Energy hunter-gatherer sensors: small power the next Big Thing

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Bologna, 01/10/2014

KETs (Key enabling technologies)

Advanced manufacturing

Photonics

Biotechnology

Advanced materials
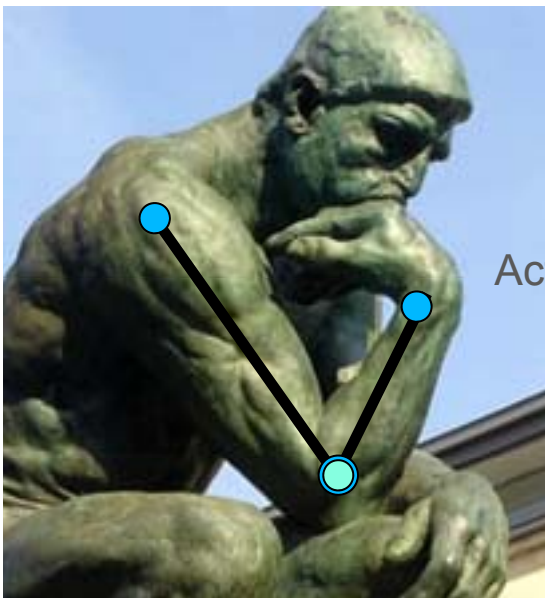
Nanotechnology

Micro-nano-electroncics

Unlocking potential

... by way of [artefacts](#)

KETs (Key enabling technologies)

Mind / **Solution prov.**

Action / **Societal Challenges**

<u>KETs</u> **Technology as a** fulcrum

Unlocking potential

... by way of artefacts

ICT

Ciber-Physical Systems

and/or

Smart Systems

EPoSS
European Technology Platform
on Smart Systems Integration

2014
LET/S

LEADING **E**NABLING **T**ECHNOLOGIES
FOR **S**OCIETAL CHALLENGES
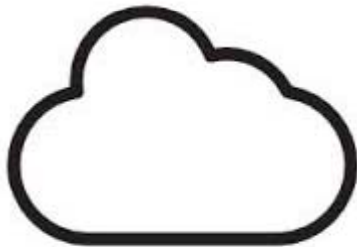
CPS & SS

(miniaturised) systems that connect the digital to the physical world

Collect info / Process info / Act or help to decide

Autonomy
Smartness
Deployability
Connected
Networked
...

From the 'cloud' to
the 'ground'

... becoming part of global
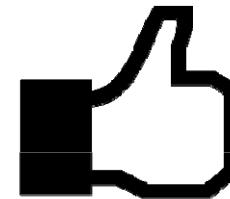problems solutions

ICT today...

ICT (computation & communication)
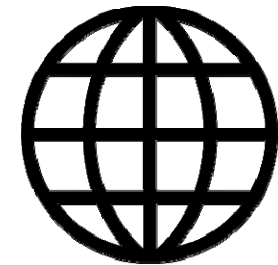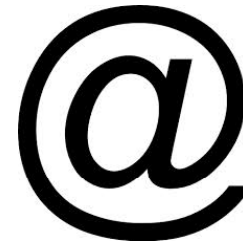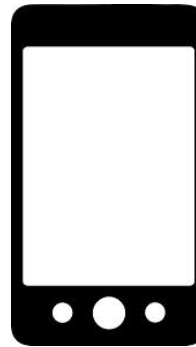
Human dimension: Social Networks

... Internet of Souls

ICT tomorrow... Internet of Things

Things talking to things
Things talking to cloud
Things talking to people
...

'friendly' cooperative objects acting on the background of human activity

http://edition.cnn.com/2012/12/04/business/leweb-parallax-internet-things/index.html

2014
LET'S

LEADING **E**NABLING **T**ECHNOLOGIES
FOR **S**OCIETAL CHALLENGES

ICT tomorrow... Trillion Sensors

Inter-**net** **net**-work

Capture & exchange

↓

Sensors

Wireless Sensors Networks

2007 – 10 mil sensors

2013 – 10 bil sensors

...

Trillions sensors in the next decade?

