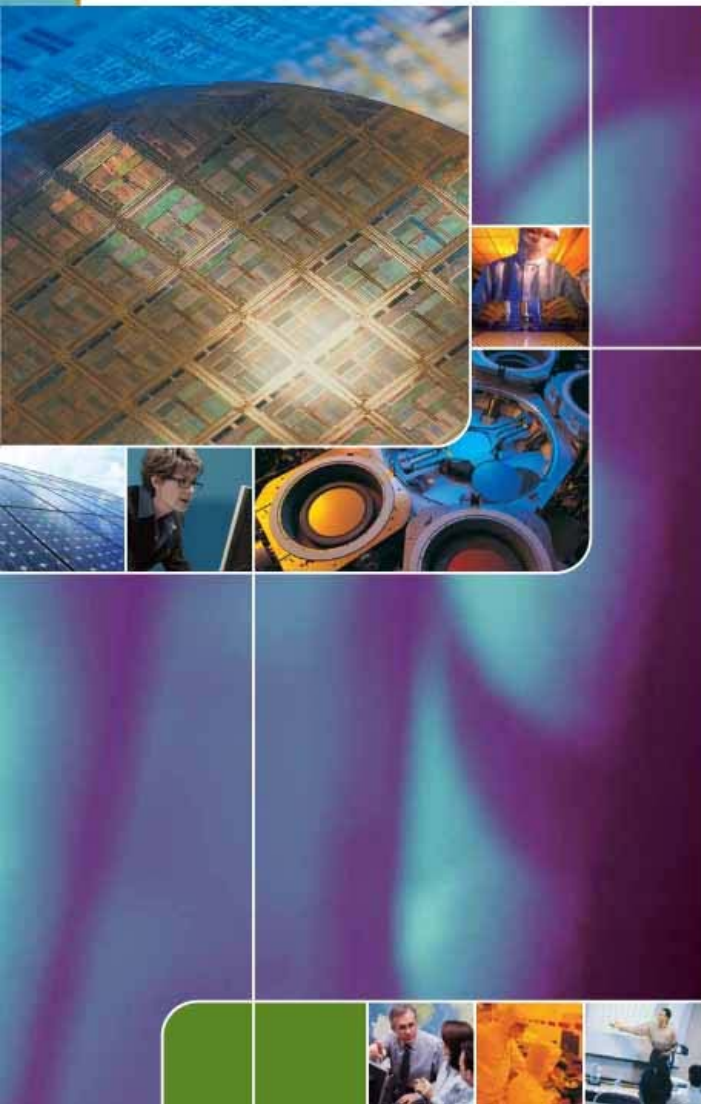


The Future of Photovoltaic Power Generation



**Photovoltaic Power
Generation Technology
Research Association**

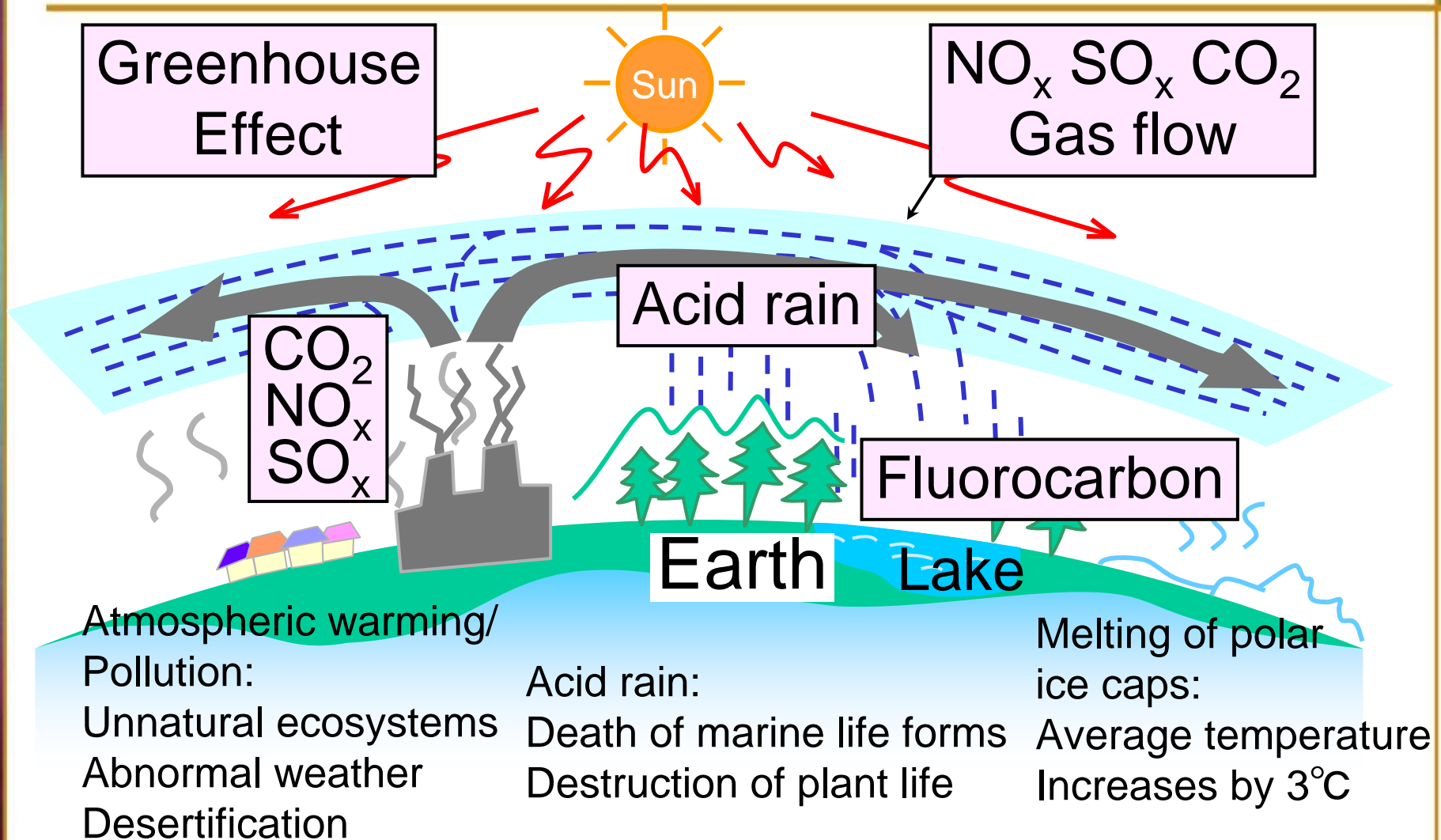
President

Dr. Yukinori Kuwano

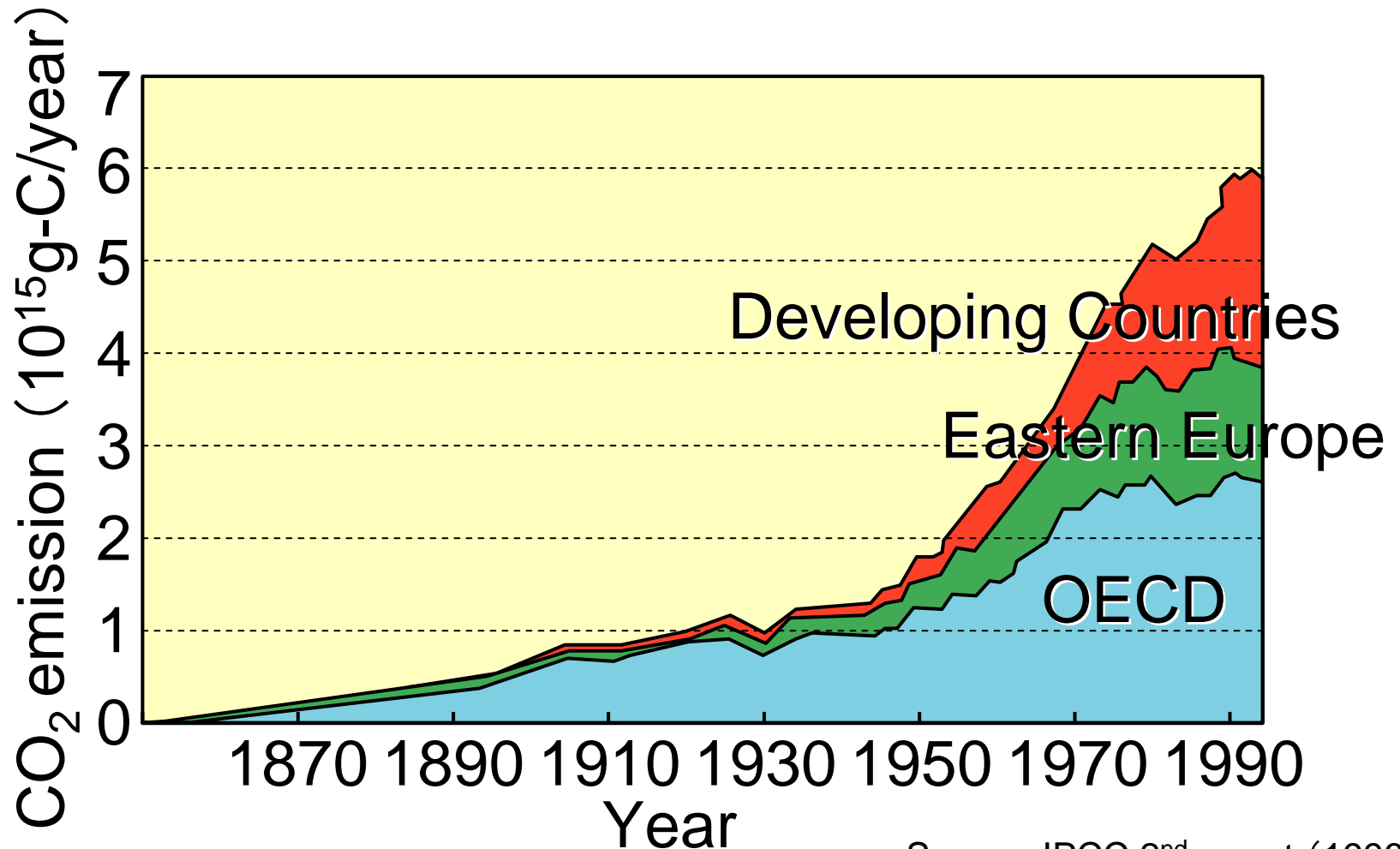
Contents

- 1. Why Photovoltaic Power Generation?**
 - Environmental issues and energy problems
 - Population problem and enhancement of living standards
- 2. PV has the possibility to save our future**
- 3. A new start after 50 years of PV history**
- 4. PV systems as basic energy suppliers**
- 5. GENESIS project – the possibility of a final energy solution**
- 6. Break through in super conducting electric power transmission**

