

Powering & Retrofitting IoT Devices for Industry 4.0

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ICT for Energy Efficiency

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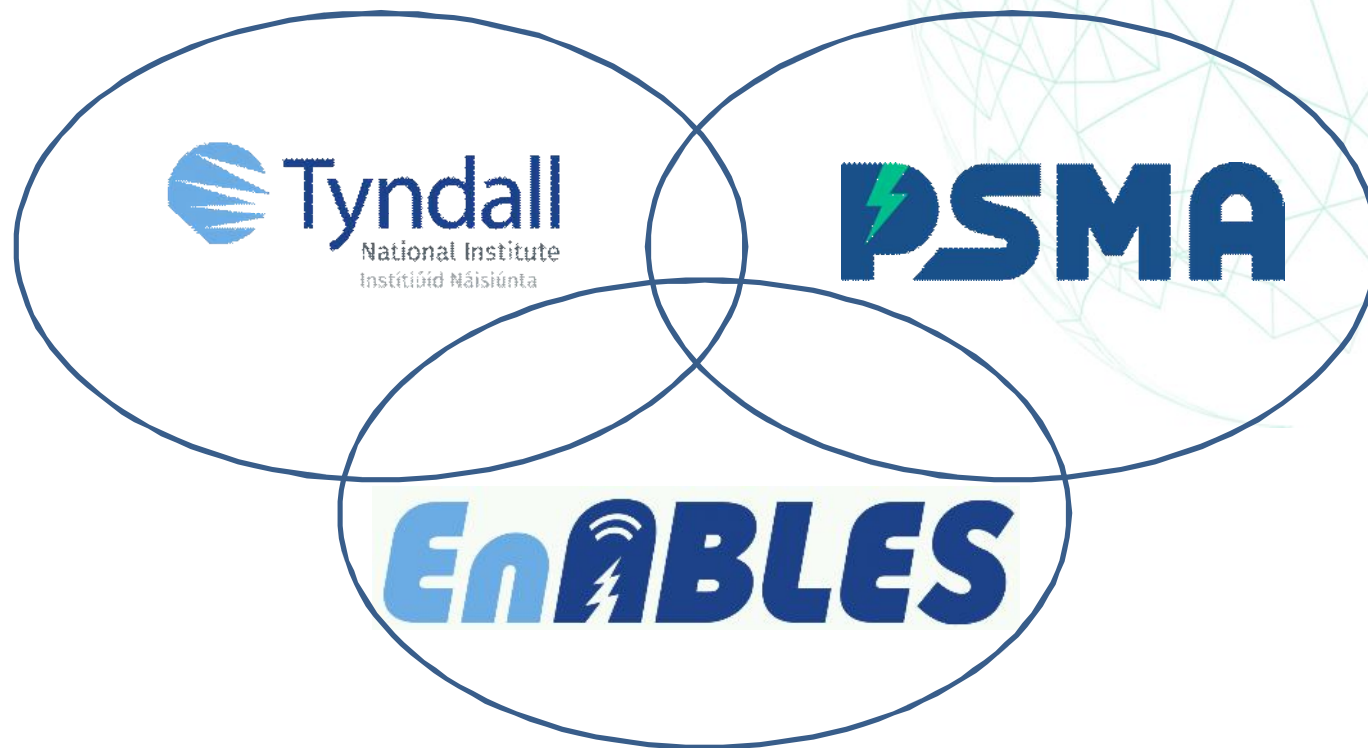


Presentation content

Industry 4.0 Retrofit Opportunity

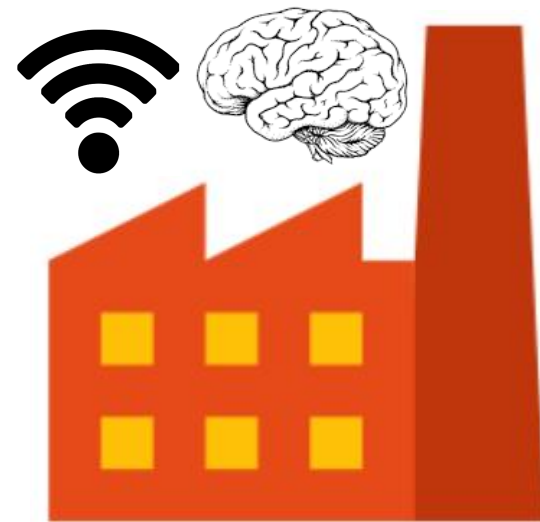
Power IoT Challenge

Power IoT Ecosystem



Introduction – Industry 4.0

- Industry 4.0 Broad Definition ¹
 - "industry 4.0" factories have machines which are augmented with wireless connectivity and sensors, connected to a system that can visualize the entire production line and make decisions on its own.
- Key concepts
 - Smart Manufacturing
 - Smart Factories
- Key Enablers
 - Digital Twin
 - Artificial Intelligence / Machine Learning
 - Industrial Internet of Things
 - Sensors and Actuators



1. https://en.wikipedia.org/wiki/Industry_4.0

Opportunity

- 100 Billion connected devices, 1 trillion sensors by 2025¹
- CAGR 12.6%, with spending forecast to reach \$1.1 trillion in 2023²
- One Third of spend will be Commercial industries
 - Discrete Manufacturing
 - Process Manufacturing
 - Transportation
- Key Applications
 - Condition Monitoring
 - Energy and process efficiencies
 - Asset Tracking
- What's needed
 - Sensors and Actuators
 - Cost effective
 - Battery powered in many cases **especially the retrofit case**
 - Deploy and forget
 - Low maintenance

← **Industry 4.0**

1. P. Diamandis, M.D. Singularity University,
<https://singularityhub.com/2015/05/11/the-world-in-2025-8-predictions-for-the-next-10-years/>
2. IDC marketing report June 2019 <https://www.idc.com/getdoc.jsp?containerId=prUS45197719>