T SENSORS SUMMIT™ FOR TRILLION SENSOR ROADMAP

2014 LETS

LEADING **E**NABLING **T**ECHNOLOGIES
FOR **S**OCIETAL CHALLENGES

ICT tomorrow... Trillion Sensors

Inter **net** **net** work

Capture & exchange

Sensors

Wireless Sensors Networks

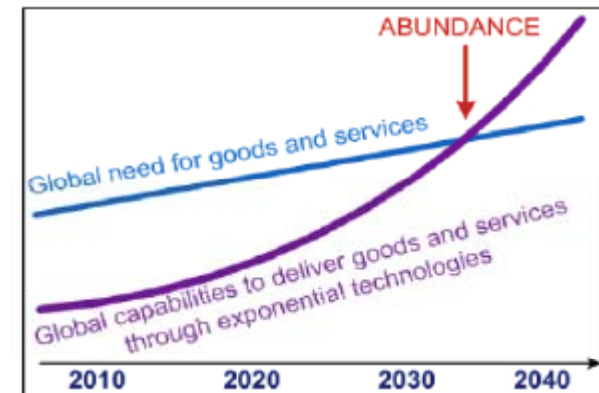**Figure 3.** Exponential technologies promise growth of goods and services to match global demand for them within one generation, enabling Abundance.

T SENSORS SUMMIT™ FOR TRILLION SENSOR ROADMAP

2014 LET'S

LEADING **E**NABLING **T**ECHNOLOGIES FOR **S**OCIETAL CHALLENGES

ICT tomorrow... Smart Everywhere

Smart mobility
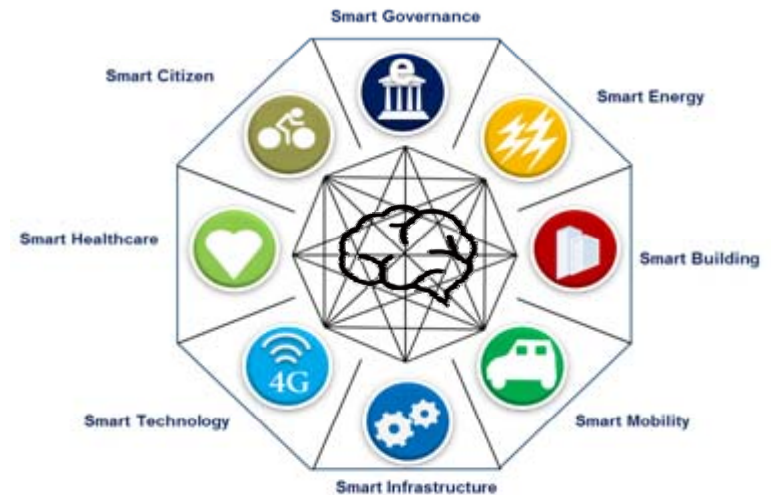
Smart health

Smart energy

Smart production

Smart cities

...

ICT tomorrow... Smart Everywhere

Sensors... better small
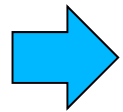
If a network of so many... better small

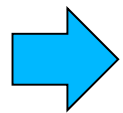less material and energy consumption – more applications

Sensors... better autonomous

As elements of Smart Systems:

➡️ Functional autonomy

➡️ Energy autonomy

grid   off grid

Energy hunter-gatherer Sensors

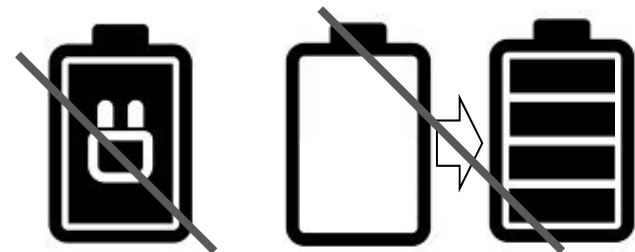For **off grid** applications batteries are OK but...

Batteries get depleted, and need **replacement** or **recharge**

What if sensors are deployed in remote locations or in harsh places?
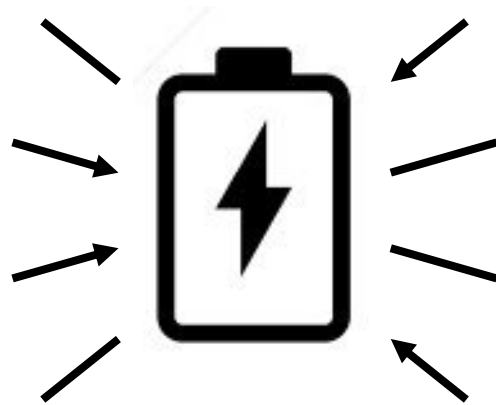- Battery replacement is not practical

What if sensors are so 'many'?
- Battery replacement is not practical

Energy hunter-gatherer Sensors

Energy autonomy in off grid long term applications?

Energy harvesting

Heat
Shock & vibrations
Electromagnetic waves
...

Get the energy or
replenish the battery
from the environment

If small ... will it provide enough?

Energy **sources** for harvesting are **low intensity** and intermittent

Harvesters are to be **small** if sensors are small

A small harvester gets a small portion of a low intensity source...

Will it be enough for energy autonomy of a micronode?

