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Energy Storage at the Heart of WSN

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The presenter, Alex Bynum, is Business Development Manager for Saft's Lithium Battery Division in North and South America focusing on industrial, commercial, and defense applications using a range of primary and secondary chemistries. Previously, Alex was Manager of Defense Sales for Saft's Space and Defense Division where he focused on business development for Saft's lithium-ion R&D group located in Cockeysville, Maryland. Additional responsibilities include his primary function as Business Development for US Navy and commercial maritime applications. This combination has provided unique knowledge and experience developing products with high energy and power densities, yet tolerant to abuse. Rechargeable battery experience includes lithium-nickel cobalt aluminum oxide, cobalt oxide, and variations of phosphates. Prior to joining Space and Defense, Alex worked three years for Saft's Lithium Battery Division in sales and manufacturing of lithium primary chemistries, including Li-SO2, Li-MnO2, Li-SOCl2, and mixed oxides along with small rechargeable systems. Alex holds a BS in Engineering from North Carolina State University with 10 year’s experience in technical management for an international manufacturing company prior to joining Saft.

About Saft

Saft (Euronext: Saft) is a world specialist in the design and manufacture of high-tech batteries for industry. Saft batteries are used in high performance applications, such as industrial infrastructure and processes, transportation, space and defence. Saft is the world’s leading manufacturer of nickel batteries for industrial applications and of primary lithium batteries for a wide range of end markets. The group is also the European leader for specialised advanced technologies for the defence and space industries and world leader in lithium-ion satellite batteries. Saft is also delivering its lithium-ion technology to new applications in clean vehicles and energy storage systems. With approximately 4,000 employees worldwide, Saft is present in 19 countries. Its 15 manufacturing sites and extensive sales network enable the group to serve its customers worldwide. Saft is listed in the SBF 120 index on the Paris Stock Market. ***For more information, visit Saft at www.saftbatteries.com***

Agenda

1 • Is long life duration and primary electrochemical energy mutually exclusive?

2 • Meeting difficult sensor load profiles with hybrid primary electrochemical solutions.

3 • Storing harvested energy in harsh uncontrolled environments.

4 • Autonomy is important: how much energy is really needed?

