

# ***Lesson 1***

## ***Current Status and Issues of Electric Power Generation***

***February 2013***

***For Elementary School***

# ***Introduction of Japan Aerospace Exploration Agency (JAXA)***

*JAXA makes research and development in two fields; space and aeronautics.  
The activities in the field of space are shown in general below;*

***Launch satellites and spacecraft***



***to study the universe***



***“HAYABUSA” etc***

***to utilize the space for humans***



***“International Space Station” etc***

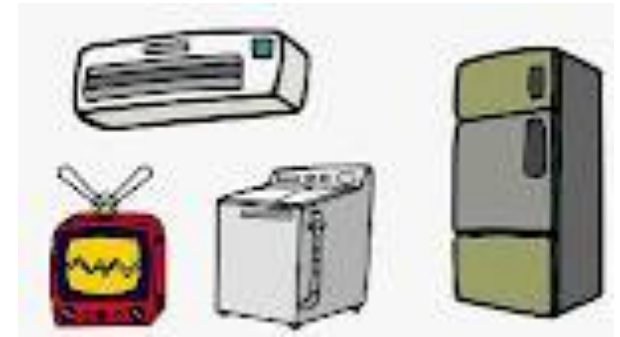
# ***“Electricity” is very important in our daily life.***



***Manufacturing plant***



***School lighting***



***Household electric appliance***



***Electric car***

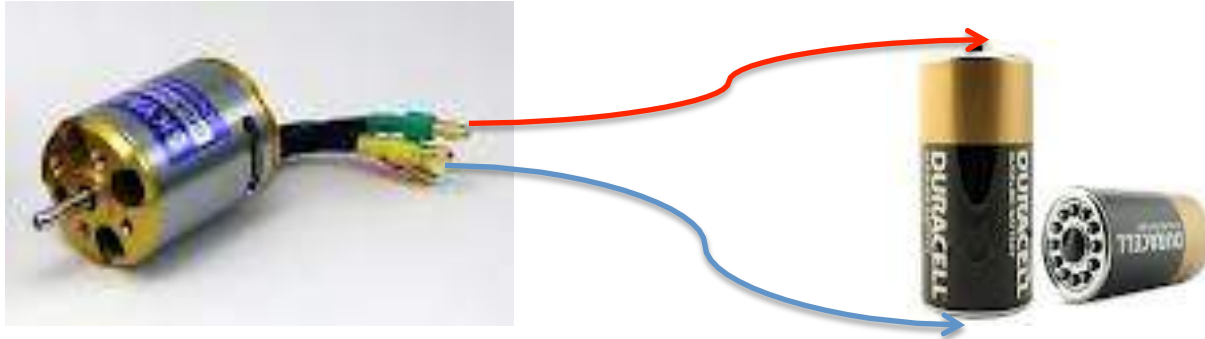


***Railway power source***

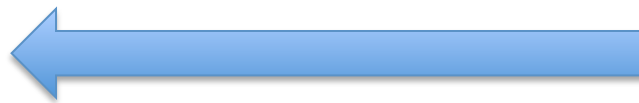


***City Illumination***

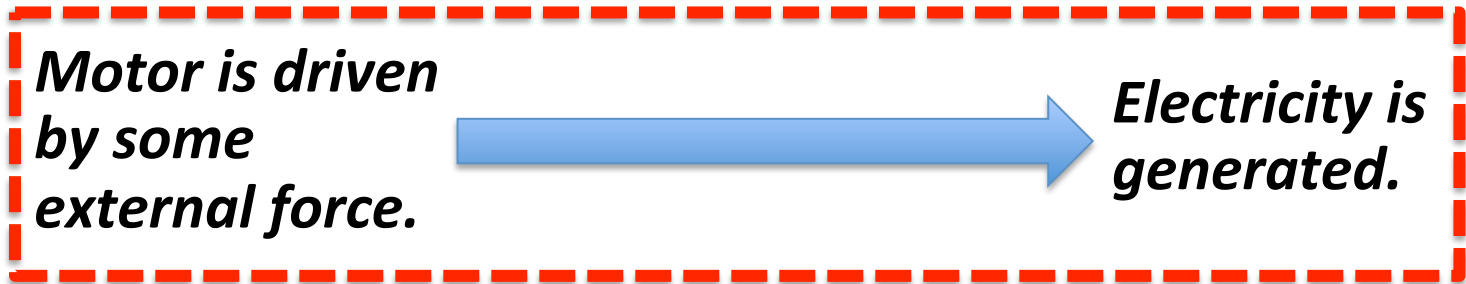
# How to generate electricity ?



*Motor is driven  
by electricity.*



*Electricity from  
battery.*



***Electric power generation***

## *Examples of Electricity Generator*



***Generator for bicycle light***



***Hand-working light***

# Power Generation and Consumption

## Power Station



Hydroelectric power plant



Thermal power plant



Nuclear power plant



Transmission network



## Power Consumption



Factories



Transportation



Homes

Before Fukushima  
Disaster (in Japan)

