Stanford University

GCEP Global Climate & Energy Project

Advanced Electricity Infrastructure Workshop

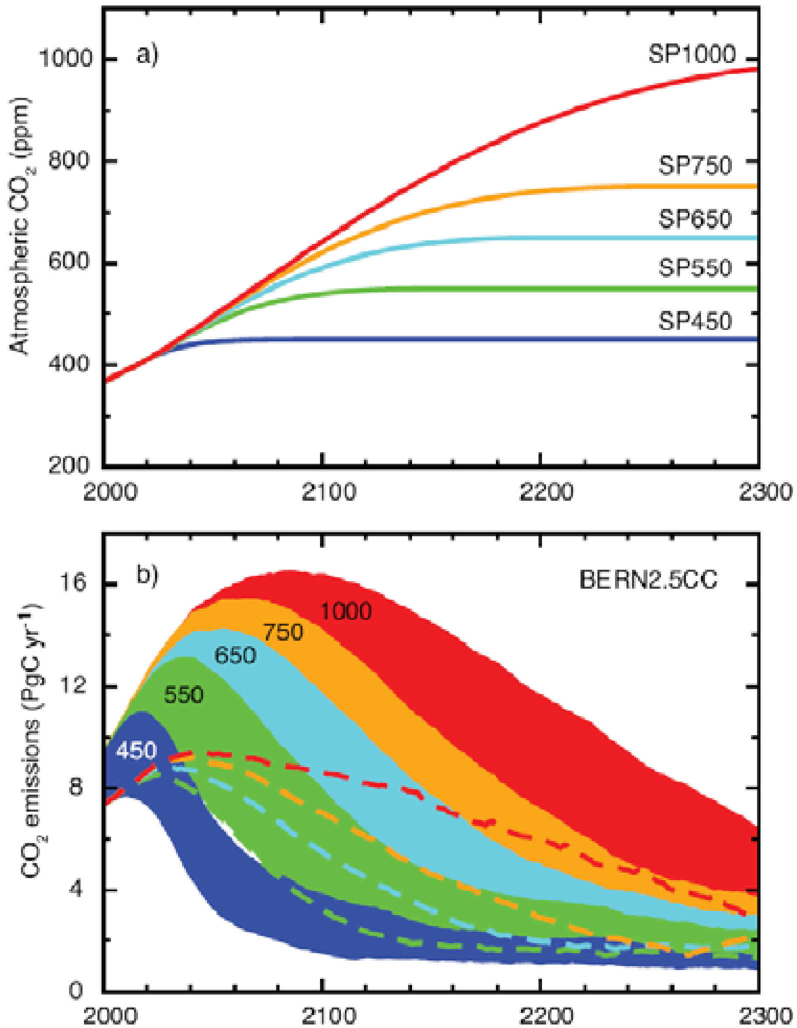
November 1-2, 2007

Overview of The Global Climate and Energy Project

Lynn Orr, GCEP Director

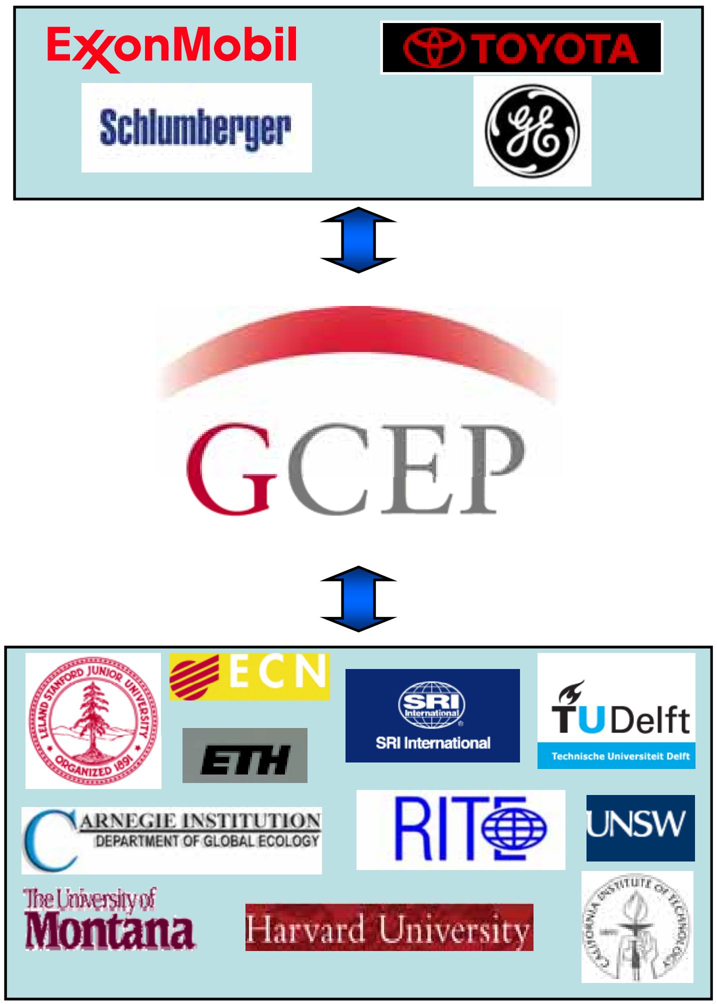
The Need for Technology

- Concentrations of CO_2 will rise above current values (380 ppm), even under the most optimistic scenarios.
- Stabilization will require that emissions peak and then decline. Peak timing depends on the stabilized concentration.
- Improvements in efficiency, introduction of renewables, nuclear power, … all help.
