

# R&D strategy to accelerate the global growth of the Hitachi Group

17<sup>th</sup> April 2012

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Hitachi, Ltd.



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1 R&D strategy

2 Development of No.1 technology

3 Global R&D

4 Strategic steps for the future



# Contents

**1** R&D strategy

2 Development of No.1 technology

3 Global R&D

4 Strategic steps for the future

## Accelerate Social Innovation Business strategy execution

Contribute to the creation of sustainable social infrastructure

Global

Fusion

Environment

- Leverage Hitachi's strengths to promote a global growth strategy
- Focus business resources on Social Innovation Business
- Strengthen the business structure to stabilize profitability

Hitachi target value

### Value created and shared with customers and partner

- Develop products and services in demand from regional communities and markets
- Combine intellectual capital to contribute to society through businesses

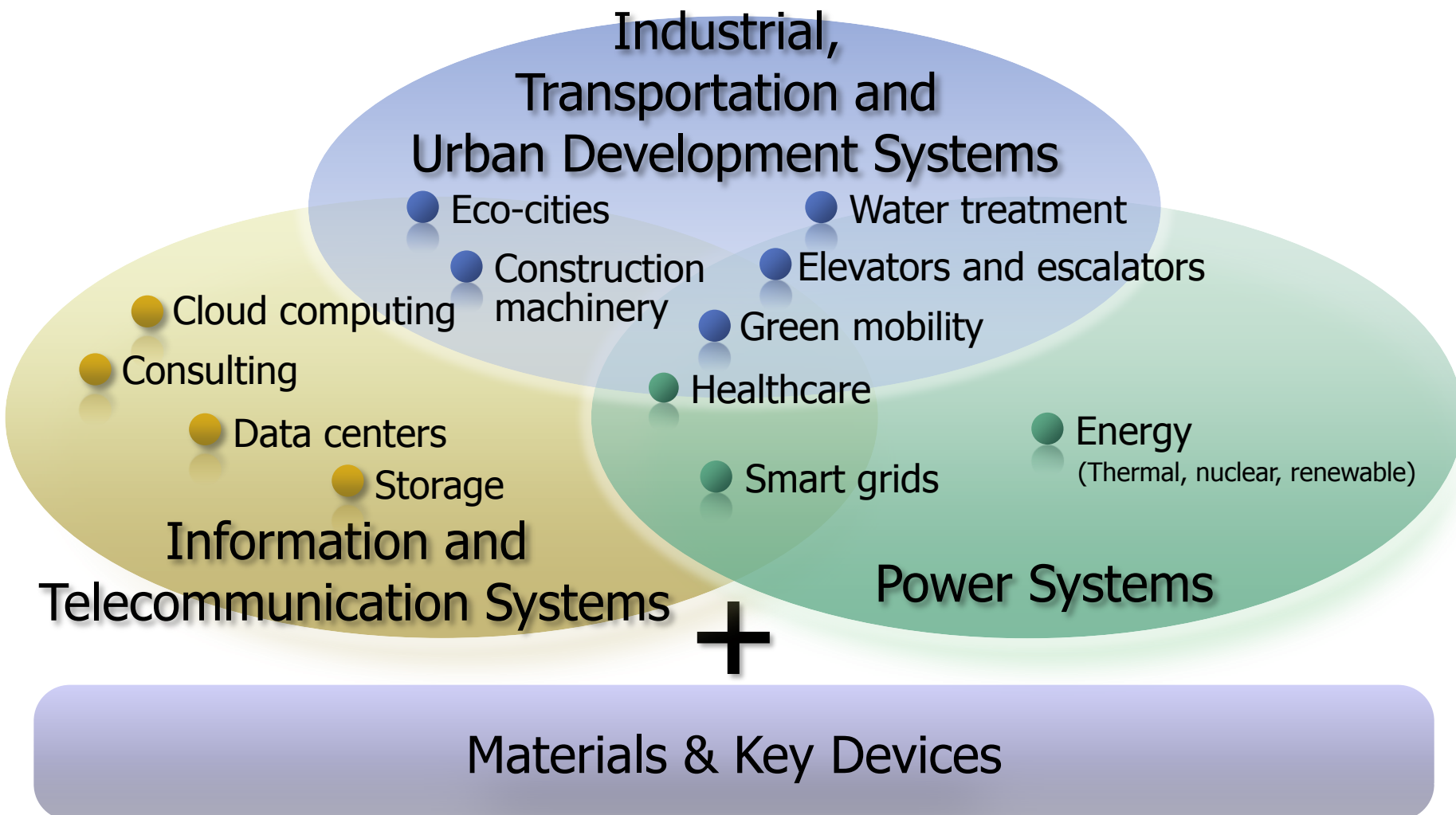
### Value that last for future generations

- Offer products, services and system management that contribute to customers' growth
- Refine systems to meet changing needs

### Value based on our role and mission as a manufacturer

- Advanced technologies and MONOZUKURI (Manufacturing) capabilities based on high ideals and vision
- Trustworthiness and reliability of Hitachi

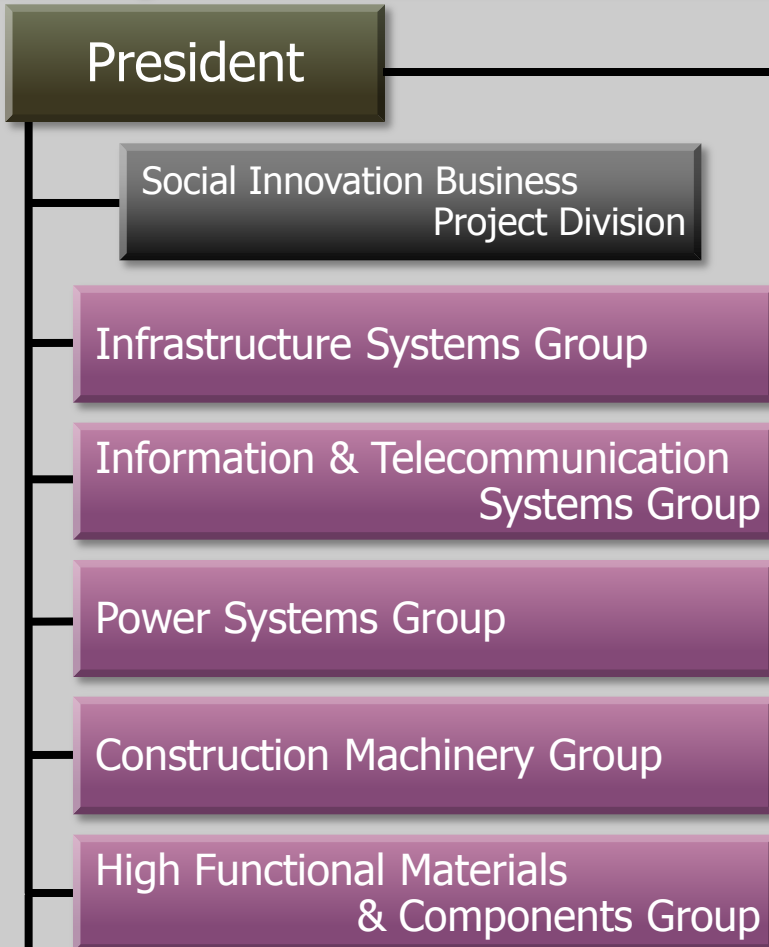
## Social Innovation Business



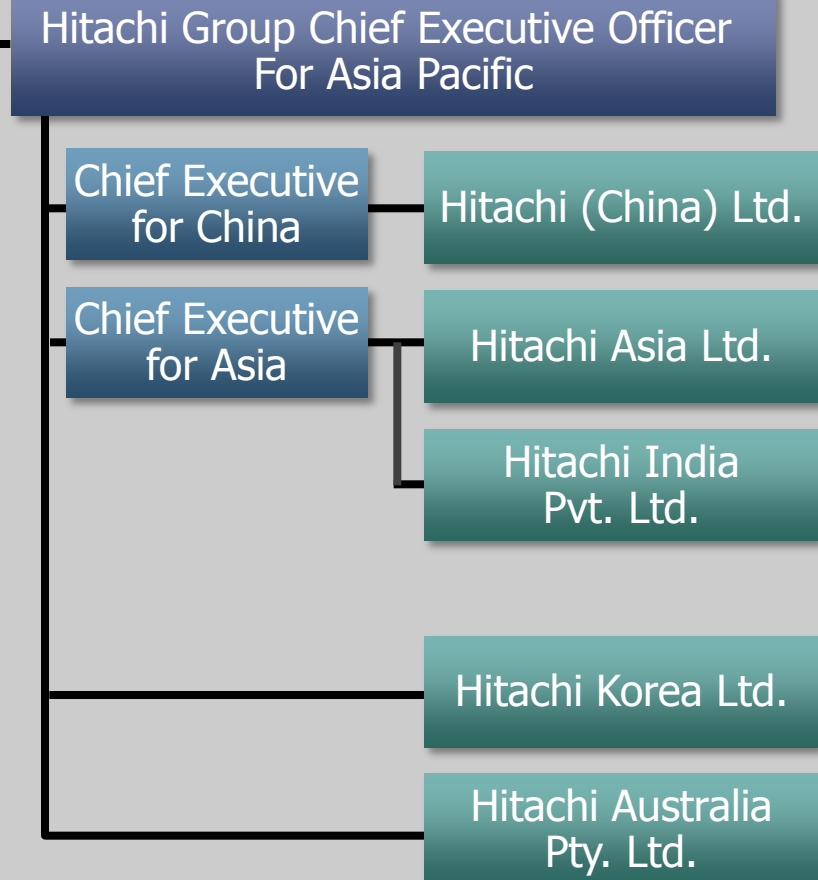
# 1-3. New management system

Towards becoming a globally competitive major player

## 5 Group structure aligned with market needs



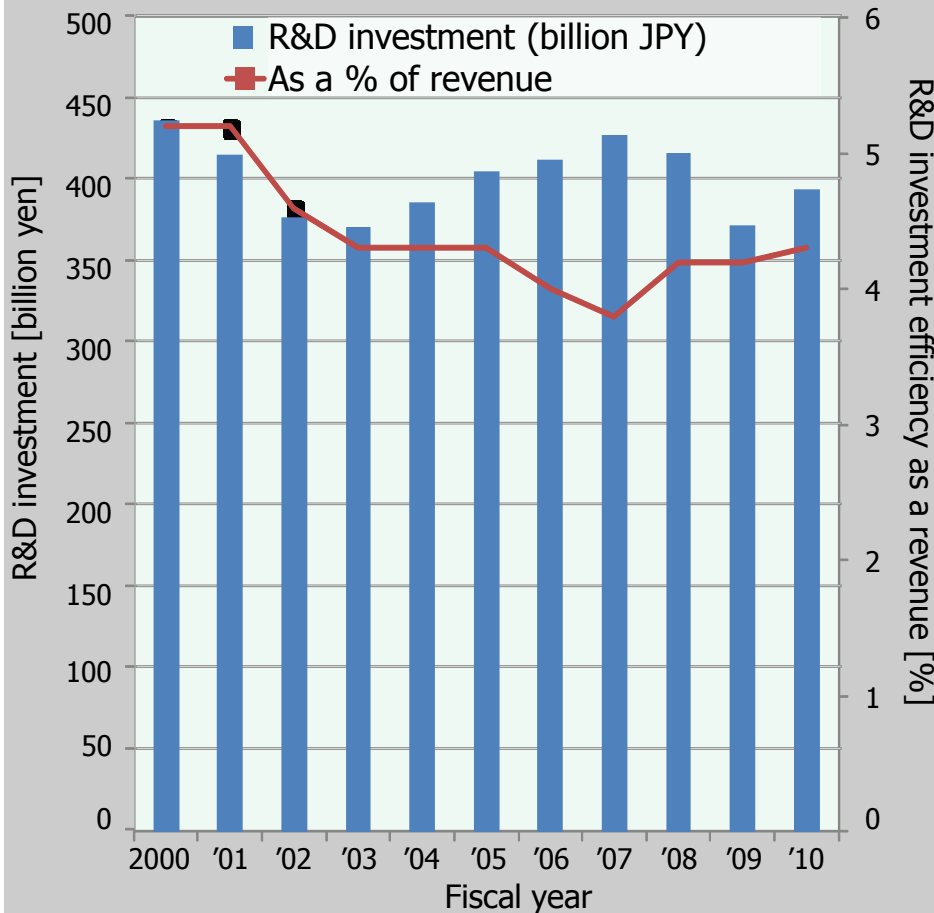
## Business expansion in the Asian belt region