Degradation of the Global Environment

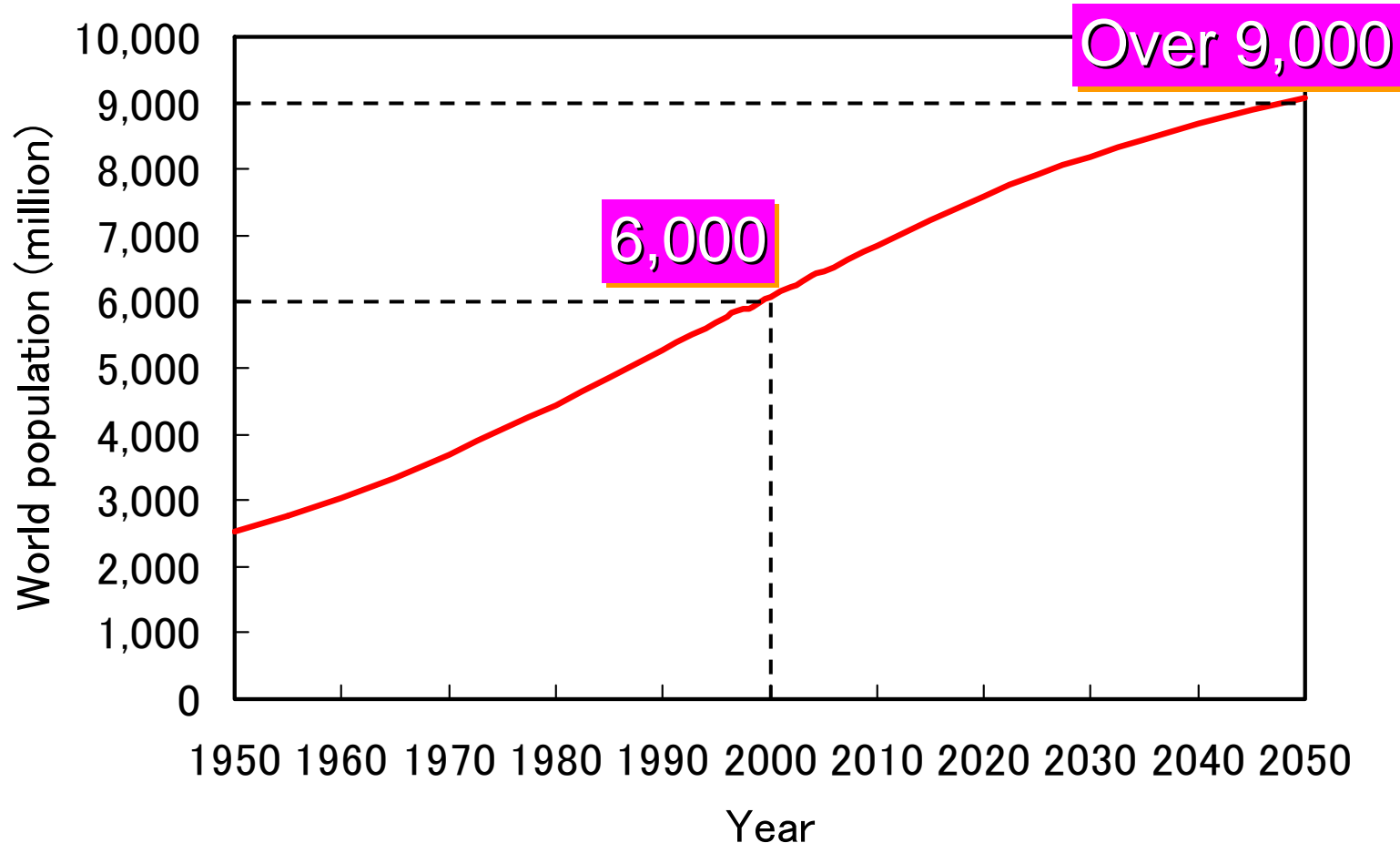


World CO₂ Emissions



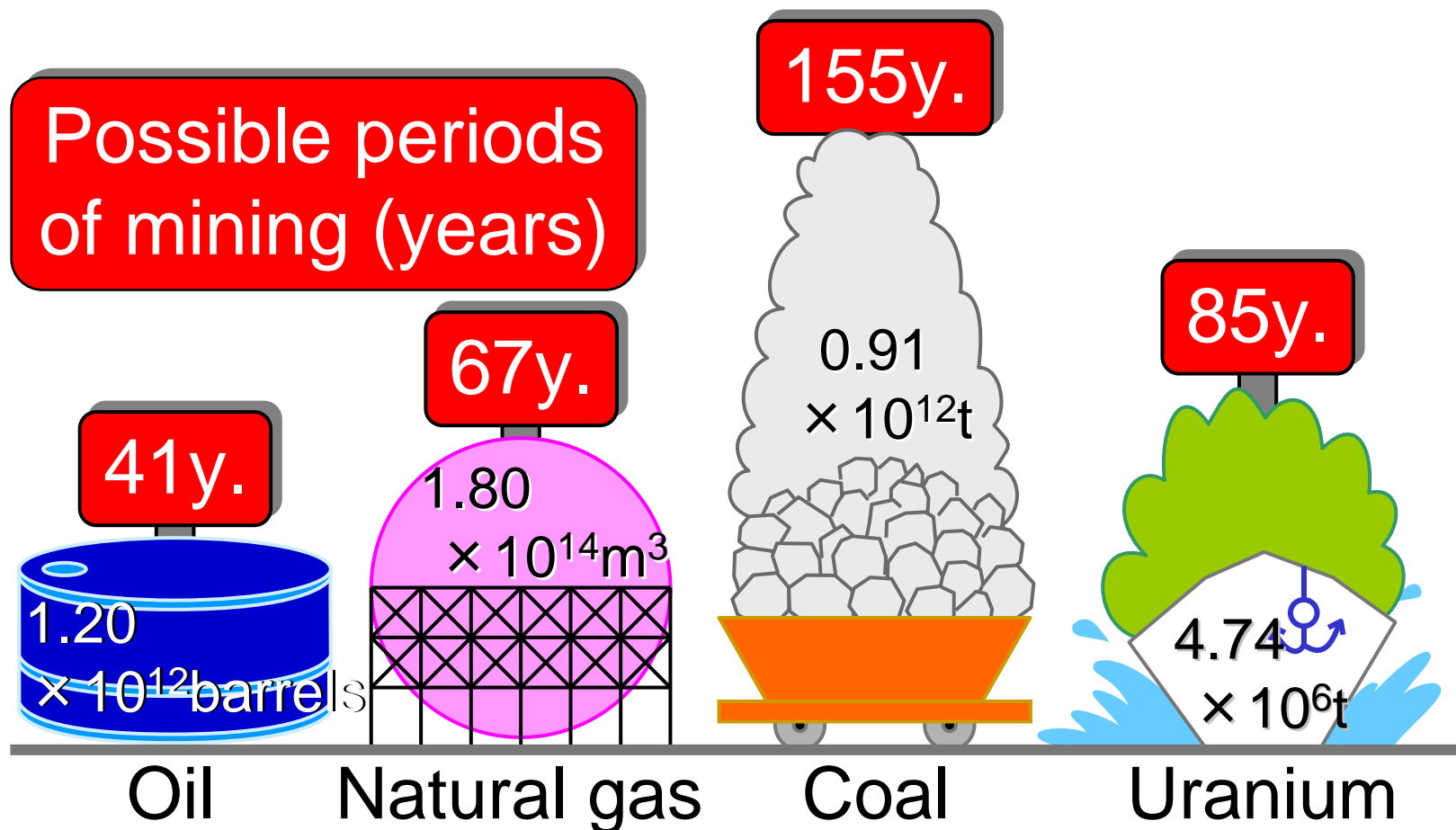
Source: IPCC 2nd report (1996)

World Population Growth Trend



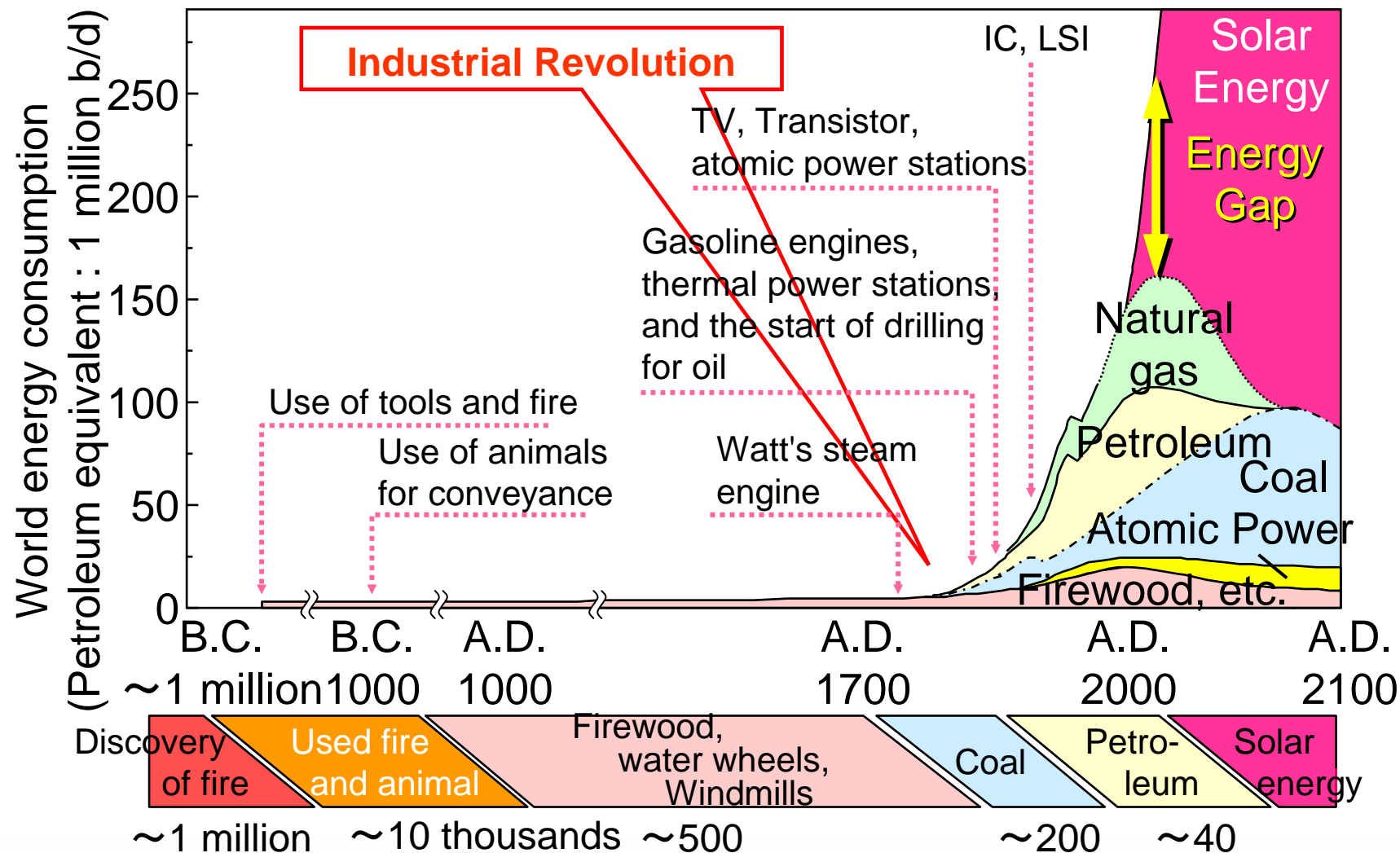
Source: Ministry of Internal Affairs and Communications, Statistics Bureau

Reserves of Various Energy Sources



British Petroleum Statistical Review of World Energy 2006, URANIUM2005

History of Energy Consumption by Humankind

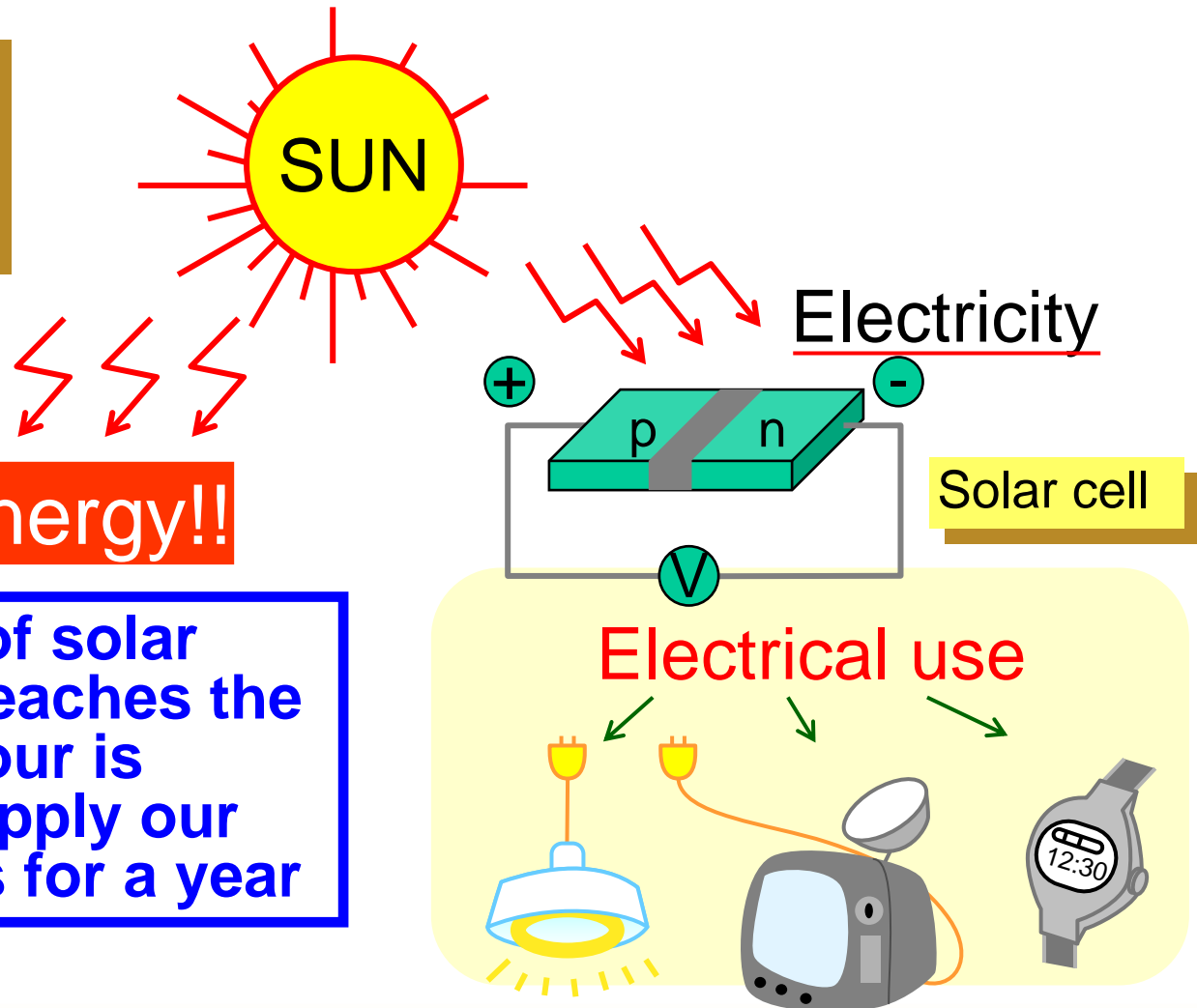


Uses of Solar Energy

- Limitless
- Clean
- Everywhere

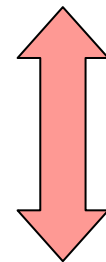
Huge energy!!

