



# Strengthening fundamental technologies and Creating New Value

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**DENSO Corporation**



# Agenda

- 1. Strengthening fundamental technologies  
(Semiconductors/Software)**
- 2. Creating New Value  
(Energy/Food and Agriculture)**

# 1

## Strengthening fundamental technologies

- Strengthen DENSO's fundamental technologies that underpin the evolution of mobility

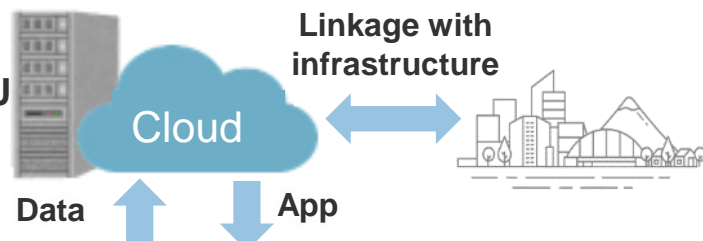


# Fundamental technologies that underpin the evolution of mobility

Evolution from a “Tier 1 supplier that supports the auto industry” to a “Tier 1 supplier that supports a mobility-centered society” by leveraging strengths cultivated through the manufacture of automotive components

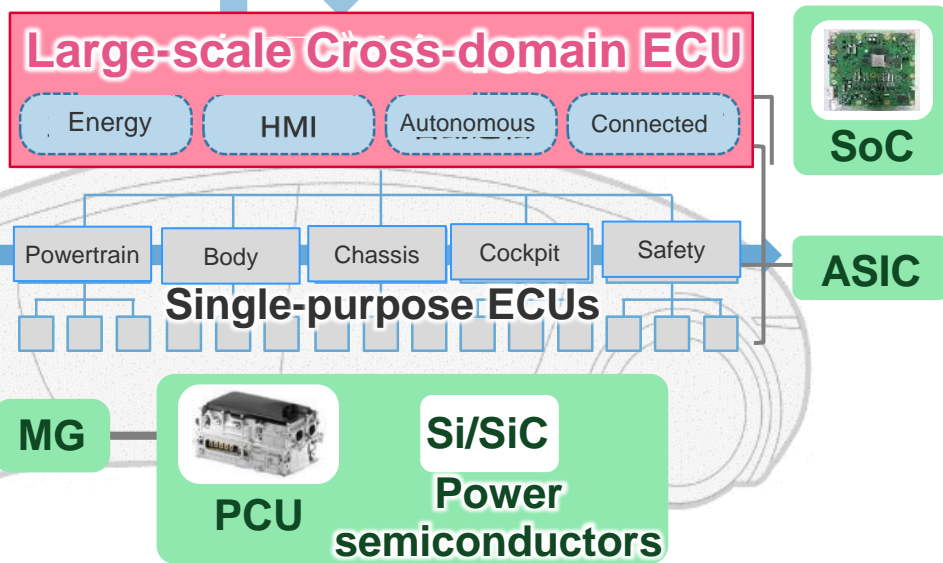
## Electronic Platforms

- Large-scale Cross-domain ECU
- Single-purpose ECUs



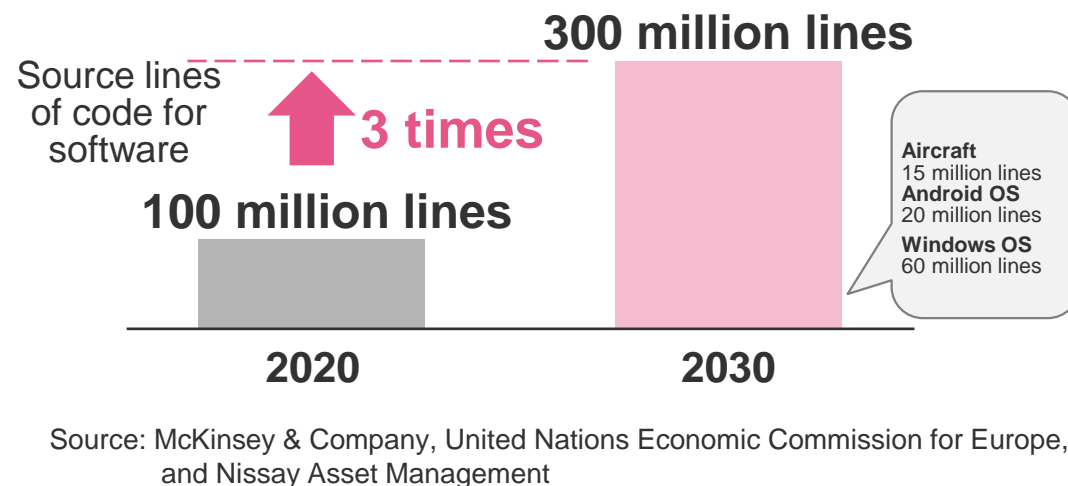
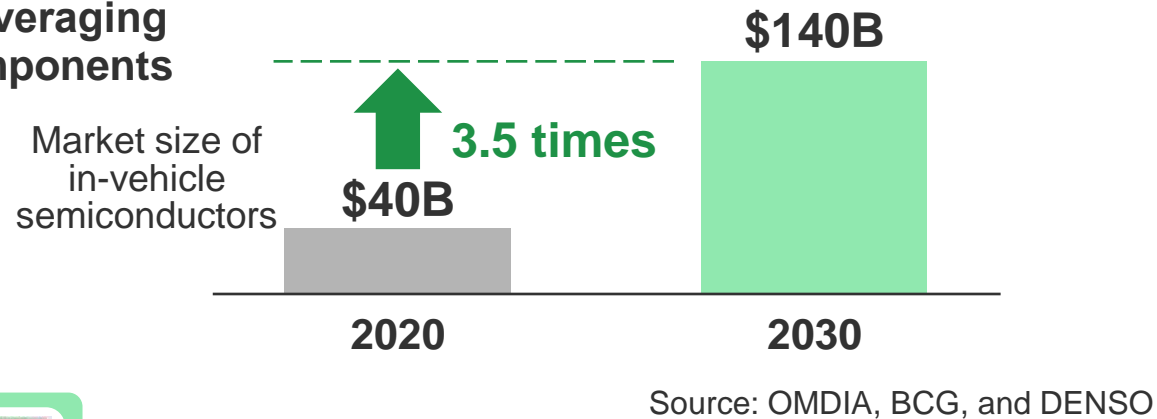
## Semiconductors

- MCU, SoC
- ASIC
- Power semiconductors



## Software

- Cross-domain
- Large scale

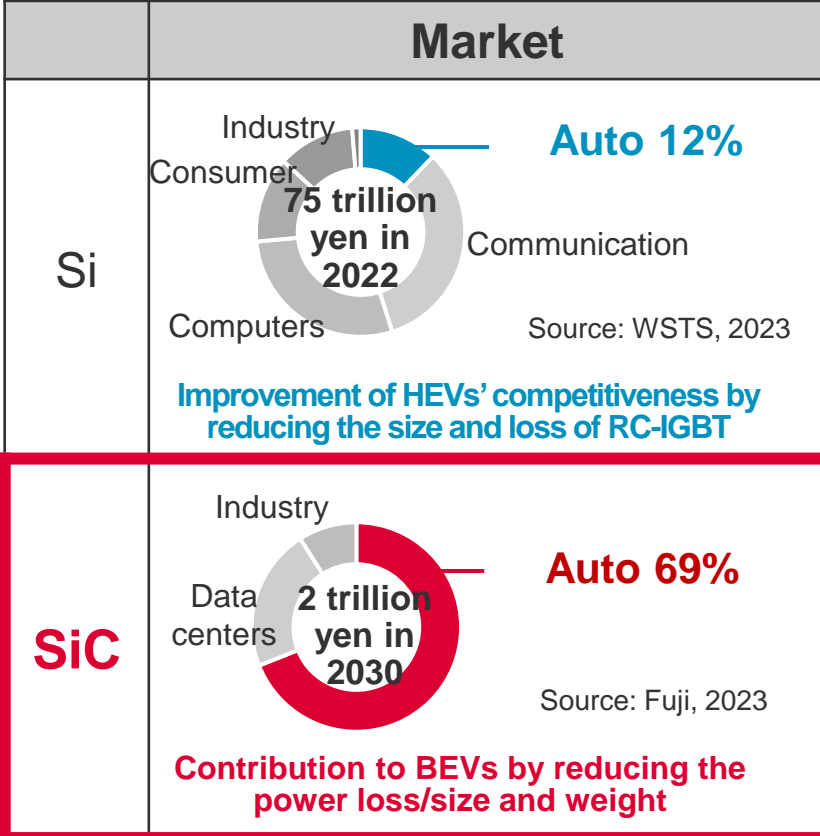


**Strengthen semiconductors and software as a “Tier 1 supplier that supports a mobility-centered society” where vehicles are connected with infrastructure**