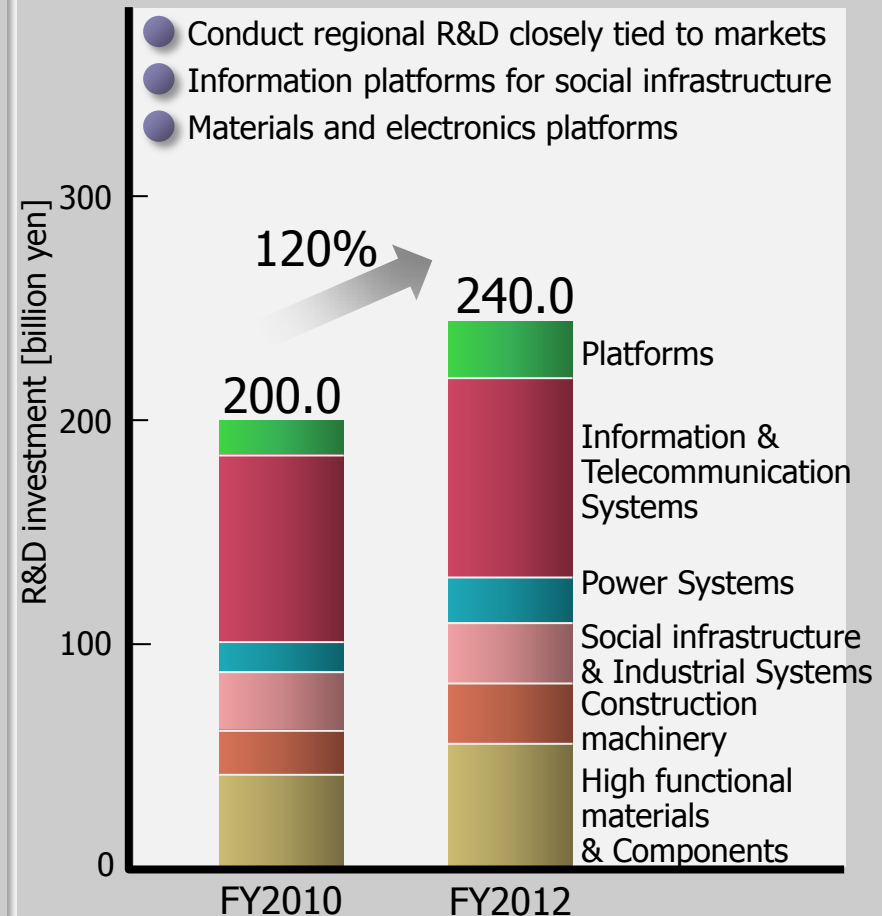
# 1-4. Hitachi Group R&D investment

Total of 670 billion yen invested in Social Innovation Business (FY 2010-2012)

R&D investment trend

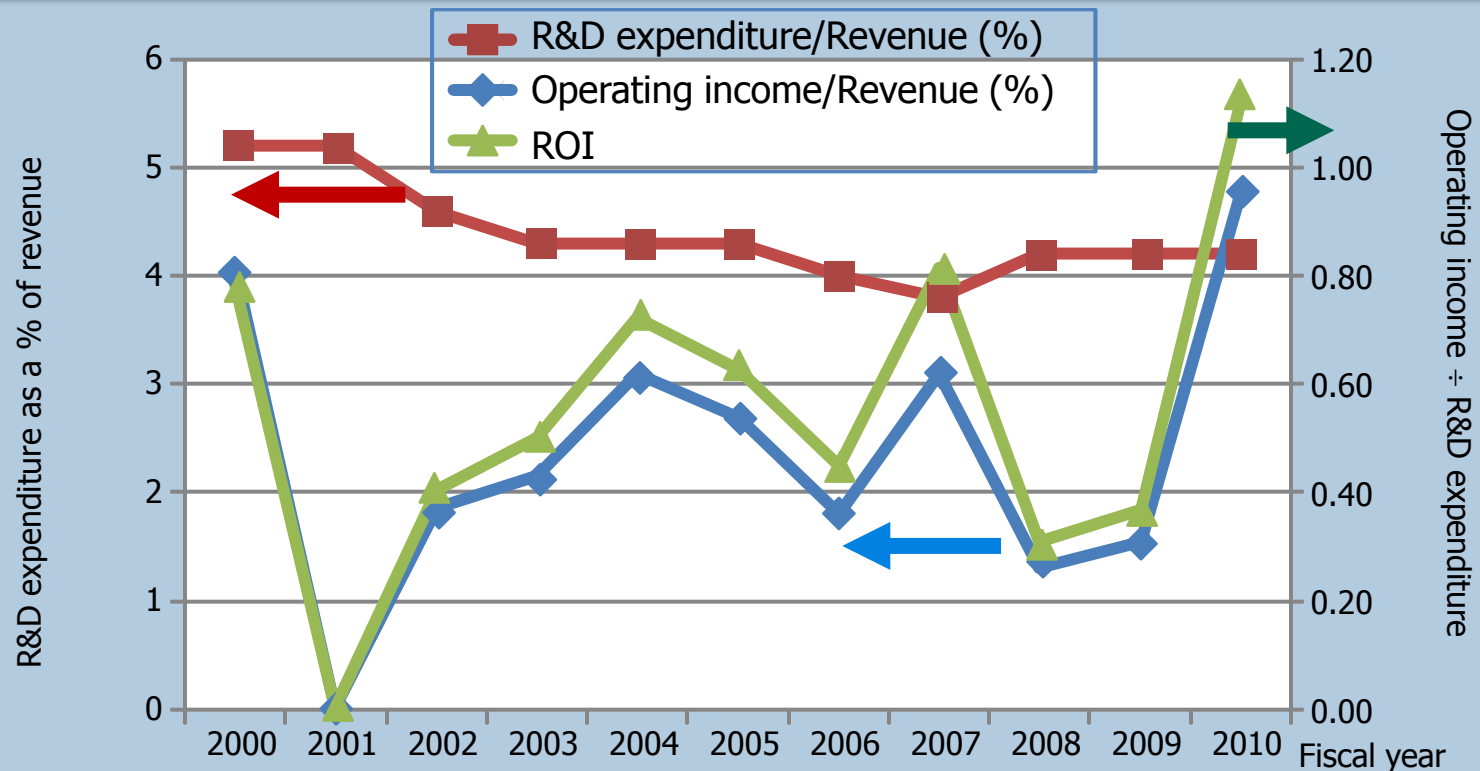


Source: 9<sup>th</sup> June 2011 "2012 Mid-term Management Plan"



# 1-5. R&D investment efficiency & R&D personnel

## Annual trend in investment return on R&D expenditure



## Annual trend in number of R&D personnel

	FY2010	FY2011	FY2012*
Hitachi, Ltd.	3,633	3,481	3,448
Hitachi Group	2,087	2,046	1,909
<b>Total</b>	<b>5,720</b>	<b>5,527</b>	<b>5,357</b>

\*as of April, 2012



## Promote R&D to support the global growth of the Hitachi Group

FY 2012

### ● Laboratories in Japan

Develop of No.1 technology to expand the range of Social Innovation Business

### ● R&D bases overseas

Promote of localized global research and development

FY 2011

- Integration of domestic laboratories (3 labs)  
⇒ Speed-up decision-making, express synergy
- Enhancement of overseas research bases  
⇒ 6 regions global R&D formation

### R&D Group

Technology Strategy Office

Central Research Lab.

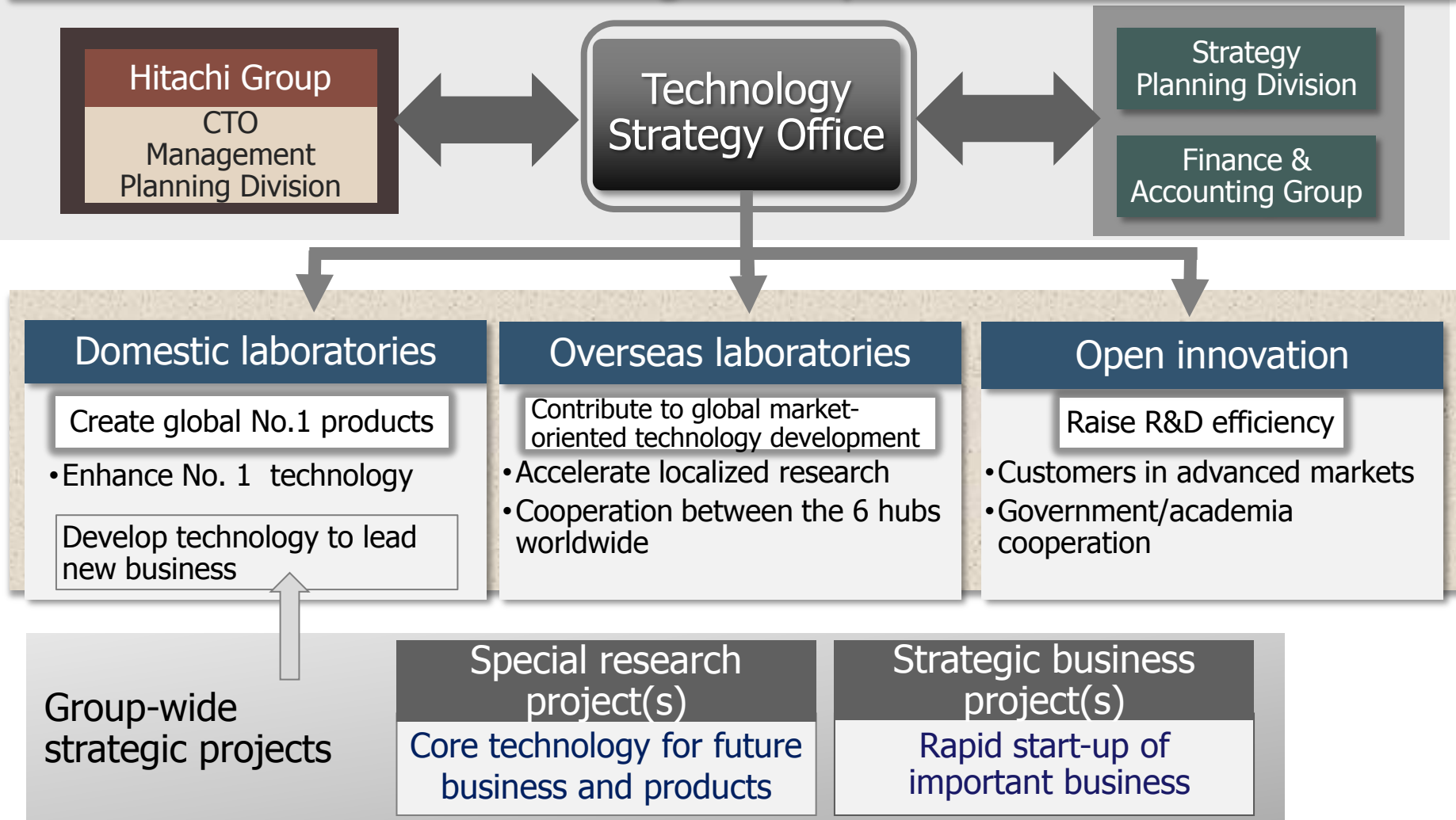
Hitachi Research Lab.

Yokohama Research Lab.

