Powering 1 Trillion Sensors in 2025

CPSS-PSMA Workshop 11-6-18

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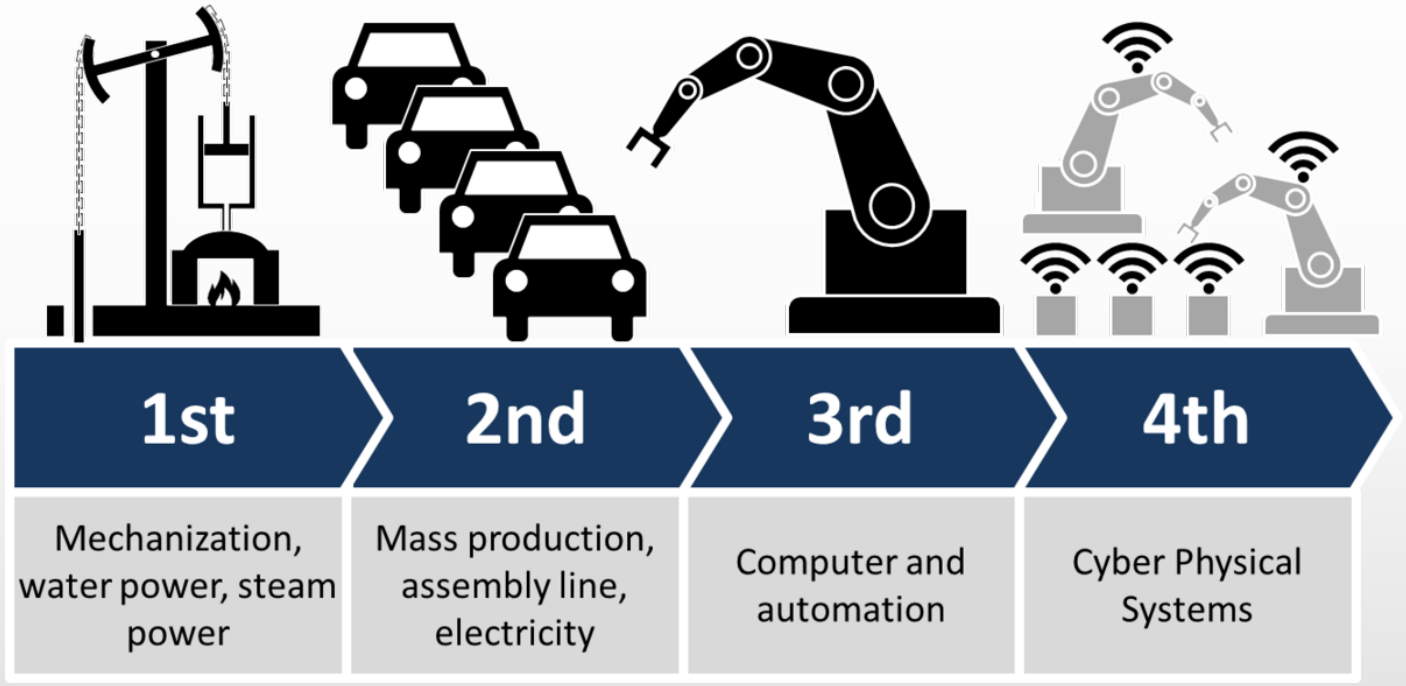
PowerRox

