

The Secrets of SDGs

7 AFFORDABLE AND
CLEAN ENERGY



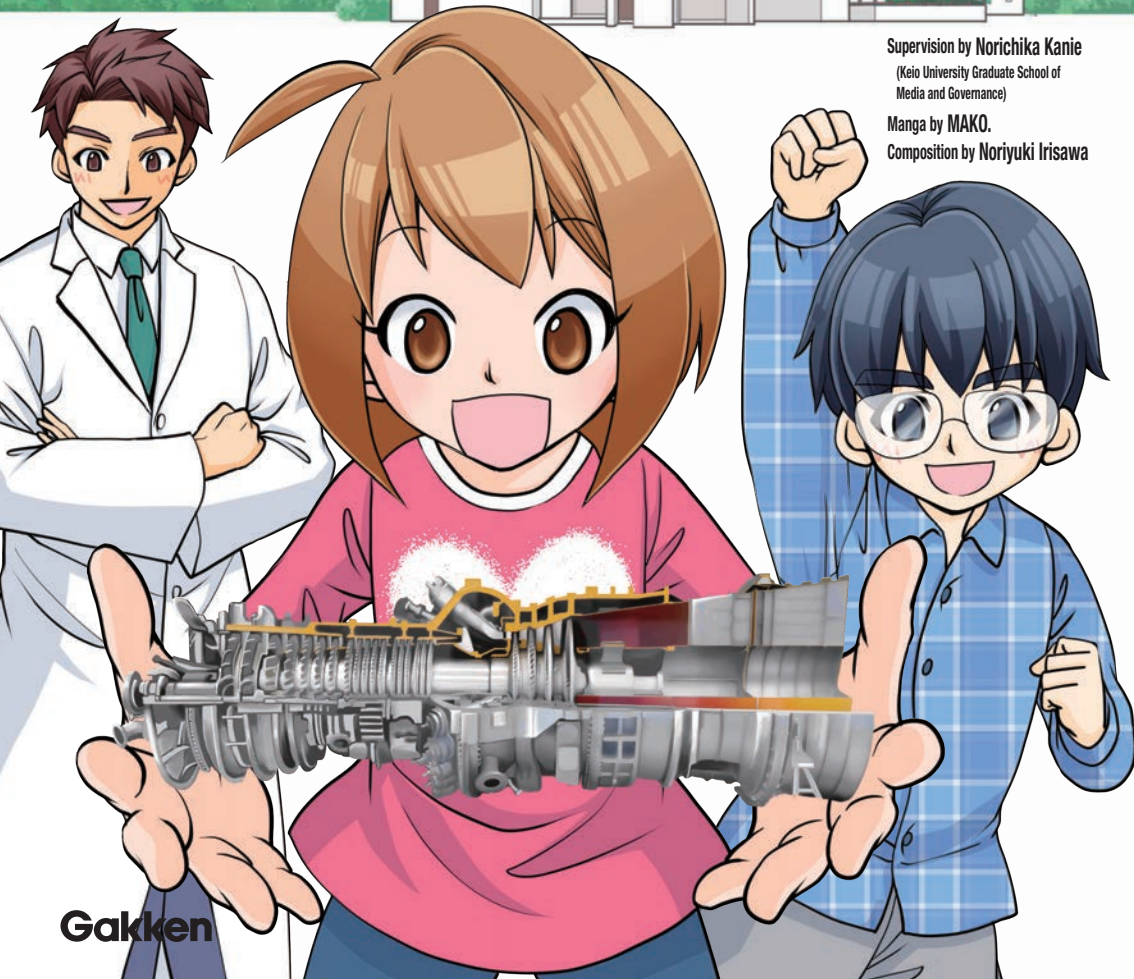
Affordable and Clean Energy

Mitsubishi Heavy Industries' Efforts

Supervision by Norichika Kanie
(Keio University Graduate School of
Media and Governance)

Manga by MAKO.

Composition by Noriyuki Irisawa



"Affordable and Clean Energy"

This is goal 7 of the SDGs.

There are nearly 800 million people in the world today who don't have access to electricity.

Everyone should be able to conveniently use electricity to live healthy lives.

But we also need to prevent global warming.

What can we do?

To solve that problem, let's think about new ways and technology to generate electrical energy, starting with hydrogen power!



SDGs (Sustainable Development Goals) are global goals set up by the world to be achieved by 2030.



Photo : imagenavi



No Poverty

There are two types of poverty: absolute poverty and relative poverty. The former is to be poor in a global sense. About 9% of the world's population lives on less than \$1.90 (about 200 yen) a day. The latter is to be poor compared to others in the same country. In Japan, approximately 2.8 million children (one in seven) cannot receive higher education due to poverty.



Zero Hunger

About one in nine people worldwide suffers from hunger daily. In addition, one in four children under the age of five suffers from stunting due to undernourishment. Hunger is a serious problem that is expected to spread in the future due to continued population growth. Cooperation from developed countries to promote sustainable agriculture is essential.



Good Health and Well-Being

Approximately 5.3 million children worldwide under the age of five die each year. About half of these are infants under one month old. Millions, including adults, also die each year from various infectious diseases. This is due to poor sanitation and the lack of access to hospitals and vaccinations.



Quality Education

About 770 million people in the world cannot read or write. Of them, two-thirds are women. There are many children who cannot attend school because helping at home is considered more important than education. If they don't know how to read, write, or do arithmetic, they cannot get a well-paying job, and thus cannot escape poverty. It is important to raise awareness of education's benefits and help it spread more widely.



Gender Equality

In addition to physical differences, men and women also have different norms and roles constructed by society. These socially-constructed differences are called gender. Many young girls worldwide are not allowed to attend school simply because they are girls. Each year, twelve million women are forced to marry before turning eighteen, regardless of their will. These inequalities must be reduced.



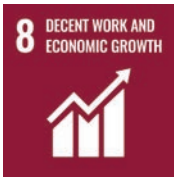
Clean Water and Sanitation

More than two million people die yearly from diarrheal diseases, and more than eight hundred children under the age of five pass away every day. The main reasons are a lack of sanitary toilets and of daily access to safe water. Many children cannot go to school because they must travel for hours to fetch water from distant water sources.



Affordable and Clean Energy

Electricity is a convenient form of energy, but approximately eight hundred million people worldwide do not have stable access to it. There are also health problems caused by burning fuels to produce energy. We must expand access to electricity, but also prevent climate change and protect the environment. This is why renewable energy and hydrogen power generation are important.



Decent Work and Economic Growth

Approximately 150 million children in the world are forced to work due to poverty. In Japan, death by overwork is a persistent problem. Conversely, hundreds of millions of people worldwide are unemployed and looking for work. We must build a world where everyone can work in humane conditions with a sense of fulfillment.



Industry, Innovation and Infrastructure

Infrastructure refers to the systems and services we need to live in a society, such as roads, railroads, electricity, gas, phones, water, and sewage systems. Many people in the world do not have access to sufficient infrastructure. For worldwide growth, we must build a disaster-resilient, stable infrastructure and develop new technologies.



Reduced Inequalities

In today's world, the richest 10% make 40% of global income, while the poorest people earn only a combined total of 2–7%. We must help the poor achieve higher, more stable income. Inequality and discrimination based on race, ethnicity, religion, disability, and gender must also be eliminated.



Sustainable Cities and Communities

Today, nearly 3.5 billion people, about half of the world's population, live in cities, seeking work. However, densely populated cities have poor living conditions with more pollution and crime. These areas are also vulnerable to natural disasters. We need to create cities that are resilient to disasters and where a diversity of people can live safely.



Responsible Consumption and Production

Every year, about a third of the world's food (about 1.3 billion tons), is spoiled, lost, and wasted. In Japan, each person throws away the equivalent of one rice ball every day. Forest resources, aquatic resources, and underground resources such as oil will also run out if no action is taken. We must all work together to eliminate waste.

13 CLIMATE ACTION



Climate Action

Climate change is caused by greenhouse gases that humans produce, such as carbon dioxide. Climate change increases water vapor in the air, resulting in frequent abnormal weather events such as torrential rainfall, large typhoons, and droughts. Sea levels are rising, and land areas are being submerged. People around the world must work together to reduce greenhouse gases.

14 LIFE BELOW WATER



Life Below Water

Our oceans, rich with life, are being polluted by large amounts of garbage and wastewater produced by humans. Sea creatures are being poisoned by harmful substances, which are then consumed by humans, endangering their health. Some species are in danger of extinction due to overfishing.

15 LIFE ON LAND



Life on Land

The world's forests are shrinking. Logging is depleting trees in large amounts, destroying animal habitats. Invasive species introduced by humans are preying on native species. The loss of biodiversity and the destruction of ecosystems caused by humans are also beginning to seriously impact human life.

16 PEACE, JUSTICE AND STRONG INSTITUTIONS



Peace, Justice and Strong Institutions

Conflict and violence are difficult to eliminate from human society. About one in nine children worldwide live in areas of conflict. The rate of death before the age of five among these children is more than twice that of other regions. Improving the social environment through institutions such as governments and justice systems is considered an effective way to reduce conflicts.

17 PARTNERSHIPS FOR THE GOALS



Partnerships for the Goals

Humans cannot live alone. The same is true for nations. Both developed and developing countries must support and cooperate with each other on an equal footing. The world must work together to achieve the SDGs. It is essential that each individual becomes aware of these issues and actively works to build partnerships.

