Toshiba Group IR Day 2022

Toshiba Group Technology Strategy

February 7, 2022

Hideaki Ishii
Corporate Senior Vice President and CTO

Toshiba Corporation
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- Unless otherwise noted, all figures are 12-month totals on a consolidated basis.
- Results in segments have been reclassified to reflect the current organizational structure, unless stated otherwise.
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- Depending on the applicable laws and regulations (including securities listing regulations and U.S. laws and regulations), developments in the application, revision and enforcement of various regulatory regimes including tax regulations, interpretations by the relevant authorities, further considerations in the future and other factors, the implementation of the Reorganization may take longer than expected and there may be changes in the structure of the reorganization.
Agenda

01 Toshiba Group Technology Strategy
02 Cutting-Edge and Fundamental Technologies
03 An R&D Structure that Demonstrates Combined Strengths
04 In Closing
Toshiba Group Technology Strategy

- Toshiba Group Technology Policy
- Further Emphasis on Focus Technologies: R&D Investment
- R&D to Strengthen Competitiveness of Key Growth Areas
- Initiatives to Visualize ROI in R&D and Enhance Efficient Investment
Contribute to solving social and customer issues guided by the Basic Commitment of the Toshiba Group "Committed to People, Committed to the Future."
Further Emphasis on Focus Technologies: R&D Investment

Increase ratio to sales and strengthen competitiveness of growth areas in energy & infrastructure and devices & storage

### Energy & Infrastructure

<table>
<thead>
<tr>
<th>Segment</th>
<th>FY25 (¥B)</th>
<th>FY30 (¥B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply systems</td>
<td>450</td>
<td>674</td>
</tr>
<tr>
<td>Transmission &amp; distribution</td>
<td>530</td>
<td>1,054</td>
</tr>
<tr>
<td>Total Net Sales</td>
<td>984</td>
<td>1,728</td>
</tr>
</tbody>
</table>

### Infrastructure, Digital

<table>
<thead>
<tr>
<th>Segment</th>
<th>FY25 (¥B)</th>
<th>FY30 (¥B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public infrastructure</td>
<td>800</td>
<td>1,203</td>
</tr>
<tr>
<td>Transport, Industrial systems</td>
<td>580</td>
<td>1,595</td>
</tr>
<tr>
<td>Digital solutions</td>
<td>395</td>
<td></td>
</tr>
<tr>
<td>Total Net Sales</td>
<td>1,775</td>
<td>3,398</td>
</tr>
</tbody>
</table>

### Group R&D Investments

<table>
<thead>
<tr>
<th>FY</th>
<th>Toshiba/Infrastructure Service Co.</th>
<th>Device Co.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY21</td>
<td>118</td>
<td>25</td>
<td>143</td>
</tr>
<tr>
<td>FY22</td>
<td>128</td>
<td>49</td>
<td>177</td>
</tr>
<tr>
<td>FY23</td>
<td>141</td>
<td>63</td>
<td>204</td>
</tr>
<tr>
<td>FY24</td>
<td>151</td>
<td>80</td>
<td>231</td>
</tr>
<tr>
<td>FY25</td>
<td>162</td>
<td>95</td>
<td>257</td>
</tr>
</tbody>
</table>

*Net Sales*¹

*¹: Sales amount of each segment include other businesses other than energy, infrastructure and digital, as well as common accounts and inter-segment eliminations

### Devices & Storage

<table>
<thead>
<tr>
<th>Segment</th>
<th>FY25 (¥B)</th>
<th>FY30 (¥B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semiconductors</td>
<td>370</td>
<td>860</td>
</tr>
<tr>
<td>HDD</td>
<td>510</td>
<td>1,010</td>
</tr>
<tr>
<td>Manufacturing equipment</td>
<td>89</td>
<td>41</td>
</tr>
</tbody>
</table>

*Net Sales* (¥B)

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Strengthen competitiveness of product & services by linking cutting-edge, product development and fundamental initiatives

