

Environmental / R&D Strategies Web Conference

Research & Development Strategy

To become a global innovation leader

February 25, 2021

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General Manager, Research & Development Group

General Manager, Corporate Venturing Office

Hitachi, Ltd.

- 1 | Expand R&D investment for carbon neutrality
- 2 | Create innovation in the environment area with the new Hitachi Group companies, Hitachi ABB Power Grids and Hitachi Astemo
- 3 | Accelerate R&D to expand Lumada business

Research & Development Strategy

Contents

1. Direction of the R&D Group
2. Innovation for value creation
3. Technology development for Lumada business expansion
4. Summary

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Global Social Issues

- Climate change
- Scarcity of resources
- Demographic changes due to aging
- Challenges in urbanization/Resilience

Covid-19 Effects

- Restrictions on the movement of people and changes in lifestyles
- "Contactless," "Remote," "Automation"
- Disruption & restructuring of supply chain
- Sustainable & resilient society

Direction of R&D

From products/SI
to customer co-creation (FY2015~)

- Creating visions for the future & resolving customer issues through customer co-creation
- Digital innovation

Value-based innovation (FY2020~)

- Realization of "environmental value," "social value" and "economic value" for a human-centric society
- Combined strength of OT × IT × Products

Become a global innovation leader driving Society 5.0 and SDGs

Basic policy

Value-based innovation

- Create innovation in "Environment," "Resilience," and "Safety & Security," and pursue No. 1 technology
- Fully leverage the technology, human resource and customer channels of Hitachi ABB Power Grids and Hitachi Astemo to perform comprehensive strengths

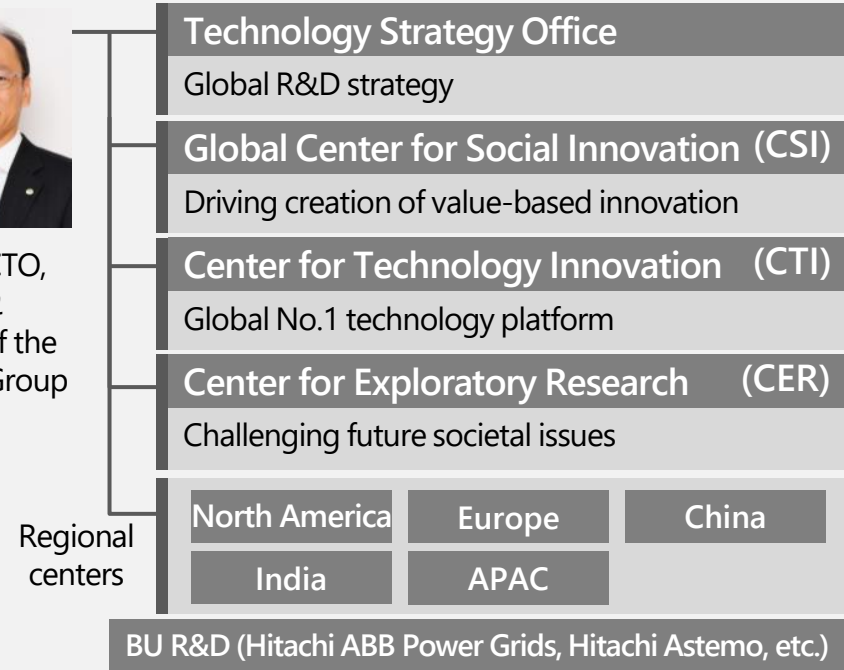
Contribute to Lumada business expansion

Accelerate core technology development to expand Lumada business

Global R&D organization



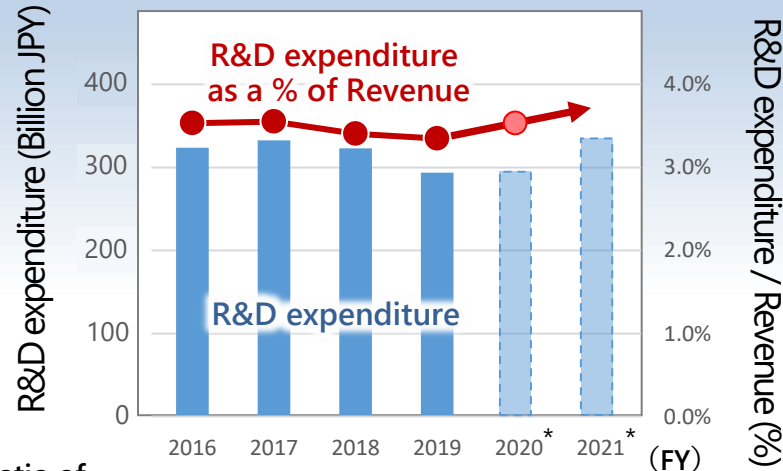
VP, CTO,
&
GM of the
R&D Group



1-3 Hitachi Gr. investment in R&D

Increase R&D investment for growth in "Environment" and "Digital"

R&D investment

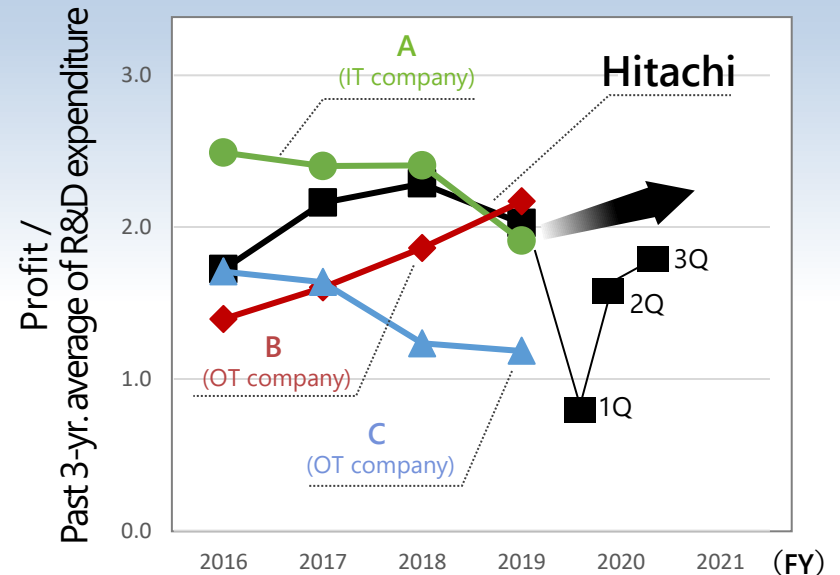


Ratio of adjusted operating income to revenue

6.4	7.6	8.0	7.5	5.1	(%)
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* Hitachi ABB Power Grids & Hitachi Astemo added