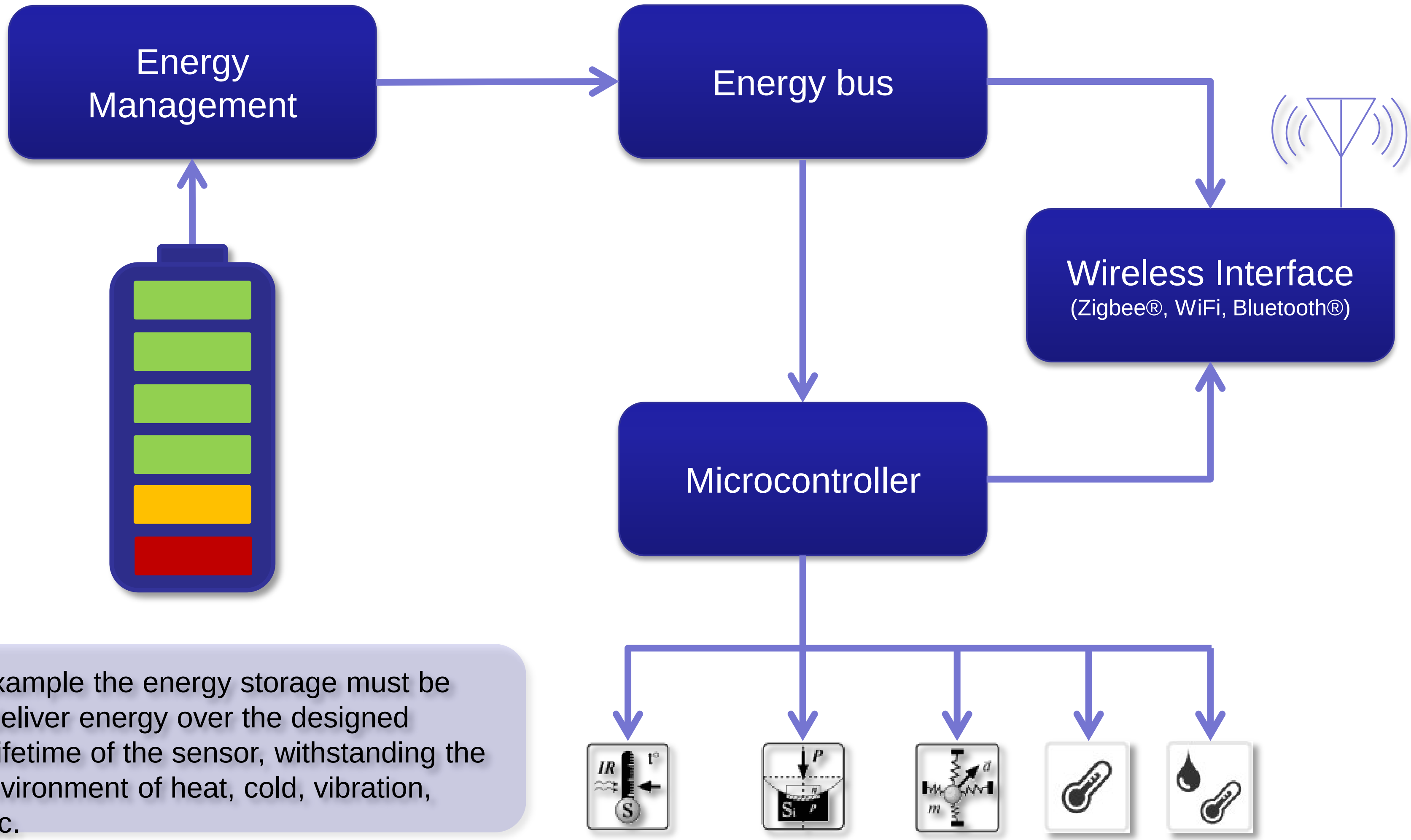
5 • Conclusions

How is "long life" in a sensor application achieved?

- Very low self discharge (<1% per annum)
- High volumetric energy density (1420 Wh/l)
- Vast amounts of laboratory and field test data have lead to very accurate performance models.
- A mature (> 30 years) *but still* developing technology
- Electrochemistry that is closely matched to application profile (temperature, voltage, current, pulses, lifetime)
- Energy management at sensor level

Technology	Li-$SOCl_2$ + HLC	Li-$SOCl_2$	Li-$SOCl_2$	Li-SO_2	Li-MnO_2	Li-CF_X
Volumetric energy	1420 Wh/l	1420 Wh/l	800 Wh/l	410 Wh/l	650 Wh/l	810 Wh/l
Power	very high	low	medium	high	high	medium
Voltage	3.6V	3.6V	3.6V	2.8V	3.0V	2.6V
Design	bobbin + spiral	bobbin	spiral	spiral	spiral	spiral
Pulse amplitude	very high	low	medium	high	high	medium
Passivation	low	medium	medium	low	very low	very low
Max life (years)	15-20	15-20	5-10	5-10	15-20	15-20
Self discharge	very low	very low	low	low	low	low
Operating range	-55°C to 85°C	-60°C to 85°C	-60°C to150C	-60°C to 70°C	-40°C to +85°C	-40°C to 70°C

