning or surge transients from damaging the transformer



A.7 Control center

System control Centre's protect the entire network from being damaged due to the failure of any of its components or equipment. They also ensure that the network is operating effectively and economically to ensure the best rates to the customers. Besides the extensive monitoring, control engineers continuously evaluate the operation of the system, predict the future demand, and establish favorable energy trade conditions between utilities. These functions require the use of sophisticated algorithms that optimize the operation of the power system.



A.8 Lubricants

The purpose of lubrication is **to reduce friction** between moving metal surfaces, as well as serving as a **coolant**, **preventing corrosion**, and **blocking the entry of contaminants**. Satisfactory lubricants will also resist separation, be reasonably stable, and not significantly change their its nature within the temperature range for which they were designed.
Lubricants are widely used in **electrical connectors**, **switches**, **circuit breakers**, and hydraulic oil which is used in **transformers** for cooling.
There are three major types of lubricants: **oils** (fluid lubricants), **greases** (soft substances), and **solid lubricants** that we can supply, and they include the following:

- **Oil** covers a broad class of fluid lubricants, such as petroleum lubrication oils (mineral oils) which are either
    - naphthenic oils which contain little wax and have a low pour point
    - paraffinic oils which are very waxy and used mainly in hydraulic equipment.
- **Synthetic Oils** are used for instrument bearings, hydraulics, air compressors, gas and steam turbines and many other applications. Silicones are not true oils and their principal advantage is excellent viscosity –temperature characteristics, good resistance to oxidation, and a wide operating temperature range.
- **Grease** consists of a thickening agent, oil or synthetic fluid and additives. Various thickeners provide different properties of grease. Grease consistency depends on the type and amount of thickener used and the viscosity of its base oil. Consistency of grease is its resistance to deformation by an applied force. The measure of consistency is called penetration.
- **Synthetic Lubricants** Base stocks for synthetic lubricants are esters, synthetic hydrocarbons, polyglycols, and silicones. Synthetic greases are a cost-effective, lifetime lubrication for bearings and other moving parts, for gaskets and seals. High thermal stability and chemical inertness make them useful for aerospace, electrical, automotive, and other high-tech or industrial applications.
- **Solid Lubricants** are usually fine powders, such as molybdenum disulfide, graphite, and Teflon (polytetrafluoroethylene). They can be used as additives in greases or dispersions, as dry film bonded lubricants, or alone. Lubricating solids can provide longer-term lubrication than unfortified oils and greases because of their ability to form burnished films on surfaces and stay longer.
- **Silicones** are very stable and very inert lubricants, which provide wider operating temperature ranges than non-silicone synthetic lubes.

B. Energy Resources

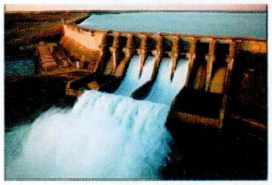
Energy resources are divided into three categories of fossil fuel, nuclear fuel and renewables:
Fossil fuels include
Fossil fuels (oil, coal and natural gas) are formed from fossils of dead plants and animals buried in the earth's crust for millions of years under pressure and heat. They are composed of high carbon and hydrogen elements such as oil, natural gas, and coal. They are nonrenewable, and the world has become extremely dependent on fossil fuels for its energy needs. The bulk of fossil fuels are used in transportation, industrial processes, generating electricity, as well as for residential and commercial heating.
But the use of fossil fuels to generate electricity has always been a subject of much public debate, because fossil fuels are limited, and burning them causes widespread pollution, which includes the release of carbon dioxide and sulfur oxide into the environment and the formation of nitrogen oxide. In addition, the availability and price of fossil fuels often fluctuate due to political tensions between nations.
Nuclear fuel includes:

- Uranium

- Plutonium

Renewable energy resources include

- Hydropower



- Wind

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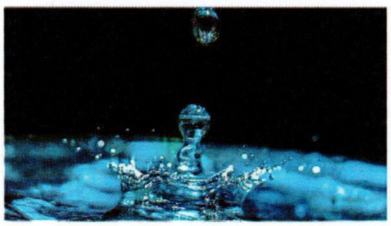
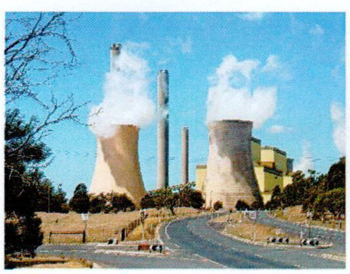
- Solar

- Hydrogen



- Biomass

- Tidal
- Geothermal



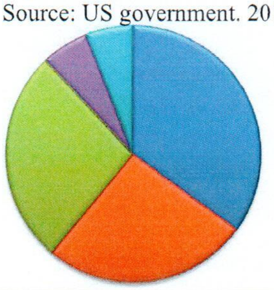
Over 99% of all electric energy worldwide is generated from fossil, nuclear and hydro-power. Other resources, although increasing rapidly, have not yet achieved a level comparable to the primary resources.

The distribution of electricity generated worldwide by primary resources is shown in the attached diagram. Most of the electrical energy is generated by oil, natural gas, and coal. Hydroelectric energy is limited to about 6% of the world's electrical energy because of the limited water resources suitable for generating electricity. Nuclear energy is only 6% of the total electrical energy because of the public resistance to building new nuclear facilities in the past 20 years.

Energy resources used to generate electricity worldwide

Resource	Percentage	Color
Oil	35	Blue
Natural gas	26	Red
Coal	27	Green
Nuclear	6	Purple
Hydro-electric	6	Light blue

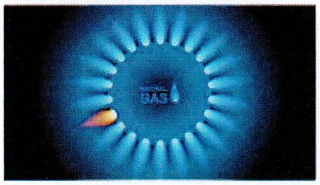
Source: US government. 2010



B.1 Oil

Oil is the most widely used fossil fuel worldwide. This high rate of consumption is troubling, and new fields must always be discovered before the available supply dries out.
Today, oil is used mainly by the transport (52%) and manufacturing industries (32%), with the rest being used by residential and commercial premises (10%), and the generation of electrical energy (6%) in 2010 according the US government.
We can supply

B.2 Gas



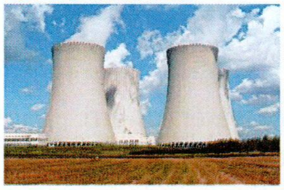
Natural Gas was long considered a byproduct of oil production and was burned out in the fields. But by the 1920s it was being commercialized. Today, 32 percent of all natural Gas production worldwide is used to generate electricity and 44 percent is used in the industrial sector.

We can supply

B.3 Coal

Coal is oldest fossil fuel and has been used for centuries. By the 1880s, coal was being used to generate electricity and countries in Asia and Oceania are the largest consumers of coal. China is the major user of coal for generating electricity. In North America and Europe, the consumption of coal is still high, but the dependency on coal for the production of electricity is reduced because of the wider use of natural gas.

B.4 Nuclear



Nuclear fuel is heavy-nuclei material that releases energy when its atoms are forced to split and in the process some of its mass is lost. The nuclear fuel used to generate electricity is mostly uranium (U), but plutonium (Pu) is also used.

Uranium is found in nature and contains several isotopes. Natural uranium is almost entirely a mixture of three isotopes, 234U, 235U, and 238U, where the superscript numbers indicate the atomic mass of the isotopes. The concentration of these isotopes in natural uranium is 99.2% for 238U and 0.7% for 235U. Only 235U can fission in nuclear reactors. Since the concentration of 235U in uranium ores is so low, an enrichment process is used to increase its concentration in nuclear fuel. For nuclear power plants, 235U concentration is about 3%–5%, and for nuclear weapons, it is over 90%.

Plutonium is the other nuclear fuel used to generate electricity, but it is mainly man-made. Plutonium is produced in breeder reactors, and it has three common isotopes: 238Pu, 239Pu, and 240Pu. The other plutonium isotopes are created by different combinations of uranium and neutron. The isotope 239Pu is used in nuclear weapons and 238Pu is used in nuclear power plants. In some cases, 238Pu is mixed with uranium to form a mixed-oxide fuel that increases the power plant output.

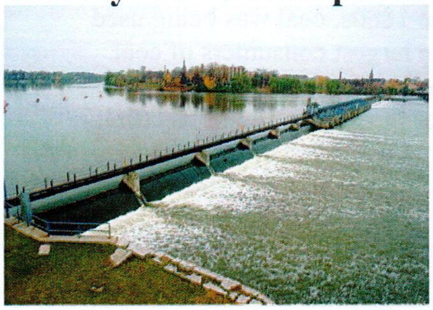
We can supply

For those thermal power stations that require **fuel oil** and **diesel** to power their burners, Gold Vision and its sister companies can supply any of the lubricants listed above, as well as fuel oil and diesel. Our companies' storage facilities and large depots in the UAE help us deliver efficiently and on time, to the customers' requirements.

C. Power plants

The vast majority of electricity generated in the world worldwide is generated using **primary** energy resources: hydropower, fossil fuel, and nuclear fuel. The type of power station is often determined by the geological and hydrological characteristics of where the power plant is to be built. For example, **coal** power plants need to be close to where coal is abundant; **hydroelectric** power plants have to be where water and water storage facilities are available, whereas **nuclear** power plants can be built anywhere since their demand for natural resources is limited only to the availability of cooling water.

C.1. Hydro-electric power plants



Hydro-electric power generation is based on harnessing the motion of water toward the oceans due to its kinetic energy. The hydroelectric power plant converts the kinetic energy into electrical energy by storing the water at high elevations, and passing it through a turbine to the turn the generators.

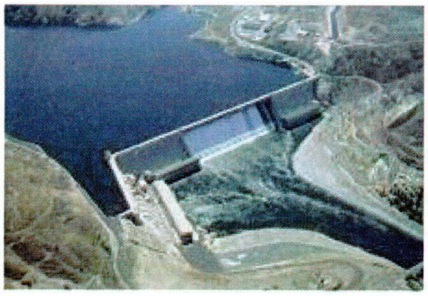
There are three types of hydro-electric power plant: **dam**, **diversion**, and **pumped**. Diversion plants are used where a river has a strong current and a dammed reservoir is not required, so its generating capacity is not as large as for dam power plants. A pump storage hydro-electric plants uses a dual action water flow system, so that when demand is low electricity is used to pump water from the lower level in front of the dam to the higher level behind, so increasing the reservoir ready for later use when demand is higher.

A diversion hydro-electric power plant

The classification of hydroelectric power plants is based on their size:

- **Large** is more than 100 MW
- **Medium** is 15–100 MW
- **Small** is 1–15 MW
- **Mini** is 100 kW–1 MW
- **Micro** size is 5–100 KW

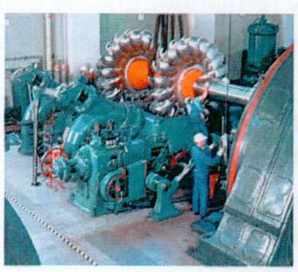
Dam power plants are the most common type of hydro-electric power plant and are suitable for generating large amounts of electricity. A typical dam hydro-electric power system has six key components: **dam**, **reservoir**, **penstock**, **turbine**, **generator**, and **governor**.



- A **dam** is a barrier that prevents water from flowing downstream, thus creating a lake behind the dam. The PE of the water behind the dam is directly proportional to the volume and height of the lake.
- The **reservoir** is the lake behind the dam which often covers a wide area of land.
- The **penstock** is the large pipeline that channels water from the reservoir to the turbine.
- The **governor** is a valve that regulates the flow of water in the penstock. When it is fully open the flow of the water is at the maximum, and if the system is to shut down, the governor has to close fully.

All three kinds of hydro-electric power stations (dam, diversion and pump storage) use the same turbines and generators:

- A **turbine** is an advanced water wheel, which the high pressure water coming from the penstocks pushes against the blades of the turbine causing the turbine shaft to rotate. There are two main types of turbines. Different designs of turbine handle different water flows from the highest water heads of 50m to 1300m, to low to medium heads of 10m to 350m and low flows from water heads of less than 40m. These include:
    - **Impulse** turbines include a series of buckets mounted all the way round a rotating wheel known as a runner, which captures the momentum of the water.



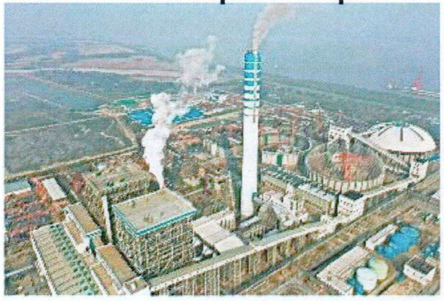
Impulse turbine being installed

    - **Reaction** turbines are completely immersed in water, and when the water enters the chamber, its flow through the blades drives the runner and captures the momentum of the water. The flow is increased by the use of water nozzles that forces the water to a higher speed.

- The **generator** is mounted on the same shaft of the turbine, so the generator rotates at the speed of the turbine. The generators used in all power plants are synchronous machines. The generator is equipped with various control mechanisms such as the excitation control and various stabilizers to maintain the voltage constant and to ensure that the generator's operation is stable.

Hydro-electric turbine generator

C.2 Thermal power plants



Thermal plants using fossil fuels like **coal**, **oil**, or **natural gas** to convert heat energy into mechanical energy, and then into electrical energy. Most fossil fuel power plants have similar designs with different burners, fuel feeders, and stack filters.

The turbine of a thermal power plant is installed between the heat source and a heat sink often known as a cooling tower. The turbine is a thermo-mechanical device that converts heat energy into mechanical energy, with any remainder energy being dissipated in the heat sink (cooling tower), without which no heat travels through the turbine.

Thermal energy constant (TEC) is defined as the amount of thermal energy produced per kg of burned fuel. The unit of TEC is called the British thermal unit (BTU). This table shows that gas is the most efficient source of energy, closely followed by petroleum products like fuel and diesel, although coal still plays a very important part in the business thanks to the legacy systems that use it.

Fuel Type	Thermal Energy Constant (BTU/kg)
Natural gas	48,000

Petroleum	45,000
Coal	27,000

All thermal power plants use a turbine and a generator. The turbine consists of blades mounted on a shaft. The angles and contours of the blades are designed to capture the maximum thermal energy from the steam.

The process for a **coal-fired thermal power station** starts with the coal first being crushed and delivered to the burner via conveyor belts. It is then burned to generate heat that is absorbed by water pipes inside the boiler. The water turns into high-pressure steam at high temperature. The steam leaves the boiler at a temperature higher than 500°C and enters the turbine at a velocity greater than 1600 km/h. The high speed steam hits the blades of the turbine and causes the turbine to rotate. The turbine's shaft is connected to the shaft of the generator, thus causing the generator to rotate at the same velocity and electricity is generated.

In the cooling tower, the steam is turned back into liquid and returns to the boiler to complete the thermal cycle. Inside the cooling tower, the condenser uses water from nearby lakes or oceans to cool the steam inside the pipes.

