

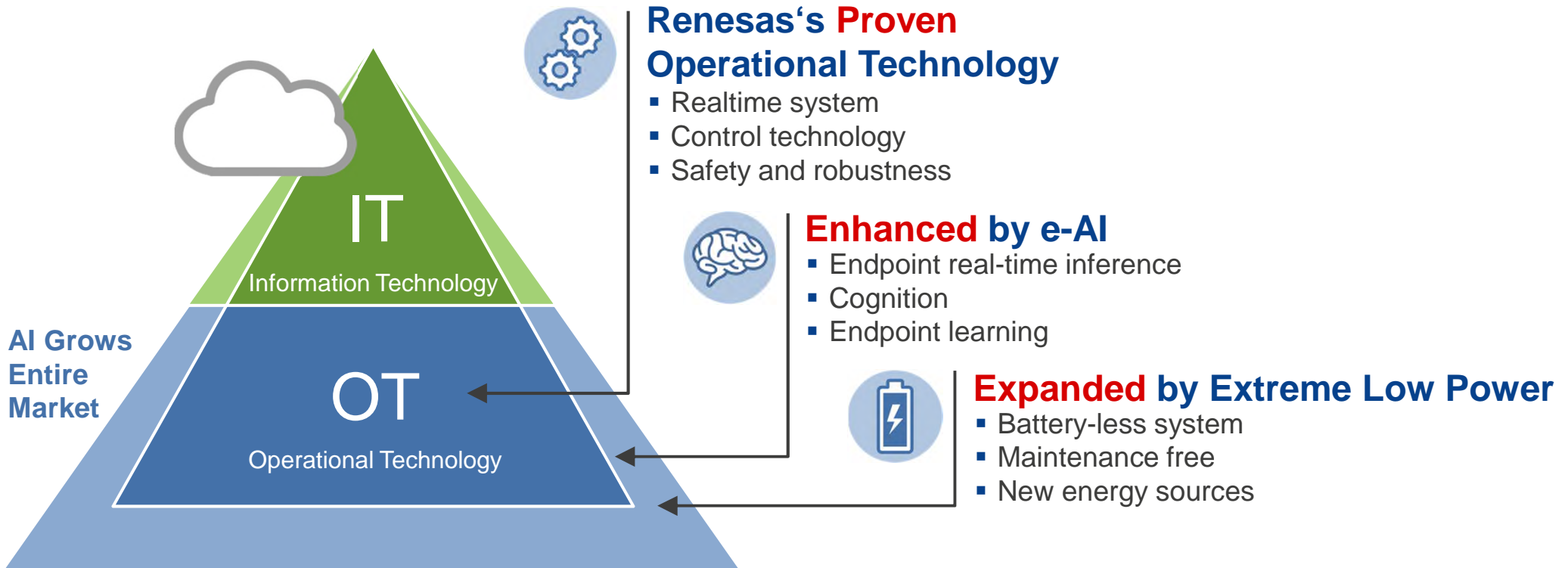
RENESAS ELECTRONICS  
PRESS CONFERENCE IN ELECTRONICA 2018

# ENDPOINT INTELLIGENCE - EXPANDED BY SOTB TECHNOLOGY

NOVEMBER 14, 2018  
MICHAEL HANNAWALD, SENIOR VICE PRESIDENT  
INDUSTRIAL SOLUTION BUSINESS UNIT  
RENESAS ELECTRONICS CORPORATION

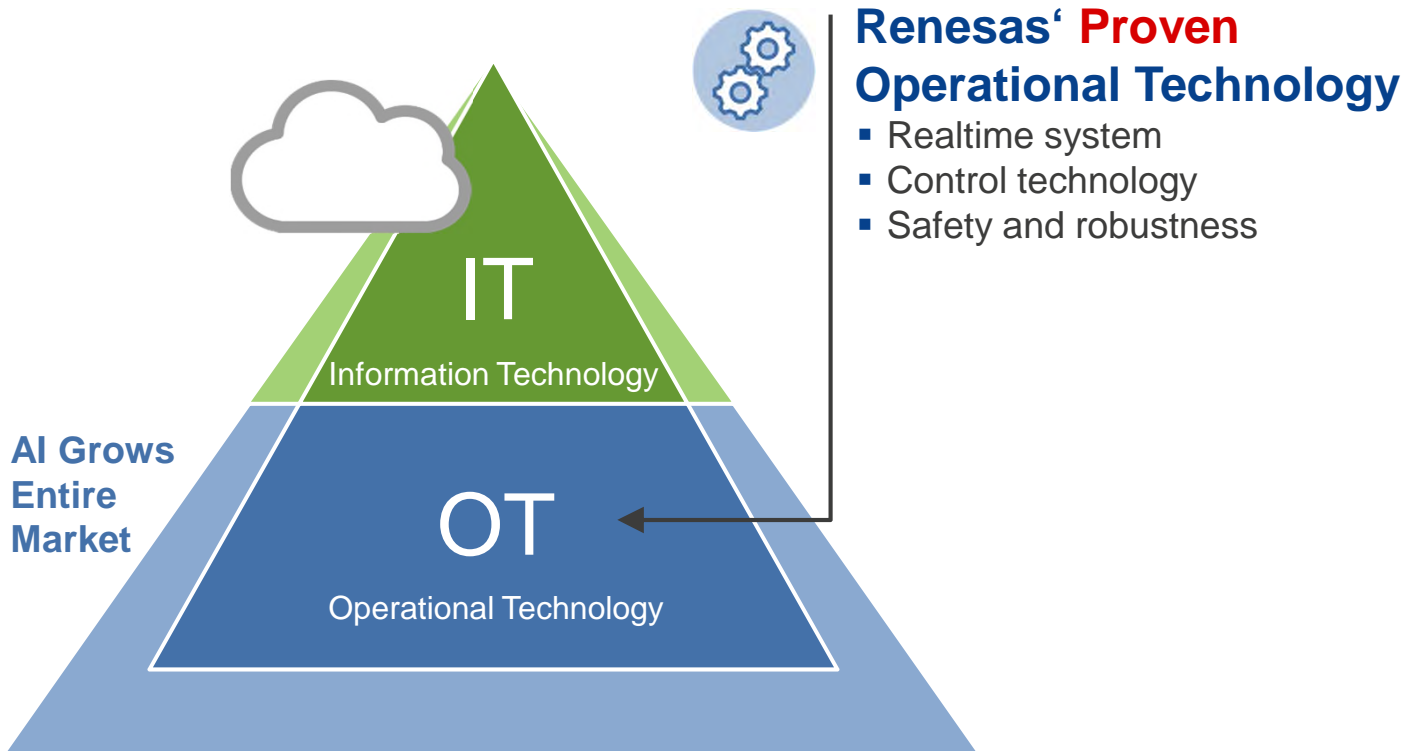
# ENDPOINT INTELLIGENCE

## INNOVATION IN OT CONSISTS OF THREE TECHNOLOGIES

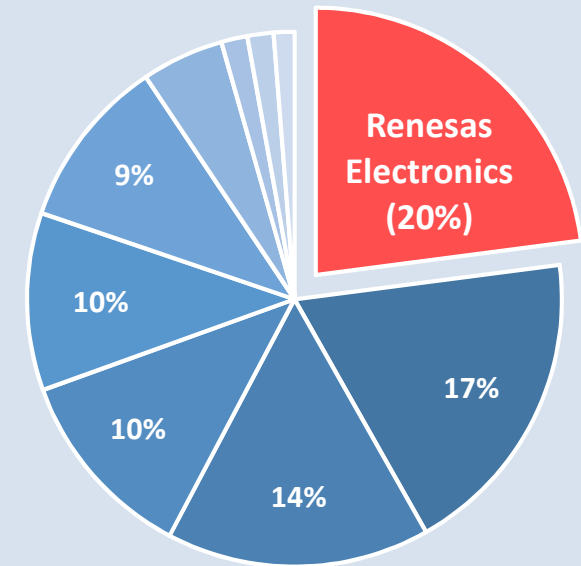


IT = Cloud, Server, and some Edge computing / OT = Some Edge computing, and Endpoints / e-AI = Embedded Artificial Intelligence