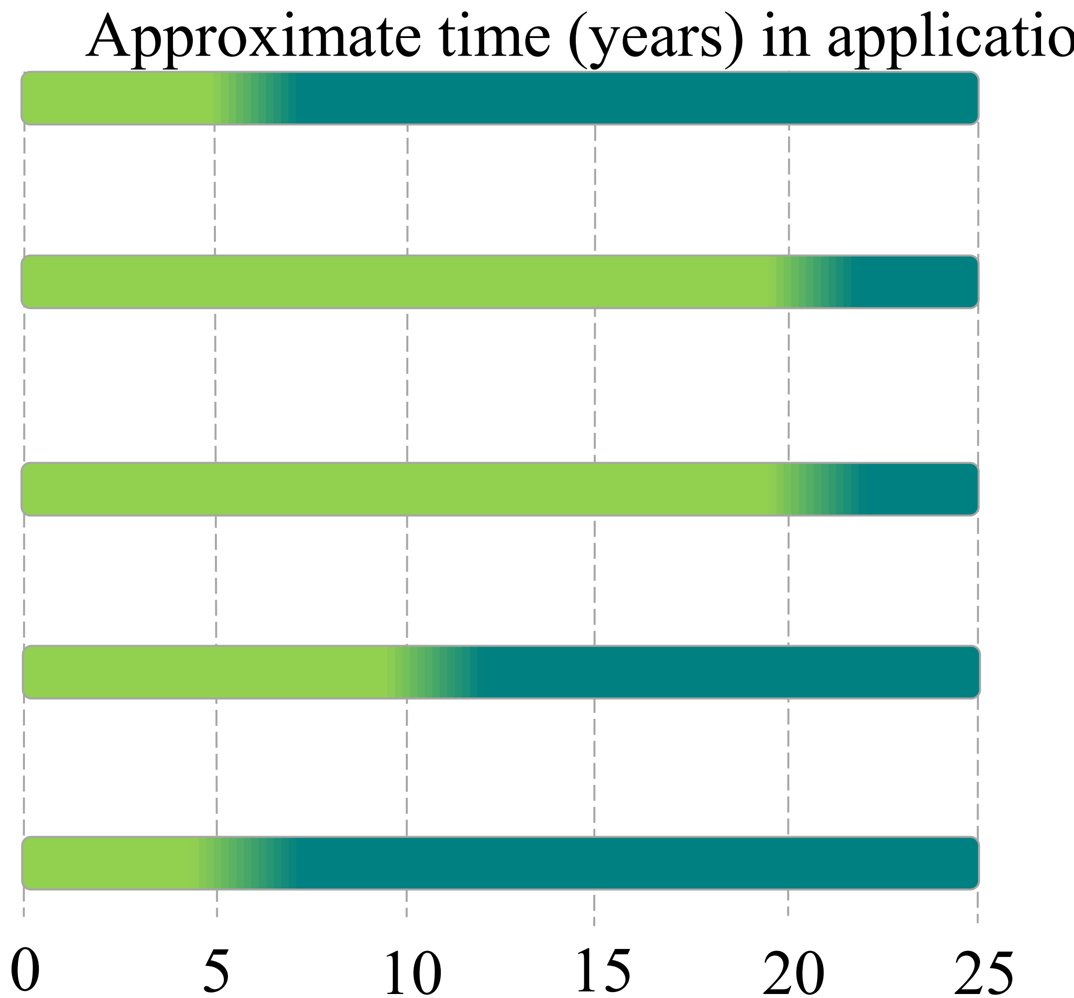
Independent system diagram (primary cells)



In this example the energy storage must be able to deliver energy over the designed system lifetime of the sensor, withstanding the same environment of heat, cold, vibration, shock etc.

Typical long duration sensor applications

- Asset monitoring (GPRS, Satellite)
- Vibration sensors (remote autonomous)
- Automatic Meter Reading (AMR)
- Tank level monitor (remote autonomous)
- Unattended ground sensors (military)