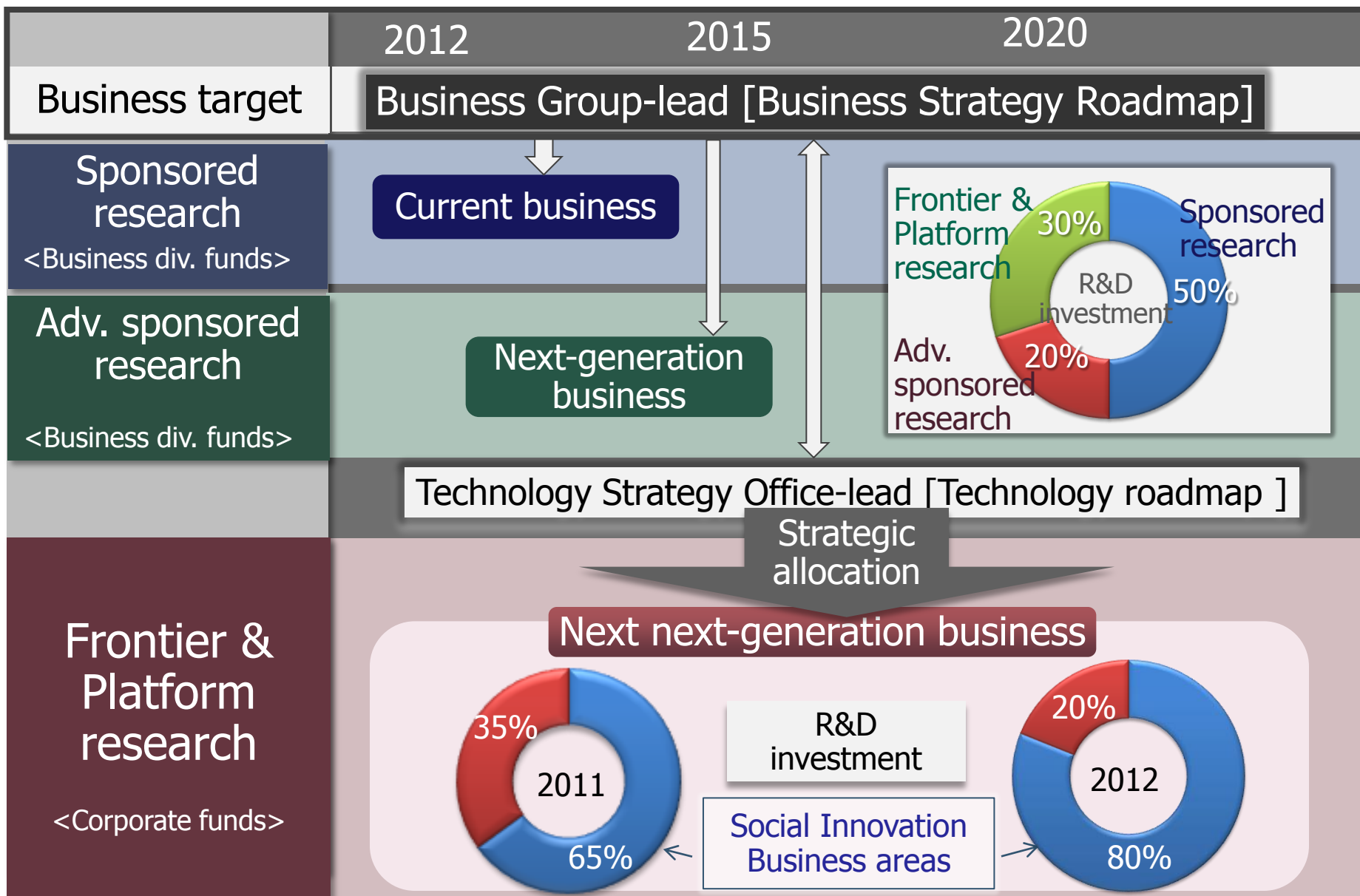
Design Division

Overseas research centers

## Formulating technology strategy to achieve Hitachi Group management plan



# 1-8. Strategic allocation of investment



# 1-9. R&D organization - 3 domestic labs & 1 HQ (FY2011-)

Purpose: No.1 technology development through rapid decision making & synergy effect

## Central Research Lab.

[approx. 900]



Hatoyama-machi, Saitama



Kokubunji-shi, Tokyo

Expand Social Innovation Business areas, Pioneer new areas in anticipation of future social needs

## Hitachi Research Lab.

[approx. 1,200]

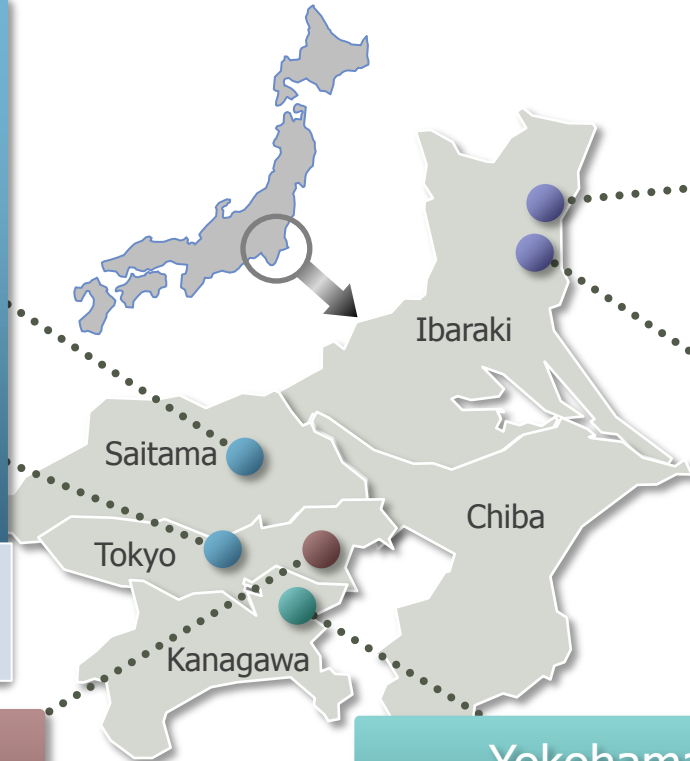


Hitachi-shi, Ibaraki



Hitachinaka-shi, Ibaraki

Energy, Social/industrial infrastructure, Life infrastructure, and supporting materials and key devices



## Design Division

[approx. 150]

Akasaka,  
Minato-ku, Tokyo



Vision design and Experience design to raise business competitiveness

## Yokohama Research Lab.

[approx. 1,100]



Yokohama-shi, Kanagawa

IT platform & MONOZUKURI technology to support IT and infrastructure fusion business

# 1-10. 6 regions global R&D formation

Purpose: Accelerate localized R&D

## Europe (Hitachi Europe Ltd.)



Maidenhead

- Adv. physics
- Rail systems
- Automotive systems
- Power systems
- Design

## China (Hitachi China R&D Corporation)



Beijing

- Social infrastructure systems
- Information & Telecommunication systems
- Medical & Healthcare
- Construction machinery
- Design

## USA (Hitachi America, Ltd.)

- Storage systems
- Automotive equipment
- Wireless communication systems
- Design



Santa Clara



Shanghai

## India (Hitachi India Pvt. Ltd.)

- IT hardware
- Middleware
- Large volume data collection
- Knowledge processing
- Social infrastructure systems



Bangalore



Singapore

## Asia (Hitachi Asia Ltd.)

- Software
- Big Data
- Network storage
- Water treatment







# Contents

1 R&D strategy

**2** Development of No.1 technology

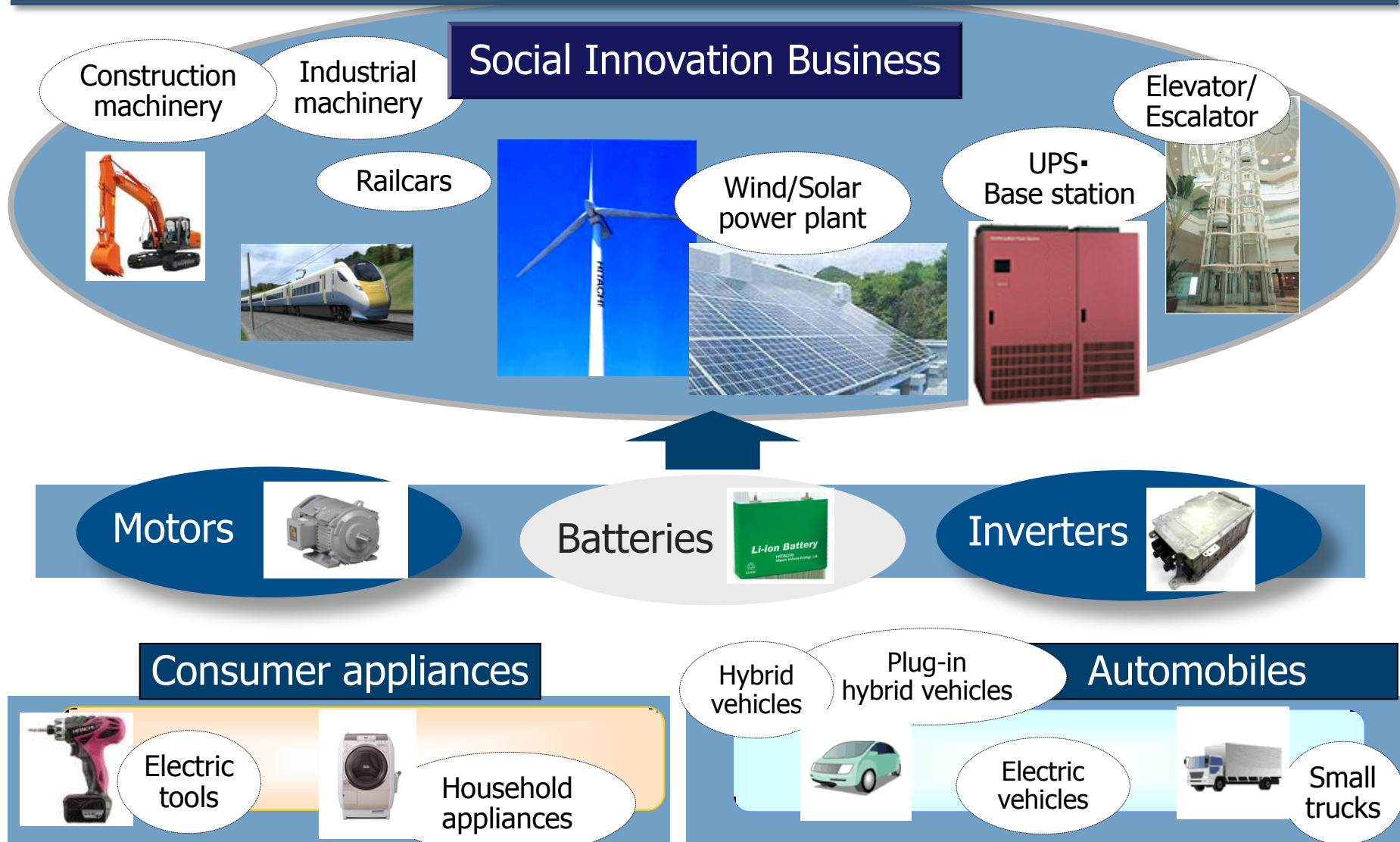
3 Global R&D

4 Strategic steps for the future

Business area		No.1 technology development	
Infrastructure Systems Group	Eco-cities	<b>1. Innovative motor &amp; inverter technology supporting infrastructure systems</b>  SiC inverters for railcars Next-generation power module for car inverter Rare-metal-less amorphous motors	
	Green mobility		
	Industry facilities		
	Healthcare		
	Elevators/ Escalators		
Information & Tele-communication Systems Group	Cloud computing	<b>2. Cutting-edge technology contributing to the expansion of healthcare business</b>  Proton beam cancer therapy system Radiation measurement technology Single cell analysis technology	
	Consulting		
	Big data		
	System integrator		
	Storage		
Power Systems Group	Energy	<b>3. Information &amp; telecommunication technology supporting Social Innovation Business</b>  Wide area network (WAN) high speed technology Advanced design in storage	
	Smart grids		
Construction Machinery Group	Construction machinery	<b>4. Innovative technology in power &amp; energy</b>  Next-generation gas turbine technology Innovative coal thermal power technology Smart grids	
High Function Materials & Components Group	High functional materials		
	Key devices		