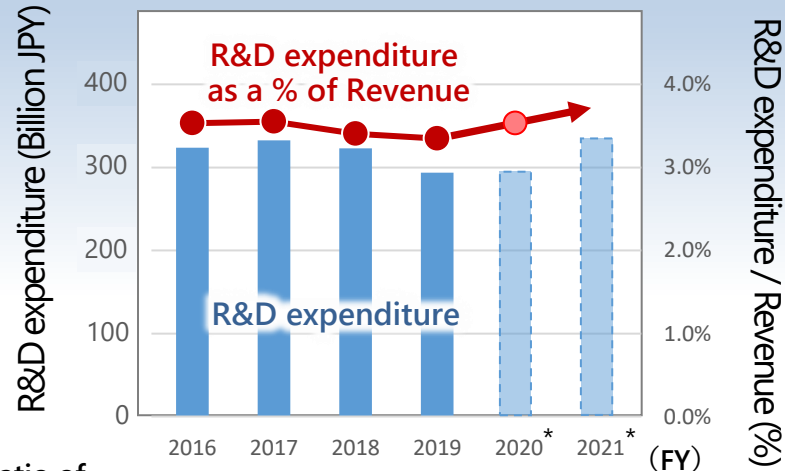
R&D efficiency



1-3 Hitachi Gr. investment in R&D

Increase R&D investment for growth in "Environment" and "Digital"

R&D investment

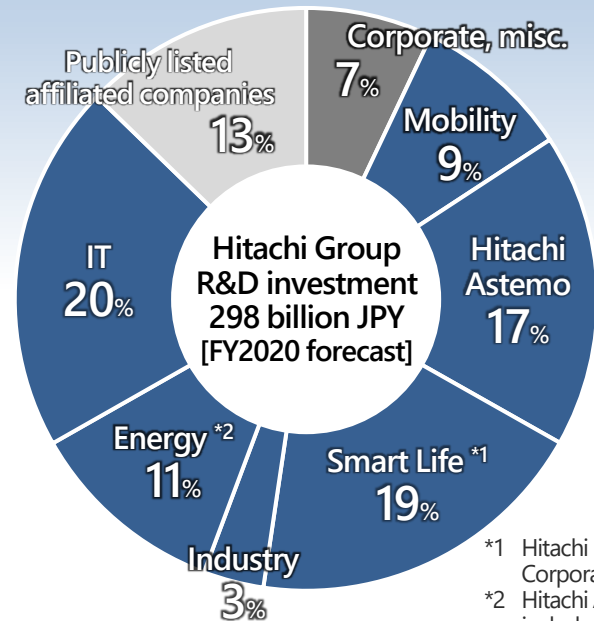


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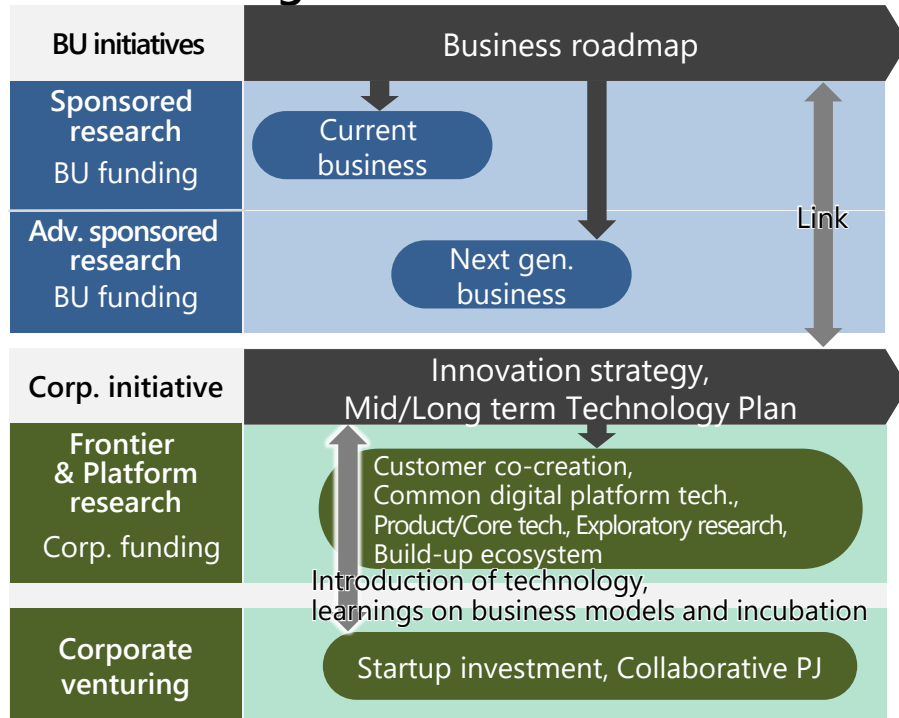
Hitachi Group R&D portfolio



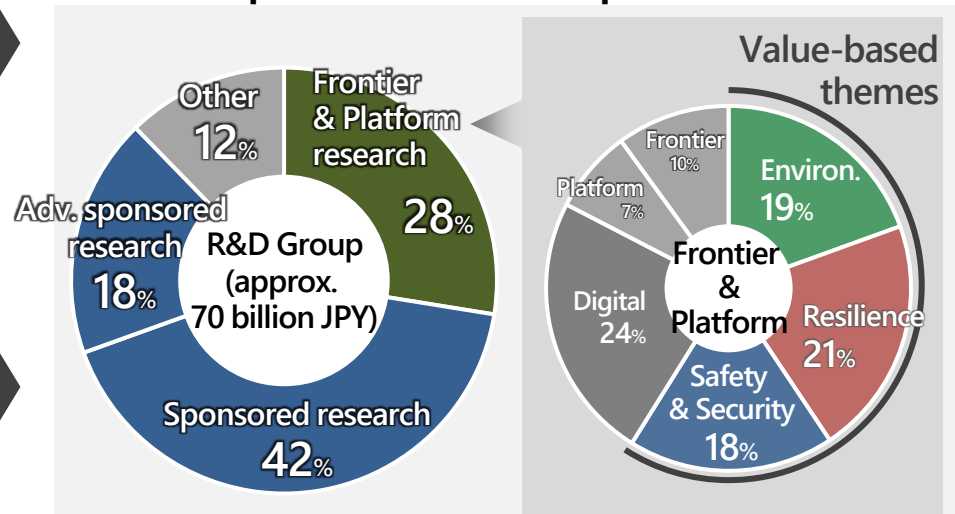
*1 Hitachi High-Tech Corporation included
*2 Hitachi ABB Power Grids included