- New technology will be needed for the really deep reductions.



Source: IPCC 2007

The Global Climate and Energy Project



Goals

- Fundamental, precommercial research
- Novel technology options for energy conversion and utilization
- Impact in the 10-50 year timeframe

Strategy

- Step-out research: revisit the fundamentals and explore new approaches
- High risk / high reward

Budget

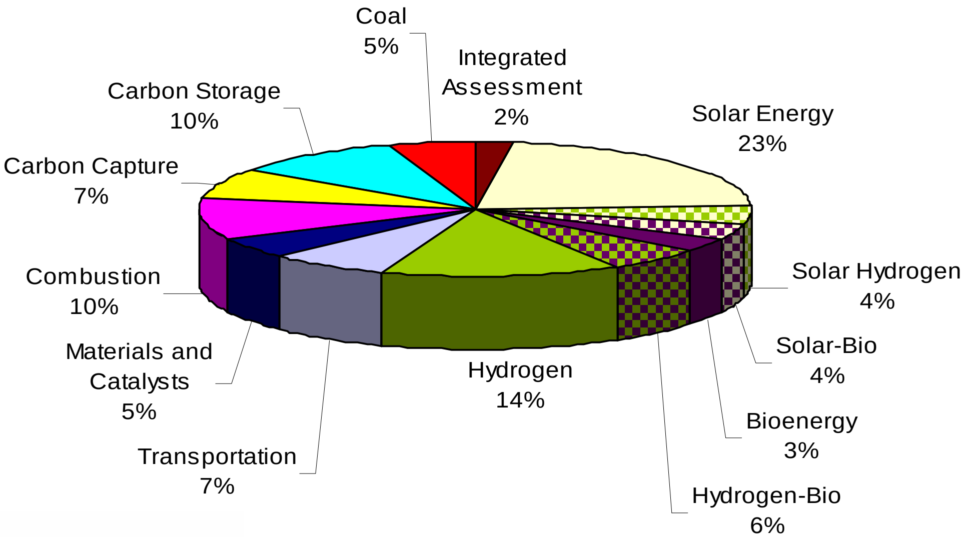
- $225M commitment

Participants

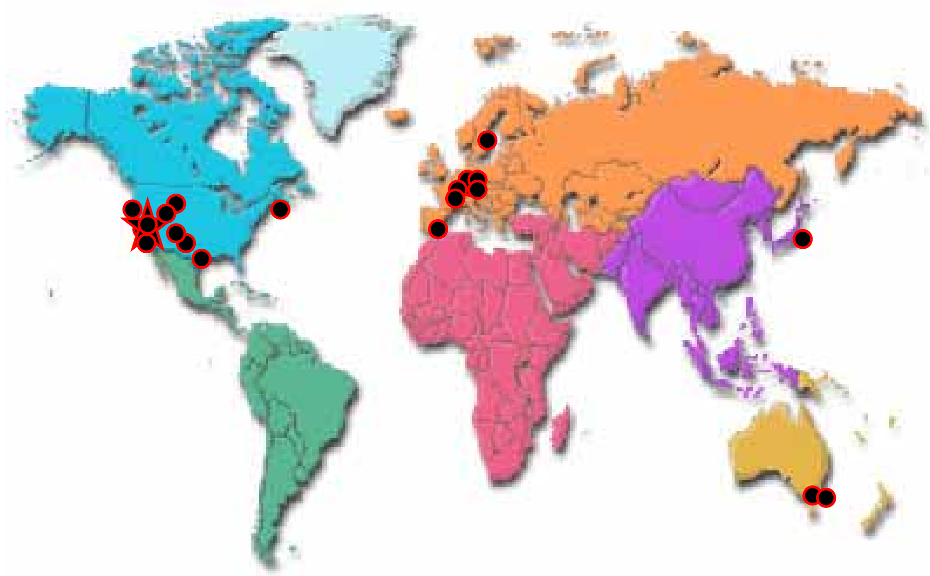
- Industrial sponsors
- Academic institutions - Stanford and an increasing number of other universities worldwide