# [Strategy in the semiconductor field (example)] Power semiconductors: from Si to SiC

Ensure stable supply of high-performance Si for HEVs/PHEVs and accelerate the development and deployment of SiC that contributes to the spread of BEVs by improving the electric mileage

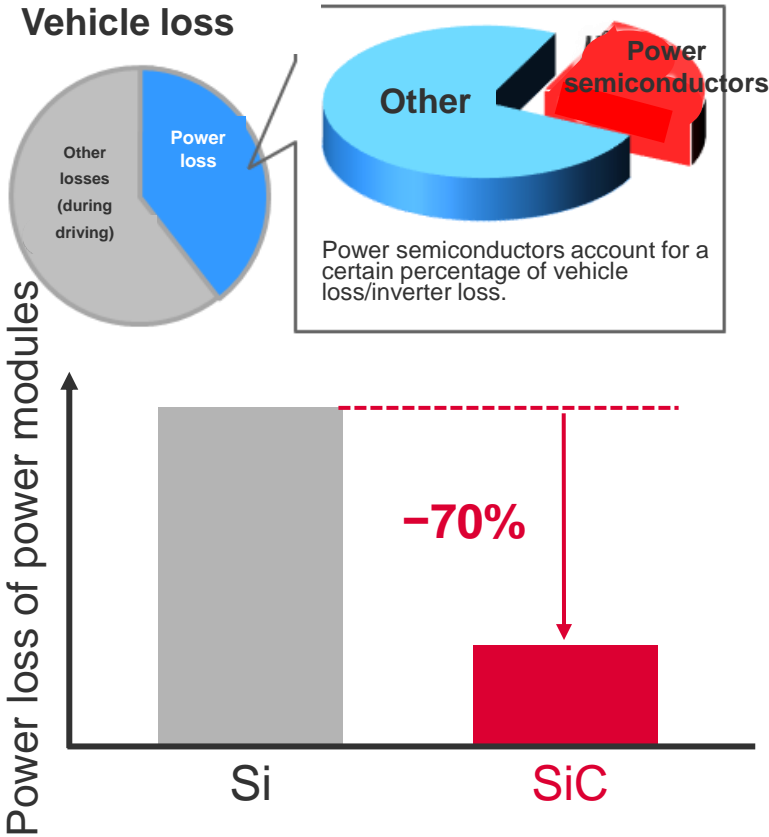
## Market comparison between Si and SiC



## Products (components) for BEVs

Products		
<b>Inverter</b>		
<b>Power module</b>		
<b>SiC power semiconductor</b>	<b>SiC device</b>	
	<b>SiC wafer</b>	Epitaxial wafer 
		Substrate 

## Satisfaction derived from using SiC



**Ensure competitiveness of SiC (performance, procurement) for devices (low loss) and wafers (low defects, high-speed growth) to meet the rapid expansion of BEVs**

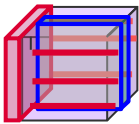
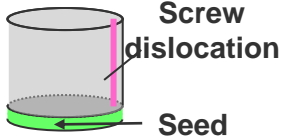
# [Strategy in the semiconductor field ] Development and stable procurement of SiC wafers

## Evolution of SiC wafer technology

### Commercialization of high-quality wafers

### Reduction of costs & CO<sub>2</sub> emissions

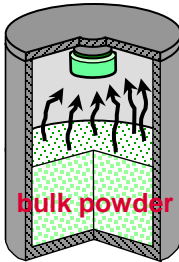
RAF method



RAF: Repeated A-Face

Sublimation method  
\* Mass production achieved

2200 deg.

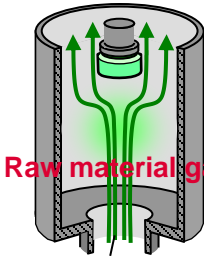


0.2mm/h

Gas method

\* Aiming to achieve mass production in 2028 and beyond

2500 deg.