**Cutting-edge**
- Future new business creation
- Contribution to business development

**Product Development**
- Contribution to business growth, and product/services expansion

**Fundamental**
- Overarching support to business growth and expansion of products and services

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### Energy and Infrastructure
- NG-QKD*1, quantum computing, superconductivity, neuromorphic HW, quantum machine learning, MI*2 etc.
- NG solar cells (perovskite, tandem type), P2C*3
- Aqueous Li-ion rechargeable batteries, SBM*4

### Devices and Storage
- NG-semiconductors (Si, SiC, GaN), NG-HDD

### Carbon Neutral
- Solar
- Offshore wind
- CCU/S*5

### Infrastructure Resilience
- Hydrogen solutions
- Water supply & sewerage
- Logistics Robots
- QKD

### Power semiconductors
- Si-MOSFET*6
- IGBT*7

### HDD
- Nearline HDD

### Manufacturing
- SiC module*8
- Motor control IC
- Multi-beam mask writers

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### Initiatives to Visualize ROI in R&D and Enhance Efficient Investment

Monitor changes over years by introducing KPIs in each target group

<table>
<thead>
<tr>
<th>R&amp;D Investment</th>
<th>Objectives</th>
<th>KPI Monitoring and evaluation of annual changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Development</td>
<td>To contribute to business growth</td>
<td>- ROI in R&amp;D (Period ROI, Annual ROI)</td>
</tr>
<tr>
<td>Cutting-edge</td>
<td>To contribute to future new business deployment</td>
<td>- Business growth (CAGR)</td>
</tr>
</tbody>
</table>
| Fundamental | To provide overarching support in all business growth | - Benchmarking  
  ✓ Evaluation based on megatrends and business strategy  
  ✓ Consistency with the roadmap in product development  
  ✓ Progress level (Business Contribution)  
  ✓ Technology Readiness level |

**Period ROI** = $\frac{\sum \text{operating profit (sum of total period)}}{\sum \text{R&D investment (sum of total period)}}$

**Annual ROI** = $\frac{\text{operating profit (every fiscal year)}}{\text{annual R&D investment (every fiscal year)}}$
Cutting-edge and Fundamental Technologies

• Cutting-edge Technologies
• Fundamental Technologies
• Recent Major Awards from Third Parties
Cutting-edge Technology Initiatives

Frontier technology development initiatives that also utilize open innovation

- Quantum Key Distribution
- Quantum and quasi-quantum computers
- Quantum technology applications

Quantum

- Cabinet Office (SIP*1), Ministry of Economy, Trade and Industry, Ministry of Internal Affairs and Communications, ToMMo*2, Tohoku University Hospital, NICT*3

Quantum technology applications

- NIMS*6, Tokyo University of Technology, Acquisition, Technology and Logistics Agency, Ministry of Education, Culture, Sports, Science and Technology

AI

- Deep clustering
- VQA*7 AI
- Sparse transfer learning
- Monocular 3D measurement AI

Deep clustering

- Conventional (accuracy 31.7%)
- Toshiba AI (accuracy 55.4%)*1

VQA*7 AI

- Picture 5C
- Sky
- Water
- Picture 5D
- Cloud
- Bicycle

Sparse transfer learning

- Database
- Sensors
- Defect cause analysis result

Monocular 3D measurement AI

- Institute of Statistical Mathematics
- Camera picture by zoomed lens
- Rust 0.35m²

Materials Devices

- Film-Based Perovskite Photovoltaic Module
- Aqueous Li-ion rechargeable batteries
- Millimeter-wave imaging
- Power semiconductor Triple-gate IGBT
- Next gen. HDD

Film-Based Perovskite Photovoltaic Module

- NEDO*8

Aqueous Li-ion rechargeable batteries

- NEDO*8

Millimeter-wave imaging

- details explained in the next 2 slides

Power semiconductor Triple-gate IGBT

- NEDO*8

Next gen. HDD

- NEDO*8

### Quantum Key Distribution (QKD)

**Commercialized in 2021**

- **World's fastest speed in key distribution**
  - 300 kb/s @10dB loss
  - *in long distance case*
- **World's longest distance in key distribution**
  - 120 km
  - *in long distance case*

