Power Project of SAN PEDRO DE ATACAMA

August 1, 2012

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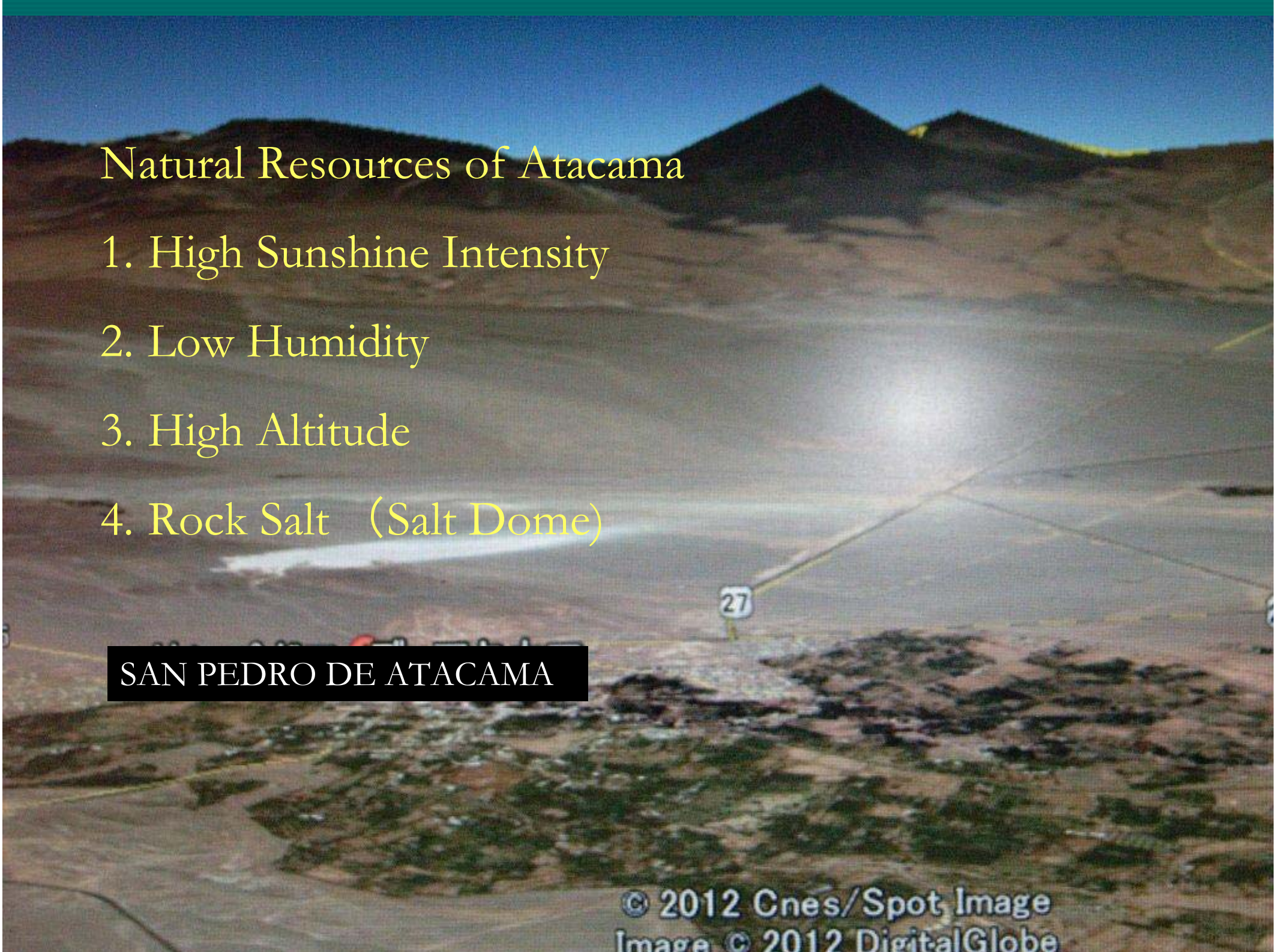
Natural Resources of Atacama
1. High Sunshine Intensity
2. Low Humidity
3. High Altitude
4. Rock Salt （Salt Dome)
27
SAN PEDRO DE ATACAMA
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A Power Supply Plan by Renewable Sources

