Wireless Sensors in Buildings

Energy Harvesting, London 12th March 2014
An EPSRC Funded Network

Gilles Chabanis

Schneider Electric

Schneider Electric at a glance

The global specialist in energy management

Large company

24

billion € of sales in 2012

41%

of sales in new economies

140 000+

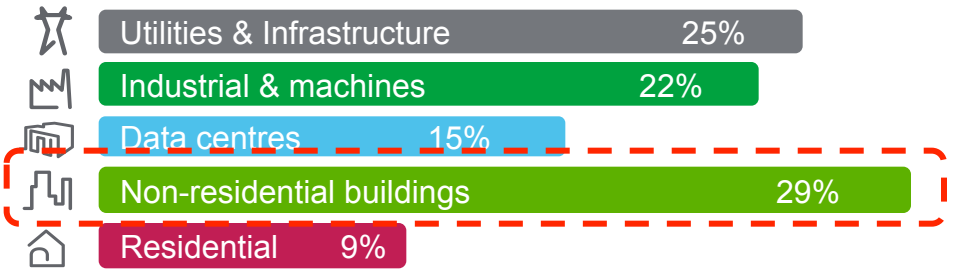
employees in 100+ countries

4–5%

of sales devoted to R&D

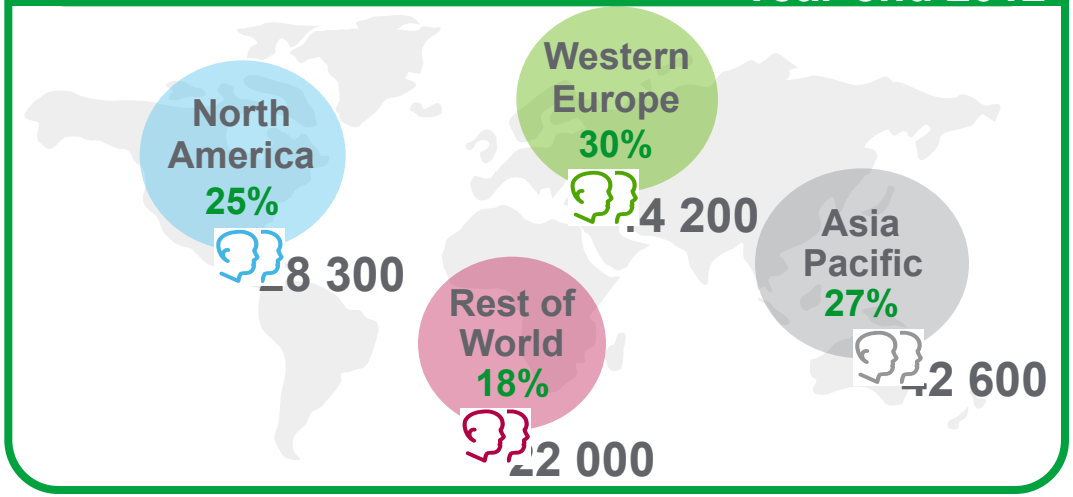
Diversified end markets

FY 2012 Sales (billion €)



