

The UT-KFUPM Workshop on Large Scale Solar Power Generation 2012
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Hyper Large Scale PV/CPV Power Generation Systems in Desert Area

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Sharp Corporation

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2. Hyper Large Scale PV/CPV Power Generation
and its technology
 - a. PV/CPV modules
 - b. Solar systems
3. Future in the Solar Energy Utilized Society

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1. Introduction

2. Hyper Large Scale PV/CPV Power Generation and its technology

a. PV/CPV modules

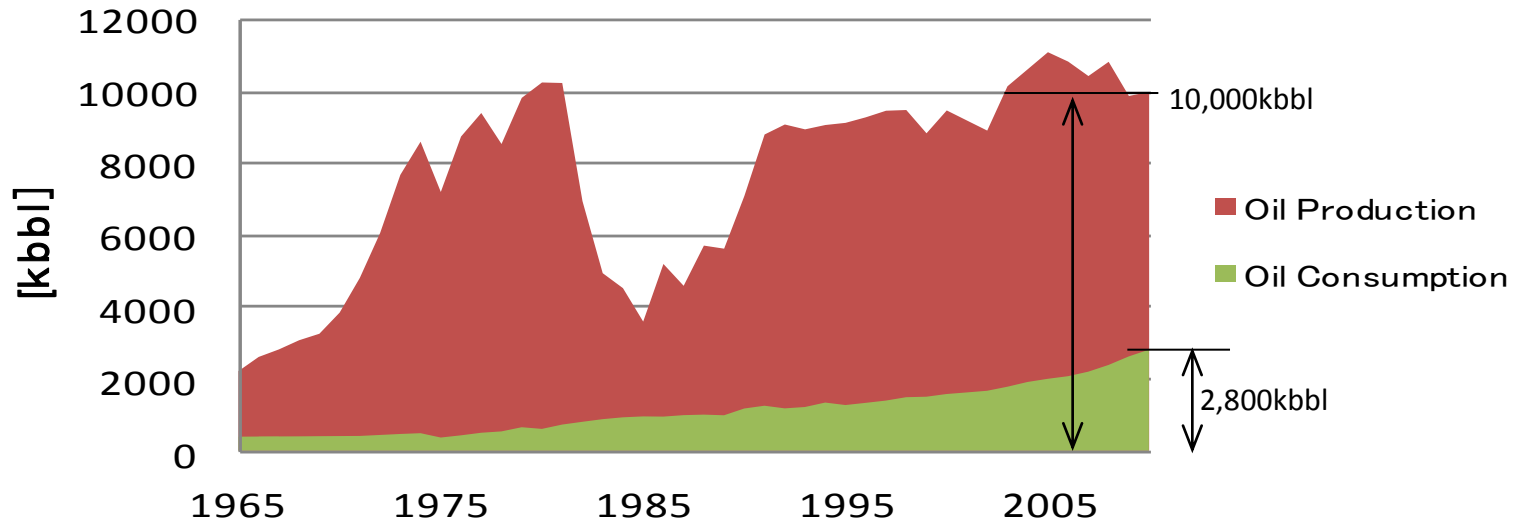
b. Solar systems

3. Future in the Solar Energy Utilized Society

Electricity Demand Trends in KSA

- ◆ Energy demand or especially electricity demand has increased by 6% every year since 2005.
- ◆ A lot of crude oil is consumed domestically under heavy subsidies.

Oil Production and Consumption in Saudi Arabia



Source: BP [Statistical Review of World Energy 2011, Historical data]

Figure 1 : Daily oil production and consumption in Saudi Arabia

Renewable Energy Utilization in KSA

- Solar Power Generation -

- ◆ At the 4th SSEF, KACARE announced that they will construct solar power generation plants with a total generation capacity of 16 GW by 2032 and introduce Feed-in-Tariffs to achieve this target amount.
- ◆ First of all, KACARE is going to conduct 2 procurement rounds in order to collect information to fix the conditions of Feed-in-Tariffs.

Table 1 : Procurement Round by KACARE

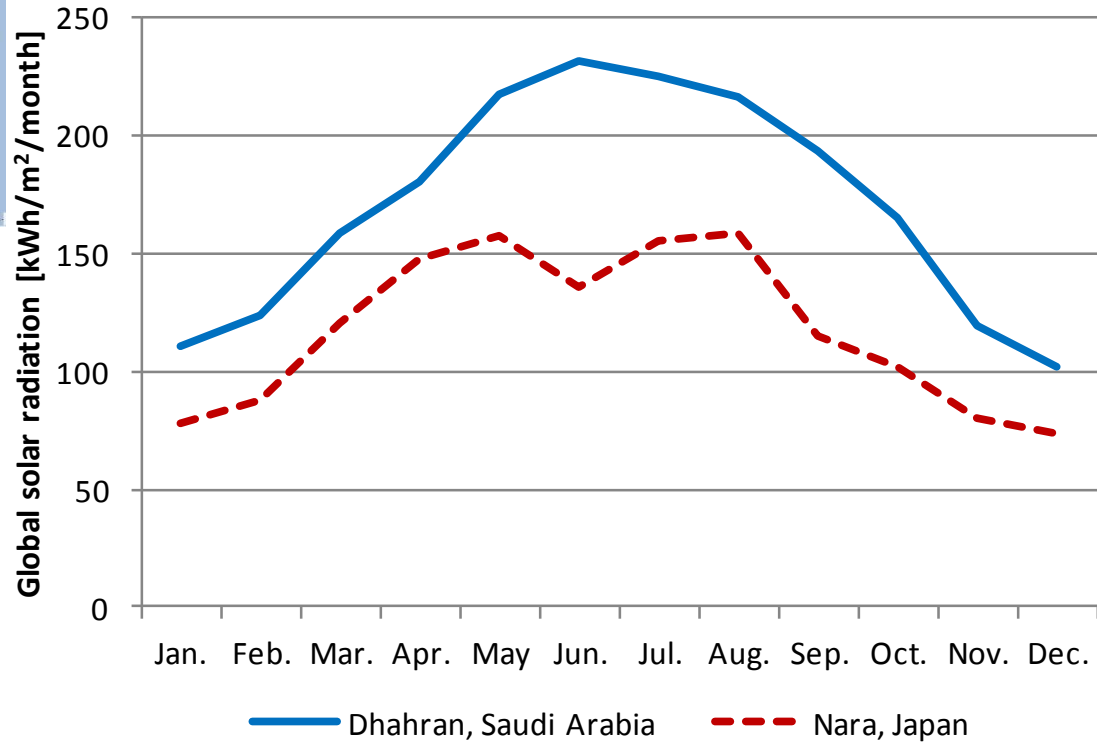
	Target Amount	Schedule
1 st Round	1,100MW (11 ~ 55 Projects)	◇ Developer Registry : 2012 Q2 ◇ Draft RFP ¹⁾ : 2013 Q1 ◇ Final RFP : 2013 Q2 ◇ COD ²⁾ : 2014 or 2015
2 nd Round	1,300MW (15 ~ 65 Projects)	◇ Draft RFP : 2013 Q3 ◇ Final RFP : 2013 Q4 ◇ COD : 2015 or 2016