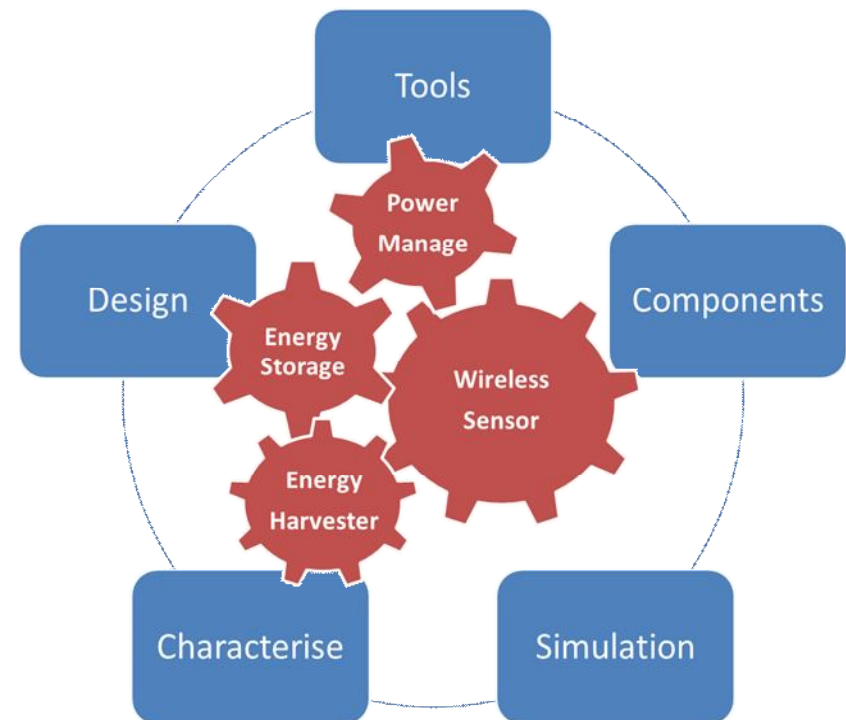
Challenges - Power

- Wireless, battery driven, deploy and forget sensors most suited to retrofit.
- Replacing batteries is expensive.
 - Cost of labour to replace
 - Cost and Impact of maintenance schedules
 - Production down time
 - Hard to access
 - Often replace batteries not yet depleted
 - Cost of battery
 - Environmental costs
- The power challenge
 - Autonomously power the wireless sensor from ambient energy.
 - OR to make the battery outlive the sensor.
 - WHILST at the same time ensuring a continuous reliable supply of power!
- The power challenge is getting harder all the time for Industry 4.0 as they tend to require
 - Low latency control systems
 - Pushing intelligence towards the sensor



Challenges - Interoperability

- An energy harvested power system is a complex system
- To enable development of these complex systems a number of functions are required.
- Effective design requires all parts to be easily integrated, this requires standardised interfaces and models
- Interoperability and co-ordination of all these elements enables
 - Higher performing designs
 - Easier design development and evaluation
 - Acceleration of state of the art.
- Enablers for interoperability
 - Standardised characterisation methods
 - Common simulation tools and interfaces
 - Common design methodologies
 - Standardised component libraries
 - Early collaboration





COMPOSITION

Some use cases - EU FoF project



Ecosystem for COllaborative Manufacturing PrOceSses – Intra- and Interfactory Integration and AutomaTION

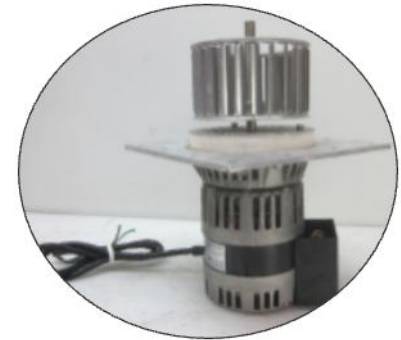
- Creating a digital automation framework (IIMS) that optimizes the manufacturing processes by exploiting existing data, knowledge and tools to increase productivity and dynamically adapt to changing market requirements.
- Development of middleware that enables inter-operability between systems was pivotal to the project (several of the partners are here today)
- **Tyndall role:** Supply expertise in WSN at component, device and system integration level for both modelling and real time operation of the use cases (particularly retrofit of self-powered sensors for inter-factory use cases)
- Gave us opportunities to show value add of wireless sensors with 2 use cases



(Grant Agreement No 723145)

Condition Monitoring (CM)

- Retrofit of wireless acoustic sensors that 'listen' to the oven blowers (fans) – detection of failure.
- Algorithms developed to accurate calculation of risk of fan failure to weeks/months
- Just 5 sensors need to monitor a cluster of 32 fans
- Move from Scheduled to Predictive Maintenance
- Estimate cost of a fan failure during production is ~ €40K (material waste + downtime)



In future projects

- Make the sensor self powered or at least make the battery last longer
- Look at 'roaming' CM system applications (rather than static)



Asset Tracking

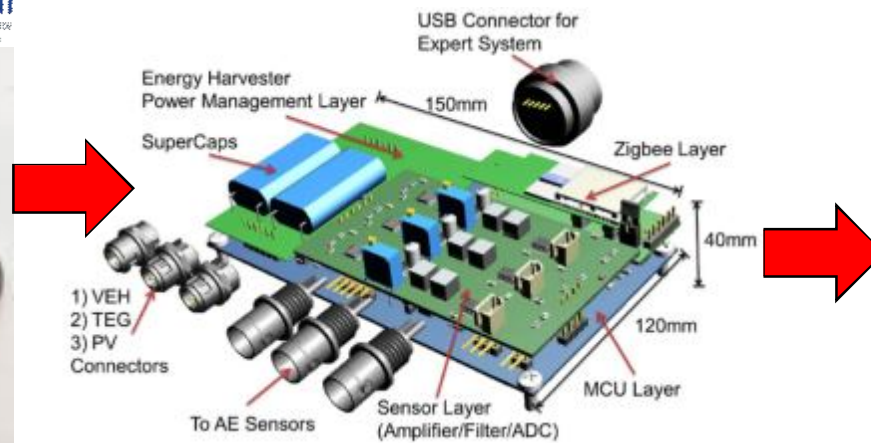
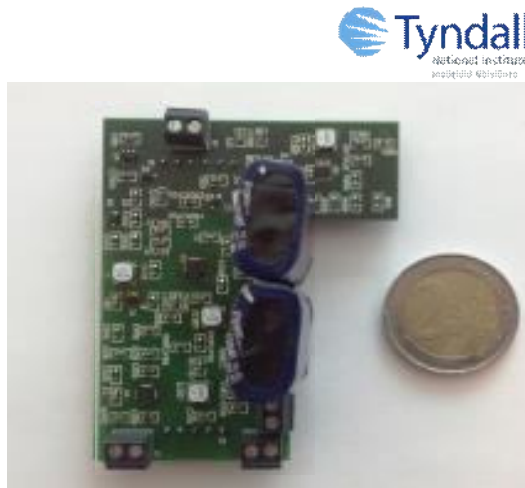
- Ability to quickly track assets, e.g. inspection microscopes, using off the shelf sensors
- Tyndall expertise used to select and install hardware, feed required data to other COMPOSITION partners
- Retrofitted PV Energy Harvesting to Beacons that doubled battery life from 260 to 550 days