# ENDPOINT INTELLIGENCE - **PROVEN STRENGTH**

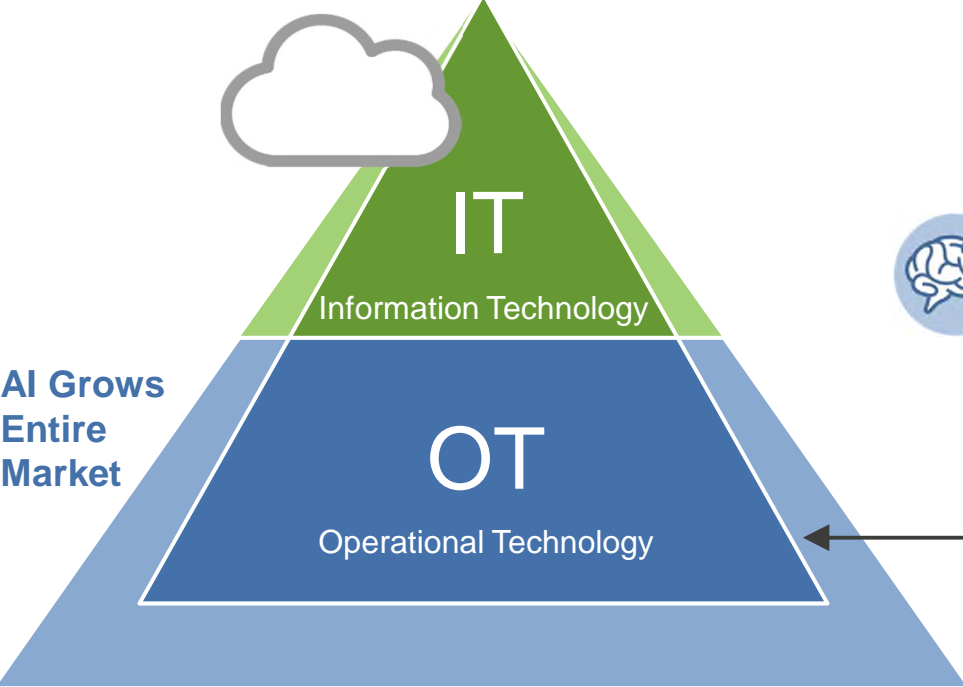


**World Wide No.1 Position**  
CY17 Market Shares MCU Ranking



Source; "Gartner Market Share: Semiconductors by End Market, Worldwide, 2017", 4 April 2018

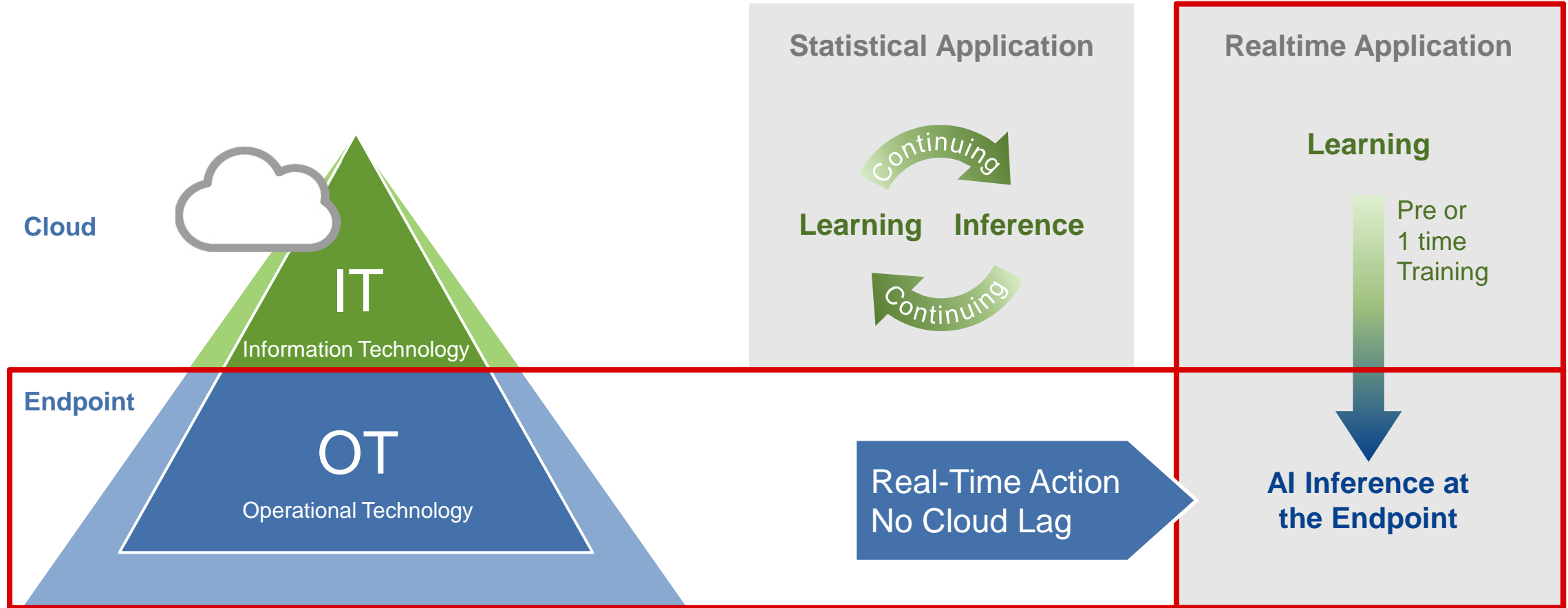
# e-AI ENHANCES ENDPOINT INTELLIGENCE



### Enhanced by e-AI

- Endpoint real-time inference
- Cognition
- Endpoint learning

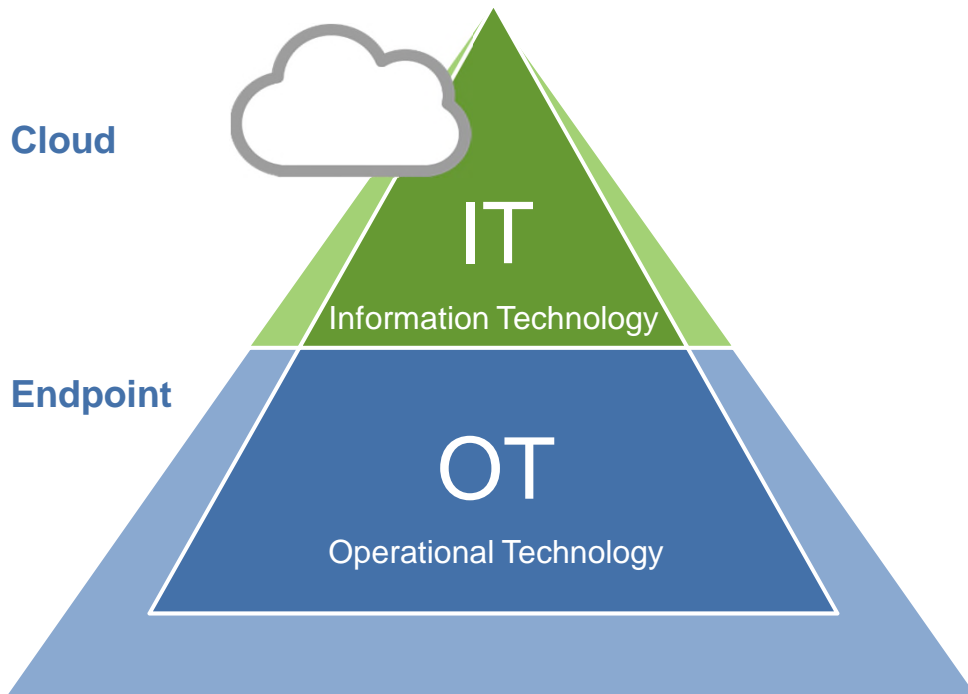
# e-AI ENHANCES ENDPOINT INTELLIGENCE BY INFERENCE IN OT