纳微 Navitas

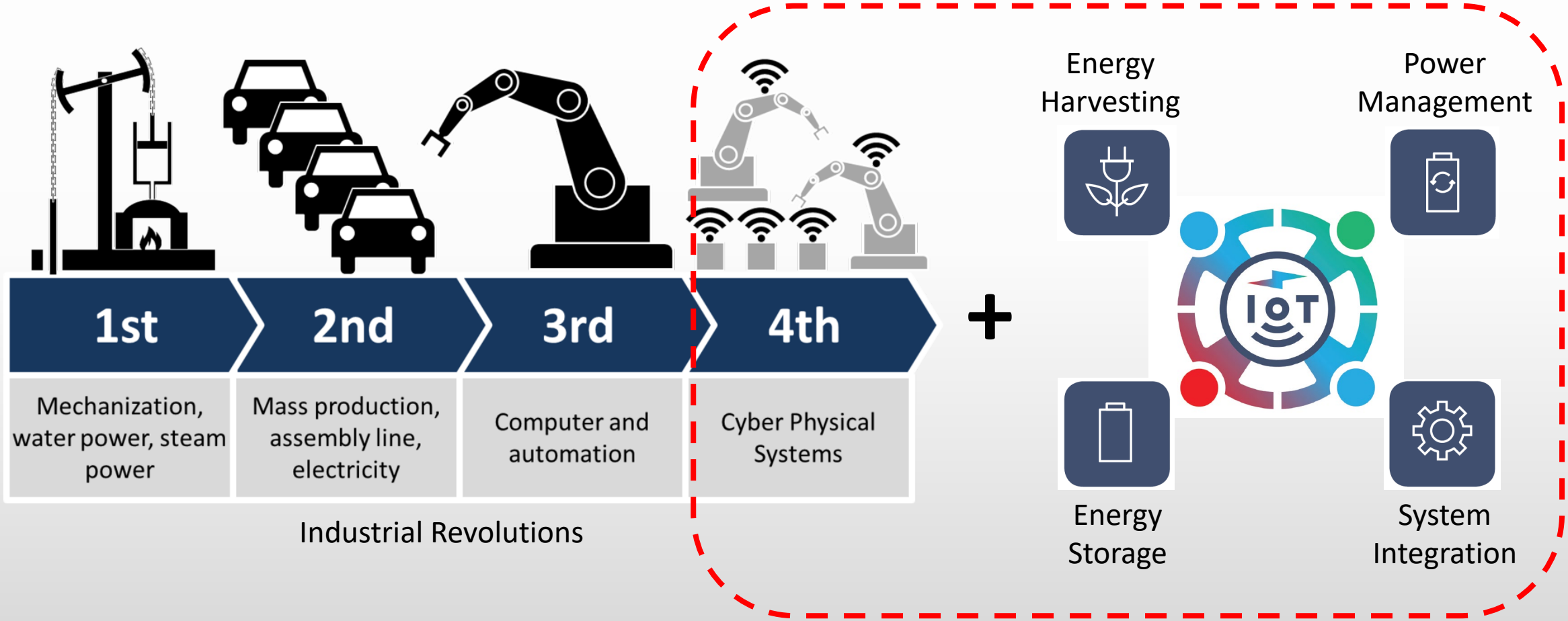
Empowering the Electronics Industry
A Power Technology Roadmap