Dear Readers,

The *Gakken: Learning with Manga series* answers your questions and provides interesting information in comic book form.

- The Secrets of SDGs 7 includes many facts and figures to help you understand the future of energy.
- Trivia is included on almost every page.
- This book was made in cooperation with Mitsubishi Heavy Industries, which provided informational assistance and materials.
- Unlike English comics, which are read from left to right, Japanese manga are read from right to left.



The Secrets of SDGs

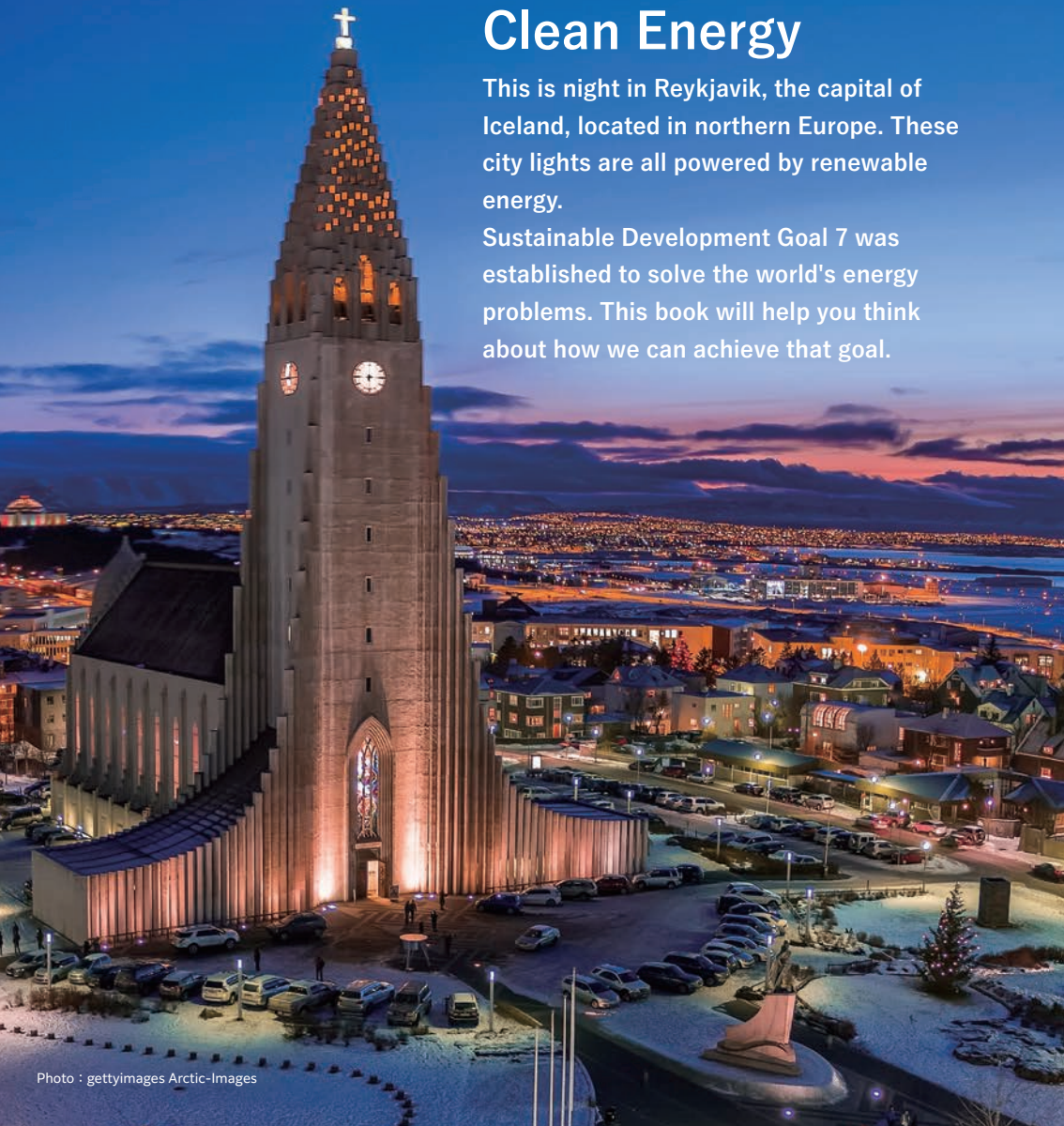
7 AFFORDABLE AND
CLEAN ENERGY



Affordable and Clean Energy

This is night in Reykjavik, the capital of Iceland, located in northern Europe. These city lights are all powered by renewable energy.

Sustainable Development Goal 7 was established to solve the world's energy problems. This book will help you think about how we can achieve that goal.



Energy Powers Our Lives

First, let's look at how energy is used in our daily lives. We use many appliances powered by electricity or fuel. These machines move, produce light and sound, provide heating and cooling, and perform many other actions to make our lives easier.

Microwave

Electricity → Heat

Hair Dryer

Electricity → Heat & Motion (Airflow)

Dishwasher

Electricity → Motion

Electric Stove

Electricity → Heat

Refrigerator

Electricity → Heat (Cooling)

LED Lamp

Electricity → Light

Electric Kettle

Electricity → Heat

These actions require power, which we call energy. Electrical energy is particularly useful because it can be easily converted into other forms of energy. To learn more, see page 39.

Washing Machine

Electricity → Motion

Bathtub

Fuel → Heat or
Electricity → Heat

Air Conditioner

Electricity → Heat & Heat (Cooling)

Lamp

Electricity → Light

Music Player

Electricity → Sound

Car

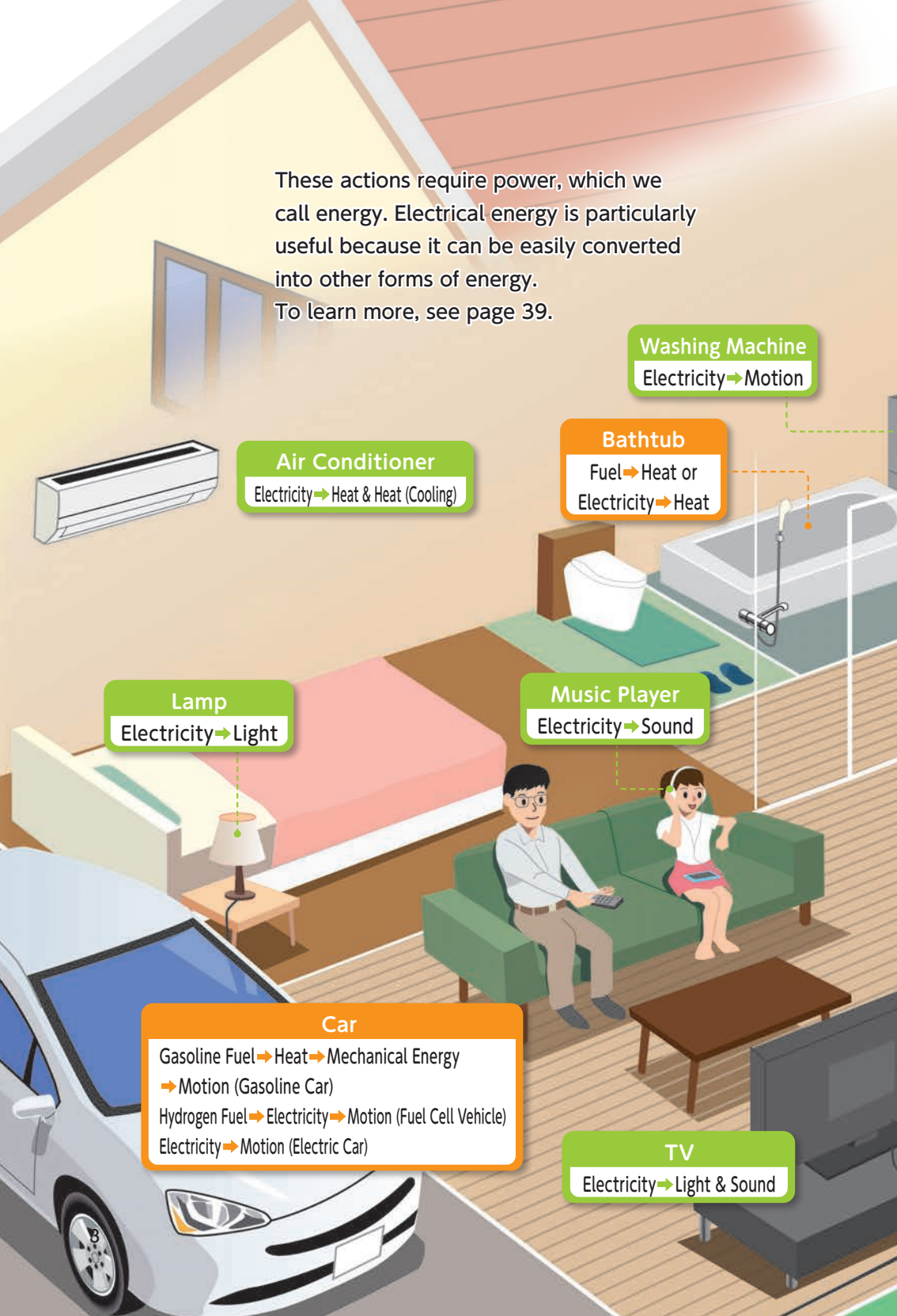
Gasoline Fuel → Heat → Mechanical Energy
→ Motion (Gasoline Car)

Hydrogen Fuel → Electricity → Motion (Fuel Cell Vehicle)

Electricity → Motion (Electric Car)

TV

Electricity → Light & Sound



A Gap in Resources

Some countries have more resources than others



Shutterstock.com

- ▲ The Kern River Oil Field of California in the United States. Only a certain number of countries have oil fields.