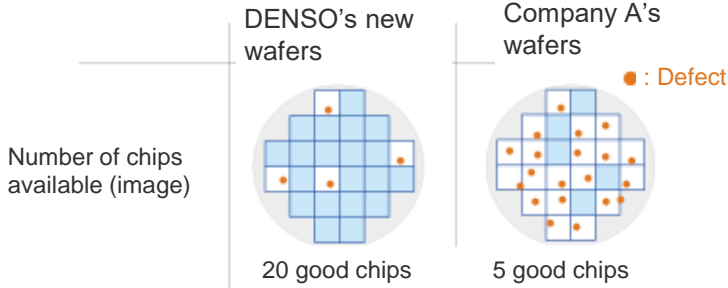
3mm/h

Wafer cost  
-30% from the current level

CO<sub>2</sub> emissions  
-90% from the current level

**x15 high-speed growth**

**Defect density: 1/3 compared to general-purpose products**



## Partnerships concluded with SiC wafer suppliers

**RESONAC**

March 31, 2023

SiC epitaxial wafers used for inverters

**COHERENT**

October 10, 2023

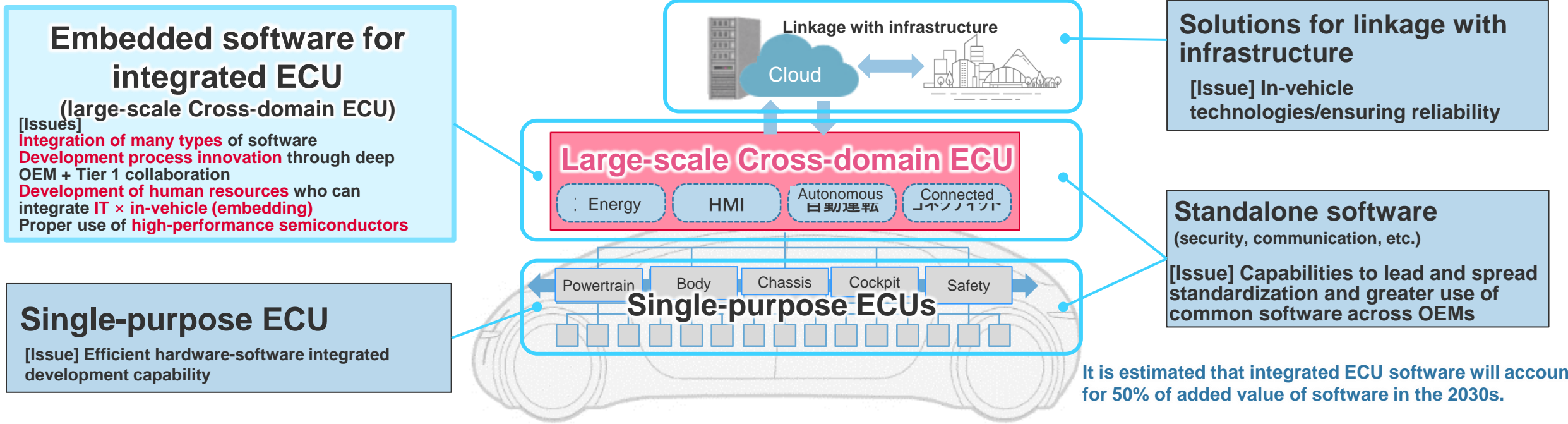
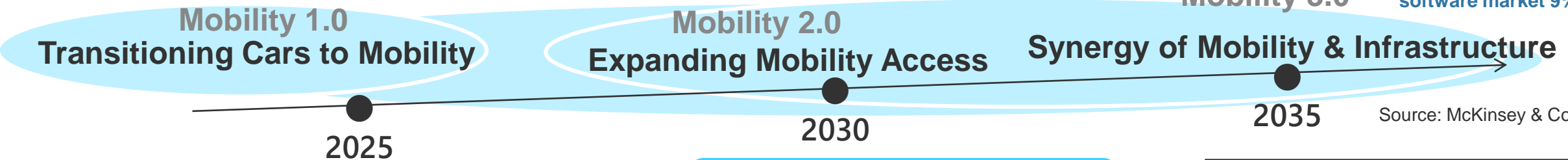
Equity participation in a SiC wafer manufacturing company