1. Efficient Use of Sunshine PV or CSP
2. Energy Storage System for Night Demand

   Battery/ Thermal Storage/ Compressed Air
3. Economy

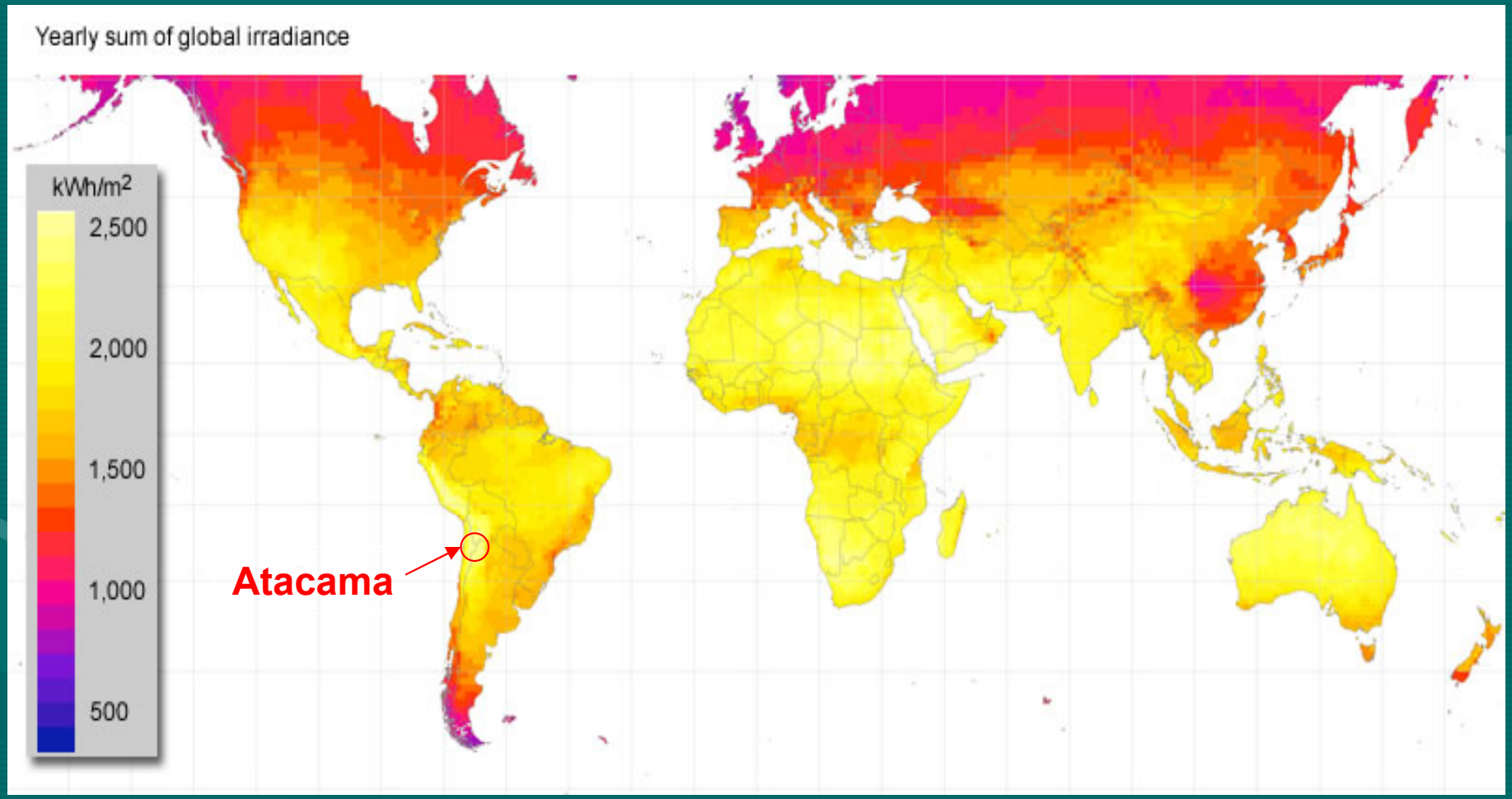
   Should be Competitive to Gas and Diesel Oil
4. Introduction of the Smart Grid Concept

   Community Energy Management System

   The Functions of Storage and Ancillary Services
5. Coordination with TAO Project

The World Solar Intensity Map

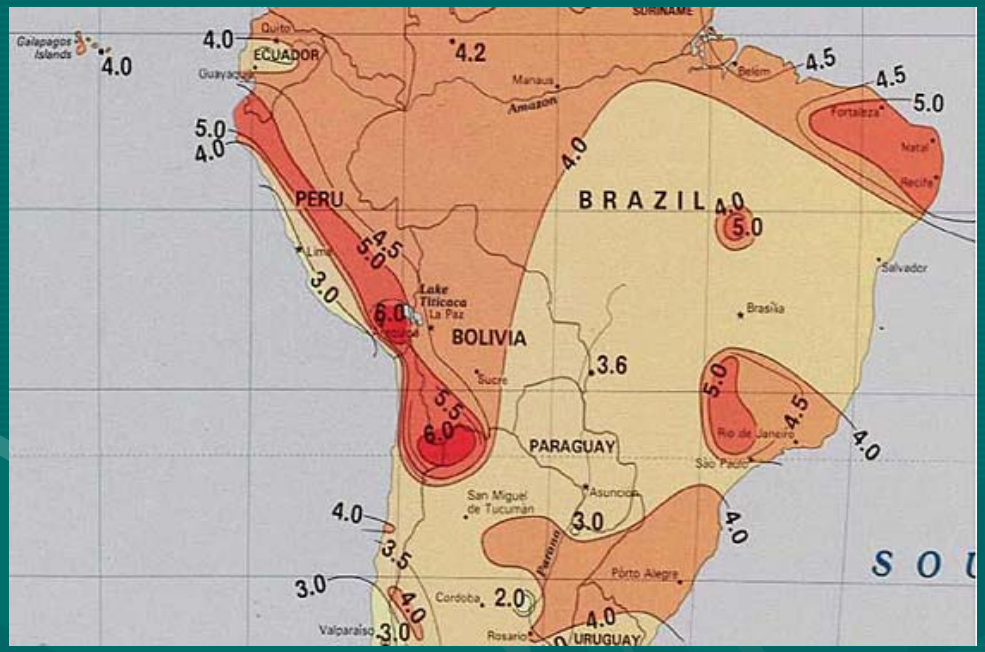
Atacama is located at the highest solar intensity area in the world.