Although coal-fired power plants are simple in design and easy to maintain, they are major producers of pollution, such as: Carbon dioxide (CO_2), carbon monoxide (CO), sulfur dioxide (SO_2), nitrous oxide (NO_x), soot, and ashes. Coal burning by power plants and the industrial sector is responsible for 30% to 40% of the total CO_2 in the air. In older and unregulated plants, most of these pollutants are vented through the stack. However, with newer technologies, large amounts of the pollutants are trapped by filters or removed from the coal before it is burned.

The process of treating coal to reduce pollution include the following:

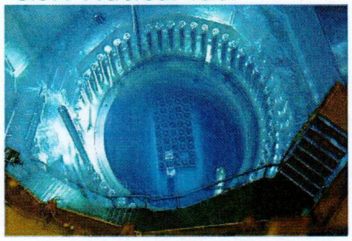
- Chemical treatment of the coal to remove most of its sulfur before it is burned
- Filters to remove fly ash and some exhaust gases from the boilers. There are various types of filters, such as:
  - wet scrubber filter - the exhaust gas passes through liquid, which traps the fly ash and SO_2 before the gas is vented through the stacks
  - fabric filter– which works like a vacuum cleaner where the fly ash is trapped in bags
- SO_2 is removed by its own scrubber system
- NO_x is reduced by upgrading the boilers to low NO_x burners
- CO_2 removal is too expensive to implement and not all power plants use carbon dioxide scrubber system.

C.3 Nuclear power plants

Nuclear fuel is the most abundant source of energy. The common fuel for nuclear power plants is uranium, and plutonium and thorium are used as well. Nuclear power plants generate electricity by one of two methods: fission and fusion:

- **Fission** is the splitting of heavy nuclei elements such as uranium, plutonium, or thorium into many lighter elements. By this process, mass is converted into energy. Almost all of the commercial nuclear power plants worldwide are fission reactors. Fission power plants have two main designs:
  - boiling water reactor, BWR
  - pressurized water reactor, PWR, which are about two-third of the nuclear reactors.
- **Fusion** is a process by which two lighter elements are combined into a heavier element. The fusion technique is not yet fully developed for commercial power plants.

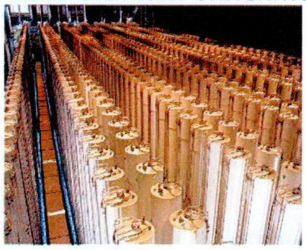
C.3.1 Nuclear fuel



Uranium is the main fuel used for nuclear power plants. The uranium extracted ore is crushed to a fine powder that is further processed to extract the uranium oxide. The processed material is called yellowcake. The color of the yellowcake is actually brown or even black. Yellowcake contains 70% to 90% uranium oxides by weight. Yellowcake is further processed chemically to produce uranium hexafluoride (UF_6). When heated, UF_6 becomes a gas, which is used to produce the nuclear fuel. Natural uranium is almost entirely a mixture of three isotopes, 234U, 235U, and 238U. The concentration of these isotopes in natural uranium is 99.2% for 238U and 0.7% for 235U. However, only 235U can fission in nuclear reactors. Since the concentration of 235U in uranium ores is so low, an enrichment process is used to increase its concentration in nuclear fuel. In nuclear power plants, 235U concentration has to be between 3% to 5%.

Another way to develop a fissionable nuclear fuel is through breeder reactors. A breeder reactor uses the widely available, non-fissionable uranium isotope 238U, together with small amounts of fissionable 235U, to produce a fissionable isotope of plutonium, 239Pu. Plutonium is a man-made element and cannot be found in nature.

C.3.2 Uranium enrichment

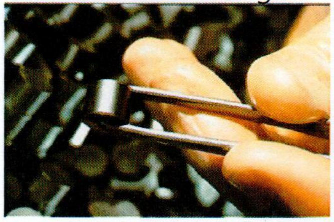


There are two common methods for uranium enrichment: **gaseous diffusion** and **gas centrifuge**.

In the **diffusion** method, the UF_6 gas is pressured through semipermeable membranes to separate the molecules of 235U from 238U. Many stages of this process are needed to achieve just 2% enrichment.

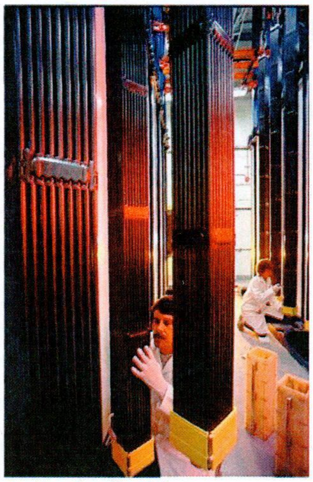
In the **centrifuge**, the gas uses centripetal force, which rotates the molecules of different masses, so that they are physically separated along the radius of rotation. The UF_6 gas enters a cylinder that rotates at a high speed, and the heavier 238U molecules move toward the outside of the cylinder while the lighter molecules containing 235U stay closer to the center. The gas in the center, with more 235U than 238U is enriched uranium. To reach 2% to 5% enrichment, several thousands of centrifuge cycles are needed.

After enrichment, the uranium is mixed with other compounds and is manufactured into fuel pellets. Each pellet is cylindrical of about 8 mm in diameter and 10 mm in height. A pellet may contain the energy equivalent of 1000 kg of coal, 700 L of oil, or 1500 m3 of natural gas.



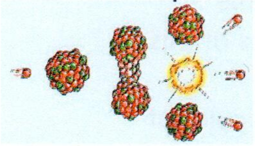
Fuel pellet

The **pellets** are loaded into zirconium alloy metal tubes known as fuel **rods**. Zirconium alloy is chosen because of its ability to resist radiation and thermal stresses. The fuel rods are grouped into an **assembly** that includes as much as 800 fuel rods. In the assembly, there are also control rods that regulate the thermal energy inside the reactor.



Fuel rod assembly

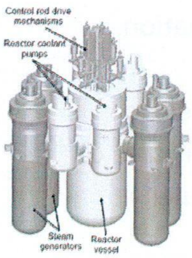
C.3.3. Fission process



In a nuclear power plant, neutrons strike uranium atoms at certain speed causing them to split (fission). The fission process produces the following:

- **Energy**: The mass of the original uranium atom with the activation neutron is more than the combined masses of the fission fragments plus the released neutrons. The lost mass is converted into energy as described by Albert Einstein's formula $e=mc^2$ where is the released energy, m is the lost mass and c is the speed of light.
- **Fission fragments**: which are the leftover materials after the uranium atoms have split, such as cesium-140 and rubidium-93 which are radioactive.
- **Released neutrons**: After each fission action, three free neutrons are released. If they hit three other uranium atoms, they cause more fission to occur, which produces nine free neutrons and so on. This is known as a chain reaction. The neutrons produced by nuclear fission are fast-moving and must be slowed down to initiate further fission. The material used for this purpose is called a moderator. Common moderators are regular water (H_2O), and heavy water (D_2O) as well as graphite. Heavy water is chemically similar to regular water but the hydrogen atoms are replaced by an isotope of hydrogen called deuterium. Deuterium has one neutron more than hydrogen, which makes D_2O heavier than H_2O by about 10%.

C.3.4 Fission control

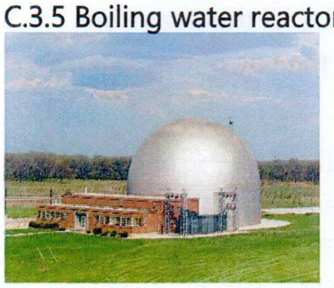


The fuel assembly (see C.3.2) is placed inside the nuclear reactor. The heat generated by the fission process is captured by the water inside the reactor. The water is turned into steam and used to generate electricity.

The fission process can be sustained indefinitely if the fuel is available and the chain reaction is maintained. To control the amount of the energy released, the chain reaction must be regulated by controlling the number of neutrons available for fission. This is done by using control rods made of material absorbent to neutrons and inserted inside the reactor between the fuel tubes. The common materials used for control rods are hafnium, cadmium, or boron.

Control rods can be inserted into or removed from the reactor by a motion control mechanism. When they are inserted, the rods absorb neutrons so fewer are available for fission. The reactor can be completely shut down by fully inserting the control rods into the core. In emergency situations, the rods are released and the gravity pulls them down inside the assembly to their fully inserted positions.

C.3.5 Boiling water reactor



Boiling water reactors (BWR) typically boil the water inside the reactor vessel itself, operating at a temperature of 300°C, with steam at a pressure of about 7 × 105 kg/m2. BWR reactors can generate as much as 1.4 GW with an overall efficiency of 33%.

A BWR nuclear power plant has the following key components:

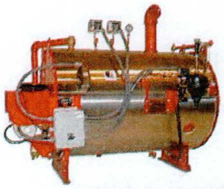
- **Containment structure**: The dome structure houses the reactor and has multiple barriers of thick steel and concrete to contain the radiations inside the structure.
- **Reactor vessel**: The reactor vessel houses the **fuel assembly**. The vessel is filled with water, which acts as a moderator for the chain reaction and also extracts the heat energy generated by the nuclear reaction. The walls of the vessel are

made of thick barriers of steel and concrete to guard against any radiation leakage or accidental meltdown.

- **Control rods**: Control rods can be inserted between the fuel assemblies or removed from the reactor to control the amount of heat generated. In case of an emergency shutdown, the rods are released and dropped to the fully inserted position to halt the chain reaction.
- **Turbine**: The energy generated by the nuclear reaction heats the water inside the reactor vessel, and steam is produced at high temperature and pressure. The steam passes through the turbine, which is a thermomechanical converter that converts the thermal energy into mechanical energy, much like the turbine of the thermal power plant.
- **Generator**: The turbine is connected to the generator via a common drive shaft. The generator is an electromechanical converter, where the mechanical energy of the turbine is converted into electrical energy.
- **Condenser**: It is the heat exchanger that extracts heat from the steam exiting the turbine. It acts as a thermal link between the turbine steam and the cooling tower.
- **Cooling tower**: The function of the cooling tower uses cold water from nearby source like a reservoir, lake, river, or ocean. The cold water is poured over the condenser pipes to cool them down. The cooling water extracts the heat from the condenser and turns into steam, which is vented from the top of the cooling tower.

Among the advantages of the BWR are its simple design and high efficiency. However, because the fuel rods are in direct contact with the steam, the radioactive material from the nuclear reaction is carried over by the steam and eventually reaches the turbine. This radioactive steam pollutes the turbine and poses a challenge to the maintenance crew working on the turbine-generator system.
We can supply;

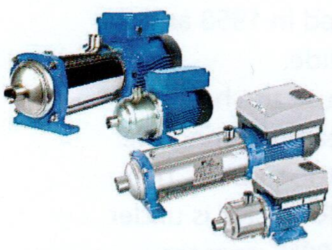
- Steam generator



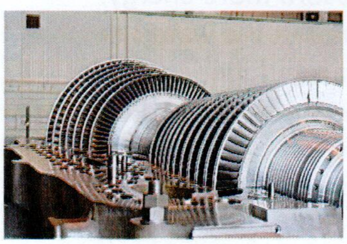
- Heat exchanger for thermal turbine

- Heat exchanger for cooling tower

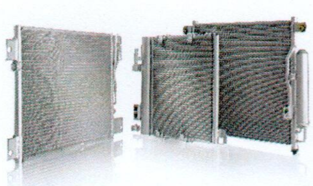
- Pumps – hot and cold water



- Thermal turbine



- Condenser



- Cooling tower components

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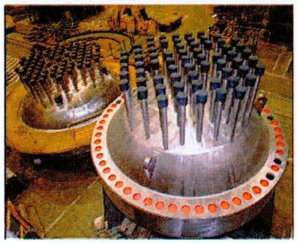
C.3.6 Pressurized water reactor



A pressurized water reactor (PWR) was originally designed as the power source for navy ships and submarines. The first commercial PWR plant started in 1958 and the PWR is now the most widely used type of nuclear reactor worldwide.
The PWR design is distinctly different from that of the BWR because the heat exchanger is placed between the water of the reactor and the steam entering the turbine. This prevents the radioactive water from contaminating the turbine. This heat exchanger is called a steam generator. The water of the PWR reactor is under enough pressure to remain in liquid form even when it reaches 300°C or more. Raising the temperature of the water under pressure makes it absorb more energy. The PWR has three separate heat exchange loops, or water loops, but the waters in these loops never mix. In the **primary loop** the pressurized water is pumped through the reactor to extract the thermal energy generated by the nuclear reaction and then passes through extremely strong pipes that lead to a steam-generator (heat exchanger). The water in the first loop is radioactive. The **secondary loop** includes the heat exchanger, the turbine, and the generator. The water in the second loop is free from any significant radioactive material. The **third loop** is the cooling loop that includes the turbine-generator, the condenser, and the cooling tower.
We can supply;

- Steam generator

- Heat exchanger in the fuel assembly

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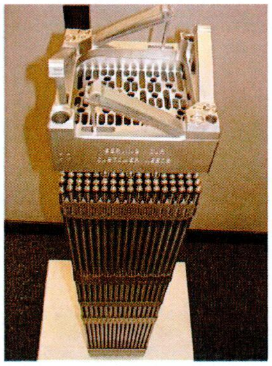
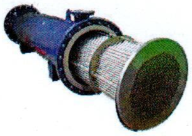
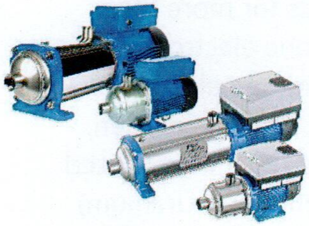


- Heat exchanger for thermal turbine

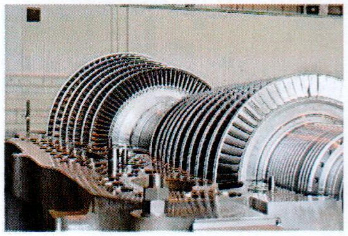


- Heat exchanger for cooling tower

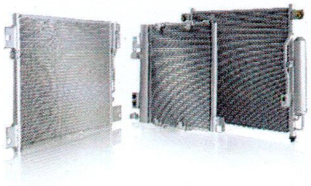
- Pumps – hot and cold water



- Thermal turbine

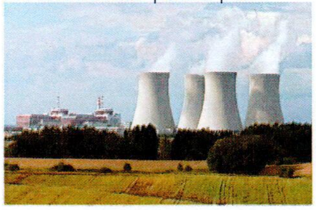


- Condenser



- Cooling tower components

A PWR nuclear power plant

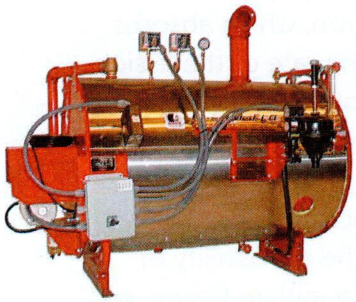


C.3.7 CANDU reactor

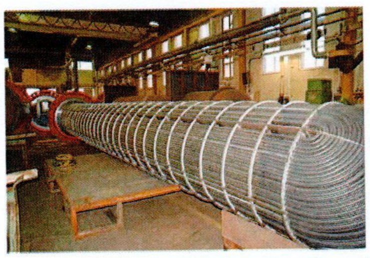
Some nuclear reactors use heavy water as the moderator for the reactor. Heavy water is one of the isotopes of normal (light) water. Hydrogen isotopes include protium and deuterium. Protium is the most abundant isotope as it accounts for more than 99.9% of all hydrogen isotopes. Its atom includes one proton and one electron. Deuterium, which is relatively rare element, has also one proton and one electron, but in addition has one neutron in its nucleus. It is therefore called heavy hydrogen. Water with highly concentrated deuterium is known as heavy water (D_2O) and is used as a moderator for nuclear reactors known as CANDU (CANada Deuterium Uranium) reactors. The ability of heavy water to absorb neutrons generated by the chain reaction is substantially reduced, so a lower concentration of uranium can be used. It is even possible to use unenriched natural uranium directly.