**Ensure stable supply of wafers through in-house efforts to achieve high quality and low-cost technologies and collaboration with development and mass production partners**

# [Strategy in the software field (example)] Enhancement of capabilities to develop embedded software for integrated ECU

Growth rate of the mobility software market 9%/year



**In-vehicle electronic platforms have changed significantly due to expansion of mobility functions and linkage with infrastructure. Embedded software for integrated ECUs, which fulfill important functions, is a strategy field with many new technological issues**

# [Strategy in the software field] Core technologies that are key to embedded software for integrated ECU

## Difficulties of integrated ECU

**① Extensive quality assurance combining different types of software**

Example of in-vehicle info-com equipment

**② Functional requirements for overwhelmingly high quality and high accuracy**

Functional requirements	Tablet computer	In-vehicle info-com equipment
Tasks	Concurrently handled tasks 7 to 10	150 (parallel) <b>20 times</b>
Responsiveness	Response speed in the event of an event 200ms	5 to 20ms <b>10 times</b>
Arbitration	Patterns that must be presented 1	Thousands <b>Thousands of times</b>

**③ Diversity employees' management that creates new value**

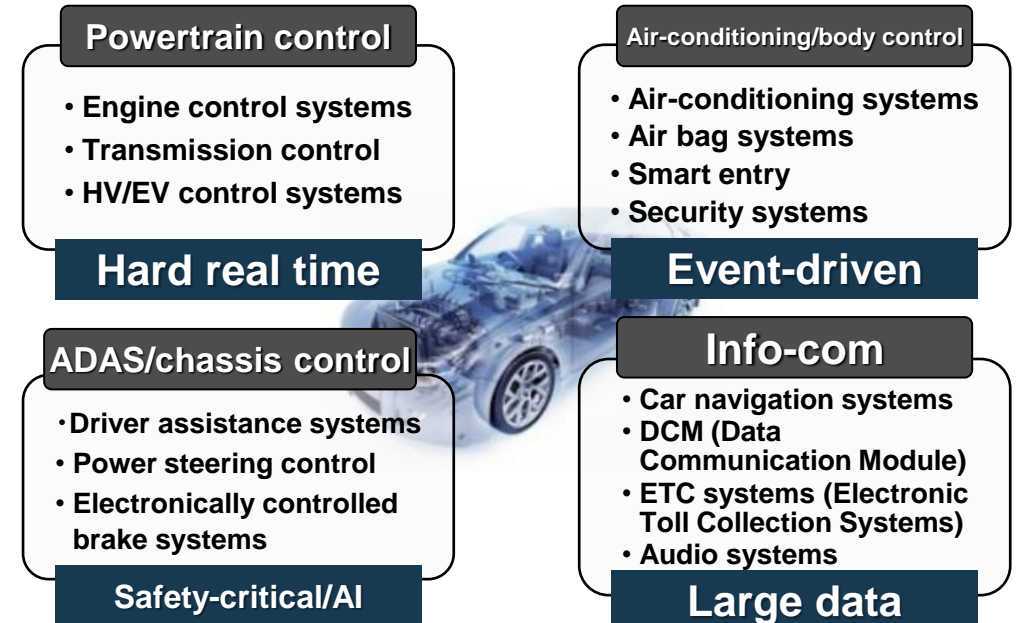
ECU as a standalone product **10 times** Integrated ECU