Current Portfolio

- $72.1M committed
- 47 3-year projects
- 69 investigators
- 20 institutions
- 225 students

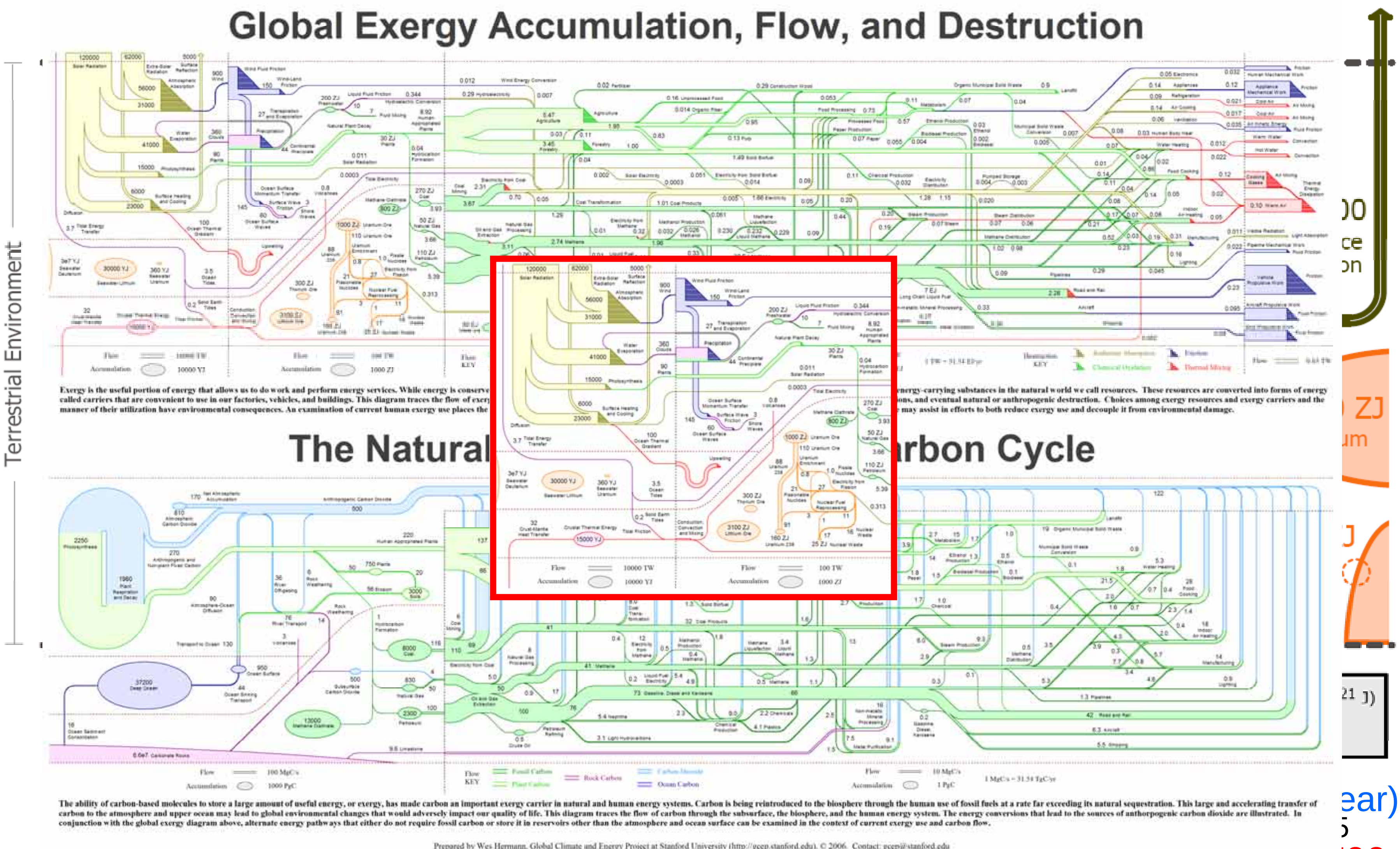


Funding Distribution



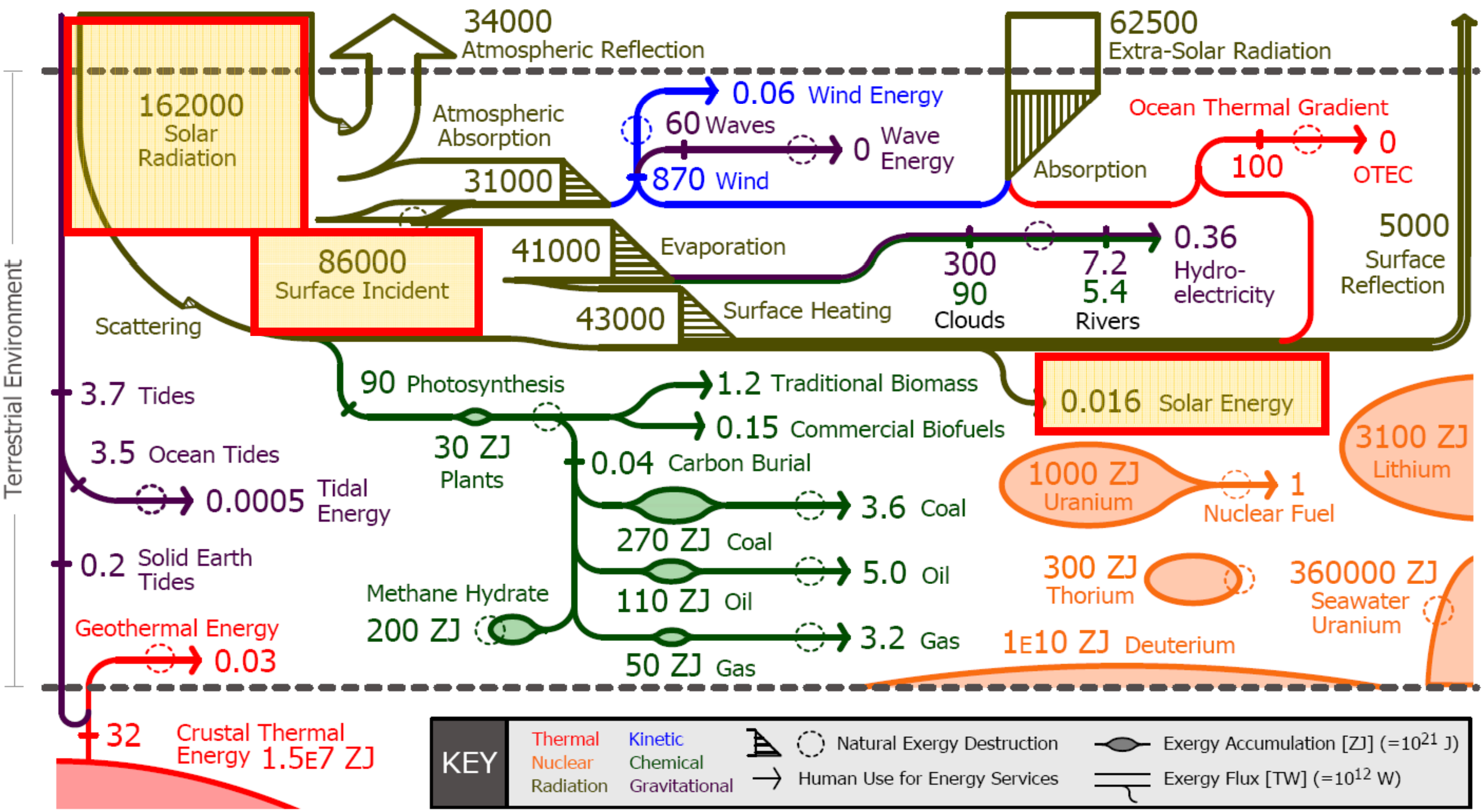
Participating Institutions

Exergy Flow of Planet Earth (TW)



Source: W. Hermann, GCEP Systems Analysis Group 2004.

Exergy Flow of Planet Earth (TW): Direct Solar Resource



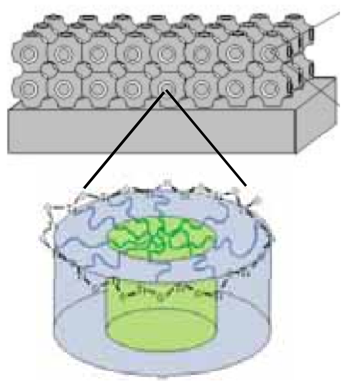
Source: W. Hermann, GCEP Systems Analysis Group 2004.

(1 ZJ = 10^{21}J)

