# ENE 101: Introduction to Energy Engineering

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# Week 3:
# Renewable Energies

Energy resources can be classified into two groups.

## Renewable


**Renewable** energy resources can be replaced or regenerated and will never run out (at least not for a very long time).

**Examples: hydropower (water), solar, wind, geothermal, and biomass, tidal energy etc.**

## Non-renewable


**Non-renewable** energy resources will eventually run out – once used they cannot be used again.

**Examples: coal, oil, gas, nuclear energy**

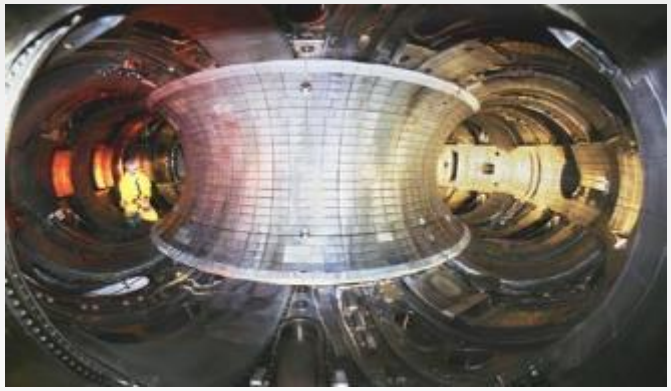
# The Energy Solution

- Development of **efficient and sustainable energy** technologies is necessary for taking the next big step in **renewable energy usage.**

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.

# Potential Sources of Energy when Fossil Fuels Run Out

**NUCLEAR FUSION**



**Waste &**

**Nuclear Proliferation**

**RENEWABLE ENERGIES**

These are resources found in nature that are self-generating
Does not lead to climate change,
Does not involve emission of pollutants

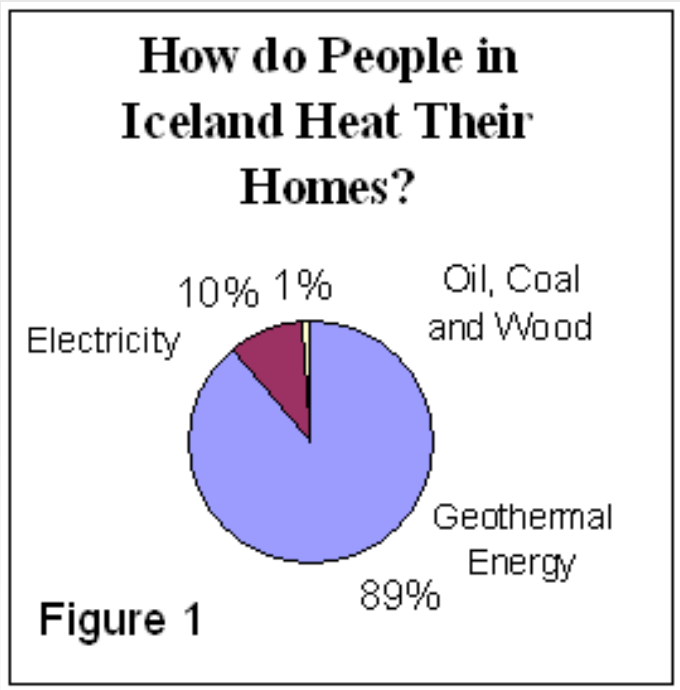
# Geothermal Energy

**It is a renewable** energy source because the water is **replenished by rainfall** and the heat is continuously produced inside the earth.

People around the world use geothermal energy to **heat** their homes and to produce **electricity** by digging deep wells and pumping the heated underground water or steam to the surface. Or, we can make use of the stable temperatures near the surface of the earth to heat and cool buildings.

Japan, Iceland, New Zealand are largest users of geothermal.

Very little potential in east and mid west.