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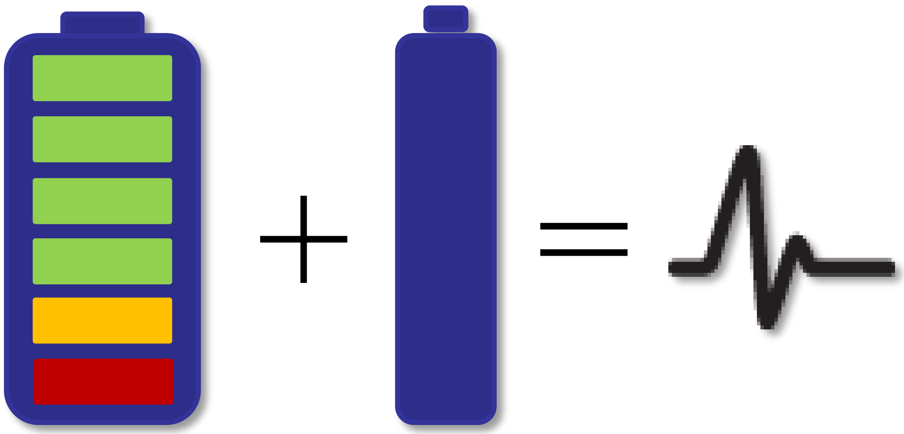
Pulsed loads need not be a problem

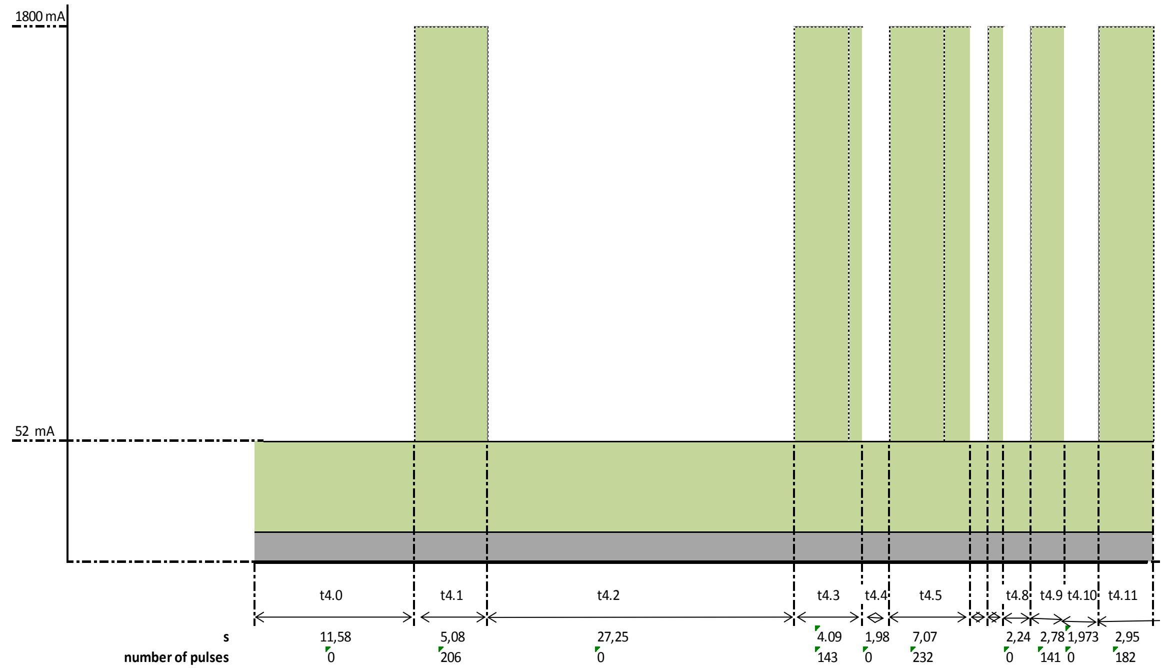


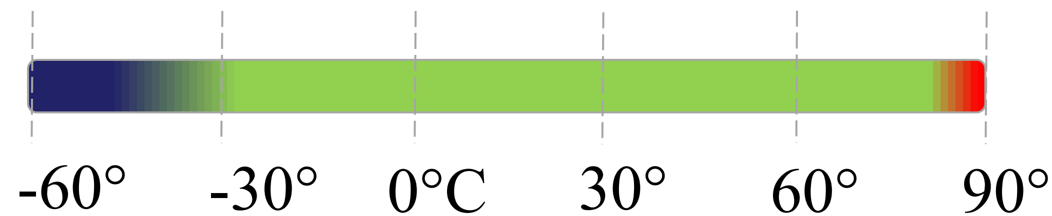
A high energy density (1420 Wh/l) primary cell such as Li-$SOCl_2$ for example coupled with an HLC (Hybrid Layer Capacitor) in parallel can easily manage pulses of 1 second at 15,000mA to 5,000mA continuously.