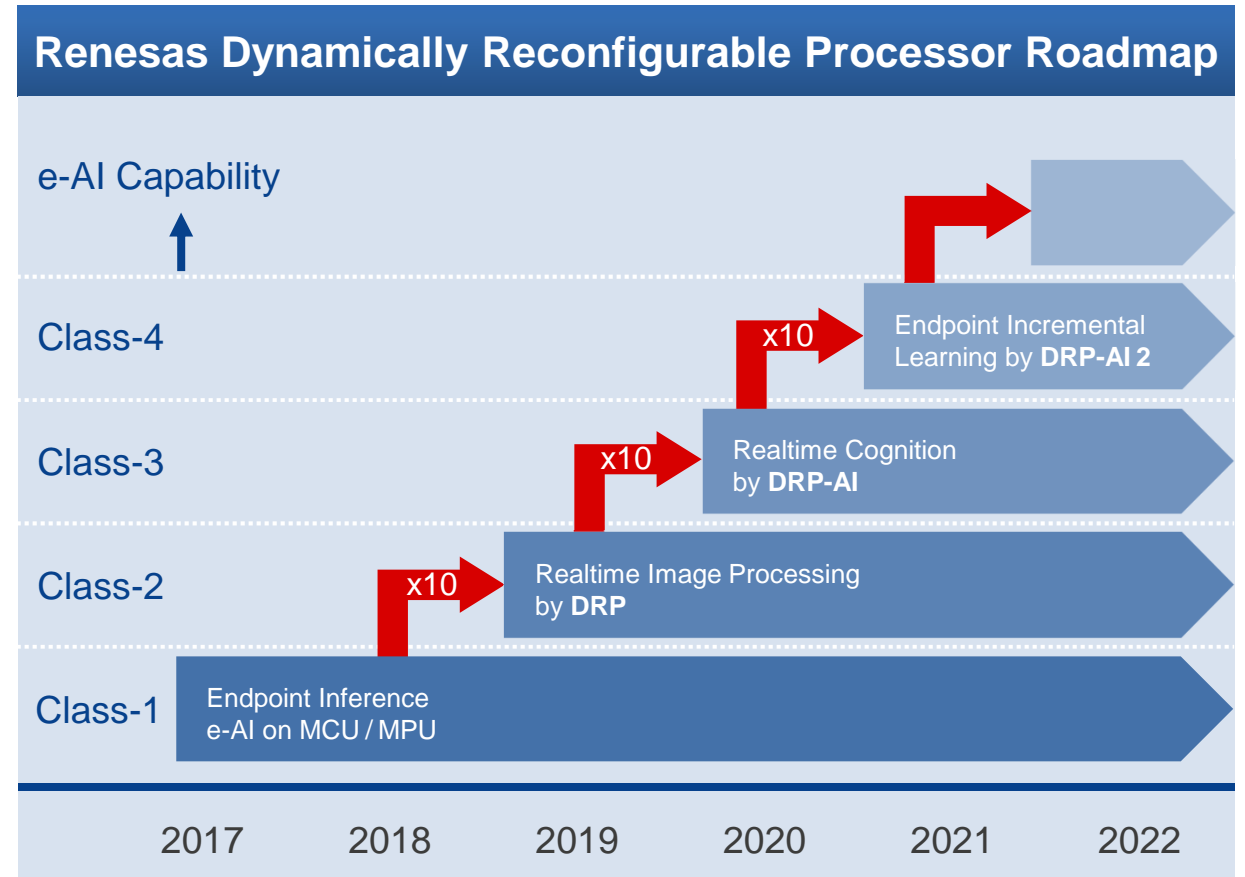
IT = Cloud, Server, and some Edge computing / OT = Some Edge computing, and Endpoints / e-AI = Embedded Artificial Intelligence

# ROADMAP OF e-AI ACCELERATED BY DRP

## e-AI ENHANCES ENDPOINT INTELLIGENCE

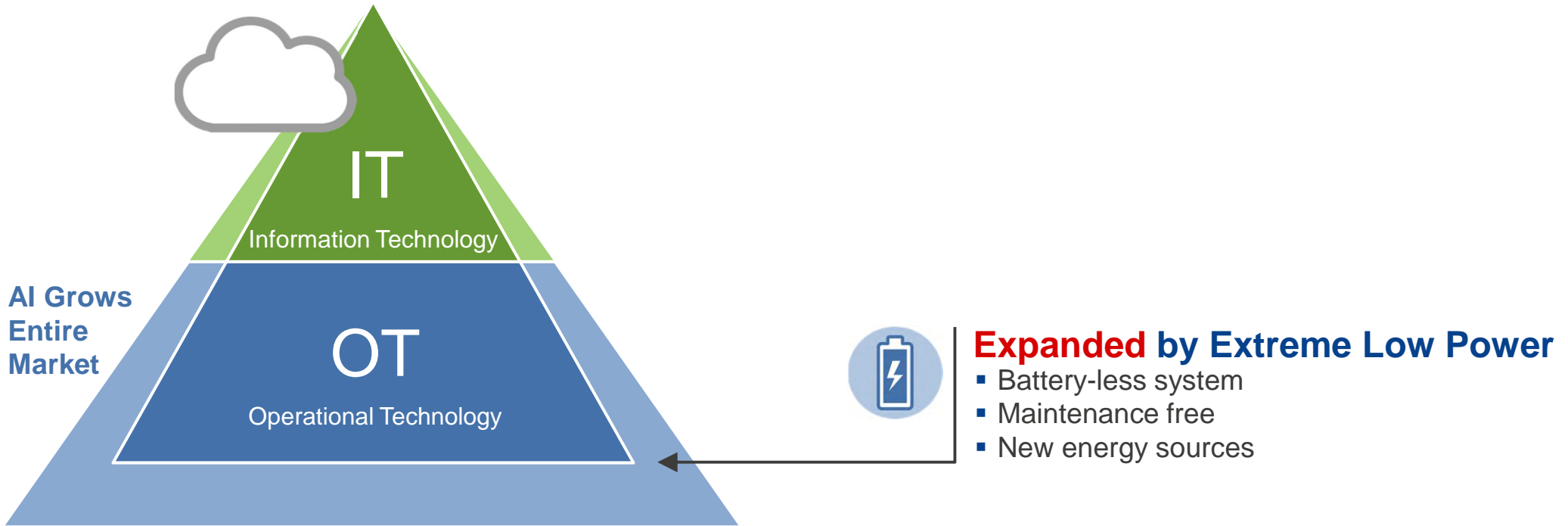


DRP: Dynamically Reconfigurable Processor



# EXPANSION OF ENDPOINT INTELLIGENCE BY EXTREME LOW POWER SOTB TECHNOLOGY

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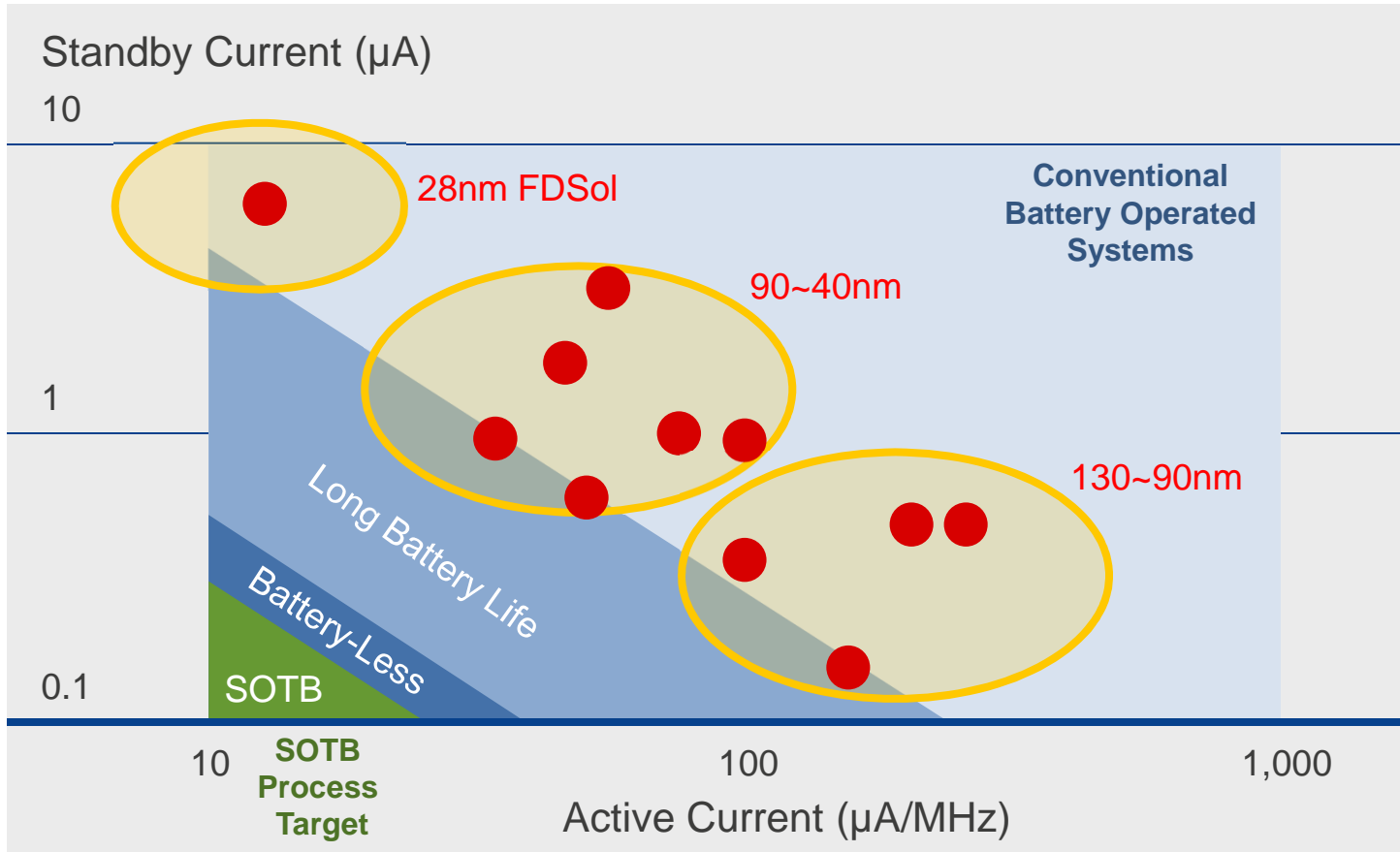
# SOTB TECHNOLOGY