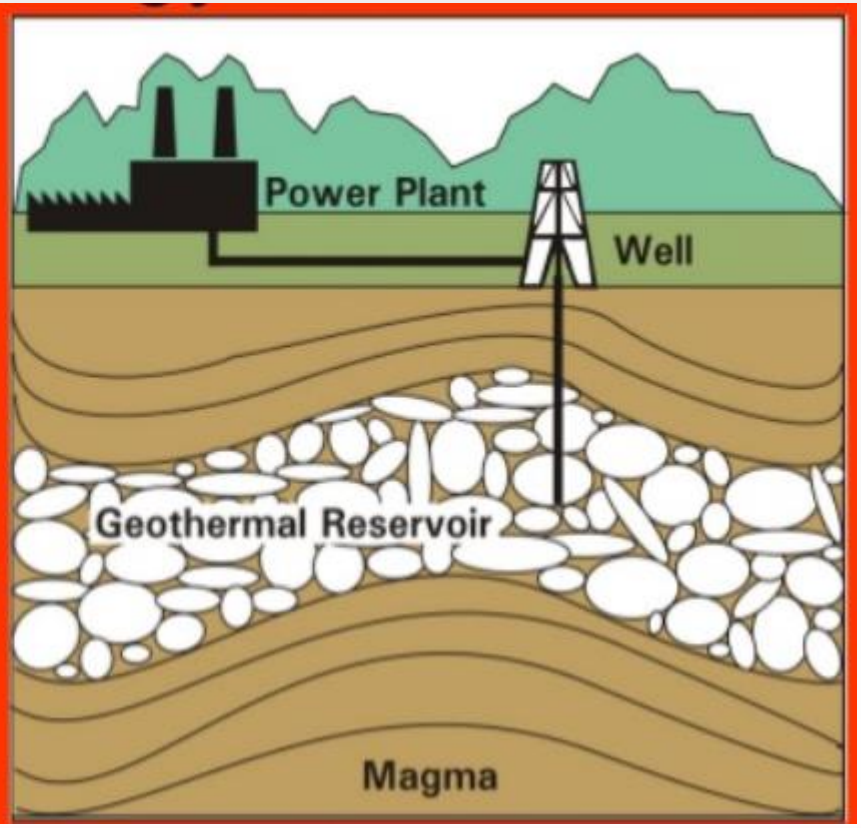


# Geothermal Energy

Heat from the earth. The inside of the earth is very hot. We can use this heat to warm our houses and produce electricity.

Uses the steam and hot water produced inside the earth to turn turbine for heating buildings or generating electricity.

- Today, power plants use **steam** from geothermal wells to make electricity.
- The steam is used to spin **turbines**.
- The turbines spin magnets in coils of copper wire to make **electricity**.