The amount of solar energy that reaches the earth in an hour is enough to supply our energy needs for a year



History of Solar Cell

1954	Single crystalline silicon solar cell (Pearson)
1973	Oil crisis
1974	National project started in U.S., E.C and Japan etc (ex. Sunshine Project)
1975	<i>P/n</i> control of amorphous Si (Spear)
1976	<i>P-i-n</i> solar cell with initial efficiency of 2.4% (Carlson and Wronski)
1980	Consumer electronics powered by a-Si solar cell (calculator etc)
1988	Revelation of environmental degradation
1989	GENESIS project (PVSEC-4, Sydney)
1992	Practical reverse-flow solar power generation system (Kuwano's solar power station)
1994	Basic guideline for new energy introduction
1996	SILK ROAD GENESIS (SRG) Plan
2004	Roadmap Toward 2030 (PV2030)
2005	Annual solar cell production exceed 1GW (equal to a nuclear power plant)
2007	Present



(1) The dawn of solar power generation



(2) Advance to supply electric power

2010

2020

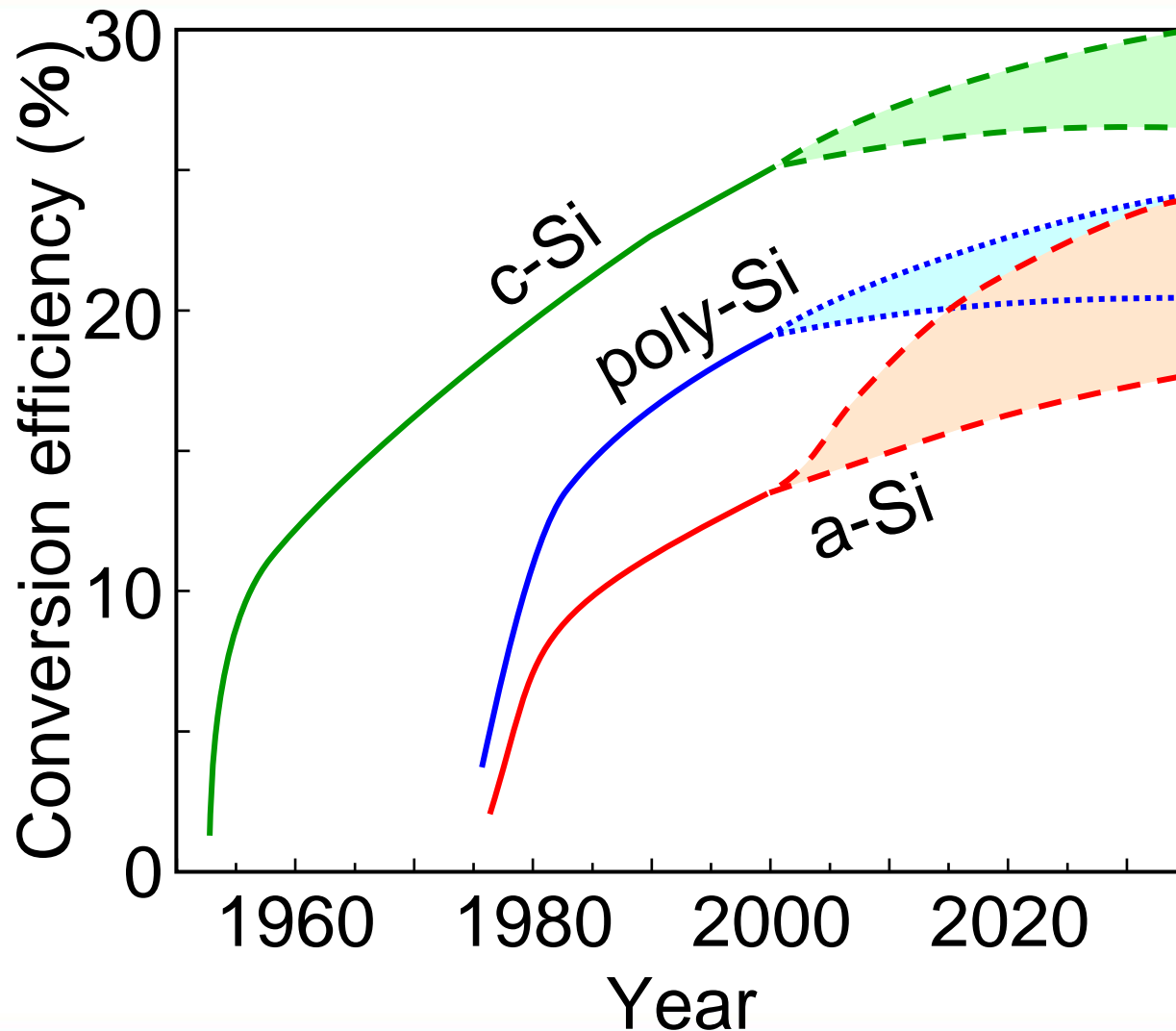
2030

-30 years
of next
stage-

Future Prospect
for Solar Cell

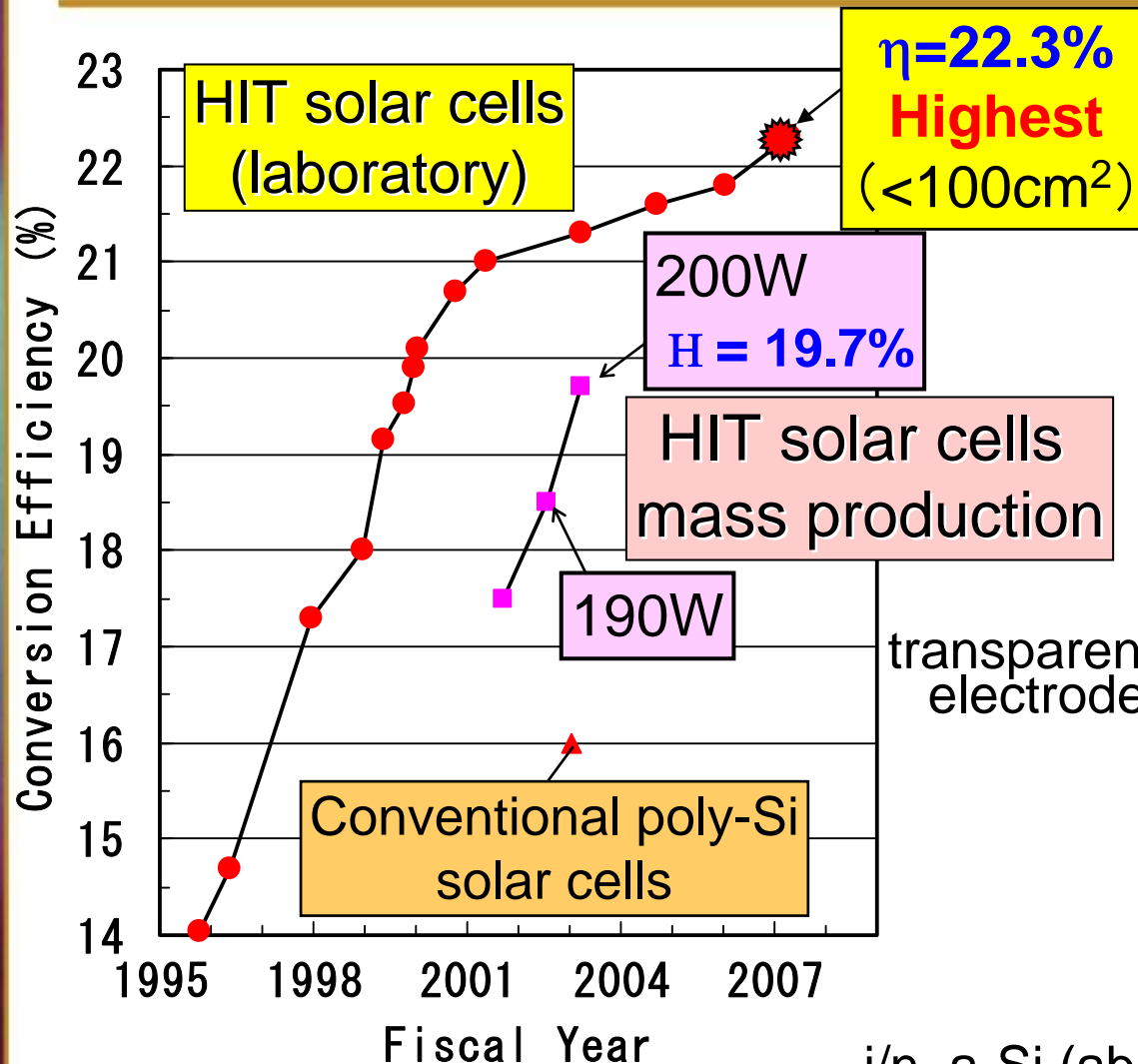
(3) Spread of solar power generation on a global scale

Progress in Conversion Efficiency of Solar Cells

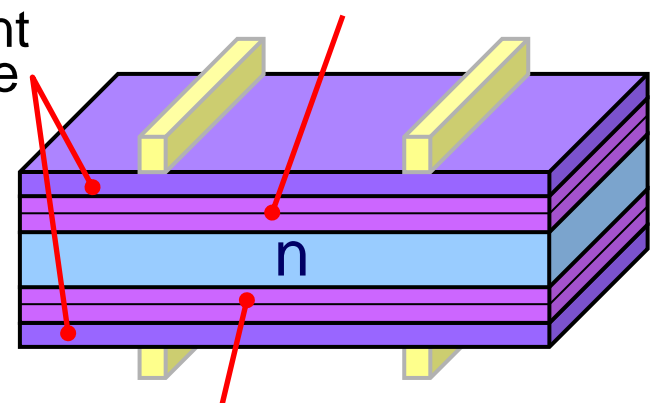


HIT Solar Cell

(HIT: Hetero-junction with Intrinsic Thin-layer)



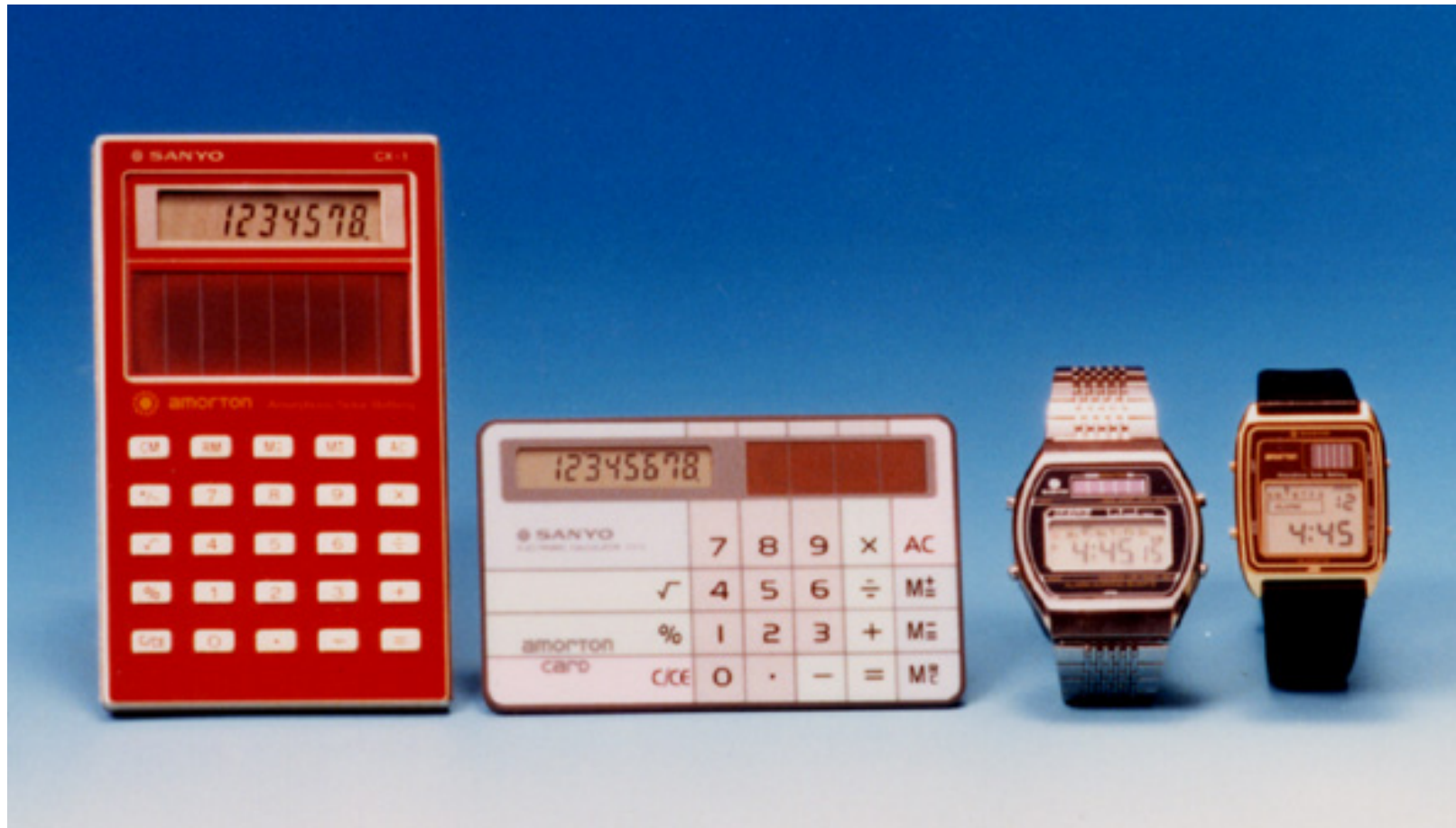
p/i a-Si
(about 0.01 μ m, $T_s < 200^\circ\text{C}$)



i/n a-Si (about 0.01 μ m, $T_s < 200^\circ\text{C}$)

Wristwatch and Electric Calculator (the First Products)