Focus corporate R&D investment to create value-based innovation

Research target



Research portfolio / Startup collaboration



- Accelerate the creation of new values such as in life sciences, next-gen. trust platforms, computing, etc. through collaboration with startups (invested in 7 co.)
- Est. Happiness Planet Ltd. in July 2020

1-5 Major external recognitions

Nikkan Kogyo Shimbun
Best 10 New Products Awards / R&D100
(Masuda Prize)

Safety & Security



PBI
(Public Biometric Infrastructure)

Ichimura Prize in Industry
for Distinguished Achievement

Environment



Adsorption tower
Development & practical application
Of simultaneous adsorbent for
radioactive cesium and strontium

Ichimura Prize in Industry
against Global Warming

Environment

Resilience



Amorphous motor

Environmental Award

Environment



**Phthalic acid inspection equipment
for RoHS2**

Cho-Monodzukuri Innovative
Parts and Components Award 2020

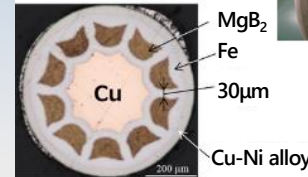
Safety & Security



**Image processing module
of immuno-analyzer**

R&D100

Environment



**MgB₂ multi-core long wire
(Magnesium di-boride)**



Good Design Awards: 11 items

Environment

Safety & Security



**New train for
Tokyo Metro
17000 series**

**Beat wash
BW-DKX120F**

1-6 Contribution to Lumada business growth

Co-creation with Lumada alliance program
Business expansion with Hitachi assets × digital

	FY2019	FY2020 *2	FY2021 *2
Lumada business revenues *1	3.4	3.6	4.5
RDG contribution / Corporate (100 billions of yen)	10.4	11.0	14.0

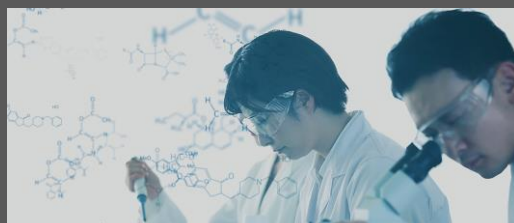
RDG: Research and Development Group, *1 Hitachi ABB Power Grids not included, *2 Expected or planned value

Strengthening through the Lumada Alliance Program



IoT platform for buildings
co-creation with Microsoft Japan

Research assets from other fields × Lumada



Materials development solution
Materials · Measurement · Know-how × Lumada

Energy/Mobility × Lumada



Integrate & expand Hitachi/ABB Power Grids' Digital Enterprise solutions within Lumada

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2-1 To solve challenges in society

Capture changes in society/customers,
form visions with industry-government-academia, disseminate globally

Hitachi U.Tokyo Lab.

Formulated scenario for
2050 carbon neutrality
日立東大ラボ 産学協創プラットフォーム

第3回 Society 5.0を支える
エネルギーシステムの
実現に向けて
Energy Forum

2050年 [18 Jan 2021]

Hitachi Kyoto U. Lab

New vision for a
societal system toward a
sustainable society

Changes caused by COVID-19

Remote, contactless

Diversification

Published "Beyond Smart Life"

Environment ecosystem

Participate in the
European decarbonization
community

Collaboration with
Fraunhofer, Imperial College

Participate in
Tokyo Zero-emission
Innovation Bay

Tsinghua Univ.

Tsinghua-Hitachi Future
Innovation Linkage Program

Digital city

Elderly health

Energy

Mobility

WEF-C4IR Japan*

Formed G20 alliance for smart
cities, Proposed DFFT

Launch of the G20 Global Smart Cities Alliance on Technology Governance
September 9th, 2019, Asia Smart City Week, Yokohama, Japan

Digital city

Chulalongkorn University
(Thailand)

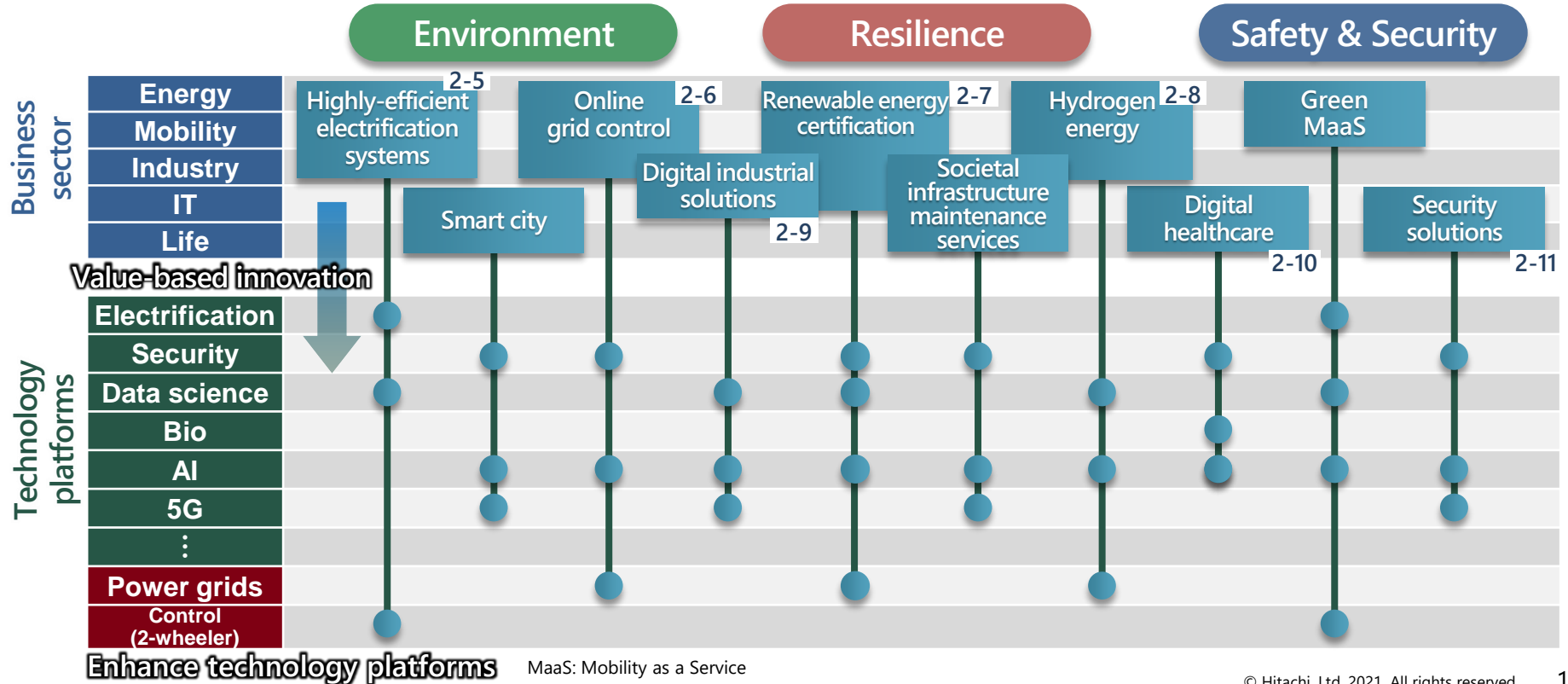
Ideathon
Hitachi & Chulalongkorn University