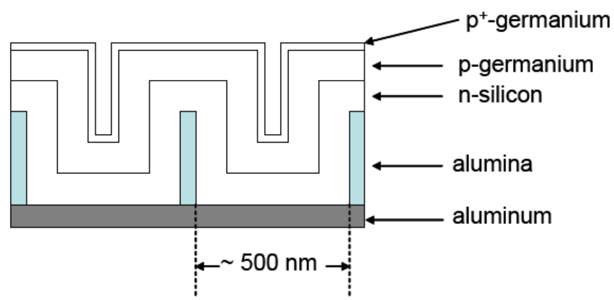
Research Examples
- Solar Area

Solar electricity

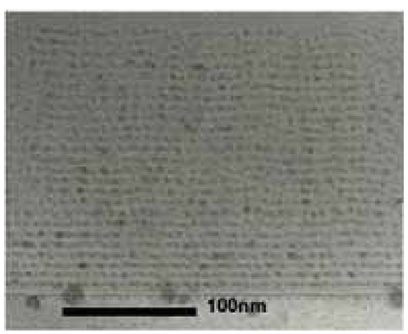
- Organic photovoltaics



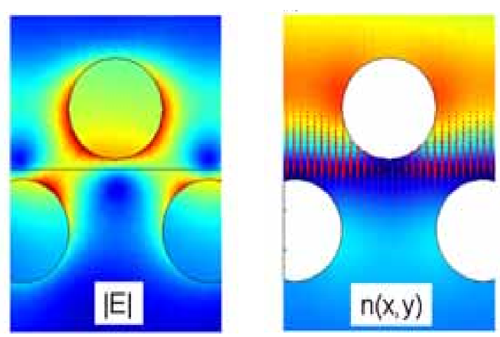
- High efficiency thin-film concepts



- Silicon-based quantum structures

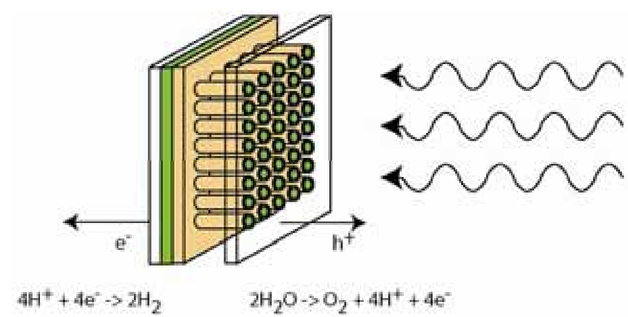


- Efficient photon collection