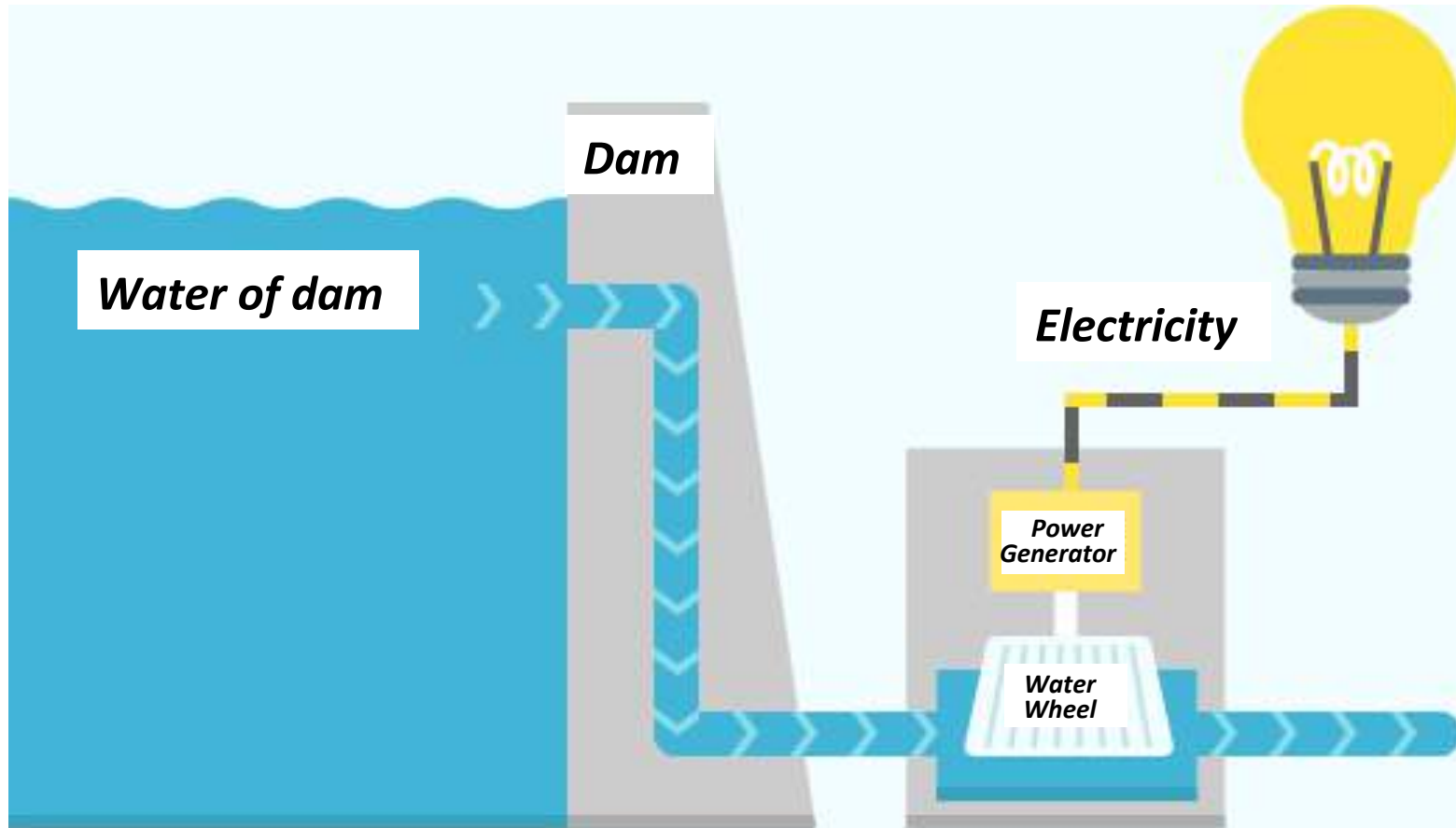
# *Hydroelectric Power Plant and Dam*



<http://www.info-toyama.com/spot/31038/>

# ***Mechanism of Hydroelectric Power Plant***

***Energy of falling water is used to rotate the power generator.***



<http://www.sbenergy.jp/study/illust/water/>



# *Thermal Power Plant*



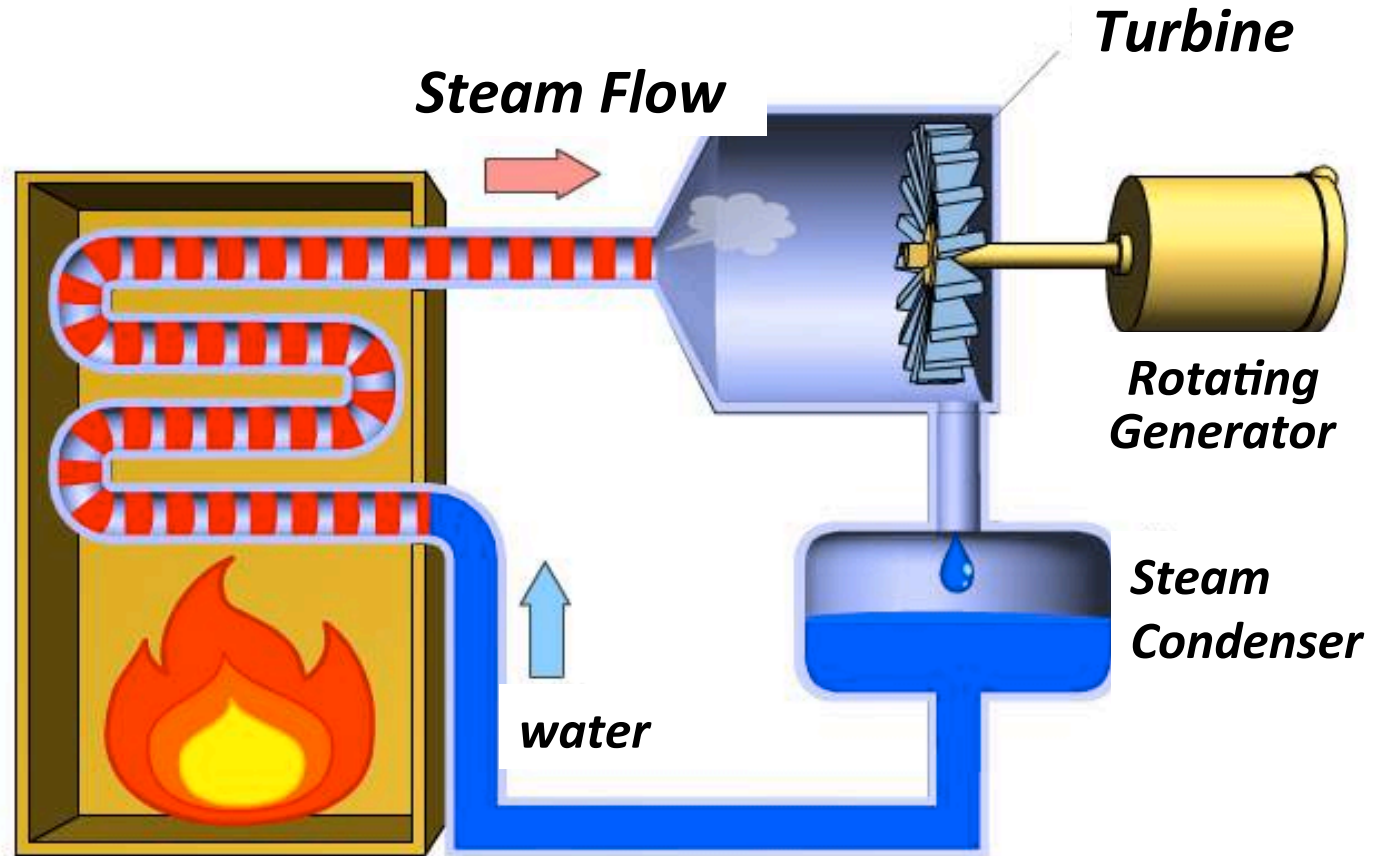
[http://gazone.morrie.biz/keizai/kkt/sin\\_kokura\\_hatudensyo.html](http://gazone.morrie.biz/keizai/kkt/sin_kokura_hatudensyo.html)

# Mechanism of Thermal Power Plant

Steam



*Steam is generated when water is boiled.*



**Combustion of Coal, Petroleum, Natural gas.  
Fuel is burned with atmospheric oxygen.**

<http://www.fepc.or.jp/enterprise/hatsuden/fire/>

# ***Nuclear Power Plant***



<http://www.tepco.co.jp/nu/f2-np/index-j.html>

***Fukushima Daini Nuclear Power Station***

# Mechanism of Nuclear Power Plant

*Steam is generated when water is boiled.*

**Boiler**

**Electricity**

**Steam flow** **Generator**

**Nuclear fission**

**Uranium 235**

**Neutron**

**Nuclear fission**

**Steam**

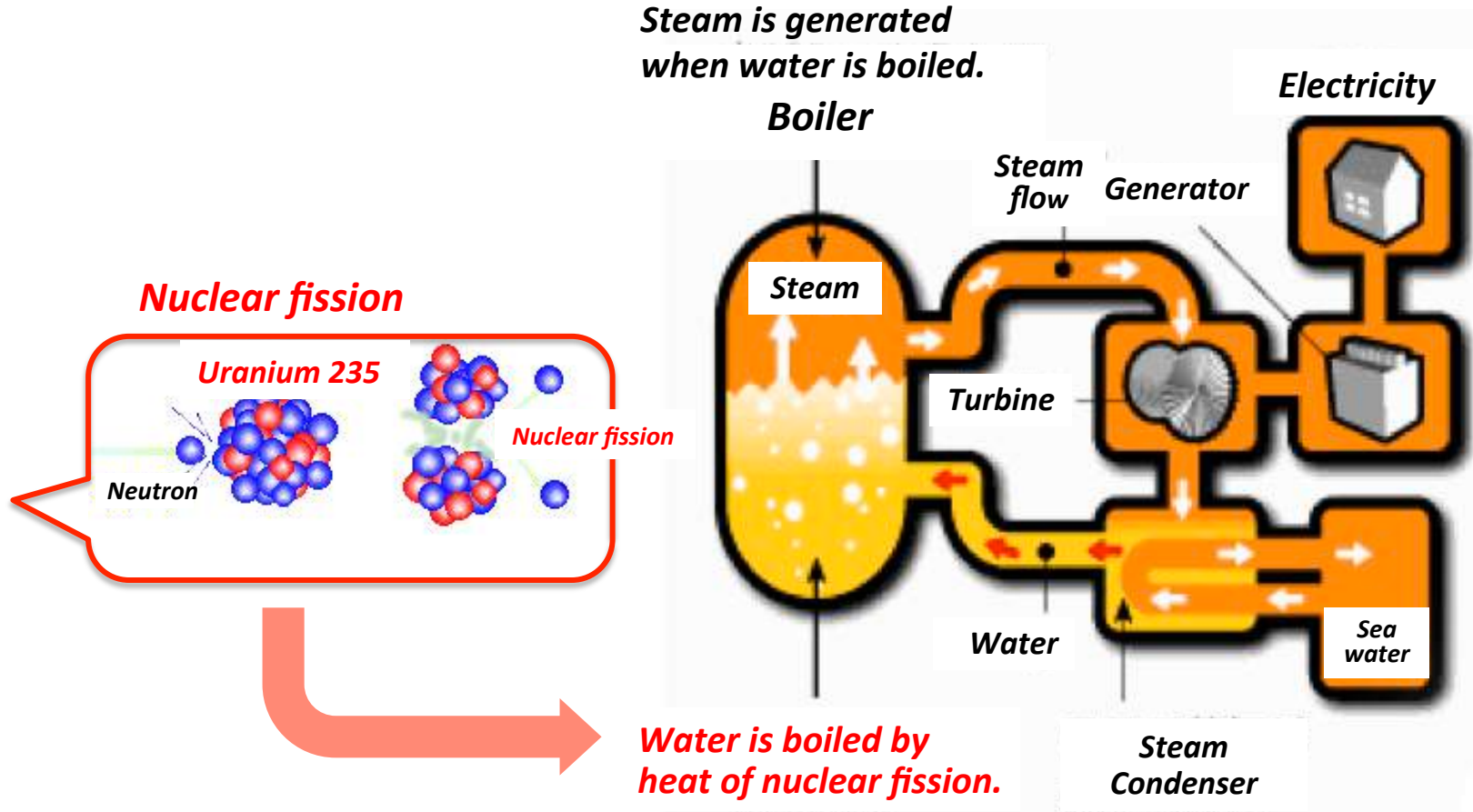
**Turbine**

**Water**

**Sea water**

**Water is boiled by heat of nuclear fission.**

**Steam Condenser**



[http://www.chuden.co.jp/kids/kids\\_denki/tsukuru/tsu\\_nuclear//](http://www.chuden.co.jp/kids/kids_denki/tsukuru/tsu_nuclear//)

# *Disaster of Fukushima Daiichi Nuclear Power Station*

*March 2011*



<http://www.tepco.co.jp/decommision/accident/index-j.html>

*Nuclear power stations will be re-operated after the saifty is fully confirmed by the new government requirements.*

*However, since many people are seriously concerned about the safety of nuclear power station, nuclear power station will not be used as many as before.*

# Current Situation of Power Generation

## Power Station



Hydroelectric power plant



Thermal power plant



Nuclear power plant

*Insufficient supply*



Transmission network

*Nearly zero after Fukushima Disaster In Japan  
(about 20% was supplied before the disaster)*



Factories



Transportation



Homes



# Power Saving !



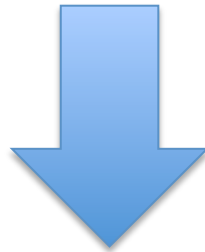
*Pictures:*

*<http://environment-illustration.com/economy/economy-dl-02.html>*

*<http://heisei.cocolog-nifty.com/heisei/2011/07/post-39b4.html>*

*<http://www.city.iruma.saitama.jp/blog/16kaneko/2011/05/post-76.html>*

*In reality, we will face **electricity shortage** in future even if we had not the Fukushima disaster.*