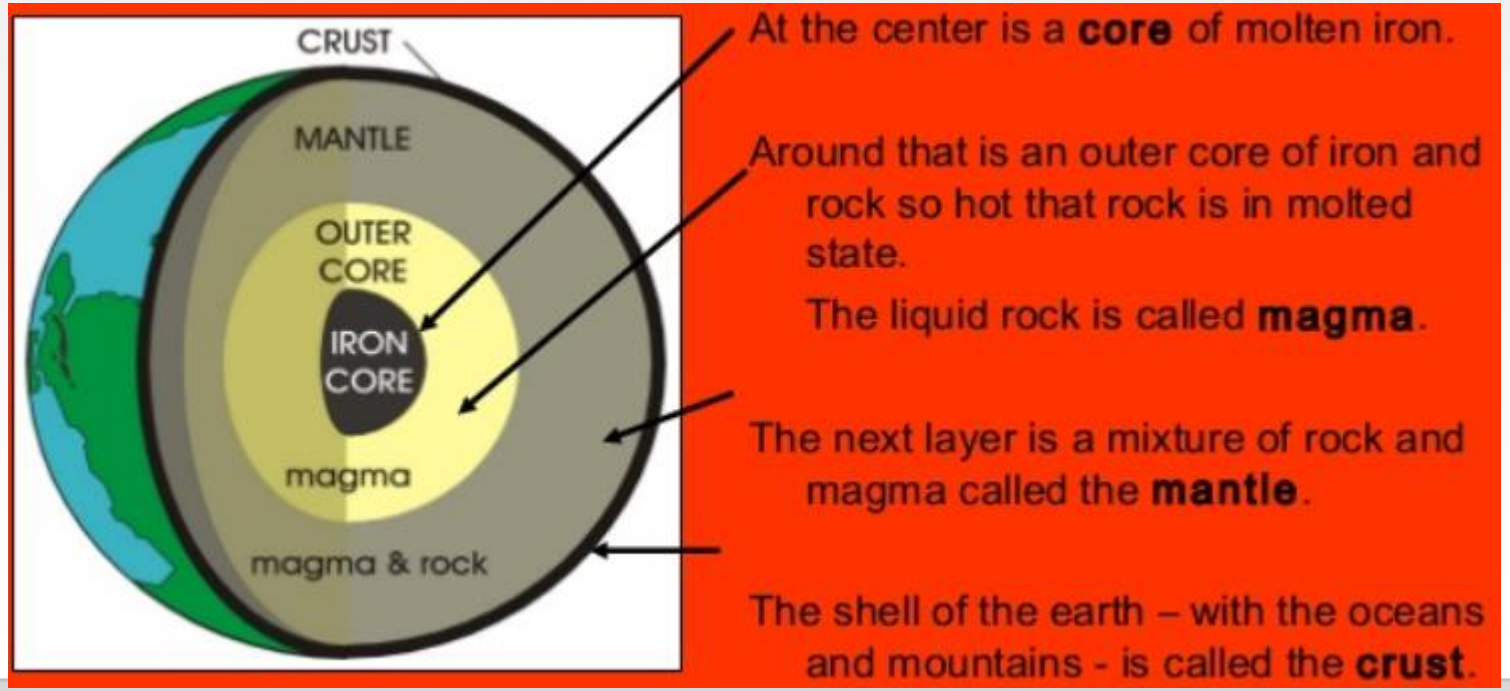


# Geothermal Energy

Geothermal energy is generated in the earth's core, about 4,000 miles below the surface.

Temperatures hotter than the sun's surface are continuously produced inside the earth by the **slow decay of radioactive particles**, a process that happens in all rocks.

The earth has a number of different layers:
The core itself has two layers: a **solid iron core** and an outer core made of very hot melted rock, called **magma**.



# Geothermal Energy

- The **mantle** which surrounds the core and is about 1,800 miles thick. It is made up of magma and rock.
- The **crust** is the outermost layer of the earth, the **land** that forms the continents and **ocean floors**. It can be three to five miles thick under the oceans and 15 to 35 miles thick on the continents.
- The earth's crust is broken into pieces called **plates**. Magma comes close to the earth's surface near the edges of these plates. This is where **volcanoe**s occur. The lava that erupts from volcanoes is partly magma. **Deep underground, the rocks and water** absorb the heat from this magma. The temperature of the rocks and water get hotter and hotter as you go deeper underground.

# Uses of Geothermal Energy

Some applications of geothermal energy use the earth's temperatures near the surface, while others require drilling miles into the earth. The three main uses of geothermal energy are:

1) Direct Use and District Heating Systems which use hot water from springs or reservoirs near the surface.

2) Electricity generation in a power plant requires water or steam at very high temperature (300 to 700 degrees Fahrenheit). Geothermal power plants are generally built where geothermal reservoirs are located within a mile or two of the surface.

3) Geothermal heat pumps use stable ground or water temperatures near the earth's surface to control building temperatures above ground.

# Uses of Geothermal Energy

https://energy.gov/eere/videos/energy-101-geothermal-energy

# Wind Energy

The terms ‘’wind energy’’ or ’’wind power’’ describe the process by which the wind is used to generate mechanical power or electricity.

- Air in motion caused by **uneven heating** of the earth’s surface by the sun.
- Large atmospheric winds that circle the earth are created because the land near the earth's equator is heated more by the sun than the land near the North and South Poles.

Thus, winds are caused by **uneven heating** of the atmosphere by sun, the **irregularities of the earth**, and **rotation of the earth**.

- Today, wind energy is mainly used to generate electricity. Wind is called a renewable energy source because the **wind will blow as long as the sun shines**.
- World leaders in wind energy use; Germany, USA, Spain, India

# Wind Energy

## Sizes and Applications

Clip slide

**Small (≤10 kW)**
- Homes
- Farms
- Remote Application

**Intermediate (10-250 kW)**
- Village Power
- Hybrid Systems
- Distributed Power

**Large (660 kW - 2+MW)**
- Central Station Wind Farms
- Distributed Power
- Community Wind

# Wind Energy

- The energy of wind is harnesses with 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).
- 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%.