# 2-2. Innovative motors & inverters supporting infrastructure systems

## Development of key devices supporting Social Innovation Business



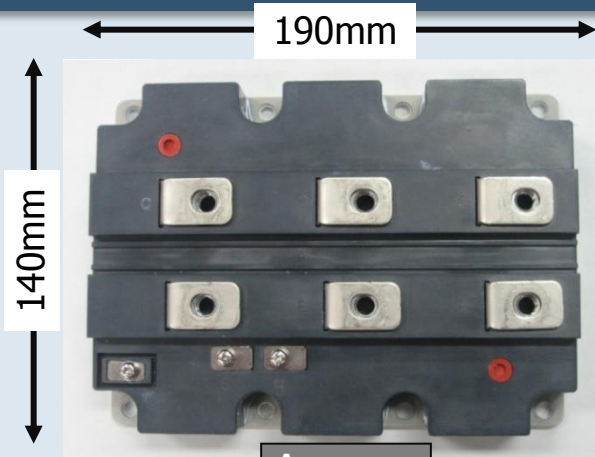


# 2-3. Compact, light & energy efficient inverters for Ralling stocks

Dramatic decrease in weight & size of rail car inverter using SiC devices

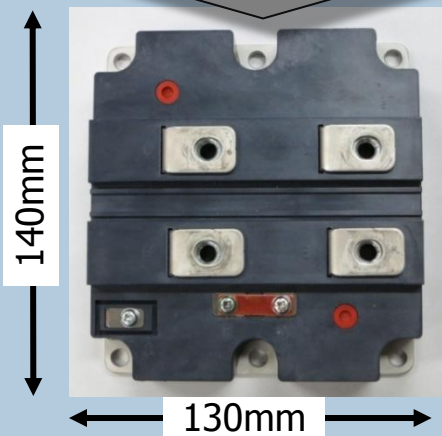
3.3 kV/1200A module: approx. 2/3 size

Si device  
(Si-IGBT\*1)



Approx.  
2/3

Si device  
(Si-IGBT)  
+  
SiC device  
(SiC-SBD\*2)



Rail car inverter for 1,500V DC overhead power supply: approx. 60%

Si-based inverter



Approx.  
3/5  
volume &  
weight

SiC-based inverter

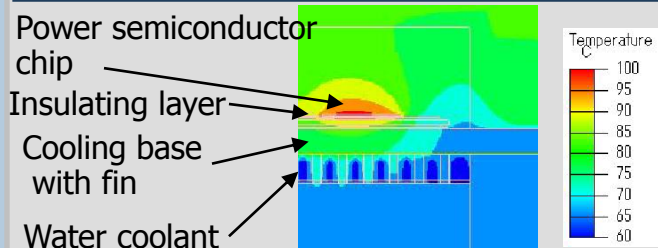


\*1 Insulated gate bipolar transistor \*2 Schottky barrier diode

## Realization of compact inverters for electric and hybrid vehicles

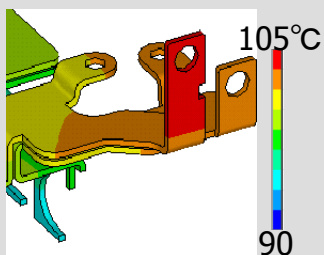
### Optimal heat radiation structure and miniaturization design

#### Computational fluid dynamics

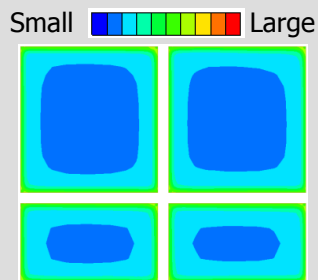


Linked

#### Electrical heat analysis



#### Stress analysis



Chip solder stress

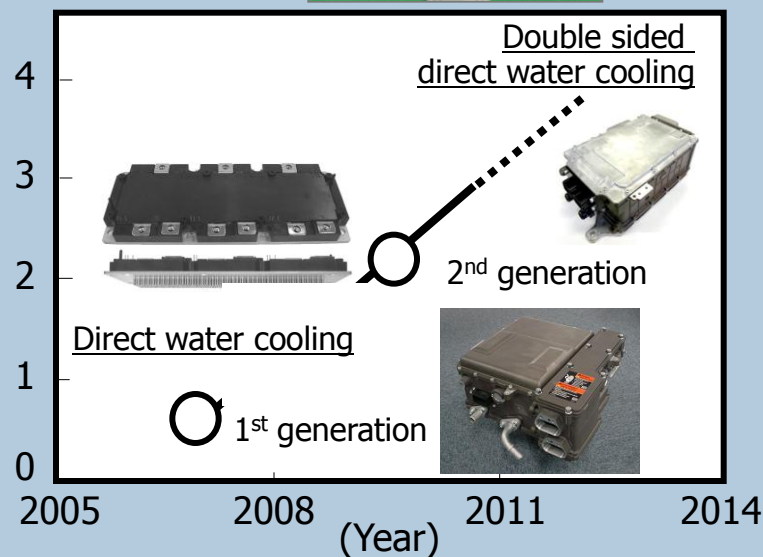
Optimal design

### Double sided direct water cooling power module

Thermal resistance characteristics:  
35% improvement  
Inverter floor space:  
50% reduction



Inverter power density (relative value)



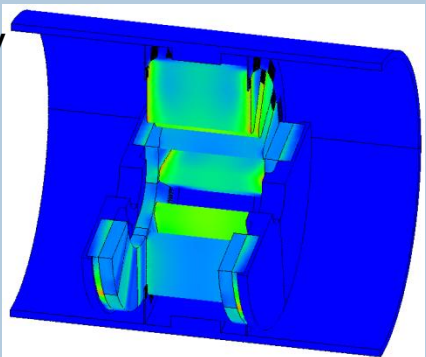
# 2-5. 11kW industrial rare-earth-metal-less motor

“-less” engineering to mitigate the risk of high resource prices (Hitachi Smart Transformation PJ)

Achieving maximum level efficiency without using rare metals such as neodymium and dysprosium

3D magnetic field analysis

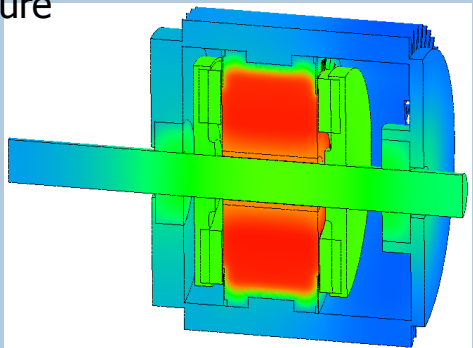
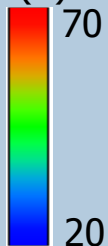
Flux density  
 $B(T)$



Linked

3D thermal analysis

Temperature rise  
 $\Delta T(K)$



Optimal design

Present induction motor      11kW permanent magnet synchronous motor



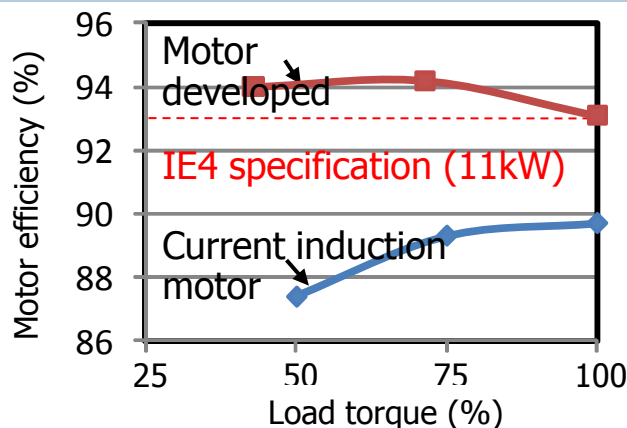
Rare earth less structure



Amorphous core stator



Double ferrite magnetic rotor



# 2-6. Cutting-edge technology contributing to the expansion of healthcare business

Development of state-of-the art technology in diagnostics, analysis and treatment

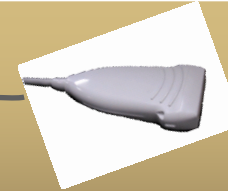
Diagnostic

Superconducting MRI equipment



Diagnostic imaging  
Semiconductor MEMS

Ultrasound



Silicon probe

Analysis

Bio-immunological Analysis\*1



Spectral analysis  
Gene analysis

DNA analysis\*2



Treatment

Proton beam therapy



Beam control  
Radiotherapy

Global business expansion

Single cell analysis  
Radiometric equip.

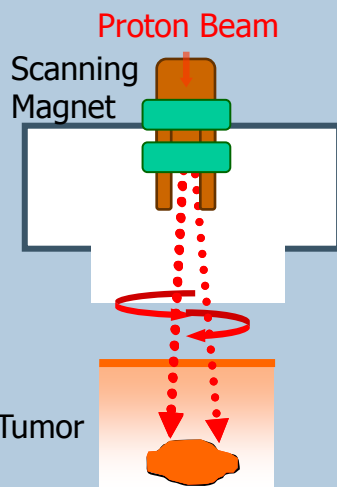
\*1 Manufactured by Hitachi High-Technologies, sold by Roche Diagnostics.

\*2 Manufactured by Hitachi High-Technologies Corp., sold by Life Technologies Corporation

## State-of-the-art cancer treatment pinpointing and delivering damage to cancerous tumors

### Innovative technology

#### Spot scanning technology



Method which scans the spot of the proton beam and irradiates the tumor

- No need for patient specific device
- Delivers high precision irradiation thus minimizing dose to healthy tissue

Nov. 2011 Authorized under the Pharmaceutical Affairs Law in Japan

### Practical application

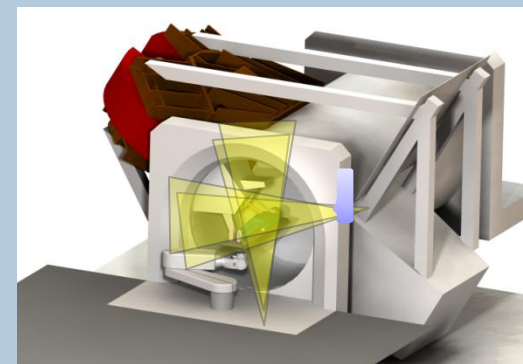


Delivered to the M.D. Anderson Cancer Center , Texas, USA. (First installation in a general hospital)

2012 Ichimura Prize in Industry  
2011 Best 10 New Products Prize

### Challenging future technology

#### Molecular tracking scanning therapy system



Integrated with the Real-time moving tumor tracking technology developed by Hokkaido University to increase irradiation precision

(Joint development lead by Prof. Hiroki SHIRATO of Hokkaido University, under the FIRST program initiated by the Council for Science and Technology Policy of the Japanese government.)