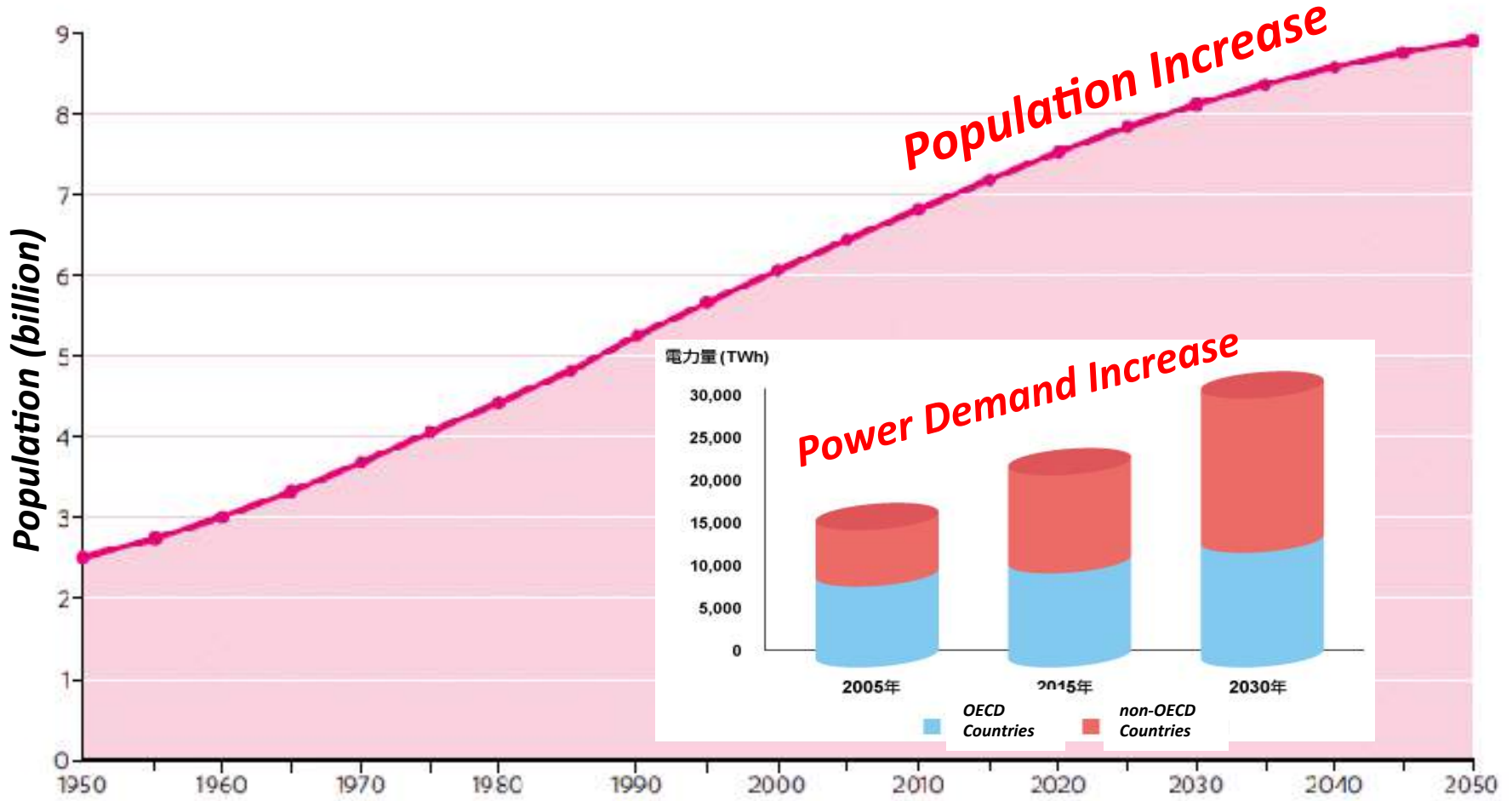


*We need **new type of power plant**, because the power capability of the current plants will not be increased or even reduced in future, while electric power demand will be certainly increased.*



# Increase of Electric Power Demand

Population Statistics by the U.N. (1950-2050)



Source: UN Population Division



now

# Future of Power Plants Currently in Operation



*Hydroelectric power plant*

**Available lands for hydroelectric power plants are limited. It will be difficult to construct them much more. *A sustainable solution for future, but we can not depend on them so much.***



*Thermal power plant*

**Fossil fuel resources will be depleted. Burning fossil fuels increases CO<sub>2</sub> emission and causes global environmental degradation. We will be unable to maintain the thermal power plants as many as we have.**

***Not a sustainable solution for future.***



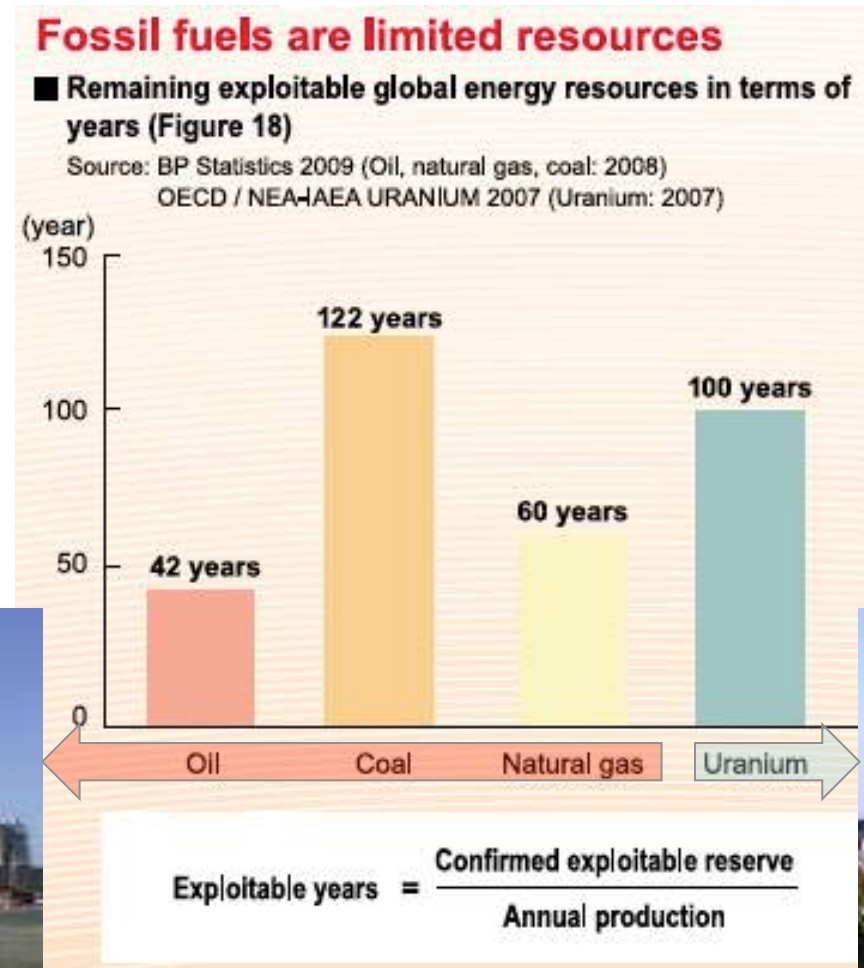
*Nuclear power plant*

**There is a big concern about the safety of the nuclear plant and nuclear waste. Uranium will be depleted in future.**

***Not a sustainable solution for future.***

# Reserves of Oil, Coal, Natural Gas, and Uranium

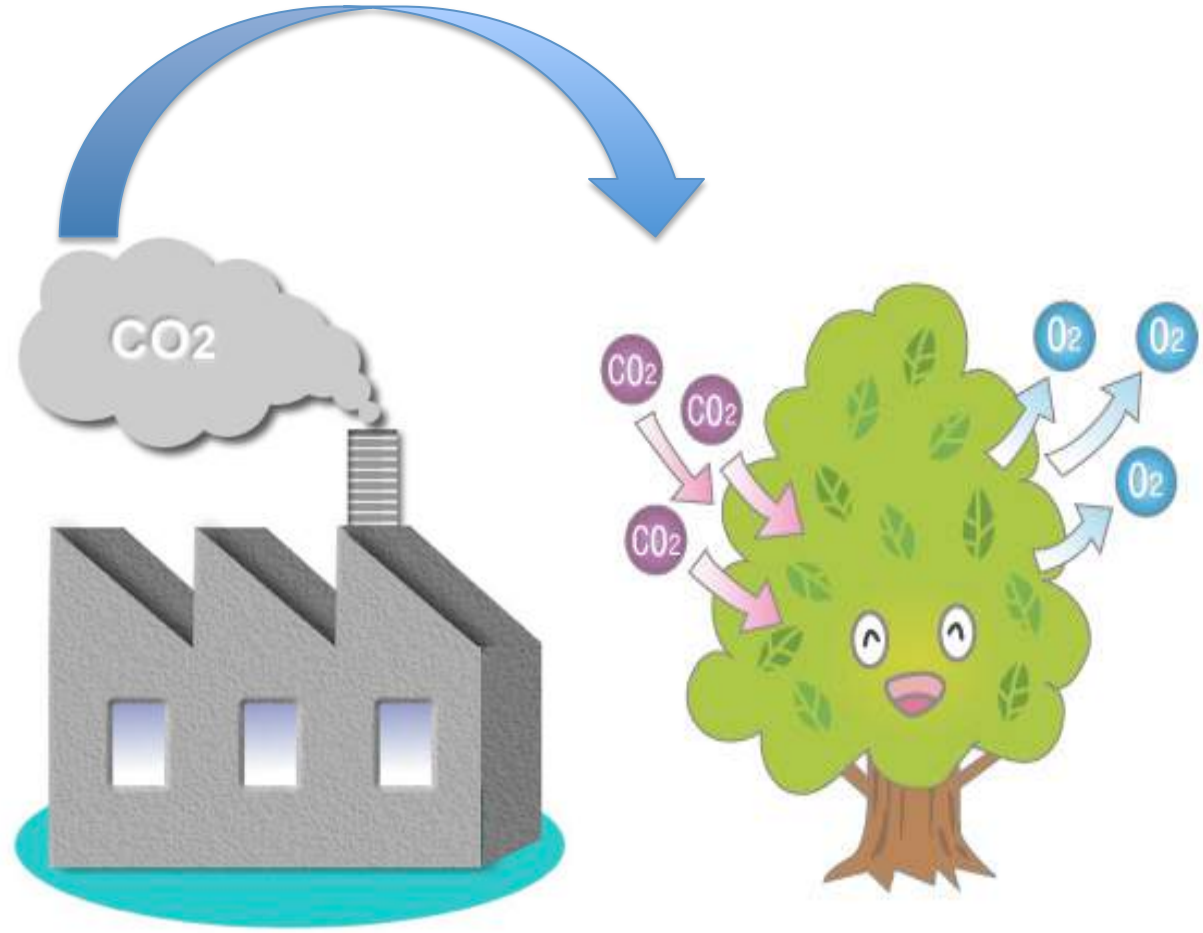
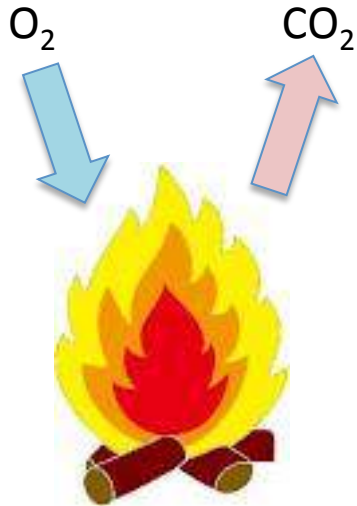
People around the world are heavily dependent on the fossil fuel, more than 80 %, but the fossil resources are limited.



