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Role of Thermal Engineering in Green Growth

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Climate Change and Global Energy Challenge

Change in Ecological System

- Increase by 0.74ºC in recent 100 years
- Projected to be 6.4ºC at the end of this century
- An increase by 2ºC exterminates 15~40% of lives.

Global Electric Energy Consumption

Projection in 2050 : 28 TW

Based on: minimum population growth (9 billion people),
economic growth of 1.6%/year,
energy efficiency 5 times as high as is in USA

- To sustain CO_2 at 450 ppm: 26.5 TW produced with no emission
- To produce 10 TW of nuclear power: 10,000 units of nuclear reactor (1 GW). Construction of one nuclear reactor every other day till 2050
- Maximum wind power available 3 TW : 1 million wind turbines
- To produce 10 TW of solar power till 2050: required to construct 1 million solar cell houses every day

N.S. Lewis, "Powering the planet", MRS Bulletin, Vol. 32, 2007

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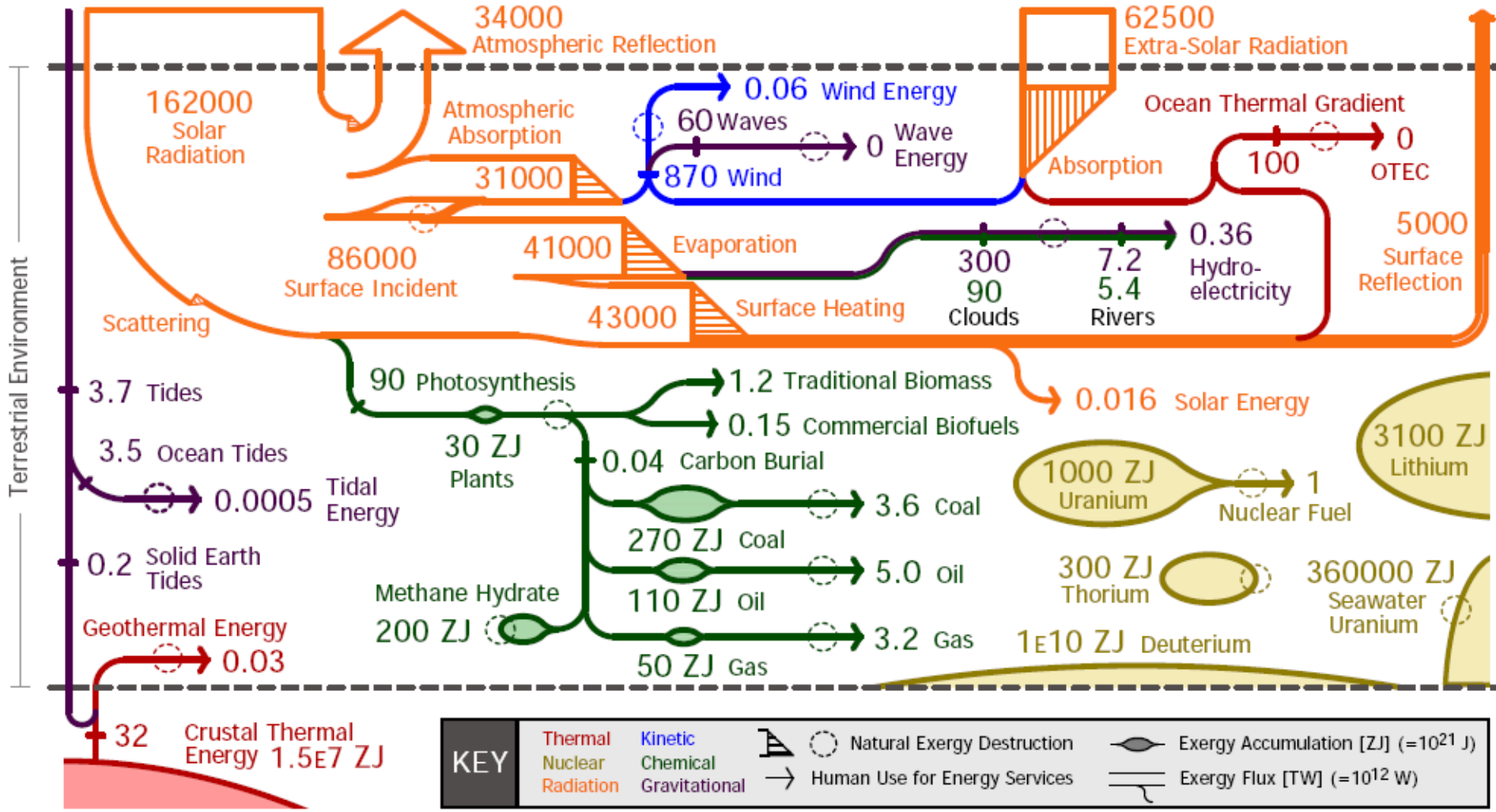
Since 1951