Some countries depend on other countries for resources



Shutterstock.com

- ▲ Atsumi Thermal Power Station (Aichi Prefecture, Japan). Oil imported to Japan on tankers is carried to it through these pipelines. Japan depends heavily on other countries for oil.

The World's Energy Problems

Energy is useful, but its production consumes resources and emits greenhouse gases. Let's see what kinds of problems this presents.

Resources such as oil, coal, and natural gas are only produced in certain areas. This means countries do not have equal access to resources.

Countries lacking in resources must buy from countries that are rich in resources. Because they're dependent on other countries, there is always a risk that the other country will cut off their supplies. This means the supply of resources is unstable.

Limited Resources

The Earth has plentiful resources, but they have a limit. We must think ahead for when they're gone.



A large coal mine in Russia.

Shutterstock.com

Climate Change

Greenhouse gases are increasing

When energy is produced or fuel is burned, greenhouse gases such as carbon dioxide, methane, and nitrous oxide are emitted. These emissions contribute to climate change.



▲ The number of cars and motorcycles is increasing in Kathmandu, the capital of Nepal. The large amount of exhaust emissions is becoming a problem.

Abnormal weather worldwide

Greenhouse gases prevent heat from escaping the Earth, thus warming the planet. This melts continental glaciers and increases the amount of seawater, causing ocean levels to rise in many areas. It is also connected to an increase in disasters caused by abnormal weather.



▲ A collapsing glacier. It is said that the Earth is losing a trillion tons of ice each year.



▲ Some countries are losing land to rising sea levels.



▲ Warmer air holds more water vapor, thus causing an increase in the occurrences of cloudbursts and related damage.



Villagers in Madagascar wash their clothes in the river and dry them on the bank because they have no electricity to power washing machines.

Kononchuk Alla / Shutterstock.com

Not Accessible to All

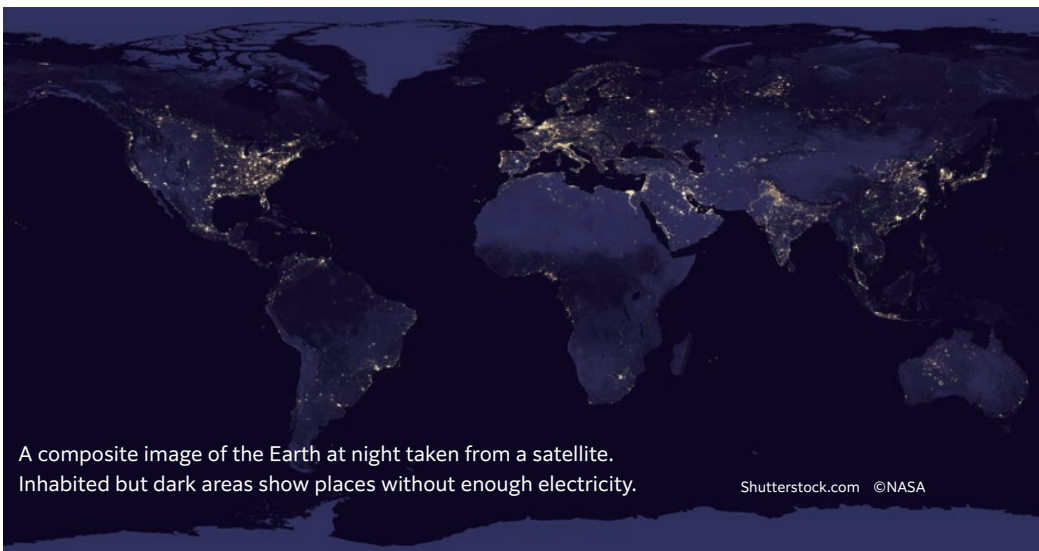
About eight hundred million people have no access to electricity



Children in a village in India attend class in a dark classroom because their school has no electricity.

Travel Stock / Shutterstock.com

Electricity is a very convenient energy source, but it requires power plants, power lines, and other facilities to be used. About one in ten people in the world still live without access to electricity.



A composite image of the Earth at night taken from a satellite. Inhabited but dark areas show places without enough electricity.

Shutterstock.com ©NASA

Sustainable Development Goal 7 aims to solve these issues

Affordable and Clean Energy

We have looked at some of the energy-related problems that Sustainable Development Goal 7 was established to solve. SDG 7 aims to ensure safe and reliable energy access for all while protecting the global environment. Let's look through some materials on energy and the significance of SDG 7 and think about energy-related issues together.

What can we do to make these things happen?



How can we ensure a stable supply of electrical energy?



How can we produce electricity while reducing climate change?



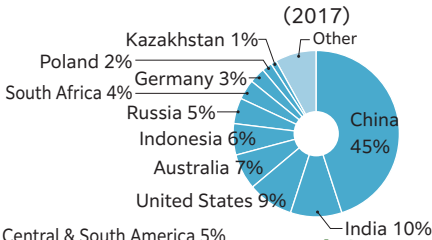
How can we provide electricity to everyone in the world?

What would you do? Let's look at more specific data.

Understand the reality of the world's energy through data.

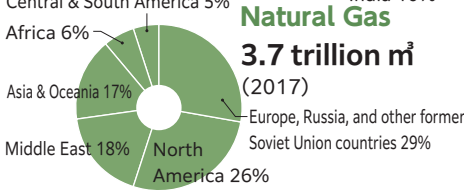
Coal

7.5 billion tons



Natural Gas

3.7 trillion m³
(2017)

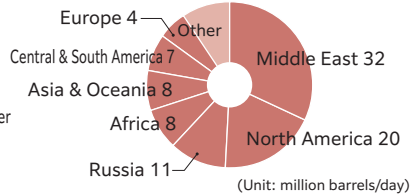


Uneven Distribution of Resources

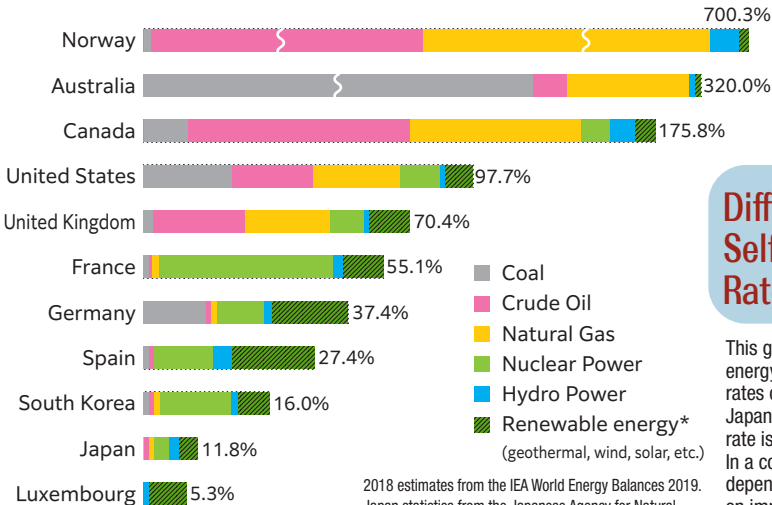
One-third of the world's crude oil is produced in the Middle East. Together with North America and Russia, they supply more than half of the oil in the world. Over three-quarters of the world's coal is produced by five countries. It is clear that distribution of resources is not even.

Crude Oil

93 million barrels per day (2017)



From the Japanese Agency for Natural Resources and Energy reporting of the BP Statistical Review of World Energy 2018 and IEA Coal Information 2018.

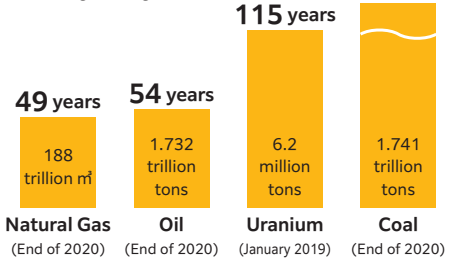


2018 estimates from the IEA World Energy Balances 2019. Japan statistics from the Japanese Agency for Natural Resources and Energy's FY 2018 General Energy Statistics.

Different Energy Self-Sufficiency Rates

This graph illustrates the energy self-sufficiency rates of different countries. Japan's self-sufficiency rate is currently very low. In a country like Japan that depends almost entirely on imported resources, a comfortable lifestyle cannot be taken for granted.