Shipped in 1980

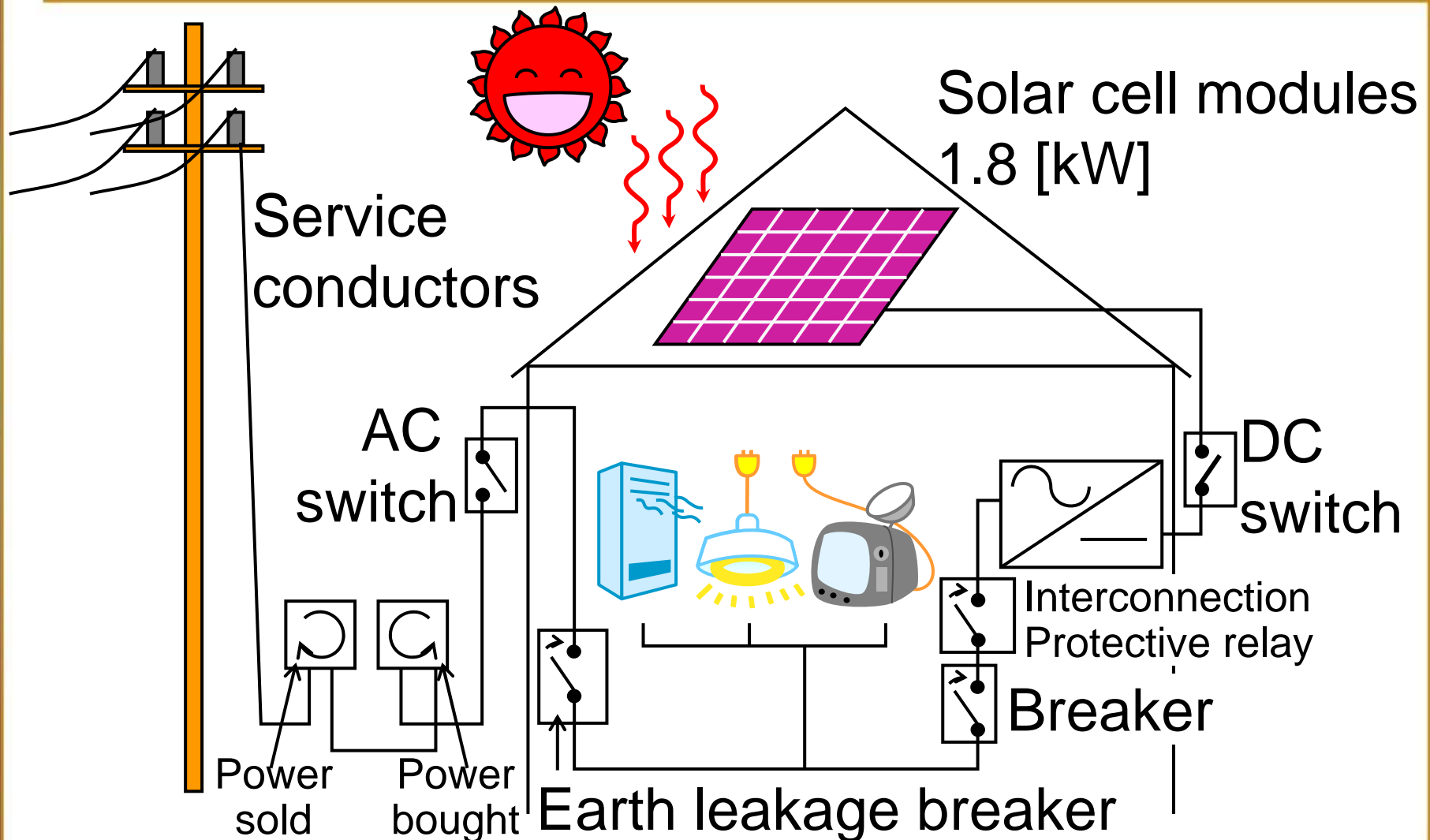


The First Practical Use of Reverse-flow PV System in a Japanese House

Construct in 1992

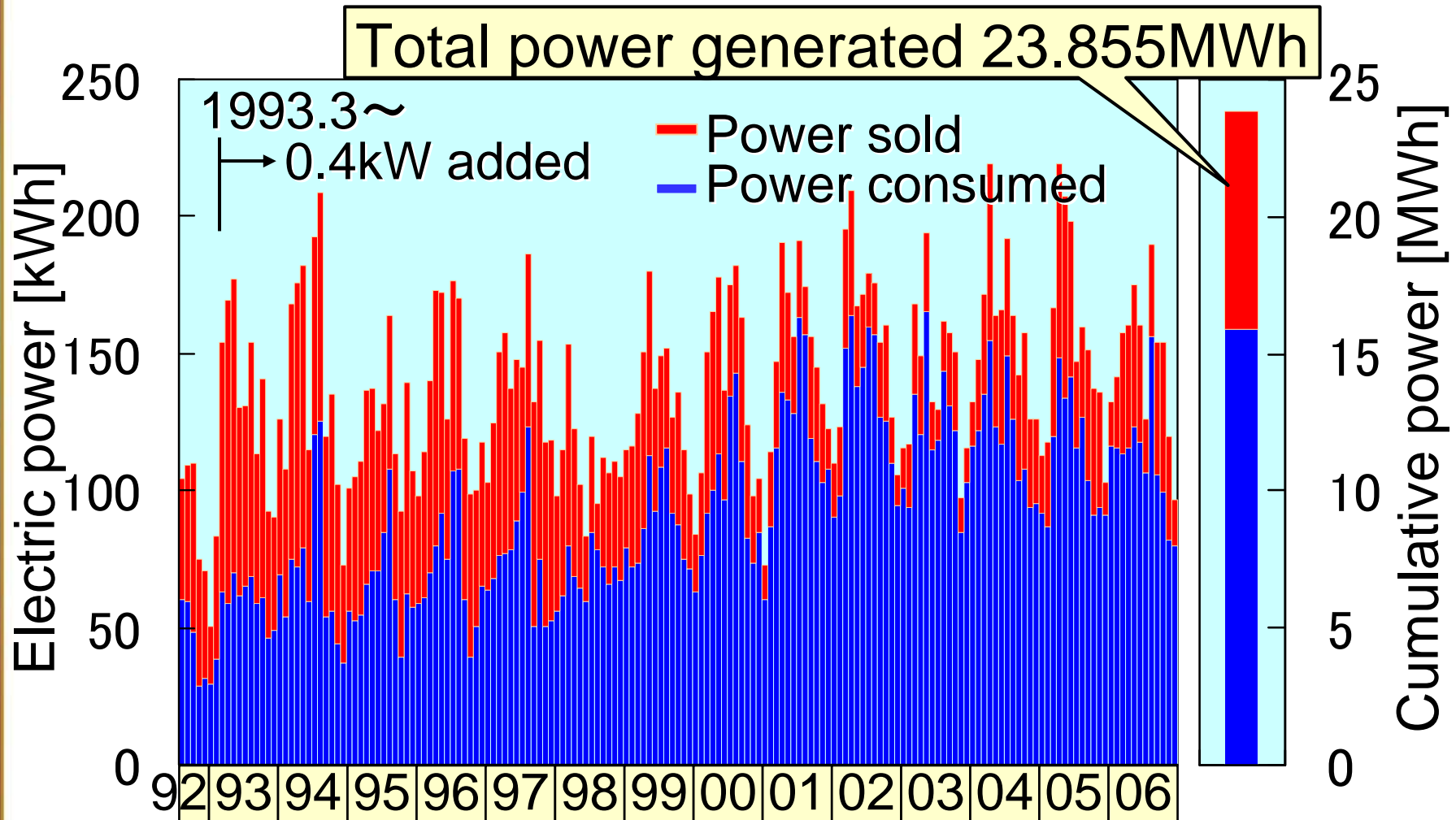


Interconnection System for Residential Use

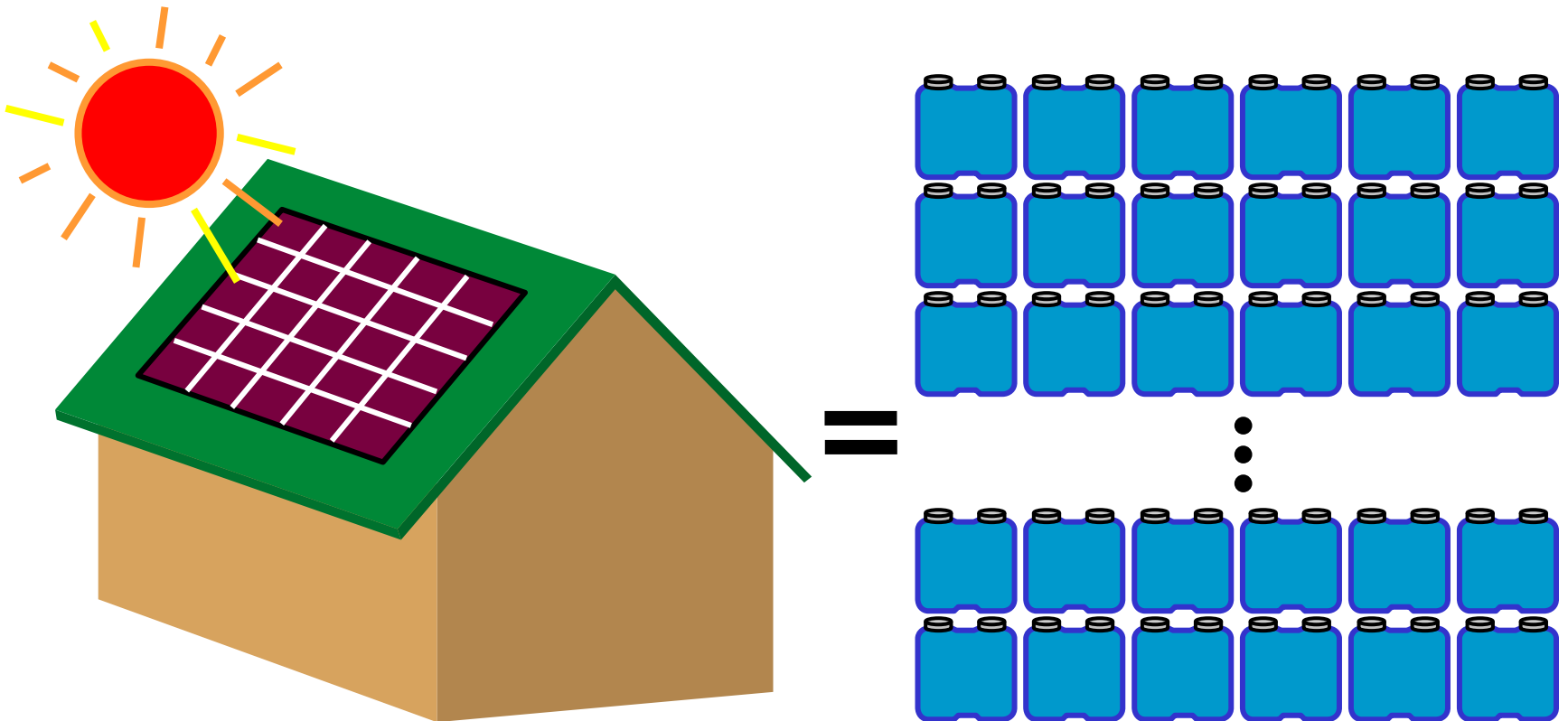


Operating Data of PV System

(This data was obtained through the cooperation of the Kansai Electric Power Co., Inc.)



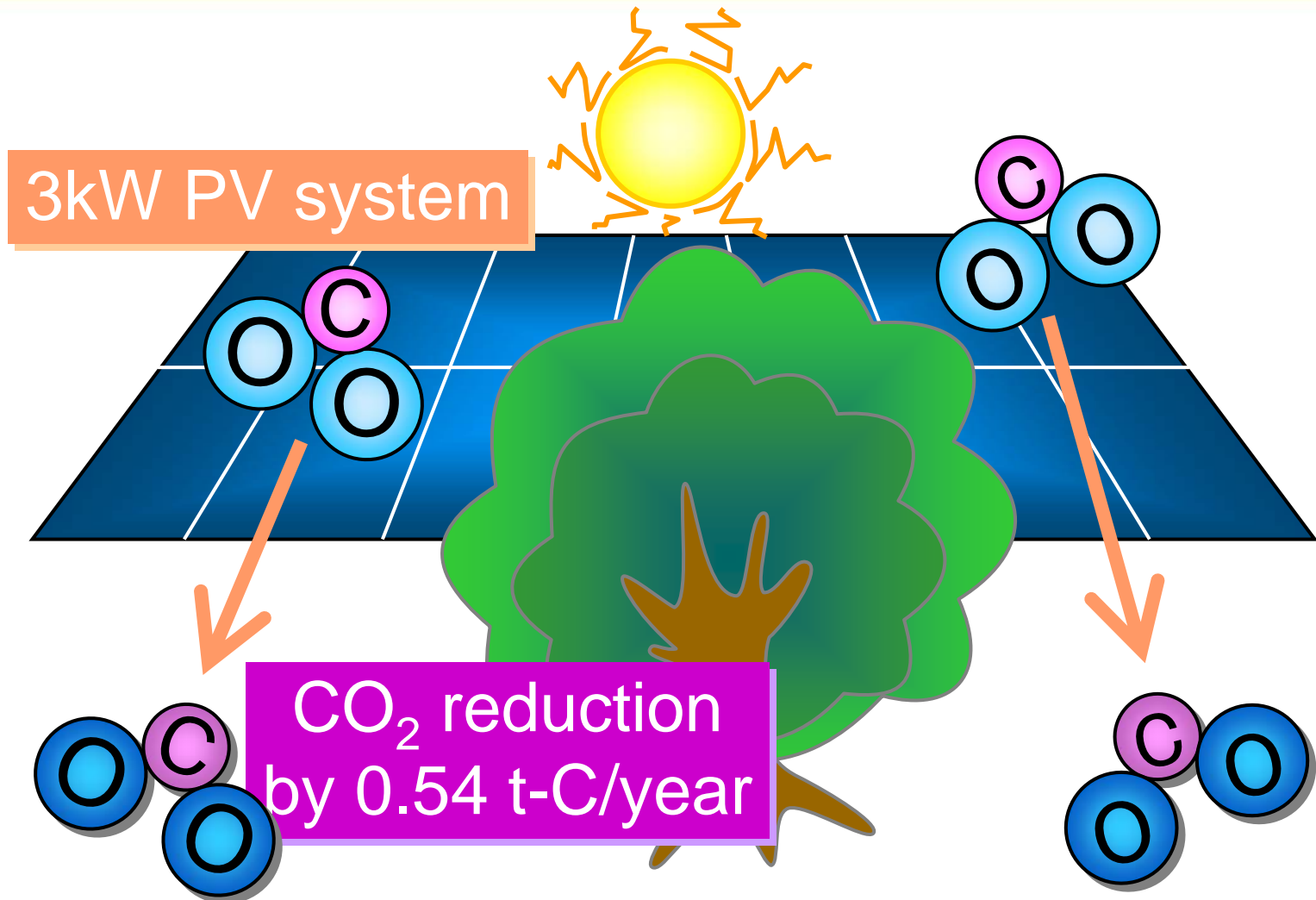
3kW PV System Saves About 700 l/year of Oil