Industry 4.0



Industrial Revolutions

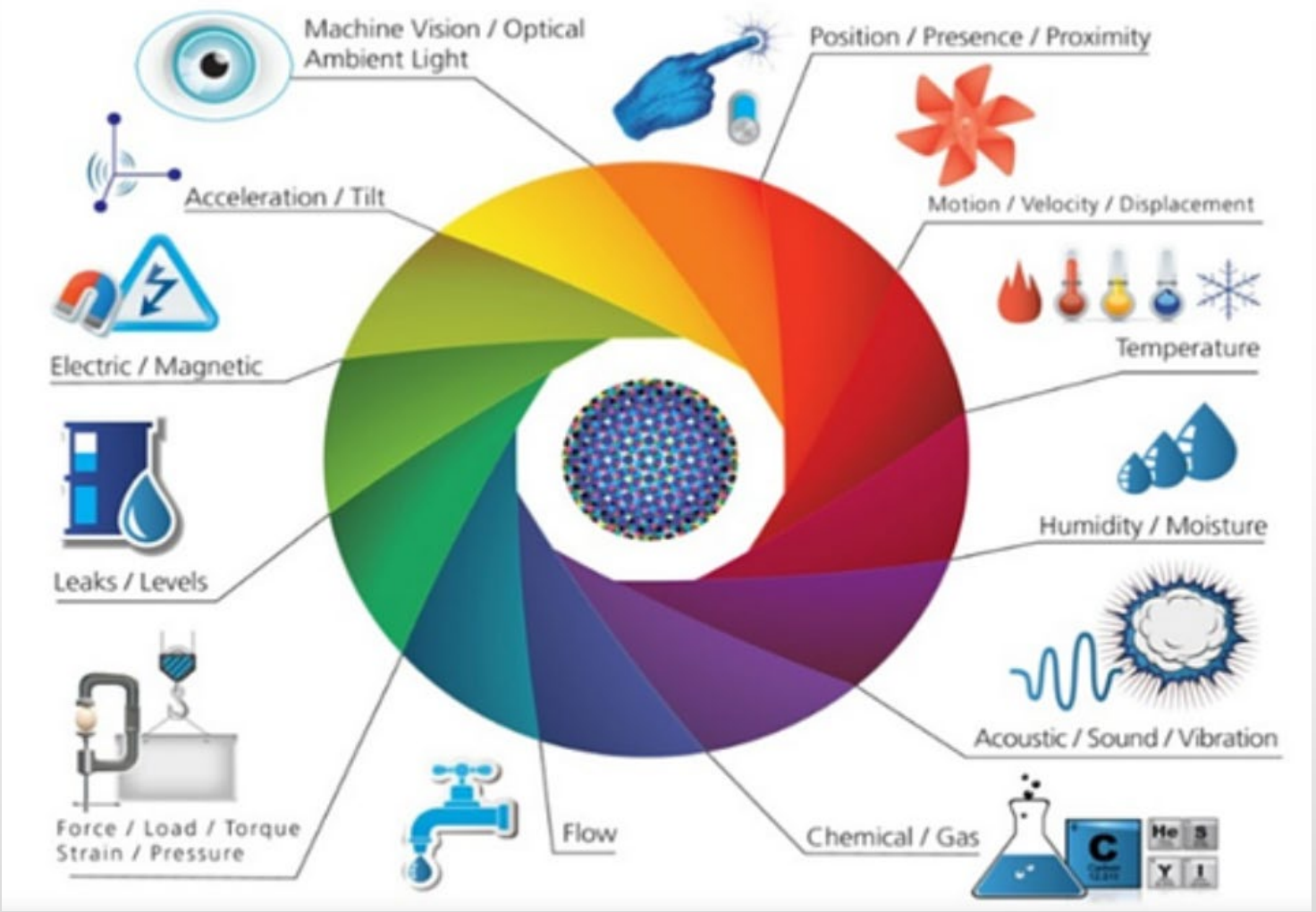
Industry 4.0 + IoT



1,000,000,000,000 Sensors in 2025

- Janusz Bryzek,
  The Trillion Sensor Summit 2015

- How to power each sensor?
  - Efficiently
  - Cost-effectively
  - Practically
  - ***Perpetually***



1,000,000,000,000 Sensors in 2025

- System Approach
  - Eliminate the need for battery replacement where possible
  - Reduce power consumption
  - Develop energy harvesting solutions
- Research excellence challenge
- Academia & Industry
  - Work together
  - Work in parallel
  - Work to the same target
  - Accelerate development

PSMA Energy Harvesting Committee

EnerHarv 2018

- First international workshop, www.EnerHarv.com 28th-30th May 2018
- Tyndall National Institute, Republic of Ireland
- Creating an ECOSYSTEM to ‘power the internet of things’
- >80 attendees from 4 continents
- Very successful, big need for cross-functional / academic-industry work
  - Energy harvesting, energy storage, micro-power management solutions
  - Share knowledge and best practices, define roadmaps
  - Encourage collaborations, identify synergies

CONNECT CPSS China Power Supply Society pels IEEE POWER ELECTRONICS SOCIETY Powering a Sustainable Future ECPE Tyndall National Institute Institiúid Náisiúnta HOW2POWER .COM Answering Your Questions About Power Design

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PSMA Empowering the Electronics Industry A Power Technology Roadmap

