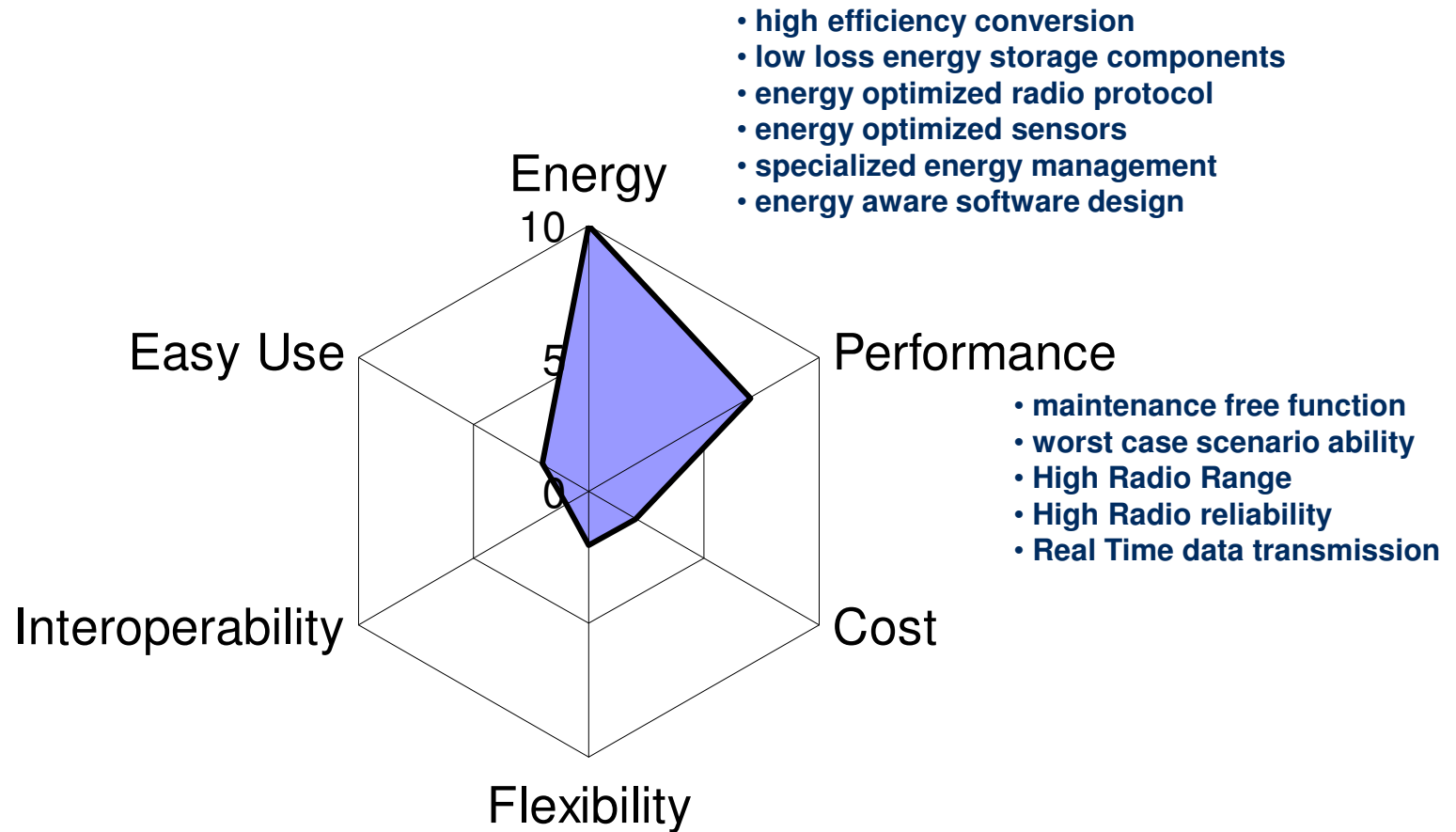# Energy Harvesting Radio Sensors for Building and Industrial Automation