Remaining Mining Life and Reserves

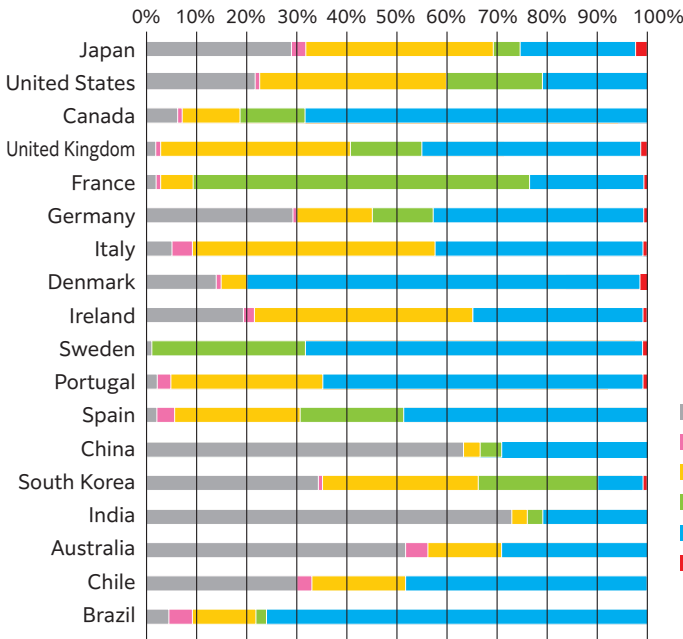


From Nuclear Power and Energy Charts 2019

Dwindling Resources

The resource extraction yield is slowly decreasing as resources are being depleted. What will the world be like when you're an adult?

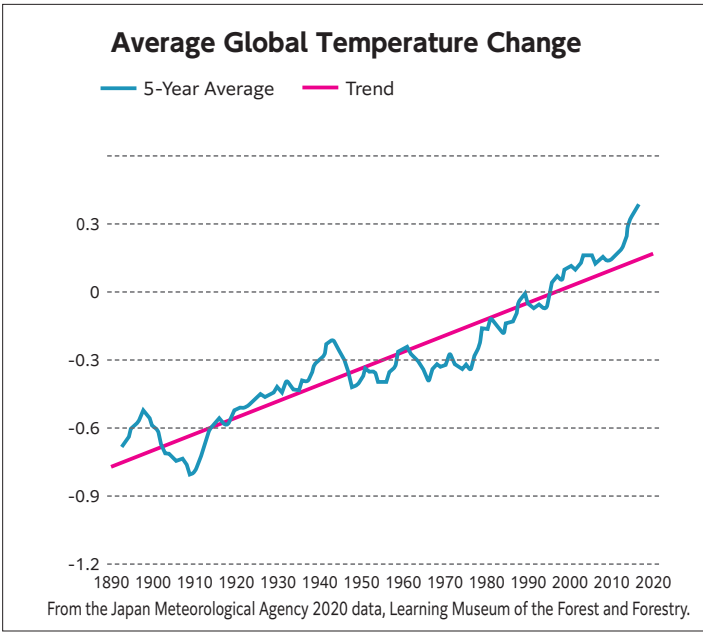
*Renewable energy is energy collected from natural sources that do not run out. It does not emit carbon dioxide.



Varying Ratios of Power Generation

Power generation methods vary as they are linked with the country's resources.

From the Renewable Energy Institute's March 2022 data.
 Source: IEA Monthly Electricity Statistics—data up to December 2021 (March 2022) (Downloaded March 16, 2022)



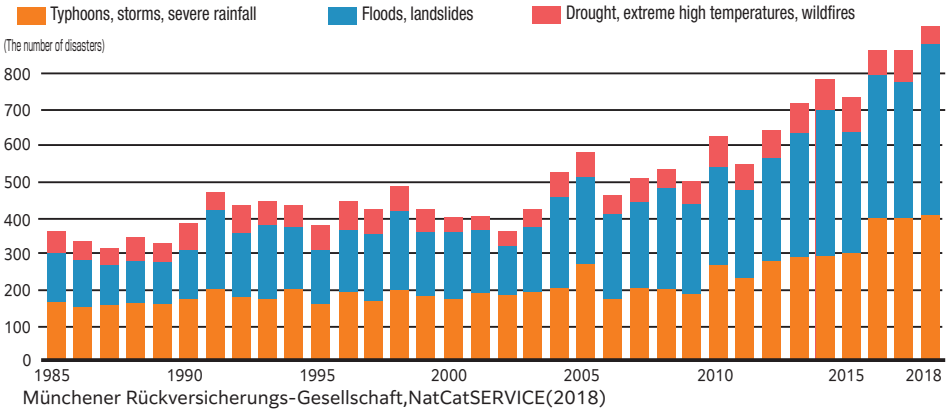
Increase in Average Global Temperature

This graph shows the average annual temperatures from 1891 to 2020. You can see the temperature has risen about 1°C (1.8°F) over 130 years. If no action is taken, the temperature will increase by another 1°C between 2041 to 2060.

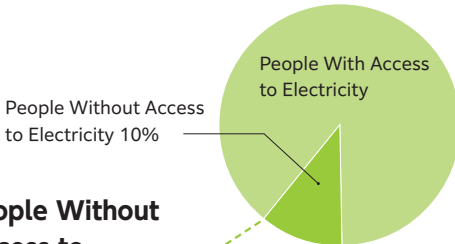
Increase in Climate-Related Natural Disasters

Floods caused by cloudbursts, typhoons, tornadoes, droughts, forest fires, and other natural disasters are increasing in frequency around us.

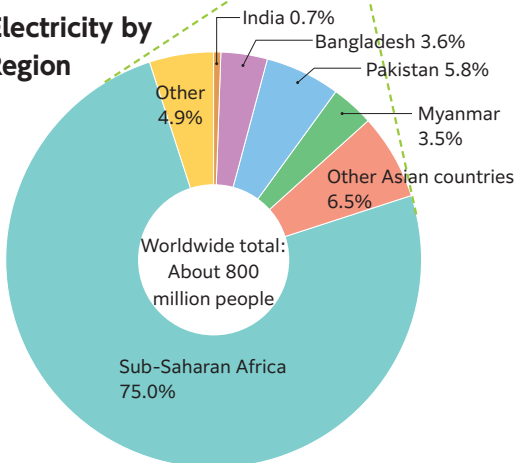
The Number of Climate-Related Natural Disasters



Global Access to Electricity



People Without Access to Electricity by Region



Charts based on the IEA's World Energy Outlook 2020.

Many People in Africa Are Without Electricity

Approximately 160 million people in developing countries in Asia and 600 million people in sub-Saharan Africa cannot lead healthy lives because they have no access to electricity.



▲ A woman carrying manure. Manure and wood are used for cooking and heating. These emit health-damaging smoke.

Denis Dymov / Shutterstock.com

How to Ensure a Stable Energy Supply While Protecting the Environment

Pros and Cons of Different Energy Sources

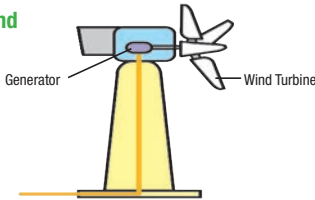
How can we produce energy so that everyone in the world can have equal access to electricity while protecting the global environment? Let's look at the pros and cons of each energy generation method.

Aside from solar power, electricity is produced by turning turbines and generators in various ways. Let's look at the pros and cons of each method.

- Green: The source of energy or fuel powering turbines and generators
- Pink: Pros
- Blue: Cons

Wind Energy

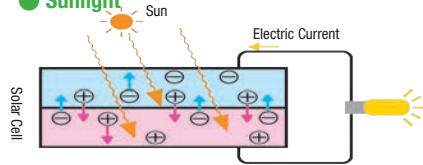
● Wind



- No carbon dioxide emissions.
- Won't run out.
- Inconsistent due to dependency on wind.

Solar Energy

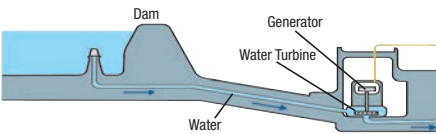
● Sunlight



- No carbon dioxide emissions.
- Won't run out.
- Inconsistent due to varying sunlight.

Hydro Power

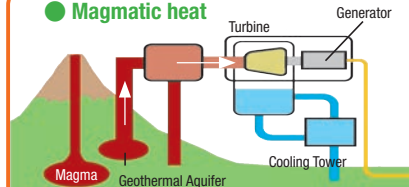
● Force of dam water



- No carbon dioxide emissions.
- The construction of dams requires timber harvesting, which has a large impact on the surrounding environment.

Geothermal Energy

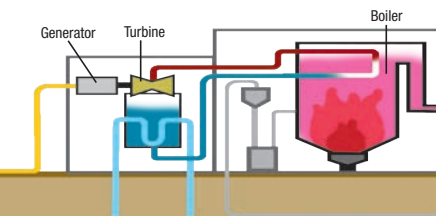
● Magmatic heat



- No carbon dioxide emissions.
- Plants can only be built in certain locations.

Thermal Power

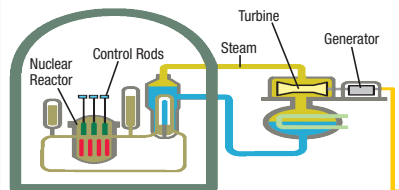
● Natural gas, coal, biomass, etc.



- Stable production of power.
- Can flexibly respond to changes in demand.
- Emits carbon dioxide.

Nuclear Power

● Thermal energy generated by nuclear fission



- Stable generation of large amount of electricity.
- Zero CO₂ emissions during operation.
- Need to dispose of radioactive waste, and to take safety measures in case of an accident.

In light of the situation we've just seen, some companies are taking action toward SDG 7. Let's take a look at their efforts.

Working Towards Sustainable Development Goal 7

Steps are already being taken toward solving energy issues and achieving Goal 7 of the SDGs. Let's look at the efforts of Mitsubishi Heavy Industries (MHI), a company involved in power generation systems.



CG render of a hydrogen power plant

Hydrogen Power

Hydrogen+Oxygen

Uses the energy from when water is made.

