Lecture on GSDM symposium

-Critical issues on energy systems and response strategies-

February 27, 2019

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Co-organizer: The University of Tokyo International Open Innovation Organization

Critical issues on energy systems

(1) Conventional uncertainties in prices of oil and gas

- **Oil demand will peak out and decrease?**
- **Natural gas resources are sufficient to meet our expectations?**
- **Geopolitical risks could be avoided?**

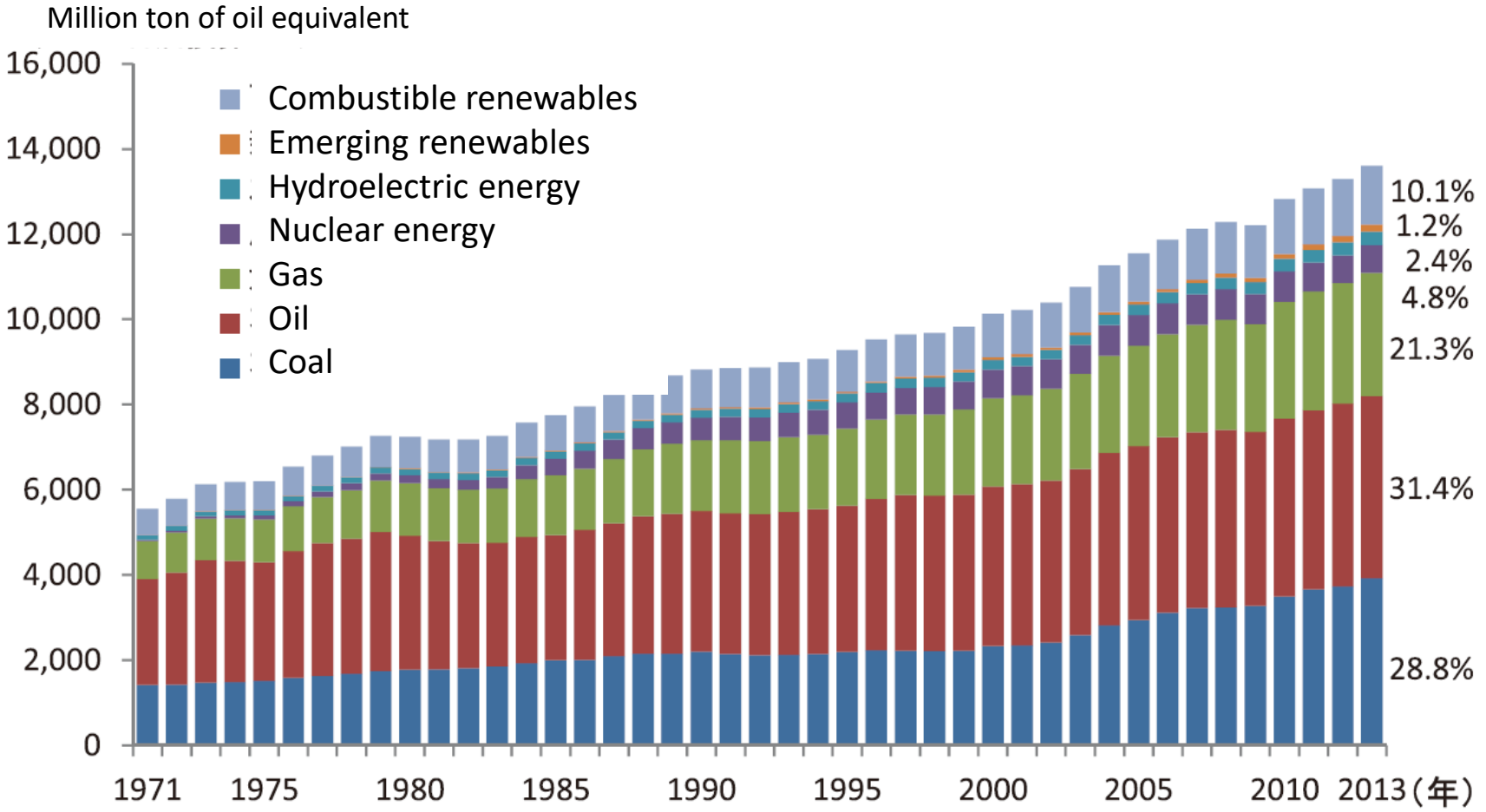
(2) Emerging uncertainties threatening Energy systems

- **How could we respond to climate change?**
- **How could we stabilize power systems even with explosive growth of variable renewable energies?**
- **How China will evolve the energy technologies and energy demand?**