Energy Harvesting 2012
London, 28th March

Frank Schmidt,
CTO & Founder
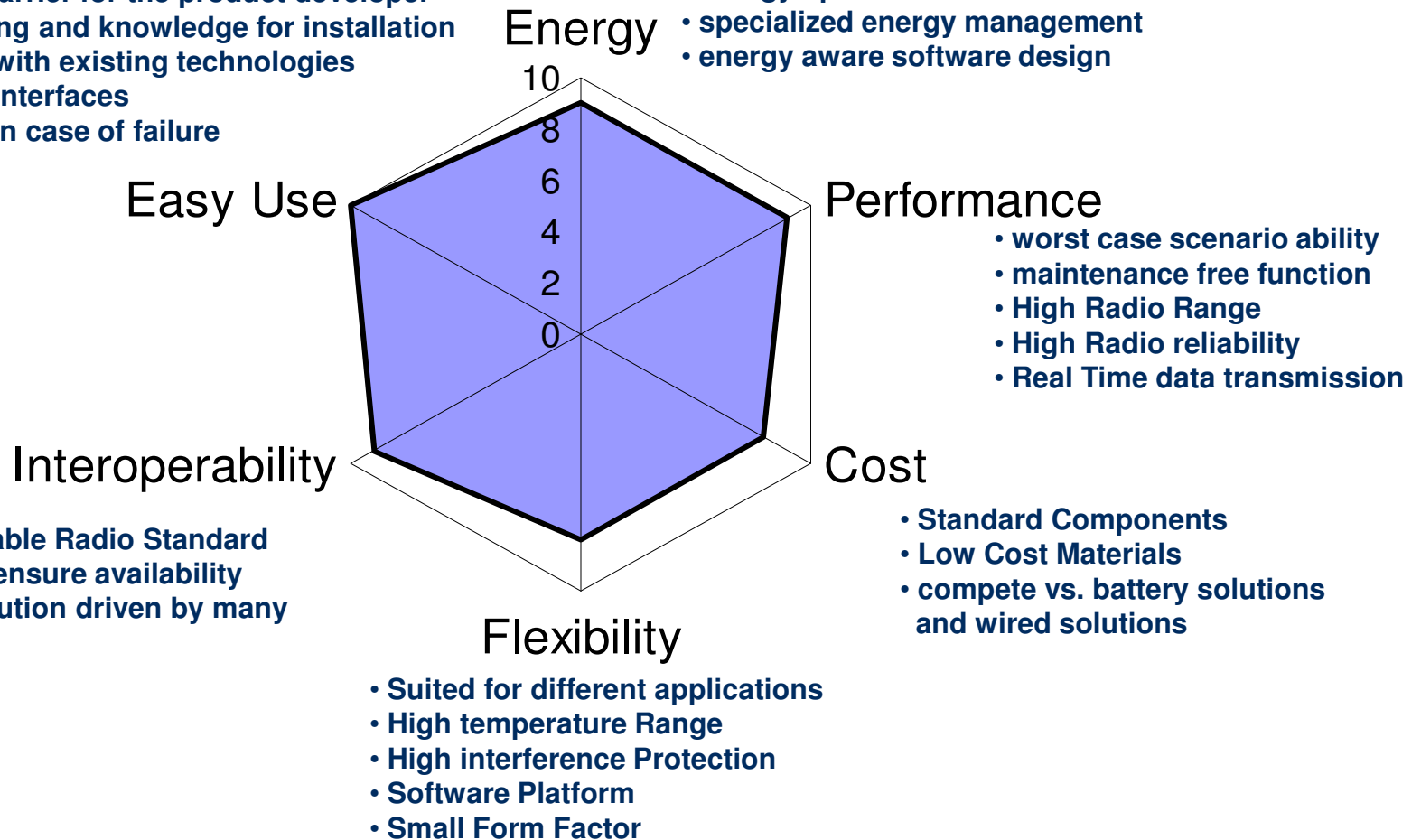
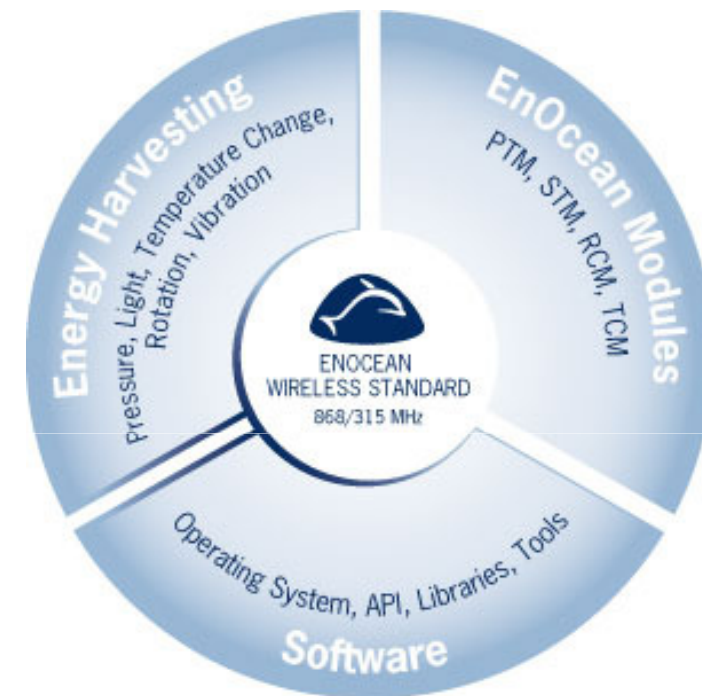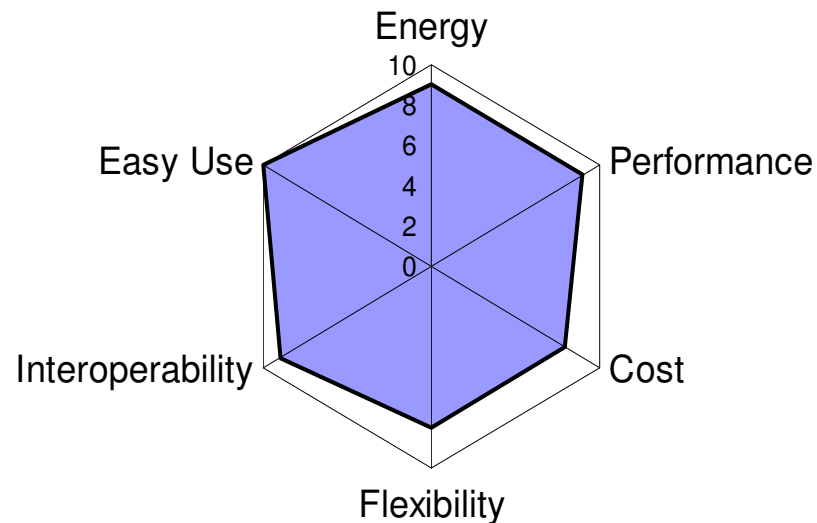# Typical Feasibility Study Optimization

- **high efficiency conversion**
- **low loss energy storage components**
- **energy optimized radio protocol**
- **energy optimized sensors**
- **specialized energy management**
- **energy aware software design**

Energy

Performance

- **maintenance free function**
- **worst case scenario ability**
- **High Radio Range**
- **High Radio reliability**
- **Real Time data transmission**

Easy Use

10

5

0

Interoperability

Cost

Flexibility

Market Driven Optimization for a Competitive Product

Green.Smart.Wireless.
enocean

• **high efficiency conversion**
• **low loss energy storage components**
• **energy optimized radio protocol**
• **energy optimized sensors**
• **specialized energy management**
• **energy aware software design**

• **Low Innovation barrier for the product developer**
• **Low level of tooling and knowledge for installation**
• **Easy integration with existing technologies**
• **standard sensor interfaces**
• **Easy debugging in case of failure**

Radar chart with axes: Energy (top, scale 0,2,4,6,8,10), Performance (right upper), Cost (right lower), Flexibility (bottom), Interoperability (left lower), Easy Use (left upper)

• **worst case scenario ability**
• **maintenance free function**
• **High Radio Range**
• **High Radio reliability**
• **Real Time data transmission**

• **Really interoperable Radio Standard**
• **Many Vendoors ensure availability**
• **Technology evolution driven by many**

• **Standard Components**
• **Low Cost Materials**
• **compete vs. battery solutions and wired solutions**

• **Suited for different applications**
• **High temperature Range**
• **High interference Protection**
• **Software Platform**
• **Small Form Factor**

System Approach – Key to Market

- Generic Development Platform
- „Construction Kit", Containing all innovative Parts
- Software API for maximum flexibility
- Low Cost reliable energy converters & storage
- International standardized Radio protocol and sensor profiles
- Developer tools and product design support
- Installers: planning tools, debugging tools, teaching

EnOcean Energy Converters – some Details
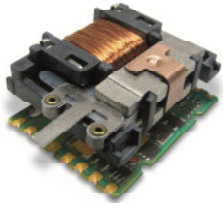
Mechanical: Energy from Movement