# Balance of CO<sub>2</sub> and O<sub>2</sub>

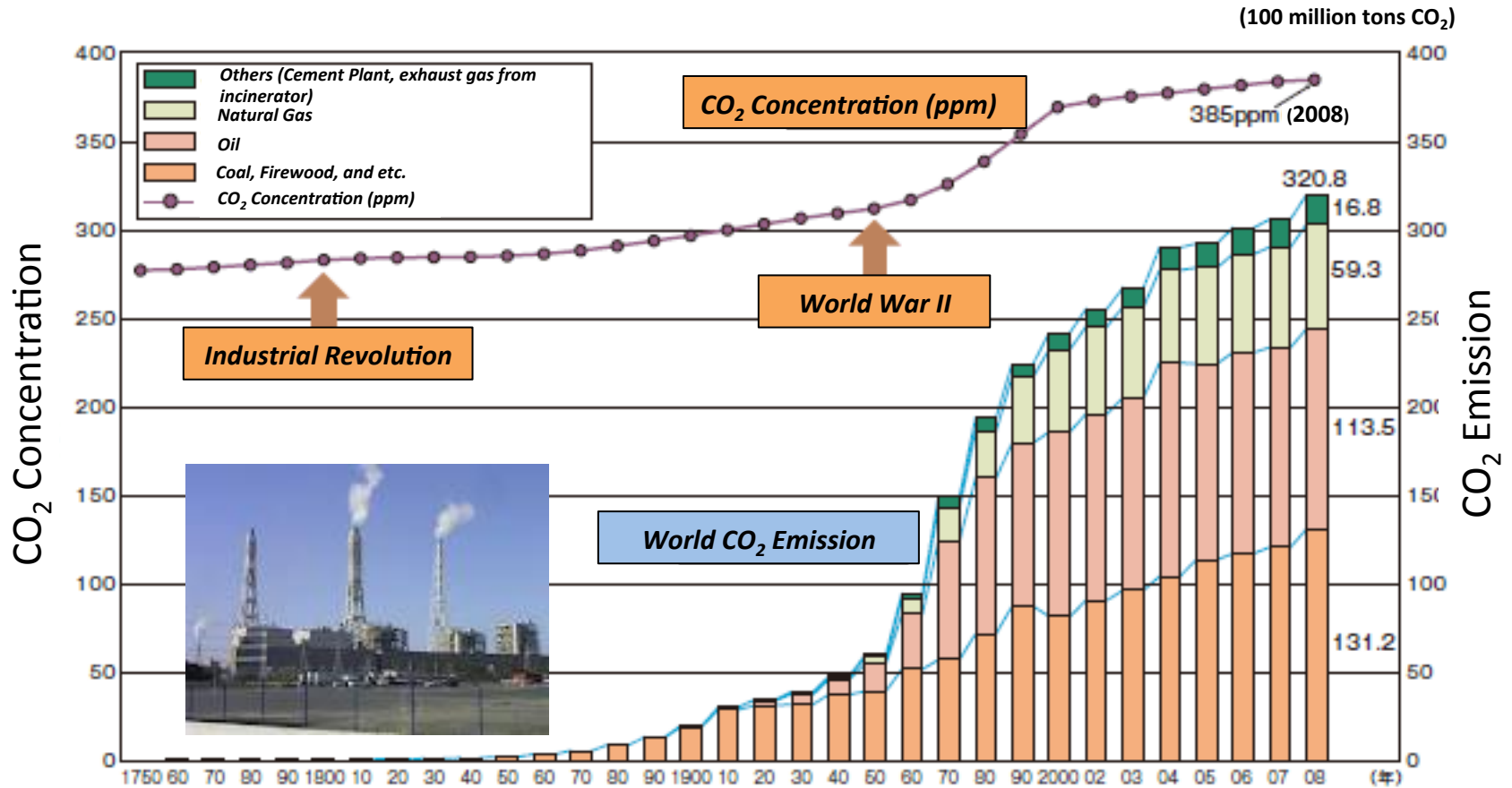
CO<sub>2</sub> generated at the thermal power plants is converted into O<sub>2</sub> by plants by using the energy of sunlight.

Burning fossil fuel  
generates CO<sub>2</sub>  
emissions.



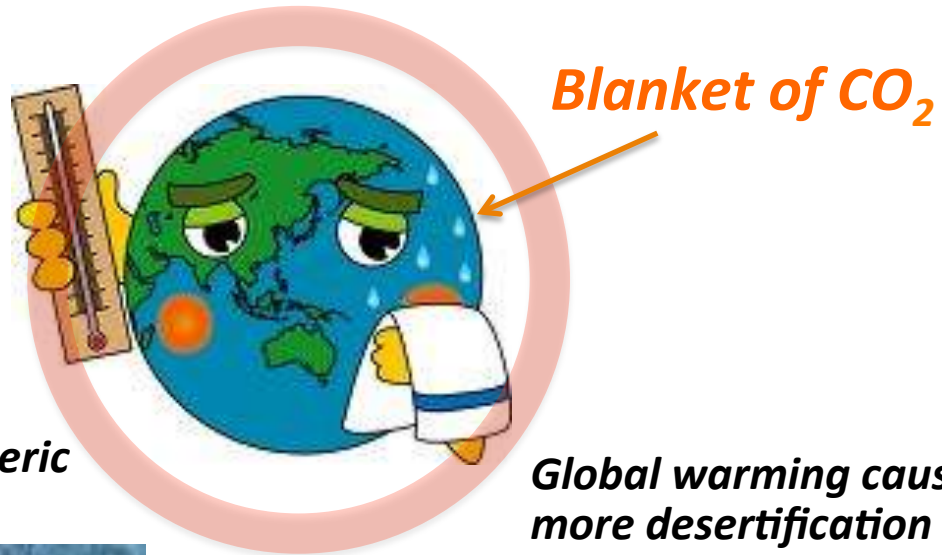
**Emitting CO<sub>2</sub> more than absorption by plants and others results in more CO<sub>2</sub> concentration in the atmosphere.**

# Relation between CO<sub>2</sub> Concentration and CO<sub>2</sub> Emissions



<http://www.yonden.co.jp/life/kids/teacher/datashu/tikyu4.html>

# The Issue of Global Warming



***Sea level rises as the atmospheric temperature rises ?***



***Global warming causes more desertification ?.***



***Note : IPCC established by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) predicts global warming. However, some climate scientists are insisting that we are headed into a period of global cooling. In any case, the artificial increase of CO<sub>2</sub> concentration will give adverse effects on the global environment.***

# ***What should we do ?***

***1. Use the power system that can be operated over a long time in future, not requiring limited natural resources.***

***2. Generate electricity using clean and safe power system.***



<b><i>Energy Type</i></b>	<b><i>Power Source</i></b>
<b><i>Renewable Energy</i></b>	<b><i>Photovoltaic power generation on ground</i></b>
	<b><i>Wind power generation</i></b>
	<b><i>Wave power generation</i></b>
	<b><i>Geothermal power generation</i></b>
	<b><i>Photovoltaic power generation in space</i></b>
<b><i>New Nuclear Energy</i></b>	<b><i>Nuclear fusion</i></b>