Note: 1) RFP - Request for Proposal, 2) COD - Commercial Operation Date

Abundant Solar Radiation in KSA



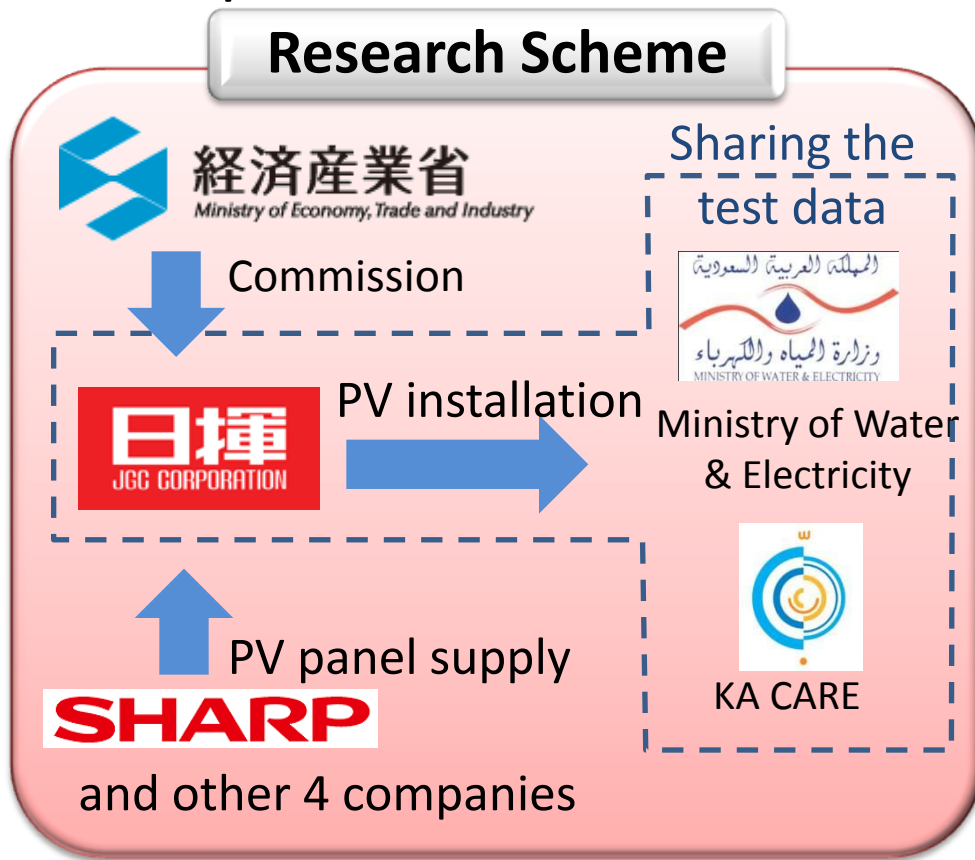
Comparison of Global solar radiation



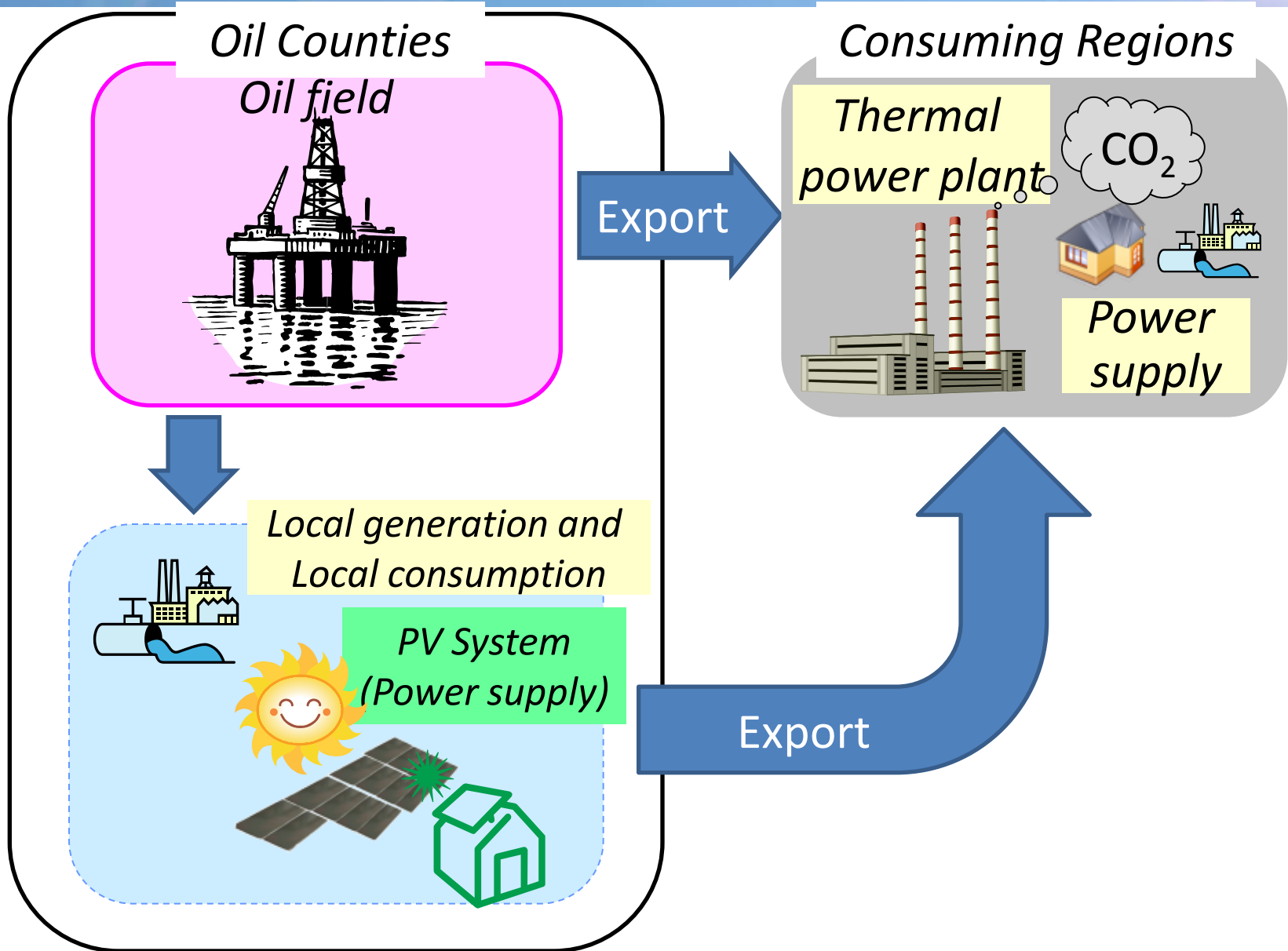
Actual solar research in KSA

Sharp's PV were utilized in "The industrial collaboration and support project for oil country in 2011" conducted by METI. JGC undertook this project and is evaluating how much power loss occurs due to sand cover.