50 to 100 engineers → 500 to 1,000 engineers

Cross-domain IT human-resources × In-vehicle Semi-conductors Tools × AI

## DENSO's strengths

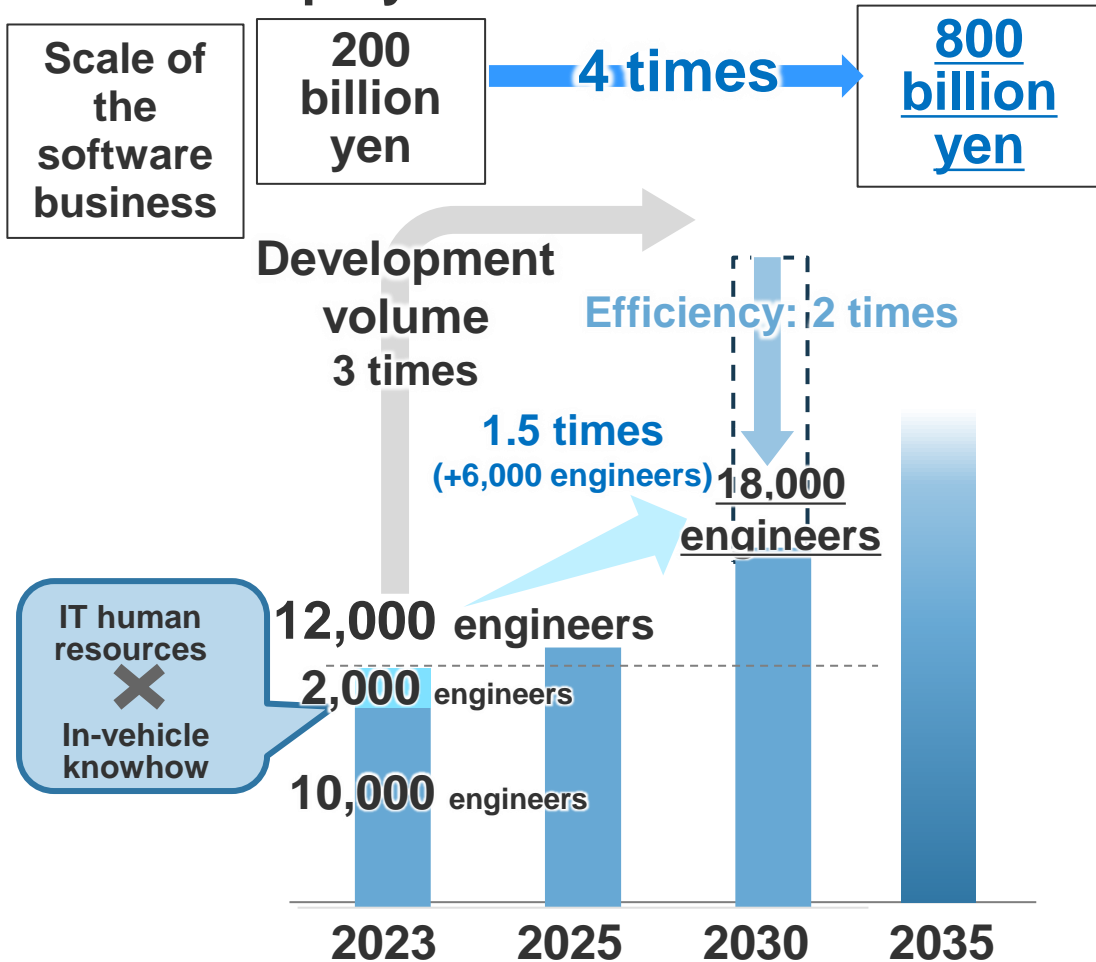
- ✓ Library of various in-vehicle software products that competitors do not have
- ✓ Participation in value creation through partnerships with OEMs
- ✓ 20 years of experience in the development of large-scale integrated ECUs and utilization of IT human resources
- ✓ Know-how to use semiconductors properly and in-house production of development tools



**Cope with in-vehicle integrated ECU software, which requires overwhelming functionality, based on our profound software IP\* and implementation capabilities**



# [Strategy in the software field] Initiatives to increase the development efficiency and strengthen our employees



Efficiency improvement

## Reform to work processes

- ✓ Collaboration with OEMs: Seamless development from specifications to implementation
- ✓ Improvement of development tools: Integration of in-house tools and generative AI
- ✓ Enhancement of utilization of expertise on semiconductors: Utilization of SoC/middleware