Global Exergy Flux, Reservoirs, and Destruction



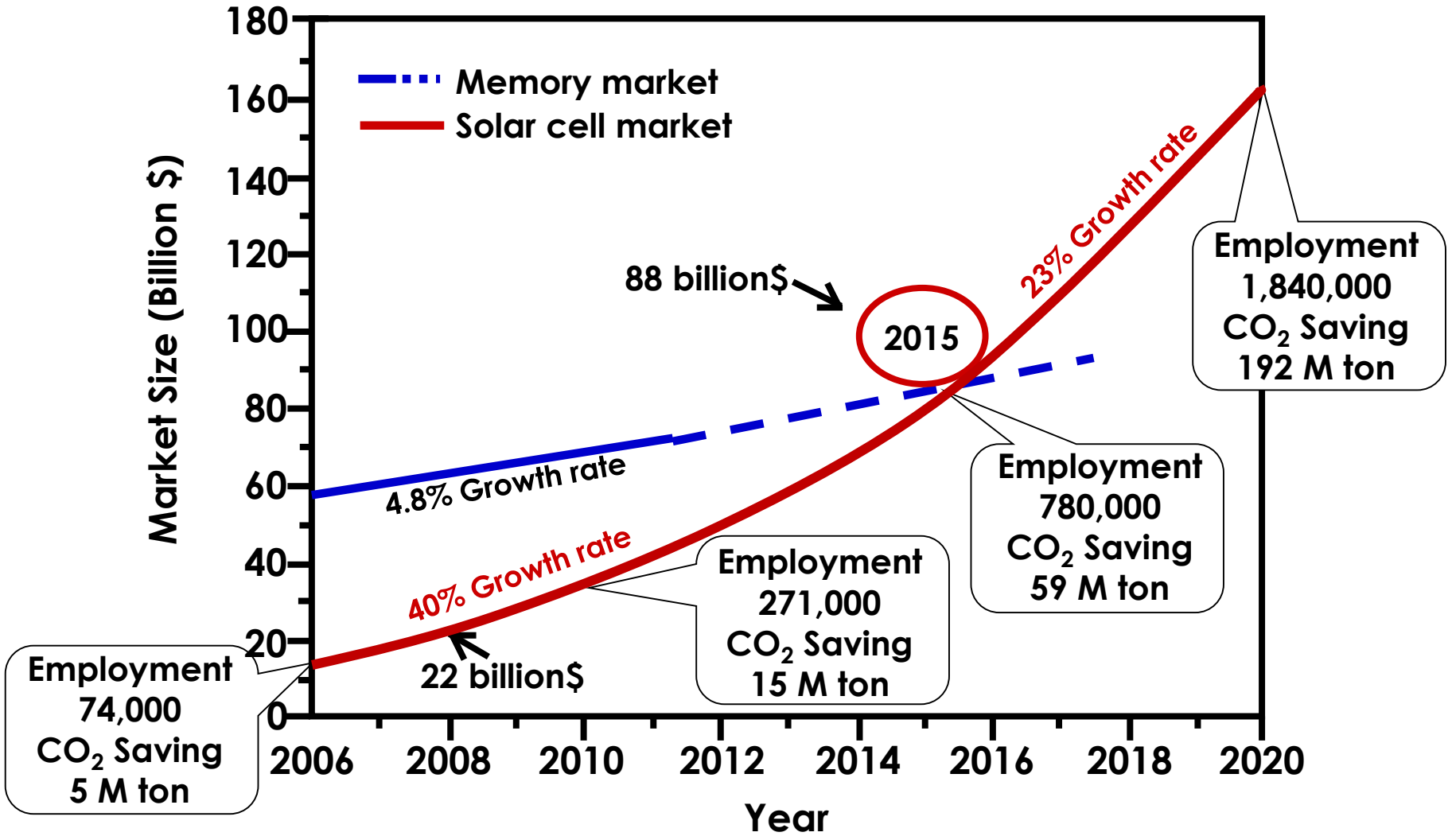
Global Climate and Energy Project at Stanford University