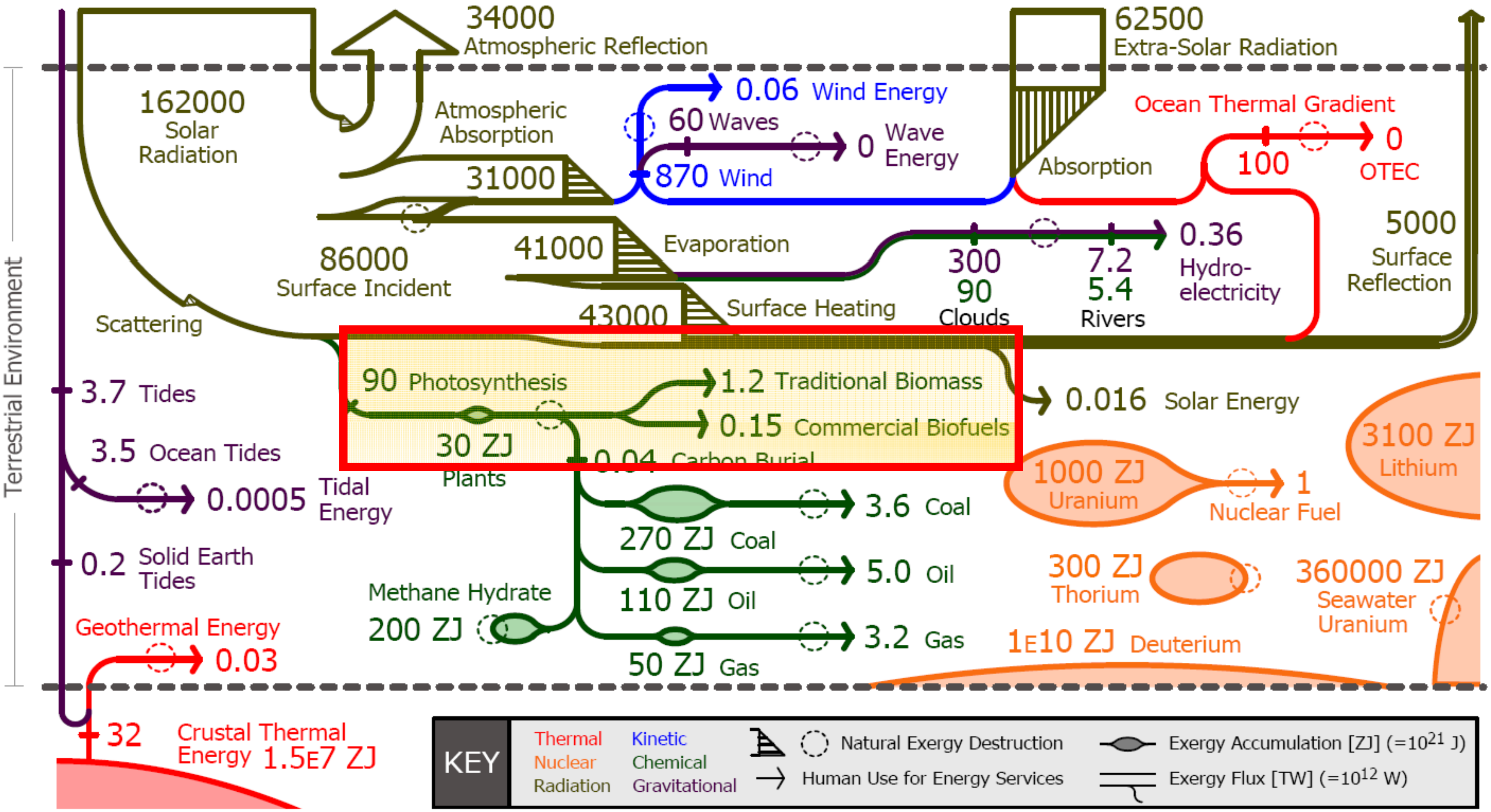


Solar hydrogen

- Photoelectrochemical water splitting



Exergy Flow of Planet Earth (TW):
Bio Resources



Source: W. Hermann, GCEP Systems Analysis Group 2004.

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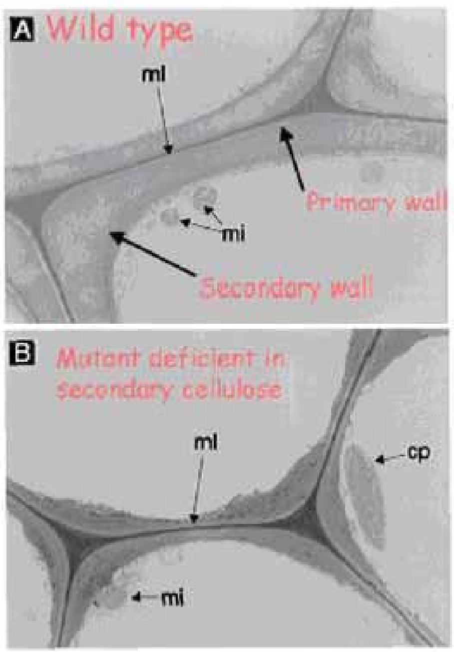
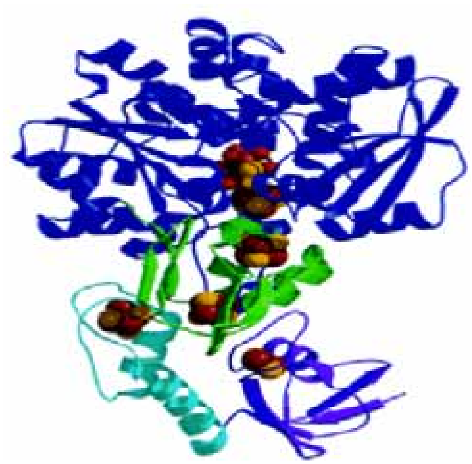
Research Examples
- Bio Area