We can supply;

- Steam generator



- Heat exchanger in the fuel assembly



- Heat exchanger for thermal turbine
- Heat exchanger for cooling tower
- Pumps – hot and cold water
- Thermal turbine
- Condenser
- Cooling tower components

C.3.8 Safety equipment for nuclear power plants

Safety is paramount in a nuclear power plant, and well-known disasters including Three Mile Island and Chernobyl made clear the necessity of getting safety procedures right, and reverse public doubts over nuclear safety. The main doubts are over the **safety of the fuel assembly**, the **effectiveness of the control rods**, and the **loss of water** inside the reactor.

Fuel rods: The fuel pellets are made from enriched uranium are a few centimeters round. Most of the pellets are enriched with 3% to 5% 235U. The fuel pellets are placed in tubes made of an alloy of zirconium and niobium. This alloy resists corrosion and has a low neutron absorption property. It is capable of maintaining its property even at high-temperature, high-pressure, and high-irradiation environments. The fuel assembly is often replaced every 3 to 5 years.

Control rods: The control rods are made of material such as boron, which absorbs neutrons. The boron impedes the chain reaction and controls the rate of the fission reaction. The control rods are inserted between the fuel tubes or mixed with the fuel rods. During emergency conditions, the control rods would drop between the fuel rods and stop the nuclear reactions completely.

Reactor water: Reactor water removes excess heat from the reactors to prevent any meltdown. Water also slows down the neutrons and increases the probability of fission. Without water, neutrons would become too energized to initiate fission, so any loss of water would slow down the fission process dramatically.

We can supply all the equipment

- Fuel assemblies including tubes, bundling devices,
- Control rods and control machinery
- Equipment to manage reactor water including pumps and pipes
- Steam generator and pumps

C.3.9 Waste and storage

Nuclear waste is radioactive for thousands of years, and the spent fuel rods needs careful storage in special facilities that prevent radiation leaks, some temporary and some permanent.

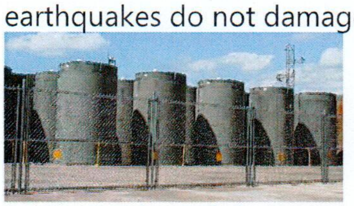
Temporary storage is in two types: wet and dry.

Wet storage is when the very hot spent fuel rods are removed from the core of the reactor and placed in a pool of boric acid to cool them down and to allow the boric acid to absorb some of the radiation of the fission fragments. The spent fuel rods are immersed in the boric acid fluid for at least 6 months before they are transported to permanent storage facilities. As an additional safety measure, control rods are placed among the spent fuel rods to inhibit any fission action of leftover U235.

Dry storage is when after the spent fuel rods have been cooled down in the wet storage facilities, they are placed in temporary dry storage made of reinforced casks or buried in concrete bunkers. The casks are steel cylinders that are welded or bolted closed. Each cylinder is surrounded by an additional steel and concrete as a further measure against radiation leaks. The casks can be used for both storage and transportation.

Permanent storage

Nuclear waste is permanently stored by burying it. **Low-level** waste which loses its radioactivity in a few hundred years is often buried in shallow sites. The **high-level** waste such as the spent fuel rods is harder to dispose and will be radioactive for thousands of years, is buried in deep geological permanent storage facilities. It is important that such deep sites have no or little groundwater to prevent the erosion of the containments (steel cylinders). The site must also be stable geologically, so earthquakes do not damage the containments.



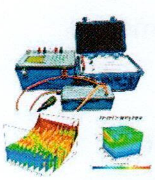
Dry storage of spent fuel

We can supply:

- Boric acid

- Steel cylinders and drums

- Geological testing equipment



- Geological monitoring equipment

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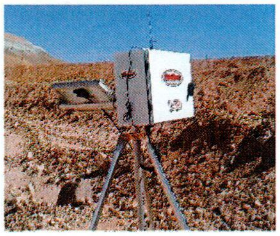
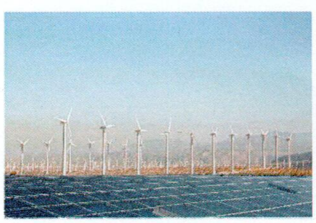


- Excavating and digging equipment


- Specialized handling equipment

- Specialized personal safety equipment

D. Renewable energy plants



Even though the world relies heavily on fossil fuel (coal, oil, and natural gas) for its ever-growing appetite for energy, major public concerns over the bad environmental impact of continuing to burn fossil fuels has encouraged the development of alternative energy resources.
Renewable energy describes any form of electric energy generated from resources other than fossil and nuclear fuels. Renewable energy resources include hydro-kinetic, wind, solar, geothermal, biomass, and hydrogen. The sun is the source of all those renewable energies with the exception of geothermal. These resources

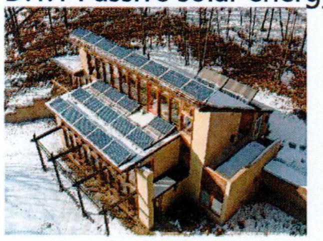
produce much less pollution than burning fossil fuels and are constantly replenished, and thus called renewable.
At the start, renewable energy technologies were not very efficient, but this has improved and will continue to do so as new technologies and systems are invented or introduced every year.

D.1. Solar energy power plants

The sun is the primary source of energy in our solar system and sunrays are packed with energy but their impact at the surface of the Earth is weakened by:

- Gases and water vapor in the earth's atmosphere absorbing some of the solar energy
- The angle with which the sunrays reach the Earth
- The reflection and scattering of sunrays by particles in the air

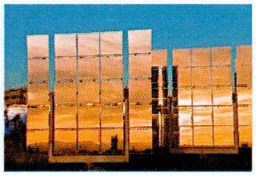
D.1.1 Passive solar energy power plants



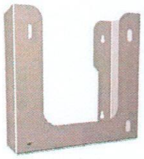
A passive solar system uses the sun's rays to heat a liquid (often water). In a **small or domestic system**, there is a solar collector, water tank, and water tubes. The collector has an outer lens (or transparent glass) that faces the sun, and houses a long zigzagged water tube. The lens concentrates the sunrays, thus increasing the temperature of water inside the tubes. The warm water moves naturally upward to the tank because hot water is less dense than cold water. Since the water in the upper part of the tank is warmer than the water in the lower part, the cold water at the bottom of the tank goes back to the collector. When warm water is needed inside the house, it is extracted from the top of the tank. This water is replaced by cooler water from the main water feeder of the house.
The passive solar system is simple, inexpensive, and requires little maintenance. However, it demands enough solar power density to make it viable, and it is most effective during the daytime.
On a **larger scale**, passive solar systems concentrate solar radiation to increase the temperature of any fluid to the level needed for industrial applications. In a solar farm the system can be integrated with a conventional thermal turbine to produce

electricity. This system is called **integrated solar combined cycle system (ISCCS)**. It consists of a large number of parabolic mirrors called collectors, which concentrate the solar radiation energy on a pipe system called receiver located at the focal area of the collector mirrors. The fluid of the receiver, which is often oil, is heated to about 400°C and is used in a heat exchanger to produce steam that can be used to generate electricity using a thermal turbine. During the night, natural gas is used to produce the steam needed by the plant. Hence, the power generation is continuous.
We can supply

- Mirrors and lenses

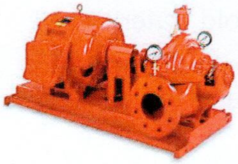



- Mirror and lens mounting



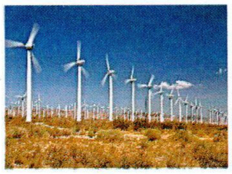

- Mirror and lens direction controls
- Collectors
- Pipes

- Pumps



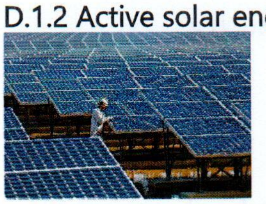
- Heat exchangers

- Turbines



- Generators

D.1.2 Active solar energy power plants (photovoltaic)



Light consists of particles called photons, which are the energy by-products of the nuclear reactions in the sun. Each photon is a packet of energy, but not all photons have the same amount of energy. Photons with shorter wavelengths (higher frequencies) such as the gamma rays (about 1020 Hz) have more energy than photons with longer wavelengths such as the visible light (4.5–7.5 × 1014 Hz).
The efficiency of photovoltaic cells depends on the material and the structure of solar cells, and ranges between 2% to 20%.
Photovoltaic cells are made of semiconductors materials that include silicon (Si) which is a good insulator. To make silicon more conductive electrically, additives (impurities) are added like phosphorus (P) and boron (B). The phosphorous-silicon compound is called n-type and it is electrically neutral. Silicon can also be doped with boron, which is called p-type, which is also electrically neutral. When the n-type silicon is attached to the p-type silicon, they turn into a device known as diode or p–n junction. When the two types are attached, which is the main component of a photovoltaic cell.
There are two major types of photovoltaic cells: **concentrating** and **flat-plate**.
A **concentrating photovoltaic cell** consists of a convex lens mounted on top of n-type material with the p-type material at the base of the cell. When the cell is illuminated, the electrons of the n-type acquire some energy from the light photons, which helps them to break free from their atoms. If we connect the two terminals of the p–n junction to a resistive load, the electrons move from the n-type material to the load and back to the p-type material instead of going through the barrier of the depletion

zone. In this process, the energy acquired by the electrons is discharged in the load resistance.

The **flat-plate photovoltaic cell** is, as the name implies, is rectangular and flat. This is the most common type of photovoltaic array used in commercial applications. They are often mounted at fixed angles that maximize the exposure to the sun throughout the year and in more flexible systems, the angle of the solar panel changes to track the optimal sun exposure during the day.

Because convex lenses concentrate light, concentrating photovoltaic cells require less material for the same power output than the flat-plate cells; thus they are smaller in size. However, concentrating cells operate best when the sky is clear of clouds. Diffused light through the clouds produces less power in the concentrated cell as compared to the flat-plate photovoltaic.

The construction of the solar cell requires several added components such as:

- cover glass
- antireflective coating
- connecting grid

The cover glass is mounted on the top of the cell to protect it from the harsh environment (dust, scratches, bird dropping, etc.). Because silicon is a very shiny material, antireflective coating is used to reduce the reflection losses of silicon. A contact grid (mesh) is used to collect the electrons from the top of the n-type material. The base at the bottom is made out of a solid plate if the cell is a single layer design.

Newer designs of photovoltaic cells consist of duel and triple-junction designs. These types of photovoltaic cells are made of two or three cells vertically stacked. Although more expensive, they produce more power and have higher efficiency and higher voltage than single layer photovoltaic cells.

Modules: A single photovoltaic **cell** of 10 cm in diameter produces about 1 W power, which is enough to run a low-power calculator. Therefore, photovoltaic cells are connected in parallel and series. The parallel connection increases the overall current, and the series connection increases the overall voltage. When several photovoltaic cells are connected they form a **module** or panel and for higher power demand, several modules are connected together to form a photovoltaic **array**. More sophisticated photovoltaic arrays are mounted on tracking devices that follow the sun throughout the day. Several of these arrays form a photovoltaic **system** similar to the one shown in the right part of Figure 6.25. When a large number of these arrays produce substantial power, they are often connected to the distribution or transmission system.



Module or panel Array System

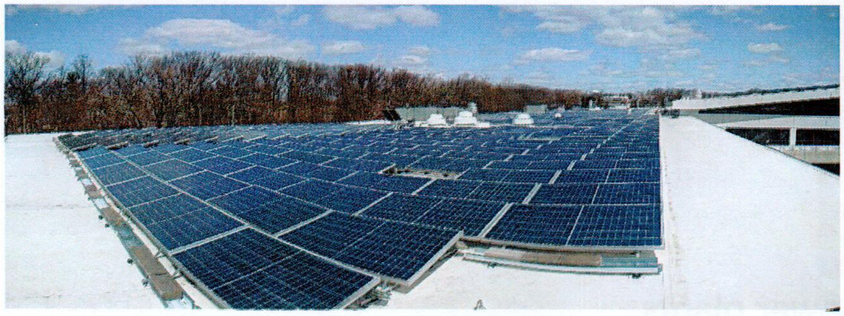
D.1.3 Photovoltaic system integration

Photovoltaic cells generate DC at low voltage, which is not useful for most power equipment and appliances which require alternating currents at 120/240 V. Therefore, a converter is needed to change the low voltage DC waveform of the photovoltaic array to an alternating current (AC) waveform at the frequency and voltage levels required by the load equipment. The solar array and the converter are the main components of the photovoltaic system.

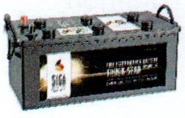
Most photovoltaic systems have two main designs: storage and direct systems.