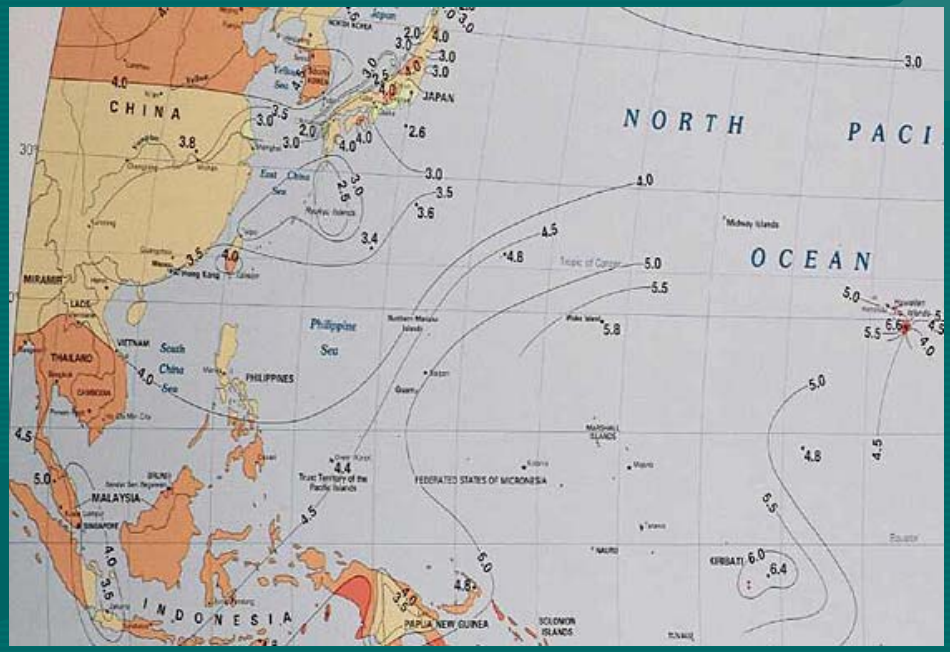
Solar Intensity of Atacama and Japan

Atacama's solar intensity is 1.5 to 1.7 times higher than that of Japan.

Solar Energy (Kwh/m²/Day) as an annual average.