## Compact but high-energy-resolution, highly-sensitive gamma-ray detection

### Semiconductor detector-based radiation sensor module

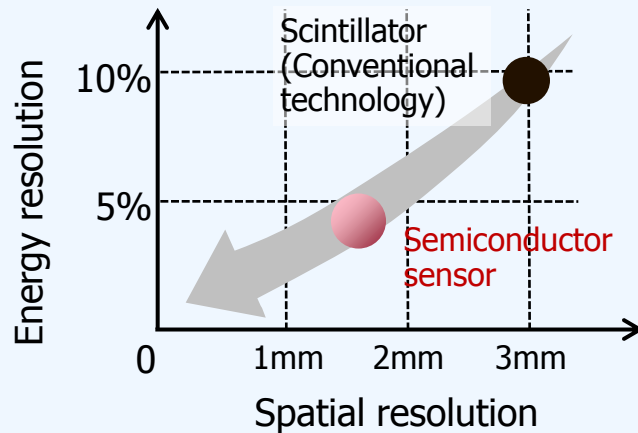
Semiconductor-based radiation detection technology (2000-)  
CRL, HRL

Developed for nuclear medicine

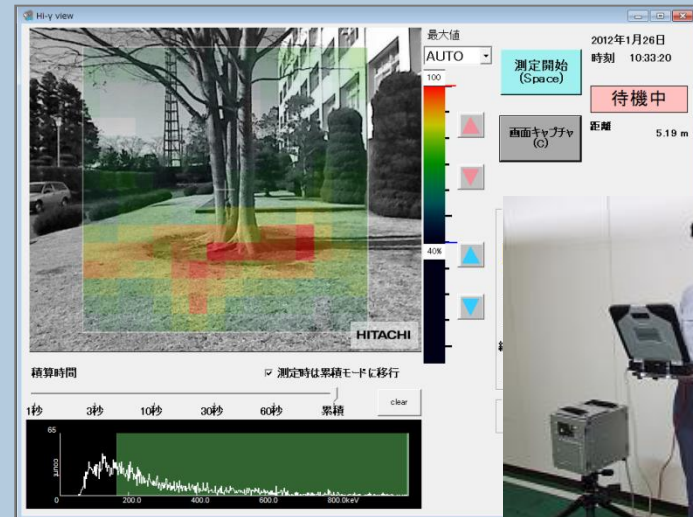


### Environmental radiation monitor

Applied to the radiation measurement  
Measured gamma-ray source intensity (color scale) is superimposed on to a video image to visualize radiation levels



Features are 1) high spatial resolution and 2) high energy resolution



Example of gamma-ray measurement



From a distance of 10m and with a view of 8m×8m

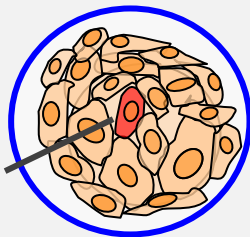
Enabling the observation of cancer stem cells which only exist in very small numbers in cancer tissue

## Single cell gene analysis

Conventional technology:

Average value from two or more cells

Cancer tissue



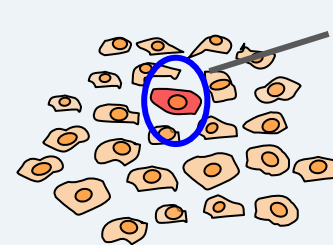
Cancer stem cell

Difficult to measure the presence of proteins or mRNA within a single cell due to the small amount present



Single cell measurement

⇒ Discovery of cancer stem cell



Cancer stem cell

Allows measurement within a single cell

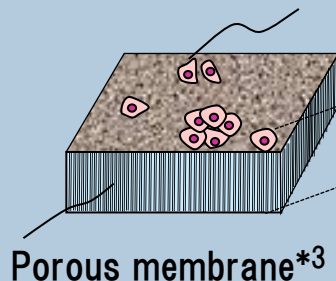
Principle: The genetic material (mRNA) from the single cell is affixed to the surface of porous membranes and repeatedly analyzed.

Collect single cell

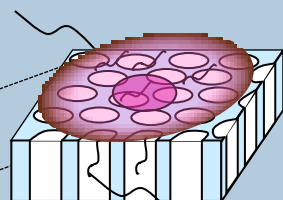
Dissolve single cell

Build-up a single cell cDNA library

Quantification by fluorescent imaging

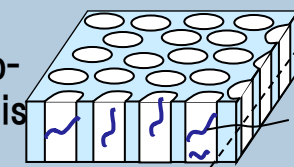


Porous membrane\*3



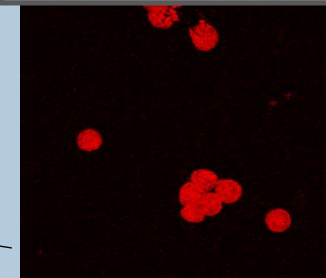
mRNA

Electrophoresis



cDNA library  
(repeatedly useable)

cDNA



# 2-10. Information & Telecommunication research supporting Social Innovation Business

Safe, secure and comfortable social infrastructure through the fusion of information and control technologies

Construction machinery



City



Green mobility



Logistics



Renewable energy



Power plant



Health information services



Financial services



Public services

Highly reliable networks

High reliability cloud

Storage  
Big data

Security

Green IT

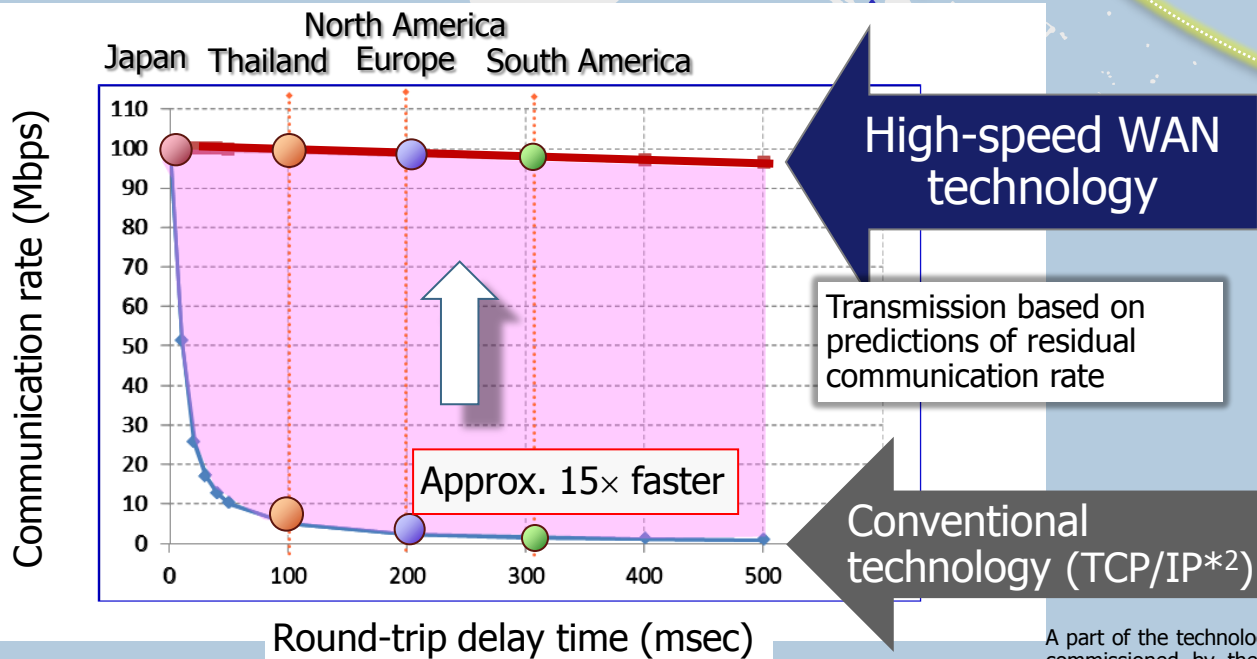
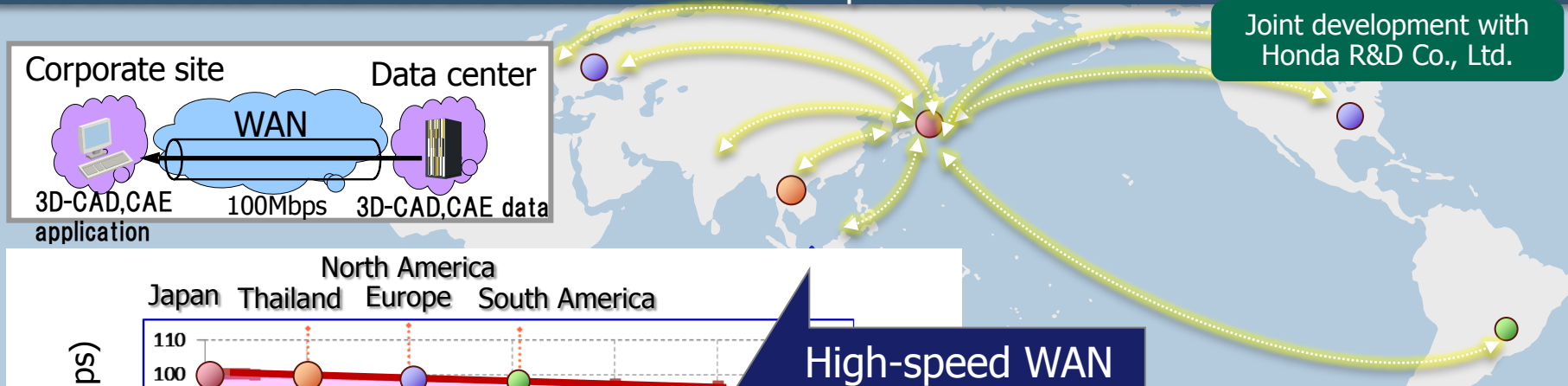
Fusion of information and control technologies



# 2-11. High-speed wide area network (WAN\*1)

Quick delivery of innovative technology to the market through cooperation with advanced customers

Create a high-response communication environment as if development/manufacturing/service sites distributed worldwide are on located the same premises

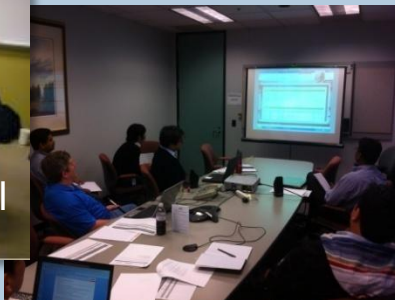
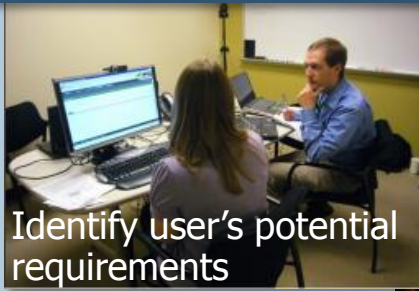


A part of the technology employed in this product is the result of research commissioned by the Ministry of Internal Affairs and Communications, Japan, under the program entitled "Research and Development on Management Platform Technologies for High Reliable Cloud Services"

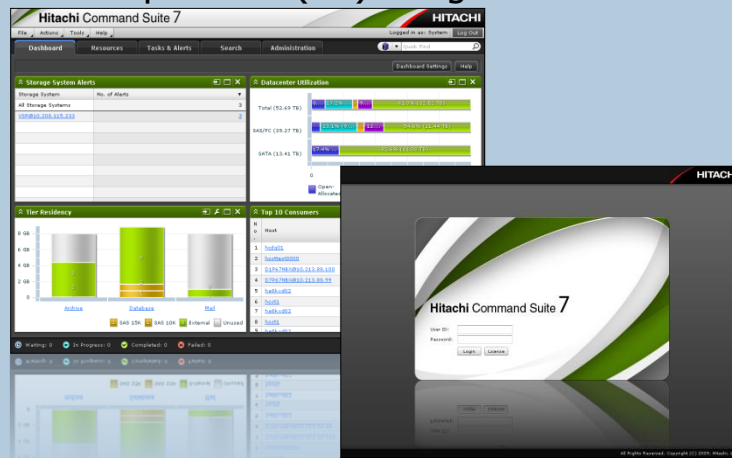
\*1 WAN: Wide Area Network \*2 TCP/IP: Transmission Control Protocol/Internet Protocol

## High-quality total design in both hardware and software

### Development of a directly operable storage management software



### User Experience (UX) design in North America



Hitachi Command Suite 7

### Design embodying high enhancement, and virtualization



Hitachi Virtual Storage Platform(VSP)

41<sup>st</sup> (2011) Machine Design Award: Minister of Economy, Trade and Industry Prize

## Development of creative energy technology for a clean & prosperous future

### Gas turbine

80 MW class (H-80)

- World's largest capacity 2-shaft gas-turbine \*1



Thermal efficiency 38%\*2

### Coal-fired thermal power plant

CO<sub>2</sub> recovery

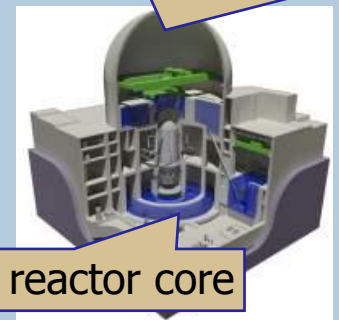
- Verification of stable combustion in oxygen combustion\*3 burners



\*Coal Energy Application for Gas, Liquid and Electricity

### Nuclear power plant

- Promoted as a national project
- Best mix of dynamic & static safety systems

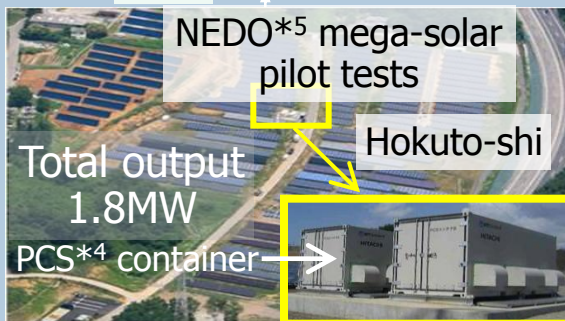


Efficient reactor core

### Renewable energy

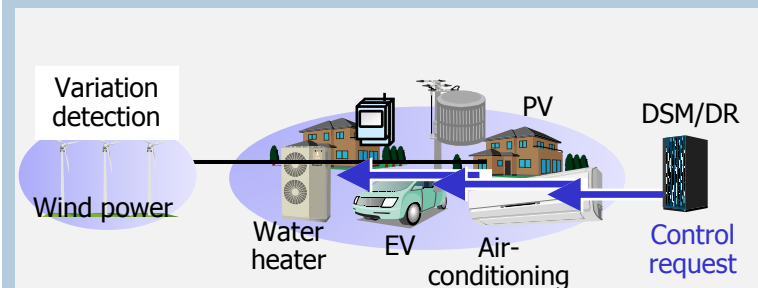
Solar

Wind



### Smart grids

Pilot tests in Hawai'i, U.S.A.



