Industry Session 11: Energy Harvesting

EnABLES – Growing the Power IoT Ecosystem

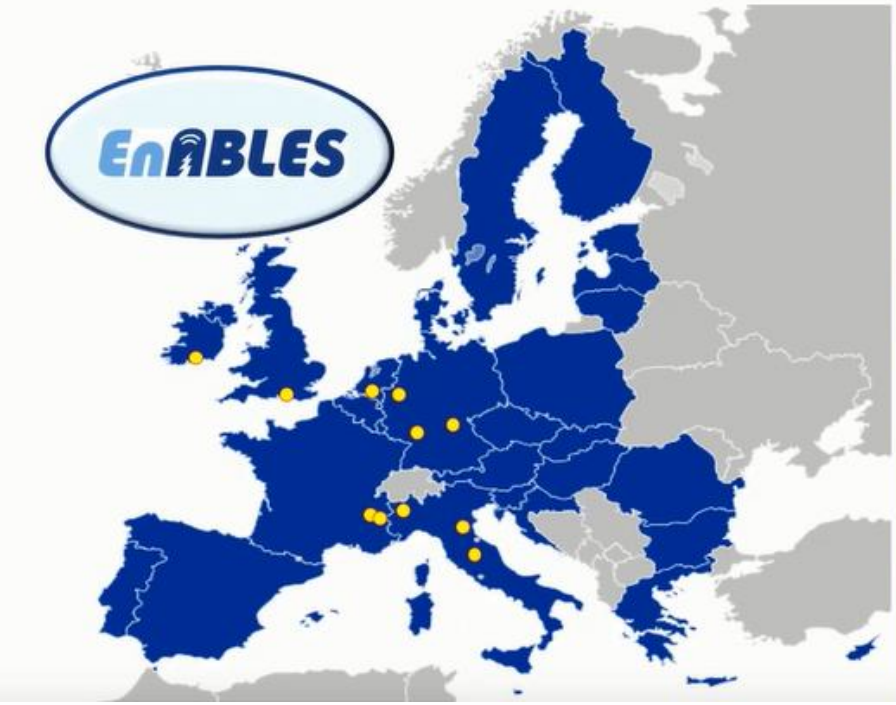
Presented By

Mike Hayes,
Tyndall National Institute

Wednesday, March 18, 2020

European Infrastructure Powering the Internet of Things

The EnABLES Consortium



Institute	Country
Tyndall National Institute	Ireland
CEA Leti & Liten	France
Fraunhofer IMS & IIS	Germany
imec	Netherlands
University of Perugia	Italy
University of Southampton	UK
Karlsruher Institute for Technology	Germany
Politecnico di Torino	Italy
University of Bologna	Italy

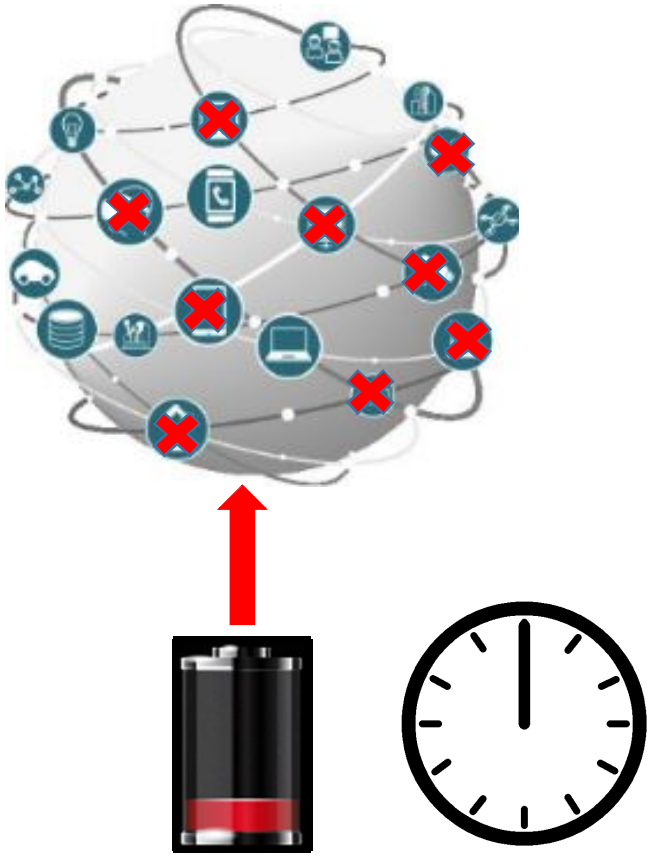
www.enables-project.eu

What problem are we solving?

The world will have 1 trillion IoT devices by 2025 all needing a power source

Most of these will be wireless devices!

Great opportunities but.....



What problem are we solving?

What technologies that will make batteries last longer, in some cases lasting 'forever'

Energy Harvesting

Mission

- Maximise energy extracted from REALISTIC ambient energy sources
- Supply it in a format that is easy to use/convert/store
- Cater for variations (lighting level, frequency, temperature gradient, etc.)
- Be small, robust, adaptable, easy to install and integrate

What problem are we solving?