Because hydrogen does not emit carbon dioxide when burned, it is gaining attention as a critical energy resource. MHI's transition to hydrogen power production will begin in 2025, using a mix of 30% hydrogen and 70% natural gas fuel. This will reduce carbon dioxide emissions by 4.6 million tons* per year. In the future, hydrogen will be increased to 100%, achieving zero carbon dioxide emissions.

Plans are also underway to build a large-scale hydrogen power plant in Utah, U.S. Electricity generated by solar and wind power will be used to split water, producing hydrogen, which will then be used to generate electricity. The hydrogen will be stored in a large underground salt dome. MHI is involved in this project as well.

The Great Salt Lake in the U.S.



*Calculated at the power generation facility of the GTCC hydrogen power project in the U.S.



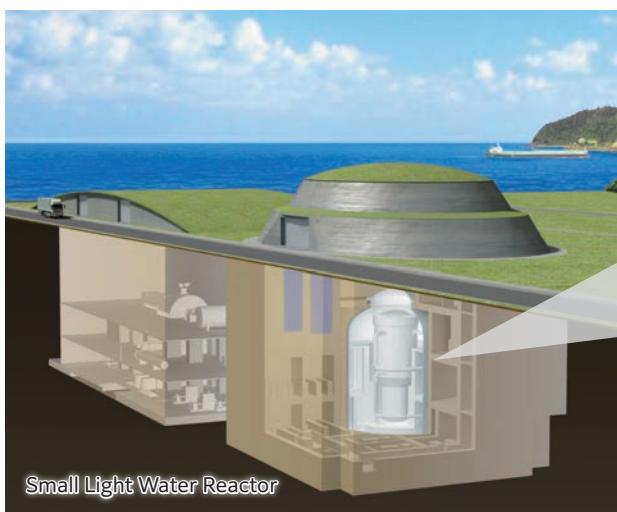
Advanced light water reactor "SRZ-1200"

Nuclear Power Generation

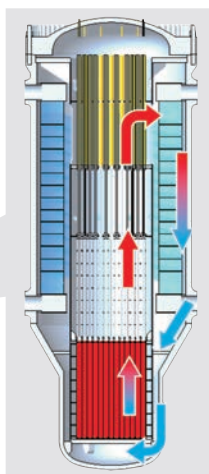
Stable power source that does not emit CO₂ during operation and is not affected by weather change.

Nuclear power generation makes use of energy generated by the nuclear fission.

While renewable power generation is changed by weather conditions, nuclear power generation is a stable power source that does not emit CO₂ during operation and is not affected by weather change. MHI is developing an advanced light water reactor "SRZ-1200" that will ensure the world's highest level of safety. Furthermore, MHI is also developing small light water reactor based on MHI's cultivated nuclear energy technology.



Small Light Water Reactor





A carbon dioxide capture plant

Carbon Dioxide Capture Plant

Can recover more than 90% of carbon dioxide.

Reducing carbon dioxide emissions to zero is essential in combating climate change (Goal 13 of the SDGs). Therefore, it is necessary to make efforts to capture carbon dioxide from the air, too. MHI's carbon dioxide capture technology is capable of capturing over 90% of the carbon dioxide contained in flue gas from power plants and other sources. Utilizing the recovered carbon dioxide as a resource in the future is being studied.

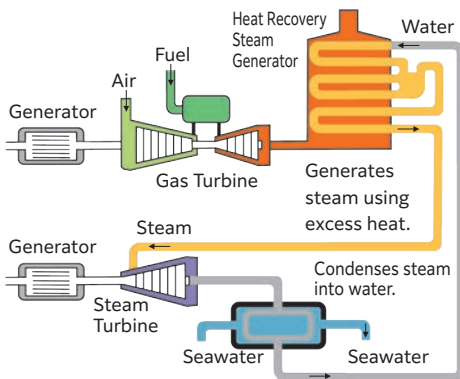
A GTCC facility. Thermal power is a power source that can flexibly adapt to demand and supports our daily lives.

New
Type

Gas-Fired Power

Reduces carbon dioxide emissions by 65% compared to other generation methods.

How the GTCC (Gas Turbine Combined Cycle) Works



Excess heat from the gas turbine is also used to generate electricity in the steam turbine. This is a state-of-the-art facility that can significantly reduce carbon dioxide emissions.

Renewable energy is environment-friendly, but because energy generation depends on the weather, it requires storage batteries and systems that allow entire cities to share electricity. As such, MHI has plans to employ state-of-the-art gas turbines that significantly reduce CO₂ emissions to improve energy efficiency until a stable renewable energy system can be established.

Geothermal Power Generation

Rainwater heated by underground magma produces steam, which rotates a turbine, producing electricity.

**Uses renewable energy.
Generate electricity from the heat of magma.**

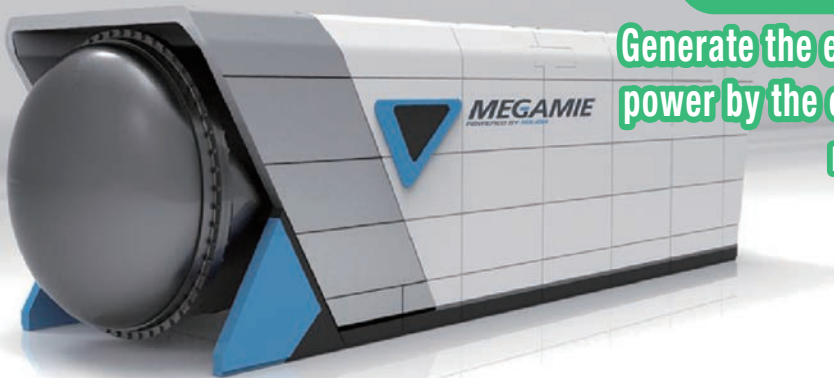


KenGen's 105MW Olkaria II Geothermal Power Plant. Source: Kenya Electricity Generating Company (KenGen) PLC

▲ A geothermal power plant in Kenya. With the construction of these power plants, Kenya's electrification rate increased from 32% (2014) to 75% (2018). Kenya generates more than 85% of its electricity from renewable sources.

Fuel Cells

**Generate the electrical
power by the chemical
reaction.**



▲ Solid oxide fuel cells (SOFC) provide the electricity and heat (which create steam and/or hot water). The system aims to contribute the zero carbon dioxide emissions by utilizing hydrogen as fuel.

The system which can generate the electrical power by the chemical reaction. Various kinds of GAS can be applied as fuel. (For ex. Hydrogen, biogas, etc)

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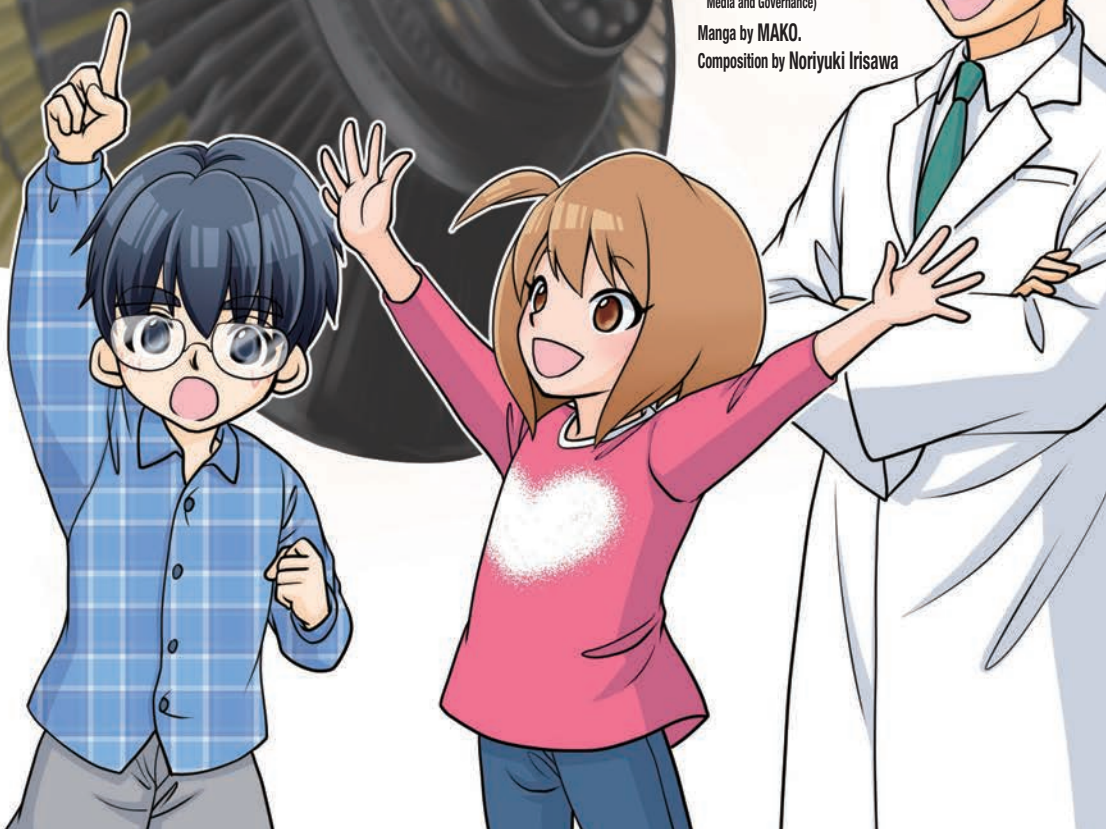