http://gcep.stanford.edu

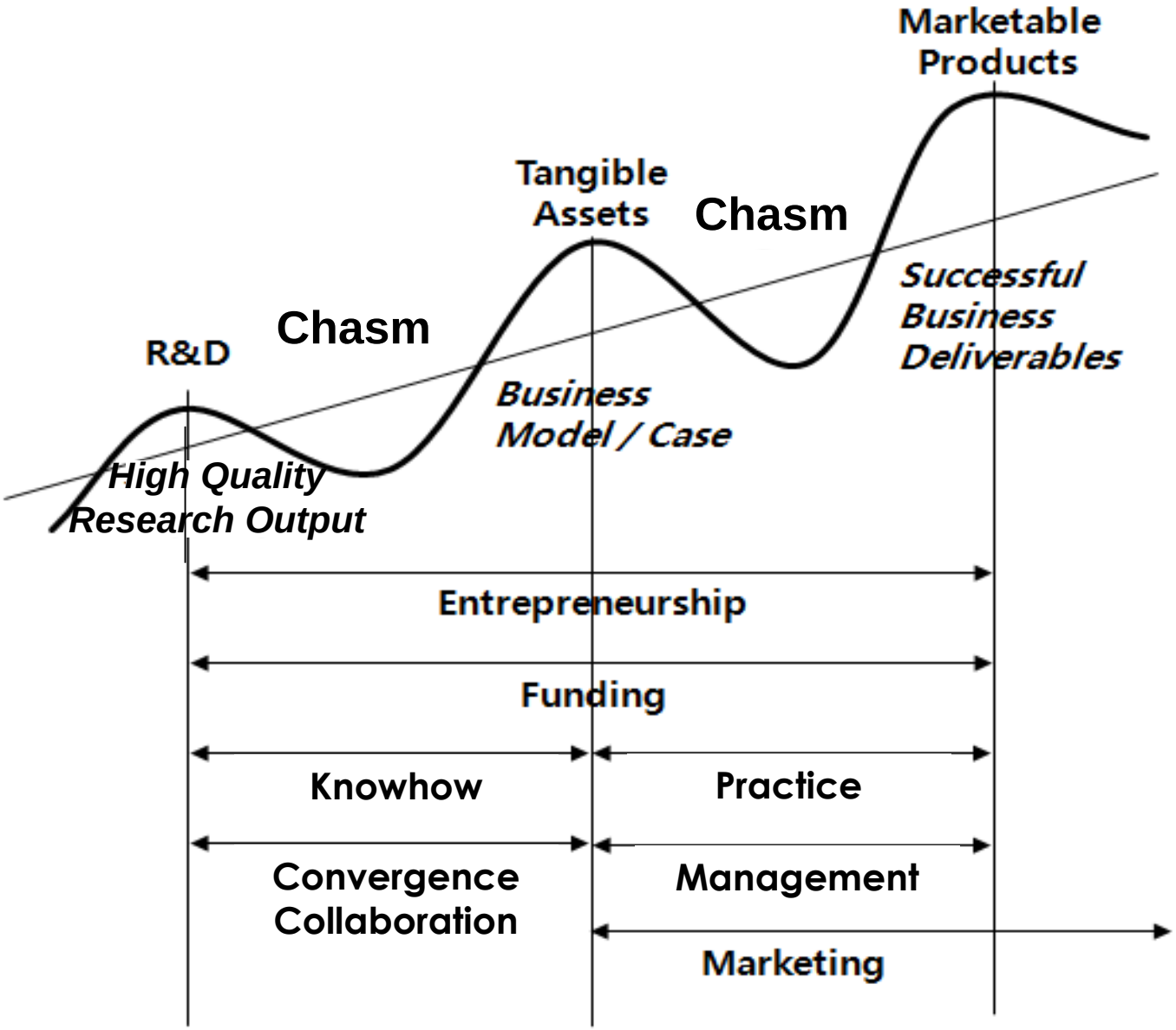
Green Growth

- a harmonic promotion of economic development and environmental sustainability at the same time through creating green-tech industries
- To create new growth engines, the strategic expansion of R&D investment is essential to enhance green technology development and to promote technology transfer for commercialization.
- The R&D investment can properly be allocated in accordance with the technology readiness level (TRL), and an extensive input should be made to overcome two chasms in the growth cycle of the start-up business,