**Key Provisioning API**

- Cryptographic Key providing Layer
- Quantum Encryption system
- Provide cryptographic key for each link

**Aiming to establish a quantum key distribution platform for the realization of end-to-end secure encrypted communication**

- **BT Group plc, Quantum Xchange, SpeQtral Pte Ltd, etc.**

**Simulated Bifurcation Machine™**

**Providing the same performance as a quantum computer using computers that is commercially available**

- **Longer distance communication distance**
  - over 600km*
  - **WW No.1**
- **Longer distance**
  - **WW First**
- **Miniaturization**
  - chip-based quantum key distribution system*
- **World's fastest speed in key distribution**
  - 300 kb/s
  - @10dB loss
- **World's longest distance in key distribution**
  - 120 km
  - *in long distance case*

**Finds the optimal solution to a one-million-bit problem in 30 minutes; a typical algorithm would take 14 months**

**Started to validate effectiveness of quasi-quantum computing for high-speed, high-frequency stock market trading for the first time in the world**

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*1: Part of this achievement is supported by the EU through the Horizon 2020 project OpenQKD.
*2: Part of this achievement is supported by Agile Quantum Safe Communications, an InnovateUK joint research and development project through the Industrial Strategy Challenge Fund of the UK Government.
Examples of Cutting-edge Technologies in Materials and Devices

Toshiba’s unique technologies save energy and achieve security and safety in energy and infrastructure

**Perovskite Solar Cells**

Commissioned by New Energy and Industrial Technology Development Organization (NEDO)

**Low Cost x Lightweight x Flexible**

Improve efficiency and productivity through one-step film formation based on meniscus technology*1

Large area film type module efficiency: **15.1%** (current)

Power generation cost target: **20 yen/kWh** (2025)

Expand applications based on the advantages of light weight, film-type cell

Buildings

- Transparent walls, even curved surfaces

Greenhouses

- Low load structure

Factories

- Low load roofs

**Aqueous Li-ion Rechargeable Batteries**

Striving for safety

- non-combustible electrolyte

- One-step process based on meniscus application

- Long life

- Low-temperature operation, (-30°C)

- WW No.1

- Non-combustible Aqueous Li-ion Battery

Expand applications based on the advantages of light weight, film-type cell

Buildings, Factories

- Easy to install in many facilities with fewer safety restrictions under the Fire Service Act in Japan*2

- Striving for safety

- Non-combustible

- Aqueous Li-ion Battery


*2: Technical standards for facilities with charging and discharging of Li-ion batteries in case that numbers of batteries are over the criteria in the Act

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### Fundamental Digital Technologies

**Fundamental digital technologies that support competitiveness of products and services**

#### AI

**AI model according to size of systems and hardware**

<table>
<thead>
<tr>
<th>Immediate processing × Various devices</th>
<th>Robots</th>
<th>Camera</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.g. Compact AI model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automatically convert to optimum AI model depending on edge device computing performance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Cybersecurity

**CPS management through lifetime protection**

<table>
<thead>
<tr>
<th>Security by design</th>
<th>Prediction &amp; detection</th>
<th>Response &amp; recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation &amp; verification</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Security Operation Center based on CPS knowledge**
- **Cyber attack emulation based on CPS attack know-how**

#### Digital Manufacturing

**CPS-based manufacturing equipment that imitates know-how of skilled engineers**

- **Recognition AI**
  - Defect image learning
  - Welding status visualization with image processing
- **Actuation AI**
  - Update to good condition (position and method)

**CPS of laser welding**

- **Observation**
- **Actuation**

**Applications**

- Nearline HDD
- SCiB™
- Motors in vehicles

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*1: A. Yaguchi et al., "Decomposable-Net: Scalable Low-Rank Compression for Neural Networks", IJCAI2021

*2: Security Operation Center
Recent Major Awards from Third Parties

**Film-Based Perovskite Photovoltaic Module**
- Japan Electronics and Information Technology Industries Association (JEITA)
- Minister of Economy, Trade and Industry Award and Grand Prix in the Carbon Neutral Category in CEATEC AWARD 2021*1