■ Electrodynamic Energy Generator

■ Energy conversion from a button press

■ Maintenance free > 1.000.000 operations

■ > 120 µWs per actuation, > 20%efficiency

■ Allows small and flat switch designs

ECO 200

Solar: natural and indoor light

■ Small solar cell 13x35mm with energy storage

■ Energy harvesting with 'quick start' and continuous operation
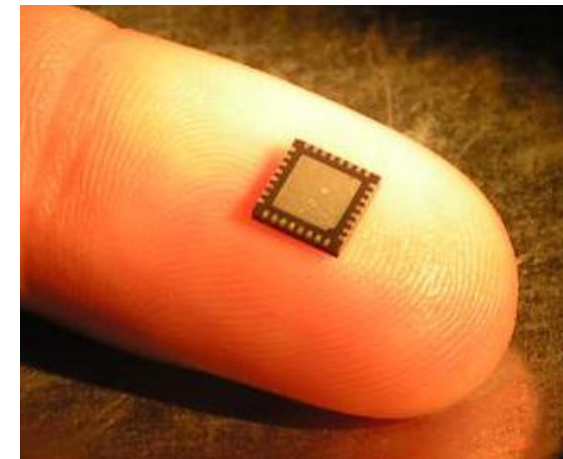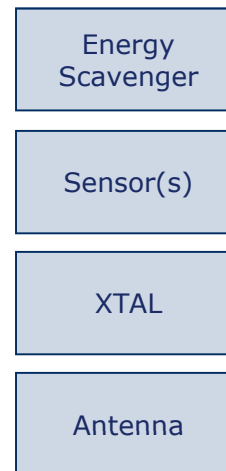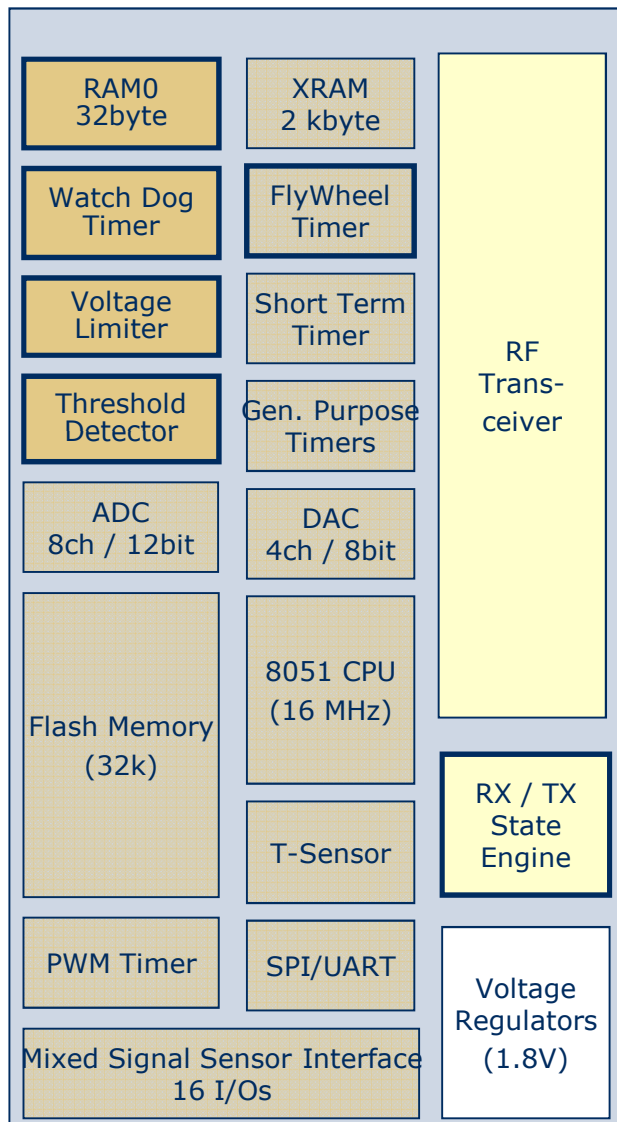
■ Operation starting at 50 Lux, >5% efficiency

ECS 200

Thermal: Peltier

■ Standard peltier element in combination with EnOcean ultra low power DC/DC converter

■ Operation starts at dT of only 2K (<20 mV)

■ Maintenance free, full integration possible

■ Enough energy for harvesting actuators!

ECT 310

# Electronics for 3rd Generation Devices: Dolphin Single Chip Solution

Green.Smart.Wireless.
enocean®

RAM0 32byte	XRAM 2 kbyte	
Watch Dog Timer	FlyWheel Timer	
Voltage Limiter	Short Term Timer	RF Trans-ceiver
Threshold Detector	Gen. Purpose Timers	
ADC 8ch / 12bit	DAC 4ch / 8bit	
Flash Memory (32k)	8051 CPU (16 MHz)	
	T-Sensor	RX / TX State Engine
PWM Timer	SPI/UART	
Mixed Signal Sensor Interface 16 I/Os		Voltage Regulators (1.8V)

- Energy Scavenger
- Sensor(s)
- XTAL
- Antenna

Superior Low Energy Need

- **OFF Mode**   **~20nA**
- **Deep Sleep Timer Mode**   **~200nA**
- **Flywheel Sleep Mode**   **~500nA**
- **Short Term Sleep Mode**   **~15µA**
- **Standby Mode**   **~1.3mA**
- **CPU Mode**   **~4mA**
- **TX (868MHz, 10dBm)**   **~25mA**
- **RX (868MHz)**   **~28mA**

- **Fast operation mode changes**
- **Only a few additional components needed**

Dolphin API – Application Programmable Interface
## More than a protocol stack
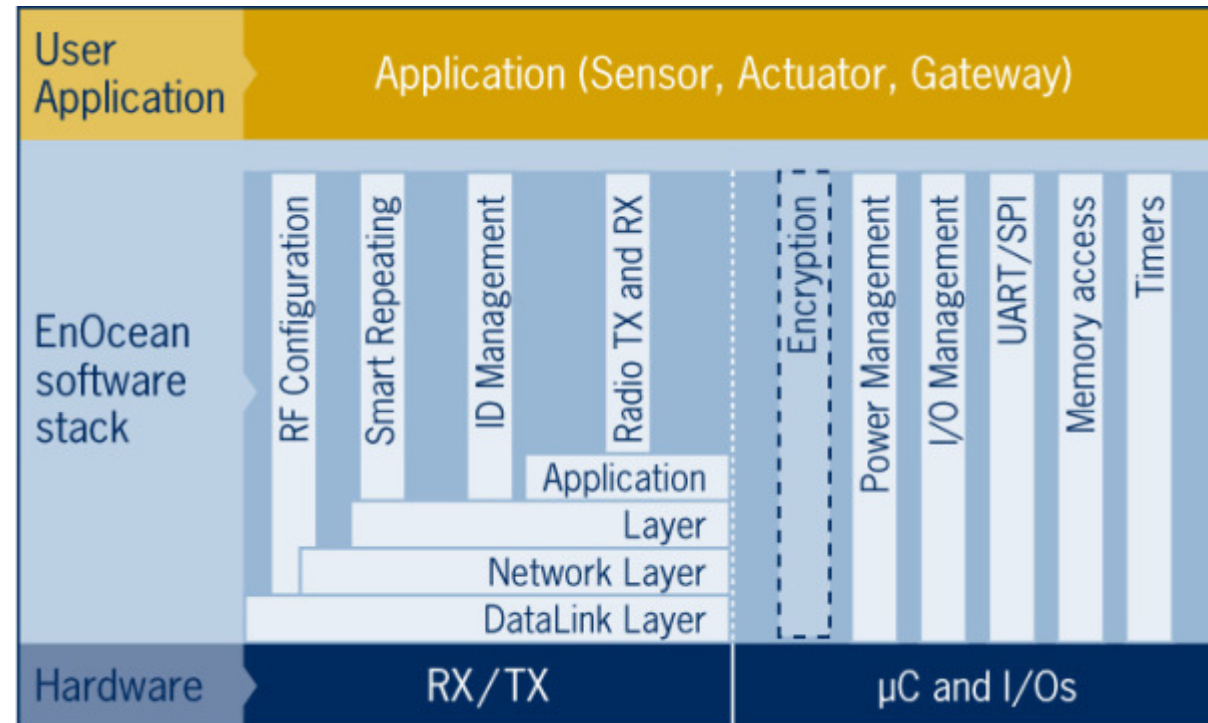
- Plug&Play firmware for TCM and STM modules (pre-programmed modules)
- Comprehensive functions library: BASIC API (RF communication, ID management, Power management, etc.) + ADVANCED API (Remote Mgmt., Smart Ack, etc.)
- Very easy programming of user applications in C-language, based on sample programs
- Tools for simple start-up, easy programming and system integration