Balanced Geographies

FY 2012 sales Year-end 2012



A huge under-served market

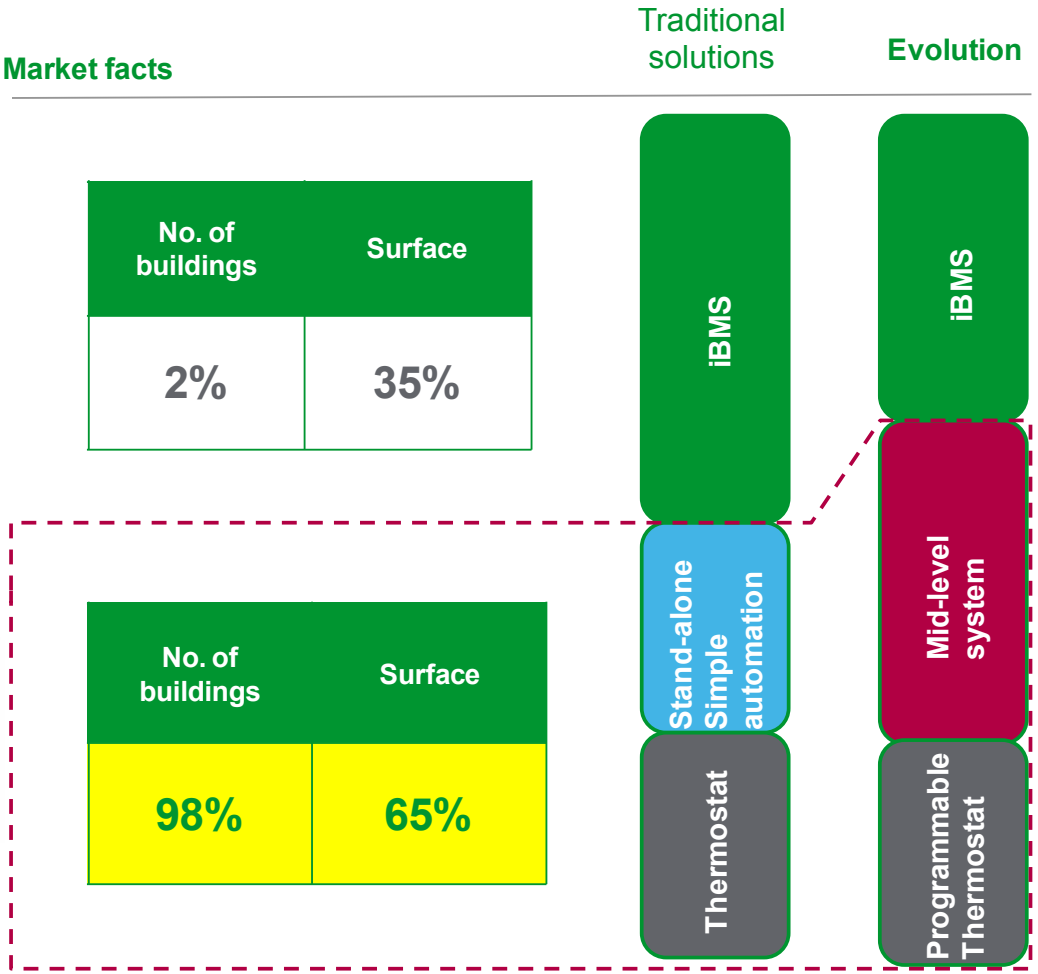
Premium & Large Buildings
>100,000 sq.ft. / 10,000 m²

Small & Medium size Buildings
<100,000 sq.ft. / 10,000 m²

Market facts

No. of buildings	Surface
2%	35%

No. of buildings	Surface
98%	65%



➔ With necessity to lower the cost of automation for small and medium buildings with dedicated offer

