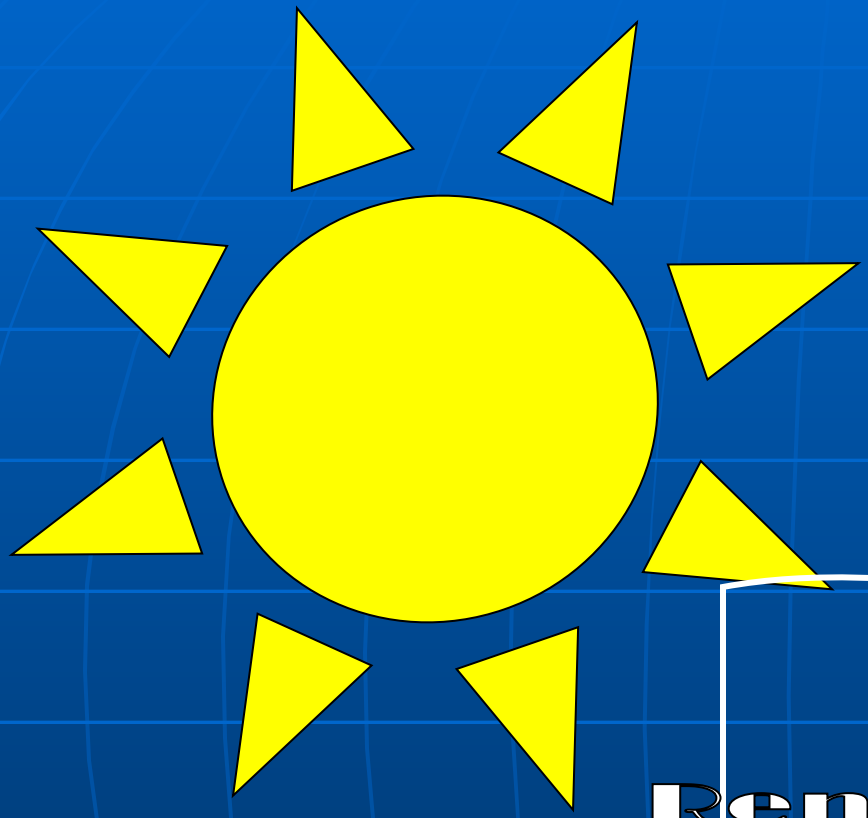

Renewable Energy So

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What renewables are

- These are resources found in nature that are self-regenerating:

- These sources are normally used to produce **clean** (or **green**) energy. This production does not lead to climate change and does not involve emission of pollutants.
- A related term is **sustainable** energy: this concept refers to generating energy with an awareness of the future, i.e. in a way that would enable future generations to meet their energy needs too. The concept is related not only to renewables, but also to **energy efficiency**.

Renewable energy is growing in importance and popularity:

- because of the desire and necessity to avert irreversible climate damage;
- because of increasing oil prices;
- because of the unreliability of non-renewable resources (e.g. the depletion of oil wells).
- In view of all these and other factors, governments worldwide support renewables with various incentives.
- This, in turn, encourages entrepreneurs to make large-scale investments in renewable energy.

Main types of renewable energy

- Solar energy
- Wind energy
- Hydropower (water power)
- Biofuels
- Geothermal energy

There are many sources of renewable energy, but all of them, except geothermal energy, are more or less directly related to the sun: the main source of clean and sustainable energy for the earth.

Solar energy

Apart from the everyday applications of solar energy, such as room lighting, it is harnessed by two quite different methods: photovoltaics and solar thermal.

Photovoltaics (PV): the application of **solar cells** to convert sunlight directly into electricity. When PV cells are assembled, they form a **PV module** (or **panel**). An installation of panels is called a **PV array**.

Solar cells are often made from **wafers**: slices of semiconductor material, such as **silicon crystal**.

World leaders in PV use: Germany, USA, Spain

Solar thermal energy (STE): a technology that uses solar energy to produce thermal energy, i.e. heat. There are low-, medium-, and high-temperature solar thermal collectors. The first two types are flat plates generally used to heat water. High-temperature collectors concentrate sunlight with mirrors or lenses and are mostly used to produce electricity. This technique is known as **concentrated solar power (CSP)**.

Solar energy (2)

CSP systems are also able to track the movement of the sun. The radiation they concentrate is used as a heat source for a conventional plant to produce heat or electricity [concentrating solar thermal (CST) systems] or is directed to PV surfaces to generate electrical power [concentrating PV (CPV) technology].

CSP allows solar installations to increase their productivity. CSP plants take up smaller areas, which helps to reduce costs.

There are various concentrating technologies, the most prominent being the **solar trough**, the **parabolic dish** and the solar power tower.