Biomass

- Genetic engineering of cellulose accumulation



Bio-hydrogen

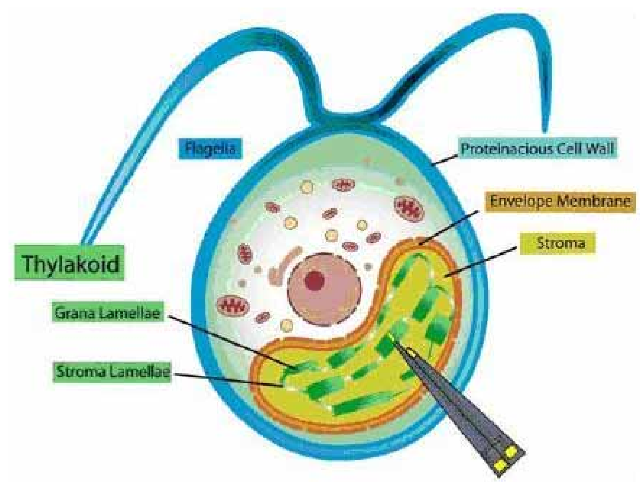


Hydrogenase enzyme

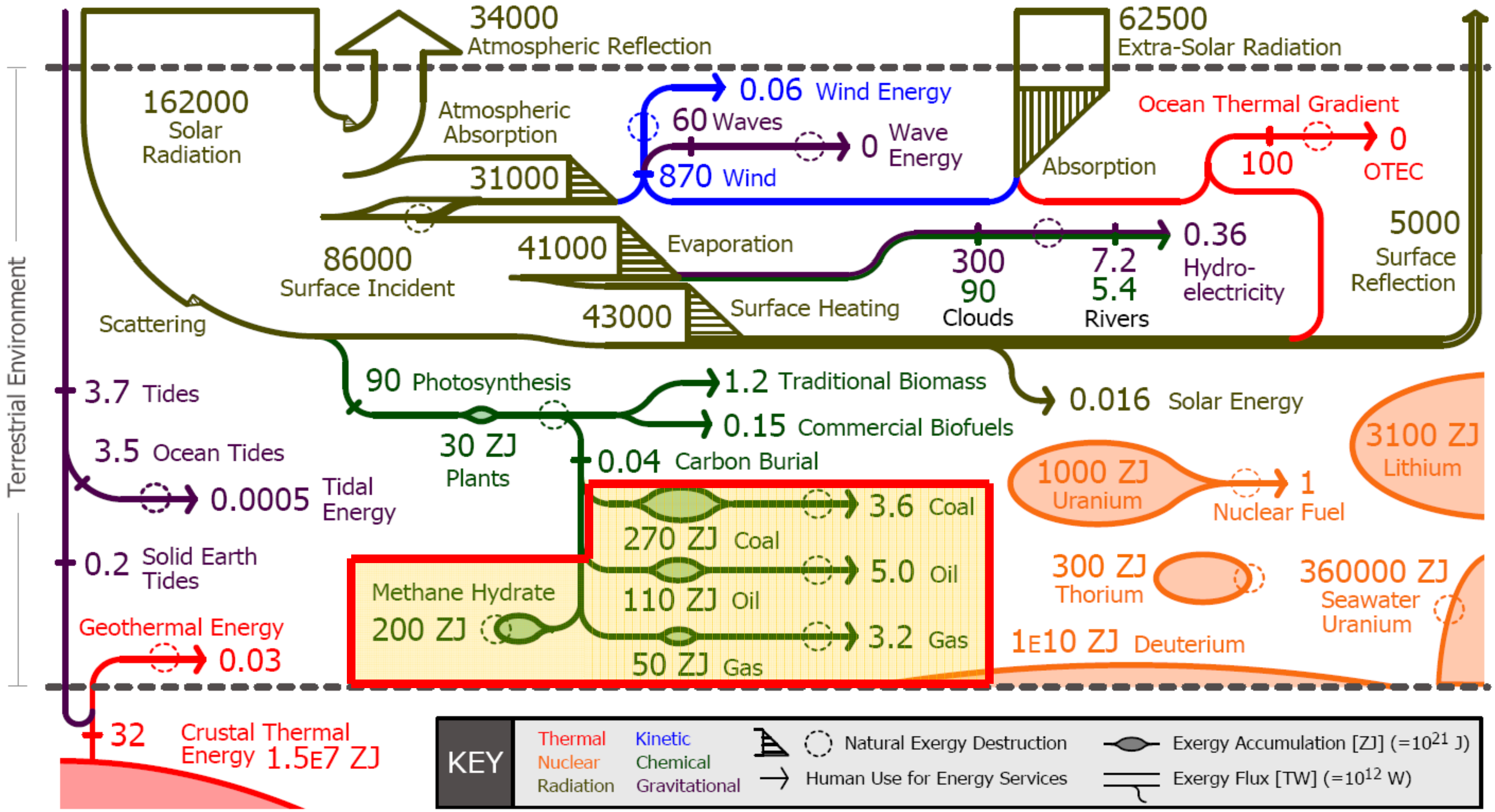
- Genetic evolution of biological systems (bacteria) to produce hydrogen

Bio-electricity

- Direct current extraction from the chloroplast of photosynthetic cells



Exergy Flow of Planet Earth (TW): Fossil Hydrocarbon Resource



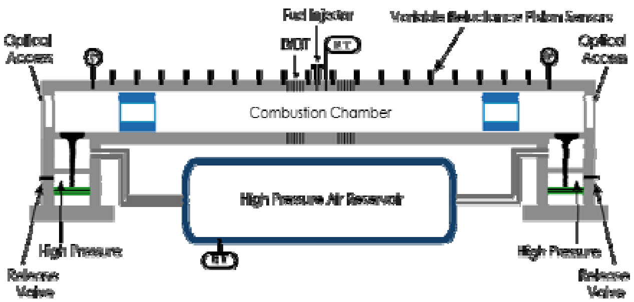
Source: W. Hermann, GCEP Systems Analysis Group 2004.

(1 ZJ = 10^{21}J)