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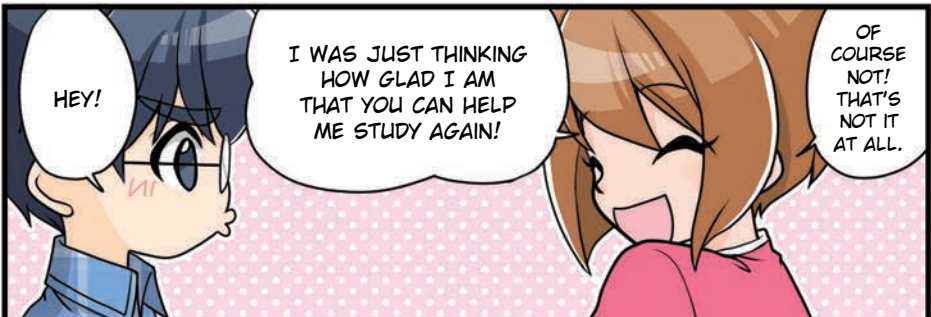
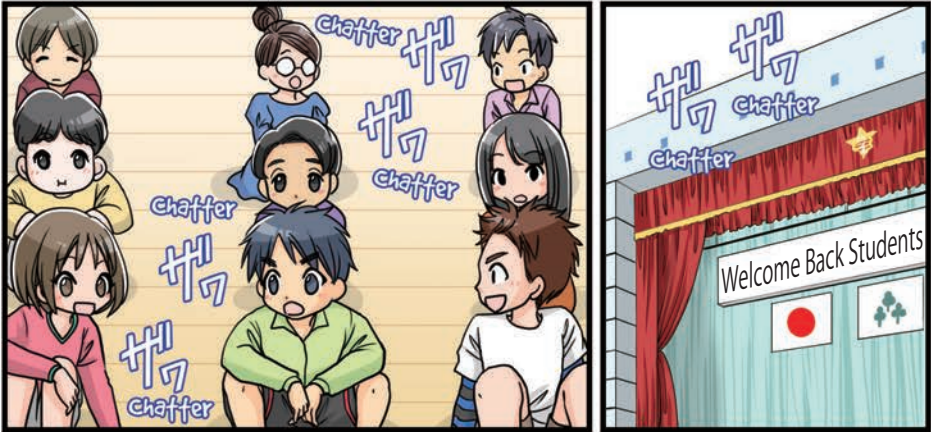
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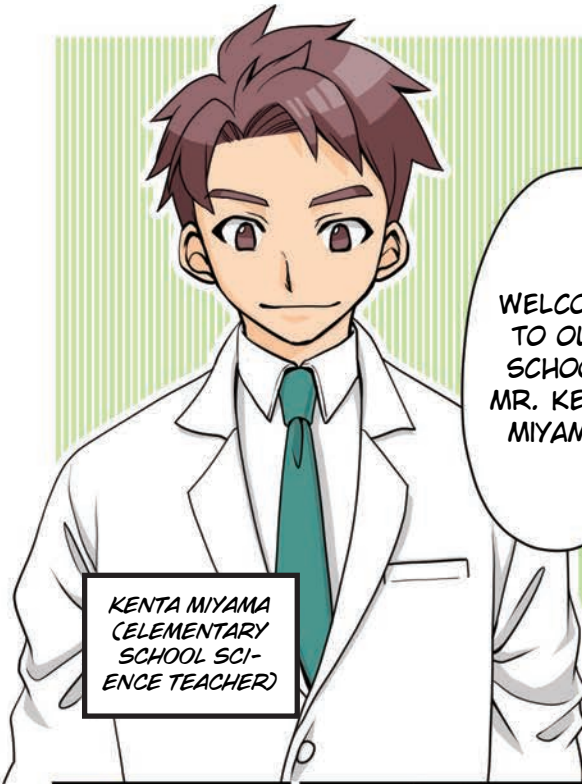
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PROLOGUE

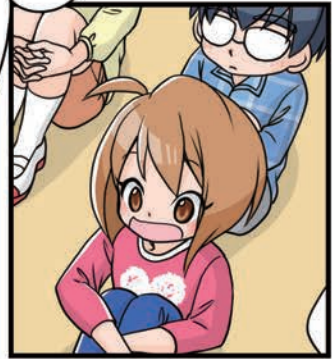
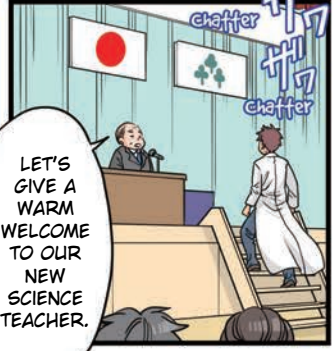




KENTA MIYAMA
(ELEMENTARY
SCHOOL SCIENCE
TEACHER)

WELCOME TO OUR SCHOOL, MR. KENTA MIYAMA!

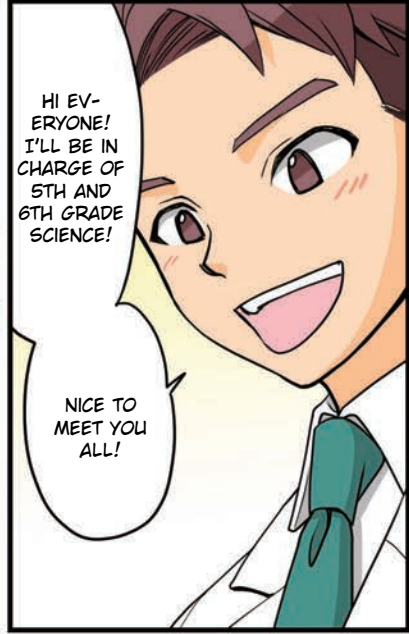
LET'S GIVE A WARM WELCOME TO OUR NEW SCIENCE TEACHER.



NO WAY!
WHAT A
COINCIDENCE!

FOR REAL
!?

HE'S MY
COUSIN...



HI EVERYONE!
I'LL BE IN
CHARGE OF
5TH AND
6TH GRADE
SCIENCE!

NICE TO
MEET YOU
ALL!



NO WAY!
KENTA!?

Whaaaa!

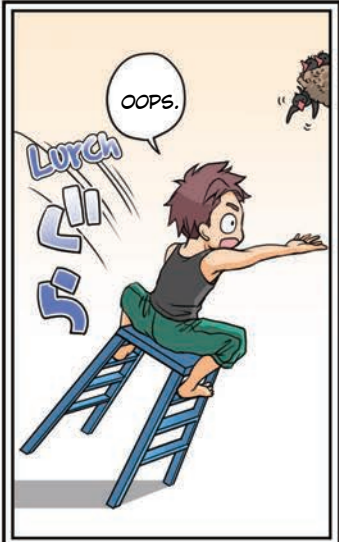
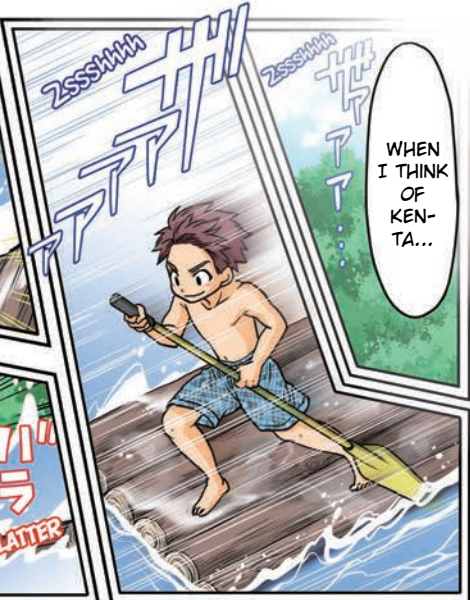
HE
HAS THE
SAME
LAST
NAME
AS YOU,
AKARI.

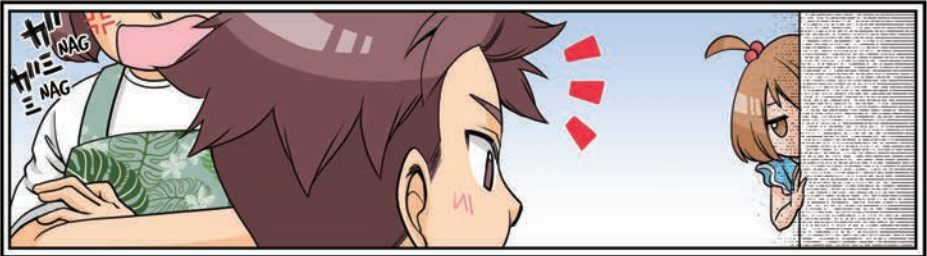
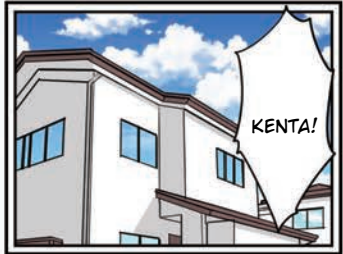
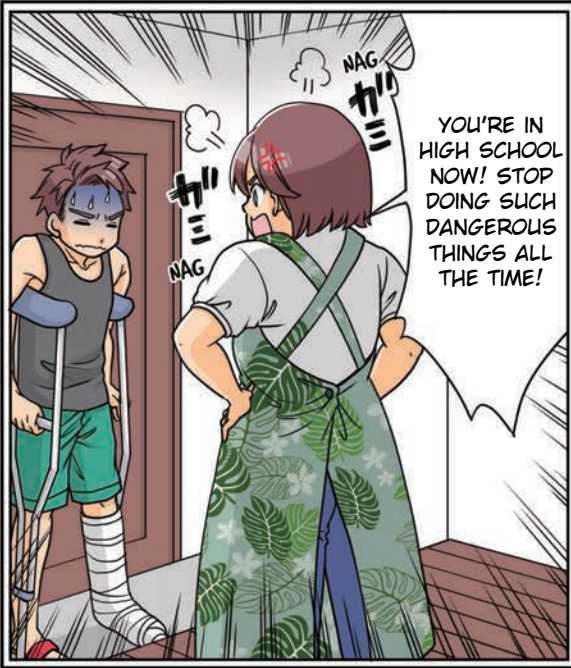


PROLOGUE

TRIVIA

JAPAN'S REVISED EFFORTS FOR ACHIEVING THE SDGs* LISTS "PLANET" AS A PRIORITY, WHICH FEATURES SDG 7 AIMS.