In future projects

- Self-power the sensors - eliminate battery maintenance
- Integrate emerging technologies that enable size reduction
- e.g. fit on trays or unobtrusively into equipment
 - (RF protocols, power management, sensors, batteries)
- Integrate emerging technologies that improve range/accuracy



Industry 4.0/ Commercial Buildings Example



Multi source harvester

Use light, vibration or heat from compressor to self-power a 'diagnostic unit'
Does predictive maintenance on cold room compressor & food storage rooms

Industry 4.0/ Commercial Buildings Example



Indoor solar powered 'Nod'

Interactive sensor to help optimize comfort in an office/factory

60% battery life extension achieved

Could become self powered as RF and air quality sensor technologies evolve

Ideas for other Industry 4.0 Use Cases

Bin fill monitoring

Done by CERTH, ELDIA & Kleeman as a COMPOSITION use case

Improved data granularity to feed to control systems

Monitor of other physical & electrochemical attributes

Holistic plant visualisation / Digital Twin e.g.

Bottleneck detection

Scenario investigations

Equipment set up optimization

Time and motion studies

Optimisation of systems & processes

Dynamic assessments

Integration of robotics, drones, AVs

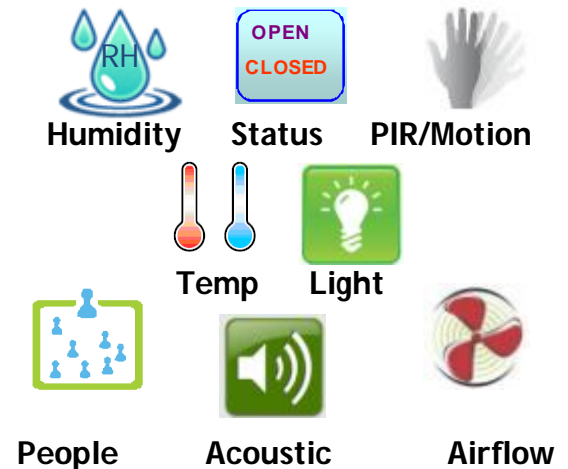
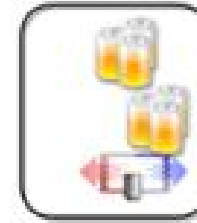


Image source: pattiengineering.com

Ideas for other Industry 4.0 Use Cases

Renewable energy integration

Heat pumps solar panels, battery banks, wind turbine, etc.



Air quality monitoring

Product quality, operative work environment



Regulatory compliance

Temp, lighting, noise, air quality, humidity, etc.



Security/Safety

Contextualize temperature, air quality, noise, vision systems



PPE

Integrate into personnel protection equipment



The 'Power IoT' Challenge



Industry challenge:

How do we make the batteries outlive these 1 trillion IoT sensors?



Solution:

Collaboratively and concurrently develop application orientated & optimised solutions

- Get academic and industry developers of energy harvesting components and systems as well as IoT devices to work together
- Accelerate & optimise development of parts and systems
- Parts should be standardised and interoperable

Tyndall doing this via internal and external collaborations
External collaborations spearheaded by



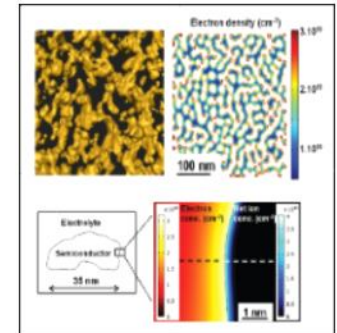
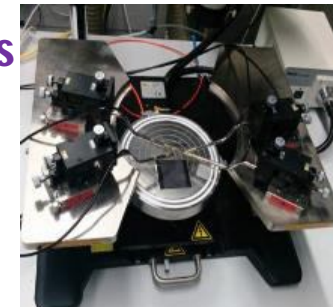
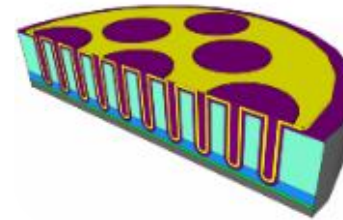