Energy Harvesting: Self-powered Devices

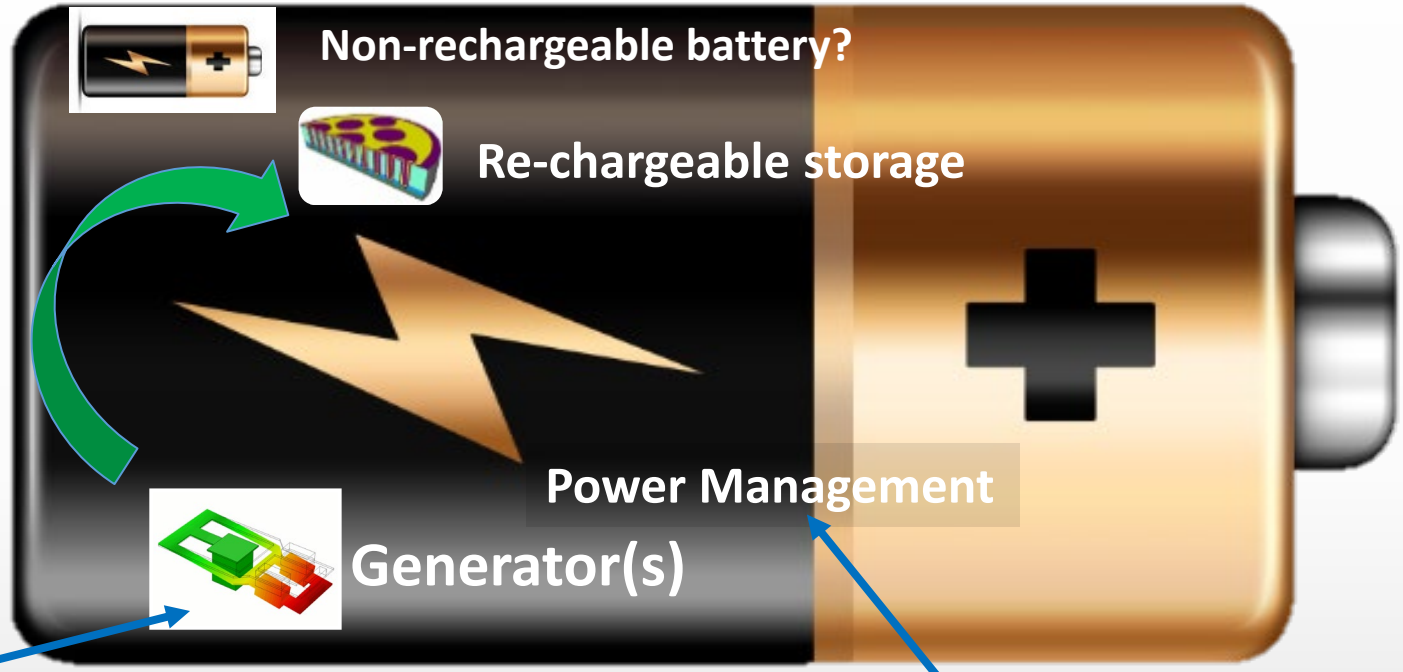
Mechanical Age

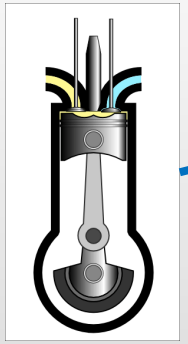
Limited Functions
Short Range
Unreliable when energy source removed (waves)

Digital Age

More Functions
Longer Range
Higher reliability (multi-modal energy sources - wave, solar), energy storage, power management
(Difficult to change the battery)