At current SoA, a harvester may power a sensor but not account for the power surge needed for the wireless communication...
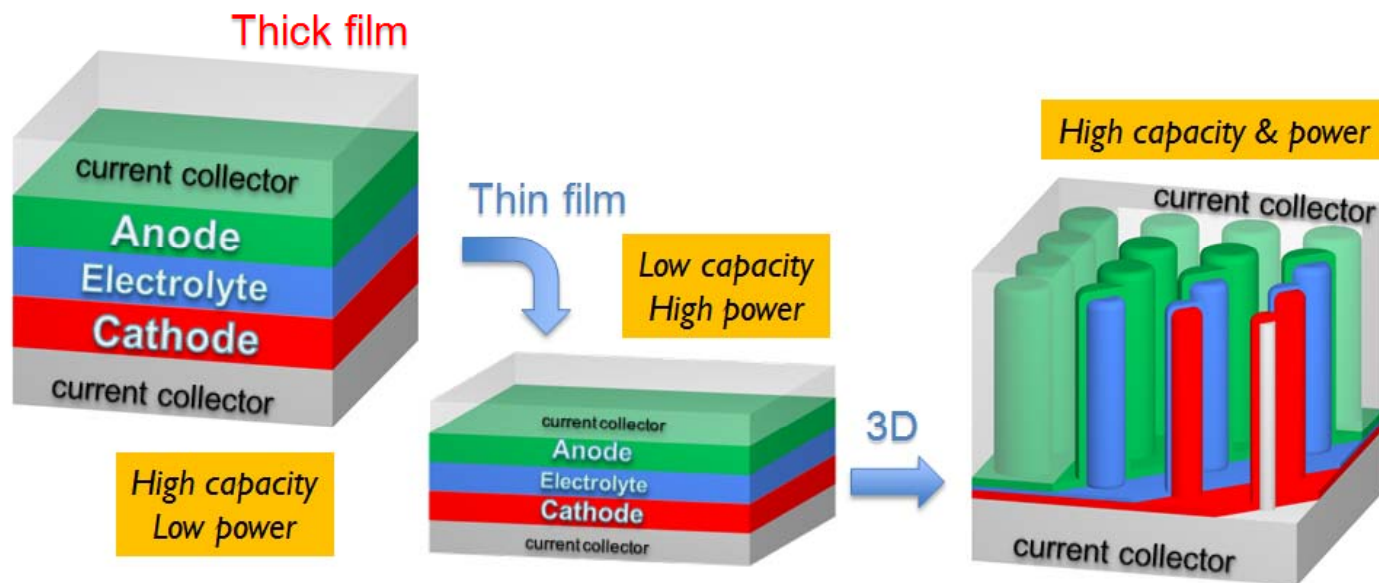
... but it may **recharge a 'battery'** and enable a moderate duty cycle operation

If small ... let it be 'dense'

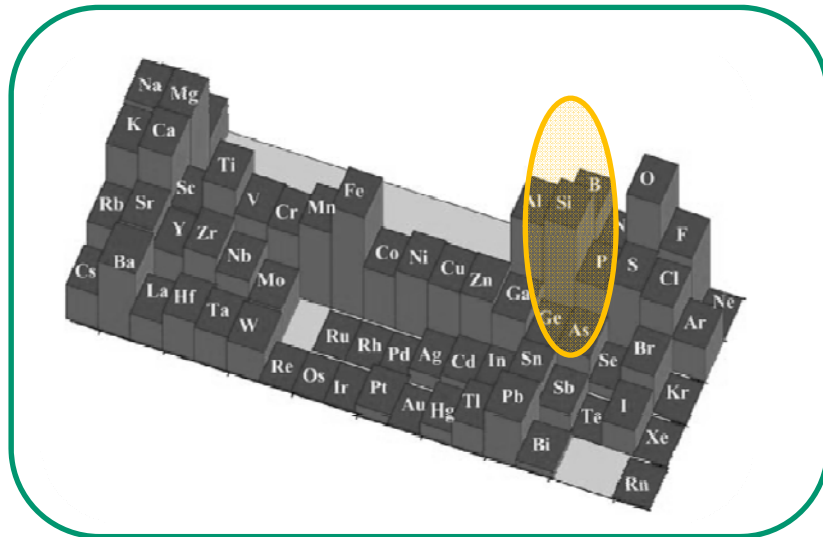**Exploit** the beneficial evolution of surface to volume ratios when going small...

High density 3D features for the harvester architecture and **nanostructured** materials will increase the power performance...