Annual electrical power generated
from 3kW PV system

40 cans of oil
(18l/can)

3kW PV System Can Reduce 0.54 t-C of CO₂ in One Year



Clustered Grid Connected PV Systems in Kobe



**The PV is installed in
100 all the houses**



Large Scale PV System “Solar Ark”

- Maximum system power : 630kW
- Annual output energy : Approx. 530,000kWh
- Overall length : 315m



Location : SANYO Electric Co., Ltd. Gifu Plant

Worldwide Large Scale PV Plants



Geiseltalsee Solar Park (4MW) Braunsbedra, Germany



Serre (3.3MW) Serre, Italy



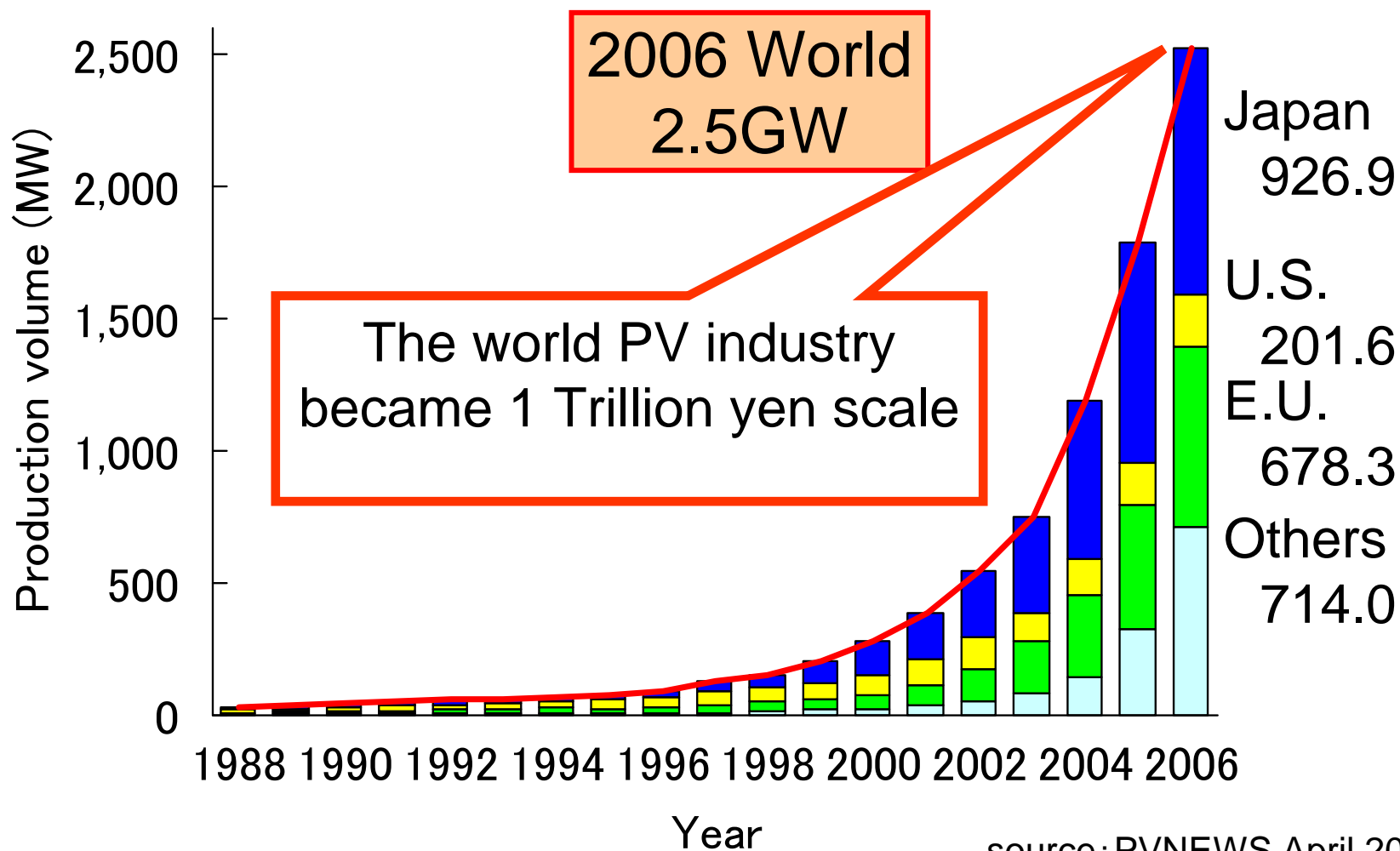
Floriade Haarlemmermeer (2.3MW)
Haarlemmermeer, Netherlands



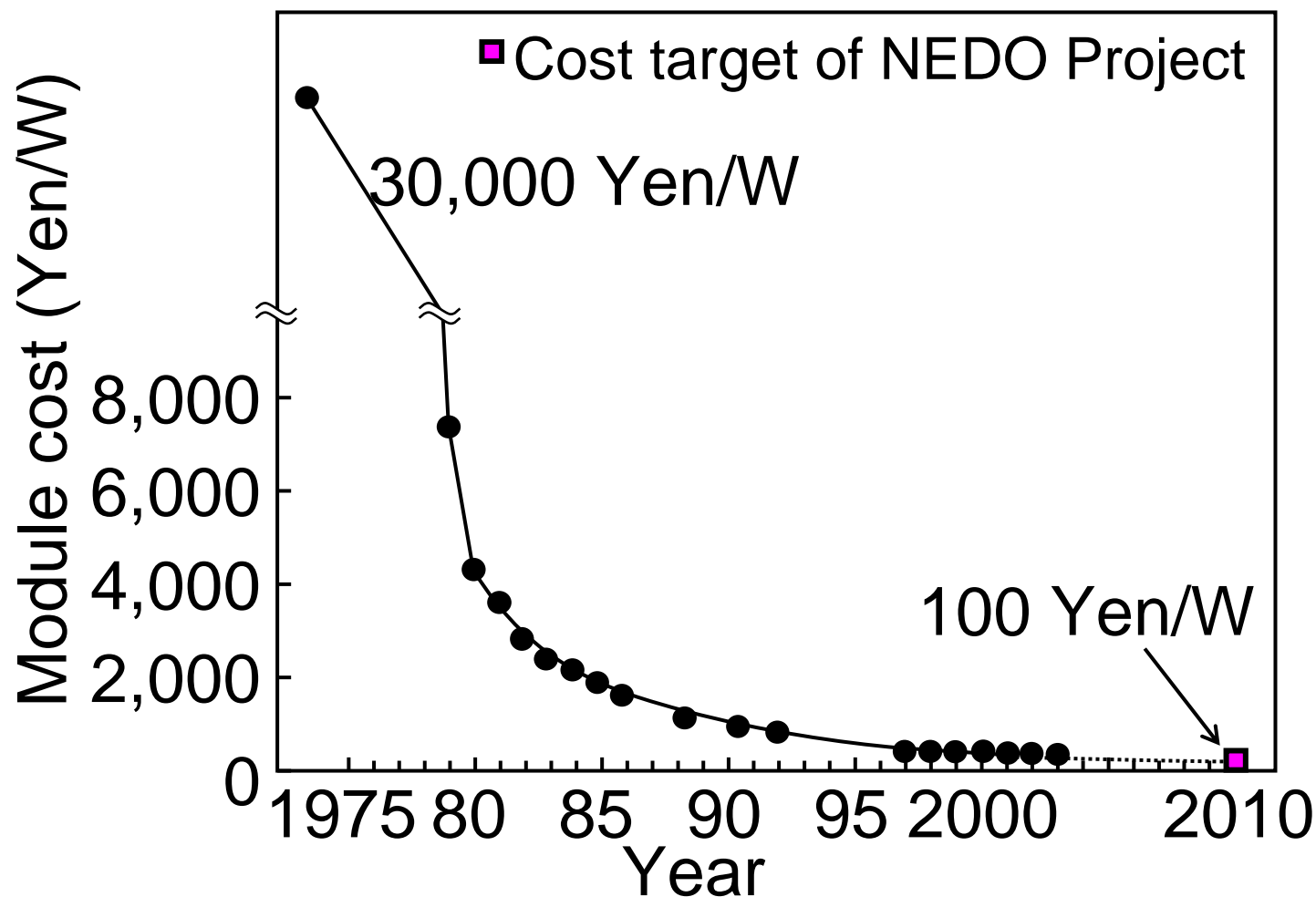
Rancho Seco (3.9MW) California, US

From : PHOTON International

Progress in Global Production Volume



Actual and Target Cost of Solar Cells



‘What are the Challenges’ for PV

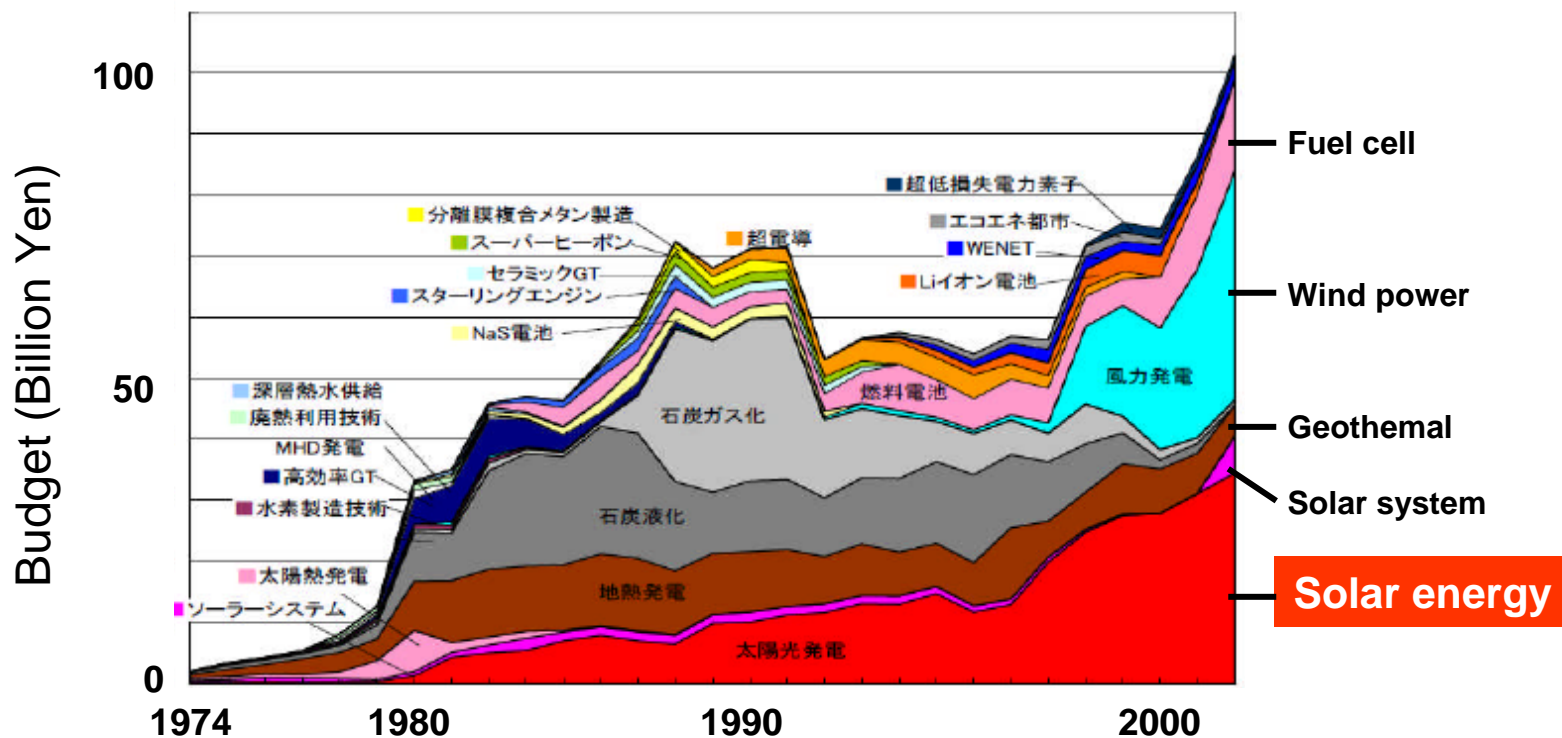
1. Results of 50 years of PV development

- a. Efficiency increases: 4 to 10 times (Silicon)**
- b. Cost reduction : 1/100**
- c. Practicability of reverse-flow PV system was confirmed**
- d. Module has more than 20 years of reliability**