# EXTREME LOW POWER – BY SOTB TECHNOLOGY

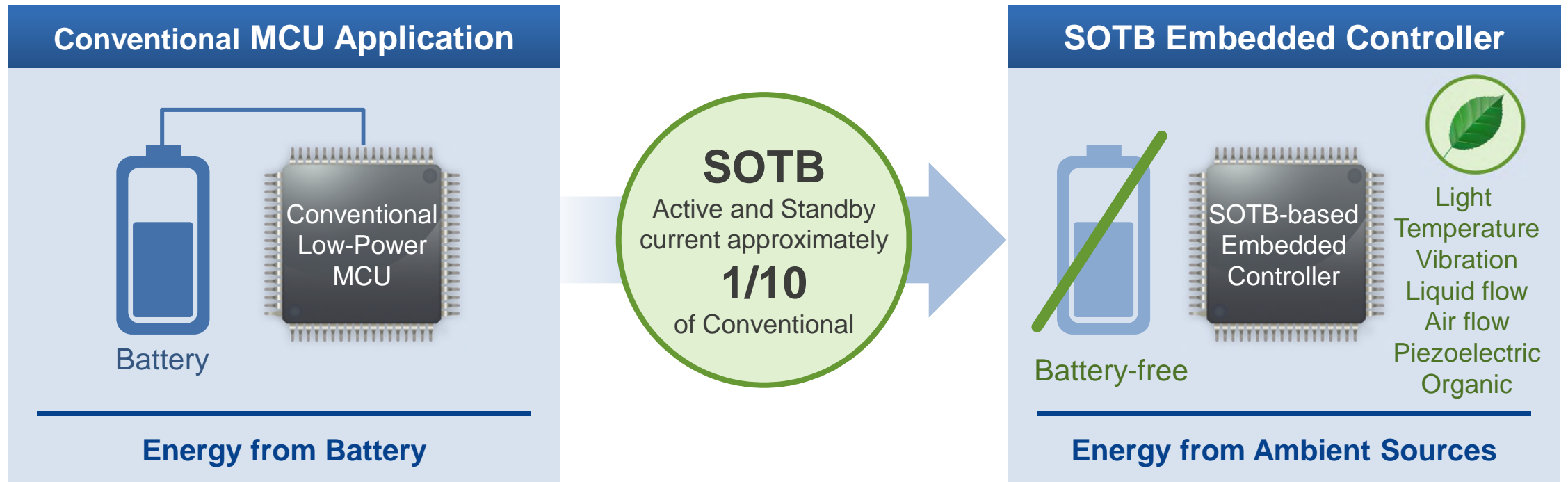
## SOTB ENABLES EXTREME LOW POWER MARKET



- SOTB achieves both:  
Low Active AND Low Standby current
- Other technologies do not achieve both – only one or the other.

# SOTB – FOR EXTREME LOW POWER ENABLES ENERGY HARVESTING IN EMBEDDED SYSTEMS

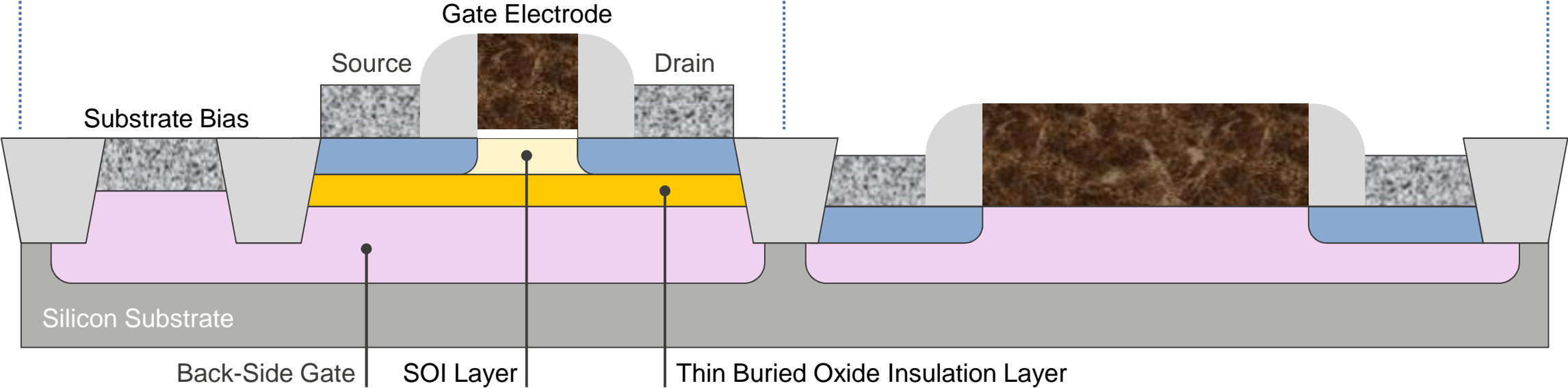
- SOTB – Silicon On Thin Buried Oxide process technology exclusively from Renesas
- Disruptive extreme low power performance