- GPRS communications profiles.
- Emergency call systems (e-Call)
- High energy sensor readings (IR, X-Ray, Ultrasonic)
- Mechanical, electrical, hydraulic or pneumatic valve and switch activation
- Long range, long periodic length (>15 min) communications.
- Sensors using pulsed sonar
- High output, long range RFID equipment.

Application example

- A combination of energy storage and capacitance
  - Will allow the system to run with the quiescent background current supplied from the Li-SOCl2 cell in this example.
  - And the pulsed loads of RF transmission can be supplied directly from the capacitor (HLC in this case).
  - Over a wide temperature range and operational lifetime





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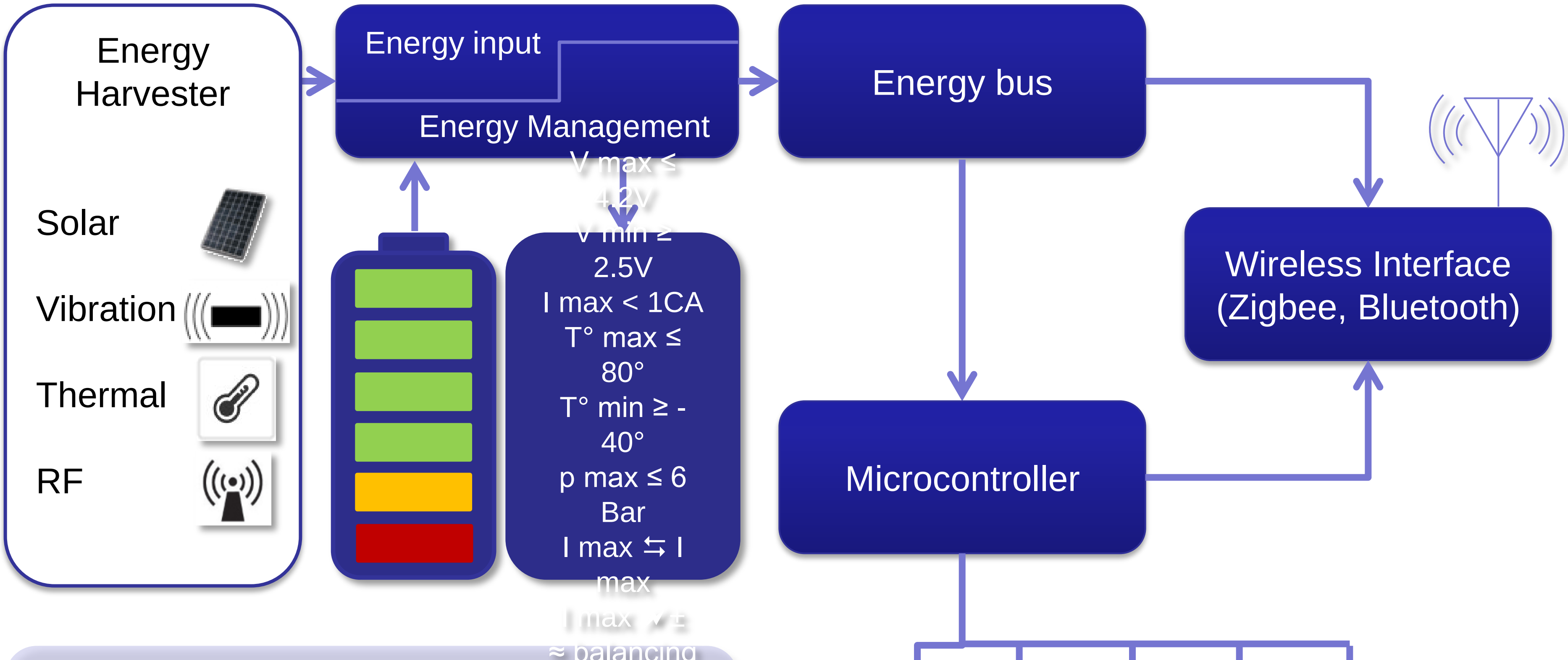
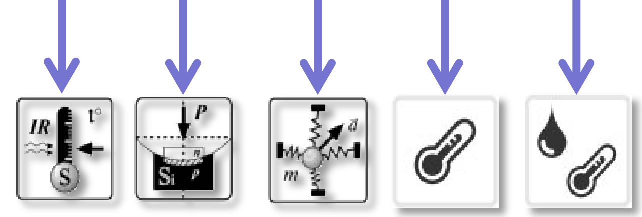
Independent system diagram (secondary cells)