Energy Harvesting: System Challenges

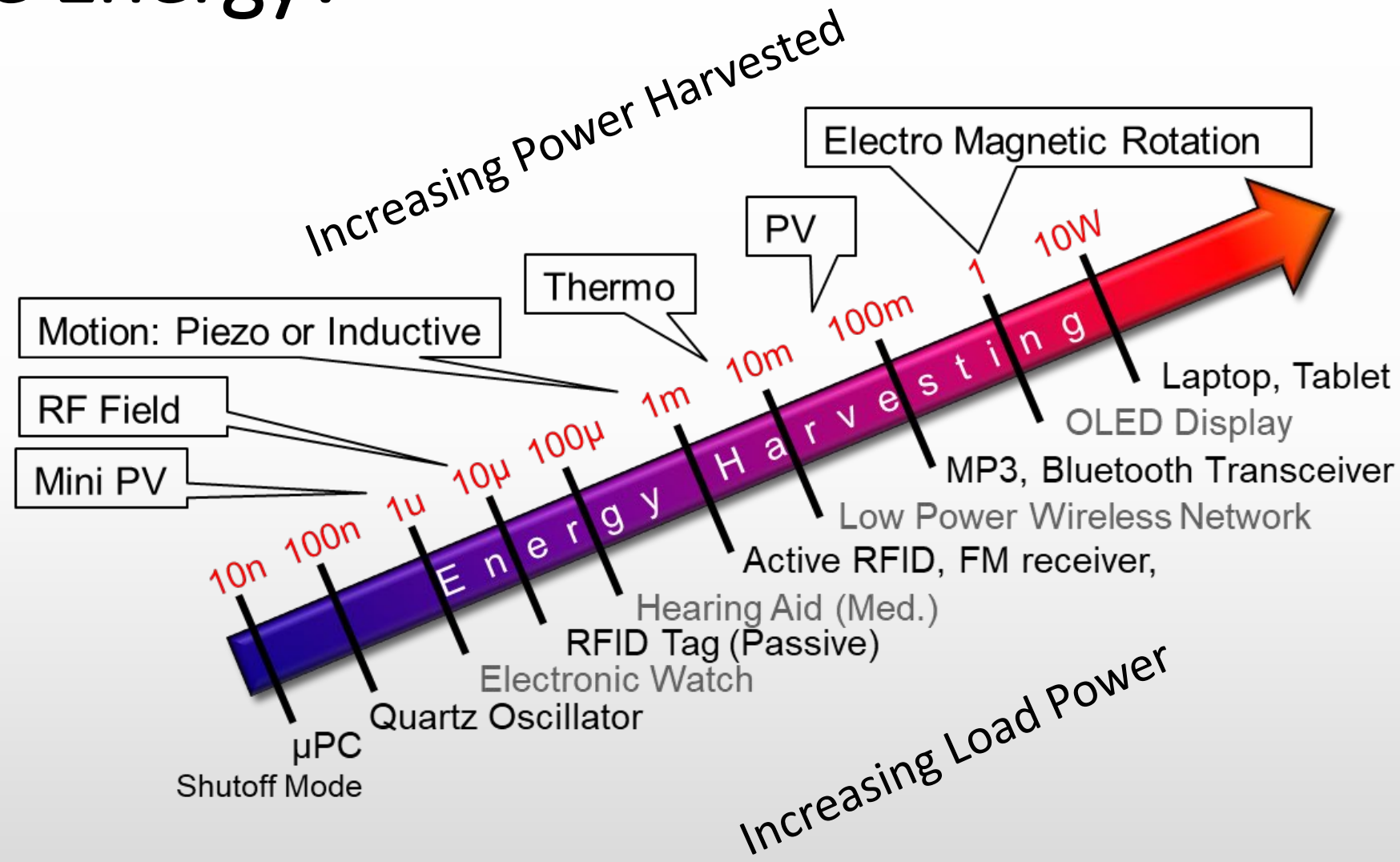




Ambient energies
(sporadic, low power levels)