Main characteristics

Ultra-low-power multisensors platform

Self-powered by a solar cell

Measuring
- **Temperature**
- **Humidity** relative
- **Light** intensity

Robust without maintenance

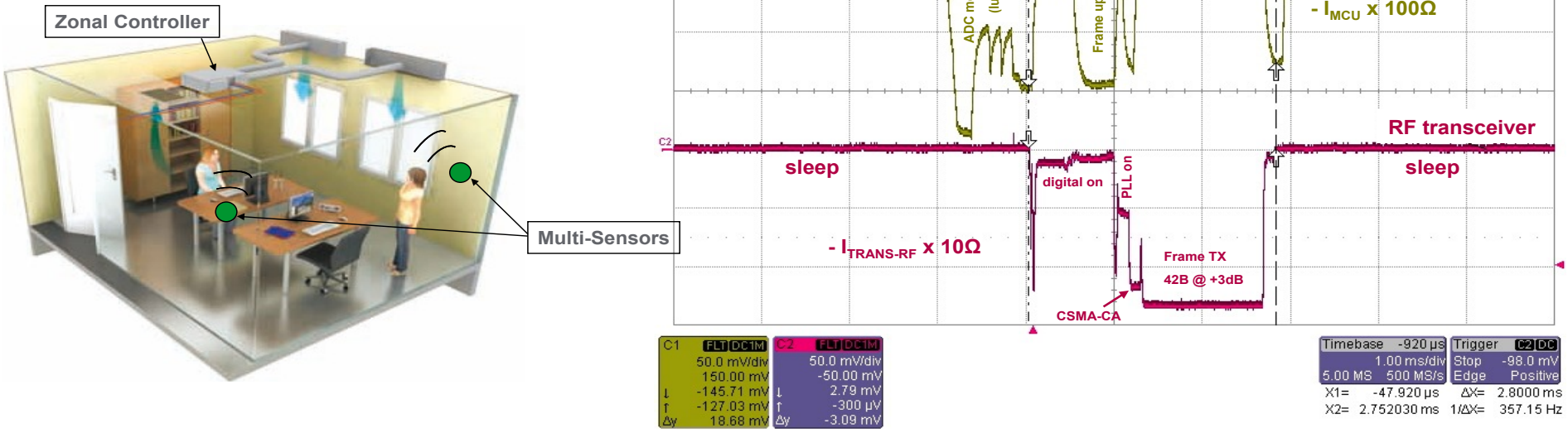
Consuming **less than 5 µW**

Size and cost optimized **wireless & self-powered** platform

Interoperability
ZGP through **ZigBee** network standard

Wireless technology

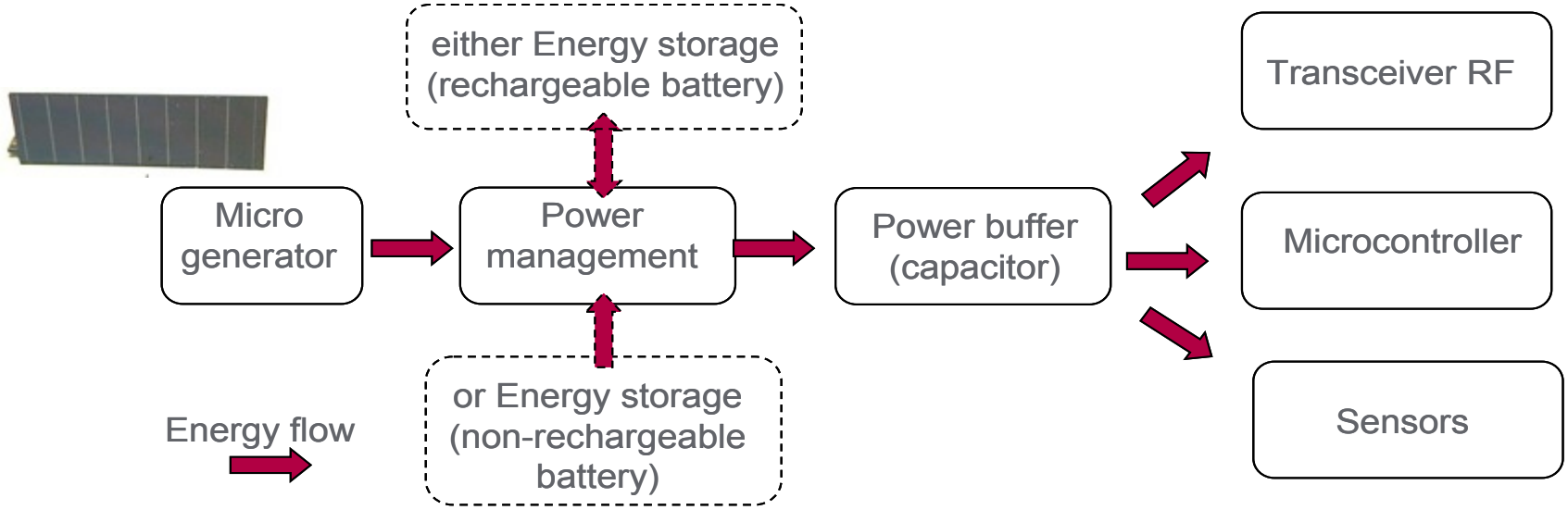
- Compliant with the ZigBee Green Power (ZGP) and IEEE 802.15.4
- Bi-directional commissioning
- Encryption of the data
- 2.4 GHz operating frequency
- Typical transmission range : 20m (indoor) / 150m (free field)
- Optimized current consumption: 110 µJ/ sent frame ➔ 0,4 µA average sending every 2 min



With Power Management allowing multi-source power supply solutions for sensors platform