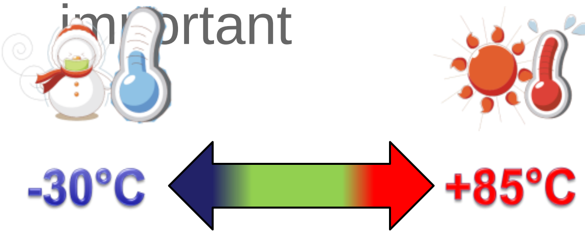


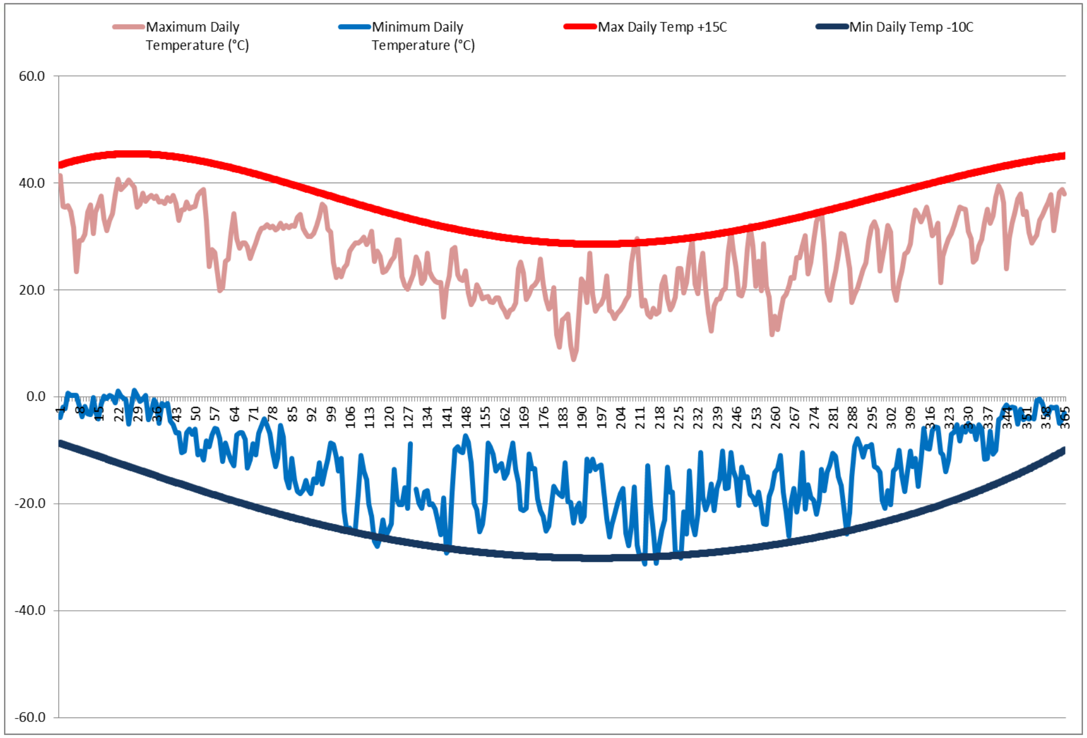


In this example the energy storage must be able to provide full function service over the design lifetime of the sensor, withstanding the same environment of heat, cold, vibration, shock etc.