The **storage photovoltaic system** consists of four main components:

- solar array



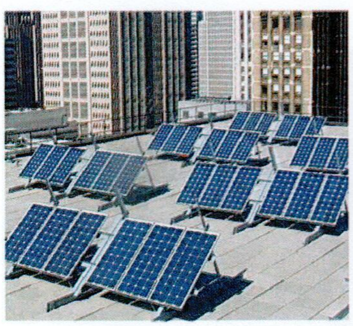
- charger/discharger
- battery




- converter

The converter is used to transform the DC power of the photovoltaic array, or the battery, into AC for household or commercial use. The commercial converters for photovoltaic applications are in the range of 1.0–6 kW, which are adequate for most household and small commercial applications. This system is also known as a stand-alone photovoltaic system and is most suitable for areas with no grid connection. The use of storage batteries is the major drawback of the stand-alone photovoltaic system. This is because the batteries decrease the overall efficiency of the photovoltaic system; about 10% of the energy stored is normally lost.
A simpler system that requires a **direct connection** to the utility grid in which the storage batteries and the charger are eliminated. The excess power in this solar system is sent to the power grid. The meter measures the net energy (photovoltaic power minus the consumed power of the house).
We can supply:

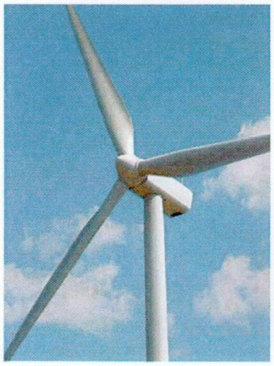
- solar array
- charger/discharger
- battery
- DC/AC converter
- meter



D.2 Wind energy power plants

Wind turbines are wind energy systems that converts the kinetic energy of wind into electrical energy. The current size of wind turbine ranges from 50 kW to up to 8 MW. Wind turbines come in a variety of designs and power ratings, but the most common design is the horizontal-axis type. It consists of the following basic components, which we can supply:

- **Tower** that keeps the rotating blades at a sufficient height to increase the exposure of the blades to wind. Large wind turbines, in the megawatt range, have their towers as high as 250m above the base.
- **Rotating blades** that capture the kinetic energy of the wind. They are normally made of fiberglass-reinforced polyester or wood-epoxy material. The length of the rotating blades ranges from 5 to over 60 m. Modern systems allows the blades to change their angle with respect to wind to maximize their absorption of wind's energy. Most wind turbines have three rotor blades.
- **Hub** that is part of the low speed shaft. The blades are mounted on to the hub and it has its own gear system and actuator to change the angle of the blade with respect to wind direction.
- **Yaw mechanism** that allows the housing box (nacelle) to rotate until the blades are perpendicular to the wind direction, thus increasing the exposure of the blades to wind.
- **Gearbox** connecting the low-speed rotating blades to the high-speed generator. It is also served as a clutch. This is because the generator operates at high speeds.
- **Turbine** that is driven by the rotating blades and is connected to the generator.
- **Generator** connected to the high-speed shaft of the gearbox to convert the mechanical energy of the rotating blades into electrical energy.
- **Controller** that integrates the wind turbine into the utility grid and regulates the generated power. It also protects the turbine against severe conditions such as grid faults and wind storms.



HAWT wind turbine

Housing of a turbine blade

D.2.1 Wind turbines

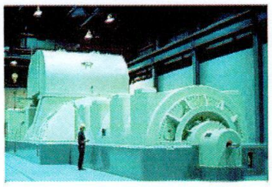
There are two kinds of **wind turbine**: horizontal axis and vertical axis.

Horizontal axis wind turbine (HAWT) are the most common type of wind turbine used today and includes the following which are all housed in a nacelle at the top of the tower:

- Drive shaft

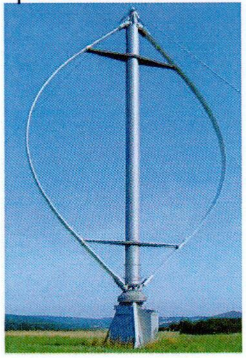
- Gearbox

- Electrical generator



- Transformer

Vertical axis wind turbine (VAWT) are much less common, and is suitable for sites with rapidly shifting wind direction as it does not need a yaw mechanism. The cut-in speed of the VAWT is generally lower than that of the HAWT.



VAWT wind turbine

The industry recognizes four types of wind turbine

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Type 1 is the simplest and has a squirrel cage induction generator directly connected to the grid without power conversion. The system has:

- **tower**
- **turbines** at the site are connected to a bus known as a farm connection point.
- **gearbox** that converts the slow speed motion of the blades to fast speed, higher than the synchronous speed of the generator, to produce electricity.
- **pitch control**.
- **step-up transformer** is used to increase the voltage of generated power to the voltage of the grid side
- **transmission line** connecting the wind farm to the grid

Type 2 is considered a variable slip type because the resistance changes the slip of the generator. Thus, the turbine operates at slightly variable speeds allowing the turbine to handle a wider range of wind speeds. It includes:

- **tower**
- **turbine**
- **generator** - slip-ring (wound rotor) induction machine
- **gear box**
- **rotor converter** which regulates the amount of power consumed by the resistance
- **Collection point** to link the wind farm to the grid

Type 3 wind turbine is the **Doubly fed induction generator** (DFIG), which offers wind turbines with flexible operation and a good level of control. The DFIG can generate electricity when the speed of wind is low causing the generator to spin below its synchronous speed. The turbine can regulate its output power and voltage. The system consists of:

- Tower
- turbine
- gearbox
- wound rotor induction generator
- Rotor converter AC/DC DC/AC
- DC link
- Link convertor AC/DC DC/AC
- Collection point to link the wind farm to the grid

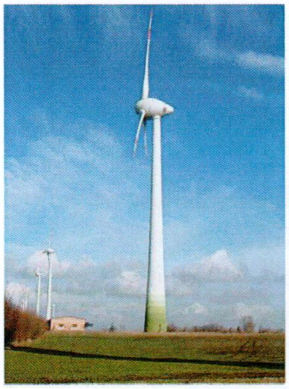
Type 4 wind turbine has no gearbox, which is a major benefit as the gearbox is one of the most expensive components of the system and also fails more frequently than other key parts. The generator used in this type is often a synchronous generator with either electric or permanent magnet. In some Type 4 systems, the generator can be an induction machine.

In either case, the generator has a large number of poles to reduce its synchronous speed. This is important since we eliminated the gearbox. Thus, the diameter of the generator is larger than that for the other types making the nacelle wider in diameter.

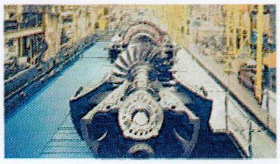
Since wind speed is variable, the frequency of the power output is also variable, which means a Type 4 cannot be connected to the fixed frequency grid. To solve this problem, a converter is installed between the generator and the grid. The function of the converter is to receive the variable frequency power of the generator and convert it to the fixed frequency needed by the grid.

The system consists of:

- Tower
- turbine
- generator – normally synchronous or rarely induction
- full converter AC/DC
- Collection point to link the wind farm to the grid



D.2.2 Generators for wind turbines

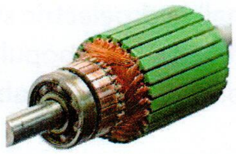


Generators for wind turbines are either asynchronous (**induction**) or **synchronous** machines.

Most generators today in wind energy are **induction generator**, of which there are two types:

- squirrel cage


- wound rotor

The squirrel cage is the cheapest and most rugged generator because its rotor is simple and the machine has no high maintenance components such as brushes or slip rings. The main drawback of the squirrel cage generator is the lack of access to its rotor circuit to implement various control actions.

The wound rotor is more complex than the rotor of the squirrel cage because it is made out of elaborate windings and it has brushes and slip rings mechanisms. But the wound rotor machine allows various control functions. The induction generator operates at a slip so its speed is not exactly constant. The machine itself without rotor injection cannot generate electricity unless it is spun above its synchronous speed.

D.3. Hydro-kinetic power plants


Hydro-kinetic systems produce electricity by harnessing the potential and kinetic energies of a body of water. Since water density is almost 900 to 1000 times the density of air, a hydrokinetic system can produce much more power than wind systems with same physical size. Hydrokinetic systems have a number of designs, the key ones of which are:

- **Small hydroelectric**: This system is similar to the hydroelectric power plants with dams but smaller.
- **Waves**: This system harnesses the energy of waves near shores.
- **Tidal**: The water rises and falls in tidal flow due to the motion of the sun and moon. The potential energy of the tide can be harnessed by dams or barrages.
- **Water stream**: Free flowing rivers and ocean currents are loaded with kinetic energy. Some of this energy can be captured without the use of dams.

D.3.1 Small systems


There are an immense number of small rivers and reservoirs that can be used to generate small amounts of electric energy enough to power neighborhoods and small cities. These types of power plants are called small hydroelectric systems. Such small hydroelectric systems run up to a few megawatts, and their popularity is due to their mature and proven technology, reliable operation, and their capability to produce electricity even with small head reservoirs.

The system works like the larger systems with dams, but the head of the reservoir is much shorter and its capacity is much smaller. The reservoir is normally a natural lake at a higher elevation than a downstream river or a lake created by a dam. The main components of the system which we can supply are:

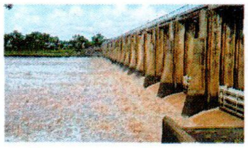
- Penstock materials
- Turbine – normally reaction turbines like Kaplan or Francis, which are immersed in water. Impulse turbines like Pelton are not suitable as they are designed for high heads.
- Generator

D.3.2 Tidal and stream energy systems


The gravitational pull of the moon which causes the oceans to rise or fall in a slow frequency of about one cycle every 12 hours, but these movements contain tremendous amounts of kinetic energy, and are probably one of the major untapped energy resources on Earth. Water streams are either major ocean currents or fast moving rivers. Ocean currents are due to natural phenomena such as tide, wind speed, and the differences in temperature and salinity. River current is due to changes in elevations and depth along the river.

Electricity production from tidal or water stream systems is predictable because water currents are known months in advance with great accuracy. This predictability of power production is very important for utilities to maintain their system reliability. There are two main technologies used to capture energy from tides and streams:

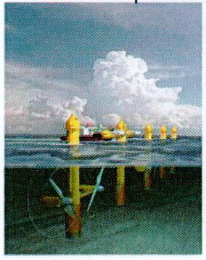
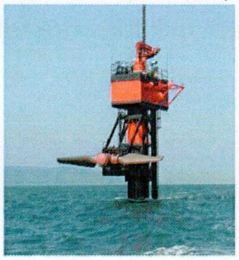
- **Barrage system**




A **barrage** is most suited for sea-inlets where there is a channel is connecting an enclosed lagoon to the open sea. At the mouth of the channel, a dam is constructed to regulate the flow of the tidal water in either direction. A **turbine** is installed inside a conduit connecting the two sides of the dam. When tide is high, the water moves from the sea to the lagoon through the turbine. The turbine and its **generator** convert the potential energy of the water into electrical energy. When the tide is low, the stored water in the lagoon at high tides goes back to sea, and in the process electricity is generated.

- **Water stream system**


A water stream system generates electricity from the kinetic energy of the moving water like a wind turbine converts wind energy into electrical energy. The system does not require the construction of water barriers such as dams or barrages, as the hydroelectric system is installed in the pathway of a river or ocean stream. The **turbine** is placed in the water flow, and linked to its **generator.**

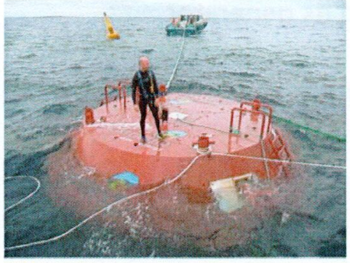
A schematic and image of an ocean-based water stream system

D.3.3. Wave energy systems


Waves are created in the oceans by the sun's heat and wind, and are continuous providing a steady supply of energy. The opportunity to generate electricity is created by difference in height between the wave's crests and troughs. There are three main technologies that harness wave energy: buoyant moored system, hinged contour system, and oscillating water column (OWC) system.

Buoyant moored system works in a buoy moored in a fixed point, in which the motion of the waves moves a magnet inside a coil of wire which generates a current. The system includes the following that we can supply:

- Float
- Anchor
- Linear generator (magnet and coil)
- Enclosure mounted on the float

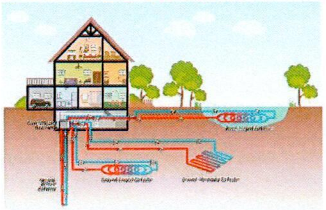


Hinge contour system consists of several floating pontoons, and each two adjacent pontoons are connected through a system of hinges and piston. The hinges are on one of the pontoons and the pistons are on the other pontoon. The system consists of several of these pontoons oriented perpendicular to the direction of waves. The differing heights of waves along the length of the system cause flexing motion at the connection of neighboring pontoons. With the motion of the wave, one of the pistons is in compression and the other is in expansion. The linear motion of the pistons is translated into rotating motion through a hydraulic motor. The motor drives a generator and electricity is generated. The system includes the following which we can supply:

- Pontoon
- Anchor
- Hydraulic motor
- Pistons
- Generator

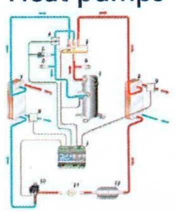
Oscillating water column system consists of a linear generator and a chamber anchored to the sea floor, which allows water to enter and exit from one side at the bottom of the chamber. When waves enter or leave the chamber, they change the air pressure inside the chamber. The air pressure pushes the magnet when the wave is moving toward the crest and pulling it when it moves toward the trough. The system, in essence, is using a column of water as a piston to pump air. The push and pull of the magnet of the linear generator produces electricity.

D.4 Geothermal energy systems



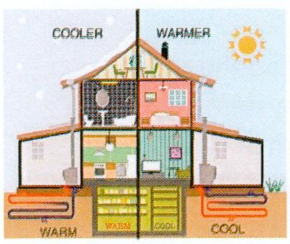
Geothermal energy systems use the difference between the heat in the Earth and its surface to power electricity generation. Geothermal energy in the uppermost 10 km of the Earth's crust is much more than the energy from all oil and gas resources discovered so far.

D.4.1 Heat pumps

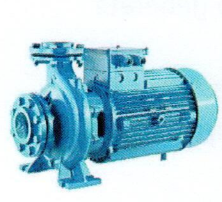


are smaller and domestic units which can use the temperature difference at just a few meters under the Earth's surface, when the soil temperature in winter is about 10°C to 20°C higher than the ambient temperature, and about 10°C to 20°C lower in the summer. At this shallow depth, heat pumps can be used to warm houses in winters and cool them down in the summers. The equipment required which we can supply includes:

- Geothermal exchanger – placed underground



- Pump



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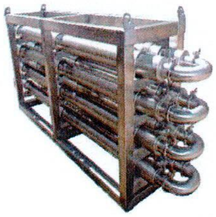
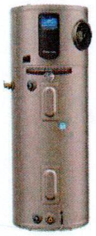
- Heat exchanger

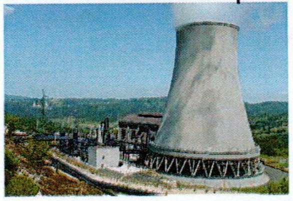


- Hot water tank



- Piping systems for hot and cold water

D.4.2 Geothermal power plants



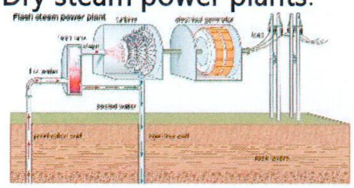
Geothermal electricity can be obtained from drilling 10 to 20 km to tap the much higher temperatures deeper in the Earth's crust. There are two main systems: Geothermal reservoir and hot dry rock, and both systems of geothermal power plant are similar to the conventional thermal power plants in many ways, and they operate in a similar manner.