## ***Lesson 2***

# ***Renewable Energy Systems and New Energy Systems in Future***



# **Power Generation by Solar Photovoltaic cell**

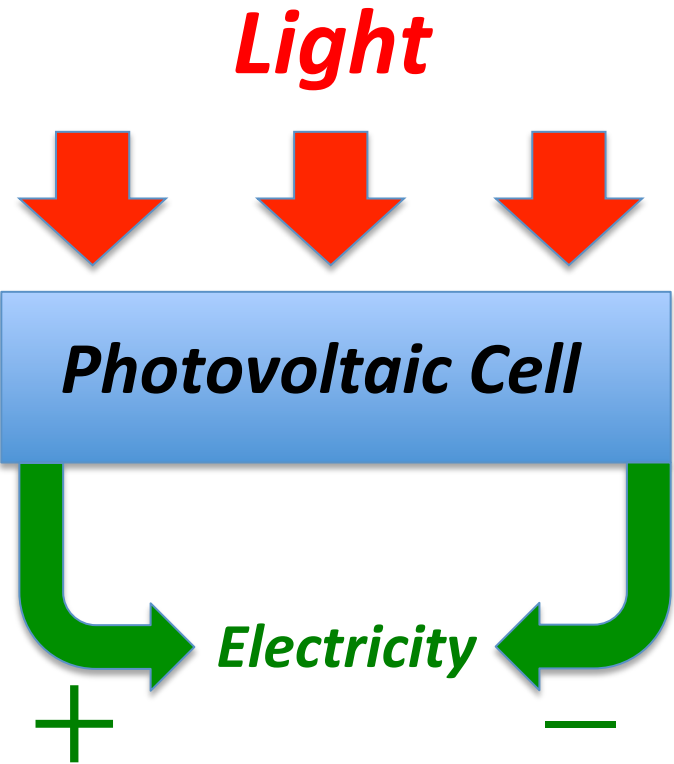
**Photovoltaic Cell**



**Pocket calculator**



**Solar watch**



***This method does not need any fuel, water, or air.***

# *Example of Photovoltaic Power Plant*



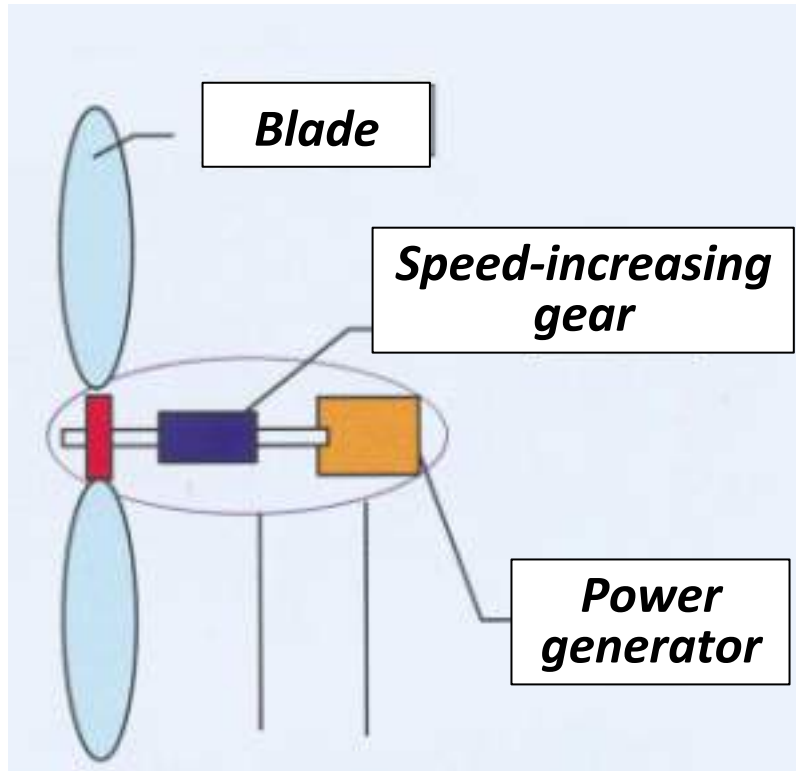
***80MW Power Plant in  
Canada (World largest,  
2010, 1km<sup>2</sup> approx.)***



***70 MW Power Plant in  
Kagoshima, Japan***

***One plant can supply power to approximately 20,000 – 30,000 households***

# *Principle of Wind Power Generation*



*Miniature model of wind-power generator for children*

# *Wind Power Generation*



[http://www.enecho.meti.go.jp/category/saving\\_and\\_new/saiene/renewable/wind/index.html](http://www.enecho.meti.go.jp/category/saving_and_new/saiene/renewable/wind/index.html)

## ***Wave Power Generation***



***Power generation turbine is rotated by the force of sea surface wave motion, up and down.***

<http://www.jamstec.go.jp/j/kids/tazunete/022/>

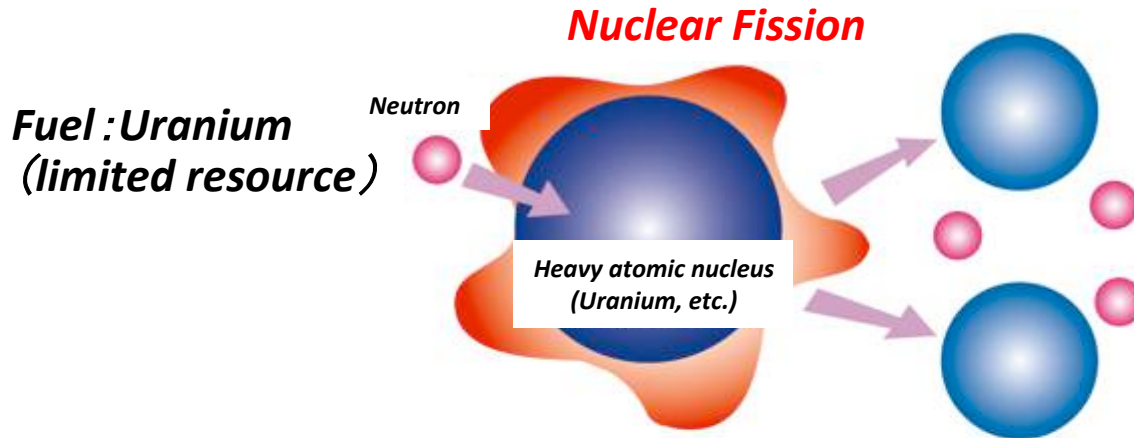
## ***Geothermal Power Generation***



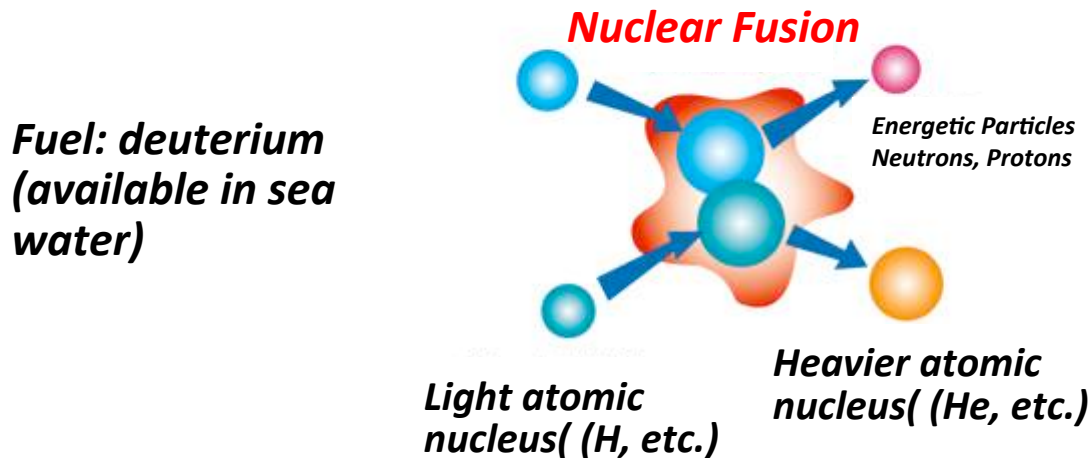
***Power generation turbine is rotated by geothermal steam.***

[http://www.enecho.meti.go.jp/category/saving\\_and\\_new/saiene/renewable/geothermal/index.html](http://www.enecho.meti.go.jp/category/saving_and_new/saiene/renewable/geothermal/index.html)