2. Future Challenge

- e. Additional cost reduction needed: 1/2 to 1/4**
- f. Reliability : from 20 Years to 50 - 100 Years**
- g. Deployment of key global energy resources**

Progress in the Energy Development Budget for Japanese Government

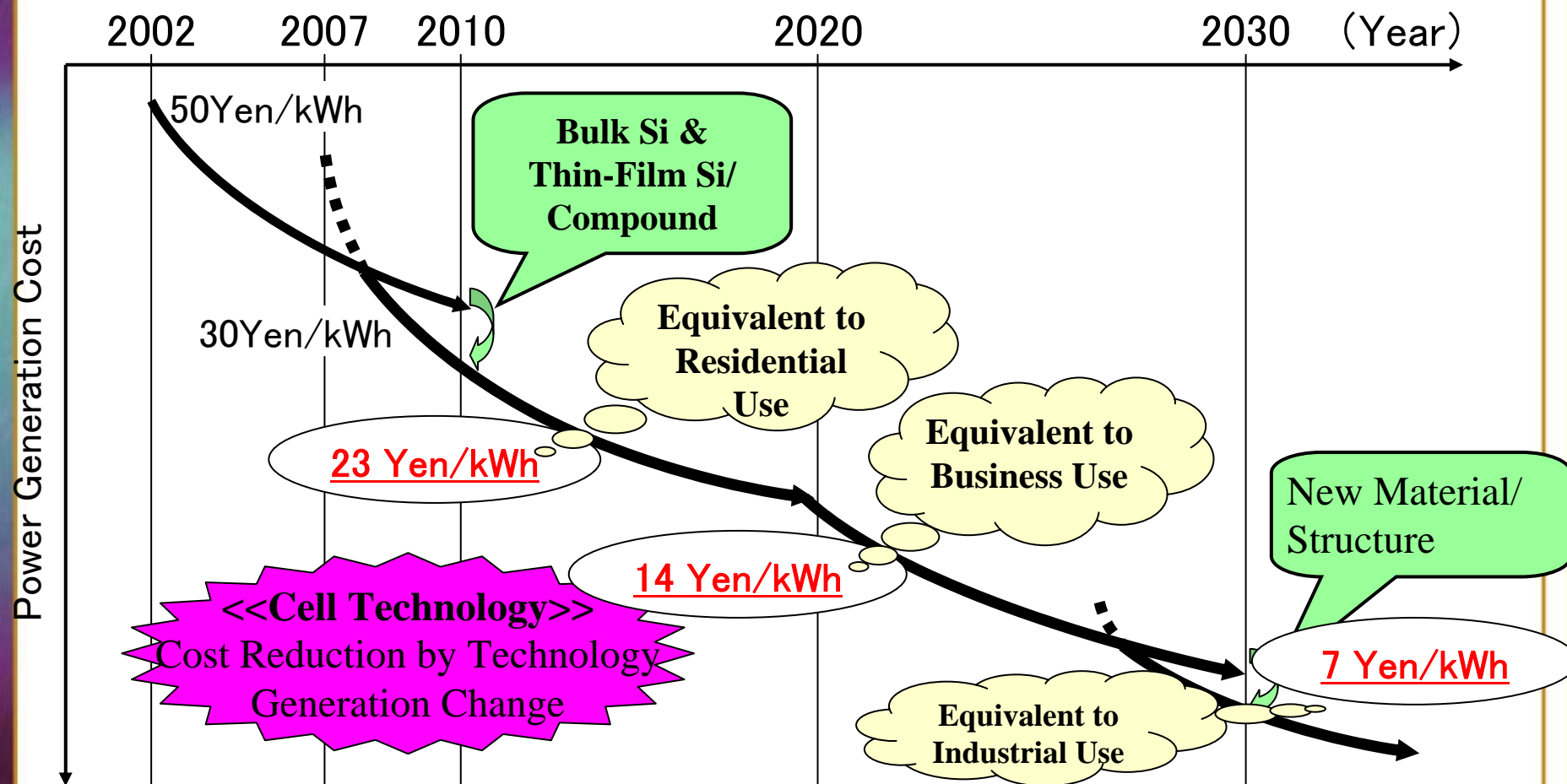


Budget on New Energy Development Projects
(1974-2002) (Including installation Support)

Source: Central Research Institute of Electric Power Industry

The Japanese government used the budget of about total 300 Billion yen for the PV-related research and development and the spread plan from 1974 to 2002.

PV Roadmap Toward 2030 (PV2030)



Source: NEDO "PV Roadmap Toward 2030" (PV2030)

Taiwan Government Support

- Supporting PV system installation
 - 2004: 80 Million
 - 2005: 100 Million
 - 2006: 330 Million
- Promote PV applications and design
- Establish policy in public construction projects where PV system installation required
 - 2006, total 1.04MW_p
 - In year 2010 target to 31MW_p
 - In Year 2015 targeted to 320MW_p



**These are
very good
plans**

Taiwan Has the Following Advantage for the PV Industry.

1. Energy import country but have rich resource of Solar Energy

2. Leading country of semiconductor industry

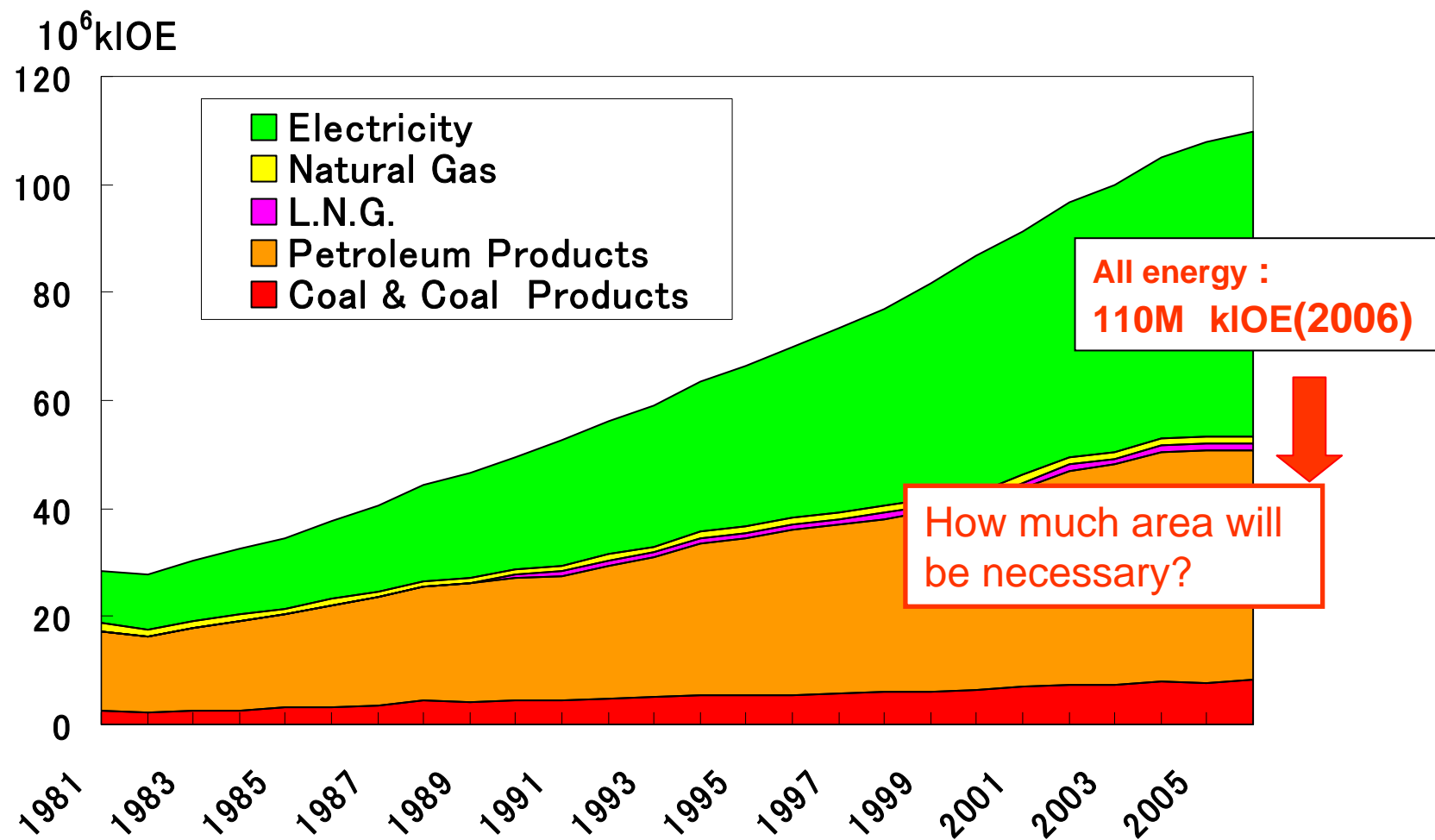
Taiwan 2006 PV production volume ranked #5 worldwide

Taiwan PV Industry total revenue has reached 37.5M in 2003 and forecast 1250M in 2007

Taiwan Solar Cell annual production capacity is 9600MW in 2007(est.)

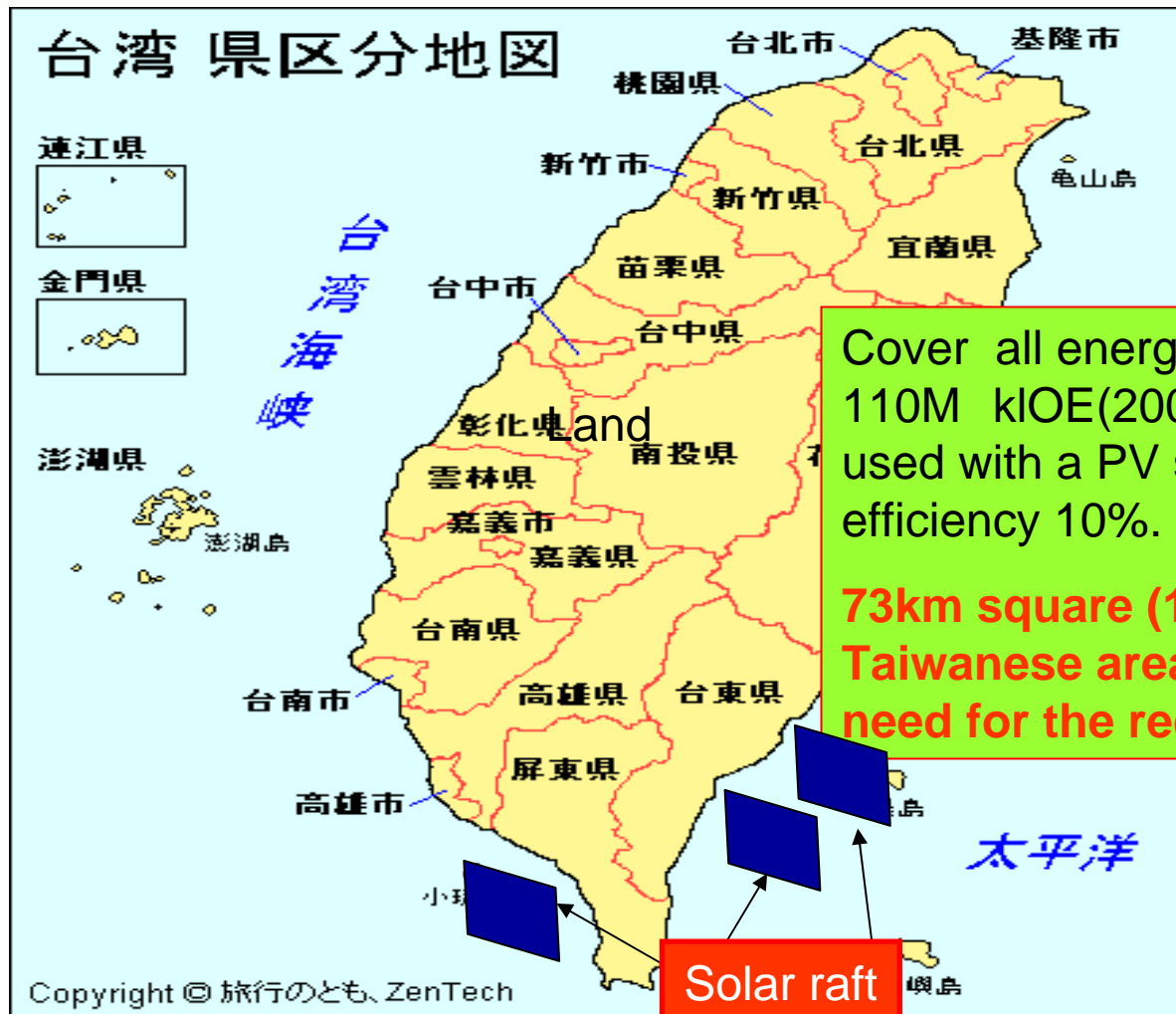
3. Challenge spirit to the new business

Energy Consumption in Taiwan (By Energy Form)