Research Examples
- Carbon Mitigation Areas

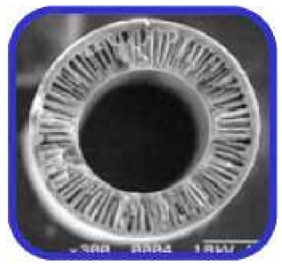
Advanced combustion

- High-efficiency IC engines with theoretical efficiency limits of ~ 60%



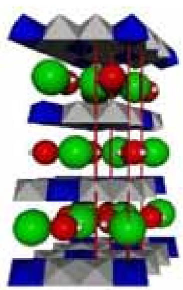
CO_2 separation

- Novel nanostructured polymeric and inorganic membrane materials



Cardo polyimide hollow fiber membrane

100µm

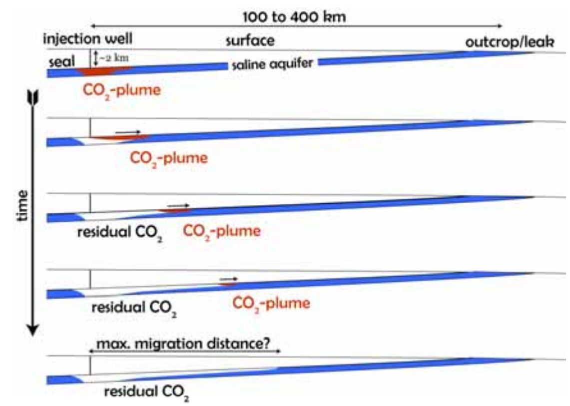


- Membrane reactors combining NG reforming and C capture

Hydrotalcite membrane

CO_2 sequestration

- Study of the long-term stability and seal integrity of geologic structures (aquifers, oil and gas reservoirs)



- Integrated coal thermal conversion process in supercritical conditions using aquifer brine as a solvent and storage medium

GCEP Goals

- A research-base for technologies that would permit substantial reductions in greenhouse gas emissions due to energy use
- A highly trained pool of researchers to address the remaining technological issues
- A better-informed technical community concerning the technical barriers and potential solutions concerning greenhouse gas emissions from energy production and utilization
- A model for industry-sponsored research to address global technological issues

Advanced Electricity Infrastructure

- Opportunity to reduce CO_2 emissions
  - 7-10% of electricity generated is lost through transmission and distribution
- Understand the needs and impacts to integrate other GCEP portfolio areas with electricity infrastructure,
  - e.g. advanced combustion, renewables, transportation
- Enable the integration of new technologies and infrastructure paradigms at a national and global scale.

The Workshop

- Define the technical issues
- Identify research opportunities that are relevant to GCEP and address the technical issues
- Develop a portfolio of fundamental research in advanced electricity infrastructure

Questions for the Workshop

- What are the research priorities in your area of investigation and why?
- What barriers exist to successful research and what breakthroughs are needed?
- What are the opportunities for fundamental, academic research to develop pathways for technologies to overcome the barriers?
- Where do you feel that a contribution by a project such as GCEP could have the most impact?

More Questions

- Where are major inefficiencies and losses in the power system (not including generation or end-use)?
- Assuming 50% penetration of renewables into the grid and no storage, what does the power system need to look like, and how would it operate?
- In a carbon-constrained world, how could the power system change to accommodate the demand for transportation?
- What would be game-changing scenarios for the electric grid?

Workshop Agenda
Day 1

	Welcome and Introduction	
8:30	GCEP Introduction and Workshop Purpose	Lynn Orr
9:00	Power System Introduction and Overview	Thomas Overbye
9:40	California Grid Operations	Jim Detmers
10:20	Break	
11:35	Industry Perspectives	Juan de Bedout
	Advanced Transmission	
11:15	High-Temperature Superconducting Transmission	Michael Gouge
11:55	Lunch	
12:55	Power Quality Requirements for Reliability	Surya Santoso
1:35	Quantum Wires for Grid Applications	Matteo Pasquali
	Power Systems, Control and Analysis	
2:15	Distributed Solutions for Grid Control	Deepak Divan
2:55	*Break*	
3:10	Integration Technologies for Power Flow Controllers	Khai Ngo
3:50	Enhanced State Estimation	Ali Abur
4:30	Computational Issues for Intelligent Grids	Bruce Wollenberg
5:10	*Reception*	

Workshop Agenda
Day 2

	Opening	
8:30	Visions for the Utility of the Future	David Mohler
	Distributed Generation	
9:10	Perspectives on Vehicles to Grid	Michael Kintner-Meyer
9:50	Impacs and Needs for Renewables in DG Integration	Giri Venkataramanan
10:30	*Break*	
10:50	Distributed Generation Expansion	Kevin Tomsovic
10:50	Voltage Control with Distributed Generators	Fangxing (Fran) Li
12:05	*Lunch*	
	Storage for Distributed Resources	
1:05	Energy Storage: A Distributed Resource	Imre Gyuk
1:45	Battery Materials for Grid Applications	Glenn Amatucci
2:25	Kinetic Energy Storage and Power Generation	Robert Hebner
3:05	*Closing Remarks*	
3:10	*Speaker Roundtable Discussion*	

Thank You!

GCEP Staff and Emilie Hung

- for the technical organization of the workshop

Nancy Sandoval

- for organizing everything else

Our Sponsors

- for making this project possible

Our Speakers

- for sharing your time, expertise, and opinions with us

The Energy Community

- for taking time to participate in our discussions