## DISADVANTAGES OF WIND POWER:

1. *Not uniform*
2. *Wind turbines are noisy. (About 70 mph).*
3. *Capacity of wind turbines is less.*
4. *Less efficiency (About 30%)*

## ADVANTAGES OF WIND POWER

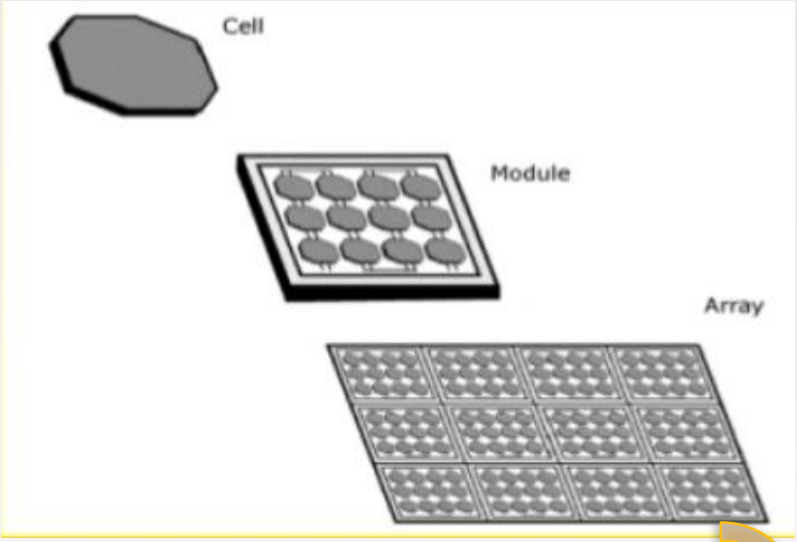
1. *No by-product is produced*
2. *Although wind turbines can be very tall each takes up only a small plot of land.*
3. *Remote areas that are not connected to the electricity power grid can use wind turbines to produce their own supply.*
4. *Wind turbines are available in a range of sizes which means a vast range of people and businesses can use them.*

# Wind Turbines

https://energy.gov/eere/videos/energy-101-wind-turbines-2014-update

# Solar Energy

Solar energy is the sun's rays (solar radiation) that reach the earth.
Can be used to heat water and heat spaces.




Solar energy can be converted to electricity in two ways:

**Photovoltaic** (PV devices) or "solar cells" – change sunlight directly into electricity. PV components are PV cells, Modules, Arrays.

**Solar Power Plants** - indirectly generates electricity when the heat from **solar thermal collectors** is used to heat a fluid which produces steam that is used to power a generator.

https://www.slideshare.net/saxenaankit2010/renewable-energy-resources-ncernonconventional-energy-resources

# Solar PV

https://energy.gov/eere/videos/energy-101-solar-pv

# Hydropower Energy

- 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.

# Hydropower Energy

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***

# Hydroelectric Power

https://energy.gov/eere/videos/energy-101-hydroelectric-power

# Biomass Energy

- Biomass is **organic material** made from plants and animals. Biomass consists of living or recently dead organisms or other biological materials; i.e. carbon.

- Biomass can be converted to other usable forms of energy like **methane gas** or **transportation fuels like ethanol and biodiesel**.