# Two Types of Reaction for Nuclear Energy Release: Nuclear Fission and Nuclear Fusion



**Nuclear Fission Power Plant**  
There are problems related to safety and nuclear waste.

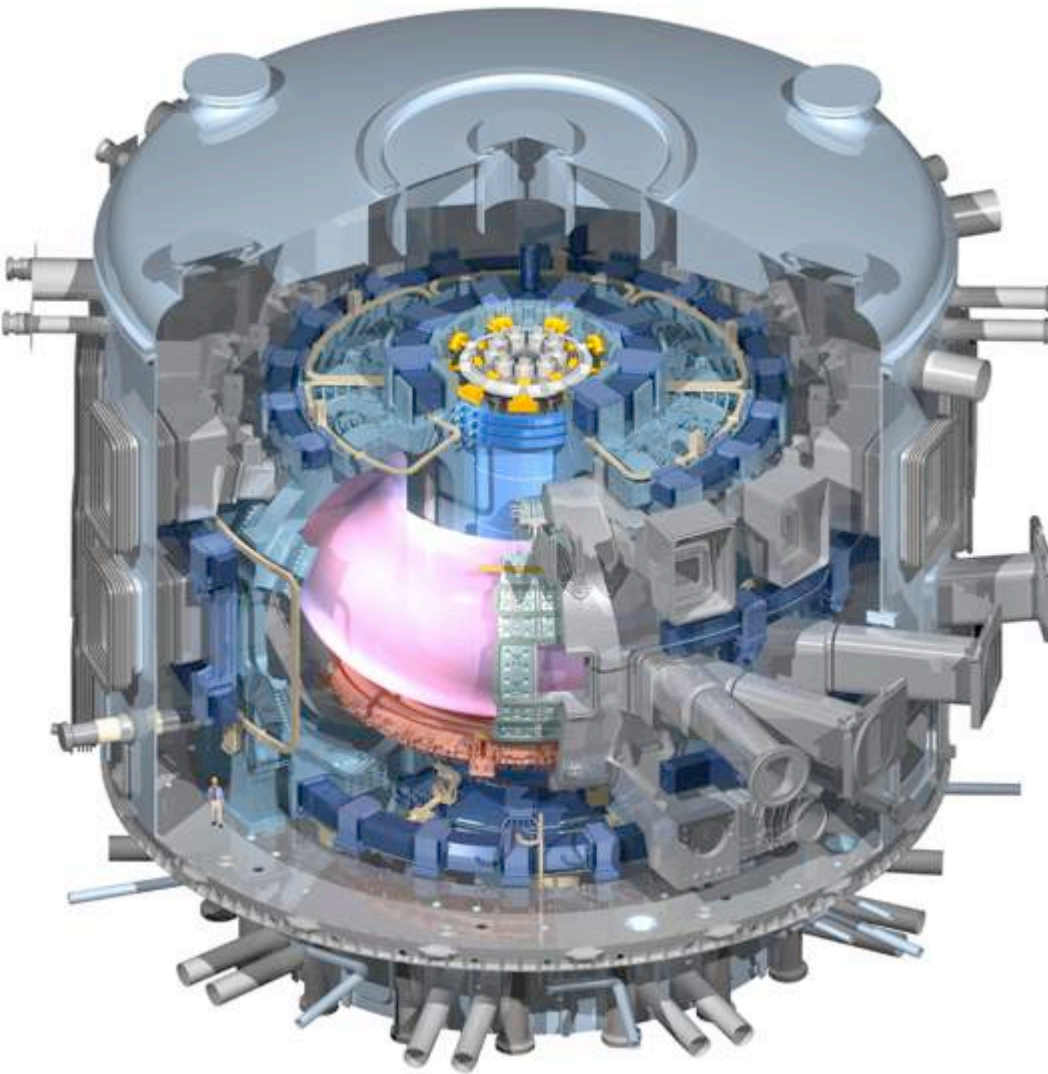


**Nuclear Fusion Power Plant**  
High level safety could be realized, not certain yet.



Nuclear fusion is the same process as that at the core of our sun

# *Research for Nuclear Fusion*



*International Thermonuclear Experimental Reactor(ITER)*

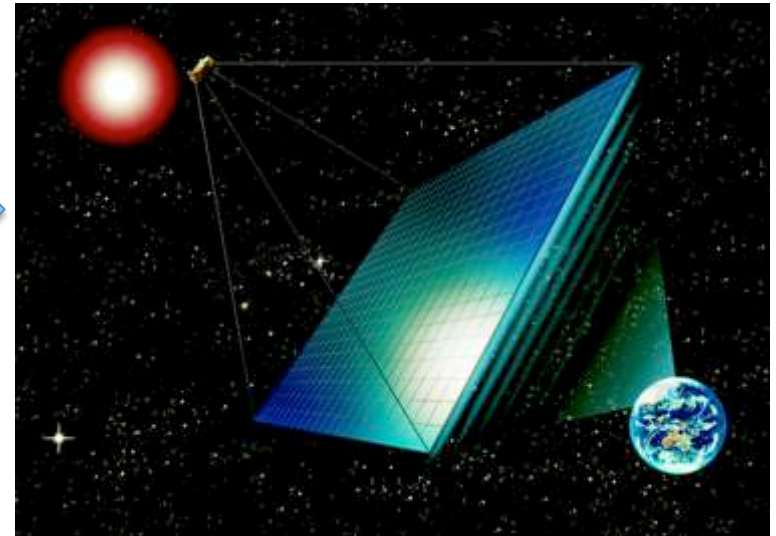
*The project is funded and run by seven member entities — Japan, European Union, India, China, Russia, South Korea, and United States. It is believed it takes another 20-30 years to realize the commercial nuclear fusion plant.*



# ***Photovoltaic Power Plant in Space – Solar Power Satellite (SPS) –***



***Transportation of the  
plant subsystem to space  
by reusable rockets***



***Assembly of subsystems into  
Solar Power Satellite in space***



***Photovoltaic Power Plant on Ground***



# Advantages of Solar Power Satellite (SPS)

## Solar Power Plant on Ground



*Rainy and cloudy days*



*Night*

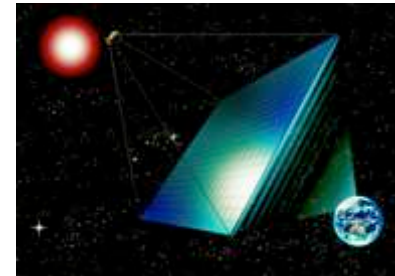


*Land problem*

## Solar Power Plant in Space



*No rainy or cloudy day*



*No night (depending on the orbit)*

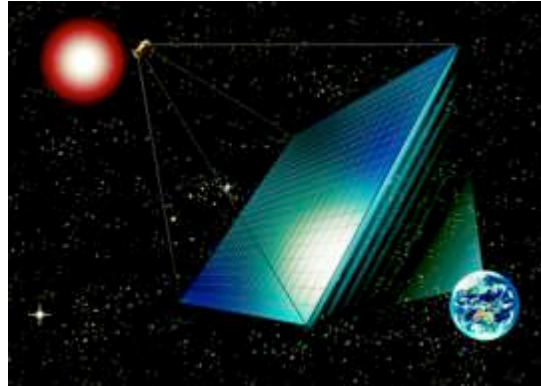


*No land problem*

*Contrast*

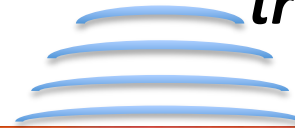


# Image of Solar Power Satellite



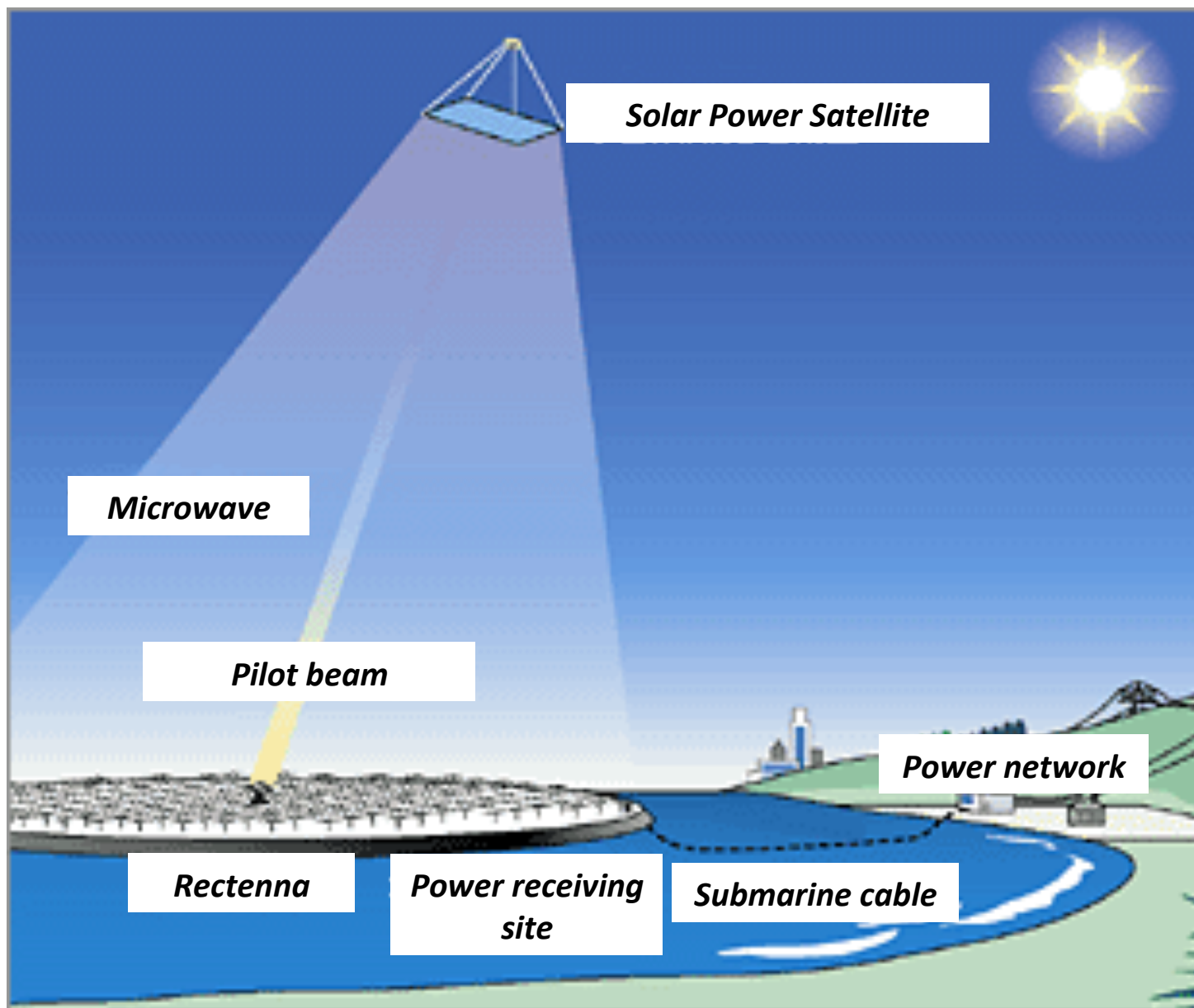
***Power is transmitted to the ground using microwave or laser (wireless power transmission).***