What technologies that will make batteries last longer, in some cases lasting 'forever'

Energy Storage

Mission

- Provide a steady voltage to the IoT load
- Use low leakage current
- Run for many cycles with minimum performance degradation*
- Accept and store ambient energies for processing &/or later usage*
- Be small, robust, adaptable, easy to install and integrate

* Re-chargeable devices

What problem are we solving?

What technologies that will make batteries last longer, in some cases lasting 'forever'

Mission

- Provide a steady voltage to the IoT load
- Use low leakage current
- Maximise conversion efficiency from harvesters and storage devices
- Be clever in turning on/off devices, changing operation modes to minimise battery drain
- Be small, robust, adaptable, easy to install and integrate

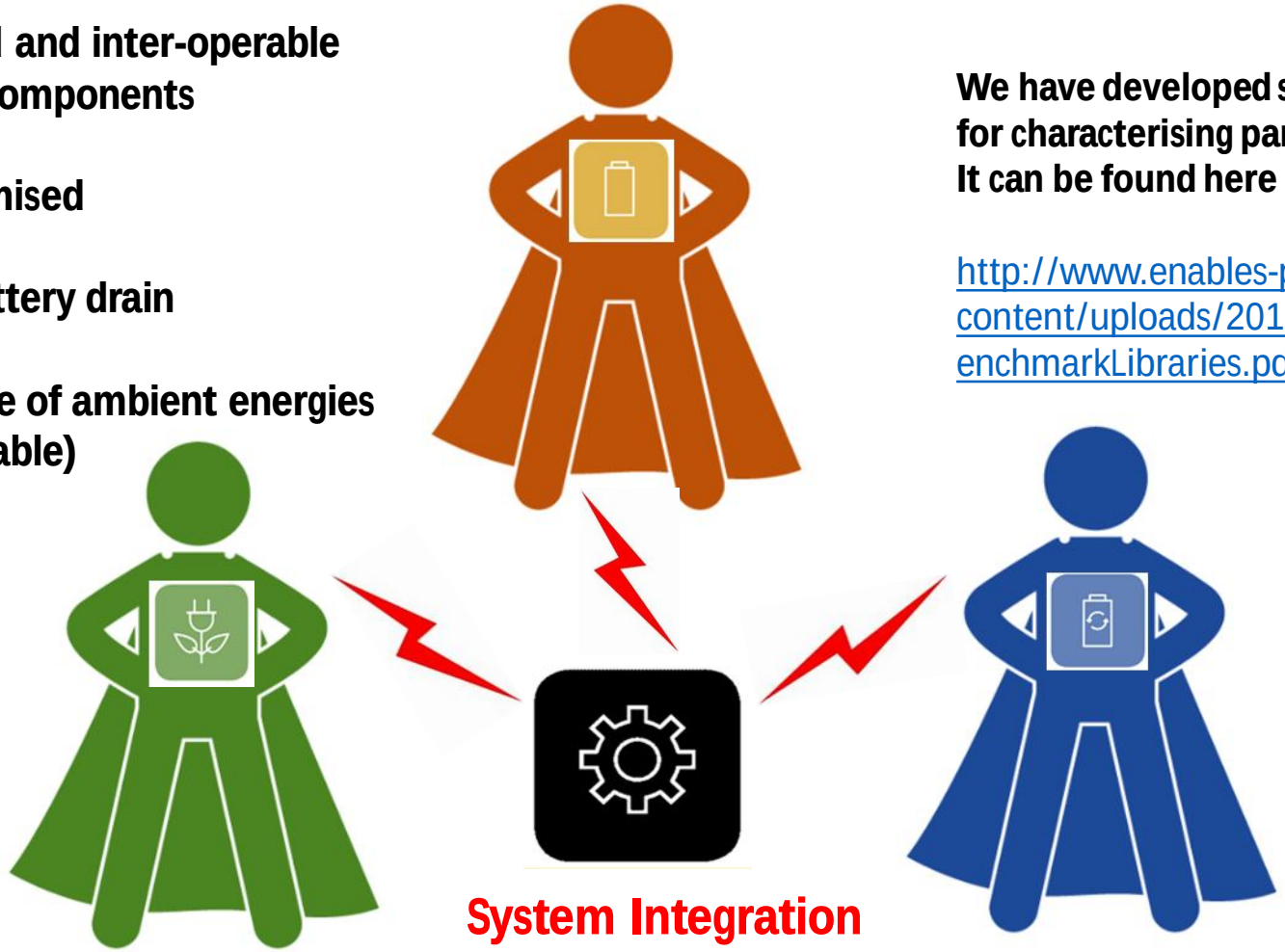
Micro-power Management

System integration is our ultimate superpower

- **Standardised and inter-operable technology components**
- **System optimised**
- **Minimize battery drain**
- **Maximise use of ambient energies (where available)**

We have developed standardised templates for characterising parts.
It can be found here

http://www.enables-project.eu/wp-content/uploads/2019/11/EnABLES_UniformBenchmarkLibraries.pdf



System Integration

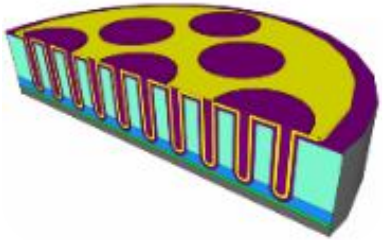
How do we achieve this - EnABLES

- Providing external fast track Transnational Access (TA) to expertise and laboratories
  - ✓ €2Bn worth of infrastructure & over 130 researchers
- Using EnABLES to foster a 'starting community' (Power IoT ecosystem)
- Creating 'self-sustaining' energy solutions to 'power the internet of things' based on energy harvesting, storage, micro-power management and system integration activities