# SOTB – HYBRID STRUCTURE

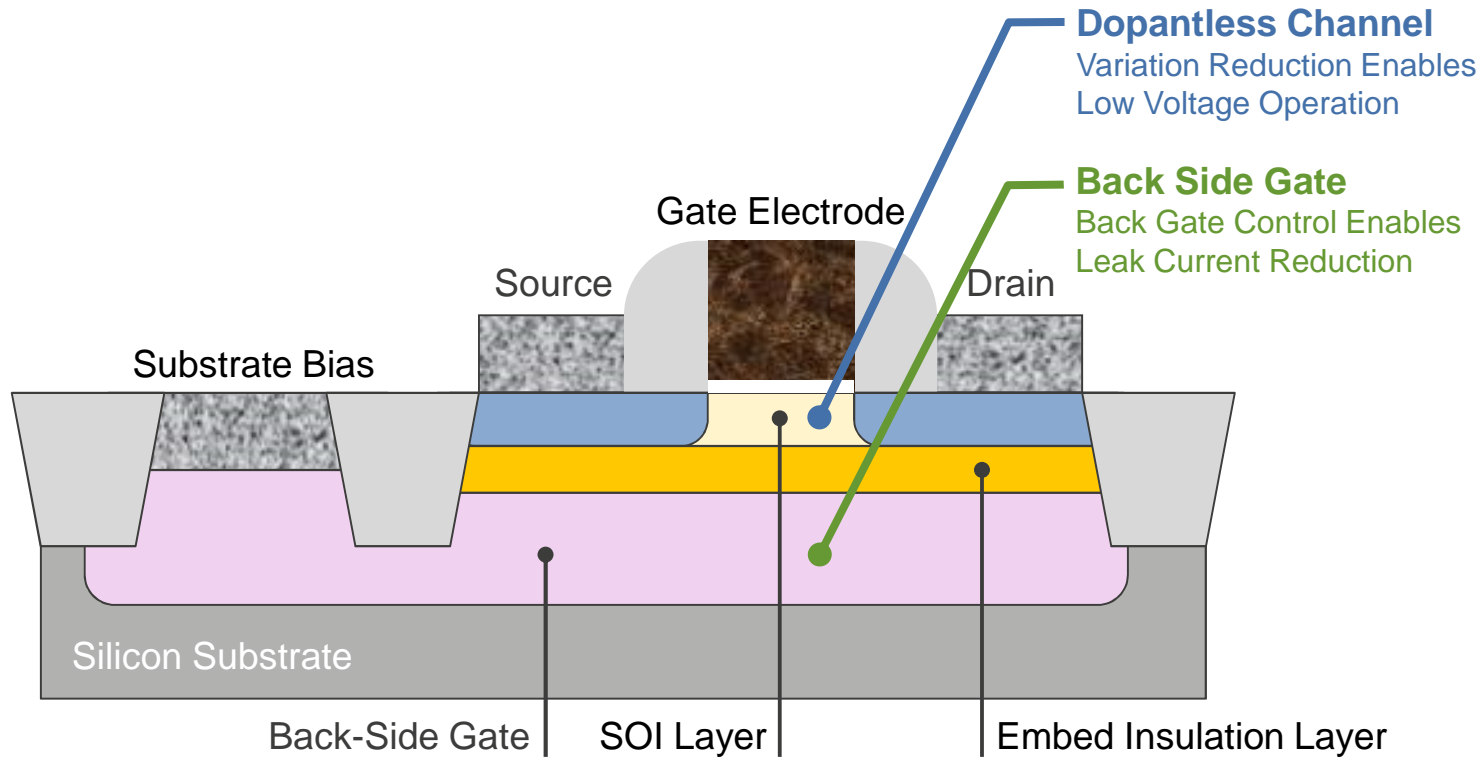
**SOTB: for Extreme Low Voltage**

**Bulk: for I/O, Flash, Analogue**

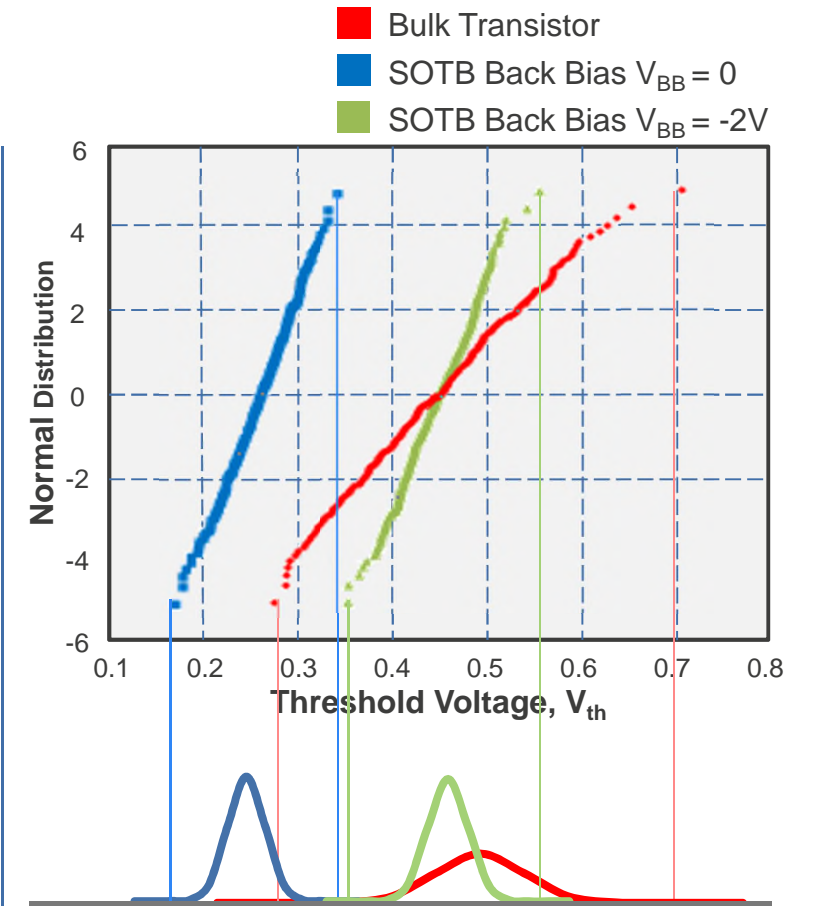


► Hybrid Structure of SOTB and Bulk offers design flexibility to optimize chip performance

# SOTB: SILICON ON THIN BURIED OXIDE ENABLES LOW ACTIVE **AND** LOW STANBY CURRENT



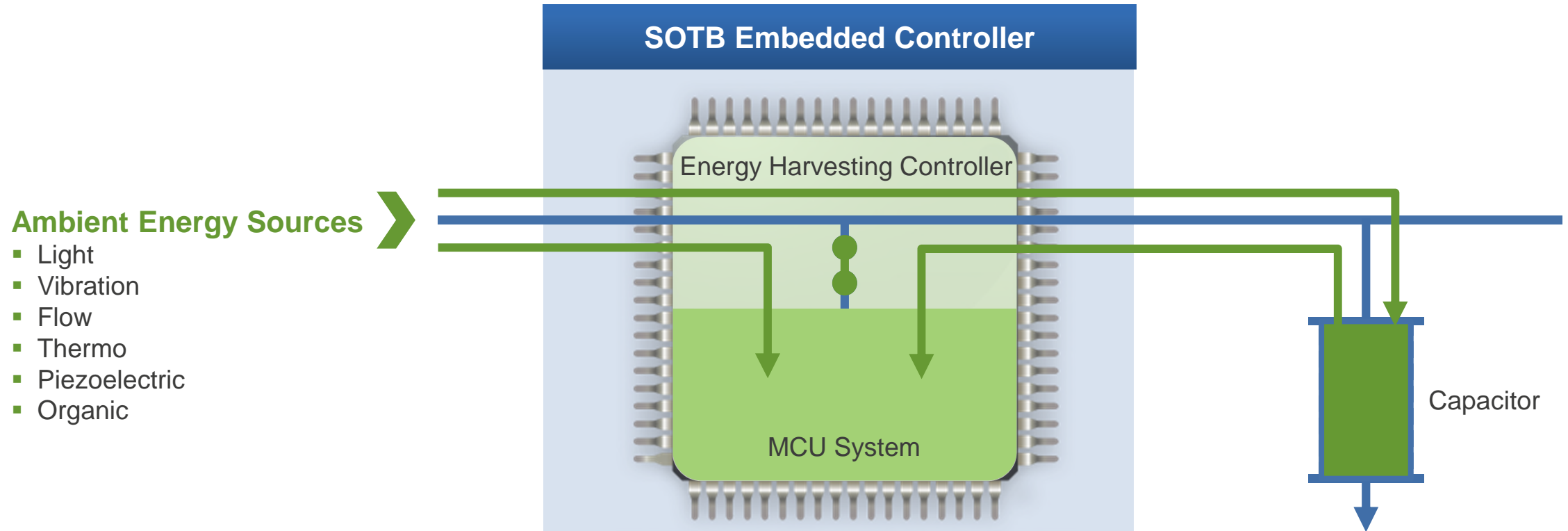
▶ Dopantless Channel and Back Side Bias enable extreme low power consumption of SOTB



Threshold voltage variability measurement from 1 Million transistors on test device.