STM 310 / 311 / 312
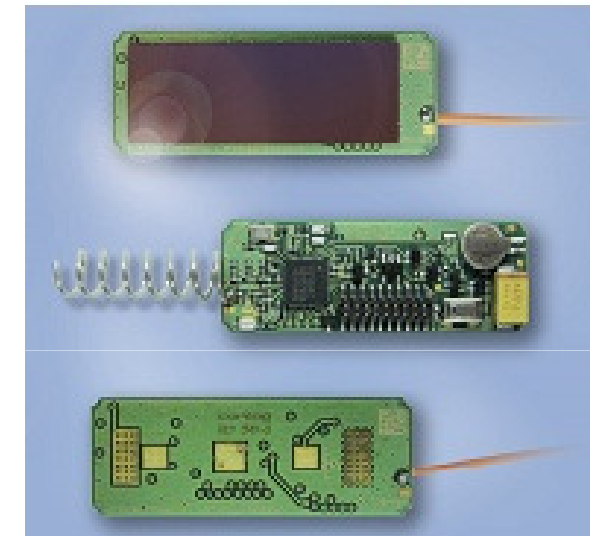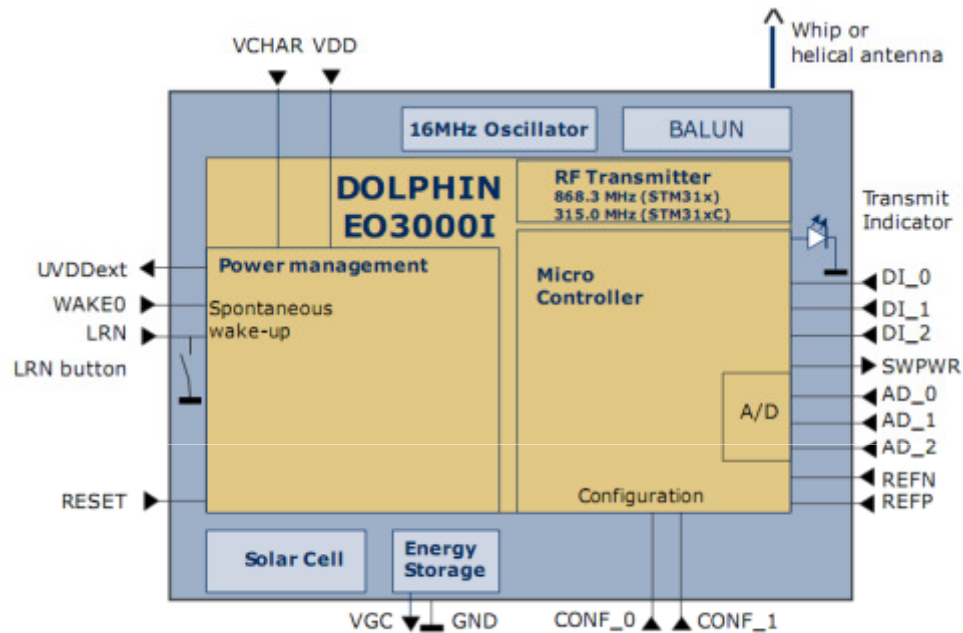
- Standard Software already installed
- 3 analog inputs
- 3 digital inputs
- On board sensors for temperature (calibrated) and magnet contact
- plug for other sensors, e.g. humidity
- up to 10 days operation in darkness (5 min sensing,15 min transmissions scenario)
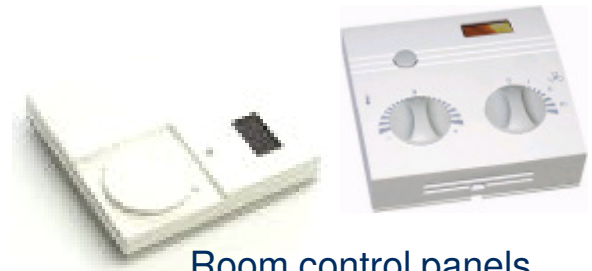
Modular Approach for Market Optimization

Green.Smart.Wireless.
enocean®

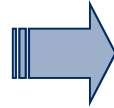Outdoor Temp. Sensor

Duct Temp. Sensor

Room control panels
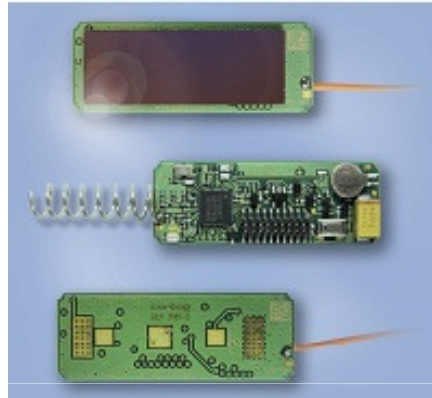
Solar Powered
Sensor Module STM 3XY

Industrial Temp. Sensor

gas sensor (CO, CO2)