***Microwaves in daily life***

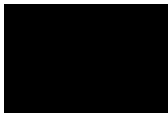


***Rectenna site in the sea near the shore (an example)***

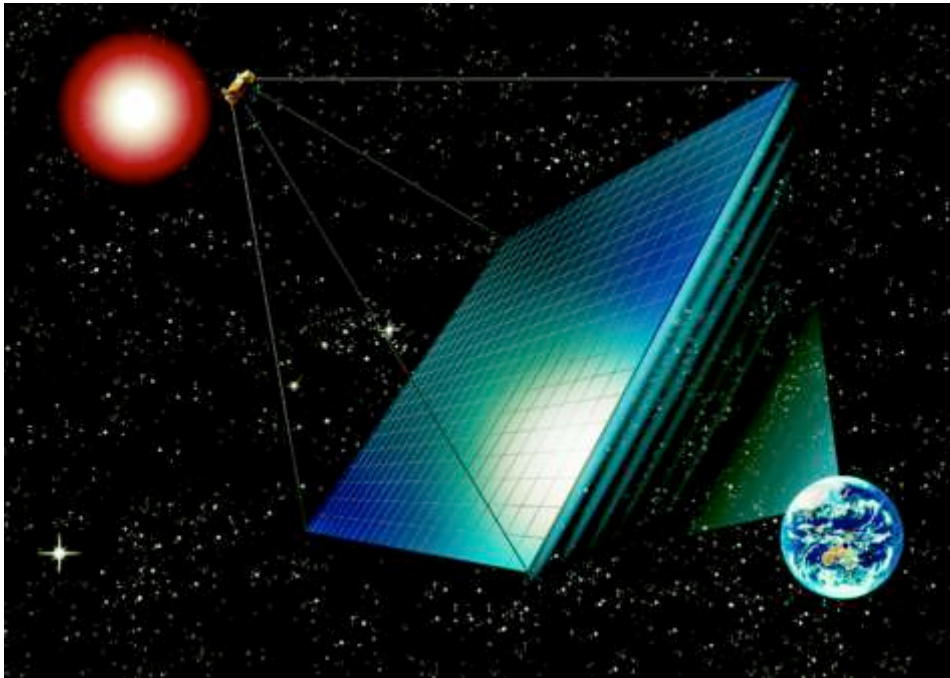
# Image of Solar Power Satellite



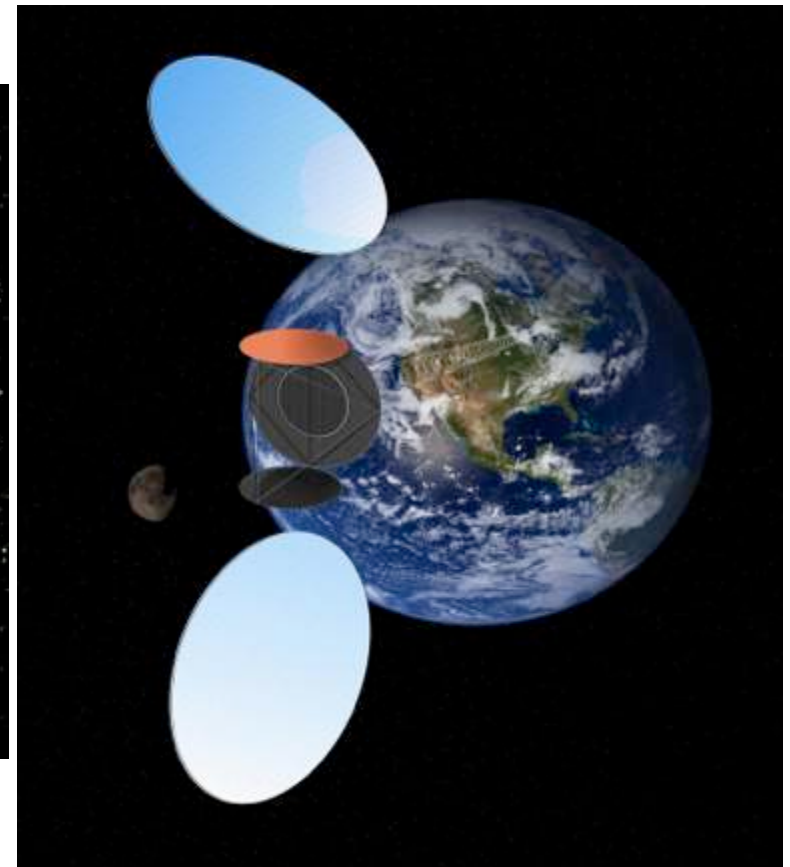
VIDEO



# *Representative SPS Model Designed in Japan*



***Basic Mode  
(USEF Tether-SPS)***



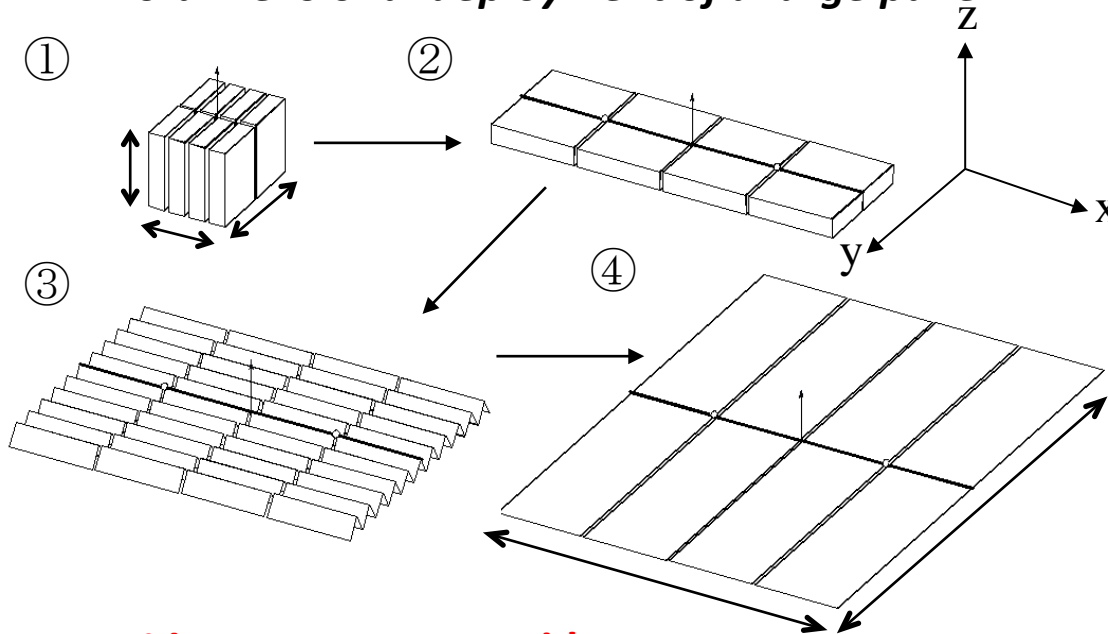
***Advanced Model  
(JAXA M-SPS)***

# ***Research Subjects Necessary to Realize SPS***

- 1. Large power generation ( $10^9$  W class) using a large solar panel (km size) in space.***
- 2. Long-range wireless power transmission to the ground, typically 36,000 km or more.***
- 3. Long life power plant more than 30 years in space environment.***

# 1. Demonstration experiment to extend a large panel in orbit

*Two-dimensional deployment of a large panel*

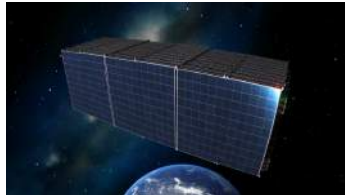


**Video**



*Laboratory deployment test*

**Video**



*CG showing a deployment procedure*



*Laboratory test using shape memory alloy as actuator devices*



## ***2. Demonstration experiment on microwave power transmission***

### ***Microwave Power Transmission***

- 1.6 kW power***
- 50 m range***
- 3 ° sharp beam***
- 0.5° pointing accuracy***

### ***Objectives***

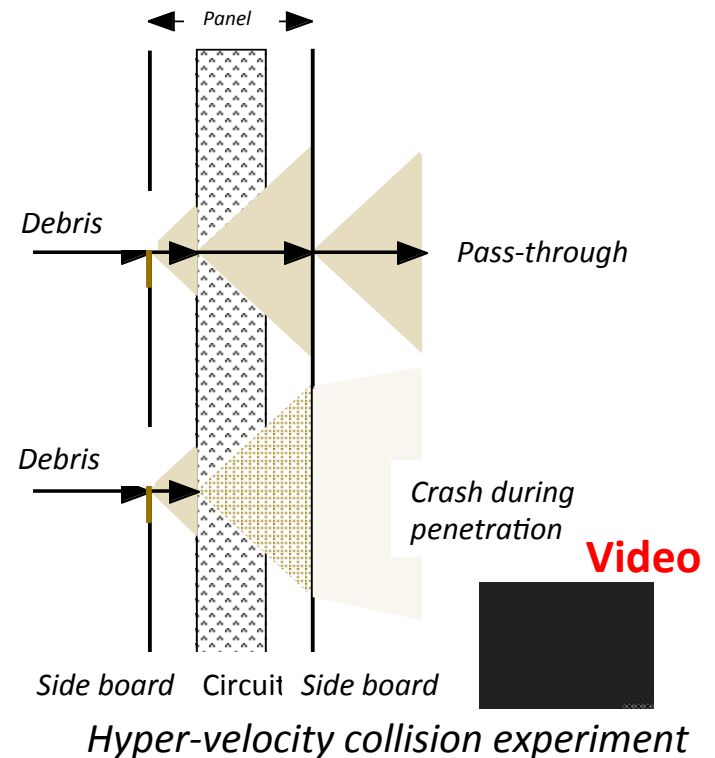
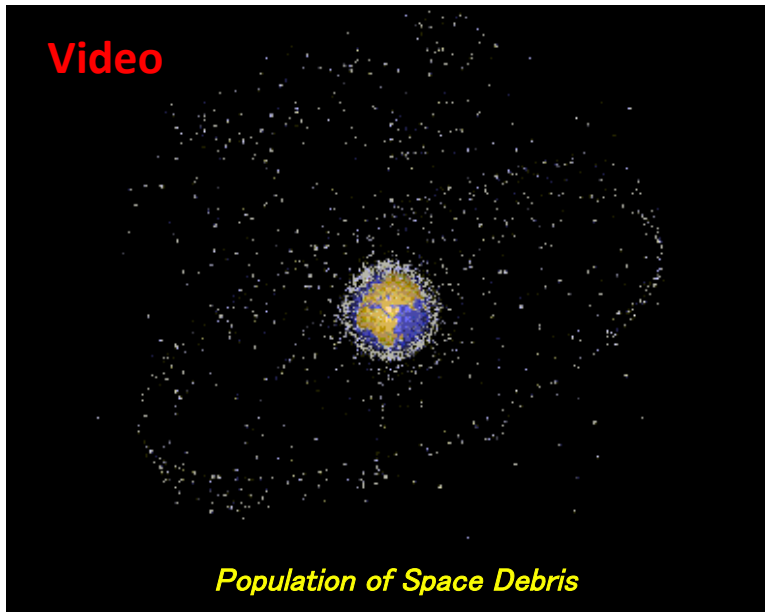
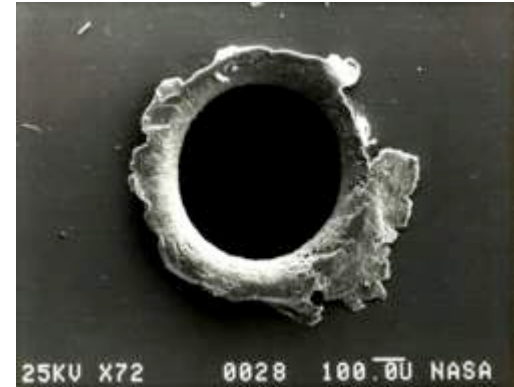
- to demonstrate technologies to control a microwave power beam and to prepare for the space experiment in the near future.***

### 3. Research for Long-life Structure in Space Environment

There are a lot of space junks or debris in orbit.