EU infrastructure project



EU Project 730957

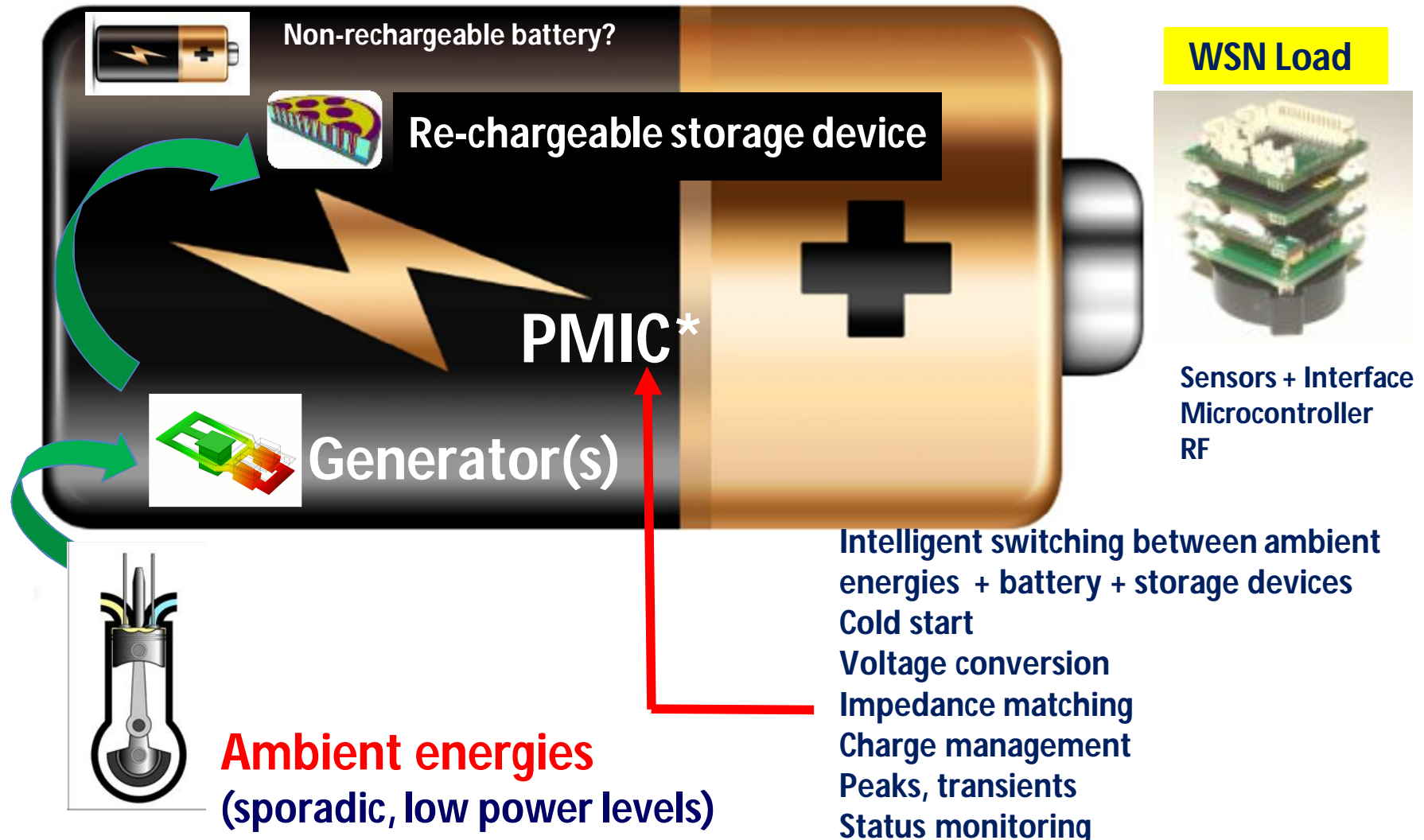
- Builds an ecosystem to power the internet of things
 - Driving system level thinking & optimization
 - Via collaboration, inter-operability, standardization
 - Its Transnational Access program* gives
 - **Free of charge** access to expertise & laboratories
 - Feasibility studies
(paper, simulation, characterisation, proto)
 - Sign Up and enquire at www.enable-project.eu
 - Joint Research Activities* are creating
 - System optimised, application orientated solutions
 - De-risked & standardised methodologies & library parts
- * Open to industry and academic applicants worldwide
- ** Done by project partners listed below



Technology - Energy harvesting

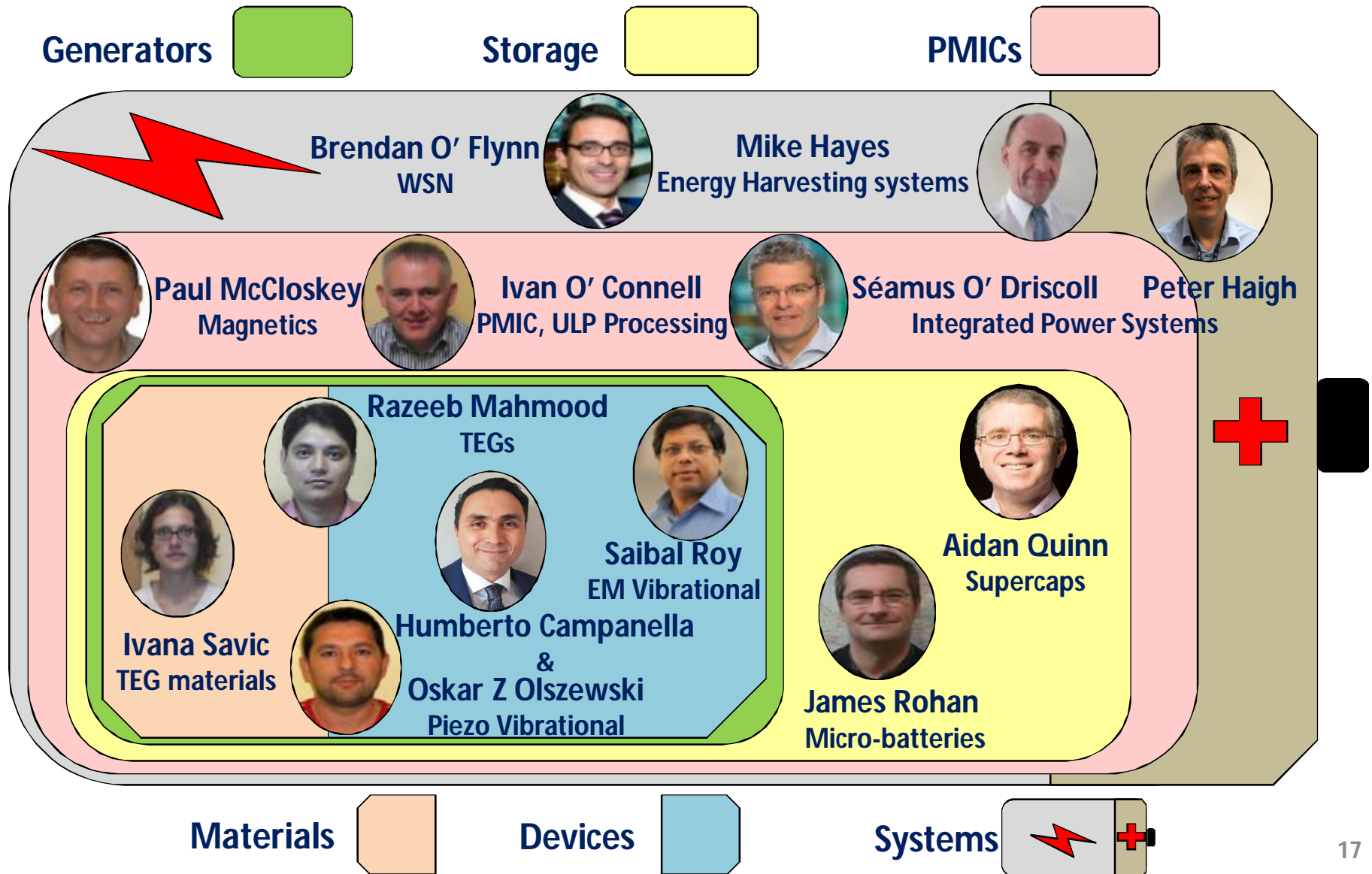
Replacing the function of a battery is not easy