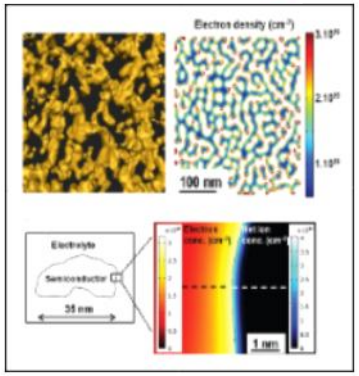
- Together we create standardised and inter-operable libraries of parts & simulation tools for optimising system level performance

TA & JRA programs

- Would you like a feasibility study to be done for free?
- Our Transnational Access (TA) program offers you this!
- Access our expertise and laboratories
  (simulations, characterisation, proto testing)

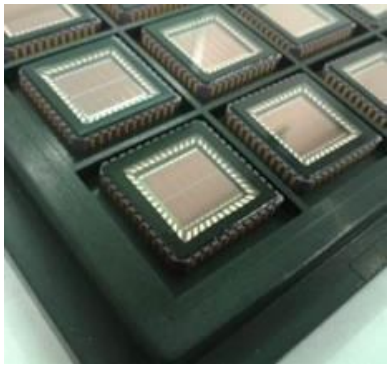


- Our Joint Research Activities (JRA) are creating the TA platforms of tomorrow
  - System optimised, application orientated solutions
  - De-risked & standardised methodologies & library parts (open source)

