

## Self-powered RadioTechnology for Building Automation Systems

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#### EnOcean Technology History







enocean®



- 1995-2001: Energy harvesting research projects at Siemens Corporate Technology
- 1997: 1st patent for energy harvesting powered wireless sensors
- 2001: EnOcean company spin-off from Siemens by management
- 2003: 1st generation products shipped to customers and installed in buildings
- 2006: 2nd generation energy harvesting products
- 2008: EnOcean Alliance founded to internationalize & standardize technology & to educate users
  - 2010: >40 patent families, several 100.000 buildings deployed by >150 OEMs offering >450 final products, introduction of 3rd Generation Platform

## Energy Harvesting Wireless - Application Areas



## Building Automation

Lighting, Heating, Cooling, Ventilation, Security, Metering ...

#### Industrial Automation

Condition Monitoring, Process Optimization, Control, Metering, Switching, ...

#### Automotive & Aviation

Condition Monitoring, Switching, ...















#### Medical

Temperature, Blood Pressure, Heart Beat, Monitoring, ...

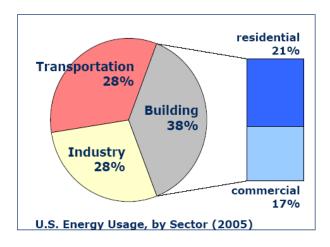


Energy Harvesting Wireless – Building Automation



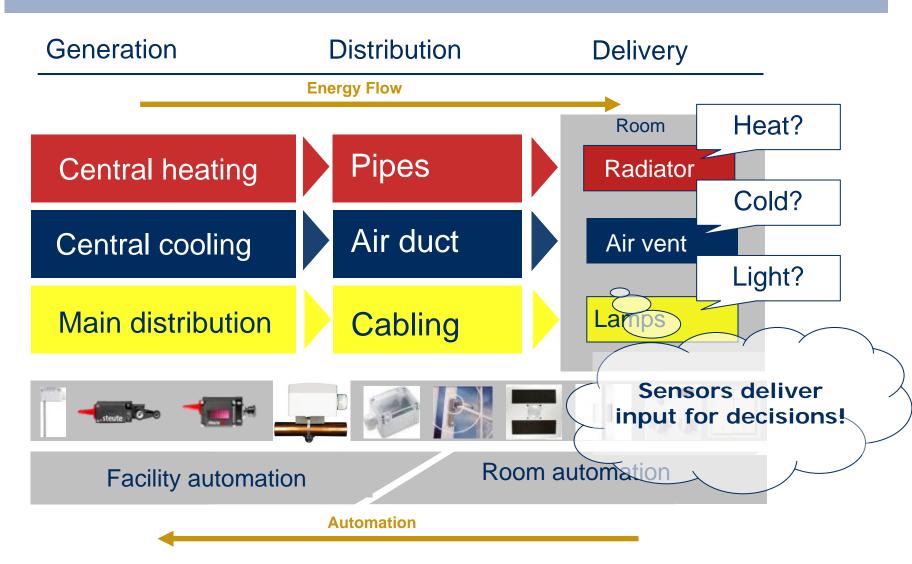
- Buildings Use 38% of our Total Energy Requirements
- Energy Use Set to Double between 2003 and 2030
- You can Save 30% with Building Automation Systems





### Sensors are essential for Building Automation





#### Self-powered Wireless Sensor Technology



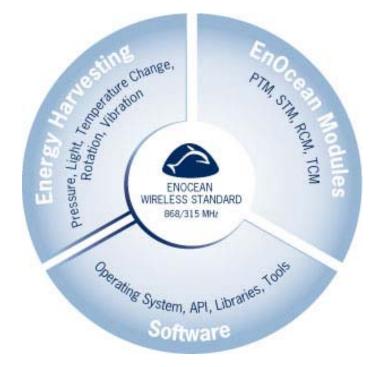
Ambient Energy: Motion, Temperature, Light, *Rotation, Vibration* 



Temperature, Pressure, Position, Movement, Air quality etc.