- **Geothermal reservoir**: The system utilizes trapped hot water under pressure that would otherwise be vented through geysers or hot springs, to generate electricity by thermal turbines.
- **Hot dry rock**: The system extracts the heat trapped in hot dry rocks, by pumping cold water into the hot rock, and then taking back the super-hearted water as steam

Both kinds of geothermal power plant take the extracted steam, which may include hot mist, from a geothermal reservoir underground and pass it through a mist eliminator or heat exchanger. The steam going to the turbines must be free from mist as it would be very damaging to the turbine blades (runners). The dry steam enters a thermal turbine that converts the steam energy into mechanical energy, which is converted by a generator into electrical energy. The steam exiting the turbine is cooled down in a cooling tower where external cold water is poured in to create the heat sink needed to complete the thermal cycle. The water exiting the cooling tower is still hot and can be used to heat buildings, and then injected back into the geothermal reservoir.

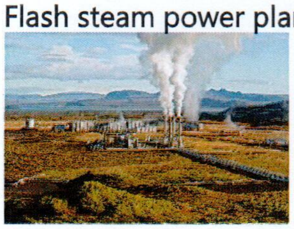
The steam from geothermal sites varies in temperatures and pressure which requires different power plant designs for different steam conditions. Today, we have three basic designs:

Dry steam power plants:



This system is used when the steam temperature is very high (300°C) and the steam is readily available.

Flash steam power plants:

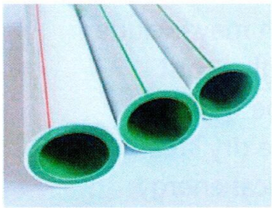


When the steam-hot water mix is above 200°C, it is drawn into an expansion tank that lowers the pressure of the mix. This causes the hot mist to rapidly vaporize (flash) into dry steam. The steam is then used to generate electricity.

Binary-cycle power plants: At moderate-temperature (below 200°C), the energy in the mix is extracted by exchanging its heat with another fluid (called binary) that has a much lower boiling point. The heat from the mix causes the secondary fluid to flash into steam, which is then used to drive the turbines.

The equipment required includes:

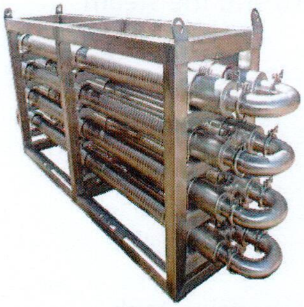
- Cold water injection pipes



- Hot water extraction pipes

- Mist eliminator – for reservoir-types plants

- Heat exchanger



- Turbine – thermal for hot dry rock plants
- Generator
- Cooling tower

D.5 Biomass energy systems

Biomass consists of garbage, agricultural waste, or tree products. The biomass is often just dumped in landfills, which is considered as health and environmental hazard, so the burning of biomass to produce electricity is becoming increasingly popular.

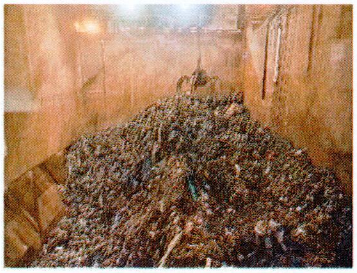
When biomass is burned in incinerators, the biomass volume is reduced by as much as 90%, and in the process, steam can be produced to generate electricity.

The biomass material is fed to a furnace where it is burned and the heat produced is used to generate steam by heating water pipes. The steam is used to generate electricity by a turbine-generator system much like the regular thermal power plant. The steam exiting the turbine is cooled to complete the thermal cycle. The ash produced in the furnace is collected and sent to landfills. The volume of the ash is about 10% of the original volume of the biomass material. The ash generated by the combustion enters the filtering stage where more ash is extracted, collected by trucks, and send to landfills. The process produces gases that are also filtered before they are vented through the stack.

The equipment required includes:

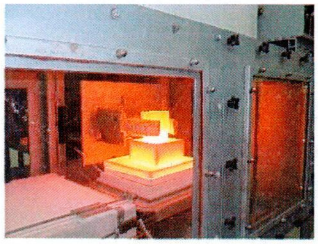
- Garbage and biomass collection

- Garbage and biomass storage



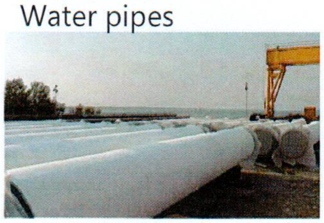
- Handling and transport equipment

- Furnace

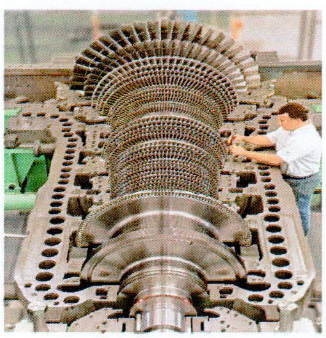


- Furnace burner

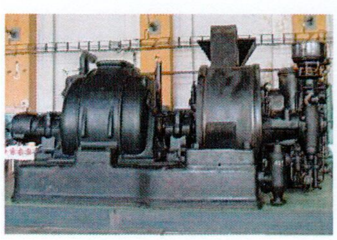
Water pipes



- Turbine



- Generator

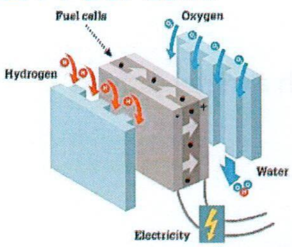


- Condenser

- Heavy ash collection
- Filter for light ash
- Transport for ash – both heavy and light – to the landfill

E. Fuel cells and energy storage systems

E.1 Fuel cells



Fuel cells will eventually dominate the power generation market in transportation, household use and utility size generation. Already in automotive, fuel cells play a significant part in forward thinking, avoiding the elaborate cooling and lubricating systems that are required by the internal combustion engines, and making the car smaller, lighter, more efficient, quieter, and cheaper to maintain.

Fuel cells are widely used as backup systems or independent sources of energy. Sensitive installations like hospitals, satellites, and military installations are using fuel cells as backup systems.

The efficiency of fuel cells alone is relatively high, with a range of between 30% to 80%.

A single fuel cell produces a DC at less than 1.5 V. This is barely enough to power small consumer electronic devices. For higher voltage applications, fuel cells are stacked in series, and the DC requires a converter to convert the DC into AC.

Main Types of Fuel cells and their operating characteristics

Fuel Cell	Electrolyte	Anode Gas	Cathode Gas	Typical Efficiency (%)
Proton exchange membrane (PEM)	Solid polymer membrane	Hydrogen	Pure or atmospheric oxygen	35–60
Alkaline (AFC)	Potassium hydroxide	Hydrogen	Pure oxygen	50–70
Phosphoric acid (PAFC)	Phosphorous	Hydrogen	Atmospheric oxygen	35–50

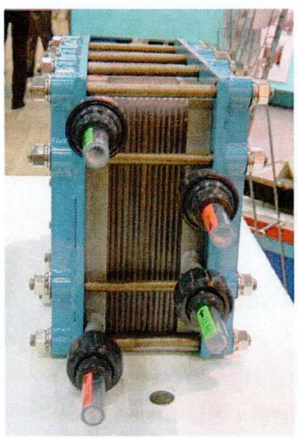
Solid oxide (SOFC) 45–60	Ceramic oxide	Hydrogen, methane	Atmospheric oxygen
Molten carbonate (MCFC) 40–55	Alkali-carbonates	Hydrogen, methane	Atmospheric oxygen
Direct methanol (DMFC) oxygen 35–40	Solid polymer membrane	Methanol solution in water	Atmospheric

The main types of fuel cell that we can supply include the following:

E.1.1 Proton exchange membrane fuel cell

The basic components of the proton exchange membrane fuel cell that we can supply are the following:

- Anode
- Cathode
- Electrolyte, which is a membrane of solid polymer coated with a metal catalyst such as platinum
- Catalyst – such as platinum
- Pressurized hydrogen
- Pressurized oxygen



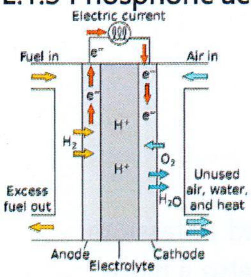
E.1.2 Alkaline fuel cell

The basic components of the Alkaline fuel cell that we can supply are the following:

- Anode
- Cathode
- Electrolyte, which is liquid alkaline solution of potassium hydroxide
- Catalyst – such as platinum
- Pressurized hydrogen
- Pressurized oxygen

- Water and water delivery systems

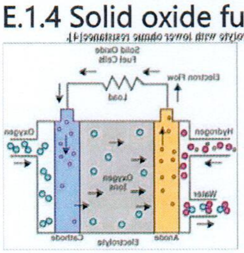
E.1.3 Phosphoric acid fuel cell



Phosphoric acid is the electrolyte medium for the phosphoric acid fuel cell. Its operating temperature is high at between 150°C to 210°C, but it is considered suitable for small and midsize generation, and works with typical efficiency of higher than 40%. The basic components of the phosphoric acid fuel cell that we can supply are the following:

- Anode
- Cathode
- Electrolyte, which is liquid alkaline solution of potassium hydroxide
- Catalyst – such as platinum
- Pressurized hydrogen
- Pressurized oxygen
- Water removal systems

E.1.4 Solid oxide fuel cell

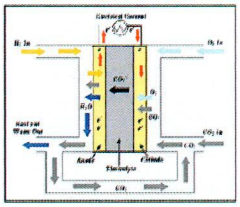


The electrolyte of the solid oxide fuel cell is a hard ceramic material such as zirconium oxide. This type of fuel cell operates at very high temperatures (600°C to 1000°C), which requires a significant time to reach its steady state. Therefore, it is slow at starting and slow at responding to changes in electricity demand. The basic components of the solid oxide fuel cell that we can supply are the following:

- Anode
- Cathode
- Electrolyte, which is liquid alkaline solution of potassium hydroxide
- Catalyst – such as platinum
- Pressurized hydrogen
- Pressurized oxygen

- Water removal systems

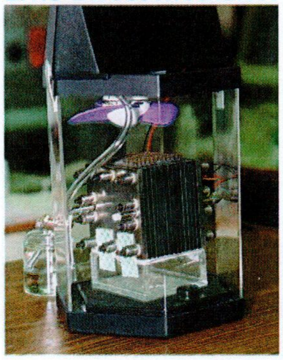
E.1.5 Molten carbonate fuel cell



The electrolyte of the molten carbonate fuel cell is lithium carbonate and potassium carbonate, or lithium carbonate and sodium carbonate. This fuel cell is also a high-temperature type, operating at 600°C to 650°C, and is suitable for large systems in the megawatt range. The basic components of the molten carbonate fuel cell that we can supply are the following:

- Anode
- Cathode
- Electrolyte, which is liquid alkaline solution of potassium hydroxide
- Catalyst – such as platinum
- Pressurized hydrogen
- Pressurized oxygen
- Water removal systems

E.1.6 Direct methanol fuel cell

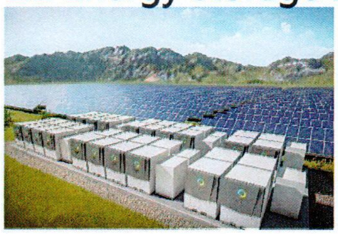


The direct methanol fuel cell is a low temperature cell (50°C to 120°C) that can use methanol directly without the need for a reformer. For these two reasons, it is suitable for consumer electronics applications such as mobile phones, entertainment devices and portable computers as well as electric vehicles. The basic components of the direct methanol fuel cell that we can supply are the following:

- Anode
- Cathode
- Electrolyte, which is liquid alkaline solution of potassium hydroxide
- Catalyst – such as platinum

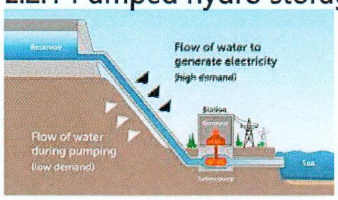
- Pressurized methanol
- Pressurized oxygen
- Water removal systems
- CO_2 removal systems

E.2 Energy storage systems



Batteries are the main option for storage, especially for low power applications without the need for fast charging. But for grid applications, there are several other technologies, such as pumped-hydro, compressed air, batteries, and flywheels.

E.2.1 Pumped hydro storage systems

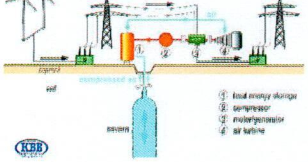


The pumped hydro storage system is one of the most effective energy storage methods. It is a dammed hydroelectric power plant with reversed water flow, which operates by using the generator of the hydro-electric system as a motor during off-peak demand, thus reversing the rotation of the turbine and the flow of water. This way, the electric energy is used to run the motor and water is collected from the river then stored in a lake at higher elevation. By adding more water to the lake, the potential energy of the lake is increased, thus energy is stored.

The equipment that we can supply includes the following:

- **Penstock** - the pipeline that channels water from the reservoir to the turbine.
- **Governor** - the valve that regulates the flow of water in the penstock.
- **Turbine**
- **Generator**
- **Transmission line** connecting the storage system to the grid

E.2.2 Compressed air energy storage



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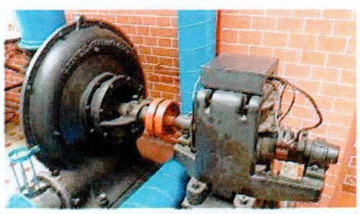
The compressed air energy storage system stores electrical energy by using a motor to compress the air into an underground reservoir such as salt cavern, abandoned hard rock mine, aquifer or pressure tank. When the stored energy is needed, the compressed air is released and heated in the recuperate then fuel is added (normally natural gas) to the hot air. The mix is ignited in a gas turbine (combustion turbine) that rotates the generator.