Aqueous Solutions

Science Lab

SPEAKING OF WHICH, DO YOU KNOW WHAT WATER IS MADE OF?

AS YOU CAN SEE, WATER IS A TYPE OF MATTER WHICH MANY THINGS CAN BE DISSOLVED IN.

SOMEONE KNOWS THEIR STUFF.

NICE!

SO... HYDROGEN AND OXYGEN?

WATER'S H₂O, RIGHT?

YOU JUST WANT TO DO AN EXPERIMENT.

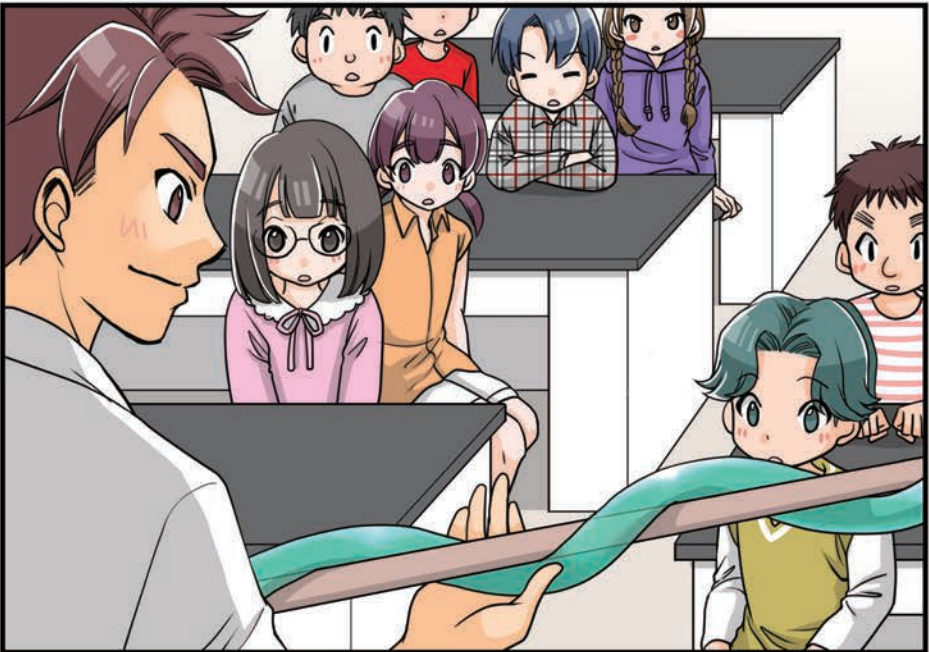
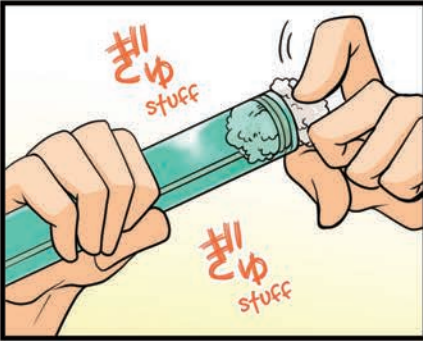
COMMEMORATE ...?

ぼんぼん Mutter

...WE'RE GOING TO MAKE REAL WATER WITH HYDROGEN AND OXYGEN!

TO COMMEMORATE OUR LESSON ON AQUEOUS SOLUTIONS...

Wooww!!
わあ~!!



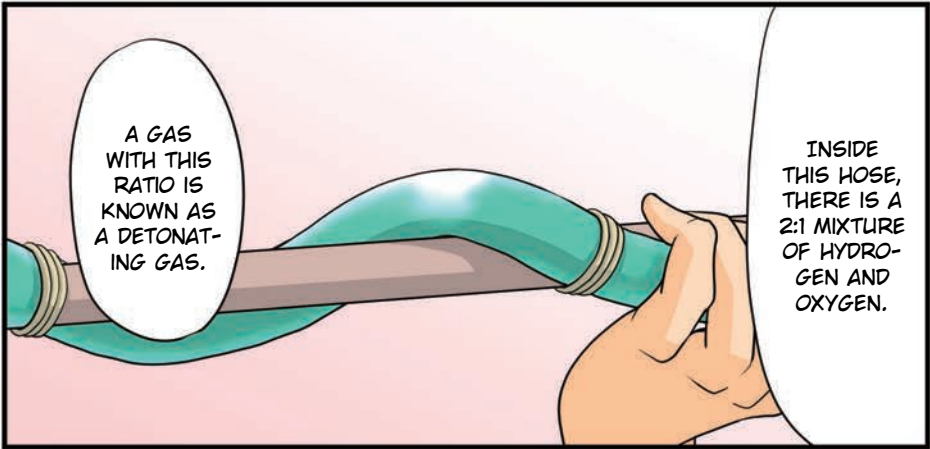
NOTE: NEVER DO THIS EXPERIMENT ON YOUR OWN. ALWAYS DO IT UNDER THE GUIDANCE OF A SCIENCE TEACHER.



PROLOGUE

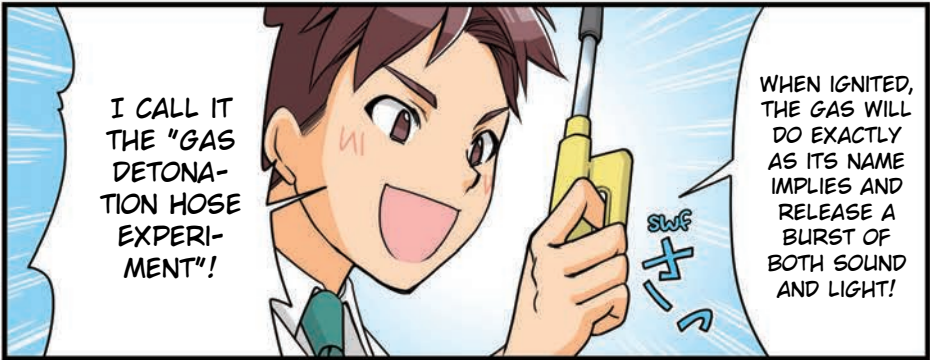
TRIVIA

HYDROGEN GAS HAS BEEN USED IN GAS BALLOONS SINCE 1783.



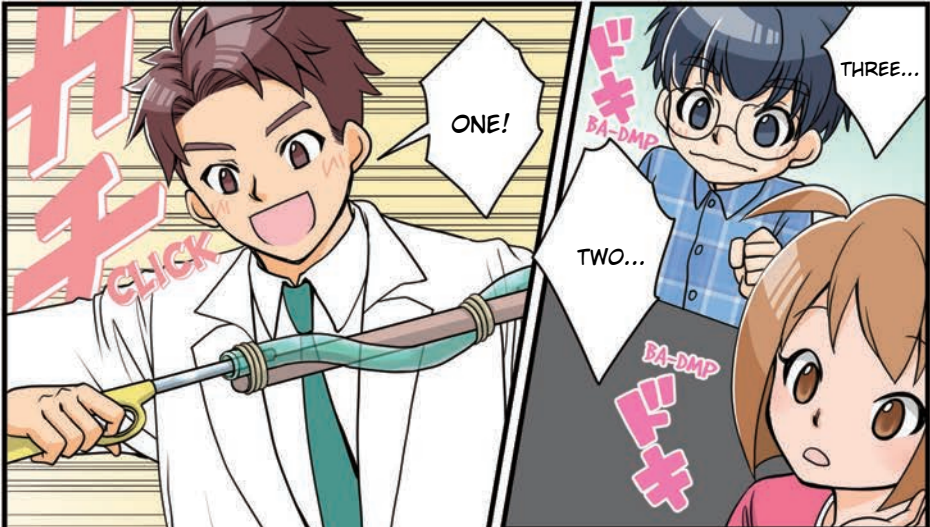
A GAS WITH THIS RATIO IS KNOWN AS A DETONATING GAS.

INSIDE THIS HOSE, THERE IS A 2:1 MIXTURE OF HYDROGEN AND OXYGEN.



I CALL IT THE "GAS DETONATION HOSE EXPERIMENT"!

WHEN IGNITED, THE GAS WILL DO EXACTLY AS ITS NAME IMPLIES AND RELEASE A BURST OF BOTH SOUND AND LIGHT!



CLICK
ONE!

