Funding and Direction in Renewable Energy Research in Japan

Kohei UOSAKI
International Center for Materials Nanoarchitectonics (WPI-MANA) and Global Research Center for Environment and Energy based on Nanomaterials Science (GREEN)
National Institute for Materials Science Nanotechnology and Materials Unit, CRDS, JST
Funding agencies

Universities
RIKEN
NIMS
AIST

CSTP(CAO)

S&T Ministries

METI
(Agency for Natural Resources and Energy)

JSPS

CSTP(CAO)

MEXT

NEDO

Projects directly funded by S&T Ministries

Directly Funded Projects (WPI, Development of Environmental technology using nanotechnology, Strategic utilization of elements, etc.)

FIRST

Independent Administrative institutions supported by the S&T ministries
Efficiency enhancement

1. Efficient LNG power generation
2. Efficient coal power generation
3. CO₂ capture and storage (CCS)
4. New solar cell
5. New nuclear power
6. Superconducting transmission

Low carbon

7. High level traffic system
8. FCV
9. PHV
10. EV
11. Novel material/production/processing
12. Novel iron manufacturing process
13. New generation lighting
14. Stationary FC
15. Fuel production from biomass
16. Super efficient heat pump
17. Energy conserv. information system

Energy consumer

Generation/transmission

Energy supply

Inter-division

Industry

Energy conservation bldg.

High performance elec. storage

Power electronics

Hydrogen production/transportation/storage

Regional EMS

Major Issues in Nanotechnology / Materials

Sustainable and Environmentally friendly Society

- International Collaboration
- Standardization
- Risk Assessment / Management

Energy
- Energy Saving
  - Ultra Low Power Devices
  - Carbon-based Nanoelectronics
  - Non-volatile Memory · CPU
- Multi-functional System
- Fusion of nano-CMOS and Spin · Photonics · Bio · MEMS
- Smart-interface (Smart-sensor·Robot, High-resolution Display, Wearable PDA) Ultra-high-speed Computation
- Quantum Computer
- Nano-photonics

Nanoelectronics

- Energy Generation
  - Solar Cell with High Efficiency and Low Cost
  - Thermo-electric device, Fuel Cell
  - Biorefinery
  - Artificial Photosynthesis (Hydrogen · Fuel Production)
- Energy Transmission & Storage
  - New battery Cell Material, Superconductor Material
- Energy Saving
  - Thermal Insulating Structural Material, Light Weight Material for Transportation
  - Complex Total Energy System
  - Environment Protection
  - Membrane Separation (Water, Gas)
  - Environment Monitoring System with High Sensitivity & Selectivity
  - Green Process, Replacement for Rare Natural Resource

Green Nanotechnology

Nanobiotechnology
- Innovative nano-medical technology
  - Drug delivery · Intracellular injection
  - Implant devices for the diagnosis and treatment
  - Materials for Regenerative medicine
  - Application of biological systems to sustainable system
  - Environmental cleanup by imitating photosynthesis
  - Environmental Monitoring by biomaterial
  - Application of biological systems to other fields
  - Devices using self-organization
  - Biomimetic ultra low power IT

New Substances / Materials

- New Magnetic Material
- Corrosion Resistant & High-refractory Metal
- Wide-gap Semiconductor
- Oxide Semiconductor
- Composite · Hybrid Material
- New Structured · Space & Gap Material
- Molecular & Organic · Bio-Material

Common & Basic Technology in Nanotech / Control Technology in Substances & Materials / Nanoscience

- Material Preparation and processing
  - Self-organization/Hierarchical Control of structure
  - Integration of Bottom-up & Top-down processes
  - Nano & Micro Printing, 3D nano-fabrication
- Theory & Design
  - Exploration and design of new material, Element Strategy
  - Design for nano-system, Theory for surface & Interface

Nano-scale Measurement & Analysis

- Three dimensional Imaging, Visualization, Dynamic Measurement
- Measurement for surface, bulk and Interface
- In-situ Measurement
### New Energy and Industrial Technology Development Organization (NEDO)

#### Energy and Environmental Technologies

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### Funding Program for World-Leading Innovative R&D on S&T (FIRST)

**CAO (CSTP) 1250 M$/30 PJ/5y**

Solar, Battery, Low power devices

### Japan Society for Promotion of Science (JSPS)

**Grant-in-Aid**

Specially Promoted Research 5M$/5y  
E.g., water splitting photocatalysts

### Japan Science and Technology Agency (JST)

**Strategic Basic Research Programs**

**CREST** (Core Research for Evolutional Science and Technology): <6M$/5y x 15  
Solar energy, Energy conv. Interphase, CO₂ Emission Control

**PRESTO** (Precursory Research for Embryonic Science and Technology): <0.5M$/3y x 30/PJ

**ERATO** (Exploratory Research for Advanced Technology): <25M$/5y

**Hashimoto Light Energy Conversion ALCA** (Advanced Low Carbon Technology Research and Development Program): 50M$/y, ~ 3M$/5y  
Cool Earth – Energy innovation technology plan
METI, March 2008