Source: Bureau of Energy, MOEA

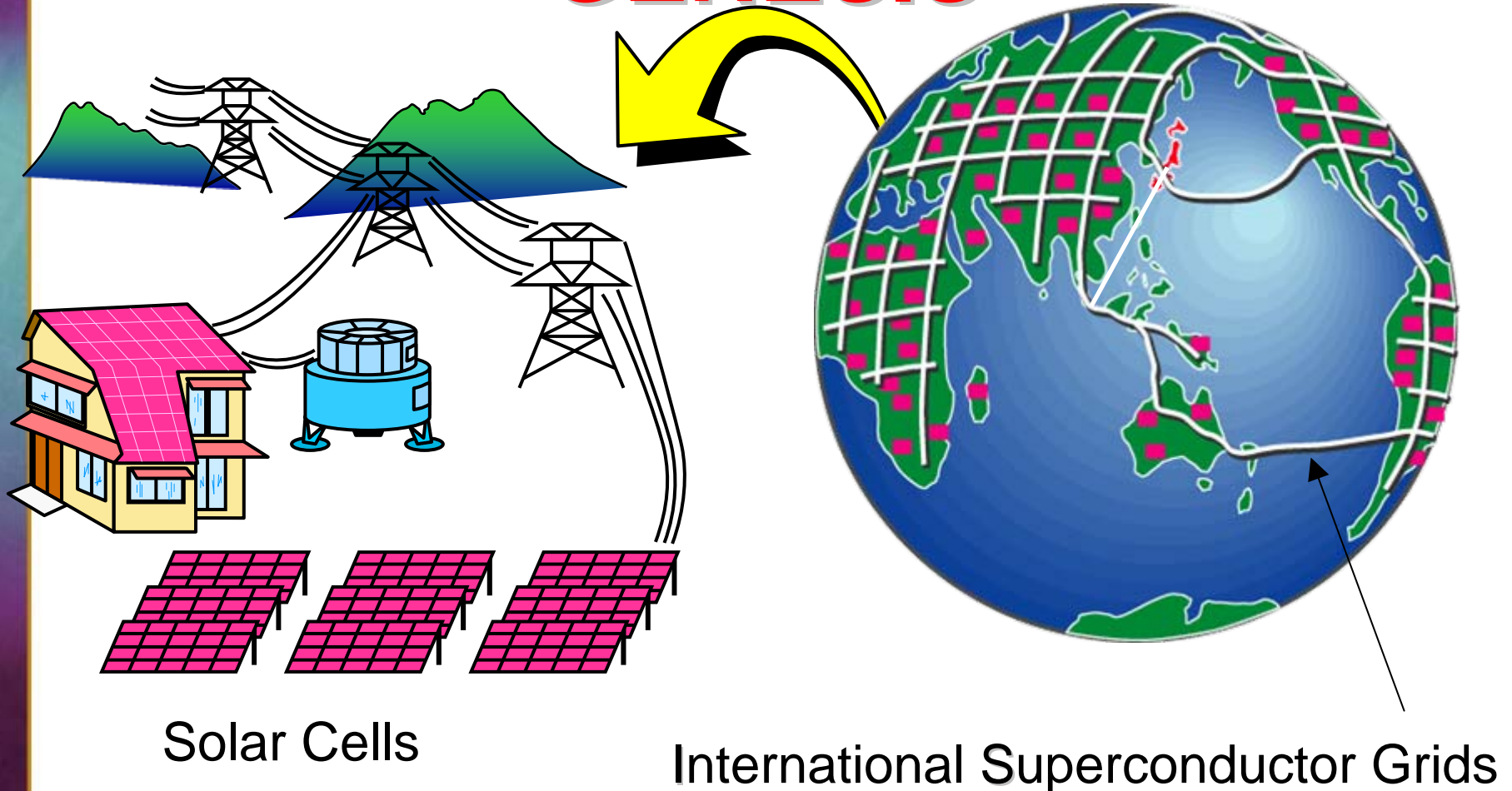
Proposal of Solar Power Generation in Taiwan



Global Energy Network Equipped with Solar Cells and International Superconductor Grids

GENESIS

Proposed in 1989



World's Energy Consumption and Required Solar Cell System Area

Year	Energy consumption (billion kl/y.)	System efficiency (%)	System area (km square)
2000	11	10	729
2010	14	10	802
2050	35	15	1,030
2100	111	15	1,850

4% of desert area

Genesis Project, Overcoming a Number of Global Environmental Problems

GENESIS Project (**Global Energy Network Equipped with Solar cells and International Superconductor grids**): **Photovoltaic power generation systems installed across the world's deserts and connected via superconductive cable.**

At the current level of efficiency, PV system area of 650,000 km² (807 km x 807 km rectangle area) is required to supply energy needs of the entire globe (14 T cal/year) in 2010. This area correspond to only 4% of the world's deserts.

Photovoltaic systems installed across the world's deserts would be connected via superconductive cable. During daylight hours, these PV system would generate power to meet the global energy needs including supplying night time energy to the other side of the globe.

GENESIS Project

Total power of 800km x 800km PV system ... 64TWp>
(Module efficiency = 10%)

Cost of modules and superconductive cable

Case A: Assumed cost 300 Yen/W
(Module 100Yen/W, BOS 100Yen/W, Transfer 100Yen/W) ... 20 Quadrillion Yen (2京円)

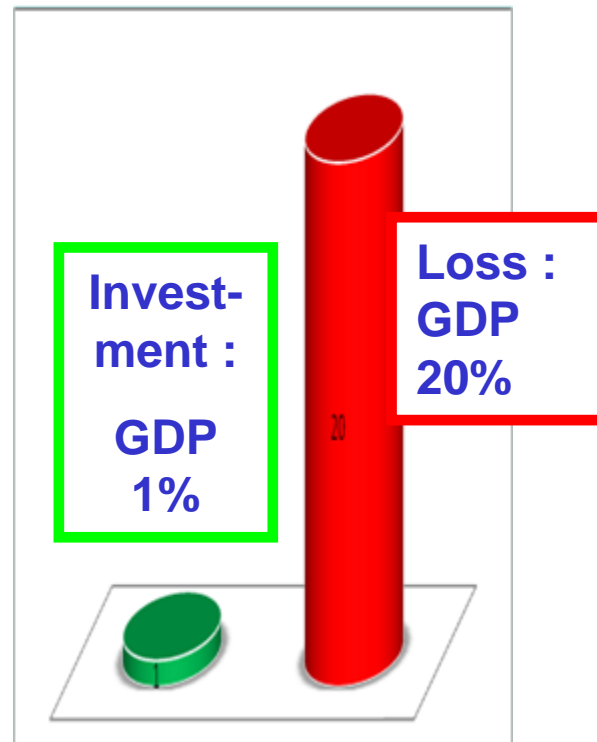
Case B: 150 Yen/W
(Module 50Yen/W, BOS 50yen/W, Transfer 50Yen/W) ... 10 Quadrillion Yen (1京円)



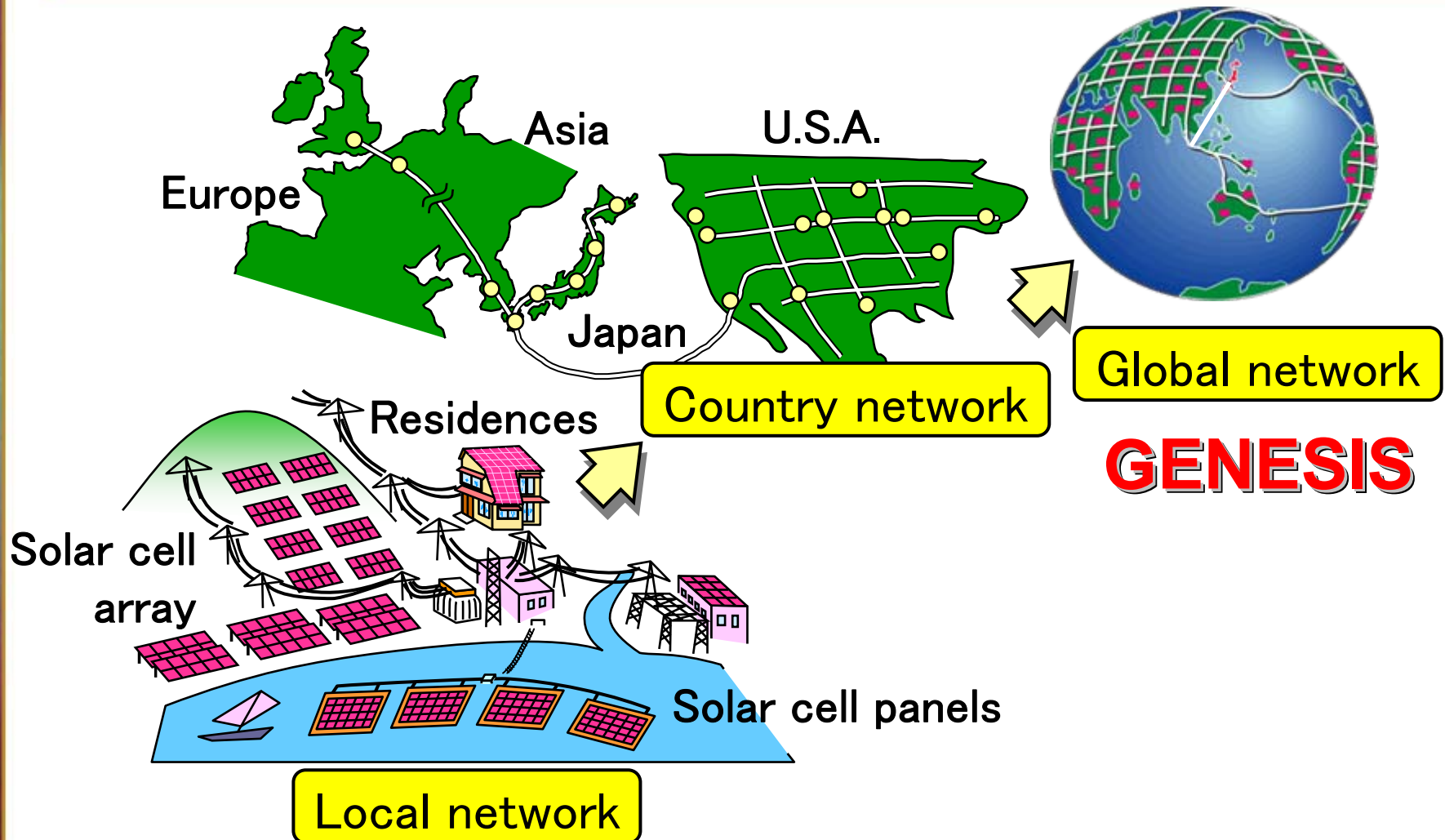
In case B, required investment is 200Trillion yen/year (4% of World GDP*1) under the assumption that it is built in 50 years.

(*1) World GDP 5000 Trillion Yen(2005) based on 115Yen/\$

Dr. Nicholas Stern, Baron Stern of Brentford



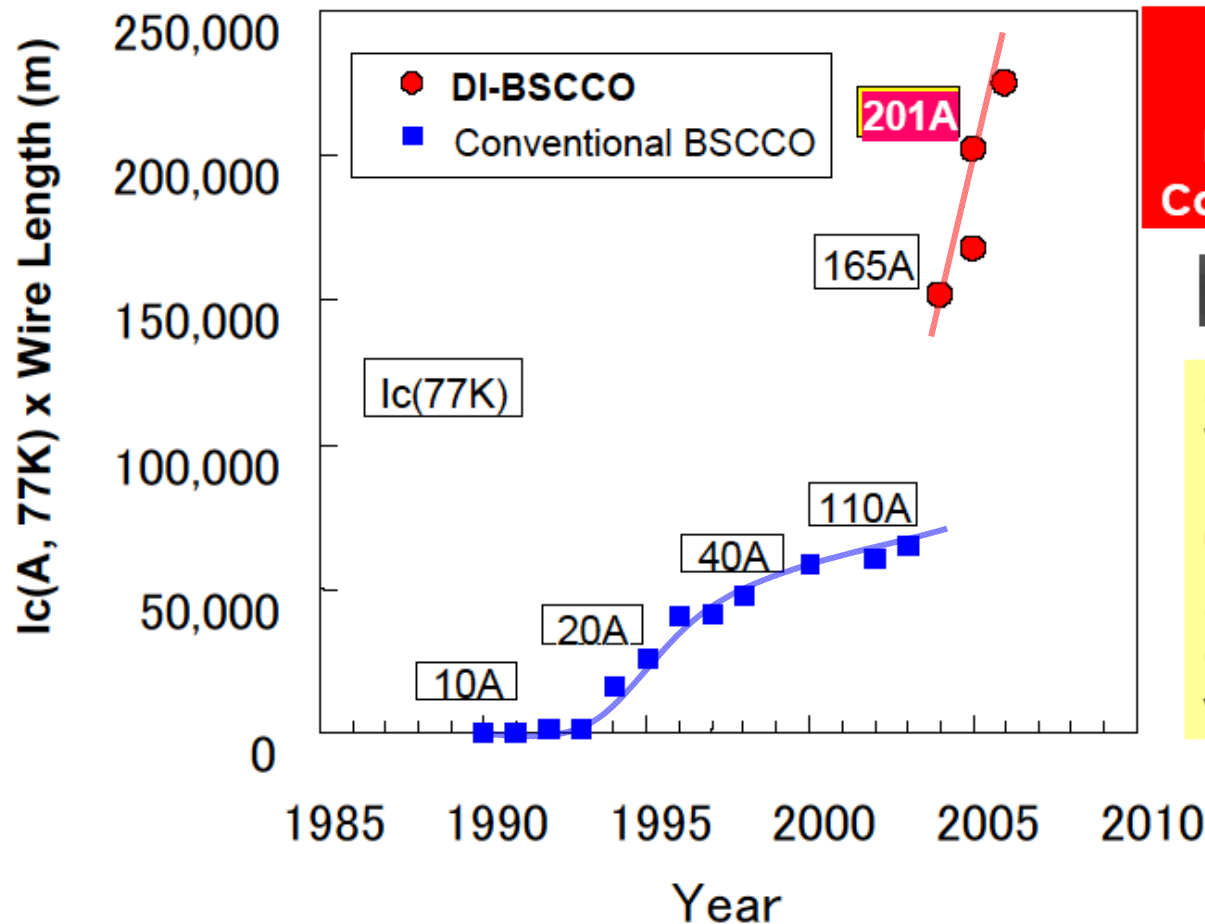
Step in the GENESIS Project



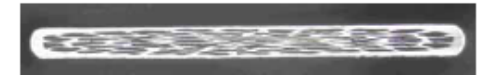
High-temperature superconducting Wire

DI-BSCCO: Drastically innovative BSCCO Wire
(BSCCO:Bi-Sr-Ca-Cu-O)