The equipment that we can supply includes the following:

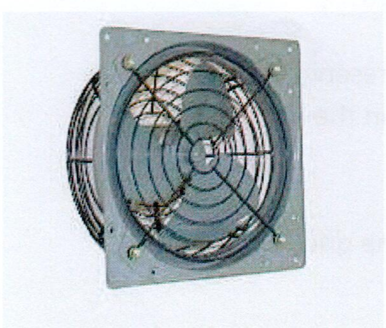
- **Motor** to drive compressor

- **Compressor** to force air into the reservoir

- **Recuperator** to heat the compressed air



- **Exhaust fan**



- **Gas** tank and supply

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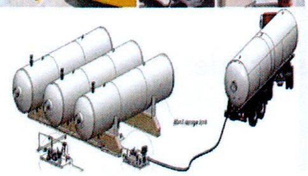
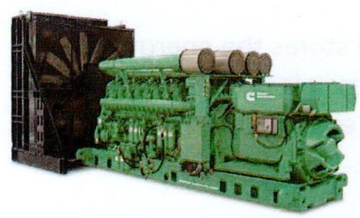
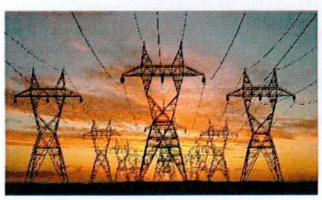


- **Turbine**

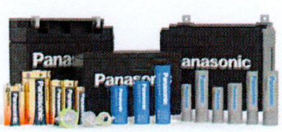
- **Generator**



- **Transmission line** connecting the storage system to the grid



E.2.3 Batteries



Batteries have yet to deliver in the two main applications that they are needed: electric vehicles and power grid. To succeed they in high power applications, they must have several key features:

- High energy densities
- Slow loss of charge
- Cost effective
- High charge/discharge efficiency

- Long cycle life
- No memory effect
- Safe to operate

Some battery types that are already in in high power applications include:

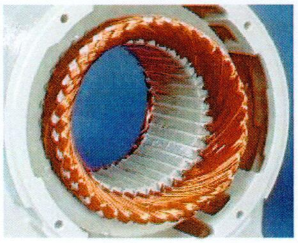
- sodium sulfur
- lithium ion
- vanadium redox flow

E.2.4 Flywheels

In order to store energy, the fly wheel operates as a motor and stores the energy in its rotating mass in the form of kinetic energy. When the energy is needed, the machine operates as a generator converting the stored kinetic energy into electrical energy.

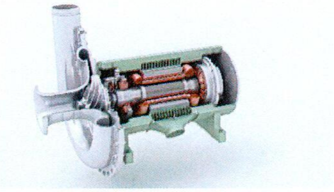
To be effective, the fly wheel need to be a high speed machine, with large inertia, and minimum energy loss. When the fly wheel is rotating, wind age and friction can consume the stored kinetic energy over a period of time, so the flywheel is often placed in a vacuum container, and magnetic bearings are used to essentially float the rotor. Flywheels with magnetic bearings can achieve over 90% efficiency. The equipment that we can supply includes the following:

- Stator winding

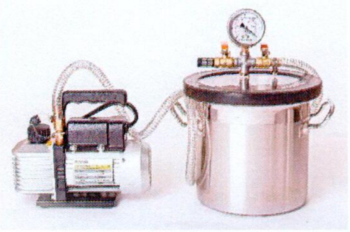


- Rotor – high intertie

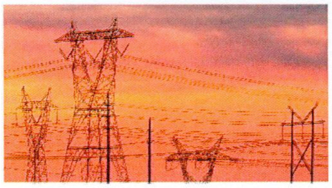
- Magnetic bearings



- Vacuum chamber



- Transmission line connecting the storage system to the grid



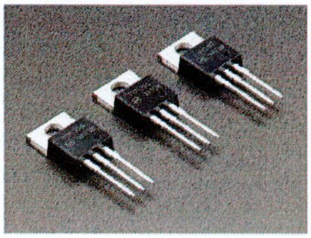
F. Power electronics

Any electrical power grid must operate at constant voltage and fixed frequency so that all the generators are synchronized and that the entire system is stable. Because of this limitation, all electrical devices and equipment were designed to operate at the voltage and frequency of the utility's feeders. Accordingly, they were limited in performance, heavy in weight, and inefficient in operation.
But with the development of power electronic devices and circuits, the newer apparatuses and equipment have electronic converters that allow users to change the voltage and frequency applied to the equipment to achieve better performance and higher efficiencies. These includes items like washing machines that allow the user to change the speed and torque of the washing cycles by adjusting the voltage and frequency of its electric motor, new air conditioning systems that operate

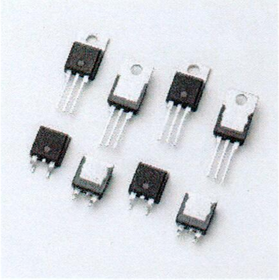
continuously at variable speeds to maximize their efficiencies and to maintain the environment to the users' settings with minimum deviations.
Power electronic devices are in two categories: single component and hybrid component.
The single components include:

- two-layer devices such as the **diodes**

- three-layer devices such as the **transistors**



- four-layer devices such as the **thyristors**



Hybrid components include many devices including:

- insulated gate bipolar **transistor**
- static induction **transistor**
- Darlington **transistor** (DT)

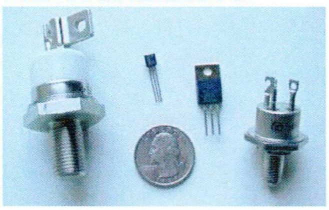
Solid-state devices are the main building components of any converter. Their function is mainly to mimic the mechanical switches by connecting and disconnecting electric loads, but at very high speeds.

F.1 Diodes

The diode, which is the simplest power electronic device, allows the current to flow only in one direction. It is built of two types of semiconductor material, p-type and n-type, placed in contact with each other, and the p-junction is the anode of the device and the n-junction is the cathode.

Diodes ranging from 6v to 5kv

F.2 Transistors



In power electronic applications, transistors are mainly used as high-frequency electronic controlled switches. Two main types of transistors are commonly used:

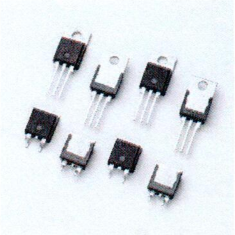
Bipolar junction transistor:

which consists of three layers of semiconductor material in n-p-n or p-n-p arrangements. The n-p-n arrangement is more common in power electronic applications. The middle layer of the transistor is thin compared to the other two layers.

bipolar power transistors of various sizes

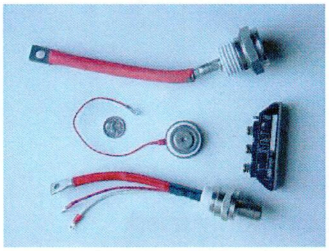
Field effect transistor: The metal oxide semiconductor field effect transistor (MOSFET) is a voltage-controlled device, giving it a great advantage over the bipolar junction transistor as the MOSFET is a more efficient device that requires a simpler driving circuit. The MOSFET is widely used in digital circuits as well as high-power electronic circuits.

F.3 Thyristors



Thyristors are widely used in high-power applications as they can handle thousands of amperes and can be cascaded to withstand hundreds of kilovolts. Thyristors include several devices such as the

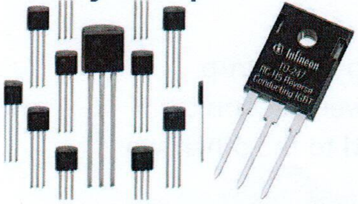
- Silicon controlled rectifier (SCR)
- Bidirectional switch (Triac)
- Gate turn-off (GTO) SCR



High-power silicon controlled rectifiers

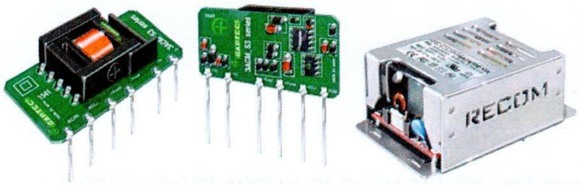
- Silicon Diode for Alternating Current which is a silicon bilateral-voltage-triggered switch used mainly in low-power control circuits.

F.4 Hybrid power electronic devices



Various hybrid devices composed of several components such as BJT and MOSFET, SCR and FET, and cascaded BJTs, offer desirable features such as higher switching speeds, higher currents, higher current gains, or higher efficiencies. The hybrid device research is fast growing and newer designs are continuously developed. Two often-used examples of hybrid devices are the **Darlington Transistor** which cascades two bipolar transistors in order to overcome the problem of the BJT's low current gain in the saturation region; and the **Insulated Gate Bipolar Transistor** which is a high-current voltage triggered device.

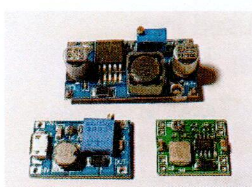
F.5 Convertors (solid-state switching circuits)



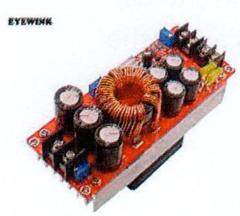
Solid-state switching circuits are often called converters, and they have various configurations. There are four types of converters:

- **AC/DC converter** which converts any ac waveform into a dc waveform with adjustable voltage.

  These are very common converters used to drive DC equipment from AC sources such as power supplies and chargers. There are three main types of AC/DC converters: fixed voltage, variable voltage, and fixed current. These include
  - rectifier circuits
  - voltage-controlled circuits
  - constant-current circuits
  - three-phase circuits
- **DC/DC converter** which converts a DC waveform into adjustable DC voltage. The three main types of DC/DC converters are
  - **Buck converter**: This is a step-down converter where the output voltage is less than the input voltage.



  - **Boost converter**: This is a step-up converter where the output voltage is higher than the input voltage.



  - **Buck–boost converter**: This is a step-down/step-up converter where the output voltage can be made either lower or higher than the input voltage.

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- **DC/AC converter** is also known as an inverter, and is used in applications such as uninterruptible power supplies, variable speed drives, and DC transmission lines. The DC/AC convertor converts a DC waveform into AC with adjustable voltage and frequency. There are two type
  - single phase
  - three phase
  - pulse width modulation
- **AC/AC convertor** consists of two SCRs connected in parallel in the back-to-back configuration, which converts the fixed voltage, fixed frequency waveform into waveforms with adjustable voltage and frequency.

G. Electric motors

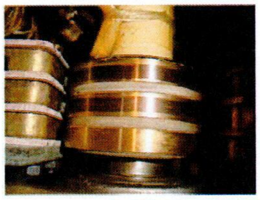
Electrical motors are electromechanical converters, which convert electrical energy into mechanical energy. Electric motors play an important part in anyone's daily life. **Household devices** that use motors include refrigerators, washers, dryers, stoves, air conditioners, hair dryers, computers, printers, clocks, electric toothbrushes, electric shavers, and fans. In the **industrial and commercial** sectors, motors are used in numerous applications such as transportation vehicles, elevators, forklifts, blowers, robots, actuators, electric and hybrid cars, machine tooling, paper mills, cooking machines, medical tools, assembly lines, and conveyor belts. The **computer hard disk**, for example, has at least two motors and the computer printer has at least four motors.

We can supply a wide range of electrical motors, such as:

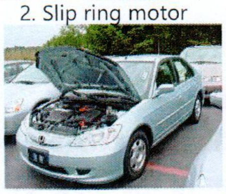
- **Rotating magnetic field motor**, which is a multiphase alternating current (ac) source produces a rotating magnetic field inside ac motors, which causes the shaft of the motor to spin.

Main parts of induction motor: 1. stator

- **Rotating induction motor**, for which there is a large demand as more than 90% of the energy consumed by electric motors is consumed by induction motors, because they are rugged, reliable, easy to maintain, and relatively inexpensive. The induction motor is composed of one stator and one rotor.



2. Slip ring motor



Induction motors are used in these vehicles

- **Linear induction motor**, which are effective drive mechanisms for transportation and actuation systems. High-power linear induction motors are used in rapid transportations, baggage handling systems, conveyors, crane drives, theme park rides, and flexible manufacturing systems. Low-power ones are used in robotics, gate controls, guided trajectories (e.g., aluminum can propulsion), and stage and curtain movements. Linear induction motors are similar to the rotating induction motor except that the linear induction motor has a flat structure instead of the cylindrical structure of the rotating motor.

Linear induction motors are used in this Maglev rapid transportation

- **Wheeled linear induction motors**

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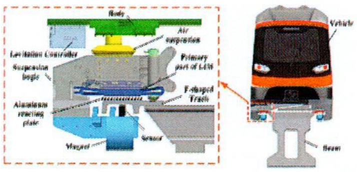
are used to propel vehicles like a train, where the rotor is the track of the train, and the stator is the train's engine. In these wheeled linear induction motors, the separation between the rotor and stator is maintained by the wheels of the train, whereas in rotating motors, the separation is maintained by the ball bearings of the rotor's shaft.

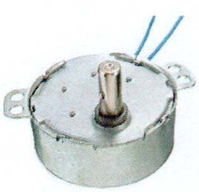
- **Magnetically levitated induction motors**



- (Maglev) allow the vehicle to magnetically levitate with virtually no friction between the bogie of the vehicle (undercarriage) and the track. The technology is based on having magnetic poles on the track that are similar to the magnetic poles on the bogie of the vehicle (both are North or South). These poles repel each other and the bogie then levitates. Hence, a Maglev train can achieve very high speeds and very smooth rides because the vehicle essentially flies.

  There are two types of Maglev systems: **levitation** and **propulsion**. In both systems, magnetic force is developed along the track to repel the bogie of the vehicle. One way is to install magnetic coils along the track, and another is to induce voltage in the coils of the track by the vehicle itself.

- **Synchronous motor**

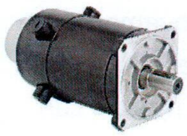


- is a dual action device: it can be used as a generator or motor. As a motor, the synchronous machine is very popular in applications that demand constant and precise speeds such as electric clocks, movie cameras, tractions, uniform actuations, gate and governor controls, constant feed industrial processes, and many others. Besides driving mechanical loads, the synchronous motor is also used to compensate for the reactive power of industrial loads.

  For **small** size synchronous motors, the rotor is often made of ferrite permanent magnet material.

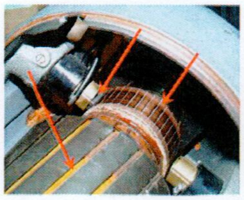
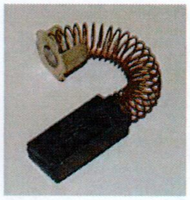
For **large** synchronous motors, the rotor is made of an electric magnet that is excited externally by a separate dc source. This is exactly the same rotor used for the synchronous generator.

- **Direct current motors**



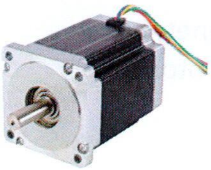
- are one of the oldest electrical devices. The DC machine can operate as a motor or a generator without any change in its design. However, it is rarely used nowadays as a DC generator because of the wide use of power electronic converters.

The DC motor consists of a stator (called field) and a rotor (called armature). The stator is either a permanent magnet or an electric magnet. The winding of this electric magnet is excited by a DC source. Thus, the magnetic field is unidirectional from the north pole to the south pole.
The rotor of the DC motor consists of independent coils in a cascade. The terminals of each coil are connected to two copper strips (segments) mounted on the rotor shaft on opposite sides. The copper segments of all coils form what is called commutator. The commutator rotates with the shaft. On the stator, two brushes are mounted on opposite sides of the commutator touching the terminals of one coil. The brush system consists of a spring and a carbon piece called brush. The spring pushes the brush against the commutator to ensue connectivity with a coil. Because the position of the brush is fixed on the stator and the commutator is rotating, the carbon brushes make contact with the coil that moves under the two brushes.