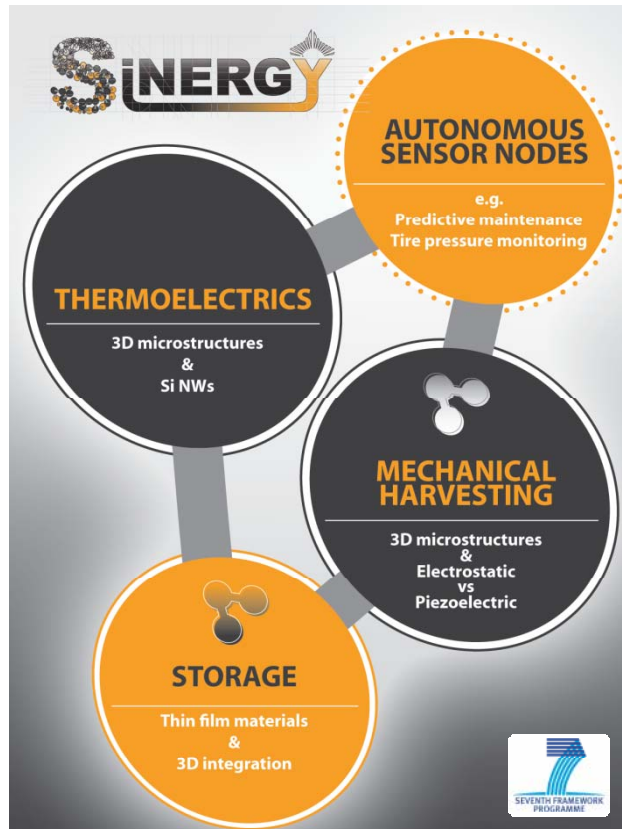# If small and dense... let it be silicon

Which materials to use?
Why not silicon (and its 'merry' friends)? It's the material of reference
of micro-nano-technologies

Abundant
Mature and enabling technology
Cost effectiveness and economy of scale
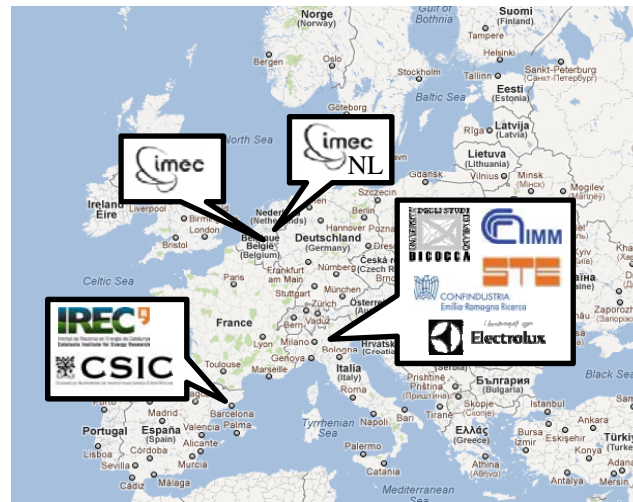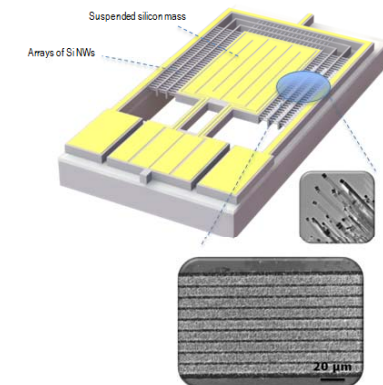Miniaturized systems and dense architectures

SiNERGY

Silicon Friendly Materials and Device Solutions for Microenergy Applications

www. sinergy-project.eu

NMP3-SL-2013-604169

- 3D microstructures + bottom-up SiNWs

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Closing the talk...

- Without an 'install and forget' approach IoT / TS may not happen → **(micro)energy autonomy is required**

- Battery-free self powered devices are the ultimate goal. EH is an option but there is still a gap between generation (µW) and consumption (mW) → **secondary batteries still needed**

- Energy/power does not (down)scale well → **high density features (3D architectures and nanomaterials) need to be handled**

- Let's try do harvesters/batteries with the same technologies already used for fabricating sensors reliably, cost-effectively and in high numbers → **Si µn-technologies (and materials)**

- Si technology enables **'smaller is better'** and **'smaller is cheaper'** scenarios

... and the loop: CROSS KETS

- **KETs (Key enabling technologies)**

- **CPS & SS**

- **ICT today...**

  ... Internet of Souls

- **ICT tomorrow...**

  ... Internet of Things

  ... Trillion Sensors

  ... Smart Everywhere

- **Sensors... small & autonomous**

- **Energy hunter-gatherer Sensors**

- **If small ... Let it be 'dense'**

- **If small and dense... Let it be silicon**

- **Closing the talk and .. and the loop: CROSS KETS**