Co-creation to identify Kizashi
and societal challenges for the
sustainable growth of Thailand

Western Sydney
regional co-creation
(Australia)

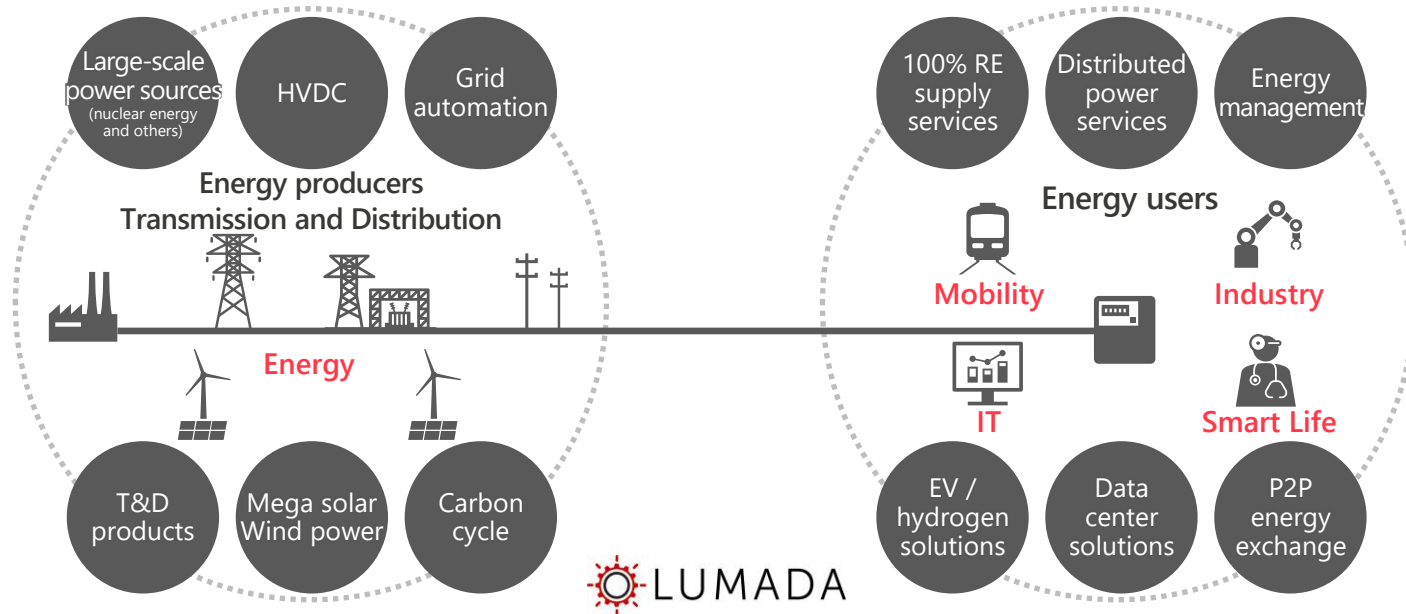
Signed MoU for
emergency/medical service
collaboration system with the
City of Liverpool [25 May 2020]

Development of global No.1 technology by focusing on "Environment," "Resilience," and "Safety & Security"



2-3 Innovation with Hitachi ABB Power Grids

Develop core business in environment through the synergy of Hitachi ABB Power Grids' and Hitachi's technology platforms



5G



Hitachi
technology platforms



2-4 Innovation with Hitachi Astemo

Become a global leader in CASE using Hitachi R&D advantage

- Multimodal transport solutions
- MaaS (Mobility-as-a-Service)
- Energy management systems



- Cybersecurity
- Data accumulation & AI analytics
- OTA

Astemo

Connected vehicles tech.
On-board devices, software

AD/ADAS
Adv. environmental recognition,
Integrated electronic control

xEV
Adv. electric powertrain/system unit

Advanced chassis
Integrated vehicular movement control



Hitachi
technology platforms



Environment

Realize net zero emission
by solving
root problems in
renewable energy,
electrification and
hydrogenation

Electrification
system

SiC
power device

Grid control

Digital
certification of
renewable
energy

Hydrogen
co-firing
power
generation

Hydrogen
production

2-5 Initiatives in electrification

Maximizing the drive efficiency of the electrified system to realize carbon neutrality

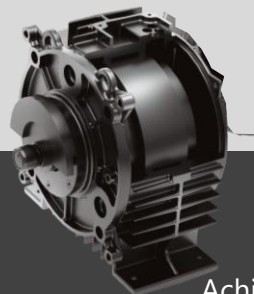
Reducing CO₂ emission throughout the value chain