Efficiency enhancement:
1. Efficient LNG power generation
2. Efficient coal power generation
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Low carbon:
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16. Super efficient heat pump
17. Energy conserv. information system
18. High performance elec. storage
19. Power electronics
20. Hydrogen production/transportation/storage

Inter-division:
15. CCS

Energy conservation building:
1. Generation/transmission
2. Industry
3. Energy conservation building
4. Superconductive
5. High level traffic system
6. FCV
7. PHV
8. EV
9. Novel material/production/processing
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16. High performance elec. storage
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18. Hydrogen production/transportation/storage
19. CCS

Roadmap of PV2030+  
(NEDO June, 2009)

**Practical Use**

- Development of Technology to Accelerate the Practical Application of Photovoltaic Power Generation Systems
- Development of Advanced Solar Cells and Modules
- Investigation for Innovative PV Technology
- R&D of Next-generation PV Generation System Technologies
- R&D of Common Fundamental Technologies for Photovoltaic Generation Systems Phase I
- R&D of Common Fundamental Technologies for Photovoltaic Generation Systems Phase II
- R&D on disseminating of PV systems (PV system usage technology, establishing reliability, wider application, demonstrative researches)
- R&D on innovative PV power generation technology (Ultra-high efficiency solar cell development)
- R&D on improving infrastructure (Evaluation technology development, strategic overseas development, etc.)

**Development Timeline**

- **2004:** Base Infrastructure
- **2006:** R&D of Next-generation PV Generation System Technologies
- **2008:** R&D of Common Fundamental Technologies for Photovoltaic Generation Systems Phase I
- **2010:** R&D of Common Fundamental Technologies for Photovoltaic Generation Systems Phase II
- **2012:** R&D on disseminating of PV systems
- **2014:** R&D on improving infrastructure

**Subsidy:** Private house
FY 2012: 400$/kW, ca. 500M$

**Organic solar cell:** 2012- FY2012 25M$ 2/3

**FIRST**
- **2010-2014**
  - OPV toward a Low-Carbon Society 37 M$
- **2008-2014**
  - Post Si (tandem, QD, etc.)
  - Highly ordered TF multi junction FY 2012 30M$

**ALCA:** Solar Cell and Solar Energy System (2010-): NP, Nanostructure/c-Si, paintable OTF, Si clathrate, Group IV TF Multi-Layered, Nano C, DSC, Liq. Si, III-V-N, hybrid C, Cu$_2$ZnSn(S,Se)$_4$ TF, Si/Ge, InGaN: 5y PJx14+α–β


Figure 6  Overview of immediate technology development projects
Electrical Energy Storage

**Challenge for new type batteries**

- **FIRST**: Innovative Basic Research Toward Creation of High-performance Battery 35 M$

**Research direction for new type batteries**

- **ALCA**: Electric Storage Device (2010~): Mg battery, All solid state Li battery x 4, Graphene capacitor, Na battery, Light metal capacitor, LIB, Metal-air battery, Li-air battery, Semiconductor secondary battery, Hybrid capacitor, Li-Si electrode, Na-S all solid state battery, Metal secondary battery, Ionic liquid base battery 5y PJx17+α–β

- **CREST**: CO$_2$ Emission Control (2008~2014): s-block metal battery, Proton elec. capacitor, All solid state Li battery 5y PJx3

**Phase Interface for Energy Conv. (2011-2017)**: none

**Batteries for next generation car 2006**

- Improved 2010
- Advanced 2015
- Limit of LIB?

**Cost**

- 200k Yen/kWh
- 100k Yen/kWh
- 5k Yen/kWh

**Energy density**

- 38M/$y 2009--2015

**Power density [W/kg]**

- 700
- 500
- 50

**Electrical Energy Storage**

- 2011 - 2015 FY2012 34M$

**Practical use of LIB 2012-2016 FY 2012 25M$**

**High performance PHV**

- 30k Yen/kWh
- 20k Yen/kWh

**Research direction for LIB**

- Cost 1/10th

**38M$/y 2009--2015**

**Power density [W/kg]**

- 4000
- 3000
- 2000
- 1500
- 1000
- 500

**Cost**

- 5k Yen/kWh

**Research direction for new type batteries**

- 1/5th

**Power density [W/kg]**

- 250

**Cost**

- 1/10th

**Power density [W/kg]**

- 70

**Cost**

- 1/40th

**Power density [W/kg]**

- 700
**Hydrogen**

**Hydrogen**
- Distribution infrastructure
  - 2011-2015
  - FY2012 40M$

**Hydrogen production/transportation/storage**
- 2008-2012
- FY2012 19M$

**Hydrogen fundamental science**
- 2008-2012
- FY2012 10M$

- Photocatalytic decomposition of water: 5y PJx1

**ALCA: Solar Cell and Solar Energy System (2010~):**
- Photocatalytic decomposition of water, 5y PJx1+α–β

**Fuel Cell and Hydrogen Subsidy: Private house**
- FY 2012: 50% hot water supply 110M+60M$

**SOFC system components**
- 2008-2012
- FY2012 8M$

**ALCA: Electric Storage Device (2010~):**
- SOFC/SOE, 5y PJx1+α–β

**PEMFC practical application**
- 2010-2014
- FY2012 44M$
- Two major centers (Yamanashi Univ., FC-Cubic) + PJs (low Pt, carbon alloy, oxide)