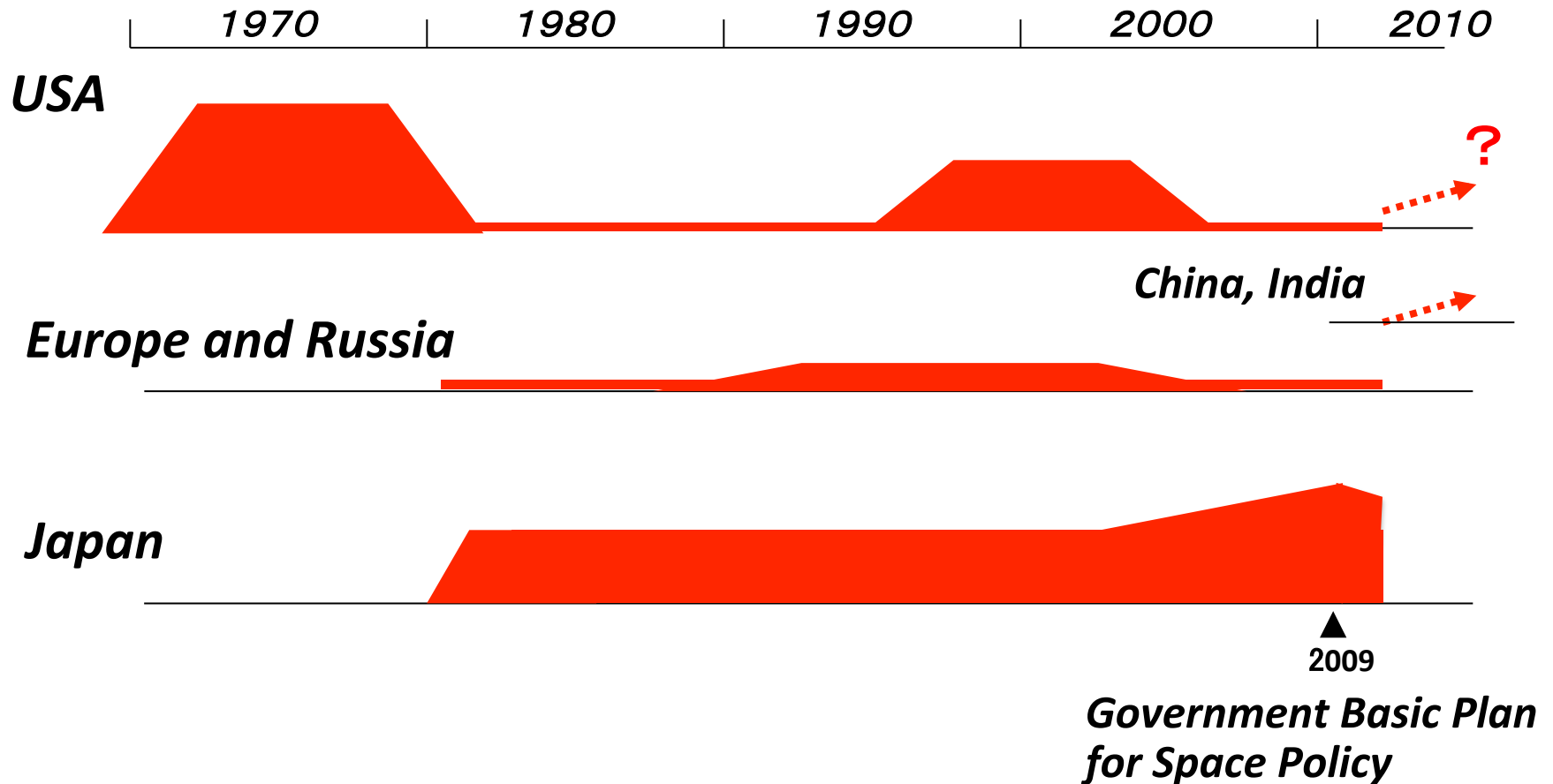
In practice, it is impossible to avoid the collision of the debris to the SPS large structure.

We need to find the structure and component to minimize the collision damage.





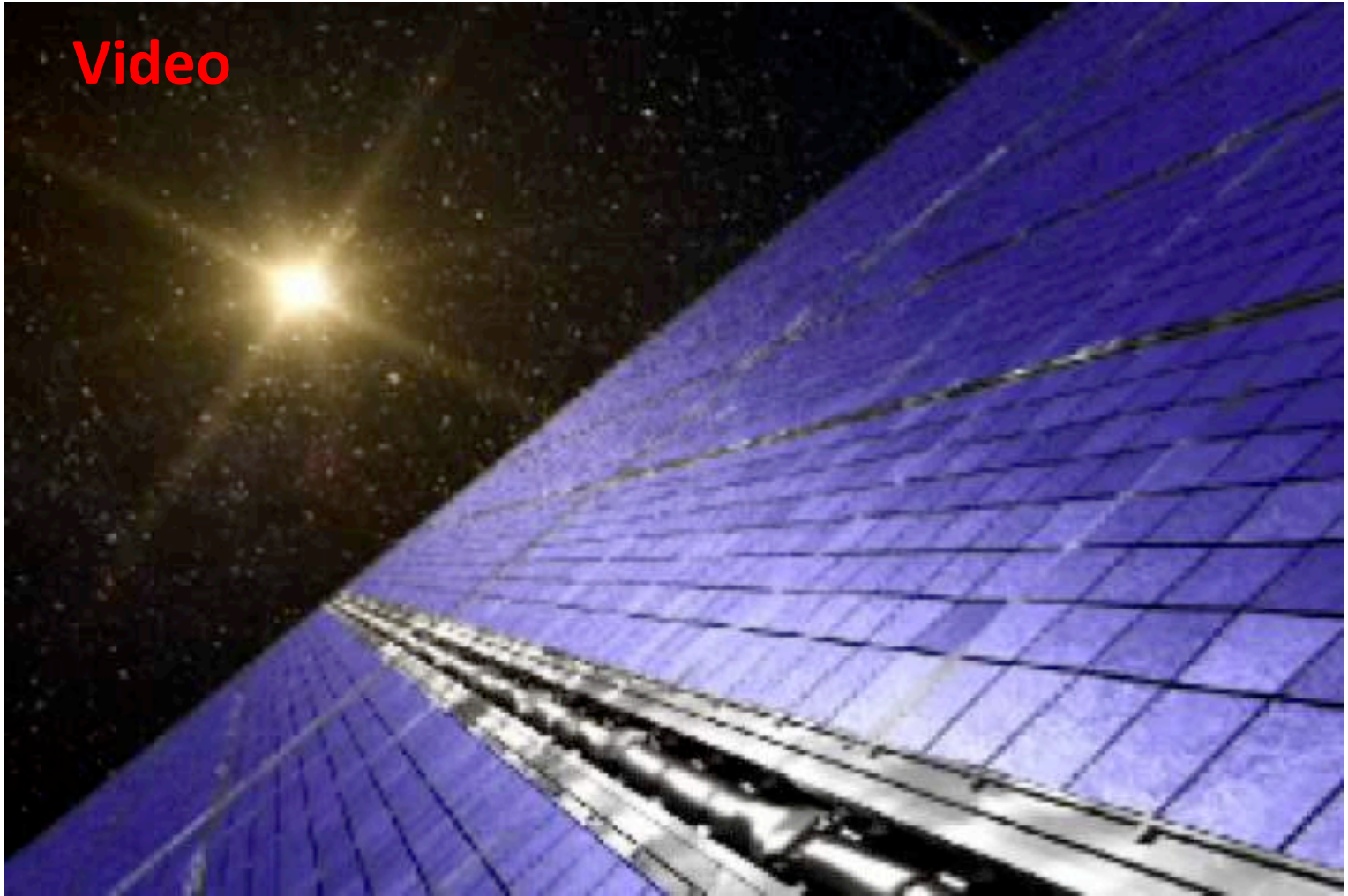
# History and Global Trend of SPS Research



**Japan is currently the leading country in the research of SPS.**

# *SPS Demonstration Experiment in Space*

Video



# Research Required for New Energy System

<b><i>Energy type</i></b>	<b><i>Power source</i></b>	<b><i>Necessary research</i></b>
<b><i>Renewable energy</i></b>	<b><i>Solar power on ground</i></b>	<b><i>Already in practical use, but needs research for low cost implementation.</i></b>
	<b><i>Wind power</i></b>	
	<b><i>Wave power</i></b>	
	<b><i>Geothermal power</i></b>	
	<b><i>Solar power in space</i></b>	<b><i>Research for practical use</i></b>
<b><i>New nuclear energy</i></b>	<b><i>Nuclear fusion</i></b>	<b><i>Research for feasibility</i></b>

# Summary

Electric Power Demand/Supply

Long future

Near future

now

Power saving

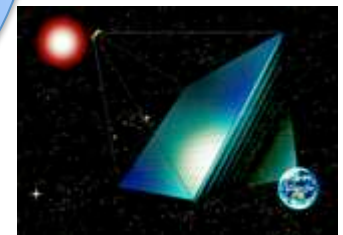


Cost reduction of renewable energy system for currently available system



Solar power plant on ground

Development of innovative energy system (SPS, nuclear fusion)



SPS (Solar power plant in space)