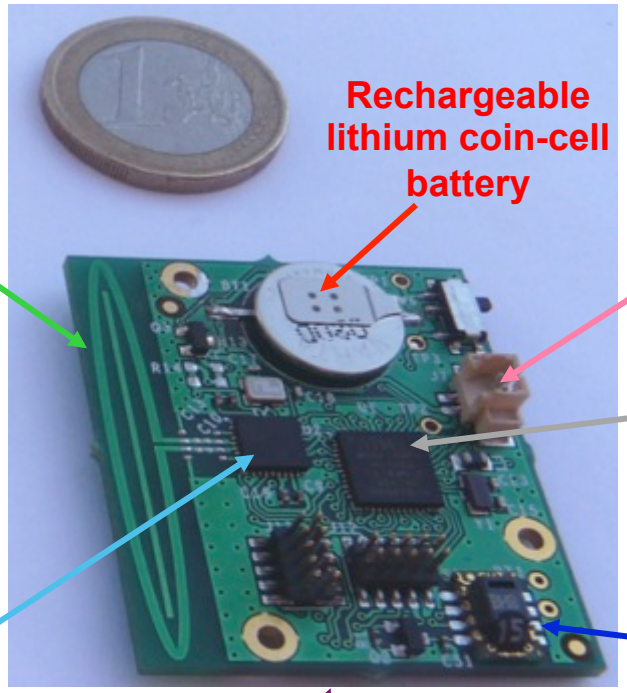
- Rechargeable / non-rechargeable cell compatible
- Photovoltaic module – Operating point imposed by the battery (simple, efficient & low cost)