South America



East Asia

Energy Management System in Atacama

Li-Ion Battery

BTB

SVC

BTB

TAO Project

SVR

CSP Farm

PV Farm

Li-Ion Battery

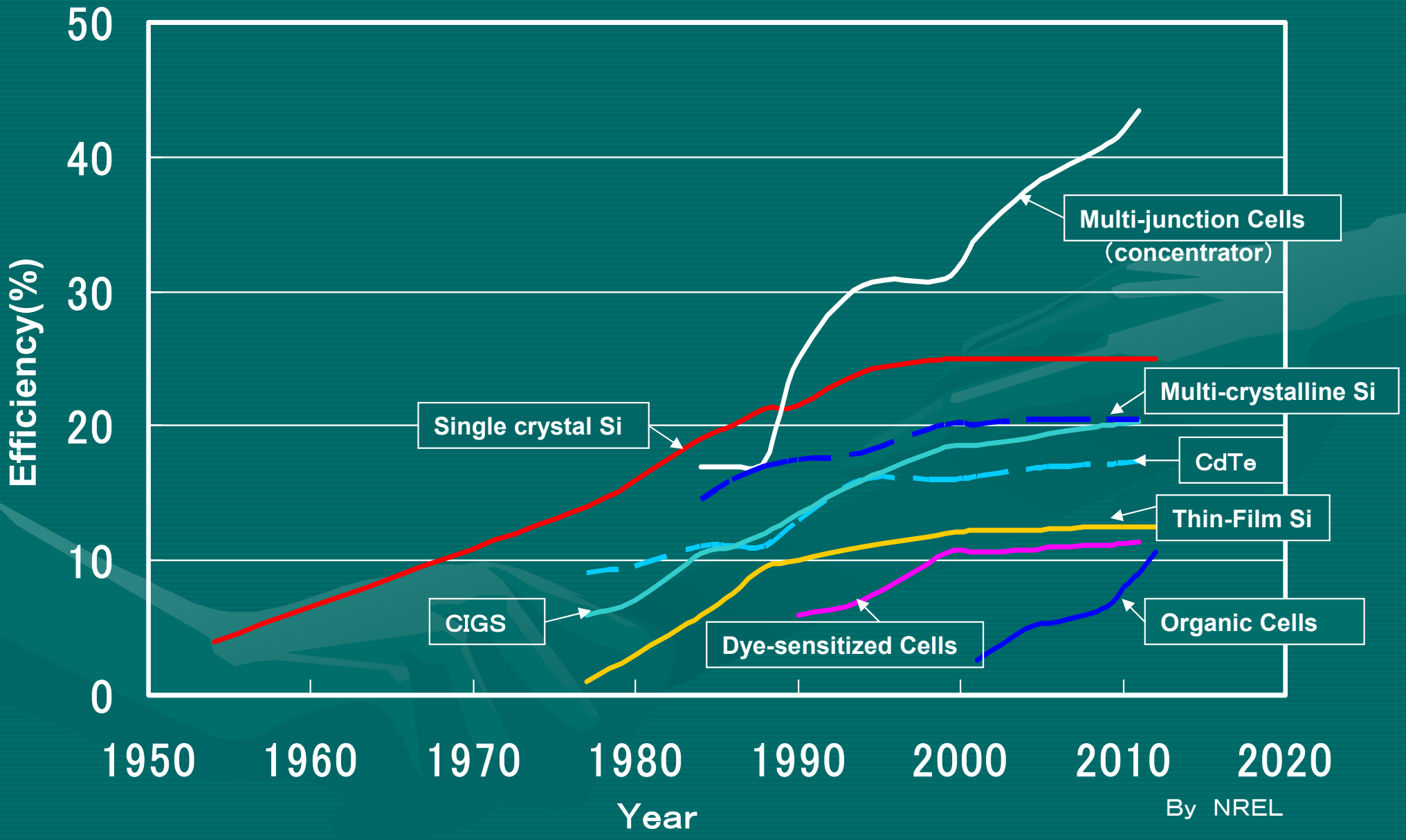
Thermal Power Plant

Control Center

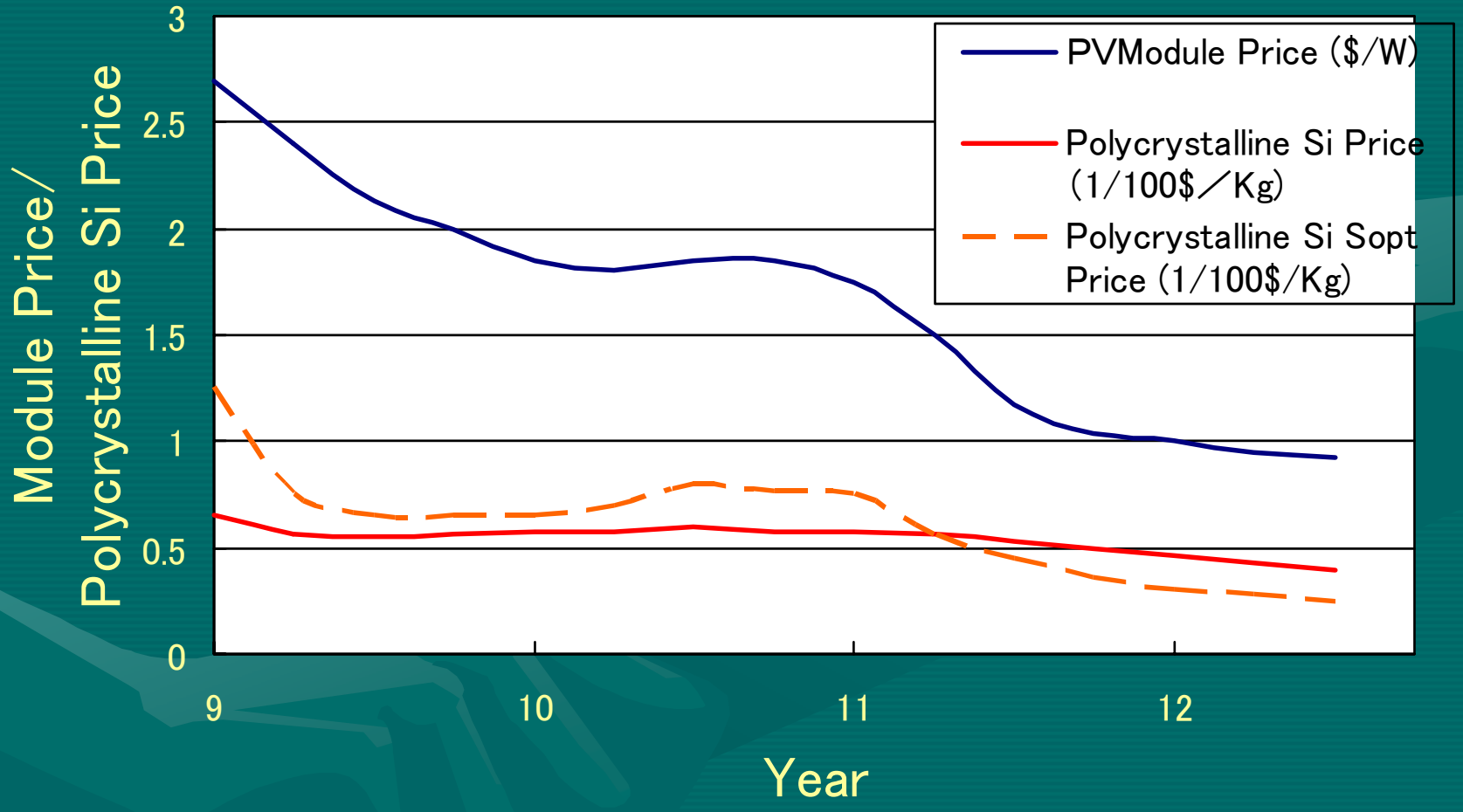
PV's in Houses

SAN PEDRO DE ATACAMA