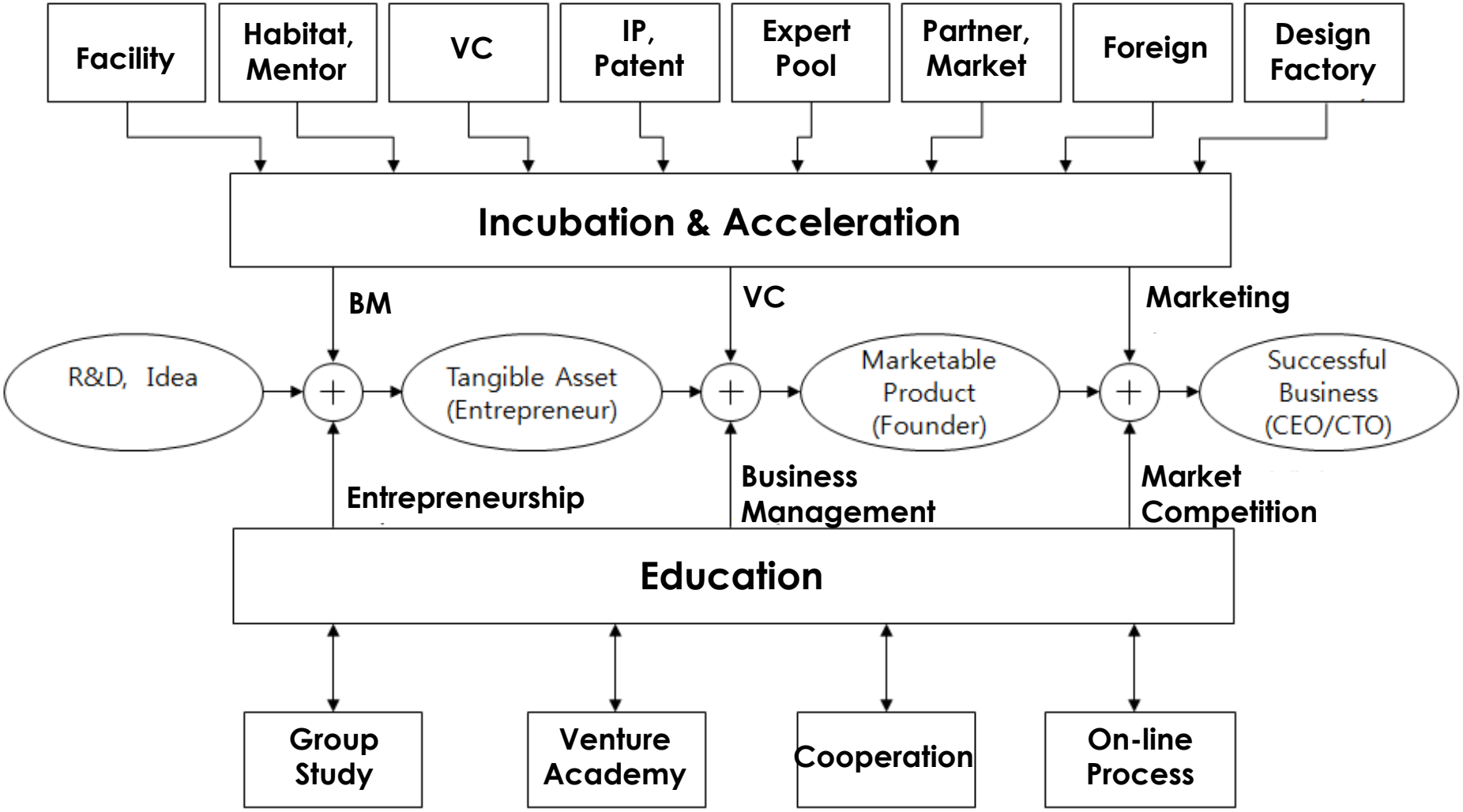
Solar Cell Market Development



Growth Cycle



Creating Tangible Assets and Converting to Successful Business



Thermal Engineering in Green-Tech Development

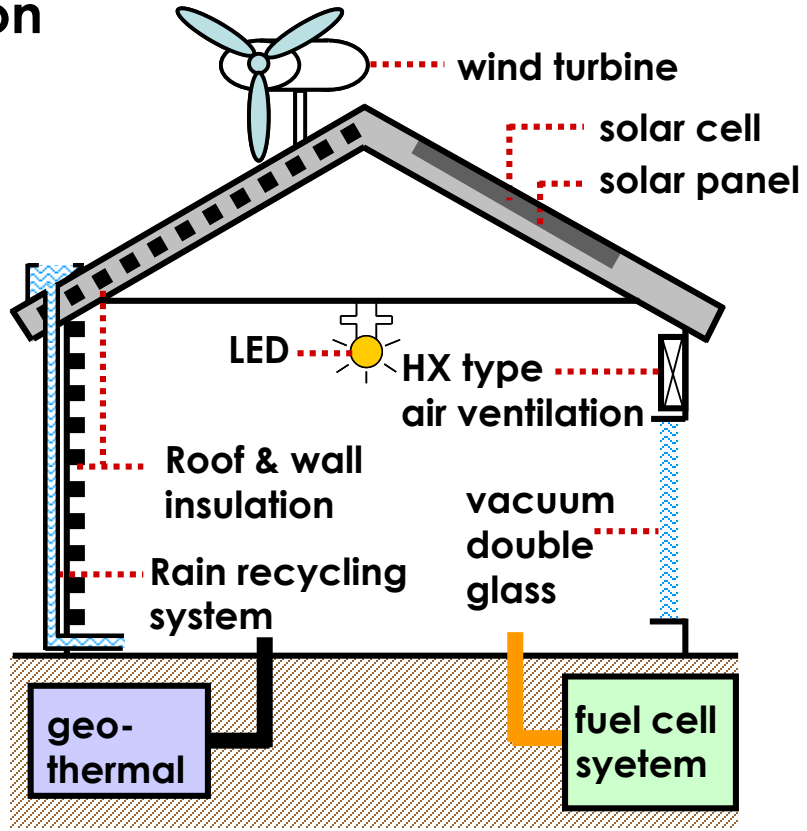
1) Efficiency improvement of thermal systems

- **the most cost-effective, near-term option**
- **multiple benefits such as reducing environmental impact, enhancing energy security and flexibility, and creating employment.**

- **High efficiency low emission and electric vehicles: clean combustion, thermal management**
- **Self-sufficient building: air conditioning, waste heat recovery, thermal insulation, renewable energy equipment**
- **Efficiency improvement of LED & IT devices: energy conversion, cooling**
- **High efficiency secondary electrical battery: thermal management**

Zero Energy Building

- **Requirement for zero energy building**
  - High efficiency low energy consumption
  - Own energy production facility
  - Connection to electric power grid



- **Technologies**
  - High efficiency air conditioning equipment
  - Air purification and circulation system for waste heat recovery
  - Environment-friendly insulation
  - Renewable energy equipment

EU: Heating energy less than 15 kWh/m^{2}yr

Korea: dwelling house 120~150 kWh/m^{2}yr, single house 150~200 kWh/m^{2}yr

2) Fossil fuel transformation

transformation toward decarbonization and clean energy system

Major challenges:

- **Expanding CCS will require cost reductions, scale-up, storage integrity and environmental compatibility, and securing storage;**
- **Growing roles for natural gas, the least carbon-intensive and cleanest fossil fuel, including for shale gas, requires that environmental issues are resolved;**
- **Co-processing of biomass, coal and natural gas with CCS is important for co-producing electricity and low carbon liquid fuels**