Research Scheme

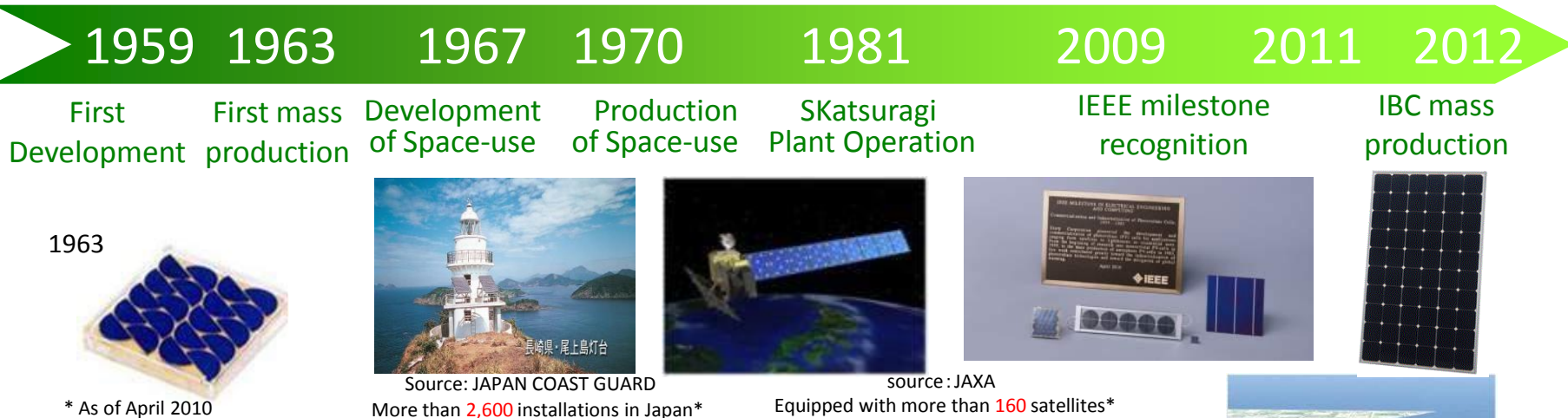


Aiming towards an Energy-Producing Country

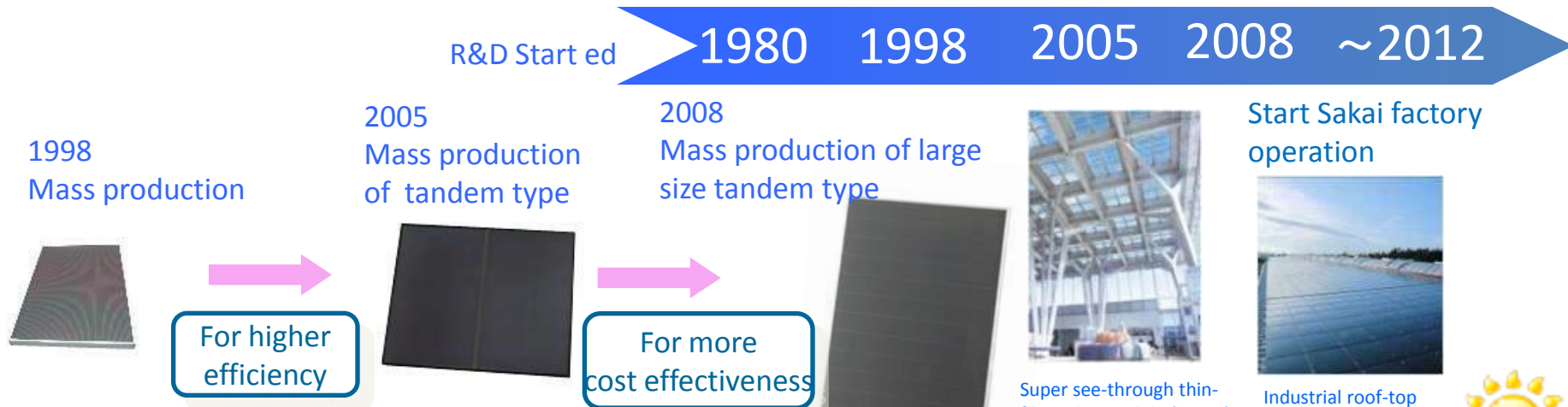


Our Long History as a Leader in technology

Crystalline Silicon Technology: 53 years of experience



Thin-Film Silicon Technology: 32 years of experience



UT-KFUPM Workshop, 2012



Solar Cells and Modules Shipped by SHARP

SHARP's Global Achievement : Global annual shipment volume No.1 share has been hold in the market for continuous 7 years of 2000 – 2006.

5.5GW
(~2011)



Satellites
(Equipped with more than 160)



Source : JAXA

Lighthouse in Japan (More than 2,600)



Source : JAPAN COAST GUARD

1963, Mass production of solar cells



1963 1966 1976

1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011

曆年



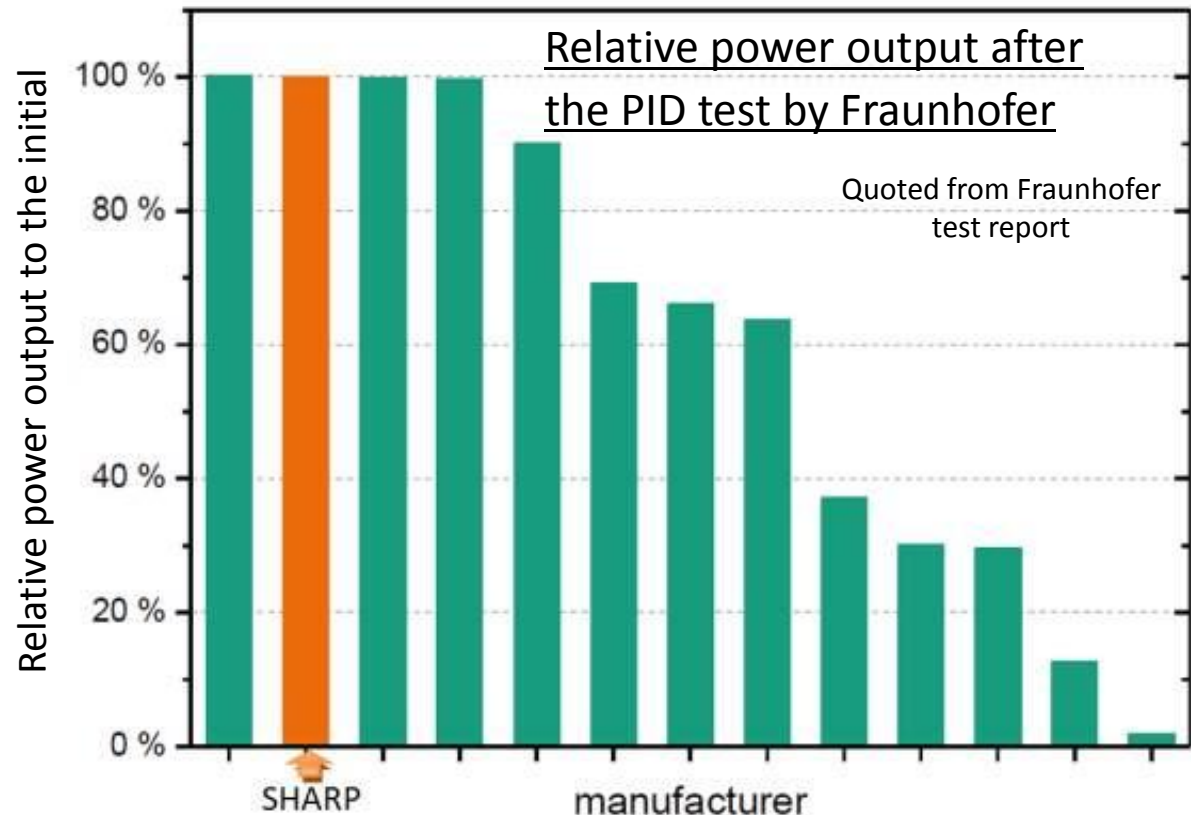
Highly Reliable Modules – PID* Free

Fraunhofer, one of the largest institutes in Europe, reported that our modules are free from potential induced degradation*.