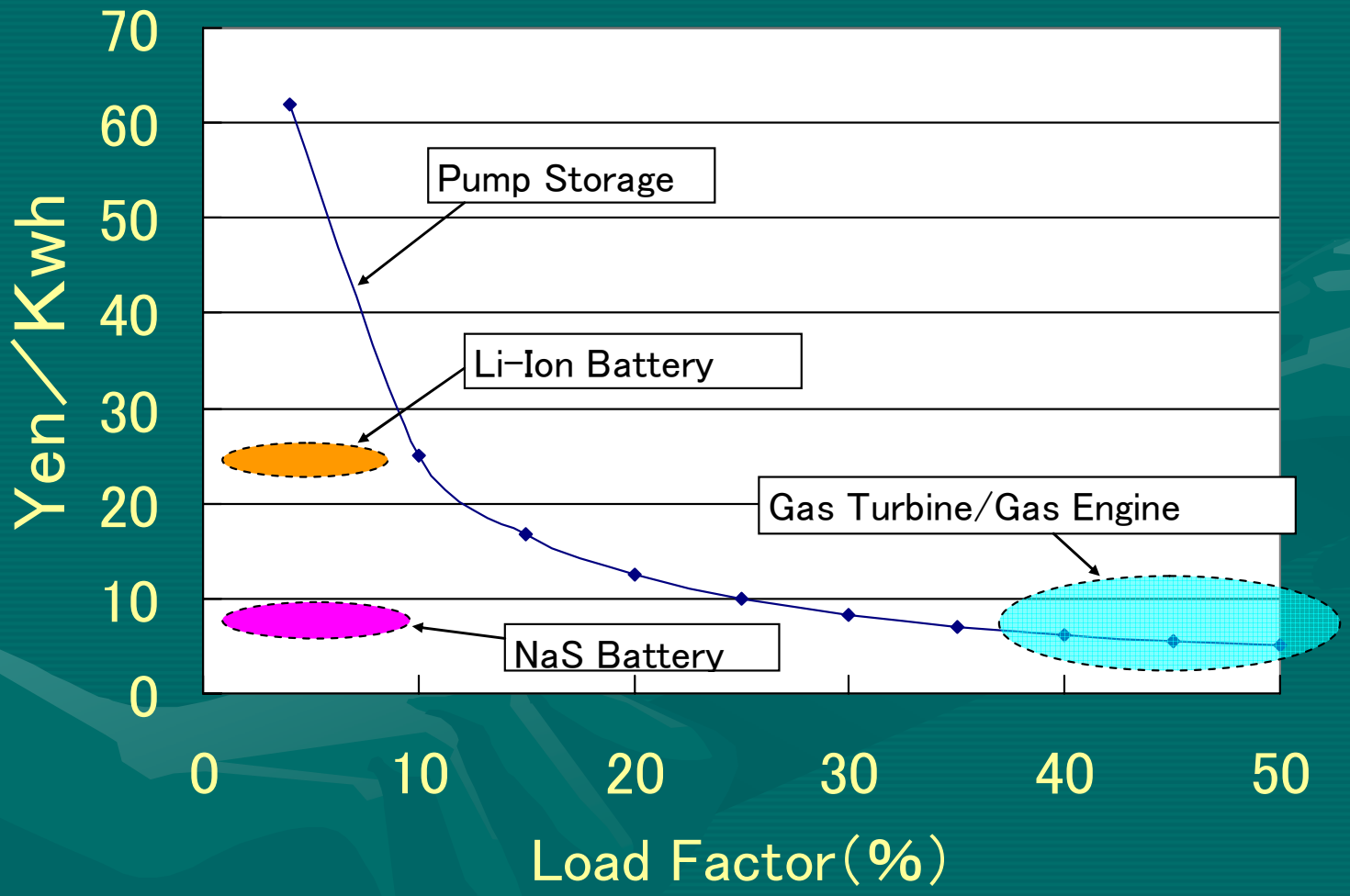
Trend of PV Efficiencies



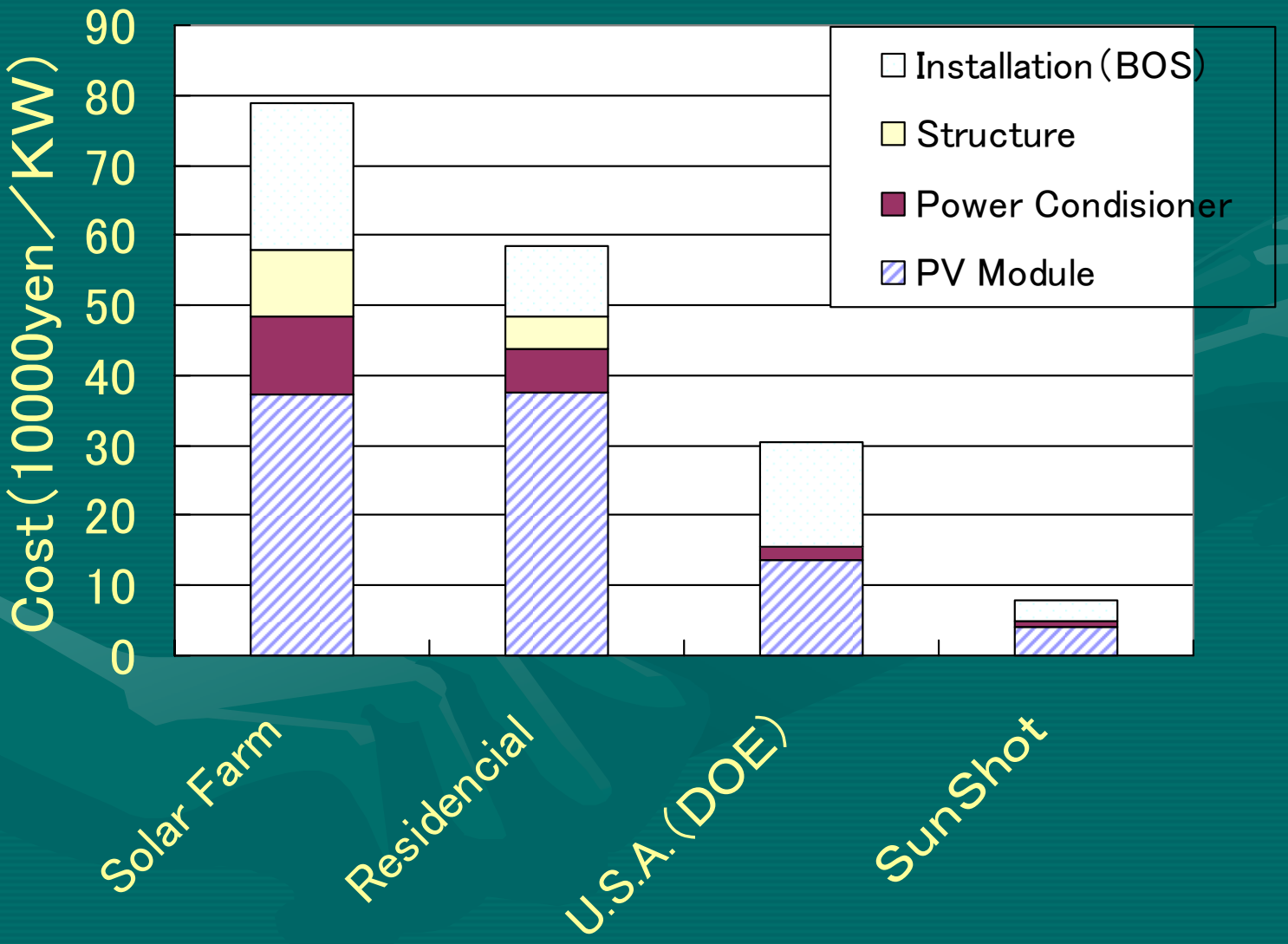
The Trend of PV Cell Price (Crystalline Si Cell)