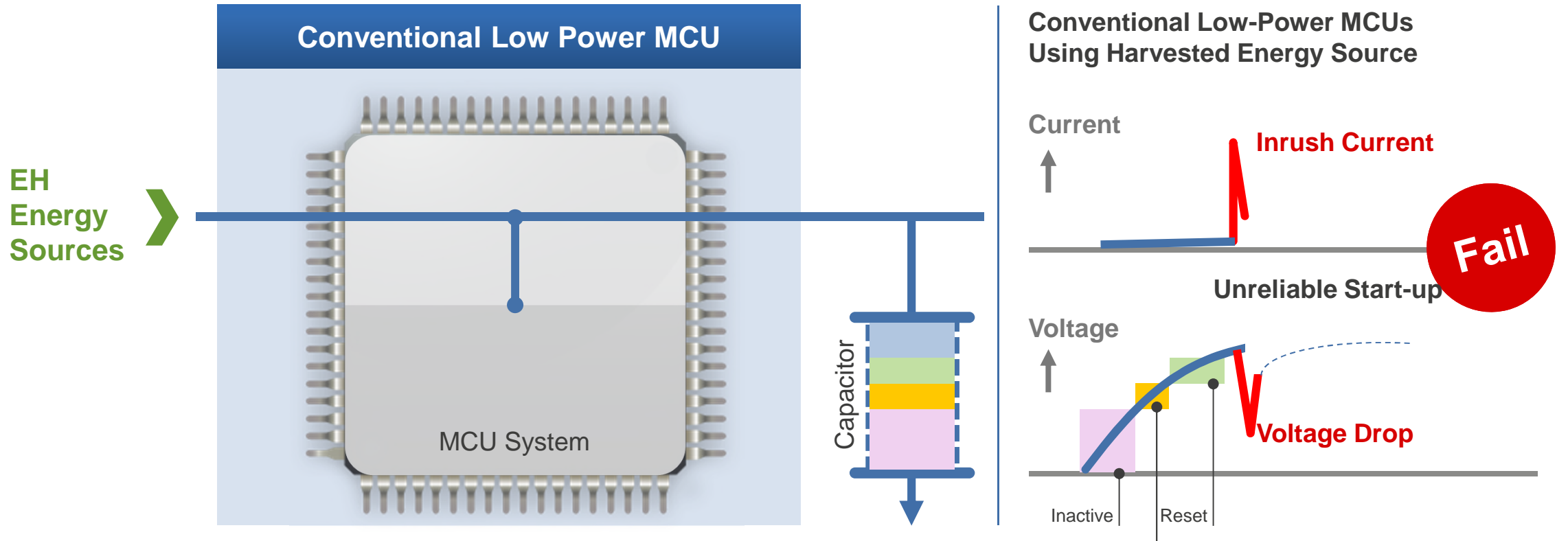
# SOTB – ENERGY HARVESTING CONTROLLER

## MANAGING VARIOUS POWER SOURCES FLEXIBLY



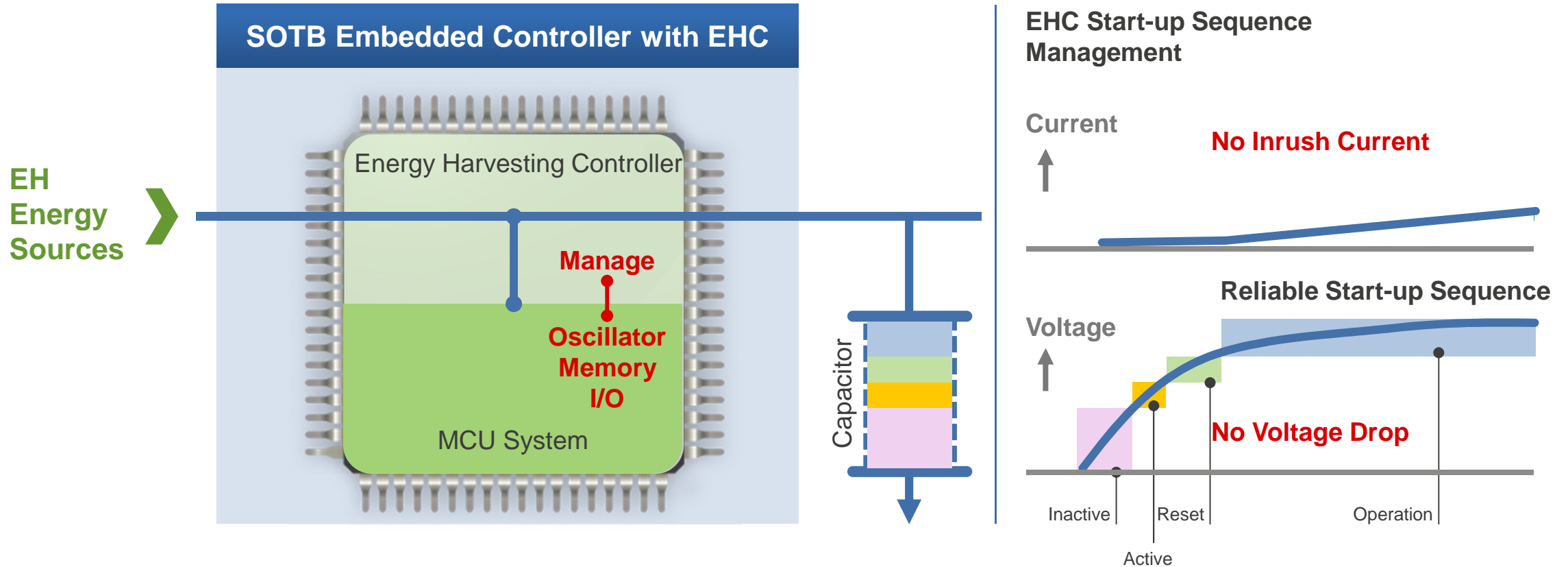
SOTB Embedded Controller manages various power sources flexibly, with minimum external components

# ENERGY HARVESTING SOLUTIONS REQUIRE SPECIAL START-UP HANDLING



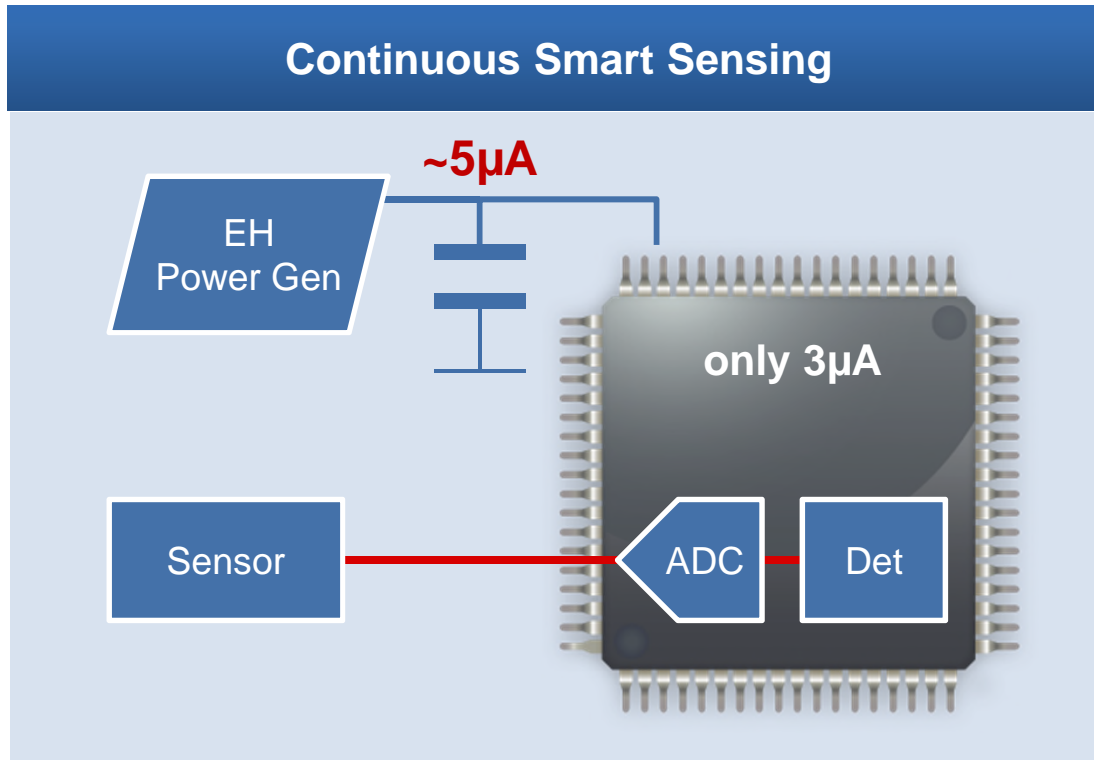
▶ Energy Harvesting systems needs to avoid voltage drop caused by in-rush current

# SOTB AVOIDS INRUSH CURRENT AND VOLTAGE DROP BY INTELLIGENT ENERGY HARVESTING CONTROLLER (EHC)

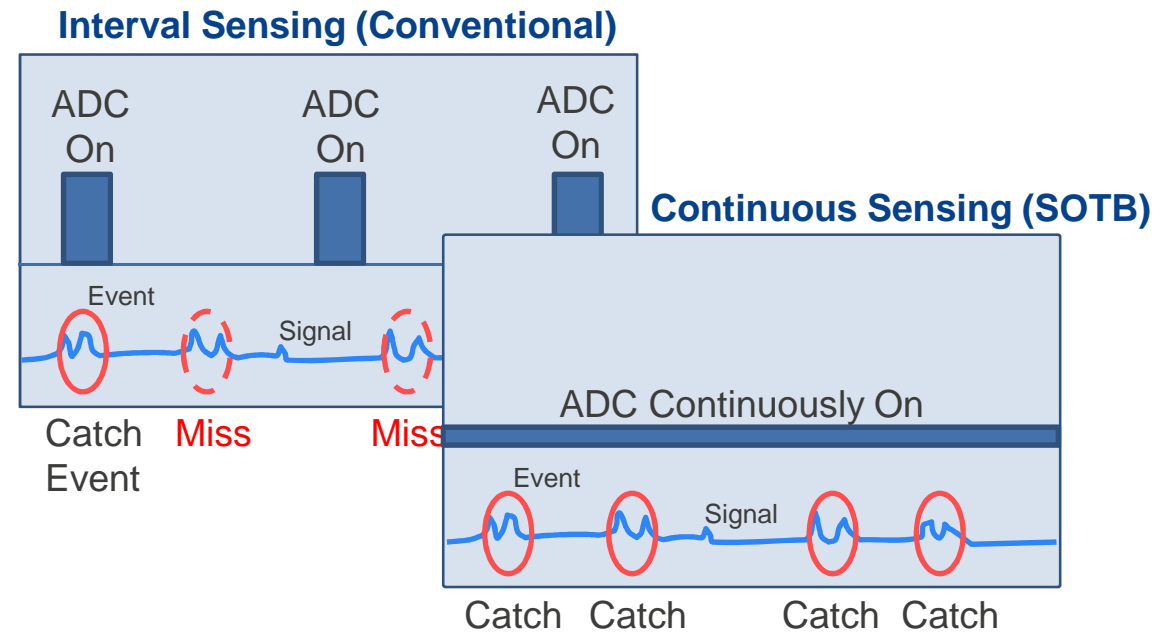


▶ EH Controller manages to prevent inrush current during start-up sequences

# NEW ADC ENABLES CONTINUOUS & ROBUST SENSING



New Analog-to-Digital Converter (ADC), optimized for EH, realizes continuous & robust sensing within 3 $\mu\text{A}$ .