* PID or Potential Induced Degradation : Output reduction of the modules caused by degradation of the photovoltaic effect induced by the potential voltage applied on the module frame.

SHARP is one of only 4 manufacturers to pass PID test with 100% relative output. This means our modules are free from PID.

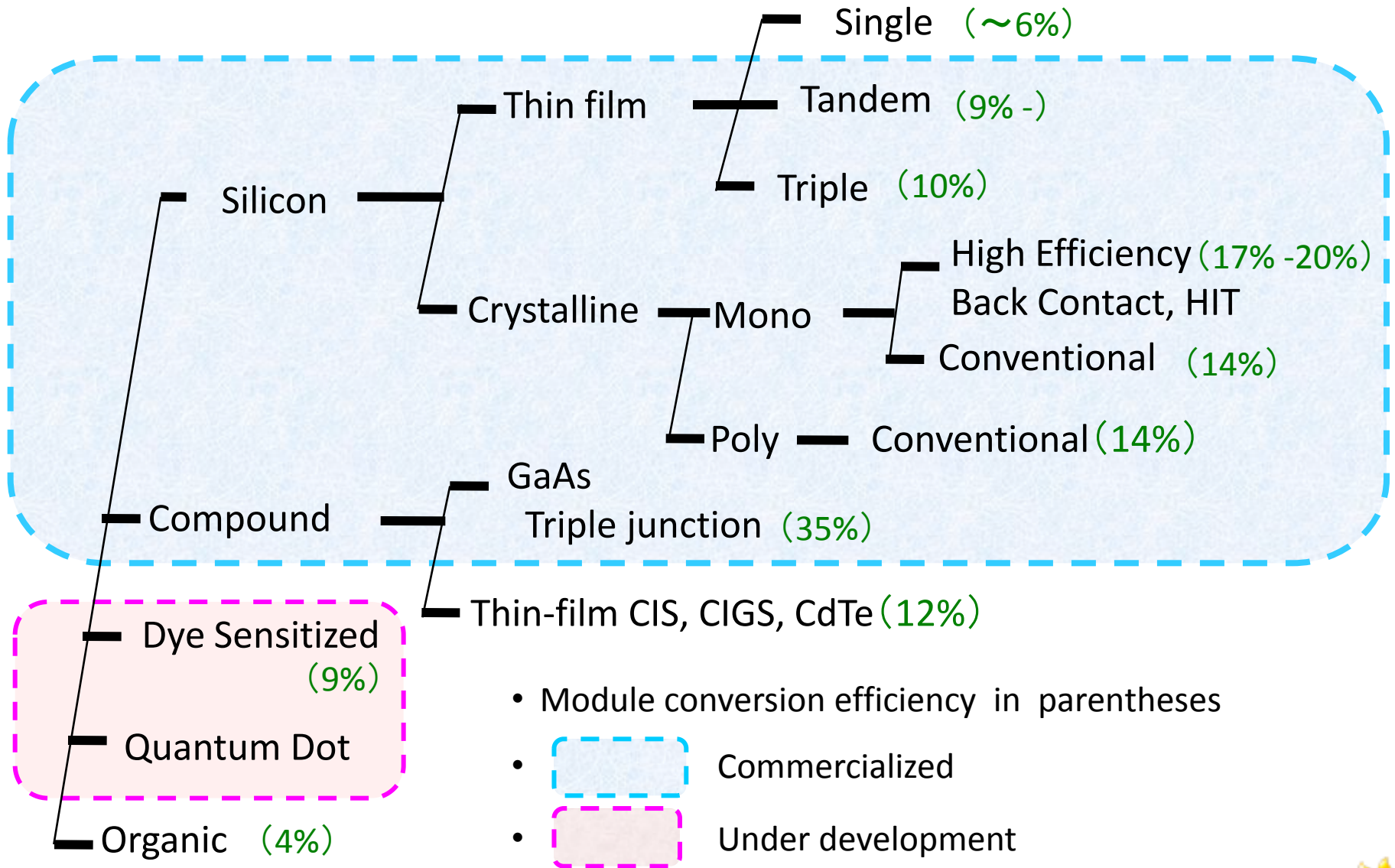
Sharp ND R250A5
STC-Power after Degradation (-1000V Al foil, 50°C, 50%, 48h)



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Various PV Modules and their Conversion Efficiency



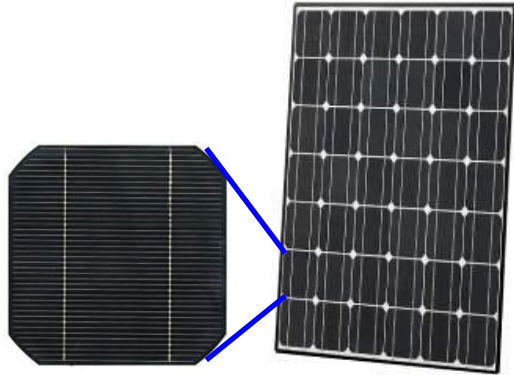
- Module conversion efficiency in parentheses