SET



**Multi-Filamentary
DI-BSCCO
Mass Production &
Commercially Available**



(1) Cross-sectional
View of DI-BSCCO
(4.2mm x 0.22mm,
0.9mm²)

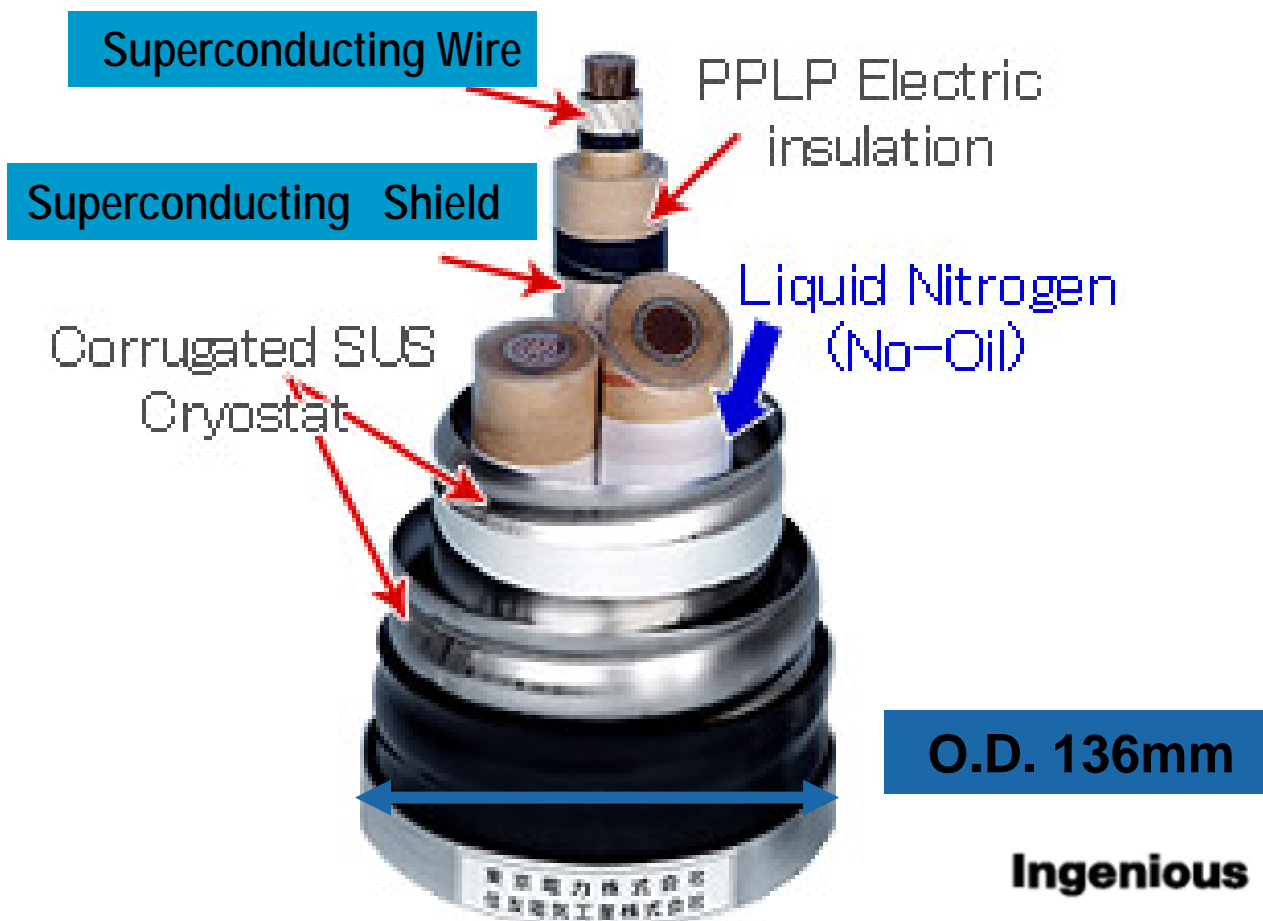
(2) 200 Times Larger
Current than Copper
without Loss

Ingenious Dynamics

Source: Sumitomo Denko

6.6kV high-temperature Superconductive Cable

3-in-One Cable



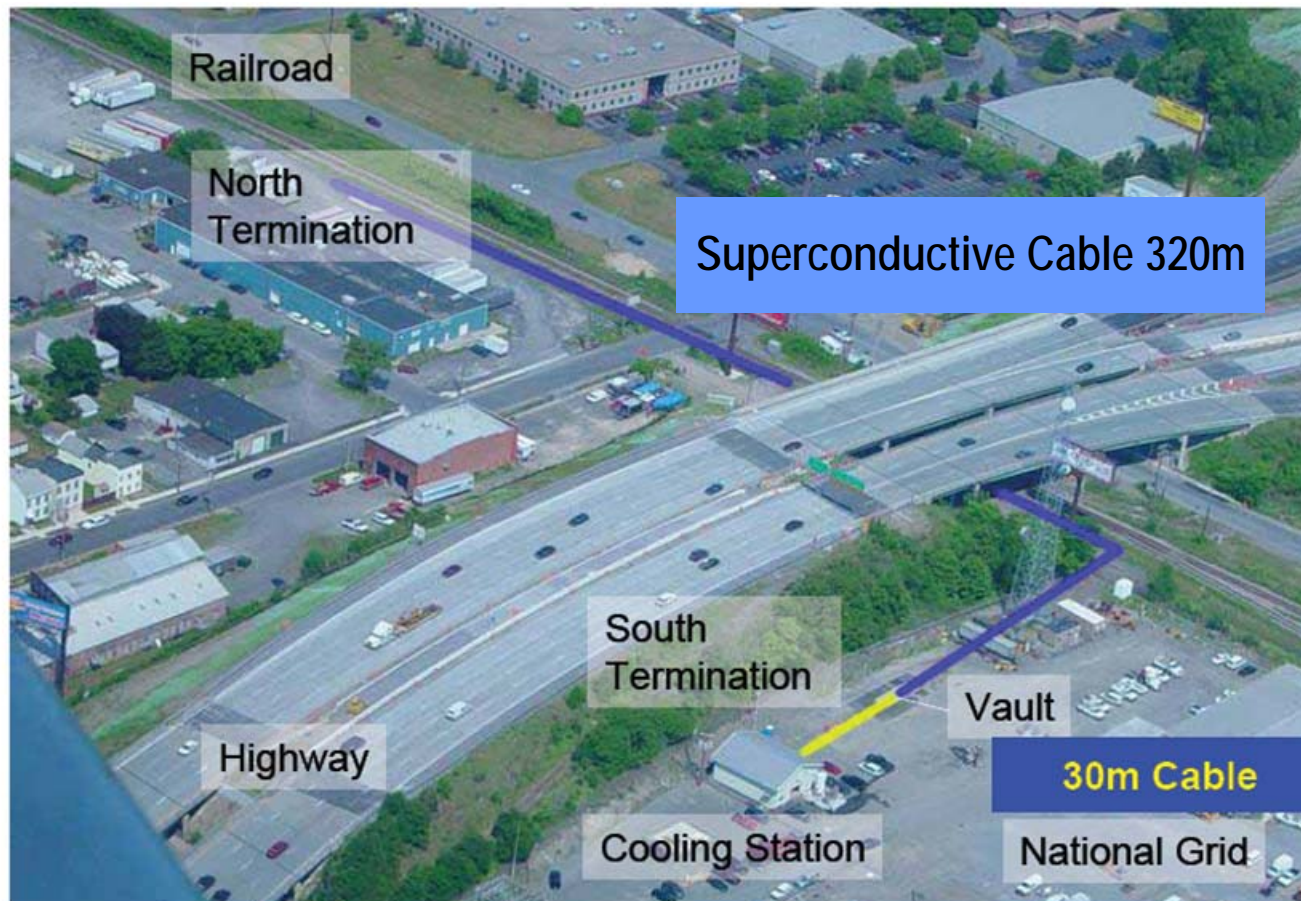
Ingenious Dynamics

Source: Sumitomo Denko

In July of 2006



Albaney Cable (350m) site



National electric transmission in USA



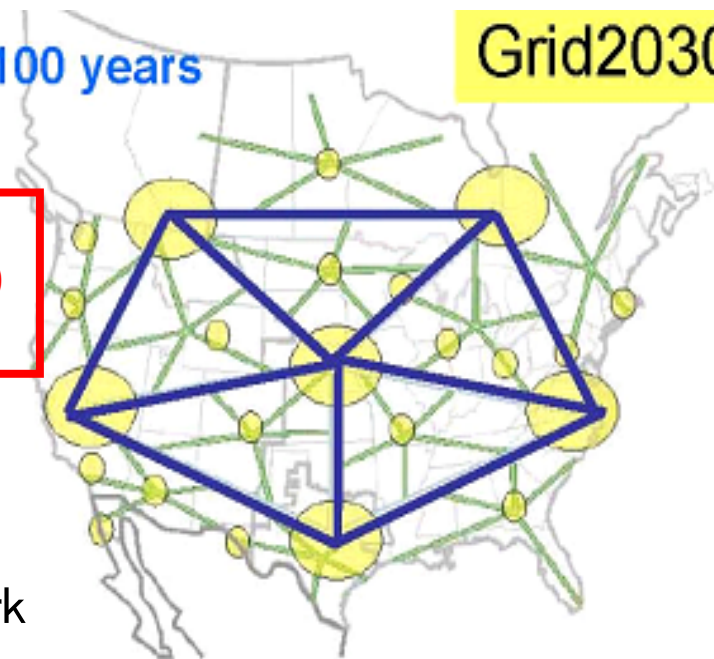
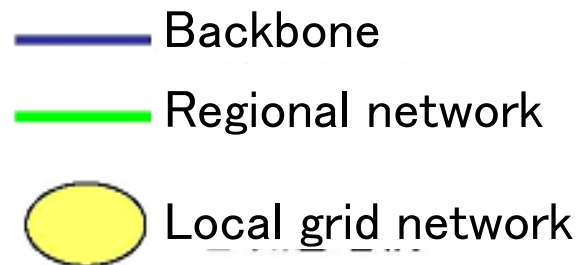
A National Vision for Electricity's Second 100 years

Discussion was started in April 2003.

Interim report was submitted in July 2003.

10 miles superconductive cable in 2010
Long-distance superconductive cable in 2020
Robust superconductive grid network in 2030

Grid2030



Electricity Backbone, Regional Networks, Plus Local, Mini- and Micro-Grids

Ingenious Dynamics

Adopted from Sumitomo Electric Industries, Ltd

SILK ROAD GENESIS(SRG) Project

As a pre-project of GENESIS, SRG has been proposed. This project is planning to build PV system network between Beijing and Moscow along the lat. 40° N.



Picture : Tokyu Construction Co., Ltd.

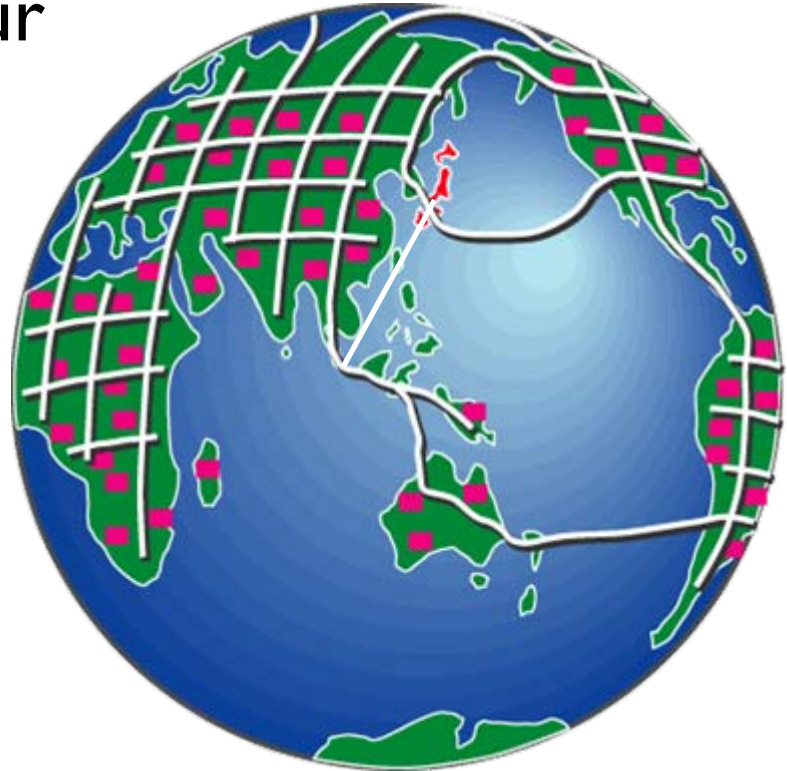
Image of Silk Road Genesis, large scale PV system

This project was planned by the Tokyu construction Co., Ltd and supported by Sanyo, Maeda, Takenaka, Toshiba and Fuji Ric.



Making Photovoltaic Power Generation on a Global Scale a Reality

If we mobilize all of our resources, we will resolve the global environmental and energy problems.



Thank you for your attention