**▶ Robust and Continuous Sensing with EH Power – Never Miss Any Slight Incident**

EH = Energy Harvesting



# R7F0E SOTB EMBEDDED CONTROLLER

## NEW PRODUCT

CPU: Arm Cortex-M0+

Operating frequency: Up to 32 MHz, and up to 64 MHz in boost mode

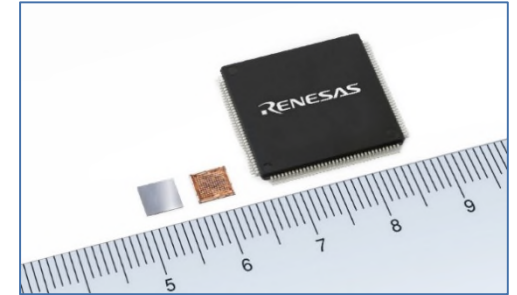
Memory: Up to 1.5 MB flash, 256 KB SRAM

Current consumption

- Active: 20  $\mu$ A/MHz
- Deep Standby: 150 nA with real-time clock source and reset manager
- Software Standby: 400 nA with retention of core logic and 32 KB SRAM data, real-time clock source, reset manager - 1nA/KB consumption

Energy Harvesting Controller (EHC): Interface for direct, robust connection to energy generating devices, and for charge management of energy storage devices

Analog-to-Digital Converter (ADC): 14-bit, 32 KHz clock frequency, 1.6K Samples/sec  
3 $\mu$ A consumption



➤ **Extreme Low Power**  
Both Active and Standby

➤ **Excellence Function**  
Towards Intelligent EH

➤ **Continuous and Robust**  
Smart Sensing with only 3 $\mu$ A

# DEVELOPMENT ECOSYSTEM

## R7F0E EMBEDDED CONTROLLER

### Complementary Software Support

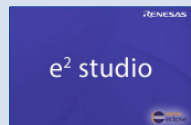


- CMSIS Core and CMSIS-Driver
- HAL Drivers
- Trusted Secure IP(TSIP) API

### Tool Support



- IAR Embedded Workbench
- IAR Compiler Support
- I-Jet Debugger Support

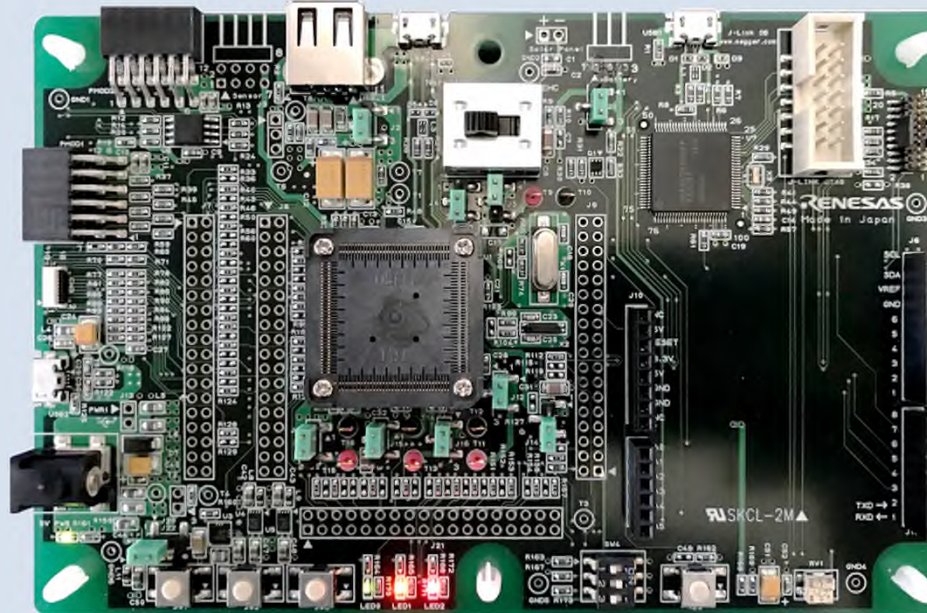


- Renesas e<sup>2</sup> studio
- GNU GCC Compiler Support



- J-Link Debugger
- J-Link OB Support

### SOTB Evaluation Board (SDK)



**RTK70E015DC02000BJ**  
(under development)

- Energy Harvesting
- MIP LCD Support
- Low IQ Buck Converter
- Arduino Interface
- PMOD Interfaces
- USB Host Full-Speed
- J-Link OB Support

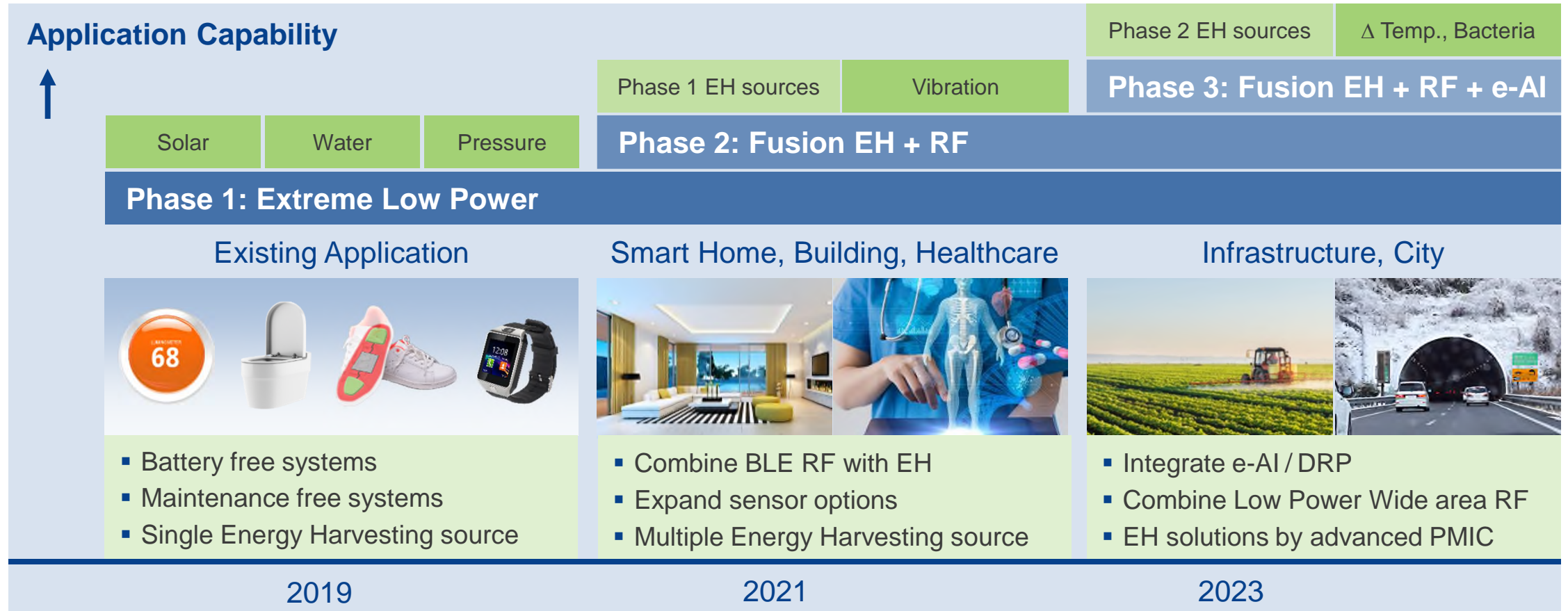
# APPLICATION USE CASES ARE EXPANDING

## EXTREME LOW POWER – MARKET GROWTH POTENTIAL

Medical / Healthcare	City / Infrastructure	Industrial / Automation	Energy Management	Gadget / Home Devices / ...	
 Fitness Wearable	 Smart Agriculture	 Urban Environment	 Equipment Monitor	 Controller	 Gadget
 Portable Device	 Public Facility	 Home/Office Security	 Worker Monitor	 Lighting	 Home Device
 Capsule Device	 Transportation	 Natural Environment	 Smart Tags	 Meter	 Sports & Outdoor
 Smart Watch	 Aquatic Product	 Monitoring			

# ROADMAP OF EXTREME LOW POWER

## CONNECT TO EVERYWHERE – BY SOTB TECHNOLOGY



EH = Energy Harvesting    RF = Radio Frequency    BLE = Bluetooth Low Energy    PMIC = Power Management IC