Strengthening of human resources

## Strengthening employees for upstream processes/advanced development

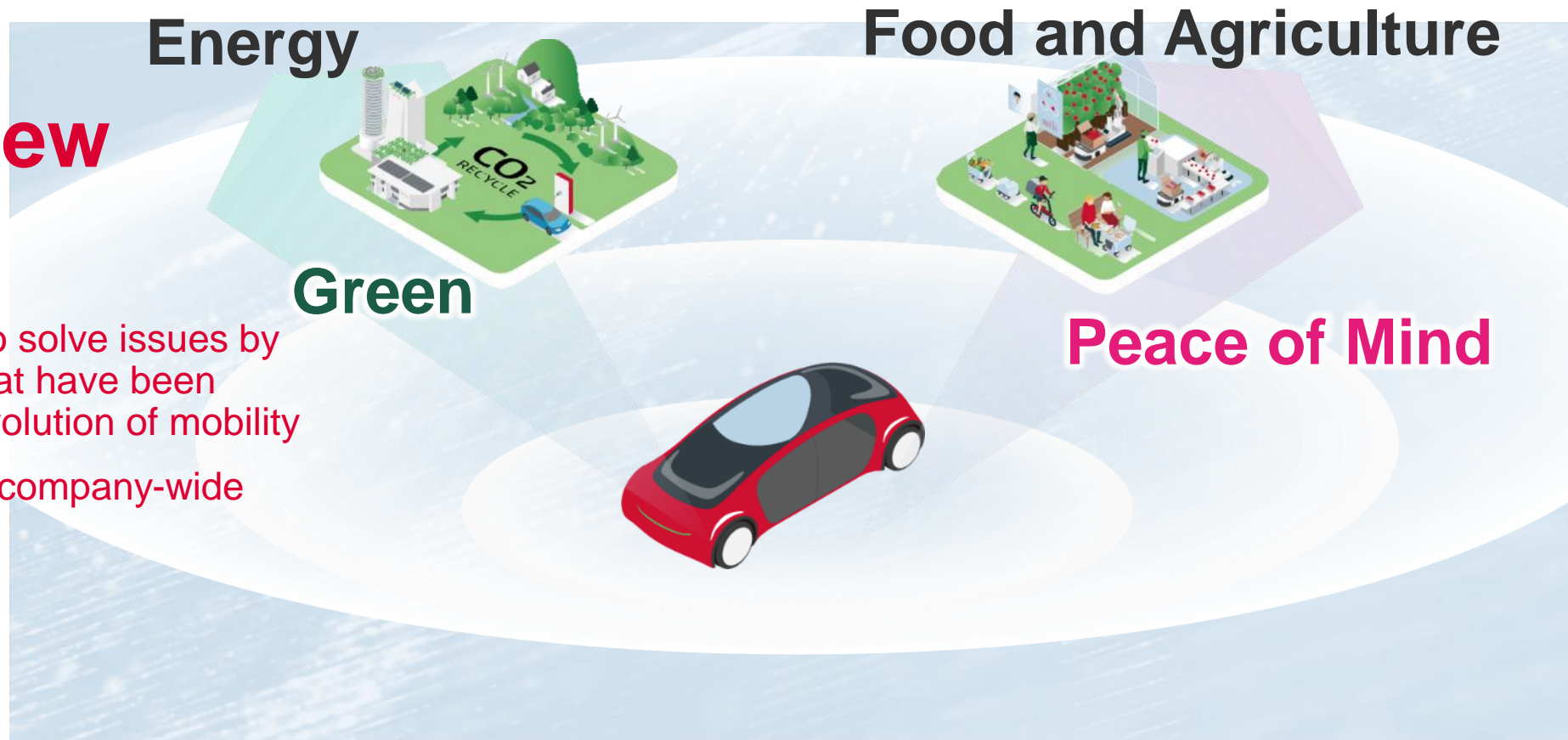
- ✓ Employees of project managers/architects: Expansion of utilization of IT professionals
- ✓ Enhancement of global capabilities to develop software: Standardization of work processes
- ✓ Active M&A with software development companies: Enhancement of alliances with the IT industry (utilization of 2,000 IT engineers as of 2023)

**Enhance the quality of human resources and increase human resources by 1.5 times to expand the scale of the software business and build a strong software development system**

# 2

## Creation of new value

- Expand the opportunities to solve issues by leveraging the strengths that have been nurtured to underpin the evolution of mobility
- Aim to achieve 20% of the company-wide revenue in 2035