A notable and ambitious project is the solar power satellite: a system of solar collectors in space that would be directly exposed to the sun's radiation and would transmit the generated power to a large antenna on the earth. The costs for the satellite's construction, however, would be very high.

Wind energy

The energy of wind is harnessed with wind turbines. They are usually grouped in **wind farms** (sometimes called **wind parks**).

There are **onshore** farms (which, however, are often near water); nearshore farms (on land or on sea within several km of a coast); and **offshore** parks (ten km or more from land).

World leaders in wind energy use: Germany, USA, Spain, India

Wind energy currently generates only 1% of all electricity on a global scale, but its share is growing rapidly. In Denmark, for example, wind already accounts for 19% of the total electricity production.

Since wind is intermittent, turbines can't constantly work at their full capacities. The ratio of actual annual productivity to the theoretical maximum capacity is called **capacity factor**. It typically reaches 20% to 40%.

Hydropower

Hydropower (also called hydraulic or water power) is derived from the force of moving water. Since water is much denser than air, its movement generates more energy than wind does.

Electricity generated with hydropower is called **hydroelectricity**.

Hydropower was harnessed with waterwheels to operate watermills, sawmills, textile machines and others long before electric power came into use.

Hydropower supplies some 19% of all electricity in the world. It is generally far cheaper than fossil fuels or nuclear energy.

Hydroelectricity is mostly generated in **dams**. Water is first collected in dams, then let flow through turbines. A great advantage of this technology is that the amount of energy produced can be easily adjusted to the level of demand by controlling the outflow of water.

Another technology that utilizes a dam but no reservoir is the **run-of-the-river** hydroelectric generation. Here, the dam cuts across the river, ensuring water will fall from its upper edge, pass through turbines and flow back into the lower level of the river. In some run-of-the-river installations, water is directed into a pipe, from where it passes through turbines and returns into the river.

Hydropower (2)

The lack of a reservoir reduces the negative environmental impact of the power installations. However, there are certain problems related to dams, such as high construction and maintenance costs, the risk of dam breakage, and perils for water fauna. To avoid these complications, **damless hydroelectricity** has been created.

Tidal power technologies convert the energy of tides into electricity. Their biggest advantage is the fact that tides are much more predictable than wind or solar energy. However, tidal power is not very common yet.

Tidal energy is captured with **tidal stream systems** which use the kinetic energy of moving water to drive turbines. A less popular technology to capture tidal energy are **barrages** (similar to dams), which use the water's potential energy. Barrages are not preferred because of higher costs and bad environmental effects.

Another up-and-coming electric source is **wave power**. One wave power technology employs buoyant objects that the waves move, creating electricity. With wind turbines, the air fluctuations caused by the moving water can also be used to produce power. A project that uses the movement of the water below its surface has also been developed.

The first **wave farm** (a collection of wave power generators) in the world was opened in 2008 in Portugal. Its capacity is 2.25 MW. Scotland plans to build an even larger facility with a 3 MW capacity.

World leaders in hydropower use: China, Brazil, Canada, USA, India

Biomass and biofuel

Biomass consists of living or recently dead organisms or other biological material, i.e. **carbon**. Biomass is used to produce biofuel. The most common material for biofuels are photosynthetic plants. A plant especially grown to be used for biofuel manufacturing is known as an **energy crop**.

Biodiesel is a very common biofuel. It is made from oils (extracted from maize, soy, rapeseed, sunflower, palm fruit and sometimes from animal products) that undergo chemical processing. Used edible vegetable oil is sometimes transformed into biodiesel too.

Biodiesel is mixed with mineral diesel to be used in diesel engines.

Biogas is produced by the biological breakdown of organic matter in the absence of oxygen. The biodegradable materials in question can be manure, sewage, green waste (plant parts), household and industrial waste. Biogases are rich in methane. They can be used to generate heat, electric or mechanical energy, or as fuel for vehicles.

Biogas is produced in facilities for biological treatment of waste. It is also formed naturally in landfills where it contributes to the greenhouse effect.

Bioalcohol (or alcohol fuel) is produced with the help of fermentation-inducing microorganisms. The most common is ethanol fuel (or bioethanol) that is widely used instead of petrol to power cars in some countries, predominantly Brazil.

World leaders in biomass use: USA, Germany, Brazil, UK

Geothermal energy

This type of energy is obtained by tapping the heat of the earth, which is mostly in the form of hot water and steam. Various technologies are used to get to the heat under the earth's surface at different depths.

Several metres under the earth's surface the temperature is between 10° and 16°C. In winter this heat can be brought to buildings with pipes.

Another technology uses deep wells in hot rock in which fluid is heated to produce steam, which then drives turbines to generate electricity. The facilities that enable this process are called dry steam, flash steam and binary-cycle plants.

