- Photovoltaics: 태양광 에너지

- Net solar power input to the earth is more than 10,000times humanity's current rate of use of fossil and nuclear fuels

- Photo: Greek word for light
- Volta: Italian inventor of battery, Alessandro Volta

- PV effect by Becquerel in 1839: wet cell battery with silver plates
- PV effect on solid selenium by Adams & Day from Cambridge in 1877
- Selenium + gold wire + glass by Fritts in 1883 with 1% efficiency

- PV effect in silicon (semiconductor) in 1953: 6% efficiency
- Single cell (1.5 watt) – Module – Array
- Efficiency in single Si cell: 17% (commercial), 24% (lab)

• Types of photovoltaics:

(1) Monocrystalline silicon

(2) Polycrystalline silicon
(3) Silicon ribbons and sheets
(4) Gallium arsenide

(5) Thin film PV:
a-Si (amorphous silicon),
CIS (Copper Indium Diselenide, $CuInSe_2$),
CIGS(Copper Indium Gallium Diselenide),
CdTe(Cadmium Telluride, CdTe)

(6) Other type:
Multi-junction PV cells,
Silicon spheres,
Photoelectrochemical cells,
Third generation with nano technology

- Principles of semiconductor:

- crystalline Si, impurity (doping process), p-n junction

- n-type: silicon + phosphorus (surplus of free electrons)
- p-type: silicon + boron (deficit of free electrons)

- PV effect: photons, depletion region

Reducing cost: Polycrystalline silicon (but effc. 14%)

(cf) polycrystalline films on ceramic or glass

(by Pacific Solar, Astropower): effc. 10%

Raising efficiency: Gallium arsenide (GaAs)
-High light absorption coeff. BUT expensive
-Operate at relatively high temp. → space etc.

Thin film PV: a-Si (amorphous silicon)

- Gas with silicon & hydrogen (e.g. silane: SiH_4) & dopant by electric.
- p-i-n junction
- thinner, high absorp., process at lower temp.& cheaper, BUT low effc. as 12% → 4~8% (a few months)
- used at calculator

Thin film PV: other types

- CIS (Copper Indium diselenide: $CuInSe_2$)

- CIGS (Copper Indium Gallium Diselenide)
- effc. 17% at lab, 10% stable by Shell Solar, Würth Solar

- CdTe (Cadium Telluride)
-Inexpensive process
-effc. 10%

Silicon spheres
by Texas Instruments

-Polycrystalline Si embedded
between thin Al sheets

-Cheaper with low-grade Si

-Used at 20MWp plant by
Automation Tooling Systems Inc.

Cell – Module – Array

- Cell size: 1 – 15 cm, 1 -2 watts
- Standard module: 36 solar cells, 60 Wp (0.5m x 1.0m, 0.33m x 1.33m)
- Cleaning of module: reduction of effc. 4 %,
  → thus req. over 20° inclination

Satellite solar power

Full 1365 W/m^2
(cf) max 1000 W/m^2 at the earth

Reducing the cost?

- If production at 500 MWp per year → $1 per peak watt

- BoS (Balance of System) cost about ¾ of module cost at present
→Should be below $1 per watt

- effc. 17% → 24% at next decade (by Sharp Corporation)

- payback time: 2~5 years → 1.5~2 years

PV resources & Future

• If 10% effc. on 0.1% earth's surface (= 500,000km^2, or 1.3% of total desert area) → 100% world's current energy !

• If 10% effc. on 1.4% on UK land → 350 TWh/year (100% !)

• Production by Sharp: 123MW → 200MW
  -by BP Solar: 71MW, by Shell Solar: 55MW in 2002
  -others: Siemens Solar (joint venture with Shell)
(doubling of world PV production every two years)

• Installation: over 200 GW by 2020,
  and 9000 TWh output by 2040 (over ¼ of global electricity demand)