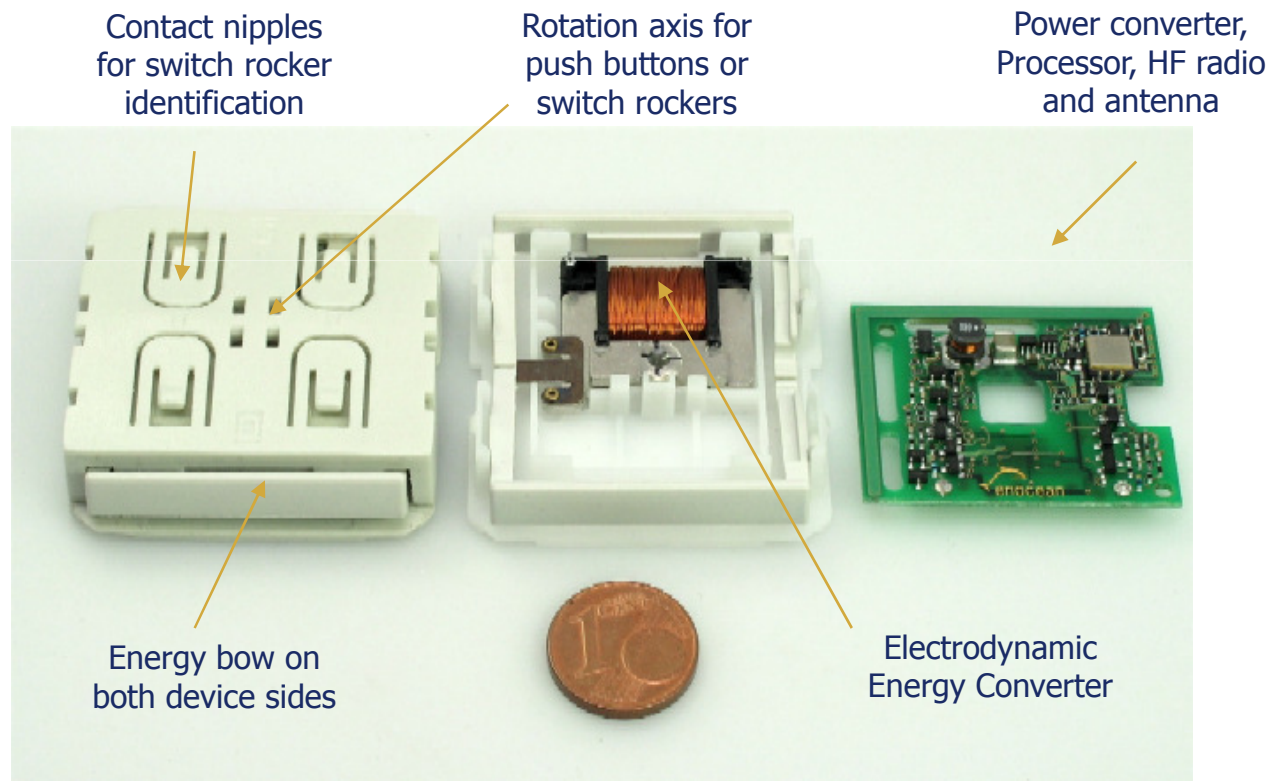Industrial Fridge
Sensor Sensor

Light Sensor

Window Contact

Industrial Temp. Sensor

PIR Presence Detection

Mechanical Energy –
Linear Movement and Button Push

"Plug & Play" Light Switch Module

Contact nipples
for switch rocker
identification

Rotation axis for
push buttons or
switch rockers

Power converter,
Processor, HF radio
and antenna

Energy bow on
both device sides

Electrodynamic
Energy Converter

Module Based Switch Product Examples
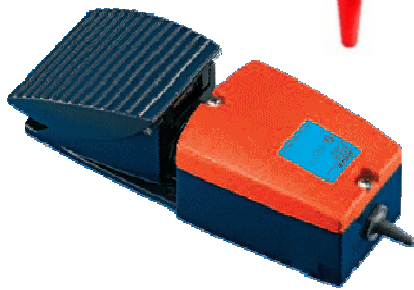
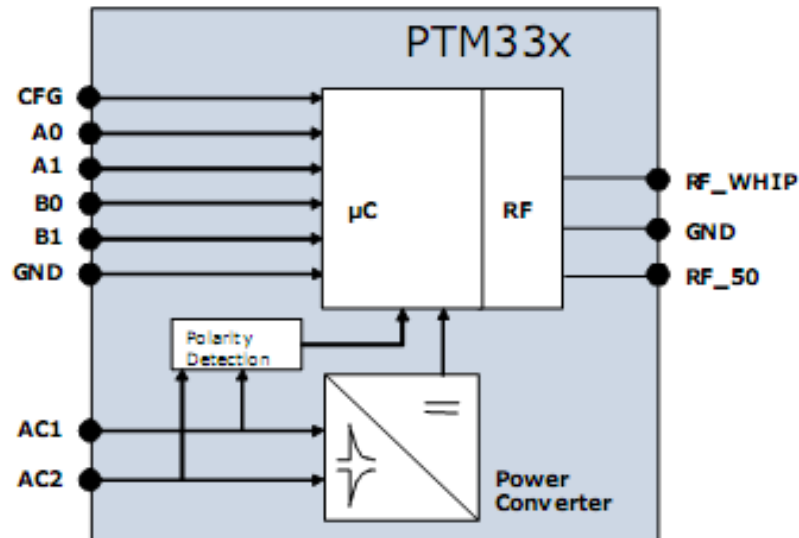# Mini switch PTM 330 / ECO 200

Key applications:
• key card switches
• window handles
• industrial switches
• handheld remote controls

Telegram content configurable
to match required EEP

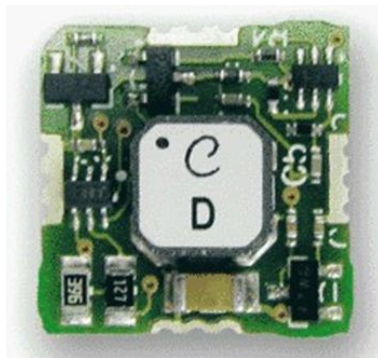PTM 330   ECO 200

Platform technology for Logistics & Transportaion
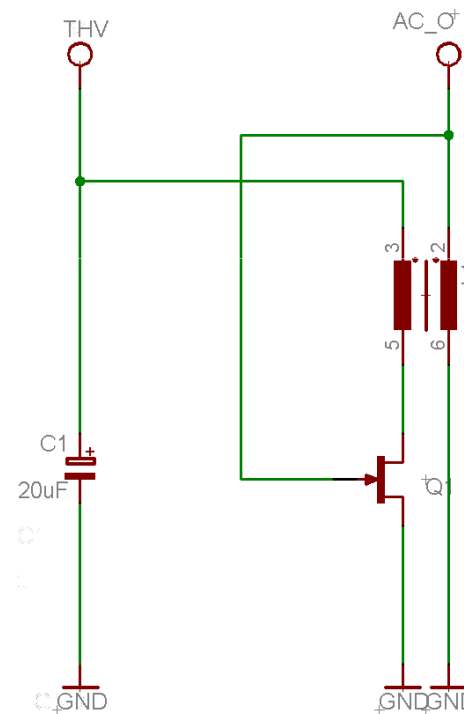

EnOcean in London City Bus Pilot

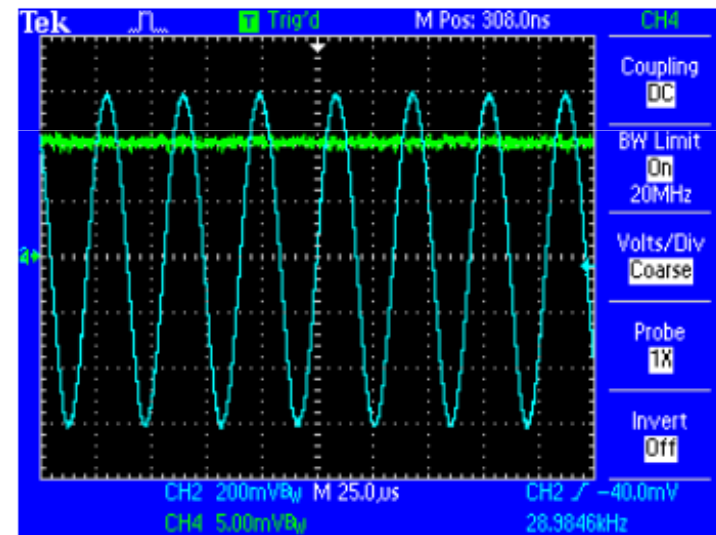# High Performance Thermal Harvester Using Low Cost Standard Components

Problem solution:

Highly optimized blocking oscillator oscillator operates already at only 20 mV.

General principle:
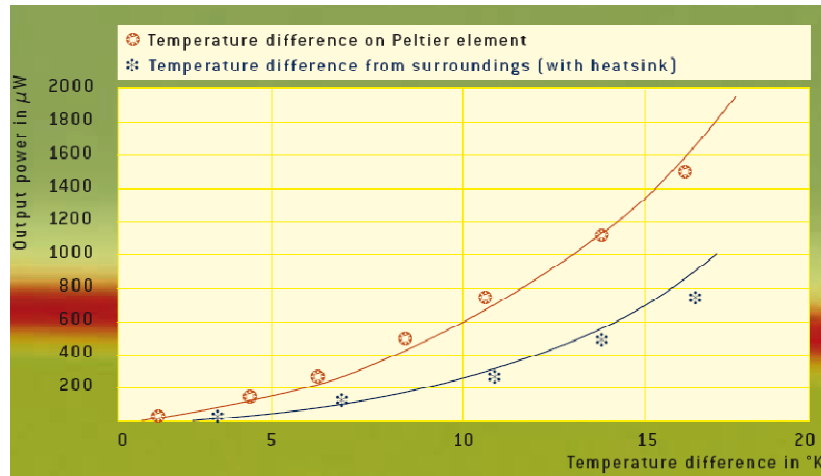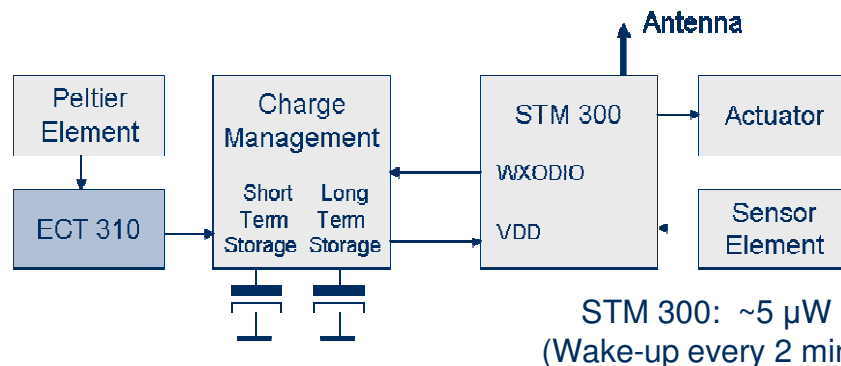**Impedance transformation in case of sufficient energy.**