#### EnOcean System Architecture





#### **Energy Harvesting**

Self-powered wireless sensors from EnOcean collect and save the tiniest amounts of energy from their environment

#### **Enocean Modules**

- Easy to integrate
- For fast and low-cost equipment development

#### Software

- A Powerful & Easy to Use Operation System
- For modular and versatile, user-friendly integration in applications

#### **Enocean Wireless Standard**

868 & 315 MHz

### The best suited radio frequency - in buildings



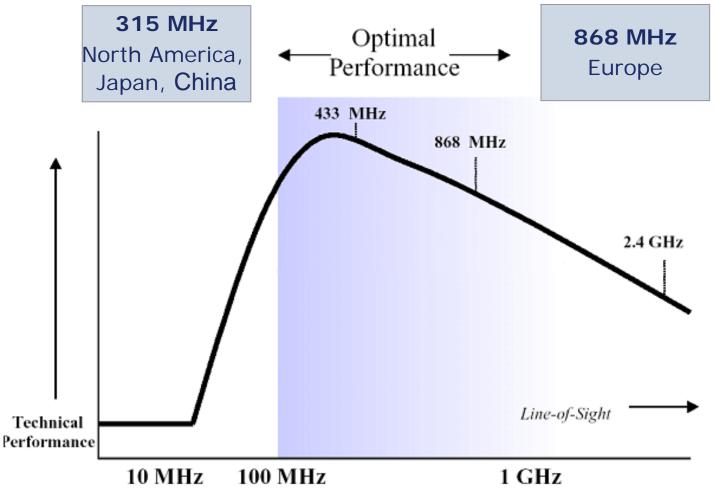


Figure 1. Frequencies between 100 MHz and 1 GHz offer the best technical performance for Active RFID.

### Energy Converters – in Detail





**ECO 200** 



#### User-independent energy conversion with button press

Mechanical: Energy by fingertip

Maintenance free 50.000 operations

Electrodynamic Energy Generator

Allows small and flat rocker designs



#### Solar: natural and indoor light

- Small solar cell 13x35mm (20x50mm) with energy storage
- Energy harvesting with "quick start"
- Function follows design

**ECT 310** 

#### Thermal: 2 Kelvin @ Peltier

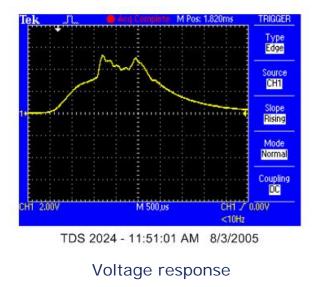
- EnOcean ultra low power DC/DC converter for standard peltier elements
- Maintenance free, full integration possible
- Allows energy harvesting actuators

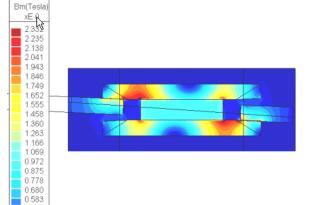


#### Mechanical Energy: Linear Movement and Button Push

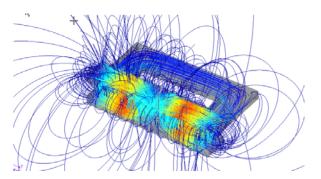


#### EnOcean ECO 200 converter module





FEM-Simulation magnetic flux density within iron core



FEM-Simulation of external magnetical field



## Mechanical Energy: Linear Displacement and Button Push





Technical Data Button Push Converter							
Operating Force (N)	5						
Displacement (mm)	1,5						
Mechanical Input Energy (µWs)	7500						
Electrical Output Energy (µWs)	350						
Efficiency	4,67%						
Radio							
Frequency (MHz)	315 or 868MHz						
RF Power (dBm)	6						
Modulation	FASK						
Data Transmission							
Number of Repetitions	35						
Single Telegram Duration (ms)	0,6						
Information Content (Bits)	60						