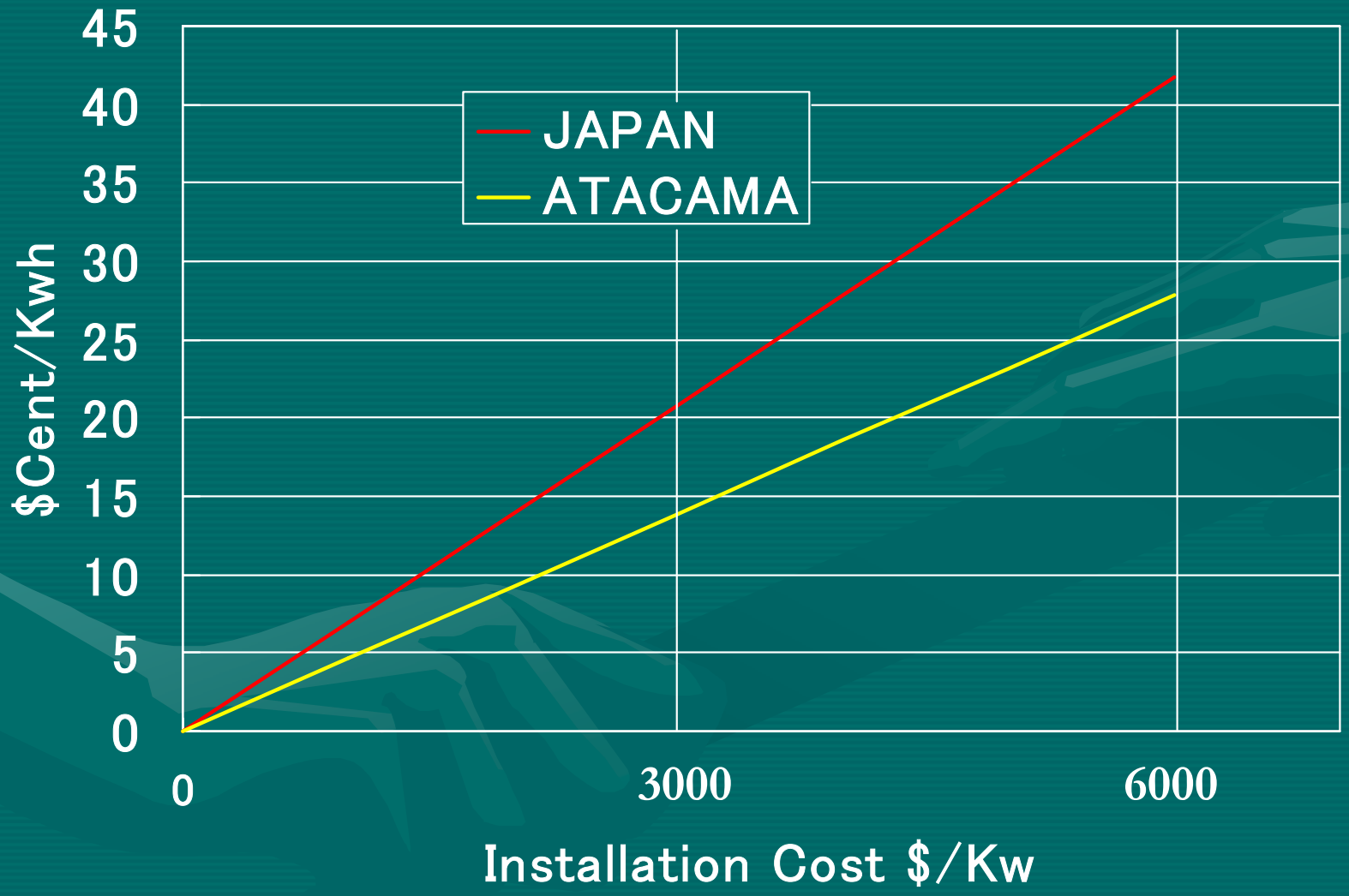
Cost of Energy Storage and Ancillary Services



Cost of PV System (Installed)



Electricity Cost by PV



Features of CSP's

Type of Collector	Working Fluid					Working Temperature (℃)	Total Efficiency (%)	Type of Engine	POWER RANGE (MW)
	Oil	Molten Salt	water	Air	N2				
Trough	○	—	○	—	—	４００	２０	Steam Turbine	１０～２００MW
	—	○	○	—	—	５００	２０＋α		
Fresnel	○	—	—	—	—	２８５	１５		
Tower	○	○	○	—	—	５６０	２４		～５０MW
	—	—	—	○	—	８５０	≧３０	Gas Turbine	～１０MW
Dish	—	—	—	—	○	８００	２０	Staring Eng.	2.5～10KW