DC motor: Stator windings   Rotor   Carbon brush

- **Stepper motors**

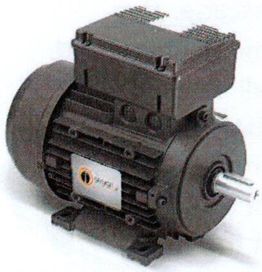


- are an excellent option for position control devices because they can control the position of the rotor and can hold the motor at this position for as long as needed. These features are essential in applications that need fine movements such as hard disk drives, printers, plotters, scanners, fax machines, medical equipment laser guiding systems, robots, and actuators. The stepper motors can achieve fine position control with a step resolution of one degree.

  Stepper motors come in three basic types:
  - Variable reluctance motor
  - Permanent magnet motor
  - Hybrid motor

  The stator of these three types is similar to that of the induction or synchronous motor.

- **Single-phase motors**

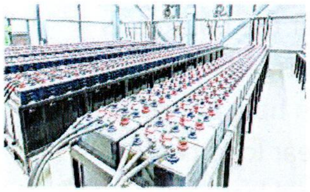


- are used in low-power applications, such as household and office equipment because the outlets in these places are only single-phase systems. Single-phase motors include:
  - Split-phase motors
  - Capacitor starting motors
  - Shaded-pole motors

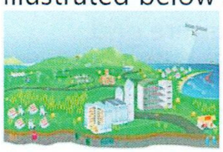
H. Future power systems

Technology and monitoring of power and its transmission and use is changing very fast. The power systems of the future will be very different from todays but the following are some technologies that will be important:

H.1 Smart Grid



The smart grid is a vision for future distribution networks that utilize new and different technologies to allow for the integration of renewable energy systems and distributed generation systems into the distribution network. One such vision is illustrated below in the image:



This smart grid of the future shows renewable energy systems (hydro-power in the lake beyond the hills, solar in the hills, wind farms in the sea, and wave generator in the sea) connected directly into the distribution network which uses a HVDC link. Renewable resources such as hydrogen have their own infrastructure to power loads and fuel cell vehicles. This requires safe and efficient storage systems for the hydrogen as well as underground pipe systems between the houses and office blocks, to transmit the gas. When the demand for electrical energy is low, renewable resources can be used to generate hydrogen through electrolysis processes. Surplus electric energy can be stored in super capacitors (at the bottom left of the picture) for long periods with minimum losses. In addition, thermal storage can be used to directly heat buildings. Customers have their equipment controlled by the utility where at peak demands, the unessential loads are disconnected, which allows both the customers to pay less, and the utility to manage its resources much better. To optimize the operation of the smart grid, local and network information is collected and transmitted to a central control system where sophisticated algorithms operate the network efficiently and reliably at all times.

H.1.1 Smart grid objectives:

- **Improve accessibility** by granting access to all customers and allow bidirectional power flow to renewable resources.
- **Increase system flexibility** by implementing technologies that respond to customers' needs while responding to changes and challenges in the grid.
- **Enhance system reliability** by assuring the energy supplies and enhance system security.
- **Reduce cost of energy** by providing the best values to the customers through innovation and efficient energy management.

H.1.2 Smart grid benefits:

- **Reduction in transmission congestion**: When renewable generation is located near load centers, the generated power can be consumed locally instead of hauling it from large power plants through transmission lines. This reduces the currents in the transmission lines, thus allowing for extra customers to be connected to the existing line instead of constructing new ones.

- **Reduced blackouts and forced outages**: The main cause for the outages is when the demand and generation are not equal, either because of inadequate generation or the lack of available transmission lines that can haul power to the customers. If more renewable generations are present near load centers, there is less dependency on generation from large utilities and less dependency on transmission lines.
- **Self-diagnosis**: Improvements in the capabilities of monitoring devices and their data communications as well as their data security will allow the controllers to monitor the power system with data that covers the entire grid. Algorithms will be able to better monitor the power grid and predict problems ahead of time, and when problems occur, the system can quickly identify the source and location of the problems.
- **Self-healing**: With better monitoring systems and with more automation in power grids, it is possible for the grid to automatically reconfigure its network to restore power quickly.
- **Reduction in restoration time**: With self-healing, the grid can restore itself automatically instead of manual restoration.
- **Peak demand shaving:** Utilities purchase energy during peak times from other utilities. The cost of this energy is part of the rate structure of customers' bills. If technologies are developed to allow for customers to reduce their demands during these times without inconveniencing them, this can potentially save costs to utilities and customers.
- **Increased system capacity**: When generation resources and transmission lines are less used, the capacity of the grid increases. Thus, more customers and more demands can be added without elaborate expansion of the infrastructure.
- **Increased power system security**: With local generation and less dependency on transmission infrastructure, the system security is improved. The loss of a transmission line feeding an area with local generation will have lesser impact than the case without local generation.
- **Hybrid and electric vehicles**: If electric vehicle penetration is high enough, it could cause a stability problem as a large number of vehicles could be plugged into the power grid after people arrive from work between 5 and 7 pm. This is because the load could rapidly increase beyond system limits. Adjustable charging techniques can address this problem.

H.1.3 Smart grid technologies:

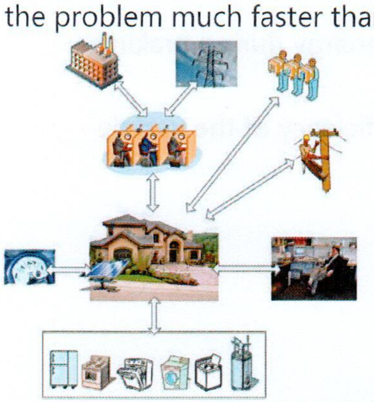
- **Energy storage**: This is the most important and the hardest goal to achieve. Large-scale energy storage has several advantages; the two key ones are the following:
    - Reduces system instability: Instability occurs when the generation does not meet the demands. With storage, the energy can come from the storage equipment until the grid normal operation is restored.
    - Some renewable energy systems, such as wind, can generate large amounts of electricity during off-peak times. In some Scandinavian countries with high wind penetration, the wind energy produced at night could be higher than the demand. With energy storage, this energy can be stored and used during high-demand periods.
- **Advanced meters and sensors:**

- This technology is needed at all levels. At the customer level where meters can measure net energy, monitor house activities to identify problems within the service area, and perform self-diagnosis and self-healing functions. At the grid level, newer sensing technology allows operators to have a better understanding of the grid status and operation. With the aid of intelligent algorithms, the system can be better controlled.
- **Grid-friendly plug-in hybrids**: If hybrid vehicles penetrate the market in a big way and are plugged into the grid within a short time, the grid could collapse. However, if the charging of the vehicle is controlled, the problem can be avoided. This requires a charging system that responds to grid conditions as well as price signals.

- **Grid-friendly loads**: Loads can participate in lessening the problems the utilities face during peak times and during disturbance. If some loads within the house can be curtailed without inconveniencing customers, it can have a major impact on the reliability of the grid.
- **Substation and distribution automation**: Until today, we still have a large number of control and protection devices operating manually. Disconnect switches and fuses are two examples. If these and other devices are replaced by automatically operating and controlling devices, the reliability of the grid can increase tremendously.
- **Communications**: With more automation, the communication needs are very high. Standardized systems and protocols are needed to allow equipment to have plug and play capability, enhancing communication security and ensuring consumers' privacy.
- **Data-intensive analysis**: Intensive data is hard to process, and its clues are hard to siphon. Algorithms and programs are needed to process the immense data and provide the user with the needed information on-demand and quickly.
- **Visualization and human interface**: Technologies are needed to visualize the immense data being collected by the control centers of the grid. Raw numbers are proved to have little value. Using visualization and virtual reality technologies can make the data more understandable.
- **Renewable energy integration**: To effectively integrate renewable energy resources, several technologies are needed.
    - **Weather prediction** is among the most important technologies. Two types of weather forecast are used: synoptic scale and mesoscale forecast. Synoptic scale (large-scale) meteorology is relatively accurate. It predicts air masses, fronts, and pressure systems. Mesoscale (local-scale) meteorology includes the effects of topography, bodies of water, urban heat island on wind speed. The mesoscale forecast is what is needed for renewable systems. Unfortunately, it is still less accurate for the reliable integration of renewable systems.
    - **Control**: Renewable energy is still not controlled by grid control centers in most parts of the world. Any control of these facilities is often done locally. If their penetration into a power grid is high, they must be part of the grid control center to ensure the reliability of the grid.

H.2 Smart house

In a 'smart house' the owner has access to a wide range of information, including all attractive energy contracts and their restrictions. The owner decides on his or her best option and gets the individual costs for his energy.
In a smart house, it is possible to regulate the energy consumption of the dwelling. In any house, there are appliances that consume large amounts of energy such as water heaters, stoves, refrigerators, washers, dryers, and air conditioners. During the time when the utility is short of energy, the house can reduce its consumption by either slowing down the process or turning off the appliances for a few minutes. If this is done on a large scale, the demand in a wide area can relieve the utility from using expensive load-following or load-regulation processes.
Furthermore, the smart house can communicate with vendors to select new products or services that increase efficiency. The smart house can also communicate directly with the maintenance department of the serving utility to inform them about any outage or disruption of service. The maintenance crew may even be able to remotely fix the problem or send the maintenance personnel to the exact location, thus fixing the problem much faster than is currently possible.

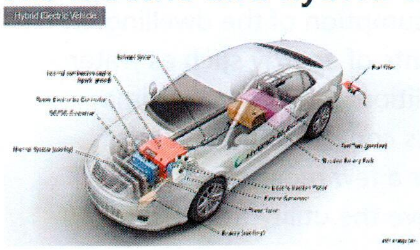


A concept of a smart house, which connects the generation utility and transmission utilities and vendors, through aggregators when necessary, along with the service departments, to the smart house, where a smart meter monitors consumption and the owner is plugged in real-time, so that he can manage his domestic devices has he sees best.

Good information systems allow the system to continuously monitor the operational status of its own components, identify areas of difficulty, and then find and implement solutions automatically. Power grids often experience problems with no prior warning, partly due to the lack of adequate smart-monitoring devices throughout the system as well as the limitation of existing communication networks and data processing systems.
Any manual methods managed by the power utility's personnel may require someone to physically drive around the system and inspect the various components, which leads to long restoration times. To prevent any failures, utility personnel have to check the health status of every device by inspecting them periodically. However,

if key variables such as temperature, winding insulations, carbon concentration, and vibrations are monitored, potential failures can be predicted.

H.3 Electric and hybrid electric vehicles



Electric vehicles have improved rapidly in recent years

- Battery technology has improved, allowing longer ranges and higher capacities
- High-efficiency motors have been designed
- Lighter material has been used to reduce the weight and energy consumption of the vehicles
- Recovery systems have been implemented to capture energy during braking or slowing down
- Smart controls have been developed to increase the efficiency of the vehicle during the various speed ranges

H.3.1 Electric vehicle

The main components of an **electric vehicle** are

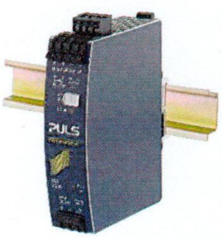
- Charger

- AC/DC convertor

- Traction batteries

- HV DC bus

- DC/DC convertor



- Main contractor

- Electric drive system

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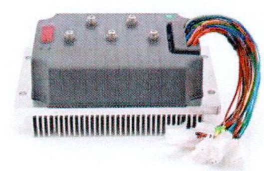
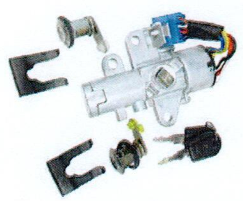
- Controller

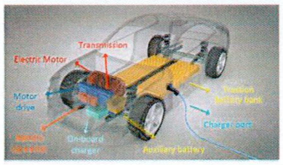


- 12v battery

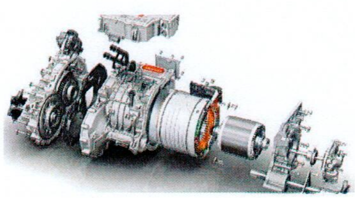
- Ignition switch



- Auxiliary system



- Electric motor



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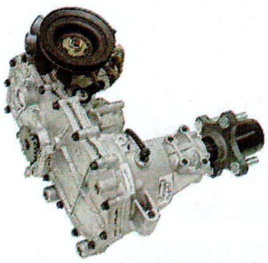
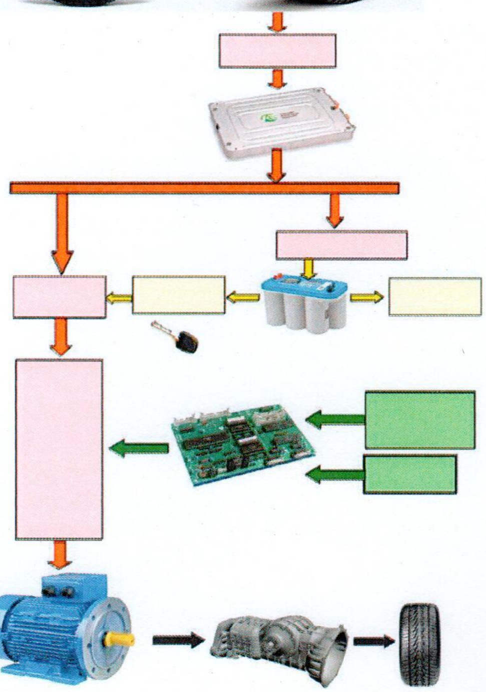
- Transaxle



- Wheels



H.3.2. Hybrid electric vehicle

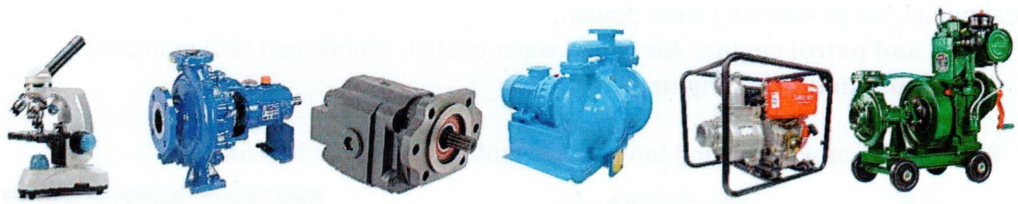
Modern batteries use better technology, but they are still limited in capacity of batteries, which led to the development of hybrid electric vehicles, which have an electric motor as well as an internal combustion engine. The vehicle switches between the two engines to achieve maximum efficiency and range. For example, during the stop-and-go traffic or during low speeds, the efficiency of the internal combustion engine is very low, so the driver uses the electric motor to drive the vehicle. For highway driving, the efficiency of the internal combustion engine is relatively high, so the electric motor is turned off and the internal combustion engine drives the vehicle to increase its range.