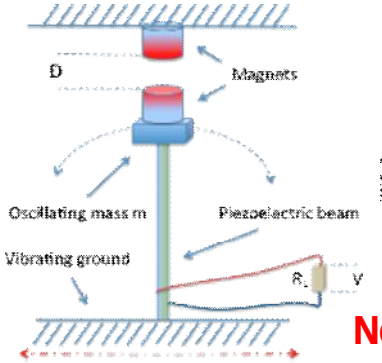


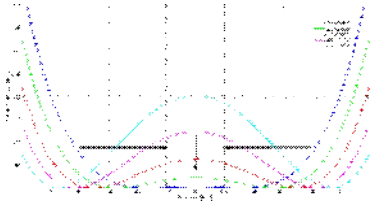
Examples of Technology Available

- **Energy Harvesting**

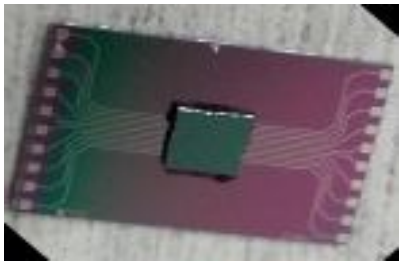


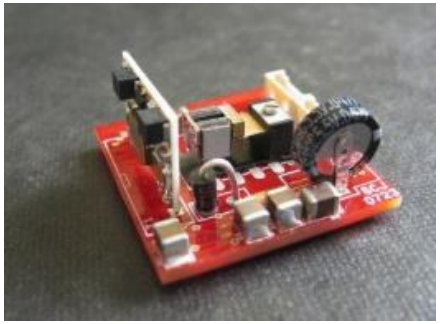
Integrated solar



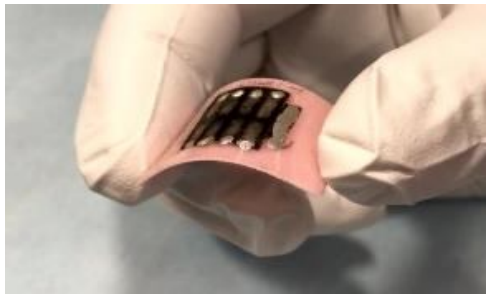


Non-linear EM



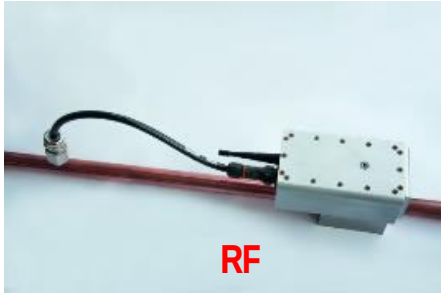


Electromagnetic (EM) Vibrational

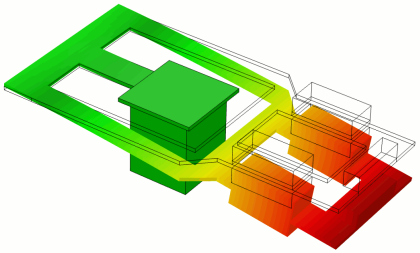


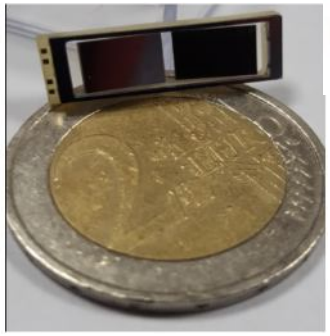
Piezo

Thermoelectric



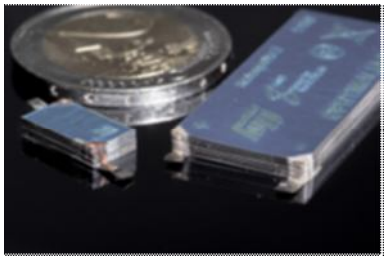
RF



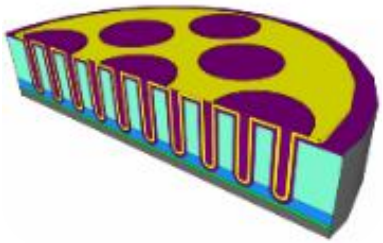


Examples of Technology Available

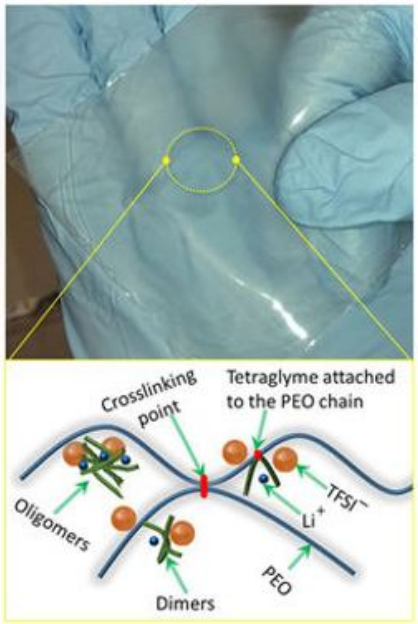
- **Energy Storage**



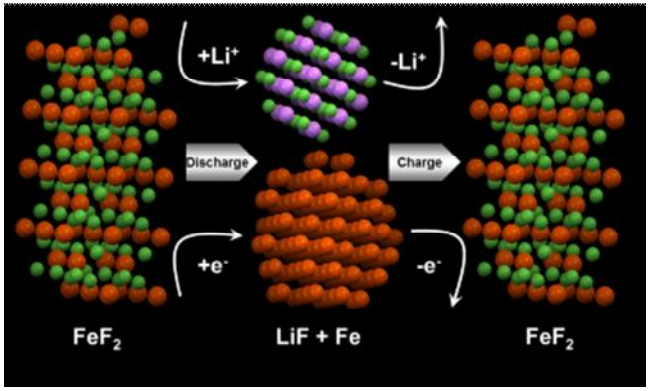
Micro-batteries



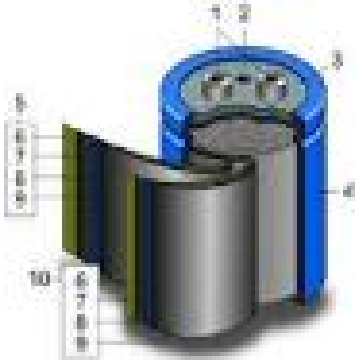
CMOS compatible Supercaps



Flexible batteries



Printed batteries

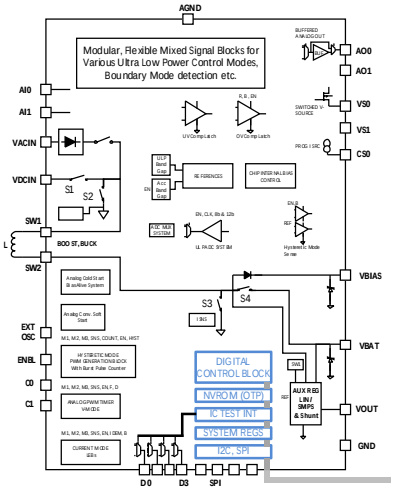


Nanomaterial supercaps

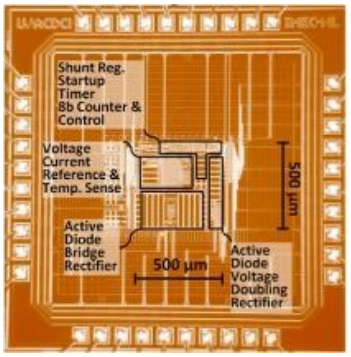
Examples of Technology Available

- **Micro-Power Management (MPM)**

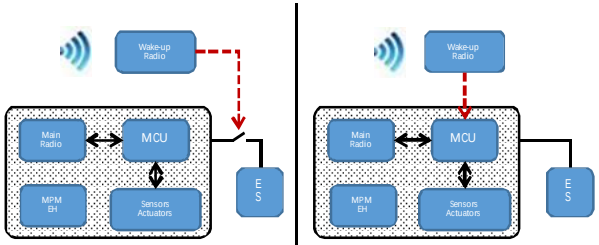
ULP (ultra low power) ASIC