(3) Role of public policy

- **The Univ. of Tokyo could support energy policy?**

Transition of global energy consumption

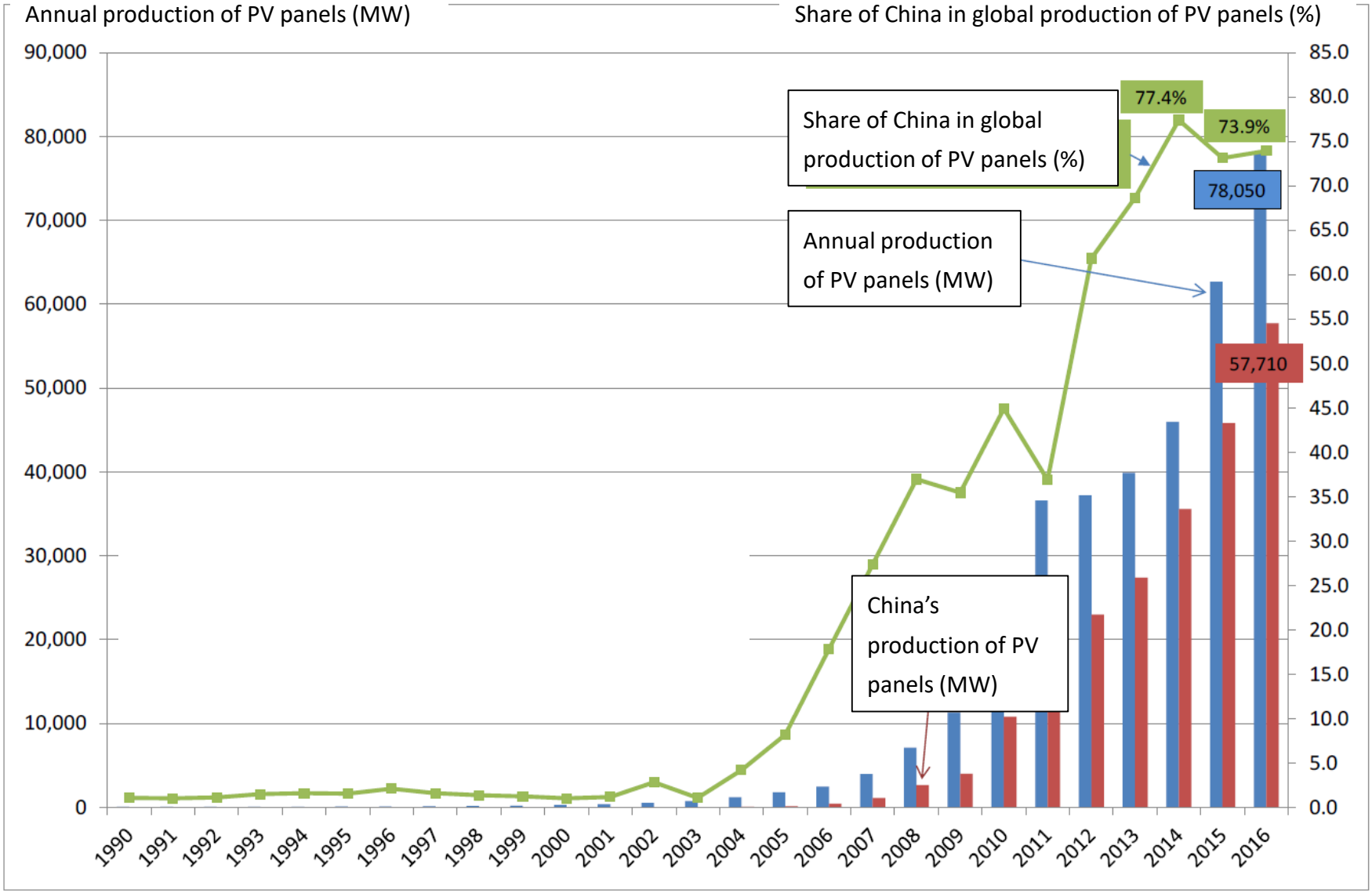


Note; Combustible renewables primarily means biomass.