The main components of a **hybrid electric vehicle** are

- Charger
- AC/DC convertor
- Traction batteries
- HV DC bus
- DC/DC convertor
- Main contractor
- Electric drive system
- Controller
- 12v battery
- Ignition switch
- Auxiliary system
- Electric motor
- Transaxle
- Wheels
- Combustion engine

I Common supplies of equipment

I.1 Pumps



We have a very wide range of vertical, horizontal, or deep well pumps, which can be multistage and single stage, which we supply along with diesel engine or electrical motor high and low voltage operated by air or solar. The pumps come mobile or skid-mounted with sound proof shelter:

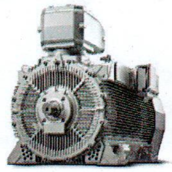
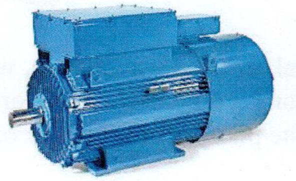
- centrifugal
- reciprocating
- self-priming
- submersible for sewage and clear water and deep well
- booster
- dosing
- metering
- radial, axial, and mixed flow
- adductor-jet
- gravity
- valve-less
- vacuum
- gear
- piston

Our range of activities covers the following industries: cement, metallic and non-metallic minerals, water (drilling and treatment), oil and gas, chemical and petrochemical, fertilizer (with a special pump for urea and phosphoric acid), power production and distribution, food processing and packaging.
The material of the pumps that we supply cover all the customers' activities, so we can supply pumps of stainless steel, carbon steel, PVC, rubber lined; and coated with rubber, Teflon or PVC.
Sizes start from half an inch up to one meter, and larger on occasion if the customer requires different capacities.
Our pumps operate in all conditions. For cold areas we offer steam jackets with different insulation, and other pumps that work in very hot temperatures.
Every industry and each specific purpose requires variations in the pumps, with different materials for the pumps' impeller, casing and shift.

I.2 Engine and motor
Pumps are driven by diesel or petrol engine, electrical AC or DC motor, or air. Increasingly electrical pumps are powered by solar power.

- **Diesel and patrol engine:** Air or and water cooled. Mobile and skid mounted.
  Picture of pump with engine

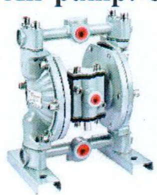
- **Electrical motor:** High and low voltage motor. Vertical or horizontal.

- **Solar panel:** Pump driven by solar power with different capacities

<u>Picture of pump with solar panel</u>

- **Air pump:** Compressors and all accessories




<u>I.1.2 Spare parts for pump</u>
All our pumps are supplied with full spare parts and maintenance
<u>Mechanical seal</u>



- Rubber mechanical seal
- Teflon mechanical seal
- Anti-acid mechanical seal
- Thermal mechanical seal
- Double side mechanical seal

Gland packing
- Teflon
- Graphite

Impeller
Open and closed type

Shaft

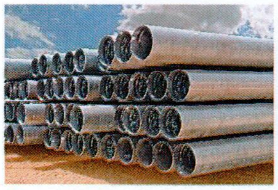
- Carbon steel
- Stainless steel
- Alloy steel
- Copper

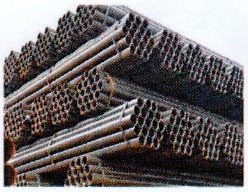
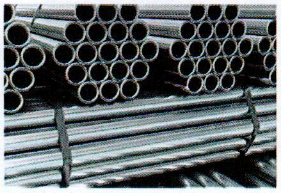
Coupling and belt



- Mechanical
- Hydraulic
- V-Belt
- Driven belt between motor, engine and pump

I.2 Pipes, clamps, pigs, hoses and nozzles



Our dedicated years' experience of supplying pipes to a wide range of industries have given us the knowledge to understand our customers' needs. We have worked in the following industries: cement, metallic and non-metallic minerals (mining and processing), water (drilling and treatment), oil and gas, chemical and petrochemical, fertilizer, power production and distribution, food processing and packaging.
We supply a wide range of pipes including

- seamless
- ERW
- SSW
- alloy steel
- casing pipe for water and oil wells
- screens for water well
- cold drawn
- cold work

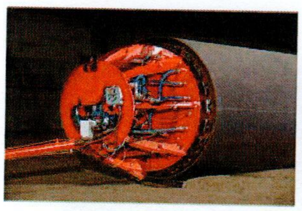
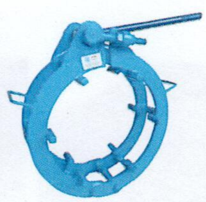
- galvanized pipe
- ductile pipe
- cement pipe
- precast concrete
- reinforced concrete
- GRP
- PVC lined corrosion-resistant reinforced
- pipes for pile support in bridge construction and underwater

We also handle all kinds of

- tubes – all kinds for boiler and heat exchangers
- pipes - for water networks
- pipes - for all kinds of domestic and commercial use.

According to the industry requirements, the pipes are manufactured in different materials including carbon steel, stainless steel, galvanized steel, brass, aluminum, alloy, copper, ductile iron, as well as pipes coated with rubber, Teflon, and PVC.
The pipes are either threaded or beveled with coupling.
The sizes range from 1 inch all the way up to 56 inches.

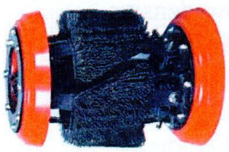
I.3 Clamps

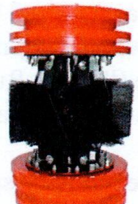



We have many years' experience in supplying pipes to government entities and private sector companies, which has given us ample opportunity to supply both internal and external clamps to pipeline contractors.

- Hydraulic Internal clamp
- External clamp

I.4 Pigs






We supply all kinds pigs including steel and foam, which are used for drying, cleaning, batching, and product removal operations, in industries including cement, metallic and non-metallic minerals, oil and gas, municipality, food and beverage, mining, chemical and petrochemical, cosmetic and pharmaceutical industries.

The sizes of the steel and foam pigs range from one inch to 60 inches.

Foam pigs are able to negotiate uncommon piping, fittings and valves, with industry standard densities of foam ranging from 2, 5, 8-pound per cubic foot. Configurations include bare, criss-cross, wire brush, plastic bristle, and silicon carbide with various design option such as double dish, double nose, special coating patterns (single-spiral, turning pattern, totally coated, etc.). These all come in various lengths and diameters, with pulling /handling ropes or cables, bypass jets, and transmitter cavities. Special configurations can be designed for unique pigging applications.

We supply the following types of pig:

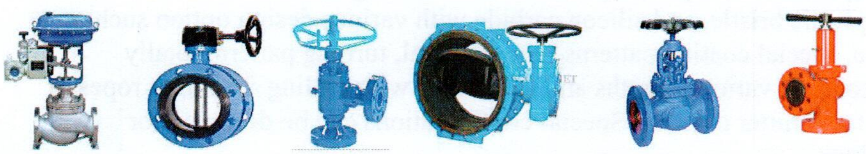
- Bare foam
- Coated foam
- Plastic bristle foam
- Silicon carbide foam
- Special design foam
- Foam wiping
- Brush foam
- Foam spheres

I.5 Hoses and Nozzles




We supply a wide range of hoses and nozzles as required by the industries listed above, and their many different functions and pressures, with different materials such as Low-density polyethylene (LDPE), Polytetrafluoroethylene (PTFE), Rubber reinforced by stainless steel, and hoses coated with corrosion and acid resistant material according to the customer's needs.
In addition, our staff can visit sites and prepare industry-specific hoses to fit and connect according the sites' requirements.

I.3 Valves

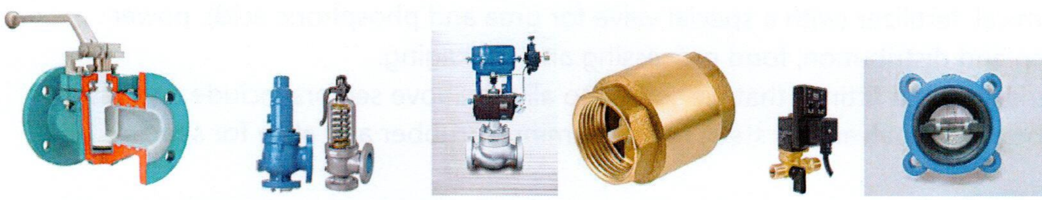


Our distinguished experience in supplying what is compatible with the requirements of customers and for many years in supplying valves to the following industries:

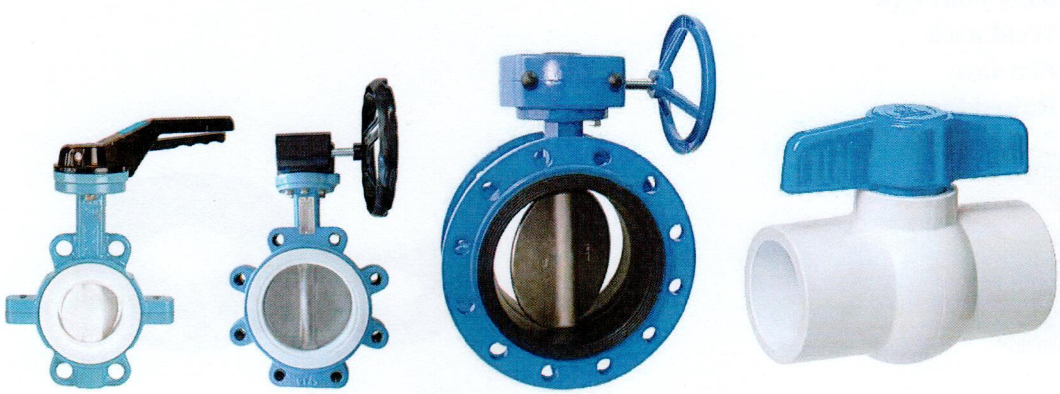
1- Special valves in industries (cement, metallic and non-metallic minerals, oil and gas, chemical and petrochemical industries, fertilizers industry (with valves for urea and phosphoric acid), water valves (drilling and processing) and food industries,
2- It is the type of flange, threaded or welded.
3- They include valves that are operated manually, by an electric motor, or hydraulic or pneumatically.
4- Which are made of stainless steel, carbon steel, galvanized steel, copper, aluminum, copper, alloys, and some valves lined with rubber or coated with rubber, Teflon or PVC.
5- And with sizes from 1 inch to 56 inch.
6- The pressure is from 150 pounds to 6000 pounds per square inch.
7- We have a mobile workshop for valve maintenance, hydrostatic testing, safety valve calibration and control which's include:

1) **Ball** (floating, trunnion ball, full weld body, top entry, side entry)
2) **Check valve** (wafer type, dual plate, swing, tilting, renewable seat)
3) **Butterfly valve** (flexible wedge and solid wedge)
4) **Gate valve** (lubricate, non-lubricated and taper)
5) **Choke valve**
6) **Solenoid valve**
7) **Globe valve**

8) **Plug valve**
9) **Safety valve**
10) **Control valve**
11) **Non-return valve**
12) **Moisture drain valve**
13) **Rubber coated valve**



14) **Teflon coated valve**
15) **Rubber lined valve**
16) **PVC valve**

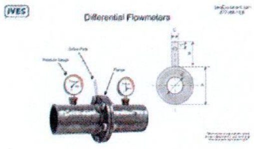


I.4 Fitting, Joints, Fastening and Sealing:

We supply flanges, tee, elbow, cross, cap, plug, nipple, unions, spacer, reducer, socket, gaskets, bolts and nuts, O-ring, rod as well as adhesive and different sealing tags including electronic tags.
We cover the following industries: cement, metallic and non-metallic minerals (mining and processing), water (drilling and treatment), oil and gas, chemical and petrochemical, fertilizer (with a special valve for urea and phosphoric acid), power production and distribution, food processing and packaging.
The materials for the fittings that we supply to all the above sectors include stainless steel, carbon steel, galvanized steel, brass, aluminum, rubber and alloy for special use.
The size varies from 1 inch to 56 inch according to requirements.
The rate flow varies from 150 psi up to 6000 psi.

1) **Flange:**
2) **Ring joint type**
3) **Weld neck**
4) **Flat face**
5) **Raised face**

6) **Orifice**
7) **Tee**
8) **Elbow**
9) **Cross**
10) **Cap**
11) **Plug Nipple**



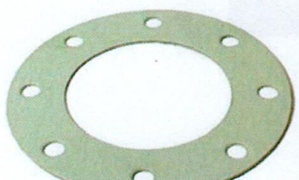


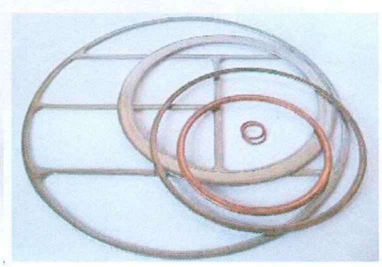



12) **Unions**
13) **Spacer**
14) **Reducer**
15) **Socket**



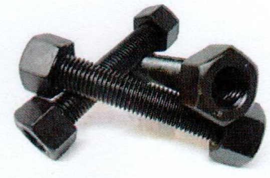

16) **Gaskets**
17) **Spiral wound**
18) **Double metal jacket**





19) **Bolts and nuts**
20) **Bolts**
21) **Stud bolts**
22) **Nuts**
23) **O-ring**
24) **Rod – threaded and non-threaded**





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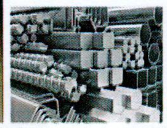
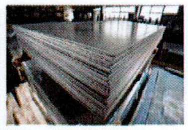
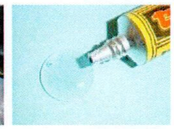
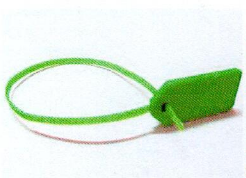
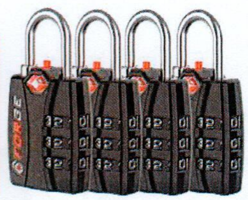
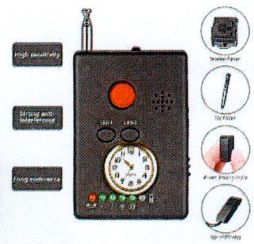
25) **Steel**
26) **Rod – threaded and non-threaded**
27) **Teflon**
28) **Metal**
29) **Metal (carbon steel, stainless steel, alloy and copper)**
30) **Adhesive**



31) **Sealing tag**
32) **E- lock standard**
33) **Alert lock**
34) **GPS Detector**



Regards!

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