## Mechanical Energy Harvesting Product Examples

















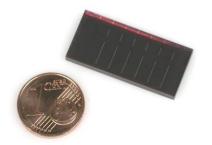


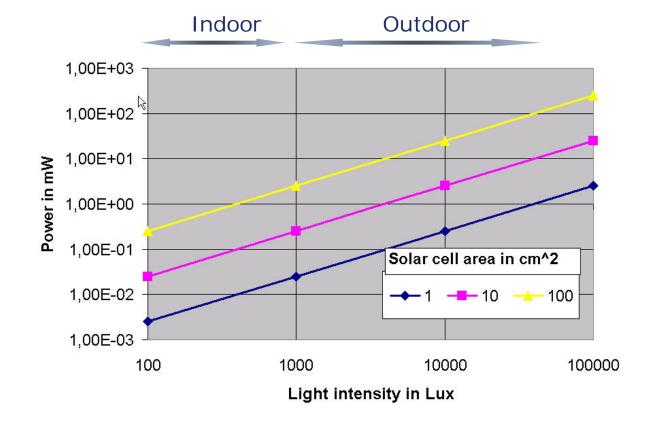




## Light Energy



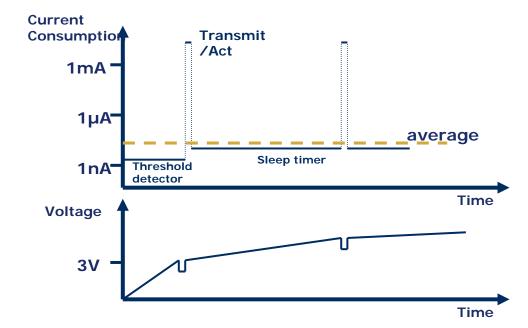




#### Attainable power from low-cost thin film solar cells

#### Energy Management & Storage





- Very short working periods of active components like CPU and RF (below 1ms)
  - Optimized timers and threshold detectors with very low standby current (20-100nA)
- Efficient DC/DC converters and impedance adaptation
- Efficient long time storage for electrical energy

#### Light Energy -Solar Powered Radio Sensor Module

#### Complete plug and play sensor system

- Small solar cell
- Energy storage
- Ultra-low-power timer
- Signal scanning and evaluation
- Radio transmission
- Designed for ultra low power consumption, e.g. 20 nA sleep timer.
- 5 days function with no light





EnOcean STM 110 Solar Sensor Module

## Light Energy Harvesting Product Examples

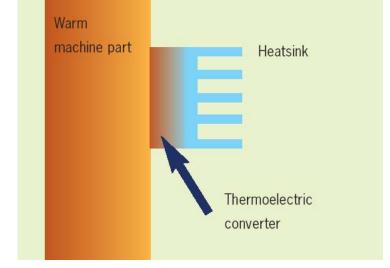




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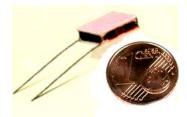
## Thermo Energy - Challenges





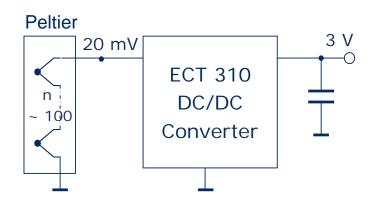
#### Concept:

Standard component usage for short development cycles and low cost



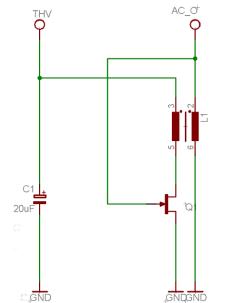
Challenge: Low cost thermoelectric elements produce only tiny voltages

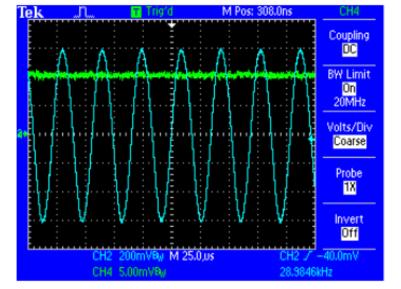
#### Solution:



## ECT 310 - Working Principle

New converter concept – Highly optimized blocking oscillator for very low voltages





