

Transcript Lesson 3. Energy Forms

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Welcome to Module 3 of the course Renewable Energy Integration in the Energy System, developed by The Hague University of Applied Sciences.

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As we learned in the first lesson, energy exists in different forms, and it can neither be created nor destroyed. Energy can only be transferred from one place to another or converted from one form into another.

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On planet Earth, we have four main energy sources. From these sources, we obtain the energy that we use in our daily lives.

The energy we use is mainly delivered in three forms: heat, electricity, and motion. Different technologies are used to transfer and/or convert energy from the sources into the forms required in our homes, factories, and vehicles.

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In many cases, the process from energy source to energy delivery involves more than one transfer or conversion step.

In this diagram, you can see examples of common energy transfer and conversion chains. Converting energy directly into heat or motion often requires only one step, whereas conversion into electricity typically requires two or three steps.

This is a simplified overview. In reality, energy systems can involve many more steps and technologies, which will be explored throughout this course.

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Electricity can be a final form of energy in some cases, but it can also be an intermediate step. Electricity allows us to transport energy easily from one place to another via a cable, and then convert it into other forms—for example, into motion using an electric motor.

Electricity can also be converted into forms that enable energy storage for later use, such as in batteries, by producing hydrogen, or by pumping water to a higher elevation.

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Another way to look at the energy transfer and conversion technologies is by organizing them in a matrix. This matrix presents the main technologies that allow energy to be transferred between systems or converted from one form into another.

The table is not exhaustive, but it represents the most important energy technologies currently in use, as well as those with strong potential for future application.

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Some energy conversion technologies are reversible. This means that the same technology can operate in both directions.

For example, a fuel cell can use hydrogen to produce electricity, while the same system operating in reverse mode (electrolysis) can use electricity to produce hydrogen. In some cases, the technology has a different name depending on the direction of conversion.

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For this course, energy transfer and conversion technologies are grouped into several categories. Each of the following modules focuses on one group of technologies.

As shown in this matrix, there are many interrelations between technologies. In practice, more than one technology is often required to move from an energy source to final energy delivery.

Because of these interconnections, dividing the course into separate modules is challenging. The structure presented here represents one possible and practical choice. Each module covers the basic working principles, as well as the advantages and disadvantages of the technologies discussed.

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Module 4a focuses on technologies that deliver heat, either by converting different energy forms into heat or by transferring heat from one place to another. For example, solar thermal collectors, which convert radiant energy from the sun into heat.

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In this course, we will also cover combustion technologies. Most of these technologies currently rely on fossil fuels and are therefore not sustainable.

However, they can also operate using fuels produced from renewable resources. Understanding combustion technologies is essential for analyzing how current energy systems operate.

One example is the combustion boiler, which is widely used for space heating and industrial processes.

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The conversion of nuclear energy into heat in a fission reactor is generally not considered renewable. However, nuclear power has no CO₂ emissions, so it is sometimes discussed as a potential option during the energy transition. The advantages and disadvantages of nuclear technology are discussed in this module.

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A simpler technological way to deliver heat is with electric boilers. These devices can be used in households to produce hot water—for example, for showers or making tea.

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In addition to conversion technologies, this module also covers the transfer of heat—for example, transferring heat from one fluid to another using a heat exchanger.

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Another example is transferring heat from a space into a phase-change material, which stores the heat and can deliver it later.

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The last heat transfer technology covered in this module is the heat pump. Heat pumps are not purely a transfer technology, because electricity is required to run the compressor and move heat from the source to the sink.

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Module 4b focuses on technologies that deliver motion, either by converting different energy forms into motion or by transferring motion from one place to another. For example, the combustion engine used in cars and trucks, which converts chemical energy into motion.

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Faster vehicles, such as aircraft, use gas turbines to convert chemical energy into motion.

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Another type of turbine is the steam turbine. In this turbine, there is no internal combustion; instead, the pressure of hot steam is converted into motion. Steam turbines are used in the conversion chains of many electricity power plants, such as gas-fired power plants, nuclear power plants, and some solar-thermal power plants.

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The movement of air (wind) and water (for example, tidal currents or water released from a dam) can be converted into rotational motion of a shaft using wind turbines and water turbines.

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This module also covers technologies that store energy by lifting water or objects, converting motion energy into potential energy, which can later be released and converted back into motion.

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Module 4c focuses on technologies that deliver electricity, either by converting different energy forms into electricity or by transferring electricity from one place to another. For example, generators and electric motors, which convert motion into electricity and electricity into motion.

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Another technology that can deliver electricity is the photovoltaic solar panel, which converts radiant energy from the sun directly into electricity.

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This module also covers transformers, which allow voltage levels to be changed and enable efficient electricity transmission over long distances.

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Finally, Module 4d focuses on electrochemical technologies, which—with their reversible operating characteristics—offer a great opportunity for energy storage. One example is electrical batteries, such as lithium-ion batteries used in electric cars.

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This module also includes fuel cell technologies, which can operate either in fuel cell mode to produce electricity or in electrolysis mode to produce hydrogen.

Together, these modules provide an overview of energy transfer and conversion technologies, including their advantages and disadvantages. This knowledge is essential for addressing the challenge of integrating multiple technologies into a single energy system.

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These are the references used in this lesson. Additional references are included on the individual slides.

Thank you for your attention, and see you in the next module.