“Realizing carbon neutrality in our own production by FY2030” to accelerate the creation of environmental value throughout our business
FY2030 Carbon Neutrality Commitment

Raw material /
Parts procurement

Production

Logistics / Use /
Disposal, Recycling



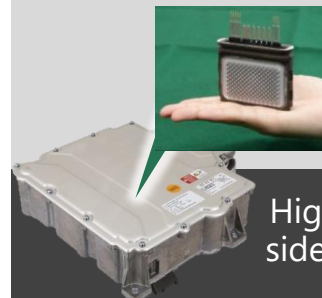
High efficiency motor^{*}

Ichimura Prize in Industry against Global Warming (2020)

Energy-saving industrial motors using amorphous magnetic alloy foil

Achieved IEC's highest standard value of IE5 with rare-earth-free magnets

^{*}A part of this technology was developed as part of a NEDO, Japan, funded project

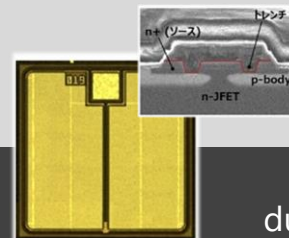


High efficiency inverter

Nikkan Kogyo Shimbun
Best 10 New Products Award (2019)

High output inverter for EV with double-sided direct water cooling power module

Achieved 2 times higher voltage (800V) and 2.7 times higher power density (94.3kVA/L) than previous Hitachi product (October 2019)



Low-loss SiC power device

New SiC power device with both durability and low power consumption

Achieved industry's highest-level performance (short-circuit tolerance improved by 20% and resistance reduced by 40%) of Trench Etched Double diffused MOSFET (TED-MOS) compared to 2018

2-6 Initiatives in energy field (1)

Grid control and energy management systems for the expanded introduction of renewable energies

Online grid control

Enhance renewable energy amount by world's first risk prediction type online grid control which synchronizes normal operation and emergency operation

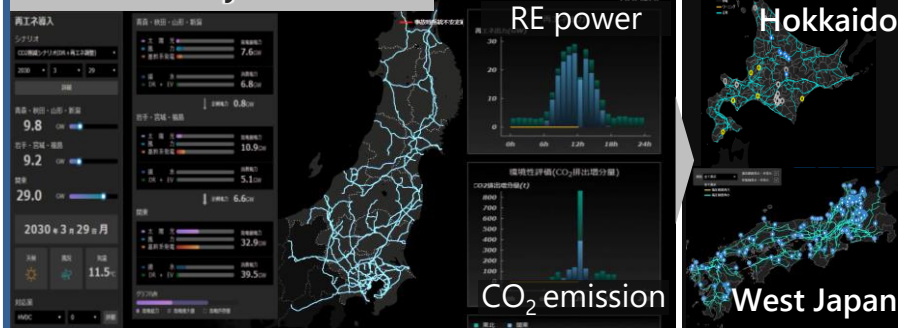
Normal
(Economic)

Synchronize

Emergency
(Post-fault)

Assume future possible faults and reflect on normal operation

Verification by simulation*



Achieve both renewable energy mass series and stable operation by utilizing existing power transmission and substation facilities

Demand side energy management

Integrate analysis of real-time forecasting and historical data to deliver operational efficiencies in office buildings, production facilities and others

Load data

Grid data

Market data

Weather data

Lumada

Real-time forecasting
Hourly, daily, and
weekly load profiles

Historical data

Hitachi ABB
Power Grids

e-mesh™ EMS (Energy management system)

Optimize operational setting
of distributed energy / renewables

Maximize renewable use
and economic benefit

Minimize grid
consumption

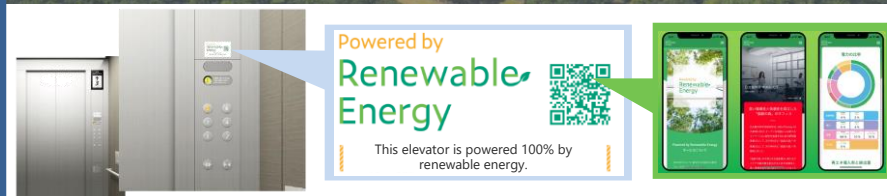
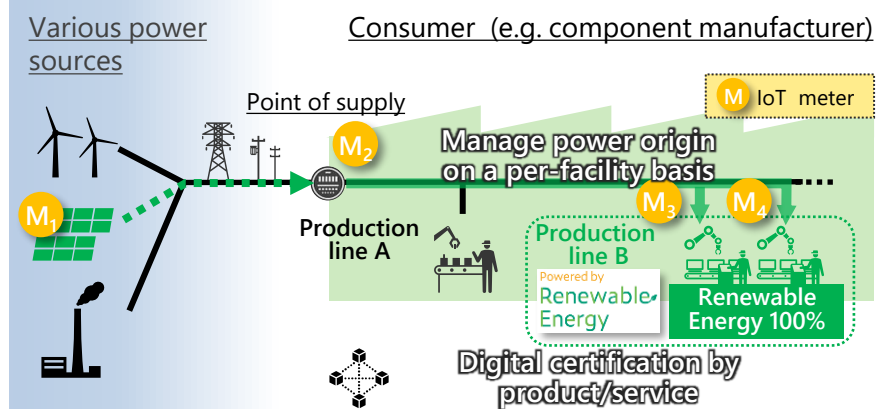


2-7 Initiatives in energy field (2)

Visualization of renewable energy usage for each facility & service

Digital certification of 100% renewable energy usage

Utilizing smart meters and blockchain technology to digitally certificate RE usage for each product / service



Provide solution to realize RE target for products/services

Office/Residences

Factories

Electric mobility

Expand scope to entire supply chain
e.g. green procurement or product use / disposal stage

2-8 Initiatives for hydrogen energy

Develop system and material technology for the realization of a sustainable hydrogen value chain

Highly efficient hydrogen co-firing power generation system

Flexible use of hydrogen with a power generation system dynamically responding to a combination of a wide variety of fuels and compositions

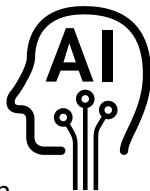
- AI control: Optimize conditions for changing fuel compositions