MISCHIEF modular PMIC

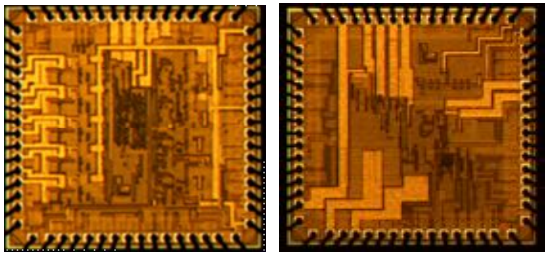


Energy Aware PMIC

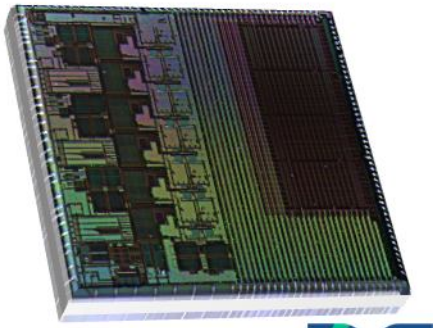


OFF-mode STANDBY-mode

RF MPM



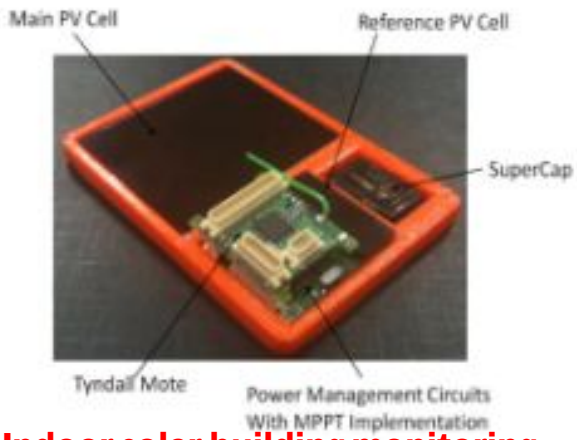
Multi- and Single-source PMICs



MuseIC

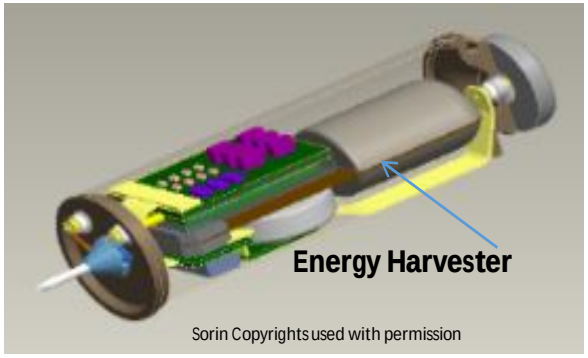
Examples of Technology Available

- **System integration**



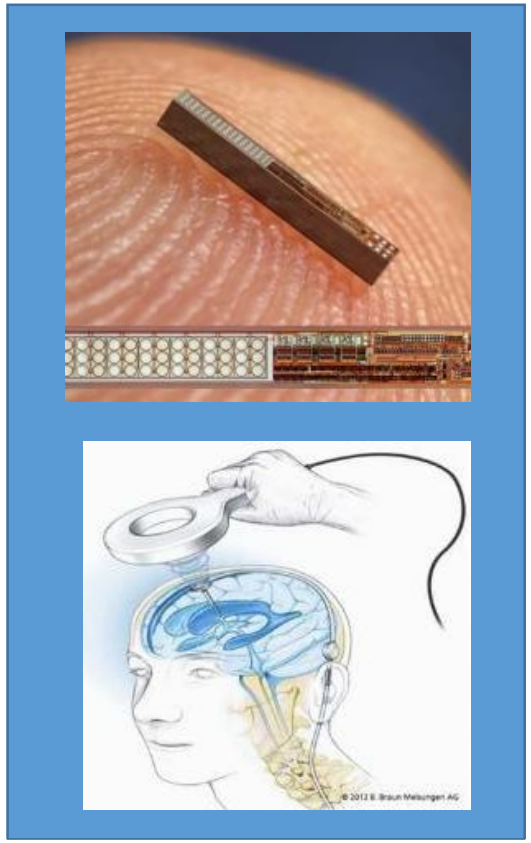
Indoor solar building monitoring

Solar powered window sensor



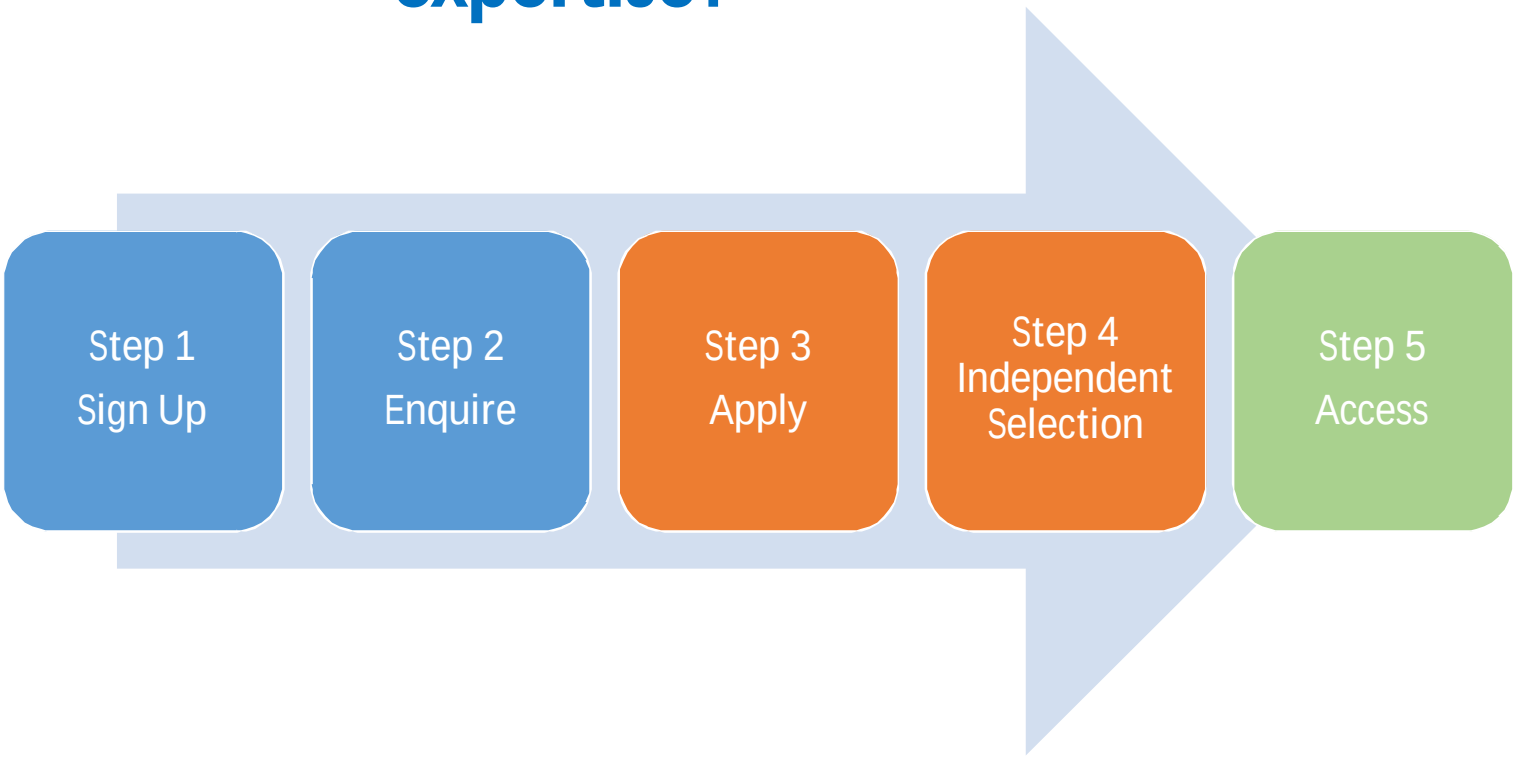
Implantable pacemaker

TEG powered sensor



RF powered sensor

How to access EnABLES technologies and expertise?



Make an enquiry today!

EnABLES Enquiry Form

*Your contact data is collected only for communications with **EnABLES** Technical Personnel. We will never share this data outside the **EnABLES** consortium.*

Name * Your Name

Position * --

Nationality For EU statistical purposes only

Gender For EU statistical purposes only

e-mail * e-mail

Organisation * Name of organisation

Website * Organisation website

Organisation type *
- Academic/University
- Research Institute
- SME
- Company