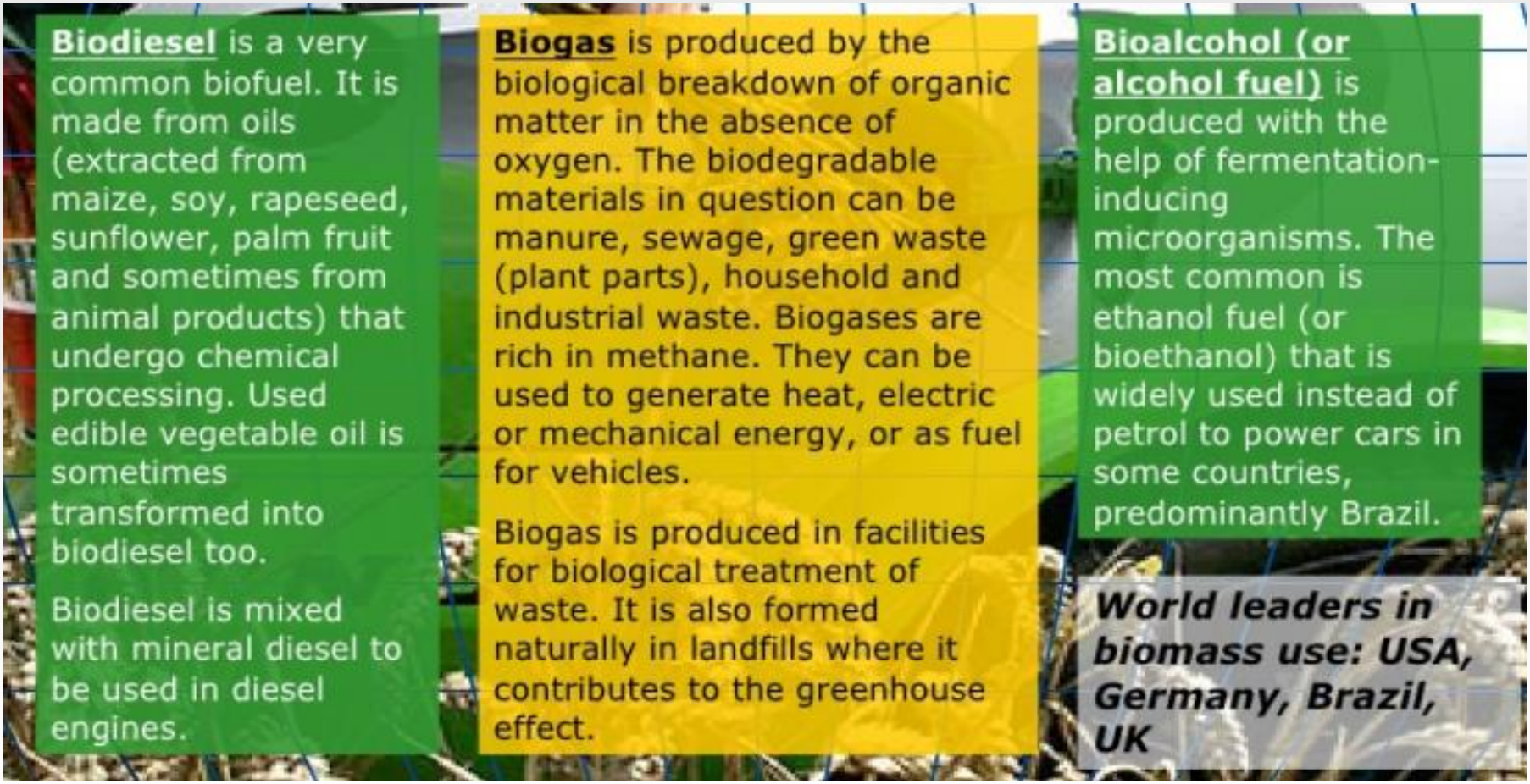
Biomass is used to produce **biofuel**.
The most common material for biofuels are **photosynthetic plants**. A plant especially grown to be used for biofuel manufacturing is known as an energy crop.

Biofuels **don't burn** as much as fossil fuels. Biofuels are cleaner burning and produce fewer air pollutants than fossil fuels.

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.

# Biofuels: Fuels Made from Biomass Material



# Biofuels

https://energy.gov/eere/videos/energy-101-biofuels

# Biomass Energy

## First generation bio-fuels :

- Bioalcohols
- Biodiesel
- Green diesel
- Vegetable oil
- Bioethers
- Biogas
- Syngas
- Solid biofuels


*Pipes carrying Biogas*

*Filtered waste vegetable oil*

https://www.slideshare.net/shalini2093/renewable-energy-resourses

# Adv. vs. Disad.

## Renewable energy

| Types of energy | Advantages | Disadvantages |
|---|---|---|
| Sun energy | Energy source is free; causes no pollution | Expensive; supply of sunlight can be interrupted |
| Wind energy | Energy source is free; causes no pollution | Only practical in areas with strong steady winds |
| Hydroelectric energy | Station cheap to operate; causes no pollution | Stations can only be built in certain locations |
| Geothermal energy | Energy source is free; causes no pollution | Only practical in a few locations |
| Biomass energy | The fuel tends to be cheap; less demand on the Earth's resources | By burning the fuel, it makes greenhouse gases |

# References

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