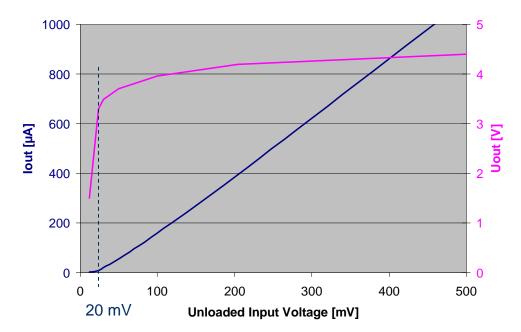




#### ECT 310 - Conversion Characteristics



- Input voltage larger than 20 mV is converted to an output voltage > 3 V
- Efficiency  $\approx$  30 % at 25 mV

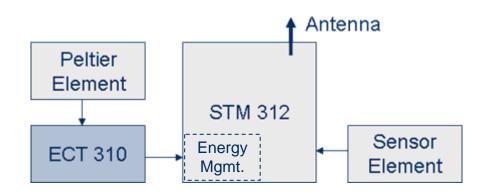


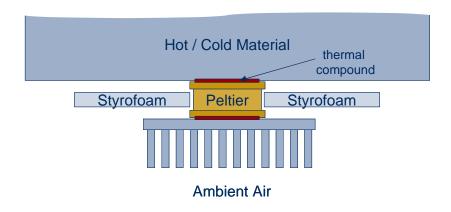
Output of ECT310 versus Input

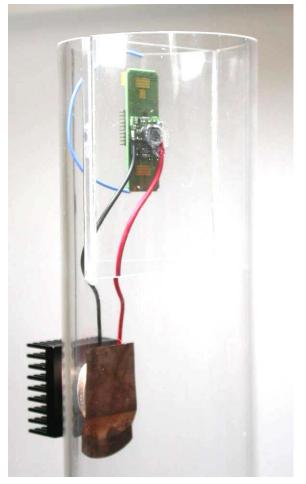
Energy source impedance = Peltier element impedance (around 1.5 Ohm)

## Sensor powered by temperature difference







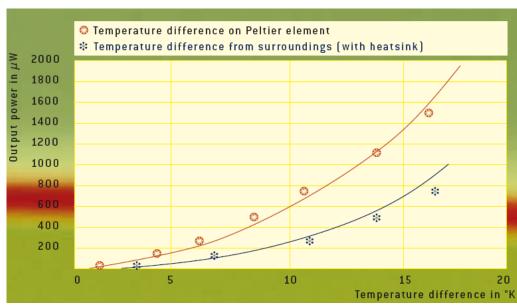


#### Self-powered air flow temperature sensor

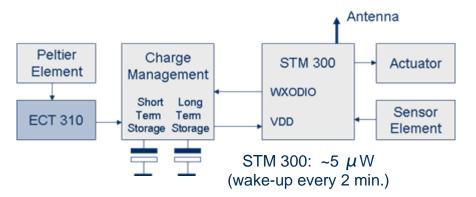
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#### Thermo-powered Wireless Actuator



~100  $\mu$ W energy available at 7 Kelvin temperature difference





## Enough energy is left even to power some actuators !

## Energy Harvesting Sources for Wireless Sensors





#### Products available

- Linear Motion
- Solar
- Thermal

#### Prototypes

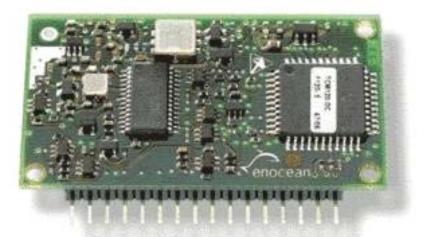
- Vibrations
- Rotation

#### **Unlimited Possibilities**

- Daily temperature changes
- Air pressure changes
- Radio waves
- Muscle contraction
- Blood sugar fuel cells