**ALCA: Electric Storage Device (2010~):**
- Carbon alloy catalyst, Liq. fuel FC 5y PJx2+α–β

**CREST: CO₂ Emission Control (2008~2014):**
- All solid state alkaline FC 5y PJx1

**Hydrogen production/transportation/storage**
- 2008-2012
- FY2012 19M$

**WPI International Institute for Carbon-Neutral Energy Research 2010 - 2019 (+ 5 years) 18M$/y**

**SOFC**
- High temp.
  - 1000 C

**PEM**
- Low temp.
  - 100 C

**High temp.**

**Low temp.**
Biomass

Process

Cellulose

Gasification

Liquefaction..

Biofuel

Highly efficient conversion of biomass 2004-2012 FY2012 25M$

Algae

Culture.. Extraction..

Biofuel

Revolutionary production process of ethanol from cellulose 2009-2013 FY2012 15M$

Chemicals

Raw Mat.

Pre-treat..

Glycation.

Fermentation.

Biofuel

Strategic next generation biomass energy technology 2010-2016 FY2012 25M$

ALCA: Biotechnology (2010~): Cellulosic biomass, Bioplastics from polysaccharides, Solid-degrading enzymes, Diatom factory, Saccharification of biomass, Lignocellulose refinery, Super photosynthesis and bioproduction, Thermo-tolerant microbes, Drop-in fuel production by bioprocess, New wood in wood-less plant, Vegetational bioprocess, Metabolism of autotrophic microorganisms, Bacillus subtilis cell factory, etc., 5y PJx25+$a$–$b$

CREST: CO$_2$ Emission Control (2008~2014): Wooden biomass production, Liquefaction of wooden biomass, Oil producing algae, Efficient production of biomaterials, Bioethanol from algae, Biodiesel from algae 5y PJx6
Wind Power

- Large scale PV
- Wind farm

Next generation wind power generation 2008-2012
FY2012 8M$

Offshore wind power generation 2008-2013
FY2012 65M$
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Hashimoto Light Energy Conversion


Global Research Center for Environment and Energy based on Nanomaterials Science (GREEN)

Targets

Solar cell

Photocatalyst

Secondary battery

Fuel cell

Cutting edge measurement

In situ measurement of surface/interface
Real environment, solid/liquid interface

Computer simulation

Electron and atom dynamics analysis
Electron transfer, Ion diffusion

To solve common problems in energy flow starting from solar energy

Understanding and control of interfacial phenomena
Collaboration and fusion of theory and experiment

Dream team

Industry

Universities and Research Institutes
World Premier International (WPI) Research Center Initiative

~To create top world-level Research hubs in Japan~

1. Top Quality of Science
2. Achievement of Breakthrough by Fusion Researches
3. Globally Visible Research Center
4. Break of Administrative Limitation

Selected Organizations & Projects (2007.10)

- NIMS  Nanotechnology · Materials
- Univ. Tokyo  Astrophysics
- Kyoto Univ.  Stem Cells
- Tohoku Univ.  Materials Science
- Osaka Univ.  Immunology
- Kyusyu Univ.  Carbon-Neutral Energy (2011.10)

- Period: 10 to 15 years
- Funding: 1.4B JPY (14M 18M US$) a year per center
- Matching fund scheme: Each center has to earn the same amount of research funding
Research organization of MANA

Nano-Green
- Fuel cells
- Solar cells
- Catalysts
- Li-ion batteries

Nano-Bio
- Bionanoparticles
- Smart biomaterials
- Biointerfaces
- Biosensing

Nano-Materials
- Nanotubes
- Nanosheets
- Super molecules
- Nanoelectronics materials

Nano-System
- Nanoelectronics devices
- Neuromorphic nano-systems
- Revolutionary nano-measurement
- Theory and modeling

Novel Nanomaterials & Nanosystems

Innovation

Five Key Technologies
- Controlled Self-organization
- Field-induced Materials Control
- Chemical Nanomanipulation
- Atom/Molecule Novel Manipulation
- Theoretical Modeling & Designing
Interaction area (every floor)

WPI-MANA Bldg.

Nano Green Bldg.

Research organization of MANA

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- Revolutionary nano-measurement
- Theory and modeling

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Solar cell
- Computer simulation
- Electron and atom dynamics analysis
- Electron transfer, Ion diffusion
- To solve common problems in energy flow starting from solar energy
- Understanding and control of interfacial phenomena
- Collaboration and fusion of theory and experiment

Photocatalyst
- Cutting edge measurement
- In situ measurement of surface/interface
- Real environment, solid/liquid interface

Industry

Universities and Research Institutes

13,500 m²
90 M$
Supplementary budget, 2009
Completed March 2012
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RIKEN
NIMS
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JSPS
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(Environment and Energy Division, Nanotechnology and Materials Section)

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