出典:IEA「Energy Balance 2015」を基に作成

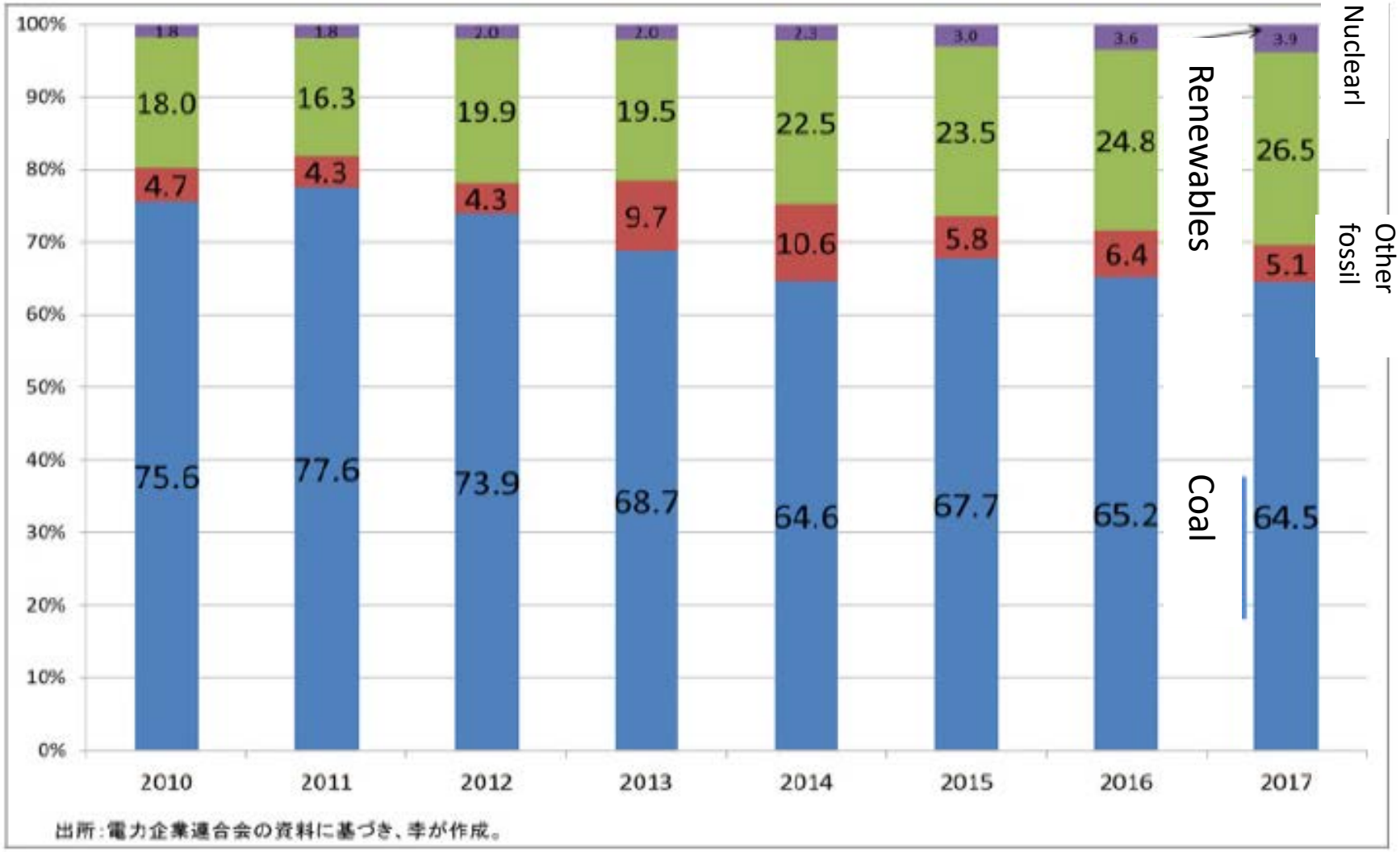
www.enecho.meti.go.jpaboutwhitepaper2016pdf, access 20192.16