# Energy domain

## Issues in accelerating carbon neutrality

### Surplus energy

Long-term storage  
Timing for optimal use

### CO<sub>2</sub> emissions

No emissions  
when used

### Resources

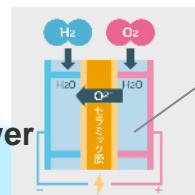
Generation from  
various resources

## Focusing on hydrogen

### SOFC (use)

- Highly efficient distributed power source
- Compatible with various fuels, including hydrogen

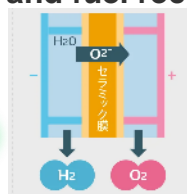
(systems equipped with a reformer)



Ceramic membrane  
Operation at 600 to 800°C

Power generation  
efficiency  
65% (target)

Key points: Temperature control  
and fuel recycling



Key point: Utilization of common  
technologies for SOFC systems

System cost  
-20% from the  
conventional level  
(target)

### SOEC (production)

- Low-cost hydrogen production
- Conversion efficiency of 70% achieved by high-temperature operation (e.g., 50% for alkaline fuel cells at 60 to 80°C)

SOFC: Solid Oxide Fuel Cell

SOEC: Solid Oxide Electrolysis Cell

## DENSO's strengths

Technologies to achieve stable operation of electricity ↔ hydrogen conversion under high temperature

### Thermal management technology



Keep the power generation unit at a uniform temperature by reducing heat radiation and recovering waste heat

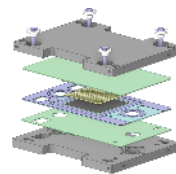
### Ejector technology



A fluid pump that operates at high temperatures and is free from moving parts

Cutting-edge material technologies to realize high conversion efficiency

### Advanced ceramic microstructures

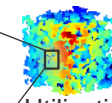


Chemical reactivity  
High-temperature durability

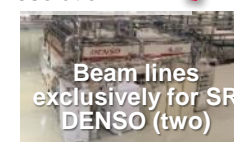


Quick introduction of atomic resolution TEM

### Structure exploration



Utilization of a supercomputer (Fugaku)



Beam lines exclusively for SR DENSO (two)

Automation technology in cyberspace



Combinatorial system

### Analysis in atomic scale

### Fabricate and test

TEM: Transmission Electron Microscopy, SR: Synchrotron Radiation

Enter the hydrogen business by leveraging thermal management and material technologies, which have been refined through business operations, to accelerate carbon neutrality

# Food and Agriculture domain

## Issues in food safety and security

### Food demand

#### Population increase

8.8 → 10.9 billion  
(2025 → 2035)

### Workforce

#### Shortage

6.0 → 6.1 billion  
(2025 → 2035)

### Weather

#### Significant change

Global warming  
by +1.5°C  
(2020 → 2040)

### Resource

#### Depletion

Securing and outflow  
of water, phosphorus,  
and nitrogen (fertilizer)  
Source:  
United Nations, etc.

## Elements necessary for stable production



Growing  
technology/  
know-how



Optimization of light,  
water, and CO<sub>2</sub>



Environmental control  
suitable for growth

Stable  
increase in  
harvest



Automation

## Partnership with Certhon Group

### Complete subsidiary establishment in 2023

#### Certhon Group's proprietary technologies

#### Capabilities to design farm systems

Capabilities to make  
proposals based on total  
optimization

#### Growth technologies

Know-how from variety  
selection/improvement to  
cultivation

#### DENSO's proprietary technologies

#### Proposal of technologies suitable for cultivation

#### Proposal of farms suitable for automation, etc.

#### Automation technologies

Recognition, judgment, and control  
technologies refined in  
ADAS/manufacturing

#### Air conditioning technologies

Air current analysis/control  
technologies refined in in-vehicle air  
conditioning

#### Technologies for effective utilization of resources

Soil sensing and flow rate control  
by applying in-vehicle technologies

## Realization of high-productivity farms (industrialization of farms)

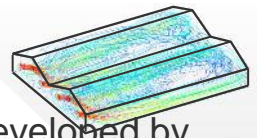
### Present

Certhon Group and DENSO are jointly  
conducting evaluations of harvesting  
robots at a European farm.  
(The labor productivity has been doubled.)



### Future

A farm model will be developed by  
using air conditioning technology in  
anticipation of areas where farming is  
difficult.



**Expand the business based on the Certhon Group's agriculture technologies and DENSO's automation and air conditioning technologies to the food and agriculture domains**

***DENSO***

Crafting the Core