With selection according to application constraints and sensors characteristics



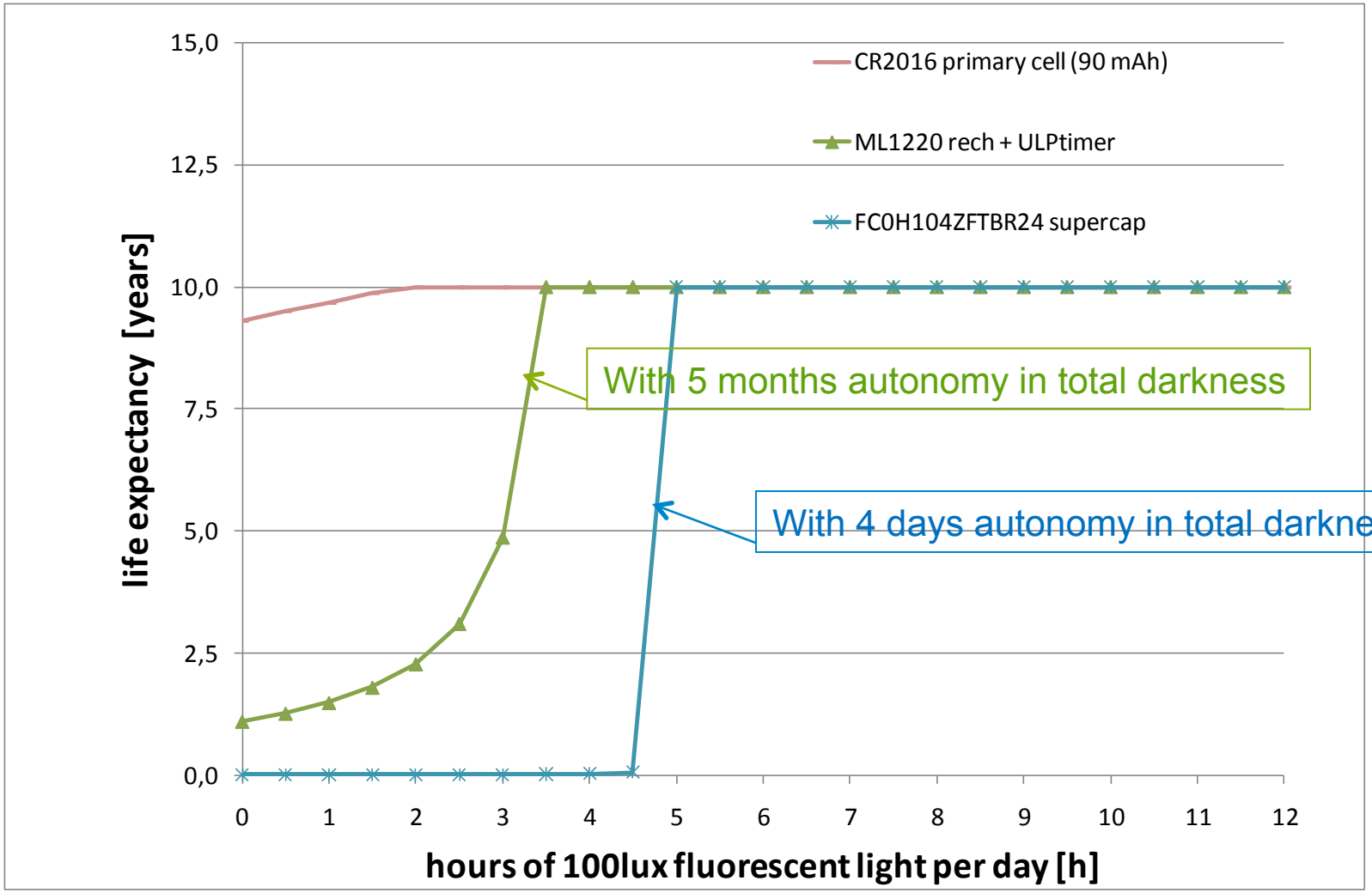
Room temperature, Rh and light sensor

- Size and Cost optimized Wireless & Self-powered platform
- measuring Temperature, relative Humidity and Light intensity
- while consuming less than 2,5 µA ➔ Last optimization is less than 1,5 µA



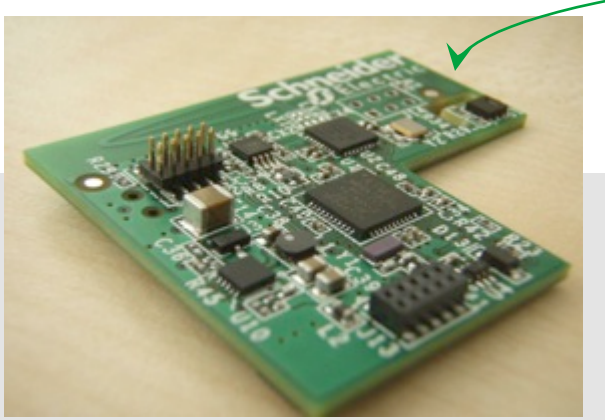
Life expectancy

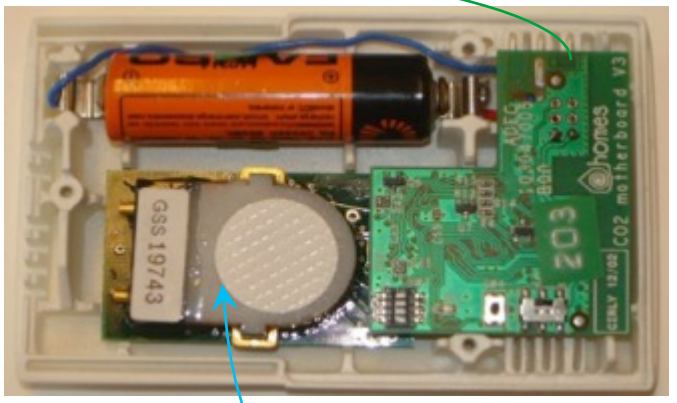
of the Optimized ULP ZGP sensor platform in function of the µ-energy storage component



with a 10cm^2 a-Si solar module

Room Temperature, Rh, CO2 sensor with co-developed ULP CO2 sensor with GSS





Temperature & Humidity sensor (*Sensirion*)

802.15.4 / ZGP Transceiver

Low power MCU

SPI

CO_2 sensor (*GSS*)

Li primary cell (AA size)

Buffer capacitor

Power switch

3.5V - 300mA pulses

Temporary powered ≈ 15ms

With Battery operated solution to supply the peak current

- Battery Operated ZGP CO_2 sensor specifications (*GSS*)
  - Resolution = $10ppm_{RMS}$ @ 1000ppm
  - Range = 0 – 3000ppm
  - Starting-up time < 5ms (electronics initialization)
  - Battery output voltage = 3.6V (AA type)
  - Battery lifetime ≈ 10 years (< 1 measurement every 2.5 min)
  - Total average power consumption < 80 µW (1 measurement every 2.5 min)