Global Production of Photovoltaics and China's share



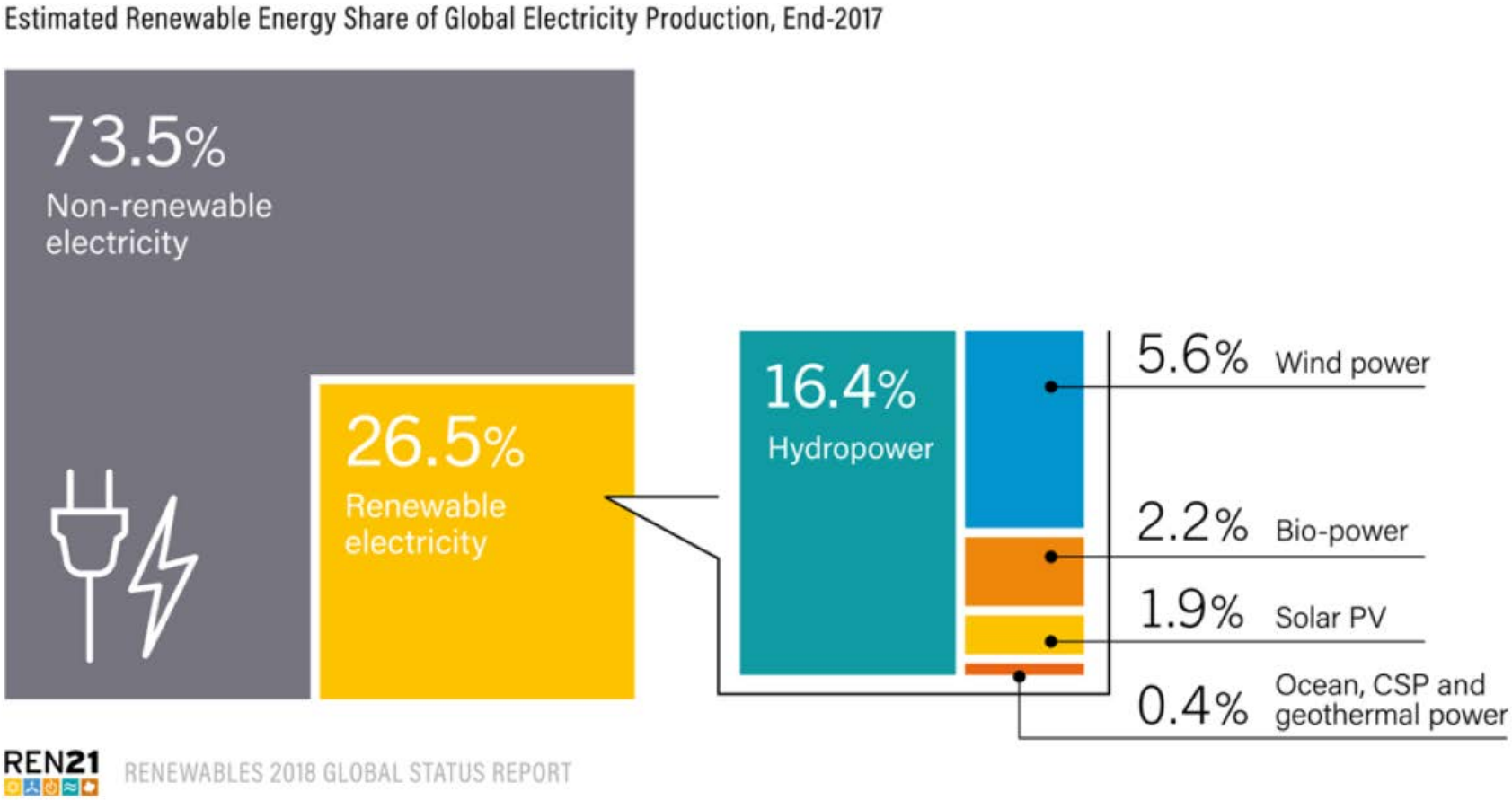
Li Shitang, A Study on revolutions on energy structure and on its response system to realize low carbon society, Proceedings of the 35th conference on energy system, economy and environment, 2019.1.29~2019.1.30

Transition of power mix in China



Li Shitang, A Study on revolutions on energy structure and on its response system to realize low carbon society, Proceedings of the 35th conference on energy system, economy and environment, 2019.1.29~2019.1.30

Share of renewable energy in global electricity production



Source: REN21 Renewables 2018 Global Status Report, http://www.ren21.net/gsr-2018/

Jill Engel-Cox, U.S. National Renewable Energy Laboratory, Invited lecture on the COI symposium of the Kyushu University, 2019.2.1