Uncontrolled environments

- Electrochemical energy storage is effected by temperature extremes
- Extremes of either heat or cold will diminish the available capacity for storage.
- Selection of the correct technology for the ambient environment is important

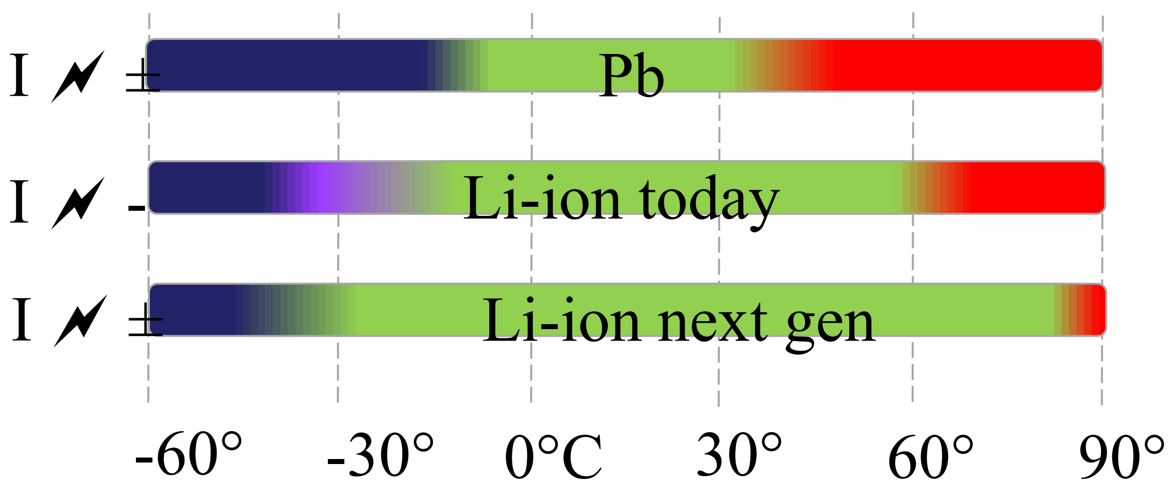




This is a full 365 day temperature profile combining Antarctica with the central Australian desert (Alice Springs). This represents possibly the worst possible outdoor temperature scenario for portable equipment

Application example

- WSN node for ATEX environments.
  - Class 1 Div2 Hazardous
- Nominal energy
  - battery 30Wh @ -40C
  - Solar panel 6W
- Operating temperature
  - Discharge -40°C to 60°C
  - Charge -20°C to 60°C
- Next generation technology
  - Discharge -40°C to 85°C
  - Charge -30°C to 85°C