Highly efficient H₂ co-firing engine

Operating conditions

Throttle, Combustion timing



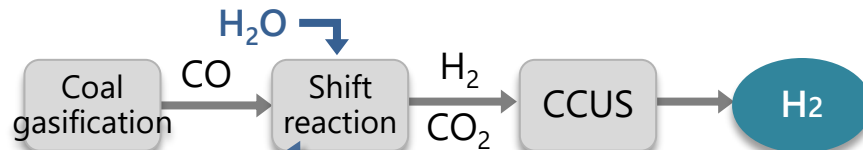
- Demonstration of hydrogen co-firing power generation



Fukushima Prefecture research project^{*1} demo with Denyo Kosan & AIST of the power generation system [FY2017-19]

Large-scale blue hydrogen production system

Realize sustainable large-scale economic H₂ production by reducing resource use by 30%



Shift catalyst

Atomic level structural control



NEDO Osaki CoolGen Project Stage2^{*2} verifications [FY2016-22]

Resilience

Improve customers' business resilience towards changes in society and environment;
Improve resilience of societal infrastructure such as national land resilience

IoT compass

Supply chain optimization

Smart manufacturing

Maintenance of societal infrastructure

Disaster prevention support

Drone operation management

Value chain optimization to flexibly respond to changes in business environment

WEF advance factory “Lighthouse”

Omika Works

Advanced factories that are world leaders in the adoption and integration of the cutting-edge technologies of the 4th Industrial Revolution as Lighthouse

High efficiency production model



Expansion to automobile and chemical manufacturers through customer collaboration

Digital solution for industry

Total optimization through planning optimization service by work site visualization and knowledge digitization LUMADA



Digital management platform (IoT compass)
Integrated management and analysis of process, human, product, and equipment data



Supply chain optimization
Total simulation of procurement, production, logistics, sales

Application of solution to support the planning and execution of optimal production and sales plans for demand fluctuations in the chemical business [June, 2020]

Co-creation with Daikin

Safety & Security

Realize a safe and secure society raises human QoL by resolving the new challenges posed by climate change, COVID-19, aging population, progress in digital economy, etc.

Regenerative
medicine

Biochemical
immuno-assay

Smart
aging

Digital
healthcare

Security
operations

"Empty-hand"
authentication
platform

Raise QoL with "Measurement × Digital" and "Bio × IT"

Clinical immuno-assay

Machine learning-based image processing tech. improves accuracy and throughput of testing

Nikkan Kogyo Shimbun
2020 Cho Monodzukuri Award

Top share
world share



Antibody testing capability for novel coronavirus (SARS-CoV-2)

Announcement on the quantitative measurement of antibodies to novel coronavirus and launch of a research test reagent [Roche Diagnostics K.K., Oct 2020].

Regenerative medicine

Provide regenerative medicine value chain platform

■ Automated cell culturing Co-creation* with Sumitomo Dainippon Pharma, Kyoto Univ.



Applied to cell production for physician-initiated clinical trials for treating Parkinson's disease using iPS cell-derived dopaminergic neural progenitor cells [Announced in Jan 2021]
(Cell prod.: Sumitomo Dainippon Pharma, Clinical trial: Kyoto University)

* With the support of AMED, Hitachi has developed automated cell culturing technology in collaboration with Sumitomo Dainippon Pharma and Kyoto University. "Project Focused on Developing Key Evaluation Technology: Evaluation for Industrialization in the Field of Regenerative Medicine" JP18be0104016

■ Traceability Co-creation with Alfresa, pharma companies, medical institutions

Integrated management platform for value chain for regenerative medicine products



Information tracing for cell collection/production /transportation/administration
Data from the entire process for regenerative medicine products

Hitachi constructs Japan's first platform for integrated management of cell and tracing information throughout the value chain for regenerative medicine products through collaborative creation with Alfresa and others [Aug 2020]

Provide safety & security to people in both cyber and physical space

“Empty-handed” authentication

World's first PBI technology  eliminating the need to store biometric data, thus enabling “empty-handed” identification

R&D100 Award

Nikkan Kogyo Shimbun
Best 10 New Products Award Masuda Prize




Can be commonly used in various situations
(e.g., empty-handed payment)

“Sarutahiko Coffee” in Yokohama office of Hitachi, Ltd.

Launch of “biometric integration platform service,” a cloud service for secure biometric authentication [Oct 2020]
Aktif Bank, Hitachi and Mitsubishi Corporation form a partnership [Mitsubishi corporation, Aktif bank, Hitachi Europe, Sept 2020]

Human flow / behavior visualization

Provide safety and security  in public areas such as train stations and airports using AI image analysis of people and luggage

High-speed similar vector search can find a person using over 100 entire body features in less than a second from data containing tens of thousands of people



Privacy-conscious novel coronavirus countermeasures

Began sales of “High-speed people detection and tracking solution” to support more efficient and sophisticated monitoring and security operations at stations, airports, commercial facilities, and public facilities. [Oct 2019]
Technology verification of “human flow visualization solution” for infection control in the official professional baseball game at Tokyo Dome [Nov 2020]

Research & Development Strategy

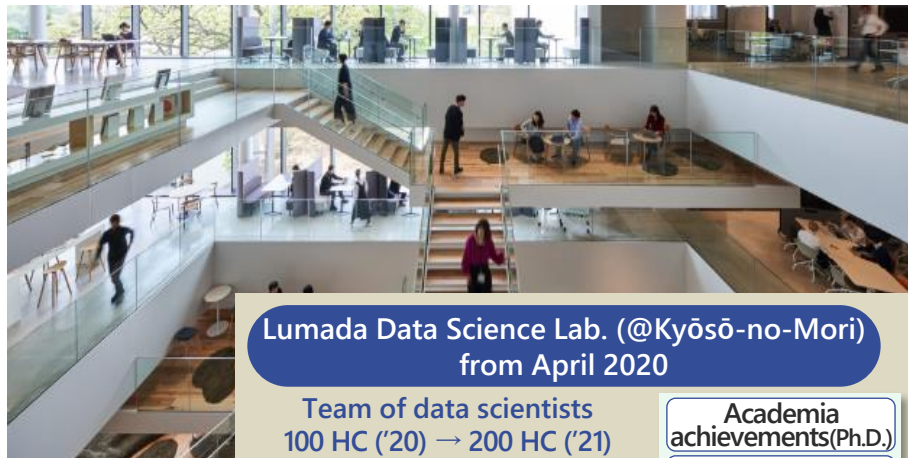
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3-1 Establishment of Lumada Data Science Lab.