Climate change and response strategies

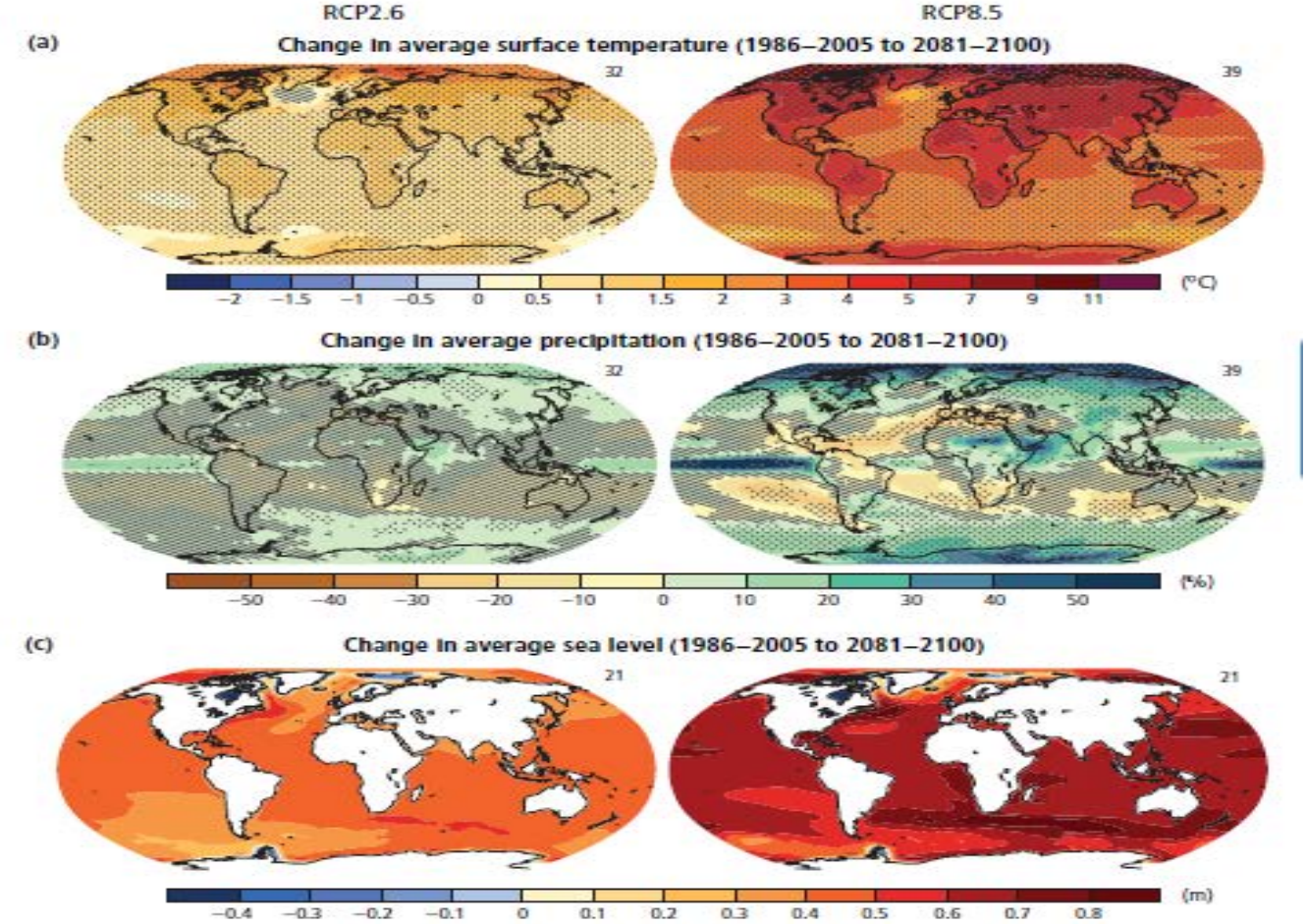
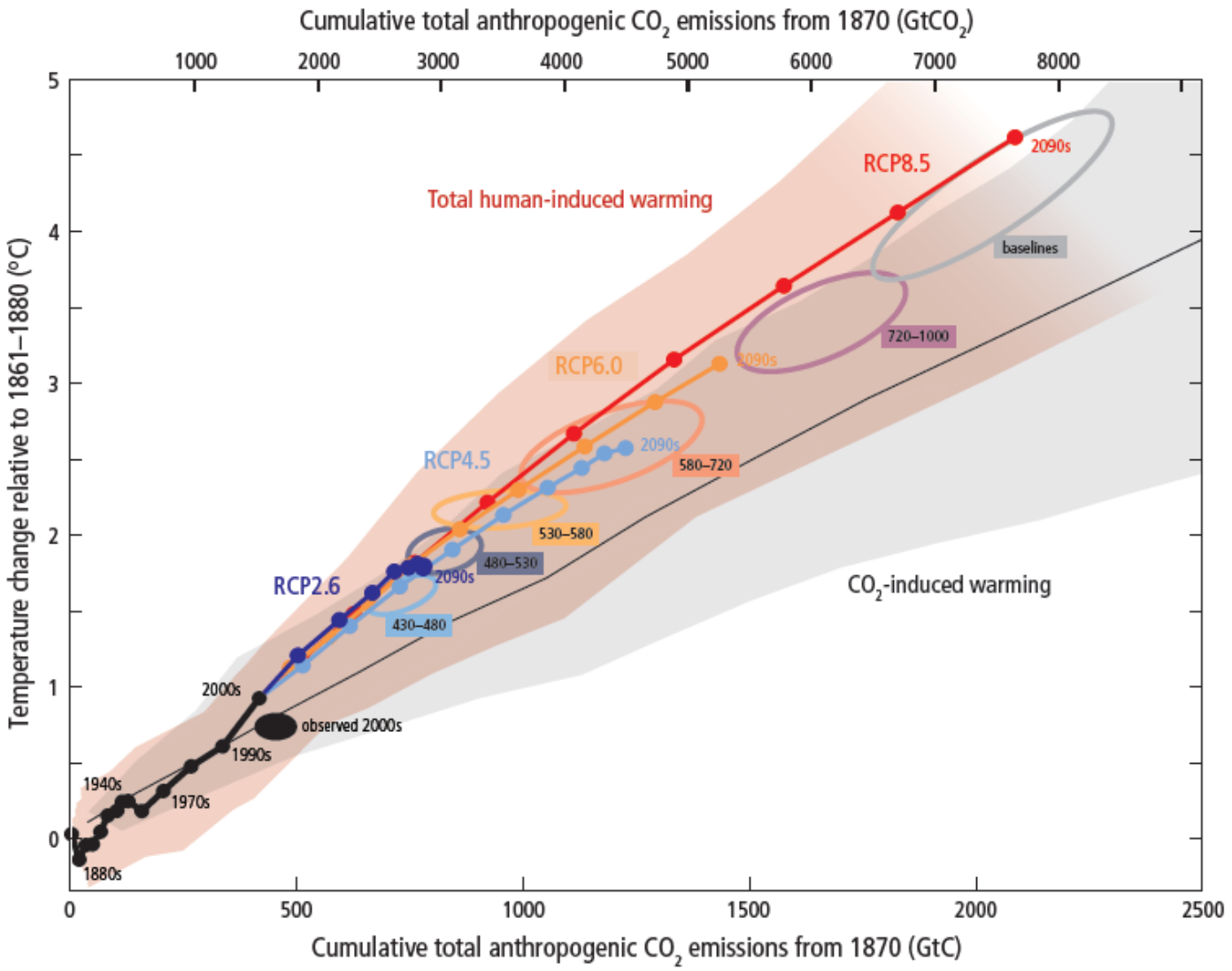