- Solar cell ZGP CO2 sensor?
  - Could be compatible to solar cell self-powered solution with 2 min sampling during day & 10 min during night:
    - Average power consumption ≈ 25µW
    - Required a solar cell with 75 µW output power @ 100 Lux

… But required also a low leakage, high peak current storage solution

Rechargeable Lithium-ion Battery (LFP30-51020) ➔ Still a Prototype developed with CEA

Benefits
- Extended autonomy and life
- Wide operating temperature range [from -40°C to +50°C]
- Easy integration into compact system
- Low self-discharge current
- Superior resistance to atmospheric humidity

Key features
- High discharge peak current (between 30 and 250mA, 5-10ms)
- Maintenance-free
- Long cycle life >2000cycles in a pulse mode (150mA, 7.2s without relaxing time)
- Safe chemistry

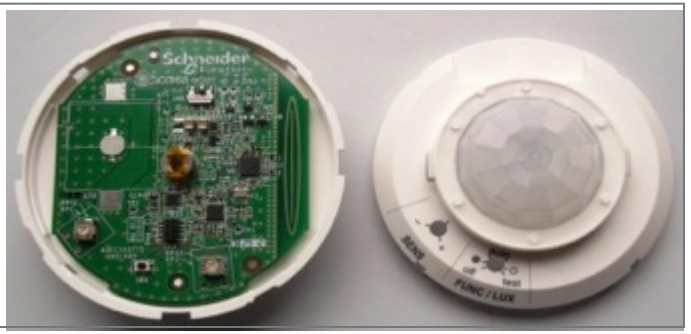
Technology:
- LiFeBPO4 BeLife based cathode Graphite-based anode
- Electrolyte : Organic solvents with a lithium salt

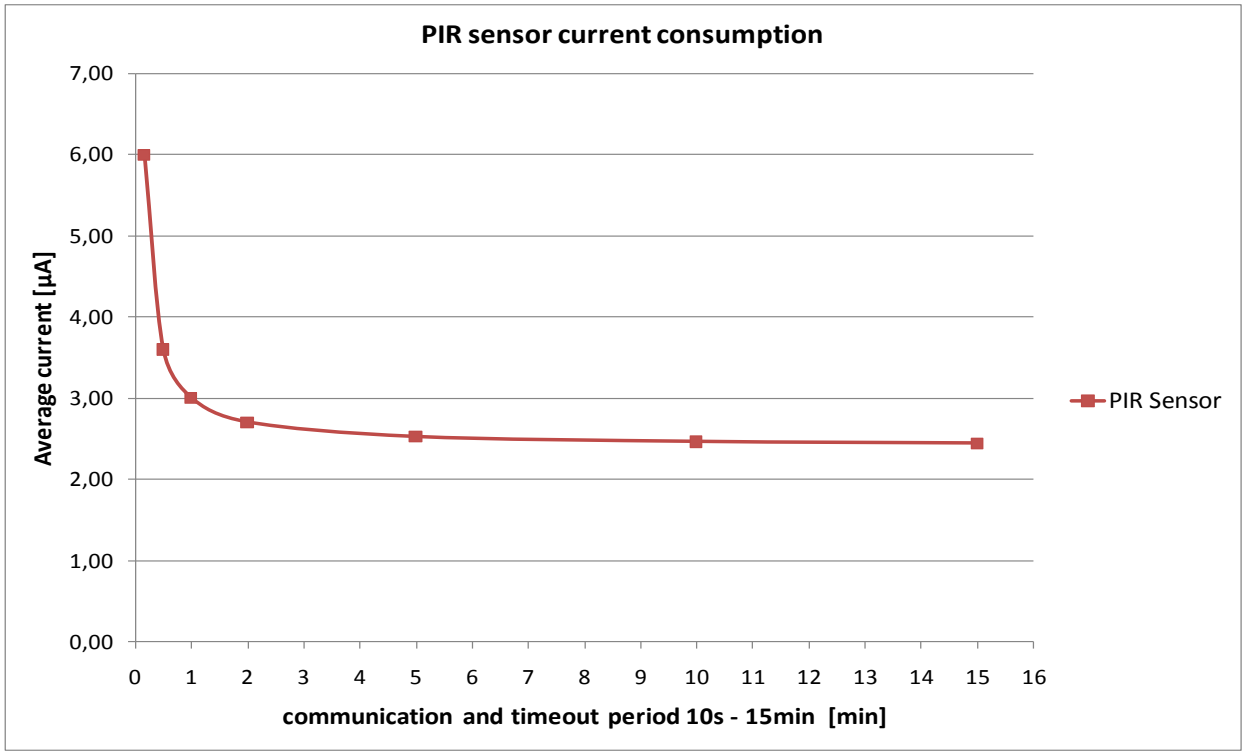
Electrical characteristics:
- Nominal capacity : 30 to 40 mAh (at 5 mA, 20°C, 3.6V cut –off)
- Nominal voltage : 3.3V
- Résistance : 140 mΩ