- Other

City * City

Country * Country

What Offer are you interested on? * --

Enquiry * Describe your technical enquiry

We would be delighted to discuss any enquiries

Sample Access projects

EnABLES-003

Thin film batteries at CEA-Leti

EnABLES-004

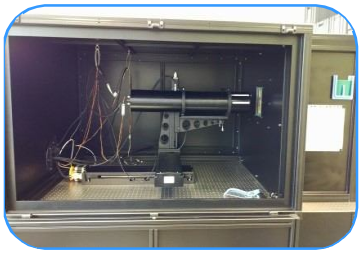
RF energy harvesting at Fraunhofer IMS

EnABLES-005

Stacked micro batteries at CEA-Leti

EnABLES-006

Low power animal tracking at Fraunhofer IIS

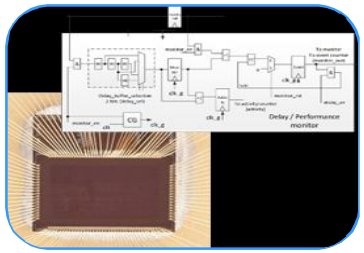


EnABLES-009

PV energy harvesting at Fraunhofer IIS

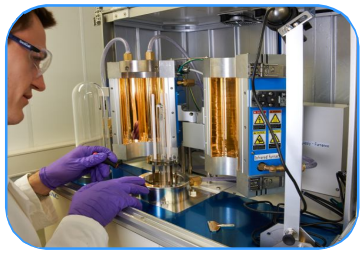
EnABLES-015

Electrochemical micro batteries at Tyndall



EnABLES-017

ASIC for Vibrational EH at imec-NL



EnABLES-025

Improve thermoelectric performance at CEA-Liten

Strategic Links to PSMA

Synergistic links with PSMA Energy Harvesting Committee

Both have similar missions… build 'power IoT' ecosystem, create synergies, solve problems

Several people are involved in both

Almost 50 members to date from 4 continents

Provided 'Power IoT' info to the PSMA PTR 2019 (Power Technology Roadmap)

New members welcome!