Figure 2.2 | Coupled Model Intercomparison Project Phase 5 (CMIP5) multi-model mean projections (i.e., the average of the model projections available) for the 2081–2100 period under the RCP2.6 (left) and RCP8.5 (right) scenarios for **(a)** change in annual mean surface temperature and **(b)** change in annual mean precipitation, in percentages, and **(c)** change in average sea level. Changes are shown relative to the 1986–2005 period. The number of CMIP5 models used to calculate the multi-model mean is indicated in the upper right corner of each panel. Stippling (dots) on (a) and (b) indicates regions where the projected change is large compared to natural internal variability (i.e., greater than two standard deviations of internal variability in 20-year means) and where 90% of the models agree on the sign of change. Hatching (diagonal lines) on (a) and (b) shows regions where the projected change is less than one standard deviation of natural internal variability in 20-year means. *(WGI Figure SPM.8, Figure 13.20, Box 12.1)*

Climate Change 2014, Synthesis Report, IPCC the Fifth Assessment Report, 2014

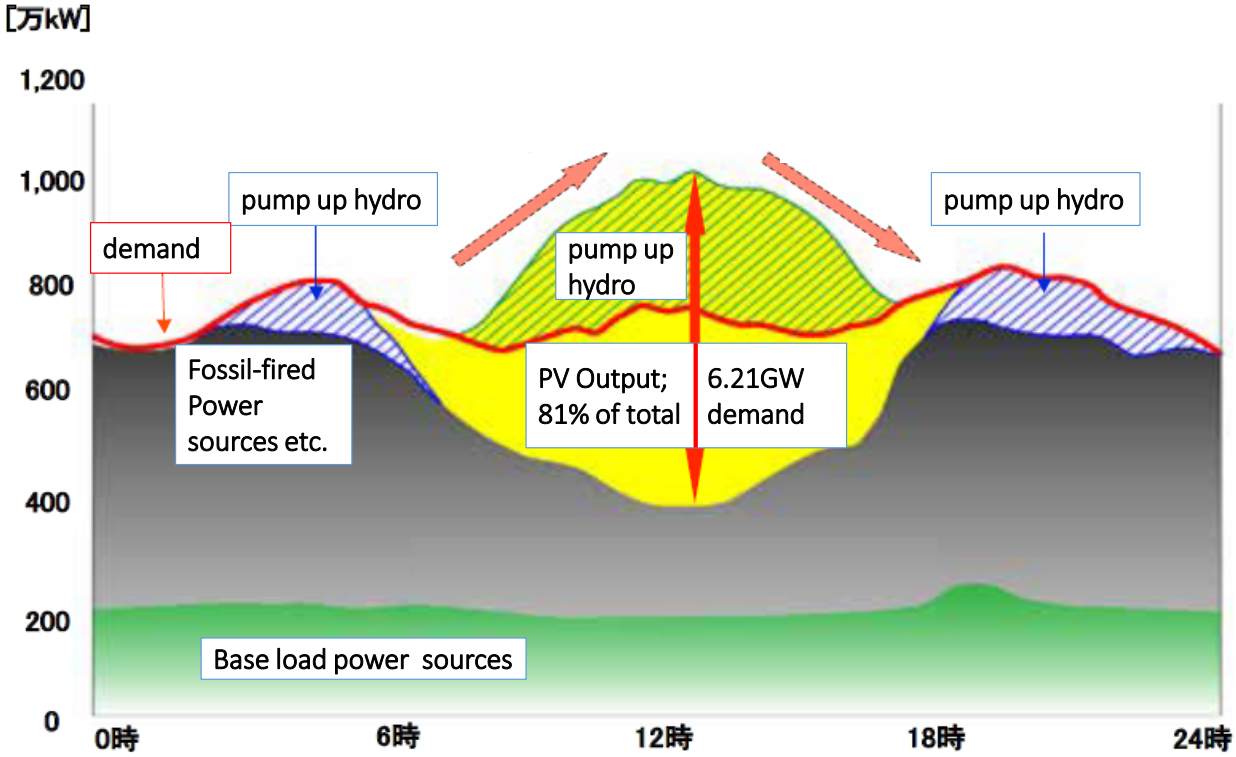
Climate change and response strategies



Climate Change 2014, Synthesis Report, IPCC the Fifth Assessment Report, 2014

Large scale integration of renewable power sources and stability of power systems

