The Back-to-Front World of Electronics

Thursday 7 March, 2024

For thousands of years, the Arabs have had sophisticated unpowered cooling of houses even via aquifers below. Contrast today's vapor compression cooling that further heats cities that are already getting hotter from global warming. However, new solid-state cooling is being very slowly developed. It may last for 100 years and cause little or no local heating emulating and even combined with the ancient Arab structures. Back to the future - somewhat. See Zhar Research report, "Solid State Cooling Markets 2024-2044."

The Pantheon has the world's largest unreinforced concrete dome. It was dedicated in 128 C.E. It is still in use, with minimal maintenance. Some Ancient Roman aqueducts from the same time still deliver water to Rome today. They called for specification of something that would be needed for thousands of years and carefully-graded concrete without rusting rebar. That concrete exhibits not one but several self-healing mechanisms as newly appreciated in 2023 research - Science Advances 6 Jan 2023 Vol 9, Issue 1 DOI: 10.1126/sciadv.add1602. Today, civil engineers cannot get hold of such concrete but we do have hydroelectric dams, pumped hydro schemes and bridges lasting for 100 years or more.

Environmentalists block more pumped hydro despite it being ideal for compensating the long-duration intermittency of the wind and solar power that is now being adopted to save money and the planet. So we are installing large numbers of big lithium-ion batteries for our grids despite the fact that they cannot perform that long duration storage. Worse, those batteries die in only a few years, if they have not caught fire in the meantime.

Glamorous electronics is ugliest of all

Dr Peter Harrop, CEO of Zhar Research warns,

> "Worst is electronics. The most popular electronic devices in numbers are backscatter tags notably 64 billion passive RFID and anti-theft tags sold yearly, most with a microchip and none with a battery. They are disposable – typically trashed soon after deployment. They do last over 100 years – as microplastic pollution. The Ancient Romans would identify two mistakes – not being specified for long life and not being made for long life. They knew that long life beats the circular economy any day. "

Smartphones, electronic vehicles

New generations of wireless communications appear every ten years. Next up is 6G in 2030. We would therefore like to keep our phones for at least ten years and their short-lived, sealed-in, polluting lithium-ion batteries make that difficult. Cars, particularly the incoming robot ones, are really electronic devices. It is good that electric cars last about twice as long as the smelly, bang-bang versions but we really want something like the Singer sewing machine. They passed from grandmother to mother to daughter and many are still working after over 100 years.

Lack of self-healing electronics

Whereas there is some deployment of self-healing materials in engineering and particularly healthcare, they are rarely used for electronics. The medical sector is even heavily researching self-healing engineered living materials to help us live for 120 years. See Zhar Research reports, "Self-Healing Engineering Material Markets, Technology: 2024-2044" and "Self-Healing Healthcare Material Markets, Technology: 2024-2044".

Long life electronics research badly needed

In electronics and electrical engineering, we need far more emphasis on long-life, battery-free technologies. See Zhar Research report, "Battery-Free Electrical Energy Storage and Storage Elimination MilliWh-GWh: Markets, Technologies 2024-2044". Indeed, wherever possible, we must progress further to zero energy devices ZED as in Zhar Research report, "Zero Energy Devices ZED: Self-Powered and Backscatter-Powered Electronics and Electrics Markets, Technology 2024-2044". A ZED example is the intelligent reflective surfaces IRS, in the transmission path of 5G and 6G Communications, which process and specularly reflect beams to more places without power or storage. Their magic metamaterials probably last 20 years or more.

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Beyond them are reconfigurable intelligent surfaces RIS, that are electronically reconfigurable while in use. They are also based on metamaterials, here collimating, polarising and redirecting the beam, increasing range. Fully-active active versions will amplify and focus the beam, following targets and increasing range even further. All RIS can be energy independent with on-board energy harvesting. Ideally all that will be one laminar smart material that lasts 100 years – if only the specifications could be stable or the devices up-gradable. Unlikely.

Internet of Things

Some of the world's largest companies trumpeted the Internet of Things IOT as trillion- dollar potential, with hundreds of billions of new units yearly, increasing global GDP by several percent. Like tulip mania and the dot com boom before it, that generated massive investment then bankruptcies and exits. We have the existing success of wireless sensors and LPWAN nodes deployed in tens of billions yearly and some rename these as "IOT" to cover their embarrassment.

However, the IOT dream was of something genuinely new and additional involving things-collaborating-with-things without human involvement at the time, each having wireless identification. You glimpse that in the excellent products of the companies within the EnOcean Alliance and 8Power with "no wires, no, batteries, no limits" for the necessary fit-and-forget. These devices variously incorporate actuators, microprocessors, transducers, supercapacitors and energy harvesting trending to multi-mode and life of perhaps 20 years.

To realise the IOT dream, researchers need to make "things collaborating with things" into solid-state materials with 50-100-year life and costs down by at least 80% in order to increase their sales 100-fold. Who is working on this?

6G Communication Phase 2, around 2035, is planned to galvanise IOT by enabling nodes without energy storage, thanks to those active Reconfigurable Intelligent Surfaces RIS in the transmission path. They will be operating edge computing devices by Simultaneous Wireless Information and Power Transfer SWIPT which is RFID backscatter on steroids. That will help get IOT node cost down by getting infrastructure cost up. Perhaps. See Zhar Research report, "6G Communications: Reconfigurable Intelligent Surface Materials and Hardware Markets 2024-2044". RIS are essential to 6G success but the IOT aspect is very speculative.

Gaps in the energy storage market

Supercapacitors have about four to ten times the life of batteries, cycle life being particularly outstanding. Where their poor energy density and self-leakage are a problem, the battery supercapacitor hybrid is rapidly taking business. Mostly, that means the lithium-ion capacitor LIC that Zhar Research predicts will become a larger value market because it has effectively infinite cycle life for most applications and a choice of ten to 30 times the energy density of a supercapacitor. LIC need minimal fire protection, temperature control and battery management systems and they are closely stackable in stark contrast to lithium-ion batteries. However, all these options are typically wet technologies, as are "long life" lithium thionyl chloride batteries, so life of more that 20 years is elusive. The electronics market needs 50-year compact energy storage and, for supercapacitors, better charge retention, yet there is almost no research on either.

Laggard

Meanwhile, supercapacitors and LIC are being adopted most eagerly by the electrical engineering industry (for trains, thermonuclear power, electromagnetic weapons, wind turbines, industrial robotics). See Zhar Research reports, "Lithium-Ion Capacitors & Other Battery Supercapacitor Hybrid Storage: Detailed Markets, Roadmaps, Deep Technology Analysis, Manufacturer Appraisal, Next Successes 2024-2044" and "Supercapacitor, Pseudocapacitor, CSH and BSH Hybrid Market Forecasts in 26 Lines, 110 Manufacturers Appraised, Technology Analysis, Roadmaps, Next Successes 2024-2044" www.zharresearch.com.

Harrop believes.

> "In electronics, we can only fix things when we are honest about problems. We must learn from civil, electrical and medical engineering. They are often ahead of us."

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