Oscillator principle

Oszillation bei Ub = 10mV

Thermocouple voltage and oscillation

Thermo-powered Wireless Actuators

~100 µW energy available at 7 Kelvin temperature difference

STM 300: ~5 µW
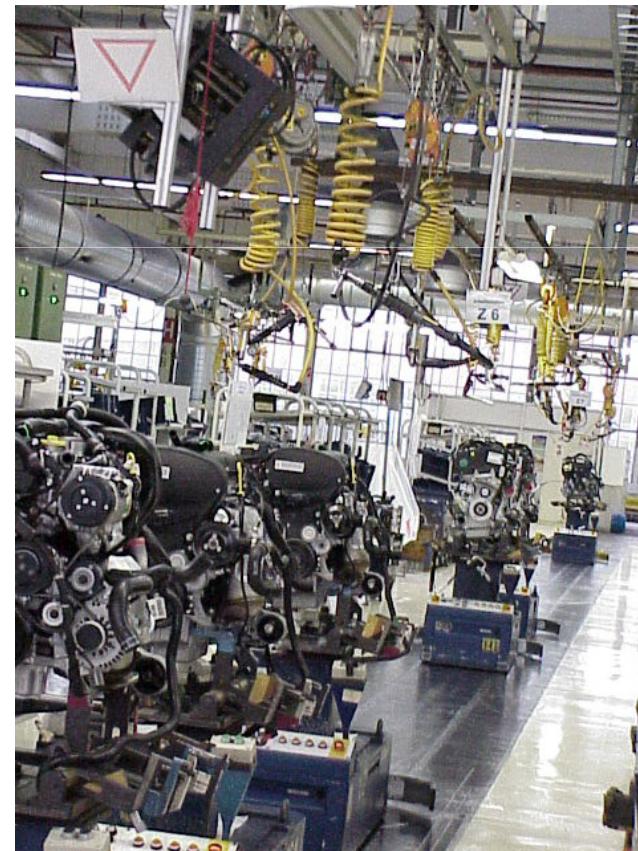(Wake-up every 2 min.)

**Energy Harvesting
Valve Actuator Products
(Kieback&Peter, Spartan)**

Energy Harvesting Radio Sensors-
Benefit in existing Solutions

1. You can Save 30% Energy with

Building Automation Systems
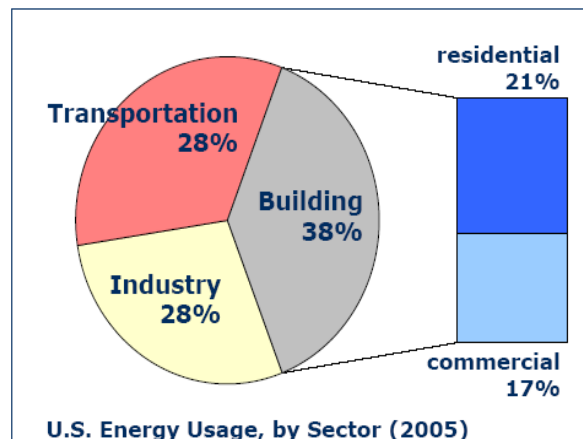
2. Energy Harvesting Sensors

are ideal for Status Monitoring

Example highlights 40 % Energy Conservation

EnOcean Inside

Energy Harvesting Wireless Sensor Module
STM 110

Wireless Transceiver Module
TCM 320

Energy Harvesting Wireless Sensor Module
STM 300

ECO 200 & PTM 330
Energy Harvesting Wireless Sensor Module
STM 320

Energy Harvesting Wireless Sensor Module
STM 310

Energy Harvesting Wirless Actuator
STM 300 and ECT 310

Energy Harvesting Wireless Switch Module
PTM 200

→ BENEFITS FOR PRODUCT MANUFACTURERS

- MAINTENANCE-FREE SENSOR SOLUTIONS
- EASY TO INTEGRATE
- FASTER TIME-TO-MARKET
- INTEROPERABILITY OF END-PRODUCTS

Best pay-back per cost period of all technical measures
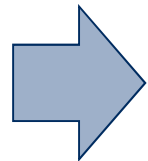
Investment in	~Energy savings	~Pay-back period
Operation Management	−5 % / −30 %	0–5 years
Technical installations and appliances	−10 % /−60 %	2–10 years
Building envelope	−50 %	10–50 years

Source: „Sustainable Urban infrastructure, London Edition – a view to 2025

Office - Torre Cristal, Madrid, Spain (2008)

Torre Cristal, Madrid, Spain (2008)

- In 2008 the worlds tallest building with wireless sensor networking building automation system: New construction, 52 floors, 249 meters

- Approximately 1,200 battery-less wireless modules connected to EIB/KNX building automation system

- Torre Espacio (2007) & Torre Caja (2009) also use EnOcean technology

- **Savings**
    - **40% Lighting Energy Costs**
    - **33 Kilometers of Cable**
    - **80% cost of retrofitting**

- Partner: Siemens

Office - Redevelopment

Headquarter of Region of Lombardi (Milan), 2010

Problem

- 39 floors
- 161 m building
- 72.000 qm office space

Solution

- 400 EnOcean-KNX-Gateways
- 1300 EnOcean Wall Switches for DALI lighting control
- 2500 EnOcean Room Temperature Sensors

Benefits

- Flexible and reliable installation
- Increased usable space
- Easy and fast installation during retrofit

OEM-Partner: Siemens

Residential - Pre-fabricated Homes

WeberHaus, House Sunshine, Germany (2008)

Problem

- Creation of a high-quality, intelligent home control
- Set new ecological standards

Solution

- 4 EnOcean automation models: Lighting, Interhome communications, Blinds, Heating-Control, window control/ contact
- Window open = air-condition/heating off

Benefits

- More flexibility
- Easy installation
- Cost efficient
- Minimum of electromagnetic pollution

University - Renovation of a Listed Building

Mond laboratory, Cambridge, UK (2009)

Problem

- Listed building
- Installing lights and switches
- Installation without harming the building