- Complex array of stuff to be integrated



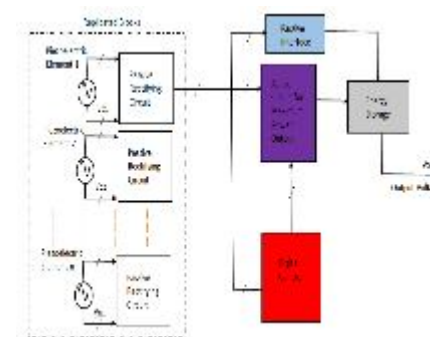
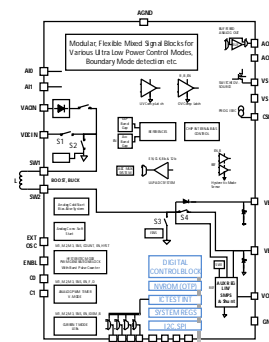
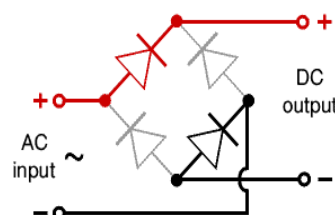
*Power Management IC

Tyndall has an Ecosystem of PIs to address this

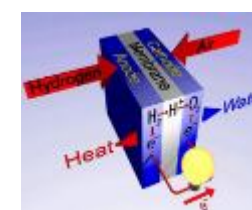
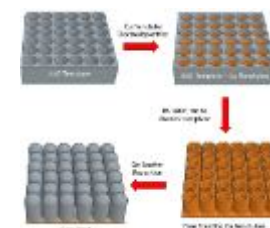
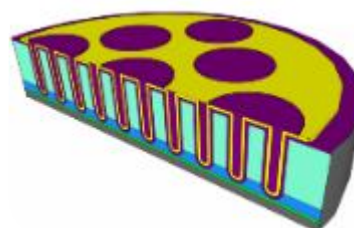
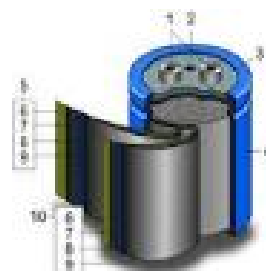


A One Stop Shop - Tyndall Energy Harvesting & Storage

Control
Power Management ICs & Circuits
Multi-source
Self-start
High efficiency

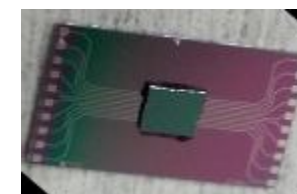
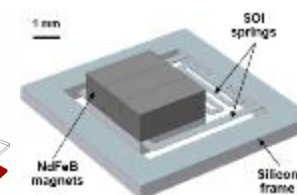
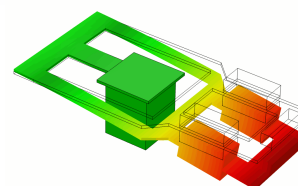
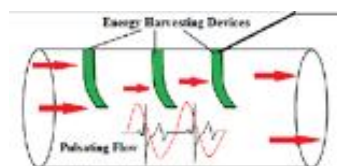


Storage
Supercaps on Silicon
Flexible batteries
Micro-batteries
Nanotube high density



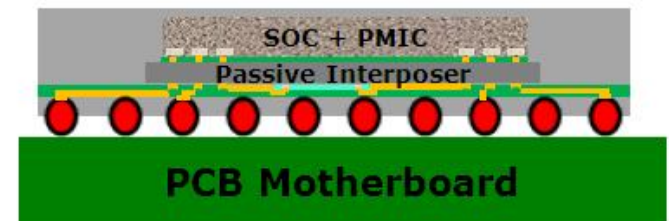
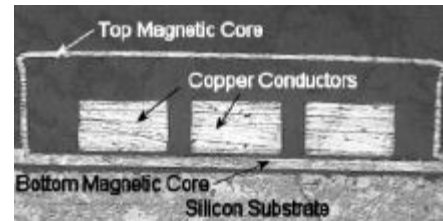
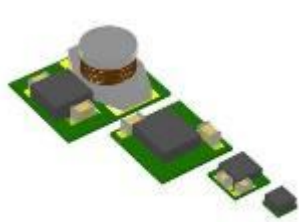
Generation

Generators on silicon
Wide bandwidth vibration
(Electromagnetic & piezo)
High density MEMS
IC integrated highest efficiency TEG materials



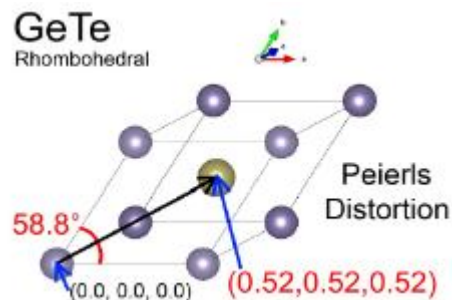
Material, Device & System Integration

Embedded Magnetics

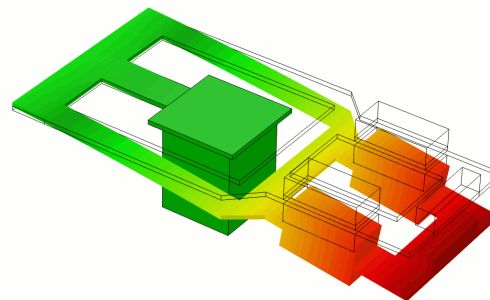


Making magnetics disappear in packages (PSiP) & onto ICs (PwrSoC)

Simulation



Atomic/material



Physical/mechanical



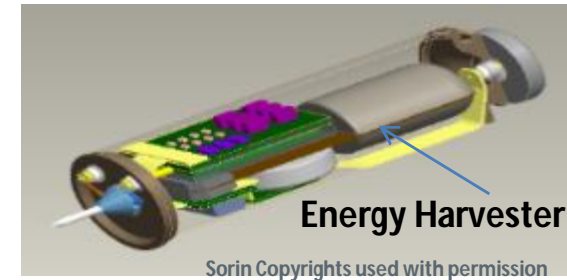
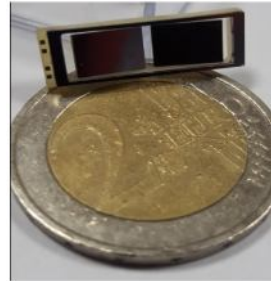
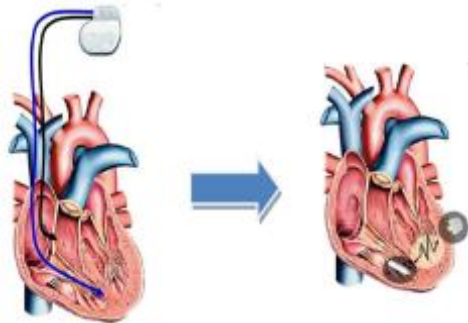
Design/Deployment tool
Circuits (discrete & CMOS)