-  Commercialized

-  Under development

Line-up of PV Cells and Modules

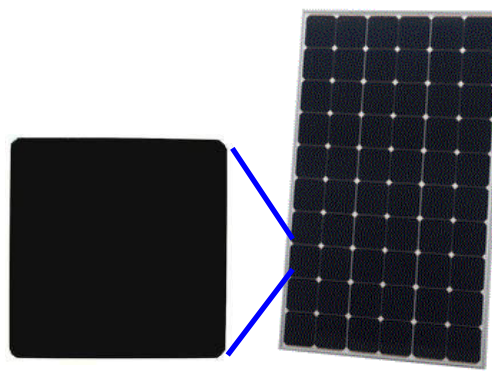
Conventional Poly-Crystalline



Cell

Module

High Efficiency Mono-Crystalline



Cell

Module

Si Thin Film

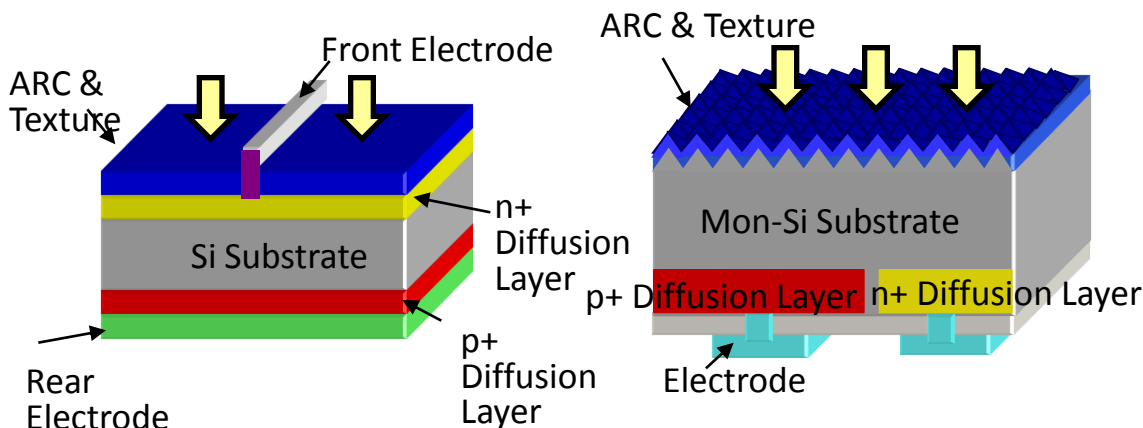


Module

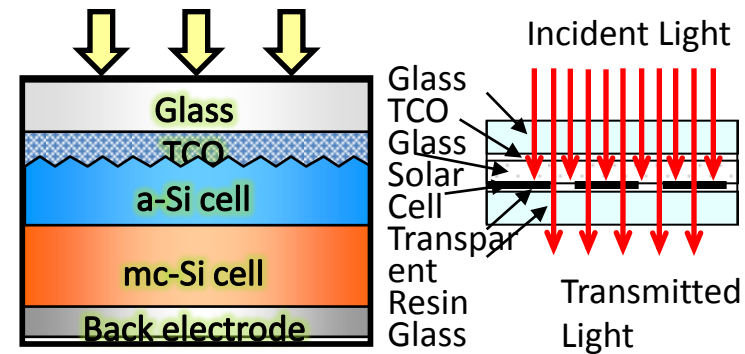
See-through Si Thin Film



Module

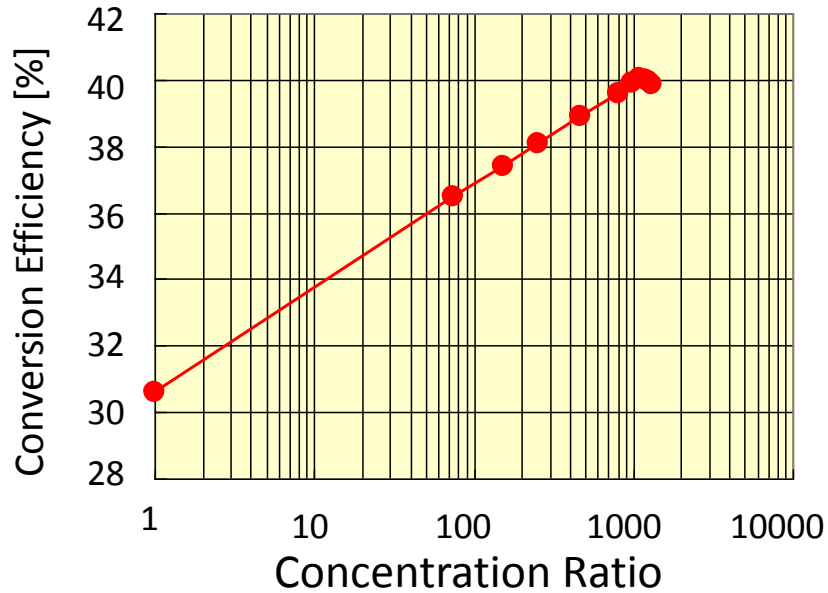


Cell Structure

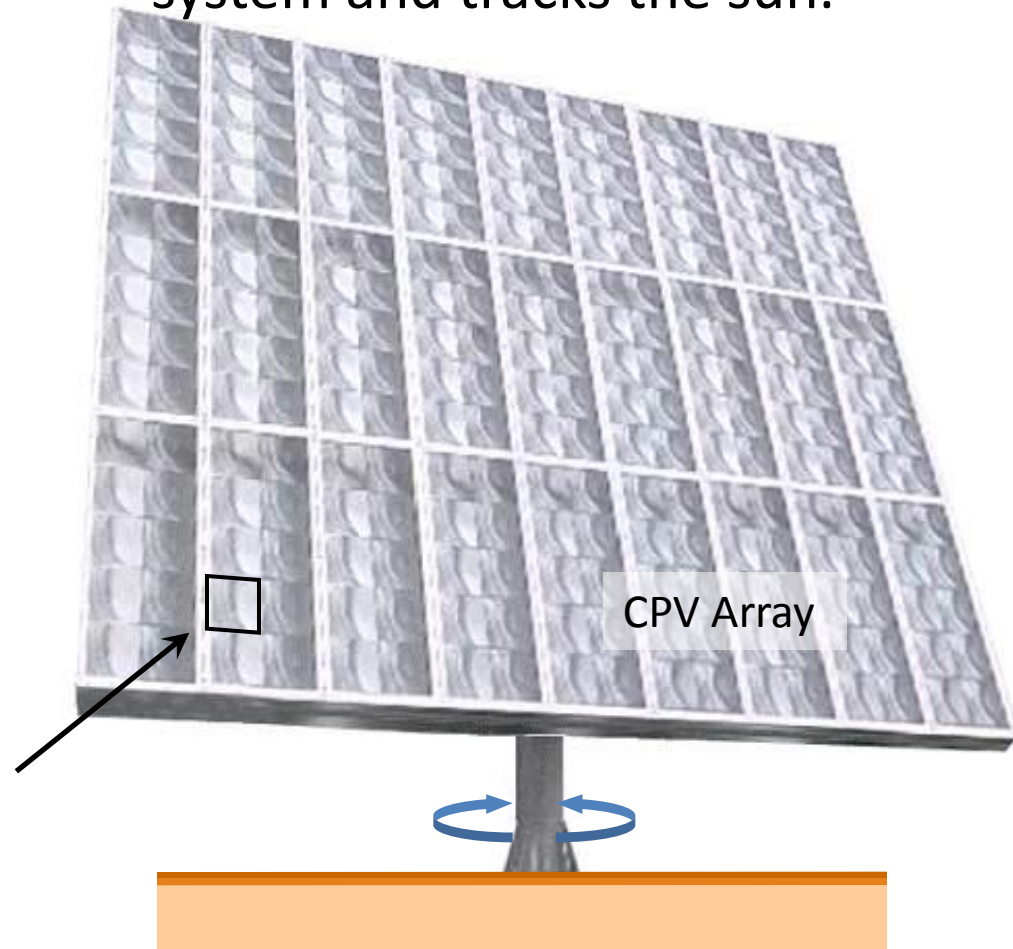
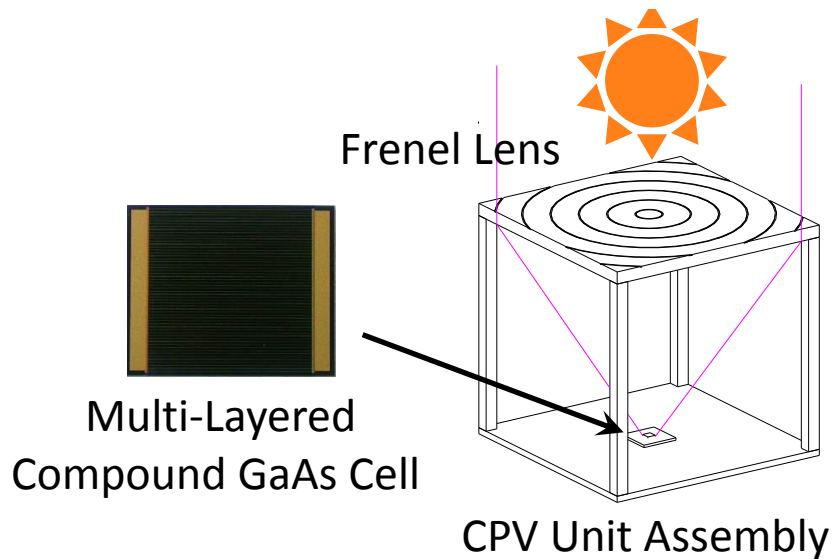