Contact Brian Zahnstecher or Mike Hayes to learn more

Technical sponsor to EnerHarv 2020 PSMA power IoT workshop

Ref next slide

Strong involvement in organising committee

Helped kick start inaugural EnerHarv 2018

EnerHarv 2020

2nd international energy harvesting and micro-power management workshop

Save the date! 16-18 June 2020

Hosted by the ASSIST Centre, North Carolina State University, USA

Check out www.EnerHarv.com

Building an ecosystem of Power IoT stakeholders

Power IoT Technologies - Energy Harvesting, Storage, Power Mgt, System Integration

Enabling Technologies – ICT, Energy Efficiency, Power Electronics, MEMS

Stakeholders – Developers, Suppliers, Users, Integrators

What did you previously miss?

EnerHarv 2018 proceedings now available (FREE) at http://www.enerharv.com/enerharv-2018-data-repository/

Further info available at https://www.psma.com/tech-forums-energy-harvesting/workshop/5840

European Infrastructure Powering the Internet of Things

Have you signed up?
Come join our Ecosystem

Thanks a lot for your time and attention!

Any questions and/or comments?

http://www.enables-project.eu/contact/

Thank you!

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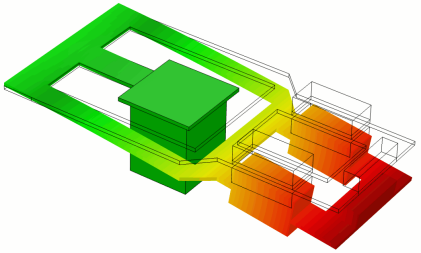
EnABLES (http://www.enables-project.eu/) has received funding from the EU Horizon 2020 research and innovation programme, under Grant Agreement no. 730957.

Additional slides not presented

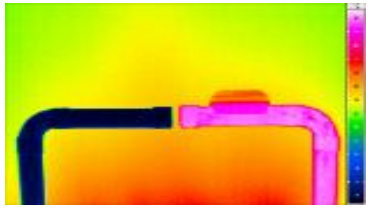
Please contact Mike Hayes or enquire via EnABLES for more info.

Some JRA Activities

Energy Harvesting (EH)



- Wide-band non-linear vibrational harvesters
- Fabrication of a fully integrated MEMS Electromagnetic Vibration Energy Harvester
- Modeling and characterizing **nonlinear wideband MEMS electrostatic Vibration Energy Harvester** & investigate its integration with electrets.
- Novel high-performance thermoelectric materials & simulation models
- New integrated technique to measure anisotropic components of Seebeck coefficient, electrical and thermal conductivities
- Increase efficiency of amorphous silicon solar cells on 8'' wafers



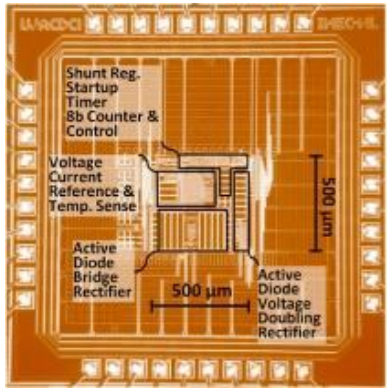
Energy Storage (ES)

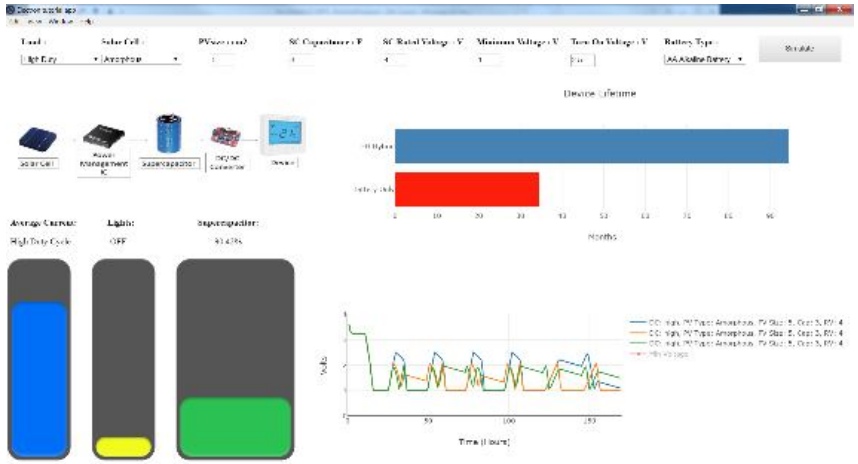
- Nanoscale materials that yield high-rate fast charging and discharge
- Enhancing cathode stability to increase the energy density
- Nanoscale protective films via ALD/CVD for higher energy density electrodes & improved lifetime
- Sulphur-based cathodes with x10 higher theoretical energy capacity
- Room temperature ionic liquids & new solid-like, solid-state and hybrid composite solutions
  – improve thermal, ion transport & safety features of electrolytes
- ALD/CVD deposition of protective materials -higher energy/power density, lower cost, long life
- High entropy oxides (HEO) - promising new material class for electrode materials.