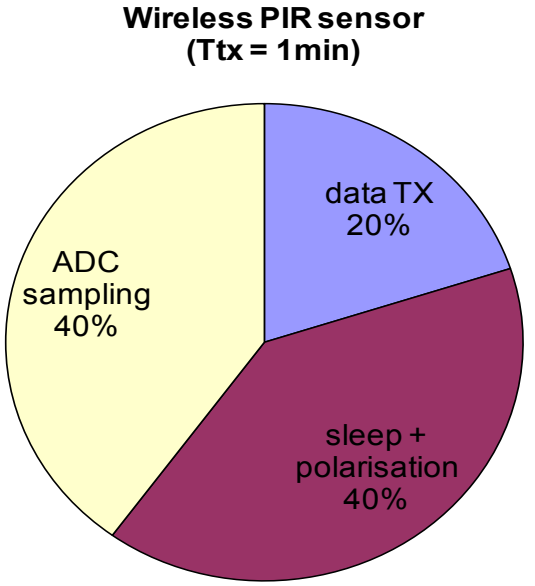
Mechanical characteristics:
- Stainless steel container
- Hermetic glass-to-metal sealing
- 20 mm x 10 mm X 5 mm
- Volume: 1 cm3

ULP Power consumption Ceiling PIR Sensor

- Specific analog front end design
- Compatible to solar cell energy harvesting
- Real motion/presence detection
- Low cost