Solution

- Installation of MK Electric's Echo product range
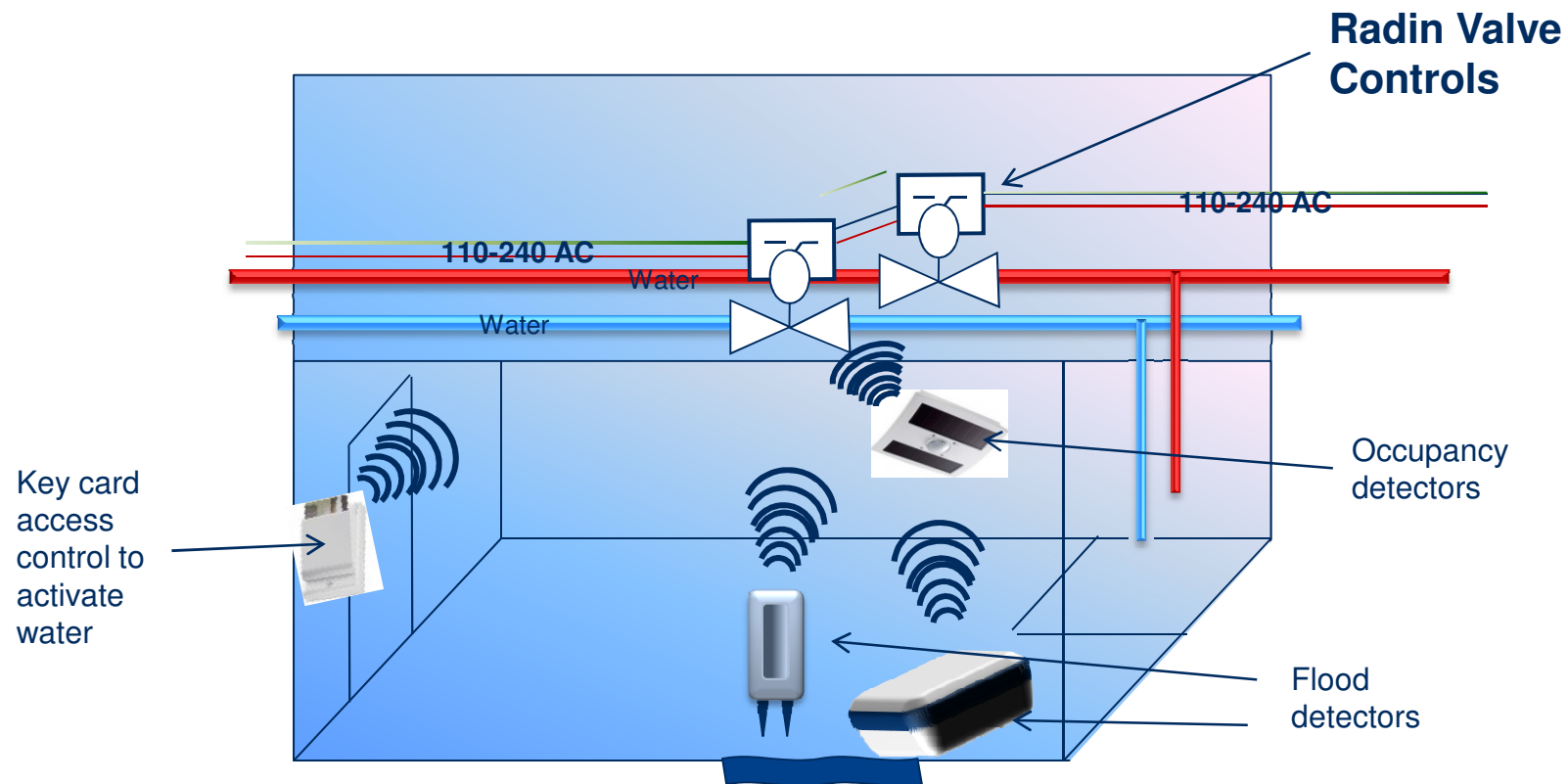
Benefits

- Less installation costs
- Obviation of wiring in the walls
- Easy installation
- High flexibility

OEM-Partner: MK Electric

Water control

Typical ceiling mounted control system All power is routed away from users.

Hot and Cold water can be shut off based on presence detection or card access

Also flood detectors can over ride and shut off if there is a leak

Radin Valve Controls

110-240 AC

110-240 AC

Water

Water

Key card access control to activate water

Occupancy detectors

Flood detectors

Industrial – Self-powered Wireless Door Handles

AXA Maschinenbau GmbH, Germany (2008)

Problem

- Communication between door handle and machine control

Solution

- steute door handle with EnOcean technology

Benefits

- All important controls are integrated in the door handle
- Wireless communication between door handle and main control
- Total flexibility

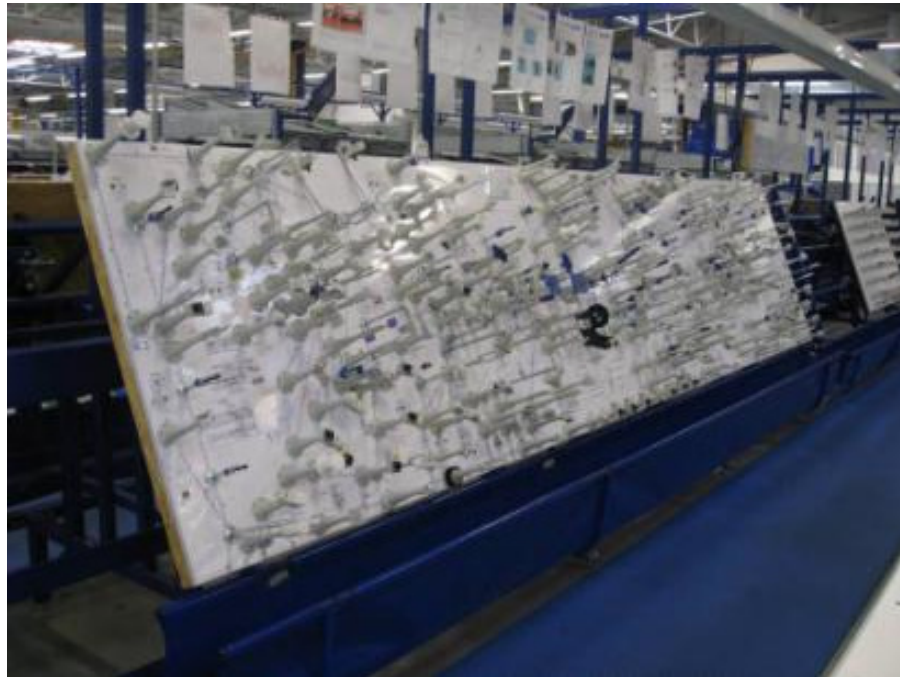OEM-Partner: steute

Industrial - Process Monitoring & Control

Automotive Engine Production (Germany, 2009)

Optimization of KANBAN systems

- Minimized process times
- Flexible installation
- Reduced efforts and down-time to re-configure

Industrial – Quality

Automatic Detection of Cable Form Position („Kabelbaum")

■■ Production Test Automation

■■ SEMD (for Automotive Industry**)**

Yacht - Individual and Flexible Solutions

Luxory yacht "Feretti 830„, Brazil (2008)

Problem

- Controlling lights, switches, fans
- Hydraulic landing stage control
- Wireless switch for lighting control