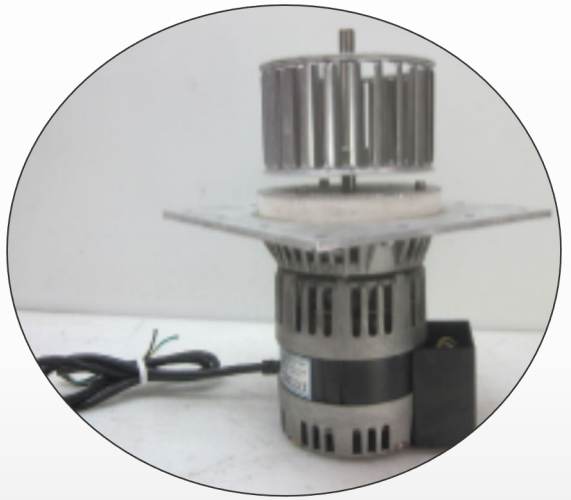
1. Intelligent switching between sources
    1. Ambient energies
    2. Battery
    3. Storage devices
2. Cold start
    1. Voltage conversion, impedance matching
3. Charge management
    1. Peaks, transients
    2. Status monitoring

Free Energy?


Increasing Power Harvested
Electro Magnetic Rotation
PV
Thermo
Motion: Piezo or Inductive
RF Field
Mini PV
10W
1
100m
10m
1m
100µ
10µ
1u
100n
10n
Energy Harvesting
Laptop, Tablet
OLED Display
MP3, Bluetooth Transceiver
Low Power Wireless Network
Active RFID, FM receiver,
Hearing Aid (Med.)
RFID Tag (Passive)
Electronic Watch
Quartz Oscillator
µPC
Shutoff Mode
Increasing Load Power

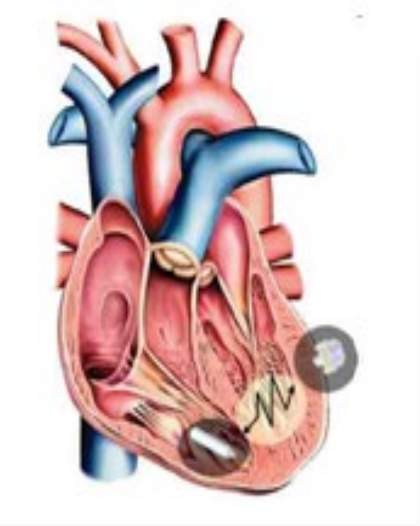
Courtesy of Boston Scientific,
Tyndall National Institute

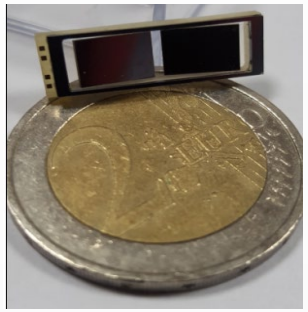
Conditional Monitoring: Reflow Oven Fan Reliability

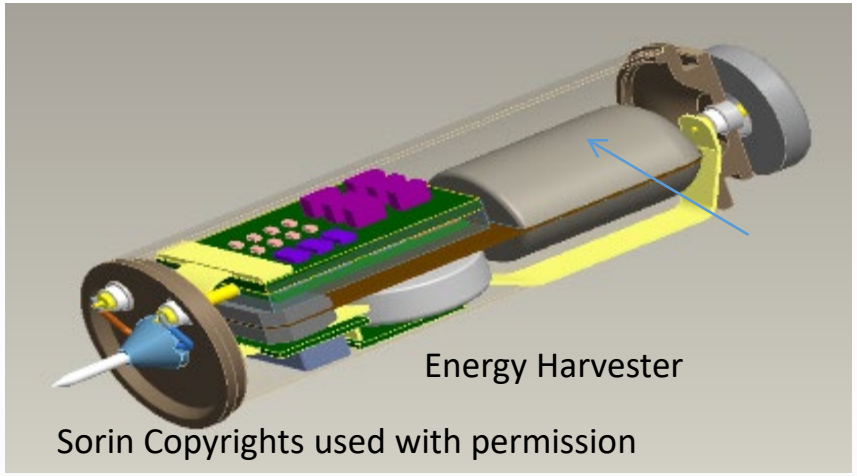


- Fans (blowers) in SMT reflow ovens wear out. Failure is expensive
  - Downtime, emergency (unskilled) repair, damaged WIP, possible fire risk
- Old method – noisy fans are replaced manually
  - Increase from 70-80dB to ~ 90-120dB.
  - Poor detection, rely on operators
- New method - Fan noise measured using acoustic sensors
  - Self-powered (energy harvesting) using VEH (Vibration Energy Harvesting) / TEG (Thermo-Electric Generator)
  - Avoids extra cost of unreliable AC-DC or DC-DC converters for sensors in high temperature environment
  - Predictable, safe, skilled maintenance