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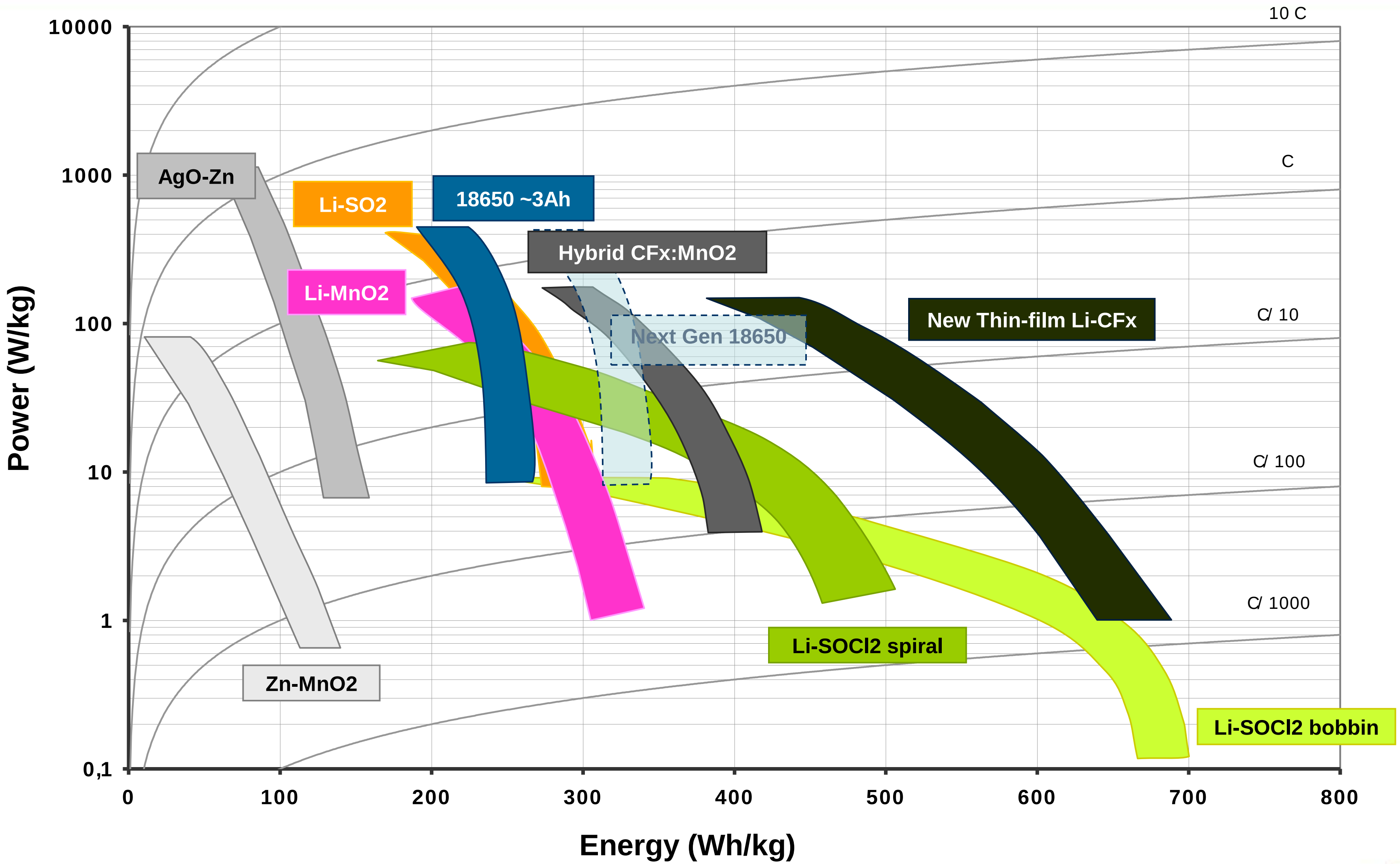
WSN energy storage today and tomorrow



Energy autonomy and points to ponder

- Consider all the factors involved supply a lifetime of energy when creating a sensor that needs to function autonomously.
  - Required operational lifetime
  - Cycle life over that life time
  - The effect of the ambient environment
  - Accessibility of the sensor when installed in the application
  - The availability of harvested energy for re-supply
  - The sensors energy debit under all conditions
  - The energy debit for communications under all conditions
  - The most *practical* solution to meet all the above needs.

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In conclusion

- It is a common theme that “energy harvesting” is in competition with “batteries”. This is not the case as primary and secondary energy storage can be *complimentary* and/or *co-dependant* on energy harvesting.
- *Electrochemistry is an enabling technology*. The energy needs of the WSN or M2M device effect its *service life* and *performance* will be less than it could otherwise be.
- Consideration of the energy storage requirements earlier rather than later in the *design phase* of your WSN device will pay dividends up front in an optimised design.

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Thank You

Questions?

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