\*1: As a heavy-duty type (according to 2010/2/22 Hitachi survey); \*2: Based on lower heating value; \*3: A method of using oxygen instead of air to burn coal, raising the CO<sub>2</sub> concentration making it easier to recover CO<sub>2</sub>; \*4 Power conditioning system;

\*5: NEDO (New Energy and Industrial Technology Development Organization)

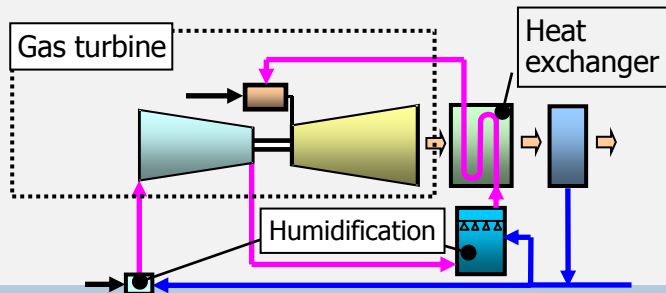
# 2-14. Next generation gas turbine (AHAT\*1)

Demonstrate practical use of axial gas turbine technology in a national project

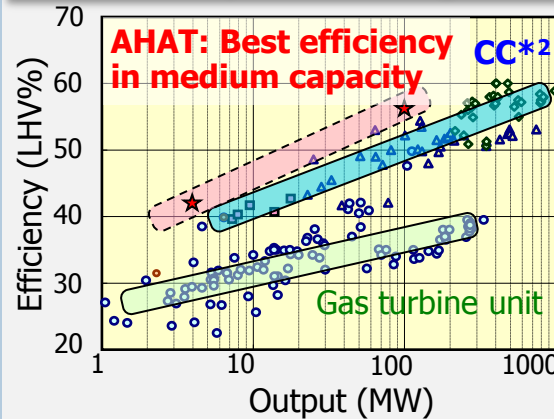
## Features

- Improve gas turbine efficiency by humidification & heat exchange

- High operability as steam turbine is unnecessary
- Eco-friendly as there is no hot water discharge

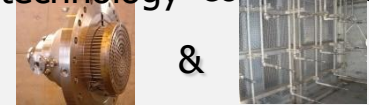


## Development target



## Technology

High humidity combustion technology & Water atomization cooling system



## Results

ASME/IGTI best paper award (2010)



## AHAT development steps

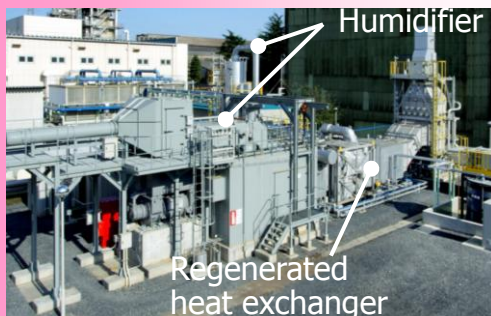
2006

2011

2020

Fiscal year

Phase I: Verify basic technology (3MW)



Phase II: Demonstrate practical use (45MW)



Phase III: Technology verification (Plan)

- **Test plant (100MW class)** (Planned start 2019 - )

Fusion of systems

Coal gasification



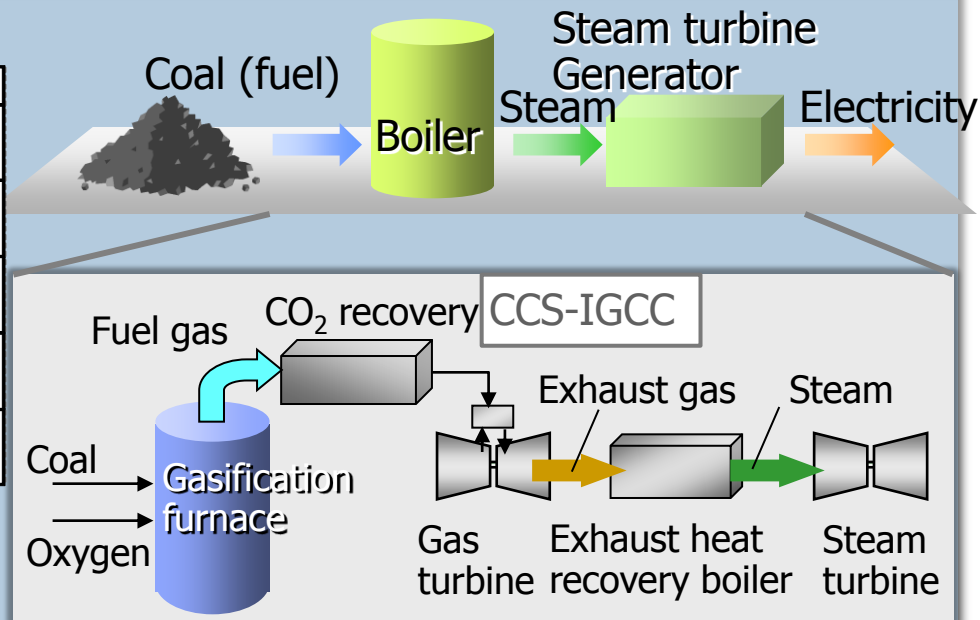
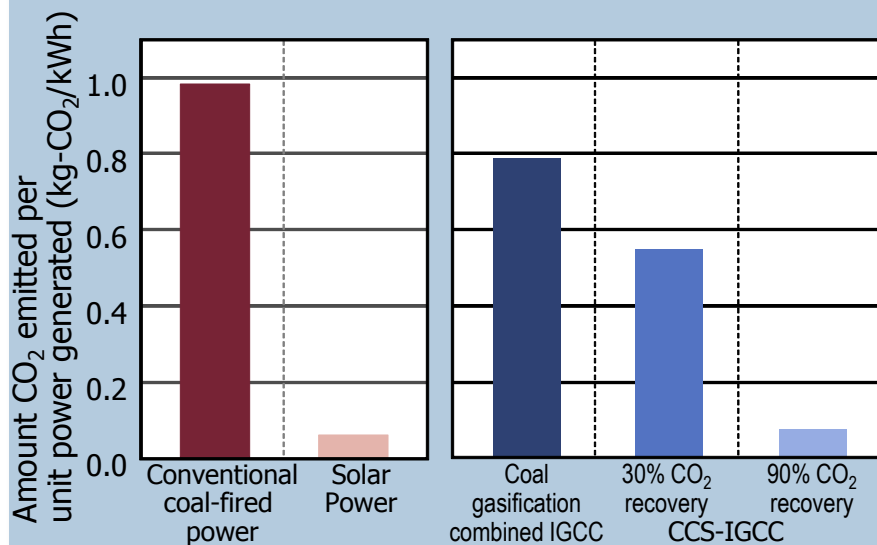
Hydrogen fuel gas turbine

\*1: Advanced humid air turbine; \*2: Combined cycle

# 2-15. Innovative coal-fired thermal power plant

CO<sub>2</sub> emission equivalent to solar power plant achieved with coal-fired thermal power plant

CO<sub>2</sub> recovery type coal gasification combined cycle (CCS\*<sup>1</sup>-IGCC\*<sup>2</sup>)



EAGLE\*



\*Energy application for gas, liquid and electricity

Reduction of NO<sub>x</sub> emission

Gas turbine clean combustion technology



Enhancement of power generation efficiency

Low temperature reactive shift catalyst

CO<sub>2</sub> solid adsorbent

\*1 Carbon Capture Storage

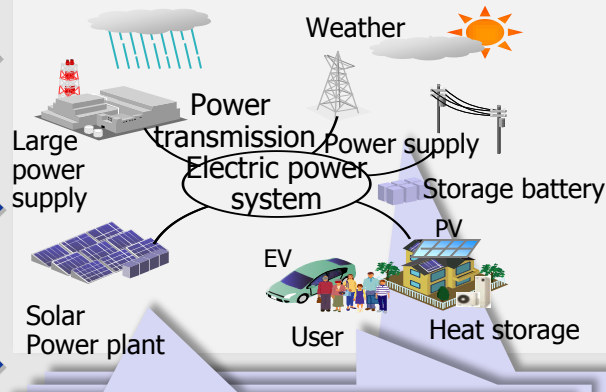
\*2 Integrated coal Gasification Combined Cycle

## Development of stabilization control using simulator

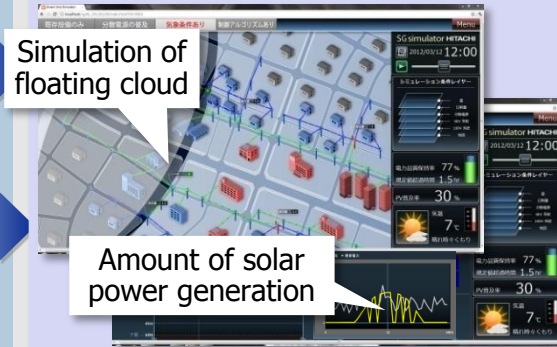
### Development of stabilization control algorithm

#### Smart grids simulator

#### Modeling of renewable energy



#### Simulation of stabilization control



Weather data

Various sensor data

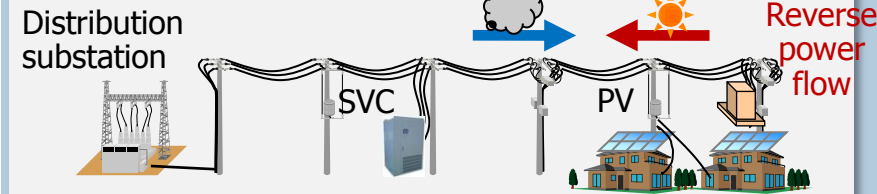
Data from past results

Operating parameters

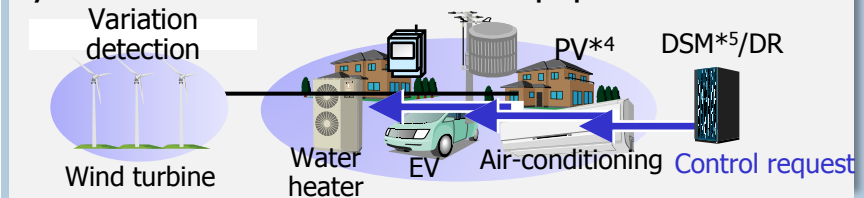
Power supply, line configurations

### Verification of efficacy through domestic and overseas pilot tests

**■ Voltage stabilization (UK WPD pilot tests\*1)**  
Stabilization of voltage fluctuations in the transmission lines due to distributed power generation sources such as wind and PV.