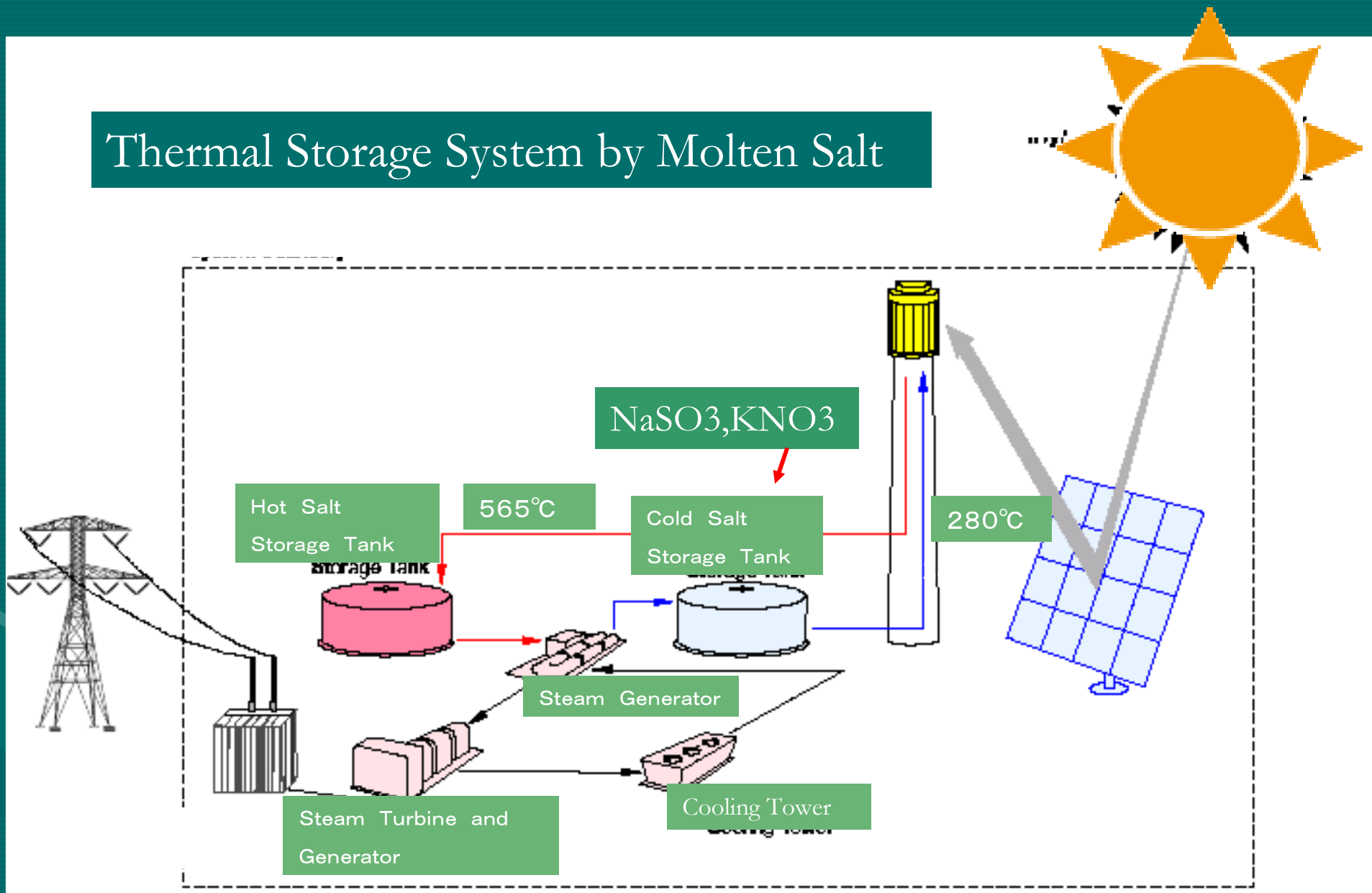
Trough

Fresnel

Dish (Staring Engine)

Tower Type CSP (Steam Turbine) PS-10/ PS-20

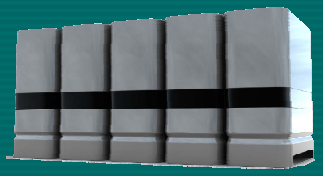
Thermal Storage System by Molten Salt



Storage and Ancillary Services

Installation capacity of PV, Battery and Engine have to be designed to minimize the cost.

PV Farm



Li-Ion Battery

A

Li-Ion Battery

Engine

Engine

B

Demand

0 6 12 18 24

Hour

Investments on the Power System Restoration

- Solar PV
  $4800/Kw→$1000/Kw
- Battery System
  $800/KwH→$250/Kwh
- CSP with Thermal Storage
  $4000/Kw→$2000/Kw
- Diesel (Gas) Engine
  ~$1000/Kw

Total Demand=20MW

PV=10MW *$3000/Kw= $30Mil.

Battery=2Hr * 10MW * $500/Kwh=
$10Mil.

CSP=10MW * $4000/Kw= $40Mil.

Diesel (Gas) Engine =
10MW * $1000/Kw=$10Mil.

Grid Installation/Sub Station = --------
(CEMS)

Total Investment = $90Mil.

Need to be 1/2 to 1/3

Compressed Air Energy Storage

By Solar

Electric Power

Mortor

Compressor

Thermal Storage

Turbine Generator

Salt Dome

Compressed Air
=5~7Mp

Cavern

Conclusions

- High possibilities of Solar Power System in Atacama.
- Need to select the cheapest Solar Power system.

  Types of PV's, PV or CSP
- Good opportunity for PV installation.

  The world trend of PV price down;

  Currently $1/W for module → $1/W for system by 2020.

  (=$1000/Kw; Sunshot Initiative by USA)
- The total management including energy storage and ancillary services is the key.

  → Concept of Community Energy Management System
- Thermal and Compressed Air Storage are to be studied.