- Concerning areas, where large scale variable renewable sources are integrated, stability of power systems are threatened.
- In particular, solar power systems of 8.3GW are introduced in Kyushu region.
- From the last autumn, output suppression on solar power started in Kyushu.
  (2018.11.4 output suppression of 1.21GW)



Supply and demand in Kyushu Electric Power Company,(May 3rd, 2018)

KYUDEN GROUP environmental report 2018, Kyushu Electric Power Company, 2018.6.27

Ancillary services presently provided in U.S.

Classification of ancillary services defined by U.S. Federal Energy Regulatory Commission (FERC)

Items	Definition	Methods
Frequency control	Service to equalize supply and demand in order to control frequency within a certain range.	**Tradable in the market**
Imbalance in electricity	Service to compensate the differences between planned and actual electricity distribution in a certain time slot.	
Spinning reserve	Service to provide power instantaneously when troubles in power generation occur.	
Operation reserve	Service to provide power in a short time period when troubles in power generation occur.	
Scheduling, Order of central dispatching unit	Order to supply electricity in the responsible area as planned.	Power system operators provide these services and recover their costs by wheeling costs etc.
Provision of reactive power, Voltage control	Service to provide necessary reactive power to maintain the voltage within a certain range.	

Nikkei technologies online, Dictionary for Terms in power systems, http://techon.nikkeibp.co.jp/article/WORD/20121105/249412

Ancillary services to be provided in Japan in future

Classification of ancillary services defined by Ministry of Economy, Industry and Trade, Japan.

Items	Definition	Methods
Governor Free control	Service to equalize supply and demand (Faster than frequency control)	Tradable in the market
Frequency control	Service to equalize supply and demand in order to control frequency within a certain range.	
Spinning reserve	Service to provide power within 5 minutes when troubles in power generation occur.	
Operation reserve 1	Service to provide power within 15 minutes when troubles in power generation occur.	
Operation reserve 2	Service to provide power within 45 minutes when troubles in power generation occur.	
Imbalance in electricity	Service to compensate the differences between planned and actual electricity distribution in a certain time slot.	TSO provide these services using wheeling costs etc.

Nikkei technologies online, Dictionary for Terms in power systems, http://techon.nikkeibp.co.jp/article/WORD/20121105/249412

Establishment of Energy Research Cluster

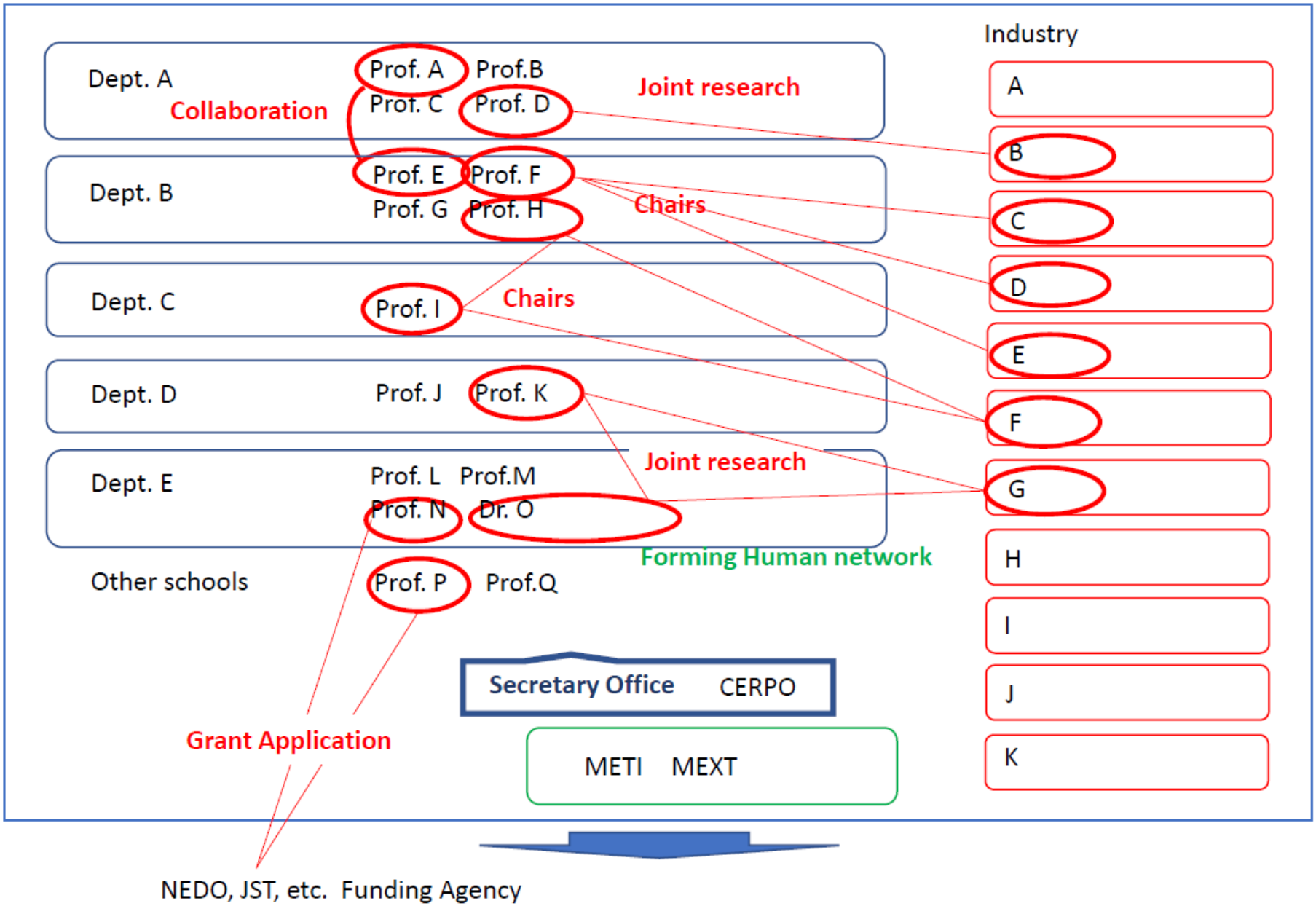
-Basic vision of energy research cluster-