Module Structure

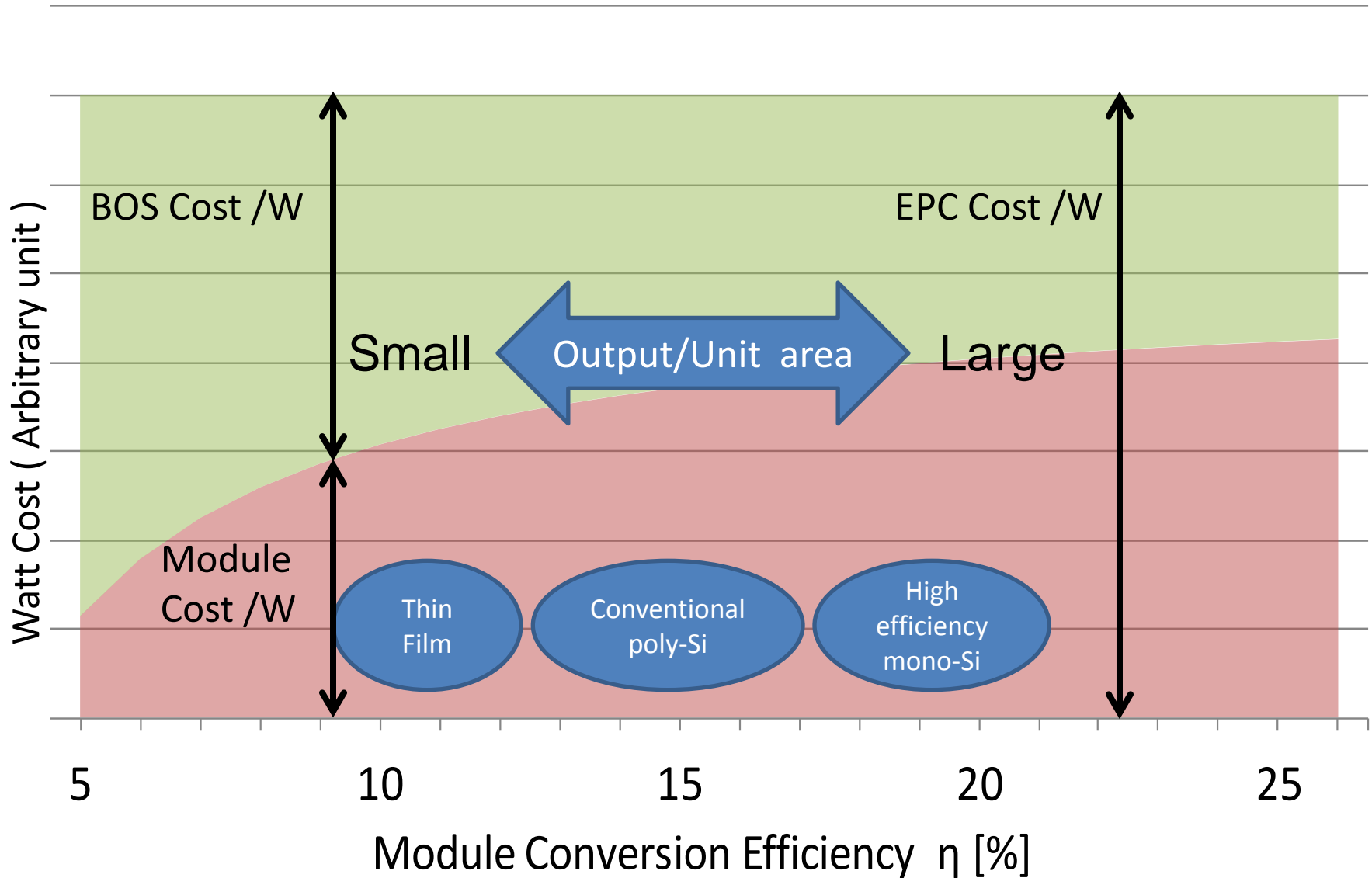
Concentrated PV Systems



CPV array sits on the tracking system and tracks the sun.



Module Conversion Efficiency & Watt Cost in KSA



What Kind of Module Should Be Utilized in KSA

Case 1.

The limited area and high land-rent cost : Rooftop, vicinity of metropolitan area

- ◆ High and medium conversion efficiency modules with crystalline silicon solar cells

Case 2.

The unlimited area and low land-rent cost : Rural area

- ◆ Low and medium conversion efficiency and low Watt cost modules with conventional poly-Si or thin films

Case 3.

High annual direct irradiation area

- ◆ Concentrated PV Systems (CPV)

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Large Solar System installed by SHARP



Customer	: Natural Energy Development Co., Ltd.
Area	: 190ha(1.9km ²)
Capacity	: DC 73MW / AC 55MW)
PV panel	: Thin film (56million pcs)
Inverter	: 50kW x 220pcs
Construction	: June 2010~March 2012 (Completed)
Location	: Lopburi, Thailand

Possible Hyper Large PV System in KSA

- ✓ In a desert area, there is almost no constraint for land acquisition, so hyper large scale PV/CPV can be built.
- ✓ In KSA the voltages of Extreme High Voltage Transmission lines are 230kV and 380kV.
- ✓ Since transmission capacity increases by square of voltage, typical capacity of these lines is several GWs.
- ✓ In consideration of available capacity(*) above, the scale of 500MW-1GW/site is a candidate of possible hyper large PV/CPV system in KSA.