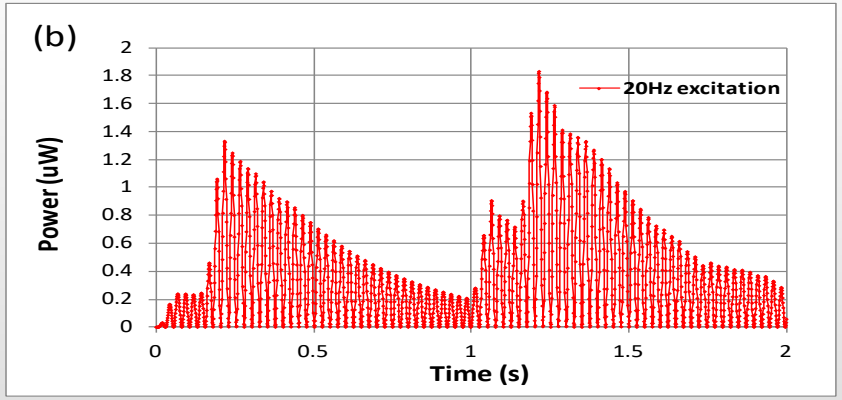
Implanted Energy Harvesting (concept)







- Potential energy sources
  - Piezo-electric (muscle flex)
  - Fluid (embedded nano-impellor)
- Energy capability
  - Piezo using Si ~0.352 µW per cantilever
  - Piezo using MEMS ~5.9 µW per cantilever



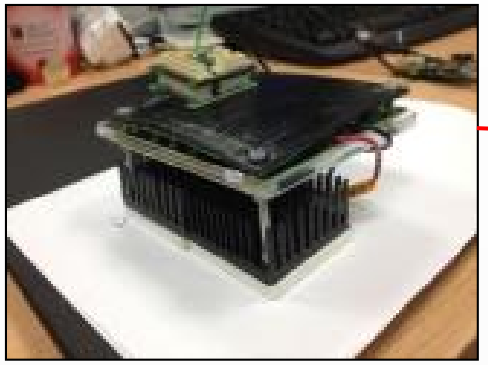
horizon-magazine.eu/article/harnessing-vibrational-energy-can-mean-heartbeat-powered-pacemakers_en.html

Courtesy of Tyndall National Institute

Food Cold Storage Compressor Control

(Temperature & Humidity Sensor)

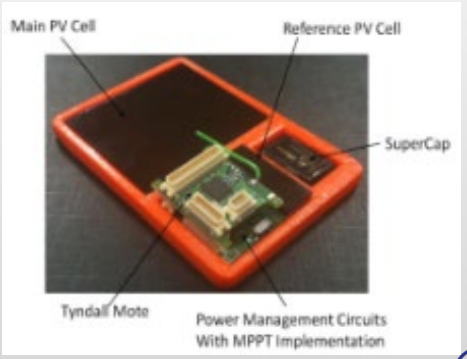
Feed temperature data back to compressor to reduce stress & optimise energy efficiency