#### Bi-directional radio solutions based on Dolphin



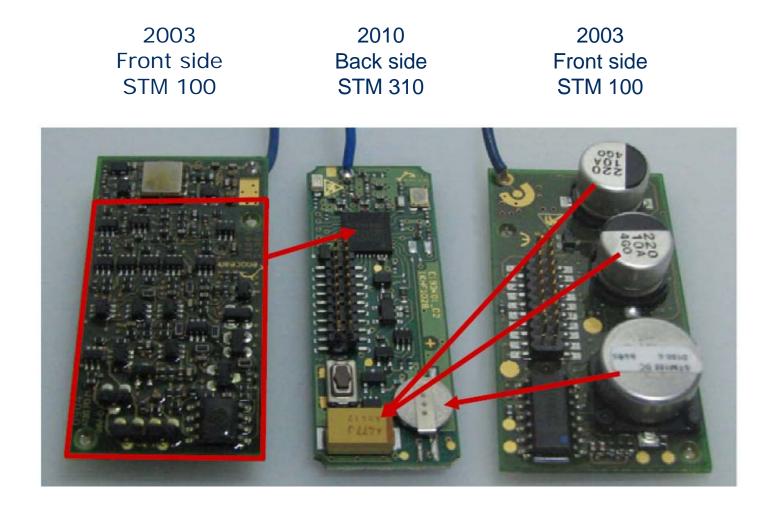




Generation 1 (2004): Discrete components on both PCB sides, 42 x 24 x 5 mm, 5V, 33 mA Generation 3 (2009): SMD device, 22 x 19 x 3 mm, 2.5V, 27 mA

## All-in-one sensor solution based on Dolphin







## STM 310 Family: All-in-one solution for battery-less radio sensors

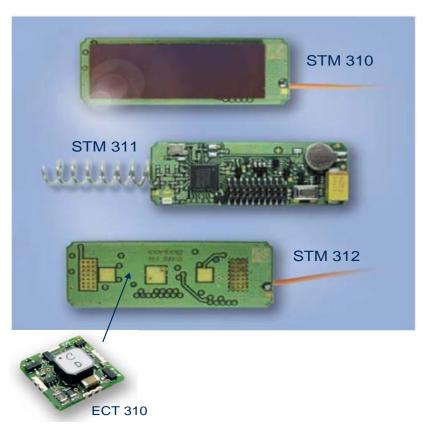
- Energy storage and management Typical 4 days without energy supply
- Processor for data processing Preinstalled Firmware, programmable
- Analogue & digital measurement inputs 3 x analog (e.g. 10/8/6 bit), 3 x digital
- Software stack for radio protocol Equipment profiles according to EEP 2.0 spec
- RF transmitter with integrated antenna 868 MHz or 315 MHz, Whip or Helix



STM 330 Temperature Sensor



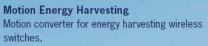




## Energy Harvesting Wireless: EnOcean Overview







Solar cell for energy harvesting wireless sensors.

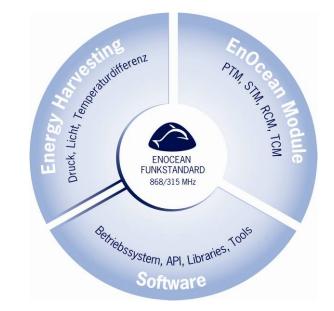
Solar Sensor Module







Thermo Energy Harvesting Thermo converter for energy harvesting wireless sensors.





STM 300 - ideal for bidirectional energy harvesting wireless sensors



STM 310 series – ideal as platform for energy harvesting wireless sensors



TCM 300/TCM 320 – ideal for permanently powered system components

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## EnOcean Alliance - Standardization



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#### EnOcean – the wireless standard for sustainable buildings

- Over 160 product manufacturers
- With over 600 interoperable products
- Deployed in >> 100,000 buildings

#### EnOcean Equipment Profiles v2.1

- Interoperability of products
- Connectivity to BAM systems
- Application Layer



#### IEC Standardization

Physical Layer

## Connectivity & Interoperability



Lighting Controls



#### Heating & Cooling Systems Sensors



#### Building Automation Systems Gateways







# Thank you for your attention.

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