Gathering top data scientists in Kyōsō-no-Mori

Facilitate the spiraling of R&D and business by bringing together technology and know-how in data use
Pursue Lumada business expansion using Hitachi's unique customer co-creation system NEXPERIENCE



Lumada Data Science Lab. (@Kyōsō-no-Mori)
from April 2020

Team of data scientists
100 HC ('20) → 200 HC ('21)

1. Ability to solve field issues:
Consultation skills
2. Ability to apply OT knowledge
and AI in the field
3. AI technical capabilities

Academia
achievements(Ph.D.)

Project leader
experience

Community
contributions

Data scientist
certification

Business
division

R&D

Advancements in Lumada

Value

Resilience

Environment

Safety & Security

Business
domain



Industry



Energy



Mobility



Life

NEXPERIENCE

Platform



Edge
processing



Massive
big data
processing



Quantum
computing

LUMADA



Real-time data collection / feedback

Real world
(Field)



Technology development based on AI ethics, Top prize in international competition

AI ethics

“AI Ethical Principles” for progress in AI technology supporting a human-centric society
(February 2020 News release)

Standards for conduct

1. We will plan the development and utilization of AI for the realization a sustainable society
2. We will implement AI in society from a human-centered perspective
3. We will maintain and manage AI to ensure that it provides long-term value

Practices common



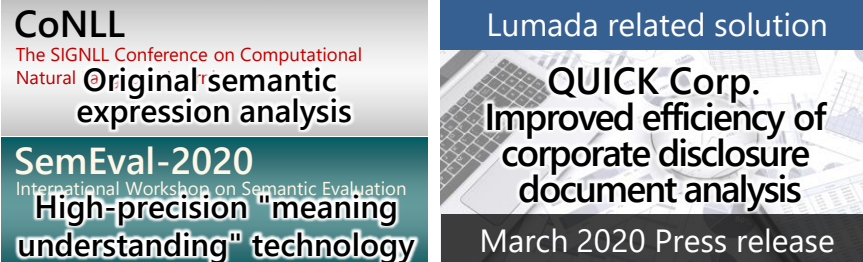
- Began operation with a checklist developed from the AI ethical principles & practices for actual LDSL projects
- Initiatives in AI ethics published in white paper

International AI competitions

Video : Top class in TRECVID 2020



NLP : 1st place in CoNLL & SemEval

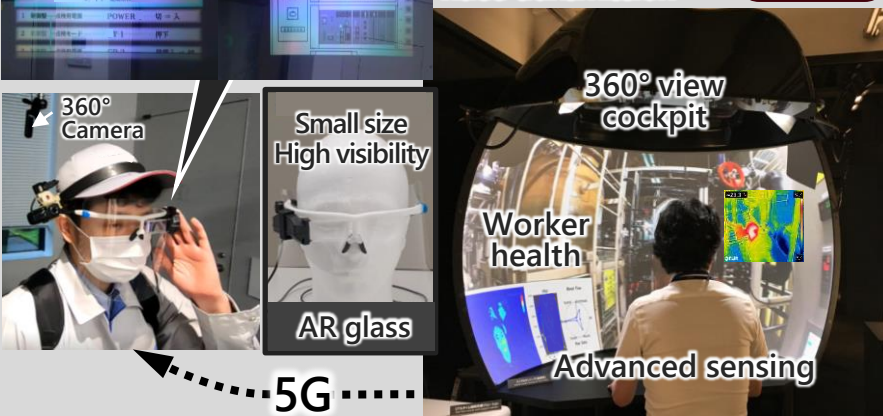


3-3 Initiatives in 5G solutions

5G demonstration environment and co-creation acceleration toward real-time control use case

Telepresence remote operation support

Realistic presence, real-time comprehension of on-site situation, and remote operation support using advanced sensing and low-latency video transmission



AR: Augmented Reality

N. America: Silicon Valley

Collabotive robotics



R&D of industrial solutions utilizing 5G

Japan: Kyōsō-no-Mori

5G utilization
Real-time control



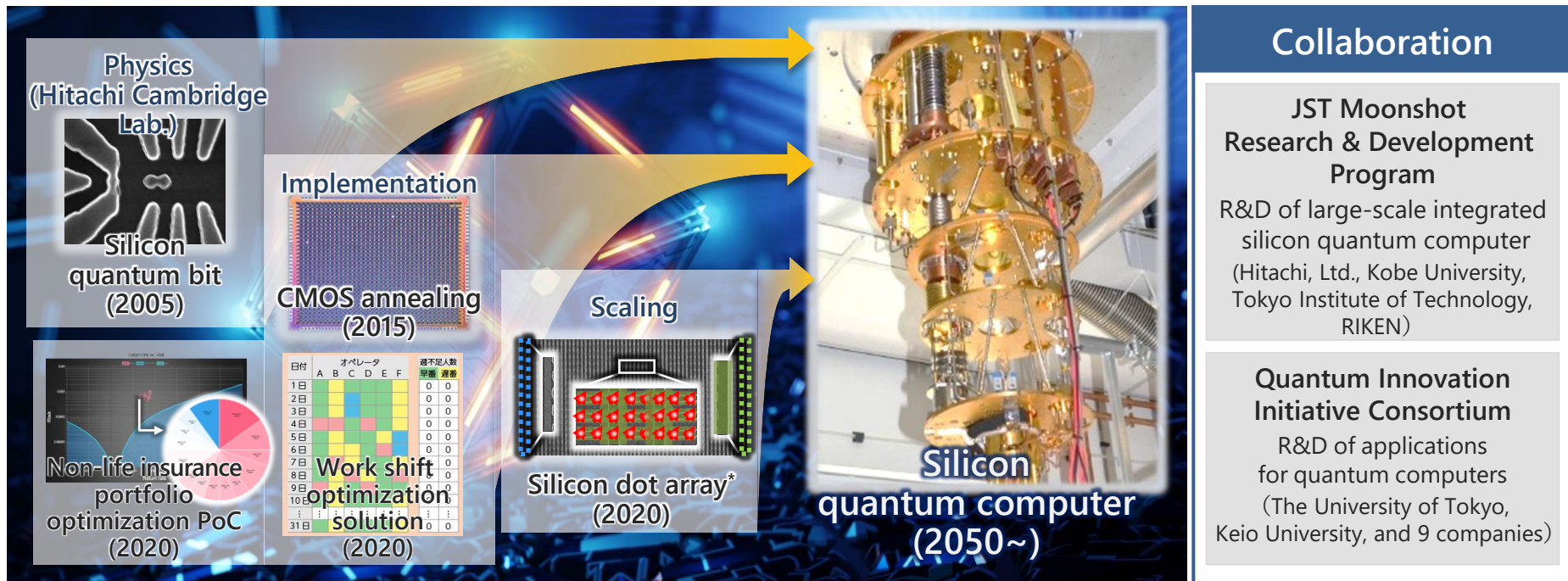
Local 5G demonstration environment to accelerate DX solution co-creation for societal infrastructure