Some JRA Activities

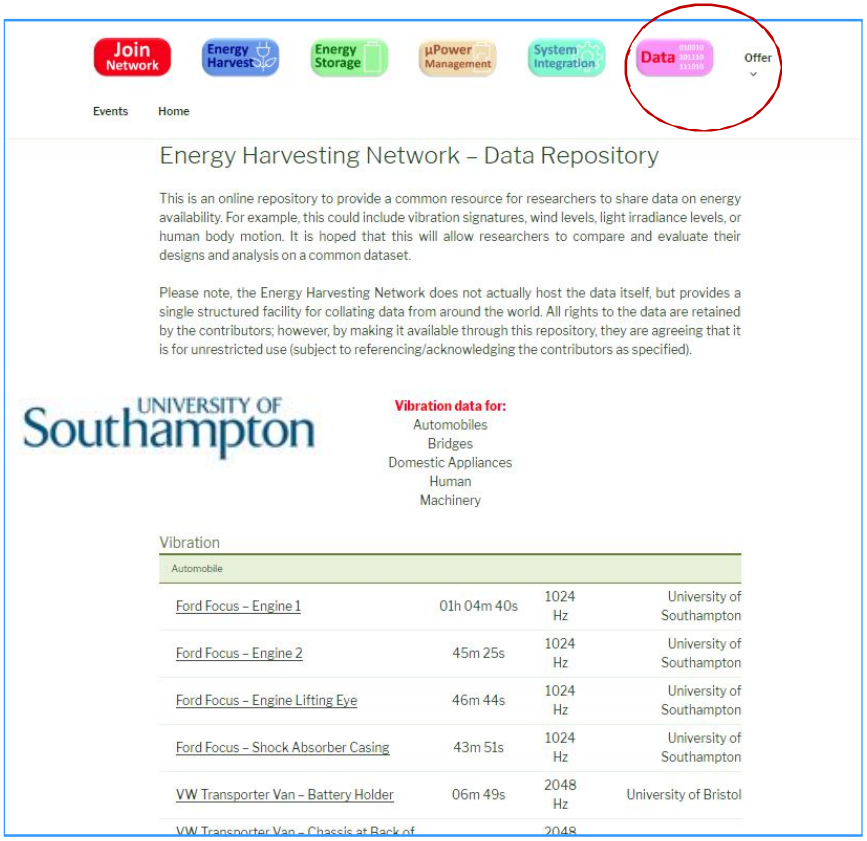
Micro-Power Management & System integration

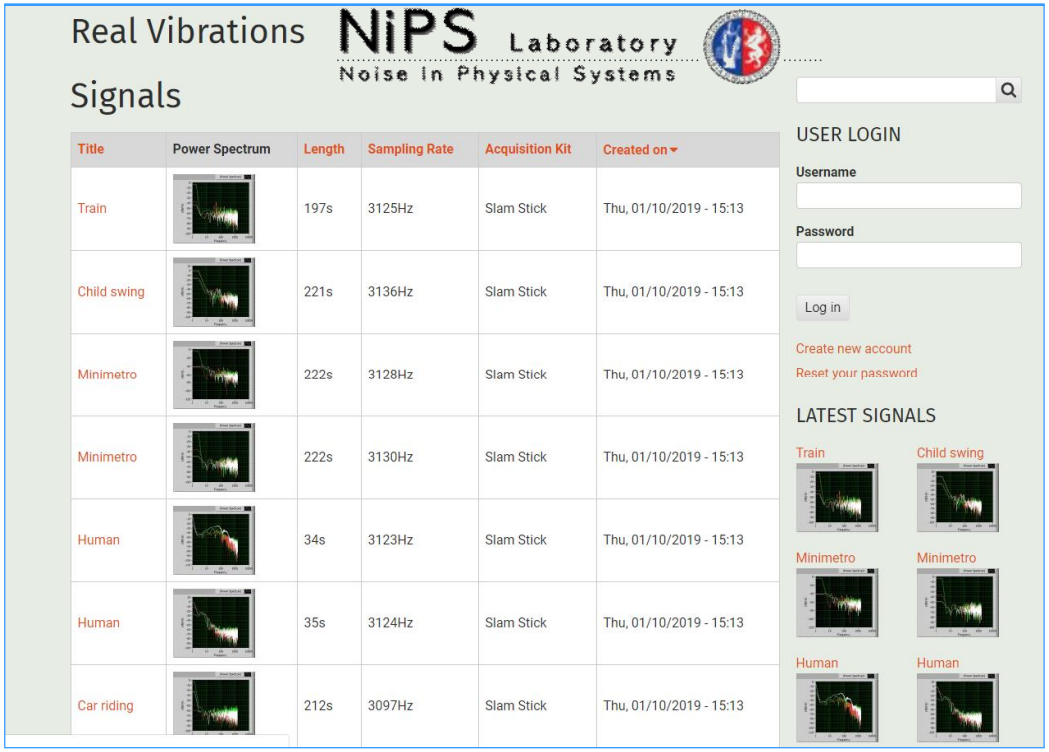
- Efficient power conversion techniques + models particularly at low voltages & power levels
- Understand best trade-offs between intrinsic consumption of circuits & conversion efficiency
- Provision for both multiple source types
- Collaborative development of circuits to maximize transducer performance
- Electronic interfaces to other IoT components with low intrinsic consumption
- New antenna and rectenna designs for textile-based RF EH & wireless power transfer
- 10mV ultra-low voltage start-up circuits
- Investigation of Maximum Power Point Tracking (MPPT) architectures in a mixed-signal programmable IC
- AC-DC converter for electro-dynamic generators
- Simulation tool for system level assessments





Virtual Access…Database of ambient energies





Free access to all who sign up to EnABLES

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Push & Pull Technology