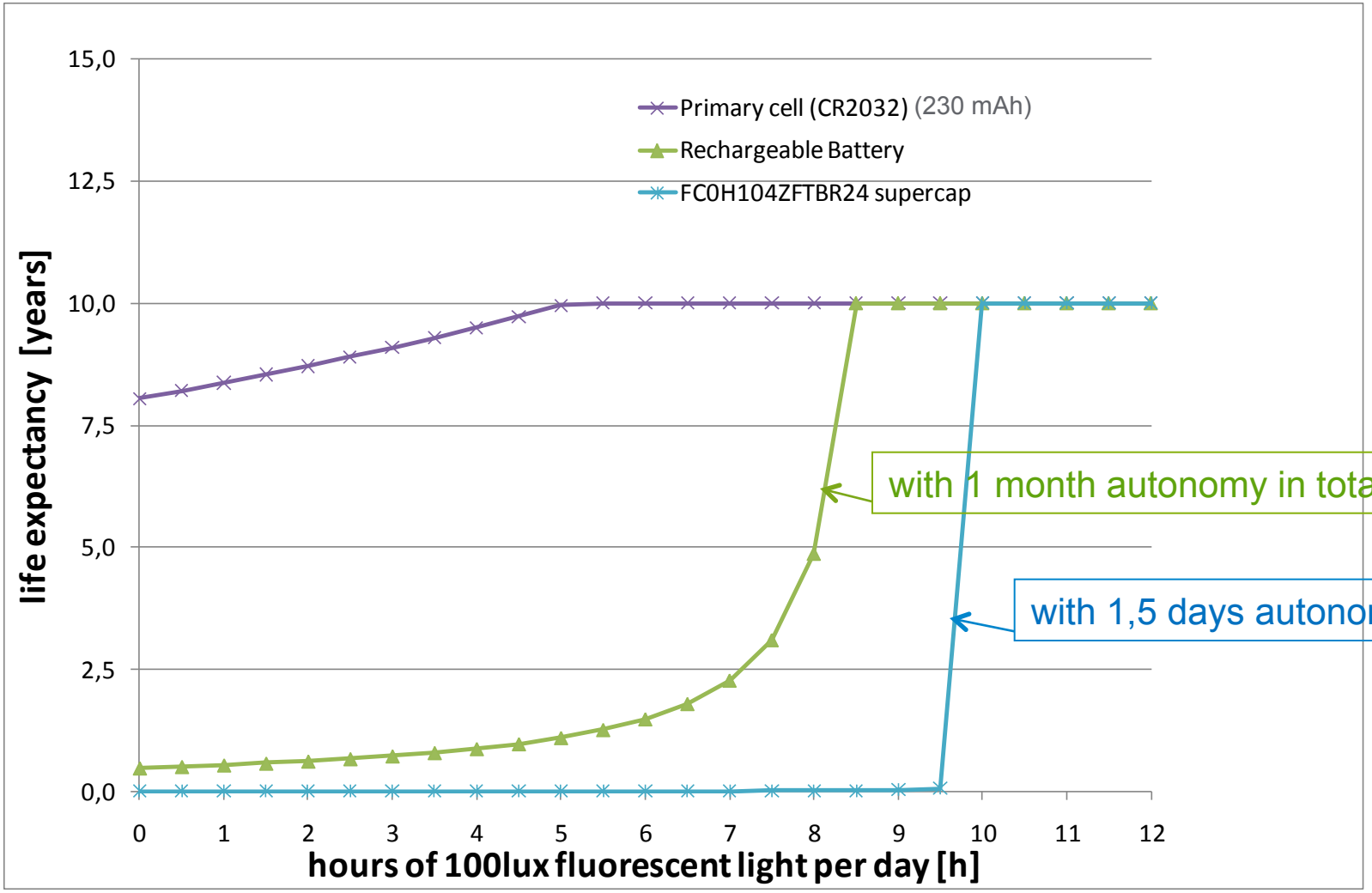




3 µA x 3V = 9 µW

Life expectancy

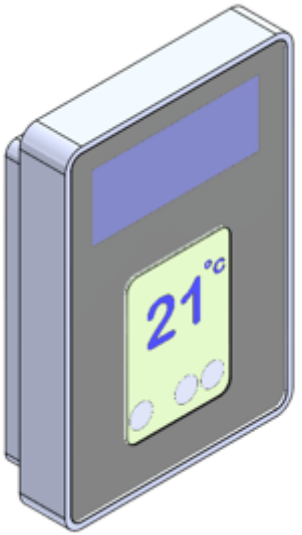
of the self-powered PIR sensor in function of the µ-energy storage component



with a 10cm^2 a-Si solar module

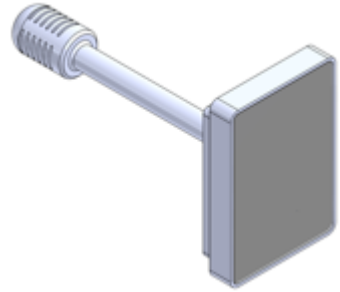
Next Steps

- For Room Sensors: Solar cell is a good solution…
  - With Power Management allowing multi-sources power supply
  - With low leakage & long life time storage solution for variable conditions (Indoor/outdoor, low/high peak current)
  - Allowing also to provide power supply to additional functionalities as compact size = key value:
    - Display
    - Multi-sensors for
      - Multi-sensing : advanced detection like
      - Or making easier commissioning/interaction with occupants…
  - …Particularly if Solar cell can be further optimized for Indoor in term of:
    - Efficiency : more power or more compact = better for functionality or for design
    - Flexibility in shape = better for design



Next Steps

- For Technical space Sensors: Need to get 15 to 20 Y life time solution with Energy Harvesting



  - As technical space sensors represent almost 50% of sensors in Buildings
  - Where even more difficult to have access to replace batteries or products (Duct, Pipe sensors)
  - With no solution identified today except using primary cell with 10 Y life time

- … And needs of wireless sensors in SE are larger than Building Automation application i.e. for monitoring the assets with different constraints and solutions but where Energy Harvesting represents a key value also