**Air-cooled Heat Pump Chillers** "EDGE32 series"
- Japan’s Energy Conservation Center (JEC)
- 2021 Energy Conservation Grand Prize, Agency for Natural Resources and Energy Director-General’s Award*2

**Carbon dioxide Capture, Utilization and Storage**
- CCUS demonstration facility construction project team (Toshiba Energy Systems, Chiyoda Corporation)
- The Engineering Advancement Association of Japan (ENAA) 2021 Encouragement Awards*3

**Nb/Ti Superconducting Magnet for freezers**
- 14th One Step on Electro Technology*4

**Ultra High Voltage substation equipment**
- (joint award of 5 companies inc. Toshiba Energy Systems)
- 14th One Step on Electro Technology*4

**Wireless LAN Communication**
- Development of high speed and high efficient wireless LAN
- Minister of Education, Culture, Sports, Science and Technology Science and Technology Award of Development Category*5

**QKD**
- Japan Electronics and Information Technology Industries Association (JEITA)
- Semi Grand Prix of Solutions Category in CEATEC AWARD 2021*1

**Water and Sewerage Treatment**
- Design, Build, Operate & Maintain and Transfer of Salori Sewage Treatment Plant and related facilities in Allahabad
- First Prize (Minister of Land, Infrastructure, Transport and Tourism Commendation) in 4th Japan Construction International Award*8

**Derwent Top100 Global Innovator 2021*9**
- Selected by US research firm Clarivate Analytics. Recognized as one of the world’s 100 most innovative companies and research institutes for ten consecutive years

**Traction energy storage system for railways, with SCiB™**
- Japan Institute of Design Promotion GOOD DESIGN AWARD 2021*10

**HAORI inverter air conditioner**
- Japan Institute of Design Promotion GOOD DESIGN AWARD 2021*10


**Japan Institute of Design Promotion GOOD DESIGN AWARD 2021**

**Japan Institute of Design Promotion GOOD DESIGN AWARD 2021**

**Japan Institute of Design Promotion GOOD DESIGN AWARD 2021**

**Japan Institute of Design Promotion GOOD DESIGN AWARD 2021**

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R&D Structure that Demonstrates Combined Strengths

• Combined Strengths in R&D
• Combined Strengths: Post Spin-off R&D Structure
• Combined Strengths: Co-creation in Power Electronics
• Combined Strengths: Opportunities Offered by the New R&D Building
Combined Strengths in R&D

Combined strengths to focus in the spin-off transition
1. Business cooperation in devices and systems (e.g. power electronics)
2. Applications of common technologies (e.g. AI, cybersecurity, manufacturing etc.)

Policies for continuing demonstration combined strengths after the spin-off

<table>
<thead>
<tr>
<th>Organization</th>
<th>Manage common technologies through cooperation where both companies have R&amp;D functions for each unique area, including basic research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agreement</td>
<td>Promote inter-company activities for co-creation, based on agreement</td>
</tr>
<tr>
<td>Environment</td>
<td>Provide opportunities for communication among researchers.</td>
</tr>
</tbody>
</table>
Combined Strengths: Post Spin-off R&D Structure

Redesign R&D structure to maximize value in both Toshiba/Infrastructure Service Co. and Device Co.

Current

Corporate Labs (CL)
- Corporate Research & Development Center
- Corporate Manufacturing Engineering Center
- Corporate Software Engineering & Technology Center

Works Labs (WL)
- Energy Systems Research and Development Center
- Infrastructure Systems Research and Development Center
- Software Systems Research and Development Center
- Electronic Devices & Storage Research & Development Center

Post spin-off

Toshiba/Infrastructure Service Co.
- CL
  - Corporate Research & Development Center
  - Corporate Manufacturing Engineering Center
  - Corporate Software Engineering & Technology Center

  WL
  - Energy Systems Research and Development Center
  - Infrastructure Systems Research and Development Center
  - Software Systems Research and Development Center

CL/WL

Device Co.
- Semiconductor and Storage Research & Development Center
 Combined Strengths: Post Spin-off R&D Structure

• Maintain an R&D function that covers the value chain, from fundamentals to commercialization, in both Co.
• Introduce an R&D function for fundamental technologies in Infrastructure Service Co. and provide its outcomes to both Co.