Solution

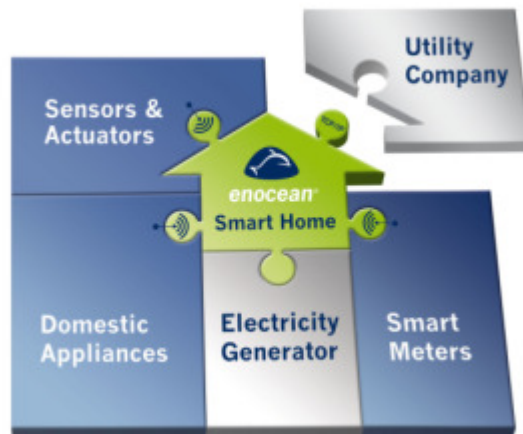- Programmable actuators REGS24 (Omnio)
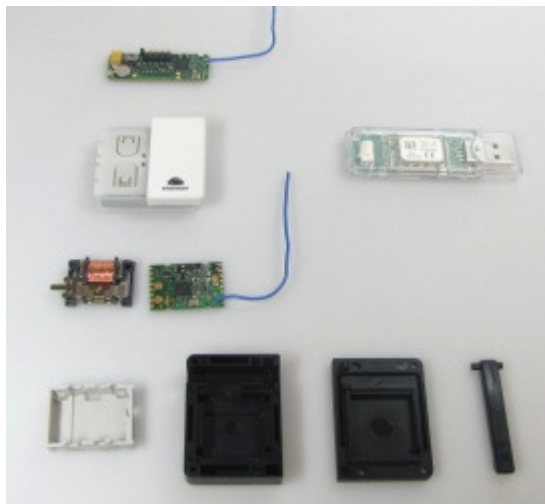- Lighting dimmers (PEHA)

Benefits

- Less installation costs
- Space extension on the yacht
- Implementation of an automation system possible

Partner: ASP Automation, Omnio, BootUp

Platform technology for Smart Home / Smart Grid (Telefunken)

ESK 300 - the ideal entry to EnOcean technology

- EnOcean Starter Kit will be the entry level product to demonstrate EnOcean's energy harvesting and ultra low power radio technology.

- ESK 300 contains USB 300 gateway and the DolphinView Basic license to visualize EnOcean telegrams

- PTM 200 push-button switch and STM 330 temperature sensor will show already pre-integrated products.

- ECO 200, PTM 330 housing examples from BSC GmbH and SEMD demonstrate the flexibility in terms of other application areas.

EDK 300 – The developer Kit for Dolphin Modules

TCM 320

TCM 3x0

EDK 300
Developer's Kit

EDK 300 and EDK 300C are designed to support hardware and software application development for following EnOcean modules:

- 868 MHz (EDK 300): TCM 3x0, STM 300
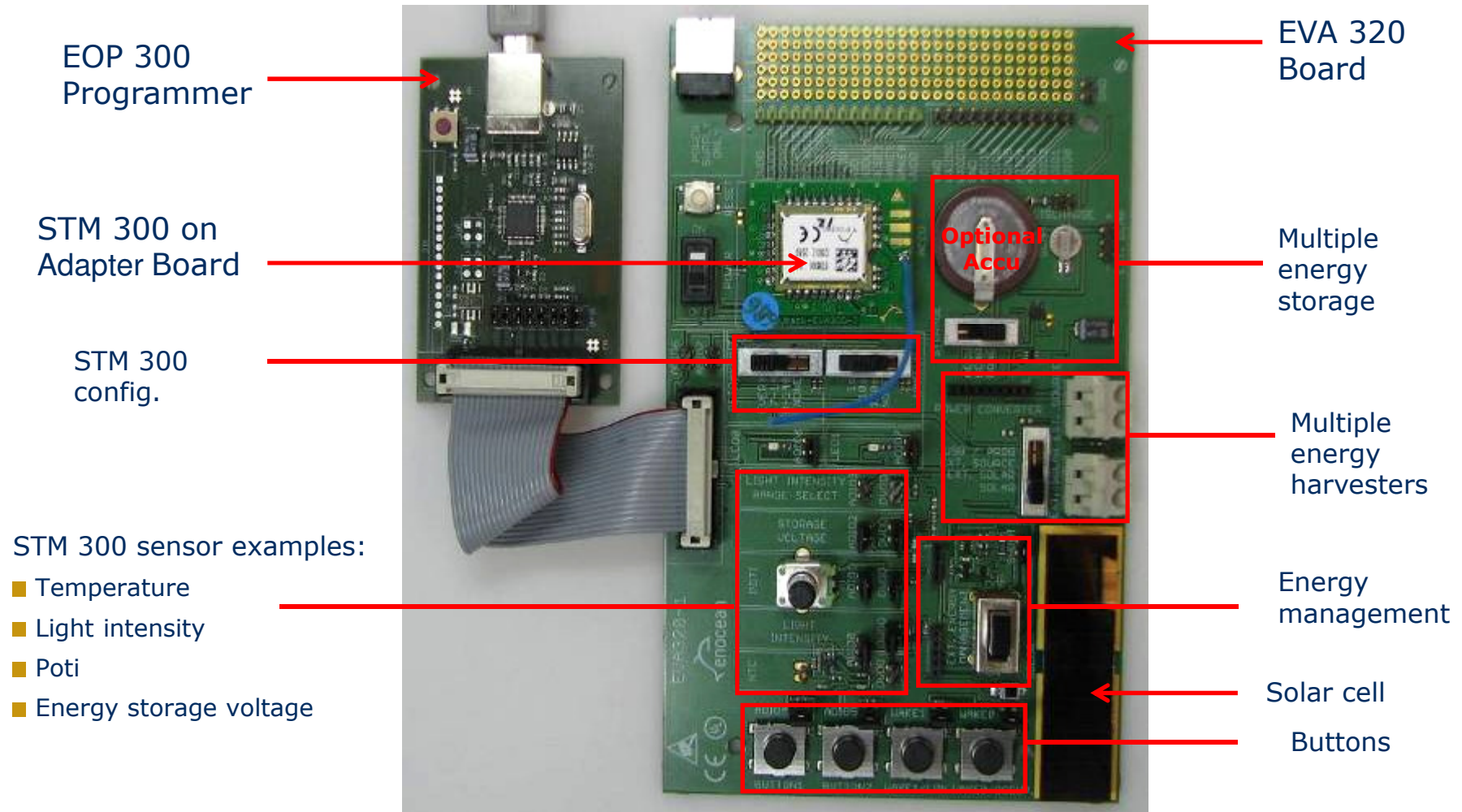- 315 MHz (EDK 300C): TCM 3x0C, STM 300C

Content of EDK 300 Developer's Kit:

- 1x EVA 300 evaluation board for TCM 3x0
- 1x EVA 320 evaluation board for STM 300
- 1x TCM 300 on adapter board
- 1x STM 300 on adapter board
- 1x TCM 320
- 2x EOP 300 programmer
- 1x PTM 2x0 with test rocker
- EDK 300
  Developer's Kit
- 2x USB cable 1x Package leaflet with download links to documentation and software tools

Additional developer kits are available for self-powered radio nodes of the STM 3xy product family:

- EDK 310 (Solar powered STM 3xy)
- EDK 312 (Thermo powered STM 3xy)

Development Platform for Self-powered Sensor Applications

EOP 300 Programmer

STM 300 on Adapter Board

STM 300 config.

STM 300 sensor examples:
- Temperature
- Light intensity
- Poti
- Energy storage voltage

EVA 320 Board

Multiple energy storage

Optional Accu

Multiple energy harvesters

Energy management

Solar cell

Buttons

100+ Customers Integrated the EnOcean Solution

… and created more than 850 interoperable products!

Energy Harvesting Radio Sensors – Status 2012

1. Energy Harvesting is Market Reality, fast growing

- Building Automation Market
- Industrial Sensor Applications
- Strong Growth, other Markets start to follow

2. Mutual Optimization of Key Components is Essential

- Electronics, Energy Management
- Energy Harvesting and Storage
- Software and Radio Protocols

3. Customers need interoperable EH System Solutions

- Interoperability is mandatory, Protocol and Sensor Profiles
- Knowledge of system integration is not yet common
- Supply of components is not sufficient

Thank you for
your attention.

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