**■ User household control (NEDO\*3 Hawai'i pilot tests)**  
Stabilization of fluctuations in wind power generation for remote island power transmission by control of user household equipment



\*1 WPD: Western Power Distribution

\*2 SVC: Static Var Compensator

\*3 NEDO: New Energy and Industrial Technology Development Organization

\*4 PV: Photovoltaic generator

\*5 DSM: Demand Side Management



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**3** Global R&D

4 Strategic steps for the future

# 3-1. Promote and expand Glocalization

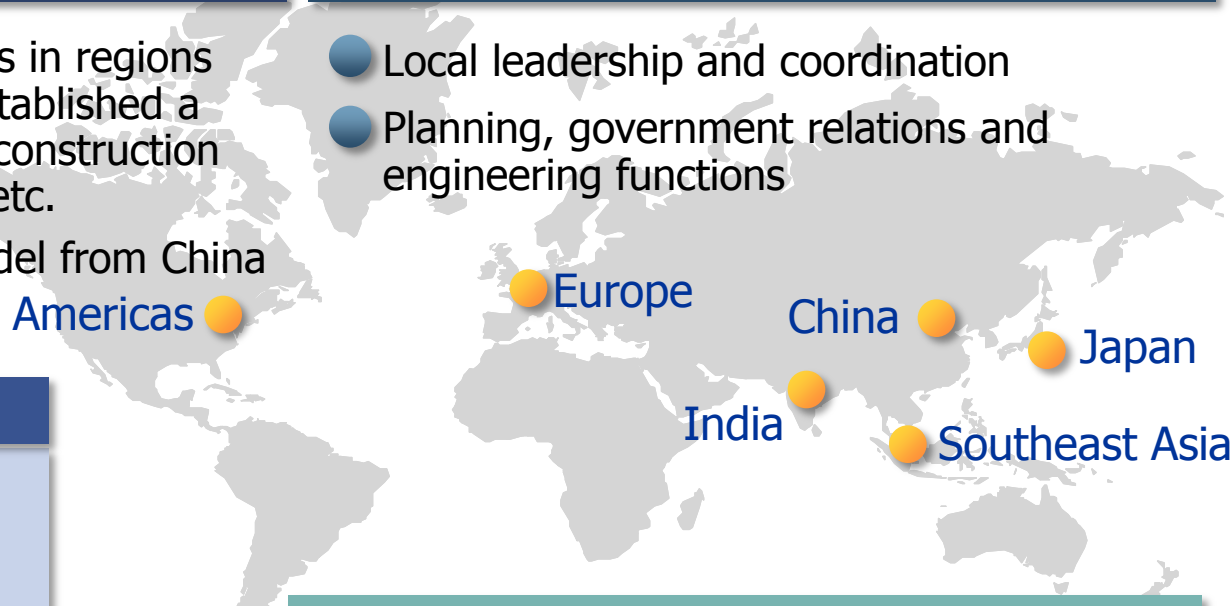
Designate 11 key regions and strengthen local project control centers

Develop the global framework comprised of 6 regions including Japan

Americas, Europe, India, Southeast Asia, China, Japan

- Cultivate and expand markets in regions where Hitachi has already established a presence in power systems, construction machinery, air conditioning, etc.
- Apply JP¥1trillion growth model from China business in other regions

- Local leadership and coordination
- Planning, government relations and engineering functions



## 11 key regions

- Indonesia
- Vietnam
- China
- India
- Saudi Arabia
- Brazil
- Turkey
- Central and Eastern Europe
- Russia
- South Africa
- Egypt

Revenues	FY 2010 1.9	→	FY 2012 2.5
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(Trillion yen)

## Expand and enhance corporate functions

- Strengthen project finance
- Enhance risk management functions
- Promote partnerships and alliances

Source: 9th June 2011 "2012 Mid-term Management Plan"



### Strengthening localized R&D

#### ■ 6 regions global R&D formation

##### ● China

- Development of system management software product (JP1\*1) through locally-led R&D
- Development of Internet-of-Things technology at the Tsinghua-Hitachi Green ICT Joint Laboratory
- R&D for the Smart City in China

##### ● Europe

- Establishment of the Transportation, Energy and Environment Research Laboratory (April 2011)
- Development of European exhaust gas regulation compliant technology
- Spin research for innovative computers

##### ● USA

- Assessment of storage for large volume information systems in cooperation with advanced customers in North America
- Development of environment-conscious automotive technology

##### ● Asia

- Development of the social infrastructure cloud storage for the social experiment being pursued in Singapore

##### ● India

- Establishment of the Hitachi India R&D Center (Oct. 2011)

### R&D to lead the expansion of local business in China

- Advanced technology and systems development in areas of investment prioritized by the Chinese government  
→ Smart grids, Information & Telecommunications, Medical care, Transportation, Water treatment
- Practice front-driven style R&D by participating in local business project teams  
→ Smart City project, **China JP1 development**, and ITS\*<sup>1</sup> project
- Generating research themes with new directions and new values based on needs in China  
→ Application of Internet-of-Things, Electronic education/publishing, Medical care

### Enhancing Hitachi Group R&D in China around HCR&D\*<sup>2</sup>

- Accelerate research in areas of growth by enhancing the organization (200 staff, 2015)
- Exercising the Hitachi Group technology hub function (e.g. regularly holding China CTO Meetings, etc.)
- Strengthening relations with top universities in China (e.g. Tsinghua, Fudan, etc.)

\*1: ITS - Intelligent Transport Systems

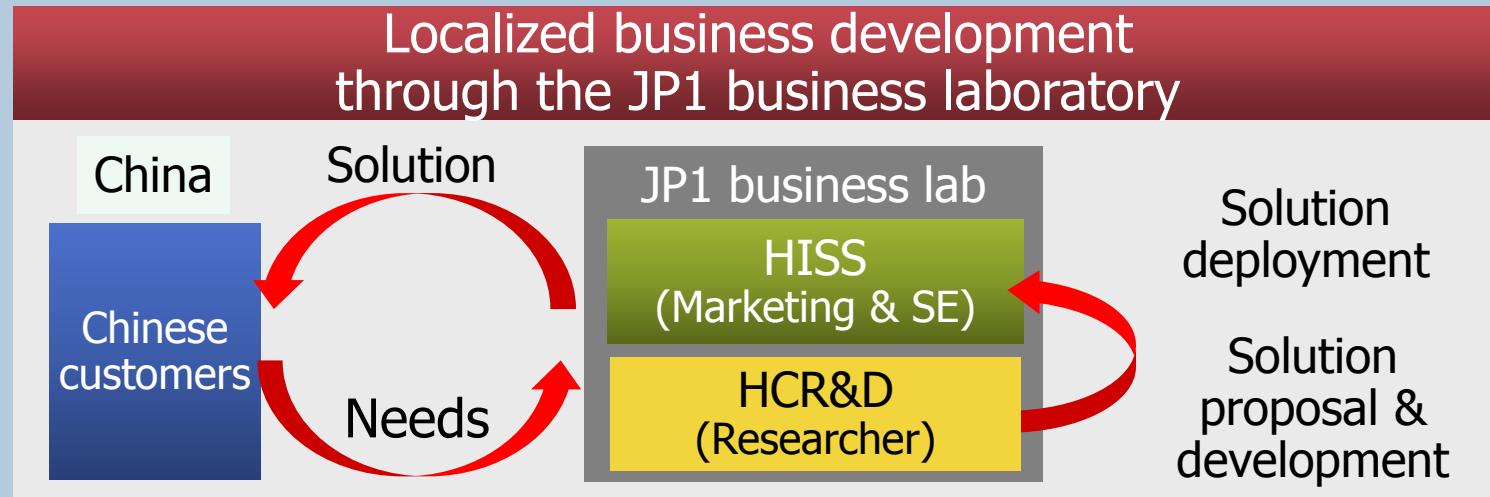
\*2: Hitachi (China) Research & Development Corporation

# 3-4. System management software product (JP1)

Aim to expand share in the Chinese management software market which grows annually by 30%

Practice of front-driven style R&D by participation in local business projects

- 2010/4 Establishment of JP1 business laboratory (HISS\*<sup>1</sup>, HCR&D\*<sup>2</sup> working at the same location)  
Formation to promptly respond with proposals, development and deployment of solutions matching the needs of Chinese customers



2010-  
2011

- Enter strategic partnership with major Chinese Linux manufacturer
- Enters Chinese securities industry through operation management solutions for securities

\*1 HISS: Hitachi Information Systems (Shanghai) Co., Ltd.

\*2 HCR&D: Hitachi (China) R&D Corporation

# 3-5. Transportation, Energy and Environment Research Laboratory (TEEL)

## Laboratory to support rail, energy and environmental business in Europe (April 2011)

### Rail systems

#### London (U.K)

- Rail systems



Joint research with  
universities  
*Maintenance & management*



IfM Distributed Information and Automation Laboratory



UNIVERSITY OF CAMBRIDGE

### Automotive system

#### Munich (Germany)

- Automotive technology



- Localized style R&D
- Local business support
- Attain cutting-edge technology through joint research with universities

### Energy systems

#### Duisburg & Aachen (Germany)

- Coal-fired thermal power
- Power electronics



*Chassis*



*Power electronics*

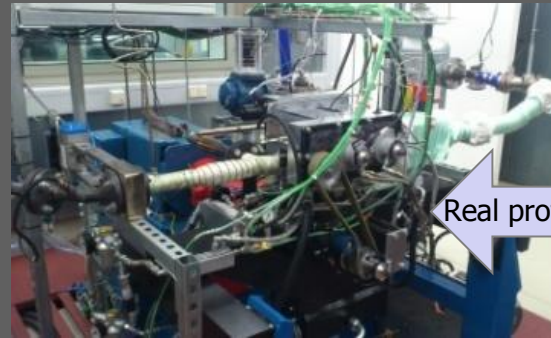
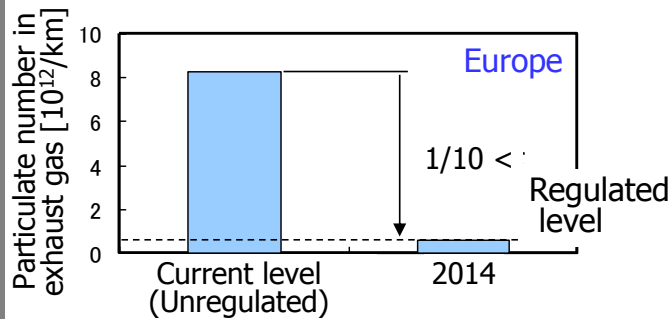


# 3-6. Technology development for European motor vehicle exhaust gas regulations

Technology complying with European regulations through cooperation between local universities & the Hitachi Research Laboratory

Simulation technology for particle generation during combustion to minimize frequency of prototype fabrication

## European regulations



Prototype test  
(TEEL & Technische Universität München)

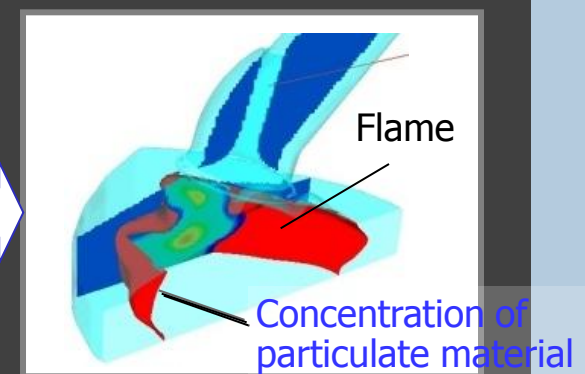
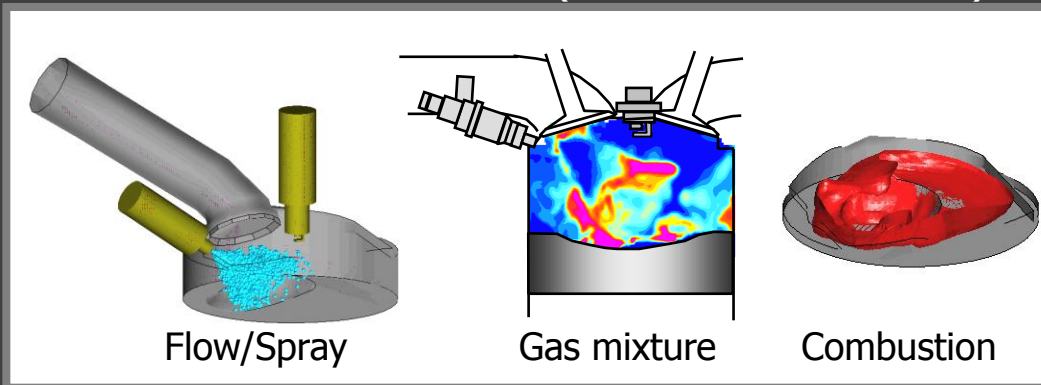
Development of engine fuel systems

- Fuel system components
- Fuel injectors
- Fuel pumps
- Controllers, etc.
- Control software

Virtual prototype

3 dimensional fluid simulation (Hitachi Research Lab.)