Infrastrucure Service Business Development Center (provisional)

- Research unique to Infrastructure Service Co. (incl. cutting edge)
- Fundamental Research: AI, IT, Security, Materials, Manufacturing, Software, Open-lab, etc.

Toshiba/Infrastructure Service Co.

Co-creation Center for Infrastructure Service (provisional)
- e.g. perovskite solar cells, automation and labor-saving solutions

Corporate Labs

- Cooperating with Toshiba/Infrastructure Service Co.
- Works Labs
  - Energy Systems R&D Center
  - Infrastructure Systems R&D Center
  - Software Systems R&D Center

Device Co.

Semiconductor and Storage R&D Center (provisional)

- Research unique to Device Co. (incl. cutting edge)

Integration

Electronic Devices & Storage R&D Center

*gathered in New R&D center
Combined Strengths: Co-creation in Power Electronics

Integration of devices and systems sustained by agreement and provision of energy-saving solutions

**Power Electronics**

Covering numerous applications in energy and infrastructure systems

- Railway drive systems that save energy
  - Permanent Magnet Synchronous Motor (PMSM)
  - VVVF*3 inverter with all-SiC devices
  - Battery for power failure operation mode with regenerate energy function

- HVDC (high voltage direct current) that expands the electricity network
  - New Hokkaido-Honshu line
    - Started operation March 2019
  - Line Commutated Converter
    - Started operation March 2021
  - Voltage Sourced Converter
    - First application in Japan

*1: Inverter  *2: On Board Charger  *3: Variable Voltage Variable Frequency control  *4: Injection Enhanced Gate Transistor
Combined Strengths: Opportunities Offered by the New R&D Building

A center to advance diverse concepts, ideas, proposals and people
An open-minded source of value for society

Innovation Palette
“Convergence of diverse expertise and knowledge”

**HR**
Recruitment, Engagement, Productivity

Significantly improve productivity, creativity and BCP capabilities held back by old building and equipment
Handle new way of work by ABW*1

**Social Value**
Future insights, Co-creation

Enhance conversation with market and customers as “Open Lab”

**Technology**
Imagination, Fundamental technology, Solution

Comprehensive strength quickly gathers technologies and engineers to solve problems

**Diversity and conversation•sympathy**

Scheduled to start operation in **FY2023**

About 3,000 in R&D divisions will work there

*1: Activity-Based Working
*2: The new R&D building is at the design stage. Start of operation, appearance, and technology demonstration items are subject to change
In Closing
Contribute to solving social and customer issues guided by the Basic Commitment of the Toshiba Group "Committed to People, Committed to the Future."

Carbon Neutral
Infrastructure Resilience

"Committed to People, Committed to the Future."

Services
- VPP
- Energy Mgmt.
- Energy Matching
- Power Gen O&M
- T&D DX
- Energy storage
- Weather Disaster prevention
- Logistics
- Smart manufacturing
- Railway IoT

Energy x Digital
- Generate
- Transfer
- Storage
- Use Smartly

Open, Connected
Toshiba’s unique “x Digital”

Infrastructure x Digital
- Prepare
- Find
- Protect
- Maintain

Cyber
- AI
- Predictive diagnosis
- Sensing
- Optimization
- Actuation
- Security

Physical
- Differentiated Devices
- Power semiconductors
- Compound semiconductors
- Power electronics
- Solar cells
- Hydrogen
- Weather radars
- Intelligent robots

Differentiated Components, Systems
- Nearline HDD
- Mask Writers (Lithography tools)
- SCiB™
- Wind power
- P2G*1/P2C*2
- Controllers
- Water supply and sewage

Supply Chain, Engineering Chain, Product Life-cycle

*1: Power to Gas  *2: Power to Chemicals

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