The Power of Collaboration

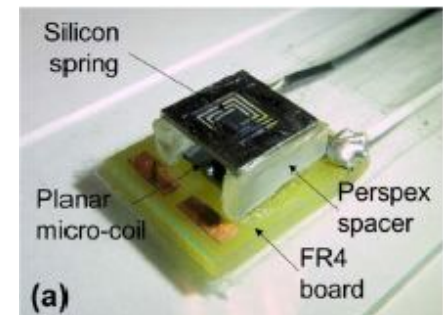
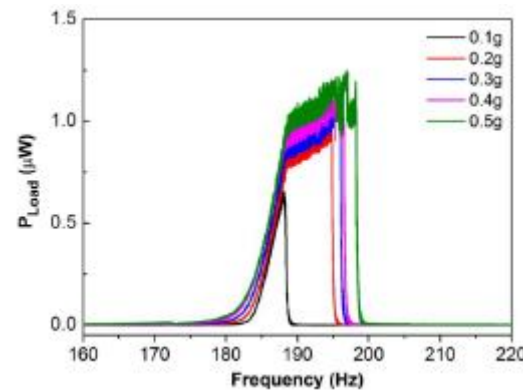
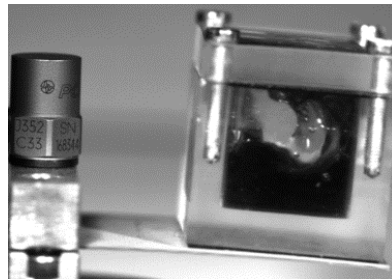
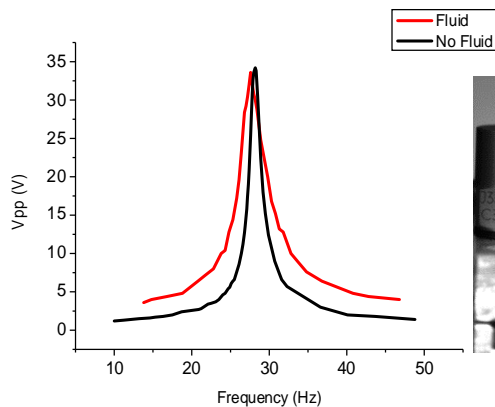
System application optimised parts & devices e.g.
Harmonise methodologies & specifications
Compatibility:- Process, Electrical, Packaging



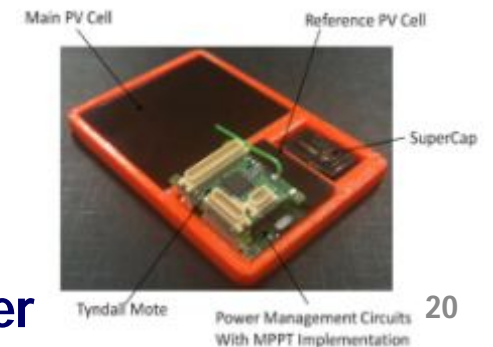
Some Application System Integration Examples



Miniaturisation:- Implantable Energy Harvester



Performance enhancement:- Wide bandwidth Vibrational Energy Harvesters



Circuit and system innovation:- Indoor solar energy harvester

"MISCHIEF" World leading Multi-source energy harvesting PMIC



Superior in key parameters outlined below

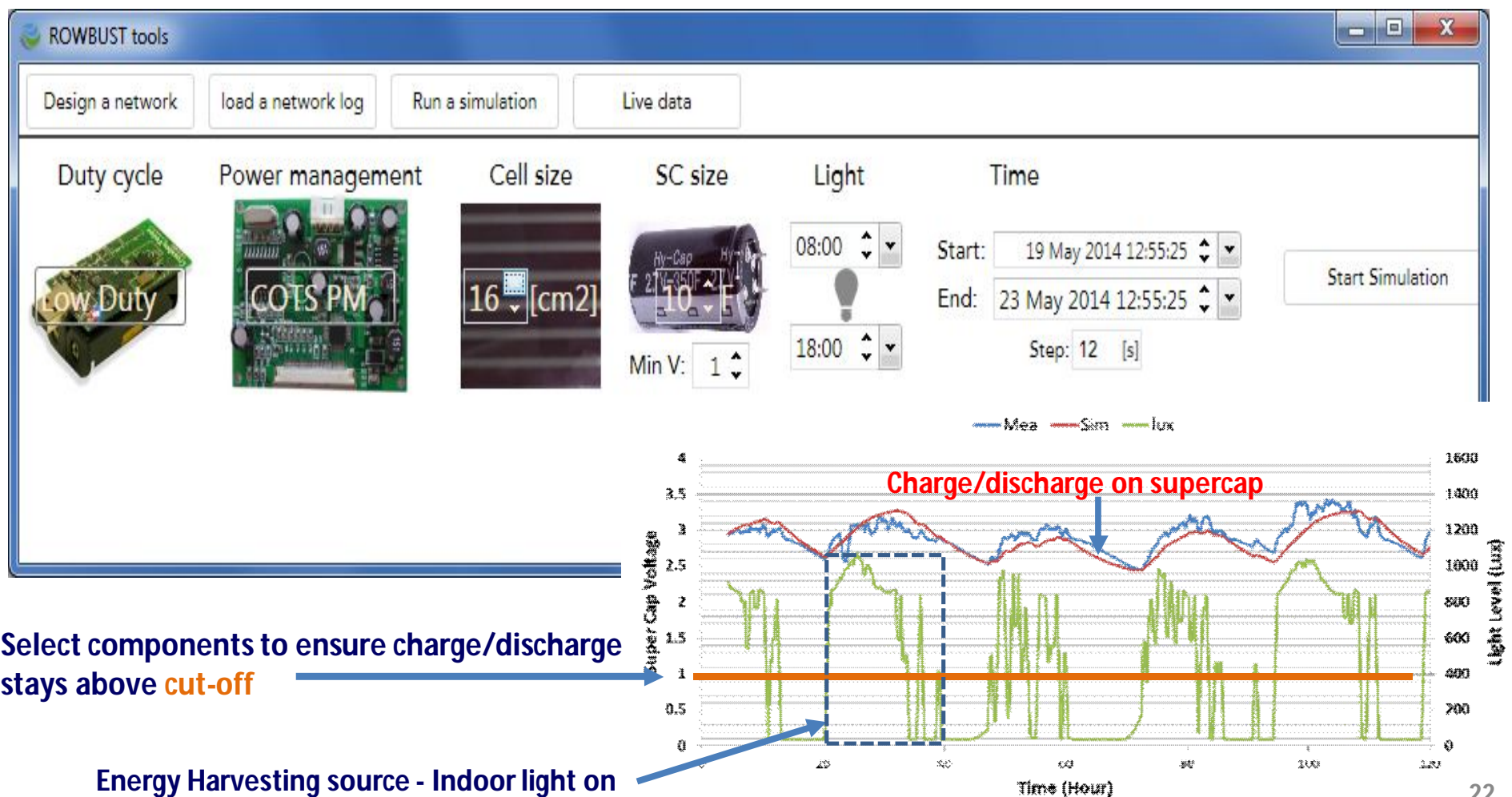
Parameter	MISCHIEF*	Best Commercial	Commentary
Efficiency	90-95% >10uW 75-90% <10uW	Typ. 2-5% lower Most are inoperable	Higher efficiency than any other PMIC especially below 10 μ W
Min. input Voltage	20mV	50mV	Also has extremely wide input and output voltage range
Min ambient energy usable	<1uW	>3uW	Many real life ambient energies are at this level
Quiescent current	<100nA	330nA	Reduces drain on battery
Digital interfacing	Yes	No	Interact with load to minimise power. Can add circuits to optimise energy harvesting and storage functions