# ENERGY HARVESTING ECOSYSTEM

## R7F0E EMBEDDED CONTROLLER

### Sensor Fusion

Magnetic Sensor

Temp. Sensor

Pulse Sensor

CO<sub>2</sub> Sensor

Accelerometer

ECG

Gyro Sensor

Pressure Sensor

Humidity Sensor

### Power Storage

EDLC

Lithium

LTO

### Radio

Wi-Fi  
BLE  
LoRa™  
LPWA

SOTB-based Embedded Controller

### Power Generator

Solar

Hydro

Thermoelectric

Rubber

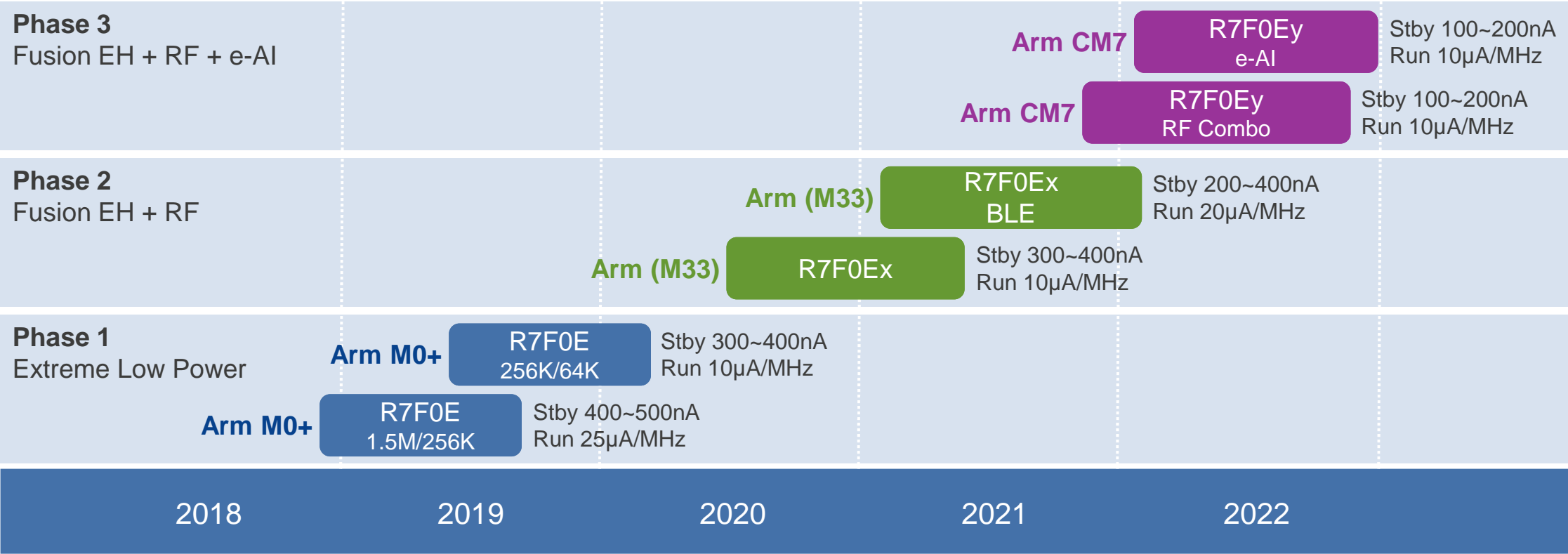
Vibration

Textile

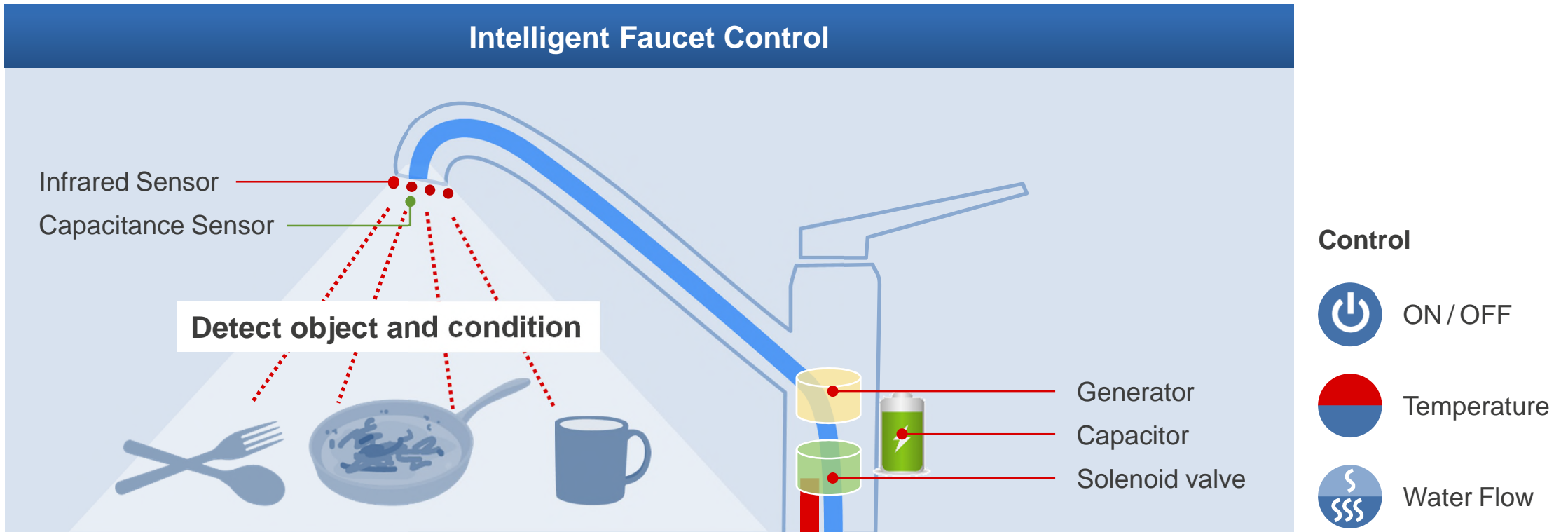
Bacteria

# SOTB R7F0E PRODUCT ROADMAP PLAN

■ Under Development   
 ■ Under Planning   
 ■ Under Consideration

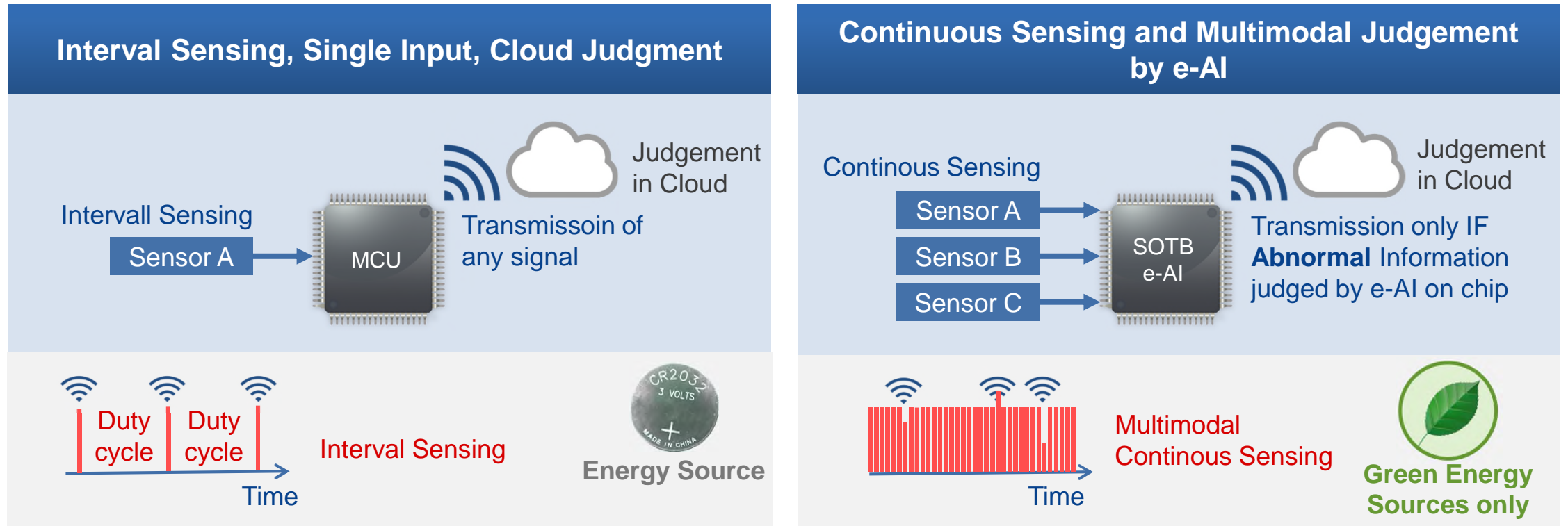


# COMBINATION OF SOTB AND e-AI EXPANDS MARKET



▶ Extreme Low-power SOTB with e-AI enables Endpoint Intelligence.

# COMBINATION OF SOTB AND e-AI EXPANDS MARKET



▶ Intelligent, autonomous, maintenance-free powered by Energy Harvesting



# TAKE AWAY

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Extreme Low Power  
Both Active  
and Standby

Energy Harvesting  
Controller  
Excellence

Continuous  
Sensing  
with EH Power

Leader of  
Energy Harvesting  
Market

Please visit us in Hall B4, Booth 556



# Renesas – Endpoint Intelligence