TWO...
THREE...
BA-DMP
ドキ

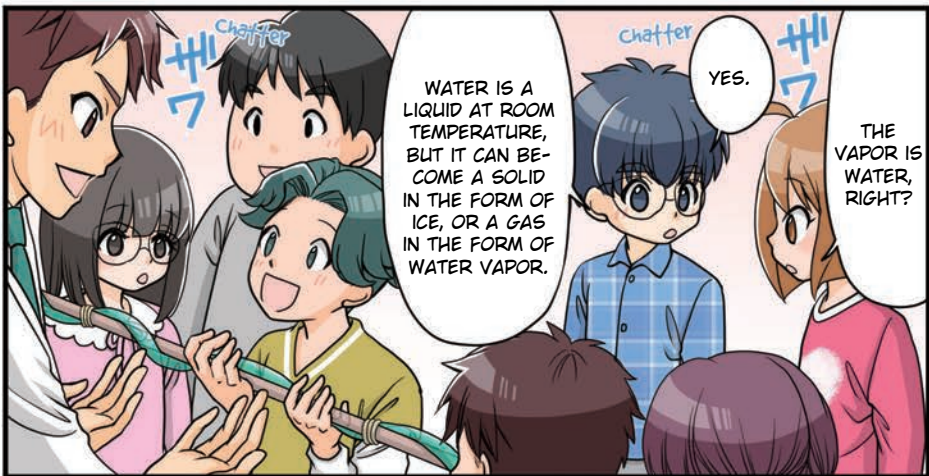
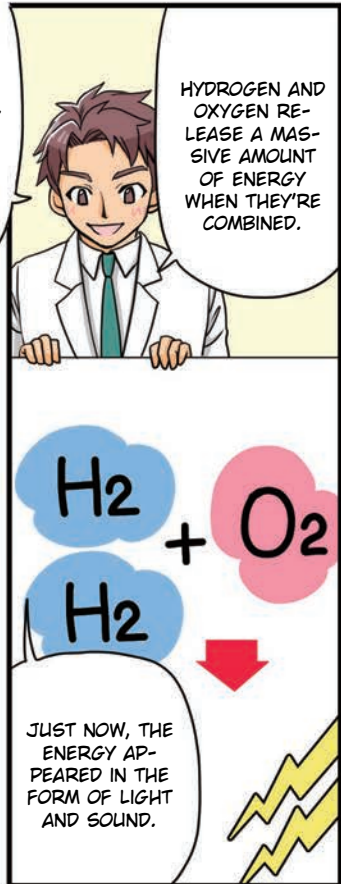
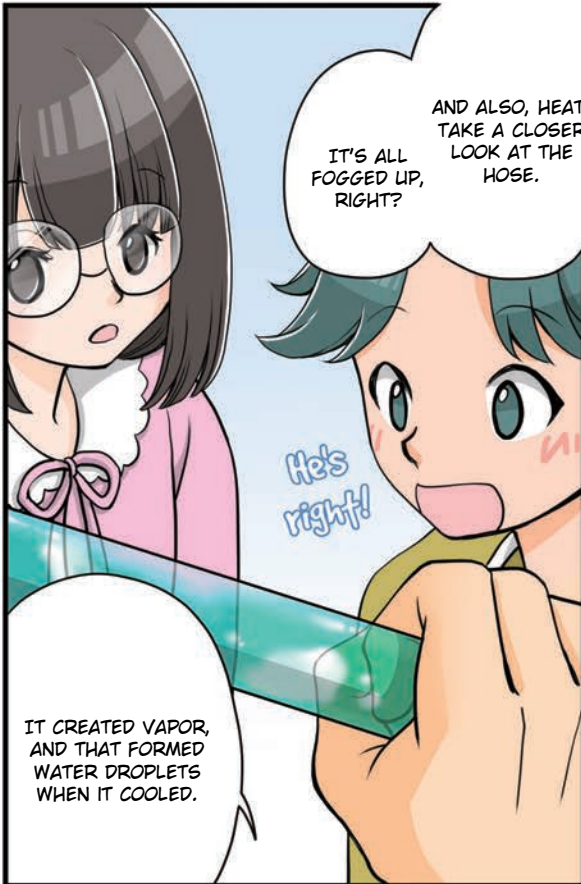


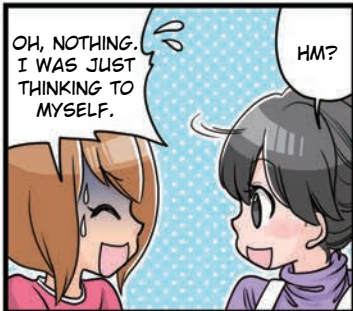
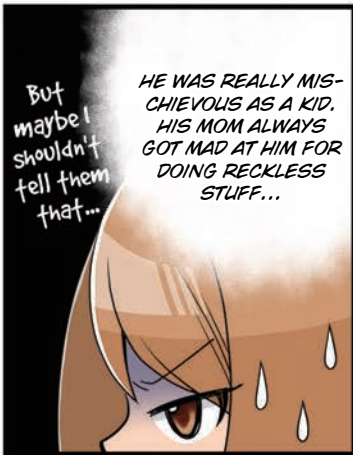
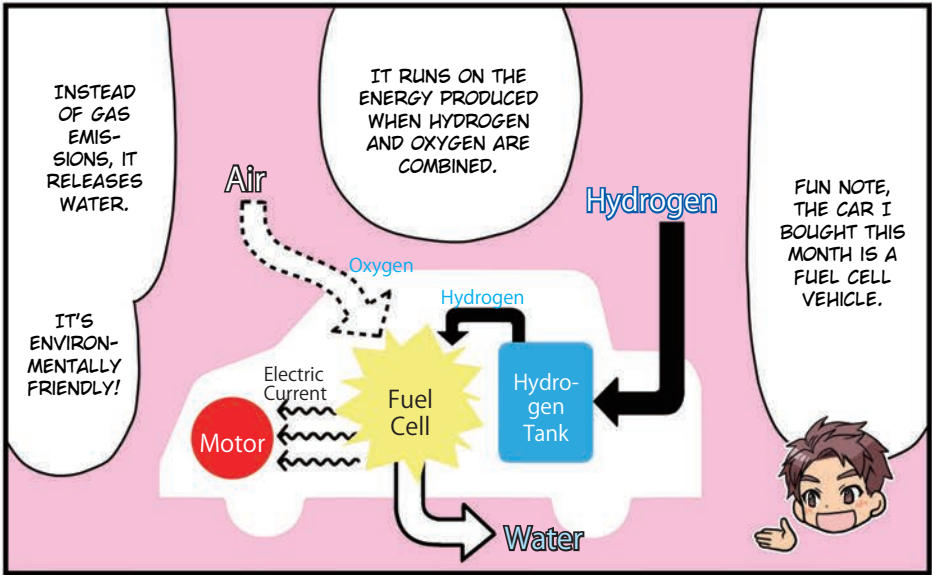


PROLOGUE

TRIVIA

IN SCIENCE, THE WORD "ENERGY" MEANS THE POWER TO MAKE SOMETHING MOVE, LIGHT UP, OR HEAT UP. CHECK PAGES 29 AND 39 FOR MORE INFORMATION.

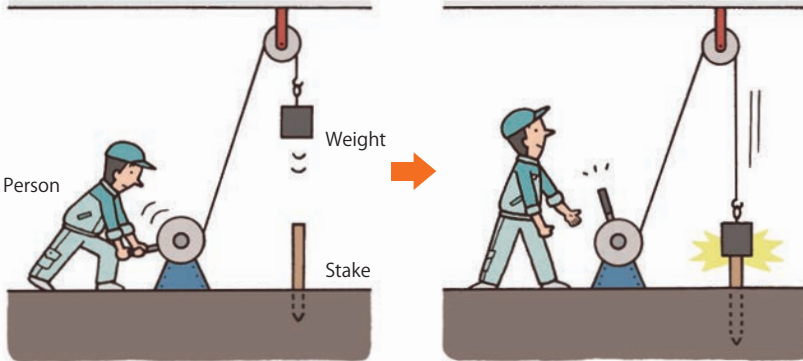






WHAT'S ENERGY? PART 1

IN SCIENTIFIC TERMS, MAKING SOMETHING MOVE OR PICKING SOMETHING UP IS CALLED "WORK." THE POWER THAT LETS SOMETHING WORK IS CALLED "ENERGY."



THE PERSON USES ENERGY TO WORK WHEN LIFTING A WEIGHT UP. THE ENERGY THE PERSON HAD IS TRANSFERRED TO THE WEIGHT THAT WAS RAISED INTO THE AIR.

NOW THAT THE WEIGHT HAS ENERGY, IT WILL FALL DOWN, HITTING THE STAKE AND PERFORMING WORK ON IT. IN THIS WAY, ENERGY IS TRANSFERRED THROUGH WORK.

HOW FUEL CELL VEHICLES WORK

BECAUSE GASOLINE PERFORMS WORK WHEN IT MOVES A VEHICLE'S ENGINE, IT IS SAID TO HAVE ENERGY. HOWEVER, THE FUEL THAT A FUEL CELL VEHICLE USES ISN'T GASOLINE. IT'S HYDROGEN. A CHEMICAL REACTION USING HYDROGEN TO MAKE WATER CREATES ELECTRICITY, WHICH IS THEN USED AS ENERGY BY THE FUEL CELL.



Fuel Cell Truck
Image: Tokyo R&D Co.,Ltd