- MODULAR circuit blocks methodology enables **FAST TRACK LOW RISK** development
- Not just for energy harvesting, also for any low power application, particularly good at interfacing with 'smart switching loads' to extend battery life

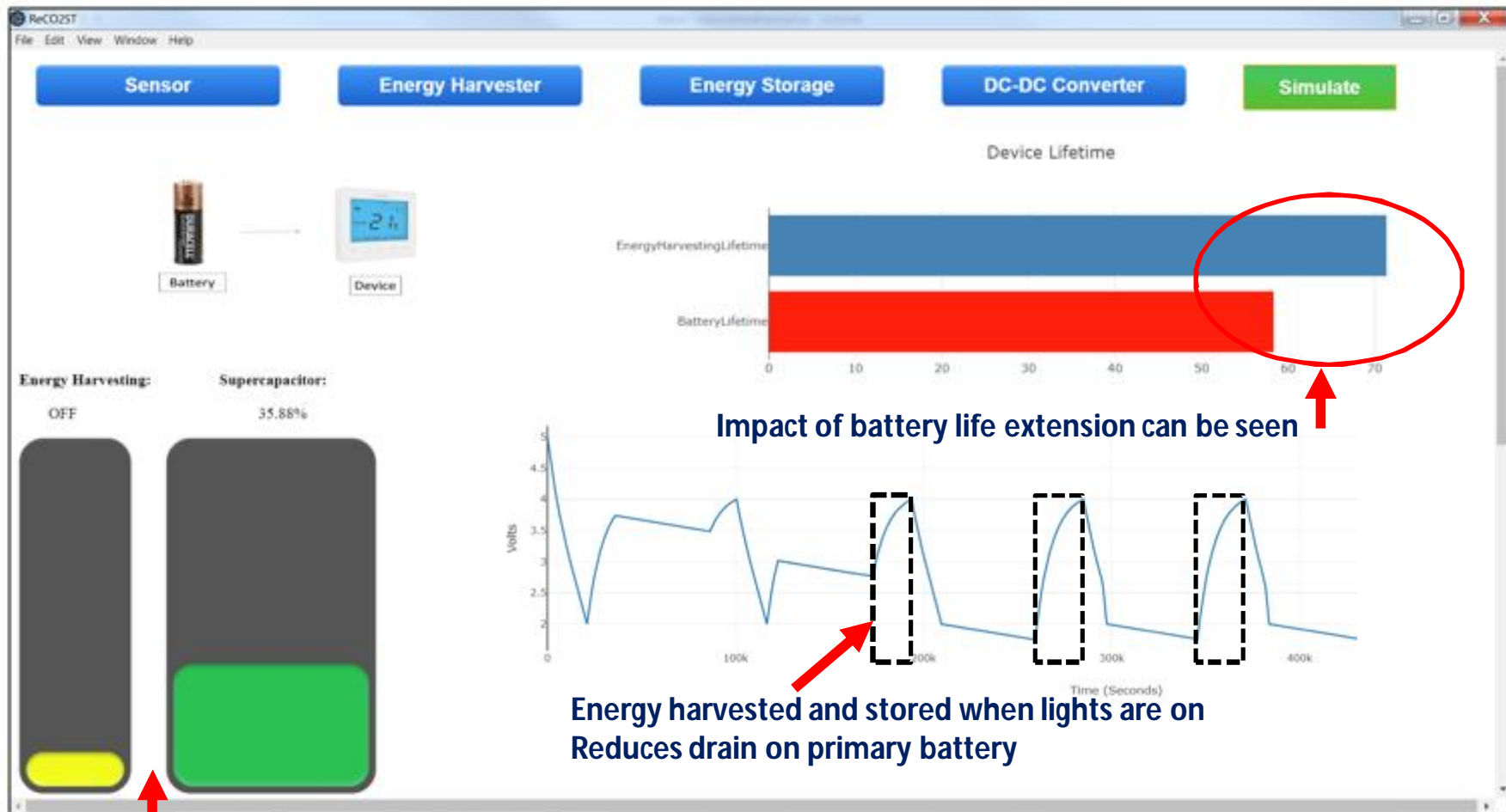
* Based on extracted simulation, proto testing Q4 2020

RoWBUST Battery life Assistance Tool

Help installers select hardware components for a potential energy harvesting deployment
No Energy Harvesting or wireless sensors expertise needed



Newest version of ROWBUST on EU ReCO2ST project will also give overall battery life estimate



Dynamic visual aid to see charge and discharge on supercap when lights are on/off

Technology Roadmaps

Perennial contributors to PSMA's PTR Led the 3D Power Packaging roadmap study part I

Technical Committee activity

- Energy Harvesting (co-founder)
- Energy management
- Packaging
- Magnetics
- Reliability

Conferences and workshops

Co-founders of PwrSoc...power supply on chip <http://pwrsocevents.com/>

Co-founders of EnerHarv, started in 2018 www.EnerHarv.com

Annual contributors to APEC industry sessions



Technology Report

3D Power Packaging

**A Special Project of the
PSMA Packaging Committee**





What problems can
we help you solve?