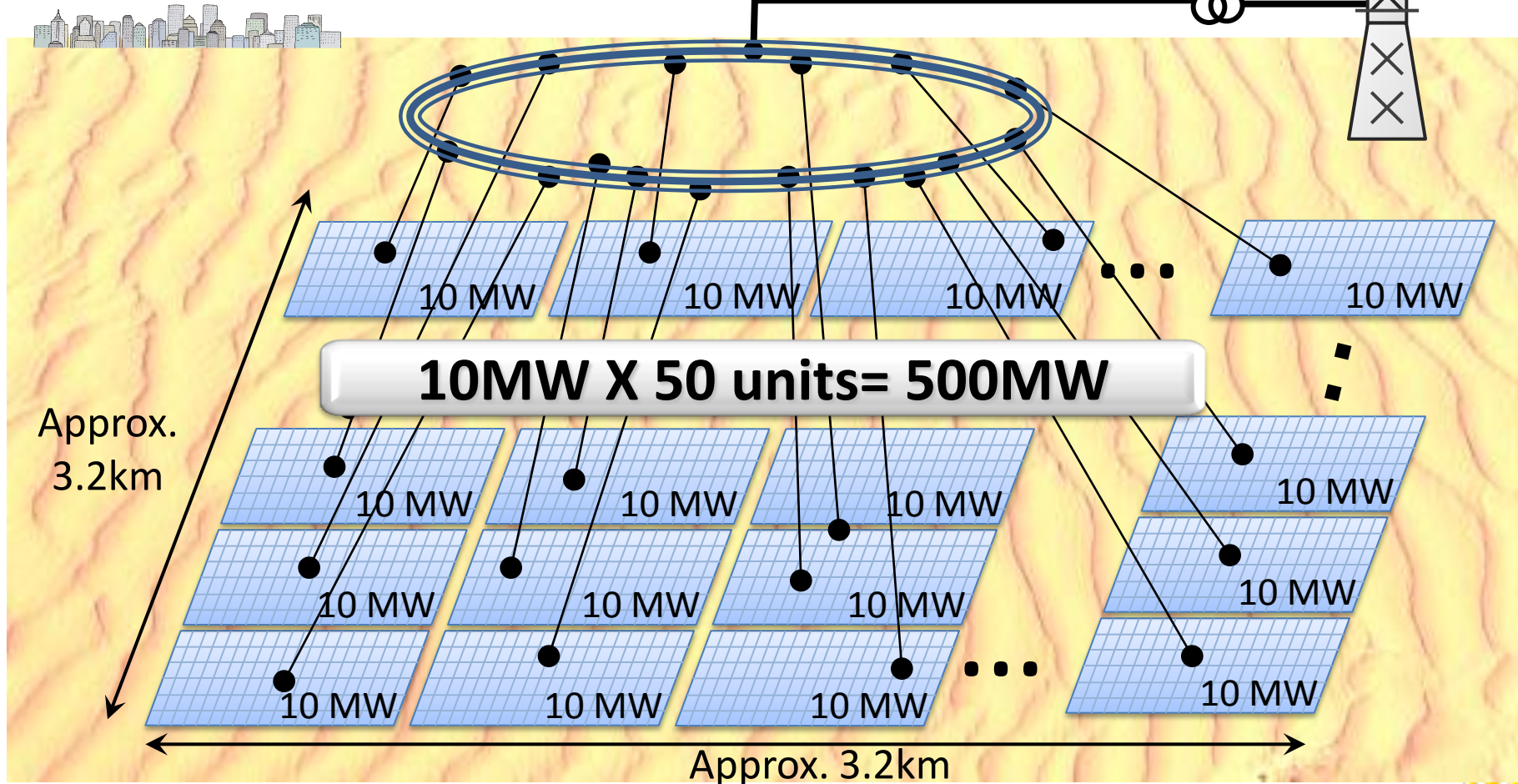
(*) It is necessary to conduct a careful survey about relevant actual power network of EHVT together with local electric companies involved.



Capacity of Hyper large PV/CPV system: 500MW

Hyper Large Scale PV/CPV System

In the case of output fluctuation due to sunshine fluctuation, the loop grid will be stabilized since 10MW units cover each other's fluctuation.



10 MW Solar System

PV Panels
PV Arrays
PV base



12.6MW as an example in Canary Islands

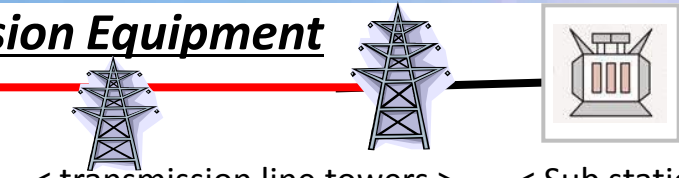
Collection box



Junction box

Transmission Equipment

Transmission line



< transmission line towers >

< Sub station >

Extra-high voltage transformation equipment

*Including switch, transformer and/or relay



Inverters

AC

DC

Data signal



Data measurement equipment

Data signal

Control room

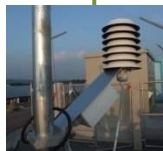


Weather Monitoring



Pyranometer

Thermometer



Wind gauge

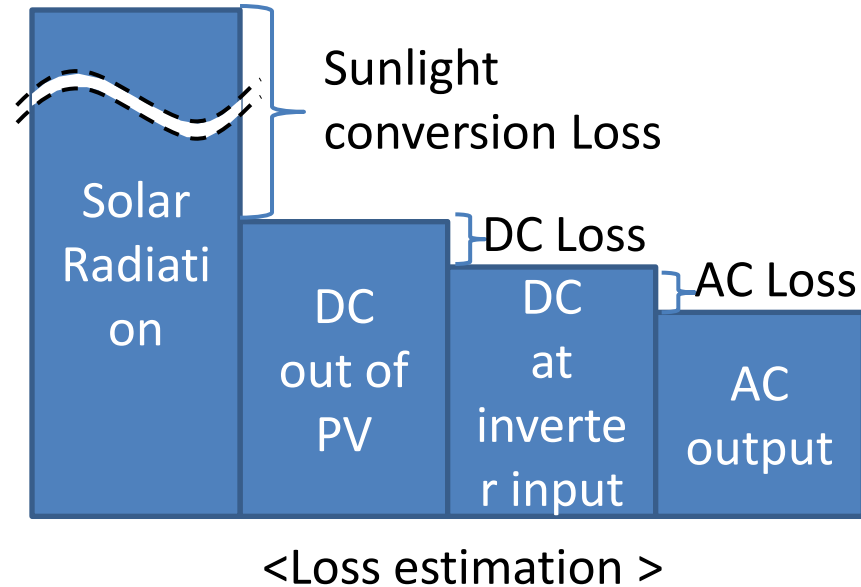
Rain gauge



Transducer

Data signal

Hyper large PV system installation



- Site selection
- Site survey



-System design considering...

- PV panel specification
- PV panel lay-out
- Array inclination angle
- Cross section of cable: thick or thin
- Climate data
- loss estimation by each loss factors
- Energy yield estimation: Annual power output