(1) We deal with comprehensive energy carriers and technologies.

(2) We provide services of entire energy related education across departments and sections.

(3) We promote cooperative researches, taking international coalition and future vision into consideration.

Image of Energy Cluster



Grand design of energy research cluster

(1) Joint research
- Industries in U.S. and in Japan
- MIT and the Univ. of Tokyo
- Professors involved in central role of energy policy
- Information exchange on power systems reform

(2) Education
- International exchange of students
- Education for industries

(3) Standardization
- ISO, IEC etc.
- One stop service for industries
- Issues for future standardization

Symposium on "Energy Research Cluster" Establishment (draft)
Organized by the University of Tokyo Graduate School of Engineering
Co-organizer: The University of Tokyo International Open Innovation Organization

Date and Time: Thursday 28th February 2019 16: 00 ~ 18: 15
Place: Tokyo Convention Hall (Direct link to Tokyo Metro · Ginza Line · Kyobashi Station

Program
16: 00-16: 10 opening remarks
Tatsuya Okubo (Dean, Graduate School of Engineering, the University of Tokyo)
16: 10-16: 25
Guest greetings, Ozawa Noriaki
Department of Economy, Trade and Industry, Agency for Natural Resources and Energy Policy coordinator
New Energy and Industrial Technology Development Organization (NEDO)
Toyota Motor Corporation

16: 25-16: 35
Purpose of establishment of "Energy research cluster" Hiroyuki Takahashi (Professor, Graduate School of Engineering, the University of Tokyo)

16: 35-18: 05
Lecture <Each 15 minutes>
<Moderator: Ryuji Matsuhashi (Department of Electrical Engineering, University of Tokyo Graduate School of Engineering)>
① Ishihara Meng (Professor, Department of Social Infrastructure Studies, Graduate School of Engineering, the University of Tokyo)
"Development and future prospect of Japanese offshore wind power generation technology"
② Okamoto Koji (Professor, Nuclear Energy Department, University of Tokyo Graduate School of Engineering)
"Energy Mix and Nuclear Energy"
③ Masataka Masuda (Professor, Research Center for Artifacts Engineering, the University of Tokyo)
"New natural gas resources: present state and future prospects of methane hydrate development technology"
④ Suzuki Yuji (Department of Mechanical Engineering, Graduate School of Engineering, the University of Tokyo)
"Present Status and Future of Combustion Engineering"
⑤ Atsuo Yamada (Professor, Department of Chemical System Engineering, Graduate School of Engineering, the University of Tokyo)
"Materials development for social implementation of a safe and secure high performance storage battery"
⑥ Matsuhashi Ryuji (Department of Electrical Engineering, University of Tokyo Graduate School of Engineering)
"Grand Design of Energy Research Cluster"
18: 05-18: 15
Closing remarks
Ryuji Matsuhashi (Professor, Department of Electrical Engineering, Graduate School of Engineering, University of Tokyo)
18: 25 - 20: 00 Roundtable party