Thank You!

Acknowledgements

- This work was sponsored by the following projects

MISCHIEF



RoWBUST



- We would like to take this opportunity to thank the ICT4EE team at Tyndall and all our EU project partners

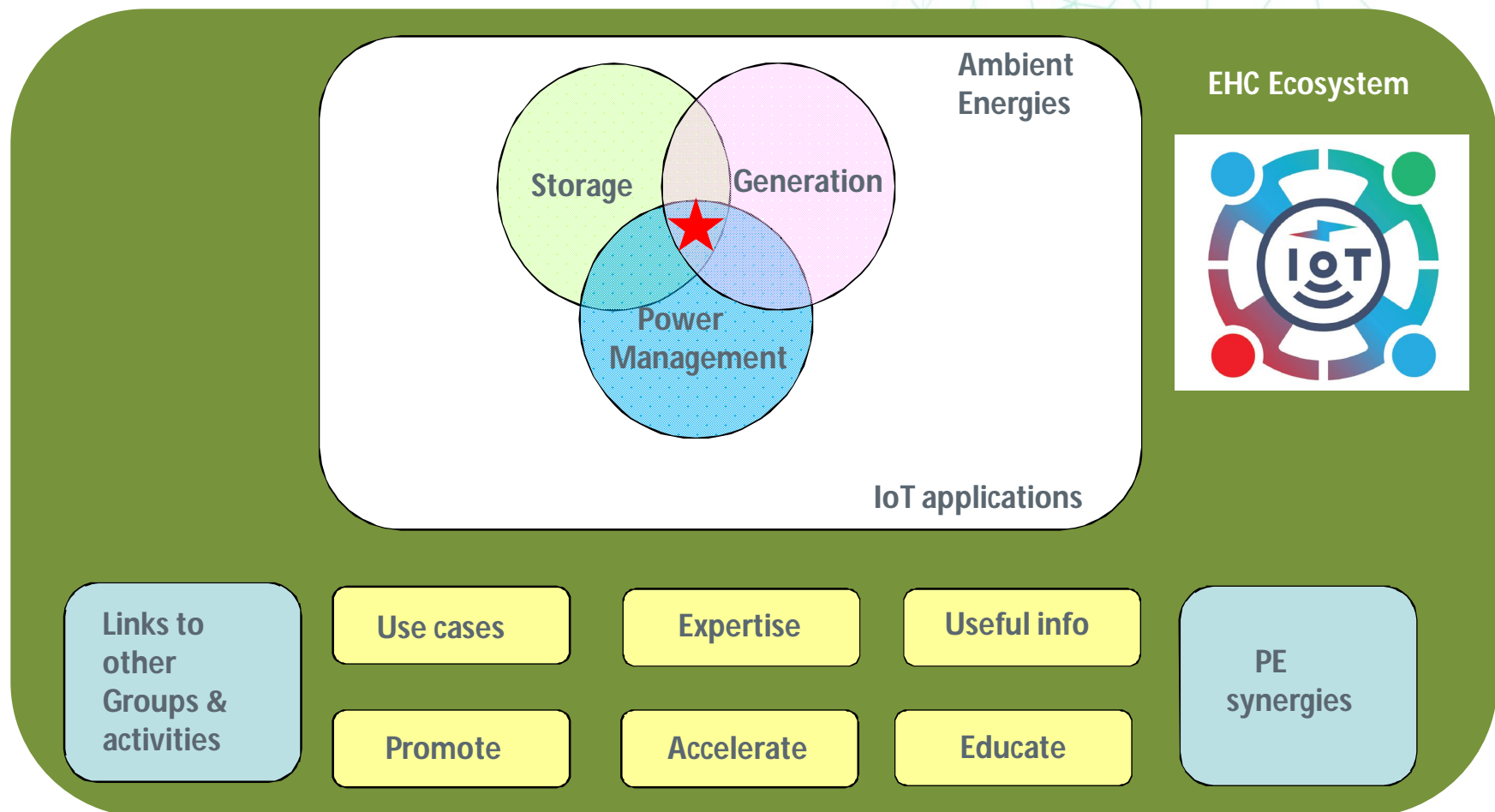
PSMA Energy Harvesting Committee (EHC)



MISSION:- To create a power IoT ecosystem

Currently has 48 members, new members welcome (you do not need to join PSMA)

Contact Michael.hayes@tyndall.ie or Brian Zahntecheer bz@powerroxx.com



Our **Ecosystem** of Stakeholders



Developers



Integrators



Suppliers



Users



Presented at



EnerHarv 2018



IoT WEBINAR Announcement

**"Micro-energy management for energy
harvesting IoT devices"**

Host: Dr Peter Spies
Fraunhofer IIS - Germany



Tuesday 16th June 2020, 15:00 CEST (UTC+2)

Registration is now OPEN

Tyndall and University of Bologna will also present

You can register here:-

<http://www.enables-project.eu/webinar-registration/>

Previous webinars are here:-

<http://www.enables-project.eu/webinars/>

Our power sources industry ecosystem for the benefit of stakeholders

*Discuss
Progress
Enhance
Educate
Inform
Guide
Connect
Publish Resource
Fund*



Capacitor



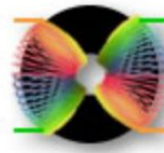
Education



Energy Harvesting



Energy Management



Magnetics



Packaging & Manufacturing



Power Technology Roadmap



Reliability



Safety & Compliance



Semiconductor



Transportation PowerElectronics

*Manufacturers
Developers
Suppliers
Educators
Integrators
Users
Funders
Regulators*

PTRs, special studies (1st copy) and webinar material free to all members

<https://www.psma.com/membership/joining-information#memb>



Our power sources industry ecosystem for the benefit of stakeholders



PTRs, special studies (1st copy) and webinar material free to all members

<https://www.psma.com/membership/joining-information#memb>