- **Carbon capture and storage system: thermal behavior of CO2, pure oxygen combustion**
- **Next generation light water reactor design and construction: thermo-hydraulics**
- **Coal gasification combined cycle power plant: thermal process and design**

GEA, 2012: "Global Energy Assessment-Toward a Sustainable Future"

3) Renewable energy

Increase in the share of renewable energy in global primary: two to threefold and in some regions 90% by 2050

Major challenges:

- **reducing costs through learning and scale-up;**
- **creating a flexible investment environment that provides the basis for scale-up and diffusion;**
- **integrating renewable energies into the energy system;**
- **enhancing research and development to ensure technical advances;**
- **assuring the sustainability of the proposed renewable technologies**

- **High efficiency solar cell: photovoltaic energy conversion, thermal process**
- **Thermoelectric power generation and cooling: energy conversion, thermal properties**
- **Bio-energy production and system: thermo-chemical transformation**
- **Nuclear fusion reactor design and construction: ultra high and low temperatures**
- **High efficiency hydrogen production & storage: pyrolysis, thermochemistry**
- **Next generation fuel cell system: energy conversion, thermal control**

Concluding Remarks

Thermal engineering plays a key role in the development of green growth as well as global sustainability, that can generate, combined with green growth polices, substantial economic, environmental, and social benefits, including creating employment, business opportunities and social welfare.

To create new growth engines, an integrated approach is necessary for coordinating R&D investment strategies, education, technology transfer for commercialization, and industrial collaboration with research institutions.