-System design finalized
Example above:
NED project in
Thailand

Hyper Large PV System Installation: Asset Management

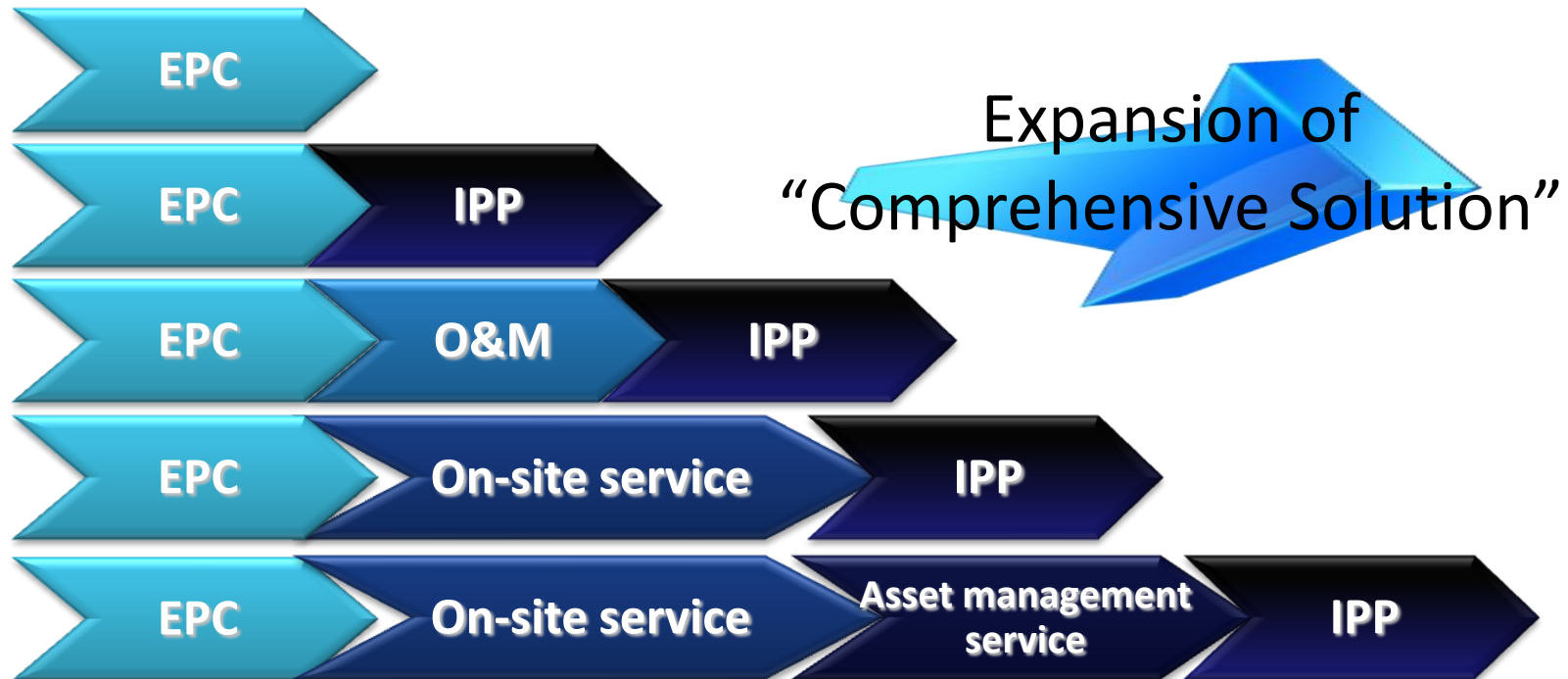
Customer/Investor

- would like to minimize the investment risk.
- Lack knowledge of how to manage generation plant.

Comprehensive Solution

More advanced than original O&M

- On-site service
- Asset management service



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Solar Farm with Hyper Large Scale PV System

Desalination factory

Vegetable factory

Water source

SHARP

One-of-a-kind technology



Removal of organic material

SHARP
Sterilization treatment / culture fluid



Vegetables like tomato, Cucumber etc. without agricultural chemicals

Hydroponic culture in the greenhouse



DC/DC

AC/DC

Common vegetable zone

High class Vegetable zone

One-of-a-kind technology



LED
Air conditioner



Hydroponic culture in semi-outdoor



Nursery plant, sprout etc. are grown in weak light under the modules.

Hyper Large PV System

SHARP
Only one technology



Mushroom



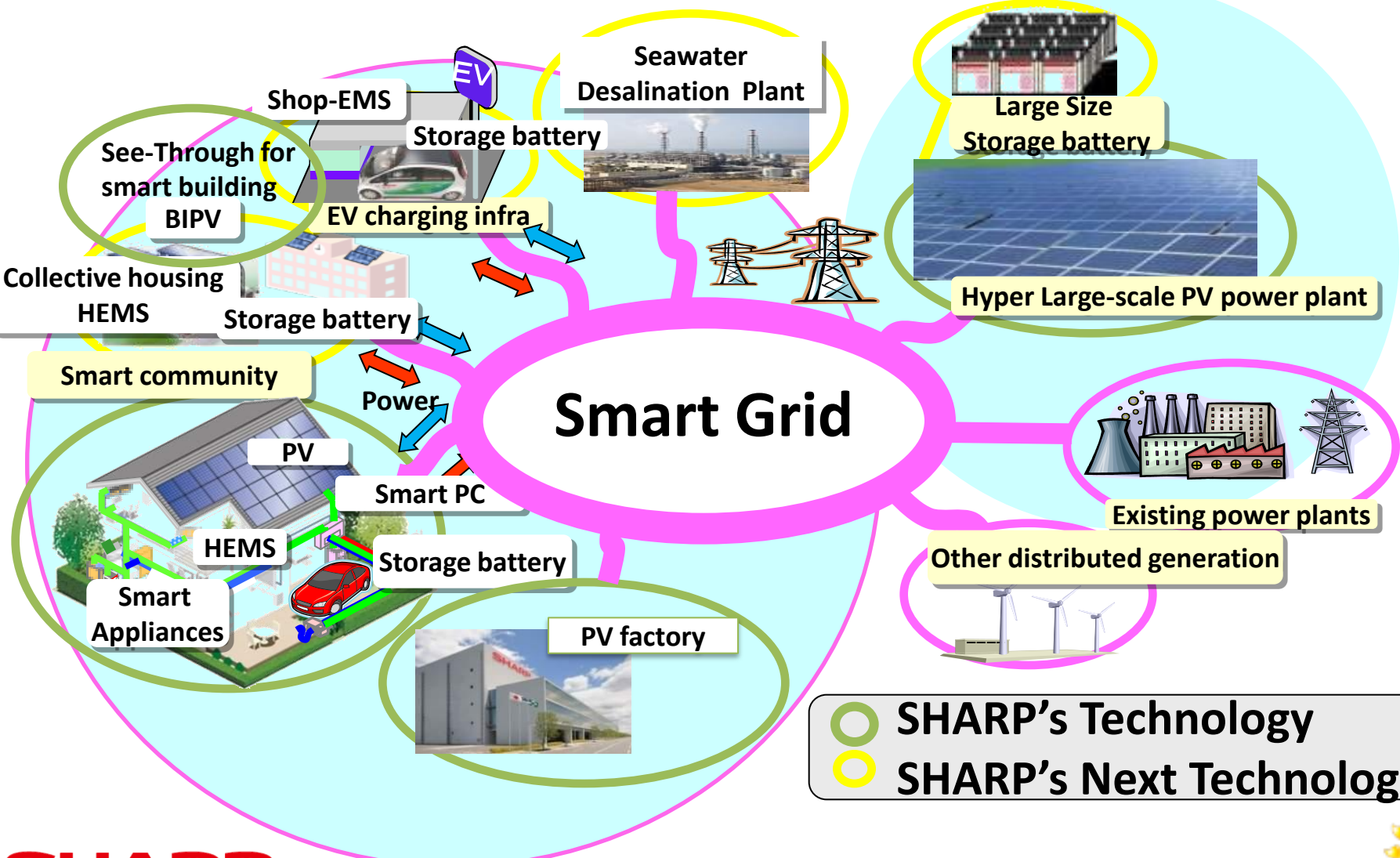
Melon, strawberry etc

Green Technologies for Smart Grid / Smart City

Smart City / Area-EMS

Power Generation

Smart Grid



SHARP

100th
ANNIVERSARY