Simulation of particle generation



Intake - Compression

Combustion - Exhaust

# 3-7. Establish of the Hitachi India R&D Centre

Promotion of market-in style technology development based on trends in the Indian market

■ Mission: Contribution to Social Innovation Business in India

■ Starting themes

- ① IT hardware and middleware for the Indian market
- ② Power device and systems for the Indian market
- ③ Storage applications: Mass data accumulation, analysis, and application programs



Indian R&D base  
(Bangalore)

## Progress



13 Oct. 2011  
Establishment of the R&D Centre  
Total 10 staff

- 2 Japanese
- 8 Indian

FY 2015 Target of 50 staff



# Contents

1 R&D strategy

2 Development of No.1 technology

3 Global R&D

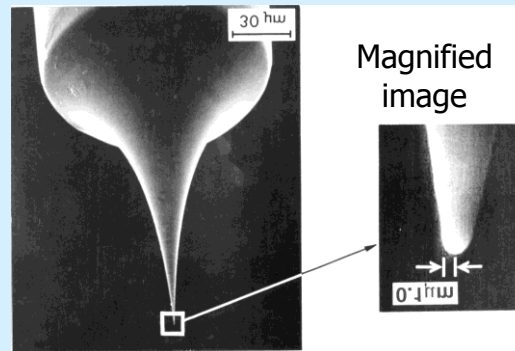
4 Strategic steps for the future

# 4-1. Global contribution towards the proliferation of innovative technology

## IEEE\* Milestone recognition (31<sup>st</sup> Jan. 2012)

A program to honor significant technical achievements that occurred at least twenty-five years ago and have made a major historical contribution

FE transmission electron microscope (First Practical Field Emission Electron Microscope, 1972)



FE electron source



Establishment of the IEEE "Innovations in Societal Infrastructure" Award (1<sup>st</sup> March 2012)

Award to recognize worldwide achievements in the area of social infrastructure (2014 – 2024)

IEEE Technical Field Award for Innovations in Societal Infrastructure  
(Sponsored by Hitachi, Ltd. and IEEE Computer Society. Call for nominations for the inaugural award open June 2012.)

For the promotion and proliferation of innovative technology in the Social Innovation Business area

\*IEEE: Institute of Electrical and Electronics Engineers, Inc. The world's largest professional engineering association with over 400,000 members in more than 160 countries.



Observing micro-phenomena at the atomic level and pioneering new business in materials

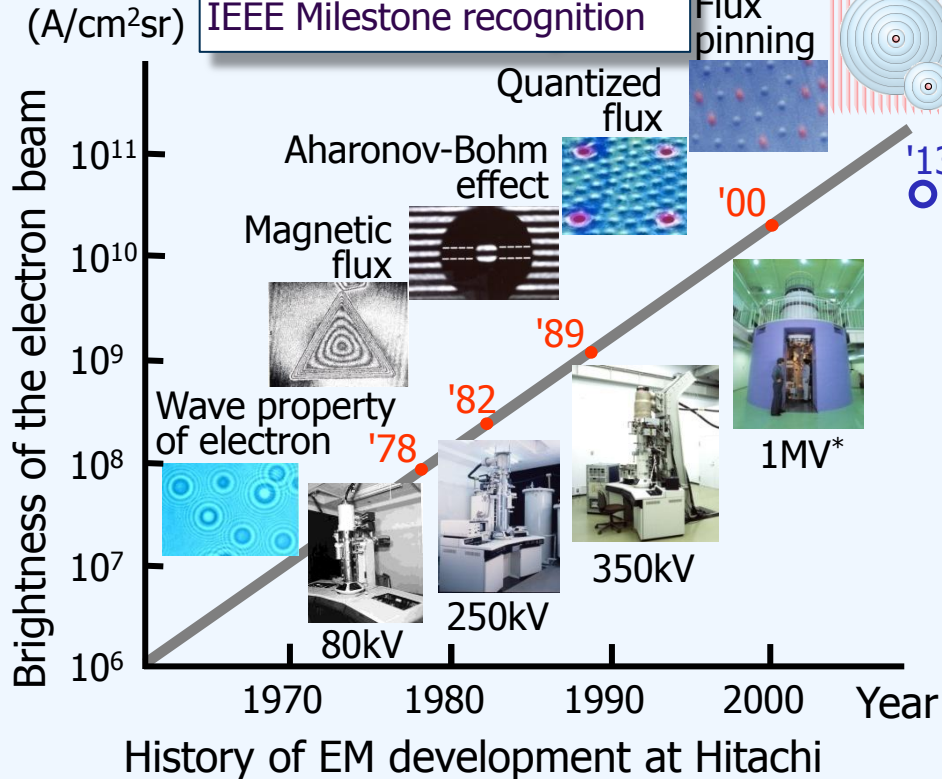
## Atomic resolution holography electron microscopy

■ Milestone for new industry (Research commenced in 1941)

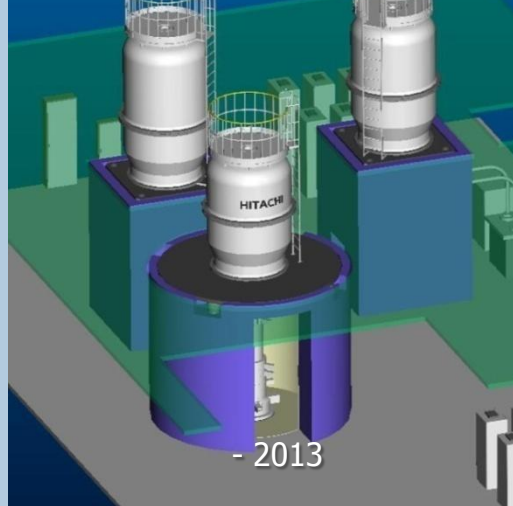
Observation of the phase of a single atom

■ Funding Program for World-Leading Innovative R&D on Science & Technology (Chief researcher : Dr. Akira TONOMURA)

Jan. 2012  
IEEE Milestone recognition



### 1.2-MV Electron beam and Aberration correction



- Material science
  - Magnetic material
- Environmental
  - Battery material
- Life science
  - Bio-, medical material

External partners: RIKEN, Japan Science & Technology Agency (JST), Okinawa Institute of Science and Technology Graduate University (OIST)

This research is granted by the Japan Society for the Promotion of Science (JSPS) through the "Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST Program), initiated by the Council for Science and Technology Policy (CSTP).

\* This work was performed in collaboration with Univ. of Tokyo, and the Japan Science and Technology Corporation (JST), and Japan Atomic Energy Research Institute.

# 4-3. Ever evolving robotics

## Integration of cutting-edge technologies for next-generation business

2007

2010

2012

Automatic mapping

Wireless communication

Intelligence

Cloud computing

Increasing autonomy & intelligence

Hear

Voice recognition

Large-scale retrieval

Talk

Voice synthesis

Natural language processing

See

LIDER\*

\*LIDER: Light detection and ranging



Maneuverability

Robust control

Predictive control

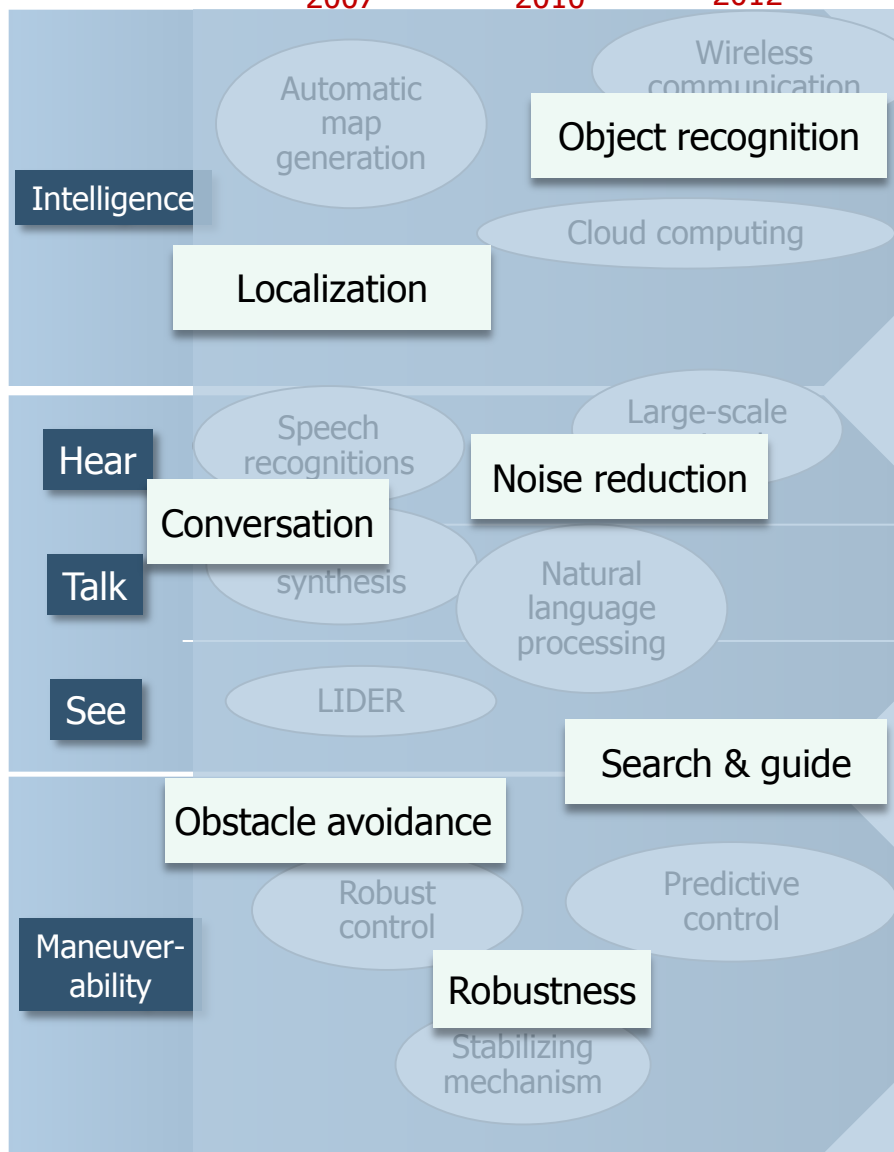
Stabilizing mechanism

Integration  
Miniaturization  
Lighter weight

# 4-3. Ever evolving robotics

## Conversion of cutting-edge technologies for next-generation business

2007                      2010                      2012



Increasing  
autonomy  
& intelligence



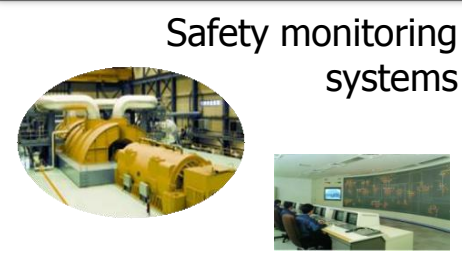
Integration  
Miniaturization  
Lighter weight

### Infrastructure systems



Safety monitoring system  
Safe operation  
Autonomous operation

### Power systems



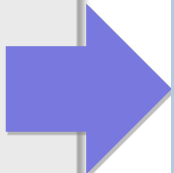
Safety monitoring systems

### Construction machinery

Disaster response robots  
Construction robots

## R&D to accelerate the global growth of Social Innovation Business

- Global R&D formation
- Development of No. 1 technology
- Development of cutting-edge technology to lead the future



Contribute to the expansion of global business

# END

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R&D strategy to accelerate the global growth  
of the Hitachi Group

2012/4/17

Executive Vice President & Executive Officer,  
General Manager, R&D Group,  
Hitachi, Ltd.

Shigeru Azuhata