Vibration Energy Harvesting

Thermo-Electric Generator

Indoor Light Energy Harvester



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Empowering the Electronics Industry
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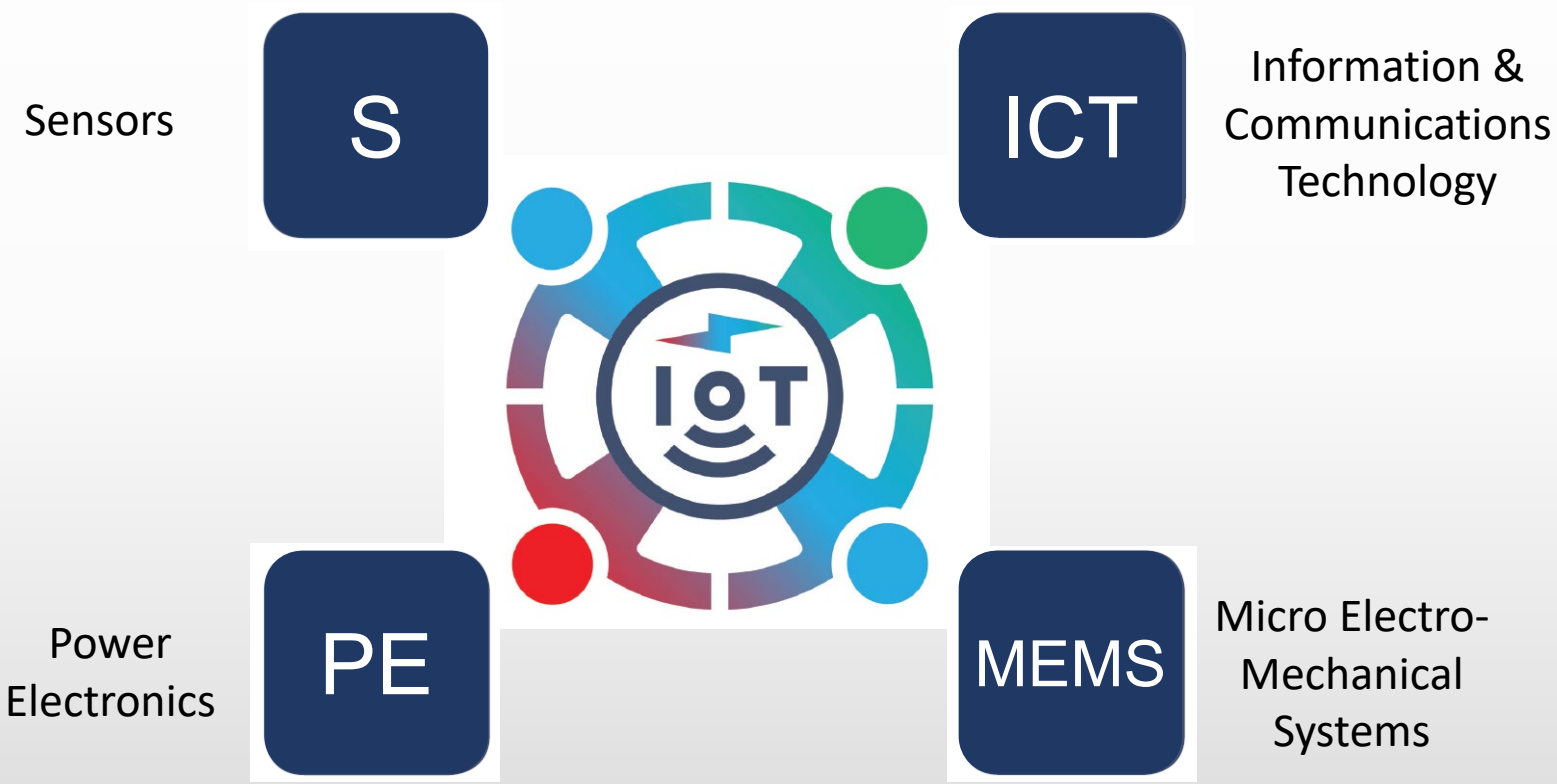
Eco-System: Energy Harvesting + Power Management

Eco-System: Enabling Technologies



Eco-System: Partners, Stakeholders

EnerHarv 2020

- ENERHARV 2020
  - Planning
    - PSMA Energy Harvesting committee meetings – welcome CPSS members
    - At APEC 2019 – welcome CPSS input
  - Target 200 attendees, welcome more from China
  - Location, date TBD
- Program
  - Energy harvesting
  - Power management topics
  - Software / protocols, “How do we process data efficiently?”
  - MEMs (packaging, industrial design, system-level multi-modal modelling)
  - EnerHarv Technology Roadmap
- Expand the Energy Harvesting eco-system / teamwork

谢谢