Geothermal power stations are expensive to build but their operating costs are low. A significant advantage is that geothermal energy is not dependent on weather conditions. A major disadvantage is the risk for land stability in the region where such a plant is constructed.

In some areas of the planet geothermal energy is closer to the surface and therefore easier to harness. One of the most favourable areas is Iceland with its high concentration of volcanoes. Geothermal sources account for 19% of Iceland's electricity production, and geothermal heating is used in 87% of homes in the country. Iceland also plans to go fully fossil-fuel free in the near future.

The country with the greatest geothermal energy production, however, is the USA. There is the biggest dry steam field, The Geysers, with an annual capacity of 750 MW.

Another country with significant geothermal energy resources and production is the Philippines.

Pros and cons

We can't run out of renewables because nature replenishes them faster than we consume them.

Biomass and geothermal energy need wise management to avoid their depletion.

The use of domestic power generators (e.g. solar panels on the roof) reduces the strain on power distribution systems.

If clean energy becomes prevalent, the electricity transmission and distribution systems must be transformed and managed more actively (why: see next slide).

Green electricity is becoming increasingly accessible to the average consumer.

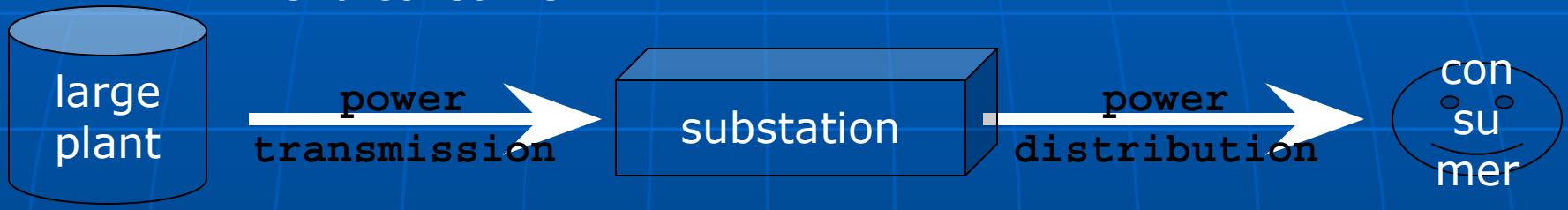
Renewable heat is still expensive and hard to access.

Renewables are generally not hazardous to the environment.

Some green energy installations take up large pieces of land that can be used to grow crops.

Distributed generation

Traditional energy generation is mostly done in centralized facilities from where energy must travel a lot to reach the end consumer:



This is done to achieve economies of scale, or to bring energy generation closer to the resource (e.g. mines) and away from populated areas (for health reasons). However, some of the energy, especially heat, is lost during the transportation.

By contrast, renewables are often associated with **distributed generation** (also called **dispersed generation** or **decentralized energy**). This is producing energy in many small facilities and transporting it over short distances. Roof solar panels and wind turbines are examples of distributed energy resources (DERs).

In order for renewable energy to become massively used, energy systems must be adjusted to reflect the shift from centralized to dispersed generation.

What energy qualifies as renewable

Some scientists and politicians argue that nuclear energy is renewable since the resources from which it is derived (such as uranium) would not be exhausted in millions of years.

These claims, however, have not been proven; furthermore, nuclear energy has an extremely dangerous byproduct: nuclear waste. For this reason, governments don't recognize nuclear energy as renewable and it is not eligible for state subsidies.

Fossil fuels could be regarded as biomass since their have biological origin; however they are neither sustainable nor green because:

- this is organic material that has undergone millennium-long geological transformation;
- thus, the regeneration rates of fossil fuels are extremely slower than the rate at which they are consumed;
- fossil fuels emit CO_2 when burnt.

Feed-in tariffs

Since renewables are still innovative and in active development, they are often not competitive with traditional energy sources. Therefore, green-minded governments provide various incentives that encourage investments in the sector and promote its faster development. Among the most common is the feed-in tariff. This is an obligation imposed on utilities by the government to buy a certain amount of renewable electricity at prices higher than the markets rates. The higher expenditure for the utility is passed on to its customers. The increase of prices that customers have to bear is usually small, but these small contributions are a powerful and effective way to support green energy.

Feed-in tariffs were introduced as early as 1978 in the USA. Now, they are implemented in around 50 countries around the world.

In Germany, for example, feed-in tariffs are regulated by the renewables law (Erneubare-Energien-Gesetz). The programme adds around EUR 1 to each monthly residential electricity bill, which translates into billions of euro of subsidies for the clean energy sector each year. The country aims at generating 12.5% of its electricity from renewable sources by 2010. The percentage should rise to 20 by 2020.

So, in a word…

A plethora of renewable energy is all around us, with even more ways to make use of it.