October 2020 Press release



3-4 Initiative in quantum computing

Promote R&D for a scalable silicon quantum computer with industry-government-academia collaboration



*N. Lee et al., "Enhancing electrostatic coupling in silicon quantum dot array by dual gate oxide thickness for large-scale integration," Appl. Phys. Lett. 116, 162106 (2020)
This work was partially supported by JST [Moonshot R&D][Grant Number JPMJMS2065]

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Strengthen R&D in environmental and digital fields
to become a global innovation leader driving carbon neutrality

A circular graphic with a dark blue background. It features several interlocking gears, a Wi-Fi symbol, a smartphone, and a person's hands holding a gear. The word "Resilience" is written in white, bold, sans-serif font across the center.

Resilience

A circular graphic with a bright green background. It shows a small green sprout with three leaves growing out of a patch of grass. The word "Environment" is written in white, bold, sans-serif font across the center.

Environment

A circular graphic with a light blue background. It depicts a person in a white lab coat using a stethoscope. Overlaid on the image are various technical icons like a hexagon with a plus sign, a Wi-Fi symbol, and a document icon. The words "Safety & Security" are written in white, bold, sans-serif font across the center.

**Safety
& Security**



Cautionary Statement

Certain statements found in this document may constitute “forward-looking statements” as defined in the U.S. Private Securities Litigation Reform Act of 1995. Such “forward-looking statements” reflect management’s current views with respect to certain future events and financial performance and include any statement that does not directly relate to any historical or current fact. Words such as “anticipate,” “believe,” “expect,” “estimate,” “forecast,” “intend,” “plan,” “project” and similar expressions which indicate future events and trends may identify “forward-looking statements.” Such statements are based on currently available information and are subject to various risks and uncertainties that could cause actual results to differ materially from those projected or implied in the “forward-looking statements” and from historical trends. Certain “forward-looking statements” are based upon current assumptions of future events which may not prove to be accurate. Undue reliance should not be placed on “forward-looking statements,” as such statements speak only as of the date of this report.

Factors that could cause actual results to differ materially from those projected or implied in any “forward-looking statement” and from historical trends include, but are not limited to:

- exacerbation of social and economic impacts of the spread of COVID-19;
- economic conditions, including consumer spending and plant and equipment investment in Hitachi’s major markets, as well as levels of demand in the major industrial sectors Hitachi serves;
- exchange rate fluctuations of the yen against other currencies in which Hitachi makes significant sales or in which Hitachi’s assets and liabilities are denominated;
- uncertainty as to Hitachi’s ability to access, or access on favorable terms, liquidity or long-term financing;
- uncertainty as to general market price levels for equity securities, declines in which may require Hitachi to write down equity securities that it holds;
- fluctuations in the price of raw materials including, without limitation, petroleum and other materials, such as copper, steel, aluminum, synthetic resins, rare metals and rare-earth minerals, or shortages of materials, parts and components;
- estimates, fluctuations in cost and cancellation of long-term projects for which Hitachi uses the percentage-of-completion method to recognize revenue from sales;
- increased commoditization of and intensifying price competition for products;
- uncertainty as to Hitachi’s ability to attract and retain skilled personnel;
- uncertainty as to Hitachi’s ability to continue to develop and market products that incorporate new technologies on a timely and cost-effective basis and to achieve market acceptance for such products;
- fluctuations in demand of products, etc. and industry capacity;
- uncertainty as to Hitachi’s ability to implement measures to reduce the potential negative impact of fluctuations in demand of products, etc., exchange rates and/or price of raw materials or shortages of materials, parts and components;
- credit conditions of Hitachi’s customers and suppliers;
- uncertainty as to Hitachi’s ability to achieve the anticipated benefits of its strategy to strengthen its Social Innovation Business;
- uncertainty as to the success of acquisitions of other companies, joint ventures and strategic alliances and the possibility of incurring related expenses;
- uncertainty as to the success of restructuring efforts to improve management efficiency by divesting or otherwise exiting underperforming businesses and to strengthen competitiveness;
- general socioeconomic and political conditions and the regulatory and trade environment of countries where Hitachi conducts business, particularly Japan, Asia, the United States and Europe, including, without limitation, direct or indirect restrictions by other nations on imports and differences in commercial and business customs including, without limitation, contract terms and conditions and labor relations;
- the potential for significant losses on Hitachi’s investments in equity-method associates and joint ventures;
- uncertainty as to the success of cost structure overhaul;
- the possibility of disruption of Hitachi’s operations by natural disasters such as earthquakes and tsunamis, the spread of infectious diseases, and geopolitical and social instability such as terrorism and conflict;
- uncertainty as to the outcome of litigation, regulatory investigations and other legal proceedings of which the Company, its subsidiaries or its equity-method associates and joint ventures have become or may become parties;
- the possibility of incurring expenses resulting from any defects in products or services of Hitachi;
- uncertainty as to Hitachi’s ability to maintain the integrity of its information systems, as well as Hitachi’s ability to protect its confidential information or that of its customers;
- uncertainty as to Hitachi’s access to, or ability to protect, certain intellectual property; and
- uncertainty as to the accuracy of key assumptions Hitachi uses to evaluate its employee benefit-related costs.

The factors listed above are not all-inclusive and are in addition to other factors contained elsewhere in this report and in other materials published by Hitachi.

Hitachi Social Innovation is

POWERING GOOD

HITACHI
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