THE FUTURE **OFENERGY** UNLIMITED THINKING . EXPONENTIAL POTENTIAL

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BECAUSE THE FUTURE MATTERS

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NERGY. It was the first thing created in the universe and it will be the last to be destroyed. Which is odd when you consider the fact that according to the Law of Thermodynamics energy can only be transformed or transferred.

However, while theoretical astrophysicists battle it out to solve that particular conundrum, the rest of us are fascinated with discovering new ways to transform energy, which we rather inaccurately refer to as "generating" it, and transferring it, or "distributing" it, so we can use it to power our modern world. And, given the fact that energy is literally all around us, as well as in us, you'd have thought that the art of generating and distributing it would be a simple affair. But so far, as history has shown, it's been anything but.

As we look towards the future, though, everything we know about the energy industry and market will change beyond all recognition, and Energy Poverty, which <u>still</u> <u>affects over 750 million people</u> worldwide, will be a thing of the past.

Today, for the majority of us at least, we still have to rely on organisations investing hundreds of billions of dollars to extract fossil fuels from the Earth and investing in energy infrastructure, which includes everything from power plants and substations to power grids. Being incredibly simplistic, the hidden cost of powering your individual business or home therefore is simply insane.

\$11.6Tr

Estimated external costs associated with the global energy system

Then there's the industry's hidden cost to the planet and society which a <u>recent report</u> from the University of Sussex pegged at a staggering \$11.6 trillion¹, or almost 14% of global GDP, and that's before we <u>factor in</u> the 33.1 Gt of carbon dioxide the electricity generation industry emits - a third of which comes from coal-based generation - and its impact on the climate. Naturally, when you think about these statistics it's clear the status quo is unsustainable.

Increasingly, though, much of this is the past. Massive centralised biomass, coal, gas, nuclear, and oil power plants are being replaced with decentralised, distributed, micro, and peer-to-peer energy generation systems like solar and wind - many of which are then aggregated together using Blockchain and other technologies to create Virtual Power Plants. Fossil fuels are giving way to hydrogen, land and marine-grown biofuels, and other renewables. Energy grids are moving from dumb and semi-automated to intelligent and fully autonomous, with plans afoot to connect the world's transcontinental super grids so energy generated in one part of the world can be seamlessly transmitted, or "exported," to anywhere else on Earth.

Perhaps the greatest impact of all these changes, though, is the fact that finally the industries and people of the world can finally predict the future cost of electricity generation and consumption with confidence as generators are no longer bound to the see sawing costs of fossil fuels.

¹ Source: Benjamin K. Sovacool, Jinsoo Kim, Minyoung Yang, The hidden costs of energy and mobility: A global meta-analysis and research synthesis of electricity and transport externalities, Energy Research & Social Science, Volume 72, 2021, 101885, ISSN 2214-6296, https://doi.org/10.1016/j.erss.2020.101885.



This is made even more profound when we consider the fact that the unsubsidised cost of renewable energy generation is rapidly approaching zero as new innovations such as using 3D printing to create even larger wind turbines, and the emergence of new Perovskite, bacterial, Graphene, and Black Silicon solar panels which are 32%, 50%, 80% and 132% energy efficient respectively, and which can generate electricity when it's cloudy, raining, snowing, and even in the dead of night, start leaving the labs.



Moonlight: The future of Solar?

132%

Nanostructured Black Silicon energy efficiency

New breakthrough energy innovations and technologies like these are everywhere, though – especially as almost every country and industry introduces new Net Zero policies which include everything from banning bunker fuel for ships and combustion engines for vehicles, to disconnecting homes from the gas grids, and expedite the electrification of everything - from aircraft and vehicles, to buildings and steel making. And everything in between.

From an energy perspective it can be truly said that we live in the Wild West again, with pioneers and investors breaking new ground everywhere we look. Whether it's developing 3D printed portable mini nuclear reactors and nanoscale Triboelectric Nanogenerators (TENGs) that can power the Implanted Medical Devices (IMDs) in our bodies by generating energy from the blood in our arteries, the development of longrange wireless energy transmission systems, and all manner of new battery and gridscale storage technologies, activity in the sector is literally exploding. And all that's merely the dust on the giant Yellowstone super volcano, which NASA and partners believe they can use to generate over 6GW of electricity from at a scant \$0.10/kWh. But that's another story.

6GW at \$0.10/kWh

The estimated energy potential of Yellowstone super volcano

Obviously, from a consumer's perspective their panacea would be to be able to generate electricity where and when it's needed at zero cost – irrespective of their use case. For example, by using a Piezoelectric energy harvesting fabric that powers the tech in their smart clothes and wearables, or harvesting energy from the environment around them – including everything from ambient light, heat, noise, and vibrations, to the mmWave 5G signal itself - so their batteryless gadgets and smartphones never need plugging ever again, and never run out of charge.

Amazingly, all these examples have already been successfully demonstrated.

Continuing this theme and scaling up,



there's even an aircraft concept that generates electricity from air friction using a variation of those same TENGs, which this time are embedded into the skin of the aircraft, that I mentioned above.

Scaling up yet again we have Solar Ovens, a type of advanced solar power concentrator, that replaces electricity from fossil-fuel generators to make cement and steel, which materially impacts the industry's greenhouse-gas emissions which are currently 5% of the global total.

And scaling up again we have Fusion on the horizon, still, with a tentatively viable path to Cold Fusion courtesy of the weirdness of 2D materials, mini nuclear reactors, floating nuclear reactors, Travelling Wave nuclear reactors, and water-free Thorium nuclear reactors - which, as the cost of renewable energy generation continues to drop could simply end up being expensive boost capacity for the grid.

There are even plans to deploy 6GW solar power plants in Low Earth Orbit (LEO) in space in the mid 2020s that can beam energy back down to Earth using laser or microwave transmission, and these too have already been tested. These platforms would also have the added benefit of being able to transmit energy to any point on Earth within minutes which, for example, would be incredibly useful during disaster situations or blackouts like the ones we saw <u>hit Texas</u> in 2021.



Despite all these fascinating developments, though, it's the battery space that's by far the most active – from 3D printed batteries that are 400% more energy dense and charge faster than their traditional counterparts, and Solid State batteries, to all manner of alternative battery technologies that include everything from Biological, Glass, Lithium Air, Lithium Metal, Lithium Sulfur, Thin Film batteries, and even Graphene based batteries and Elon Musk's favourite - ultracapacitors.

400%

3D Printed battery energy density compared to traditional batteries

Further afield there have also been breakthroughs in the development of room temperature superconductors which could reduce the amount of United States energy wastage by 5% - which would be massive. But that's a story for a future time, and frankly my energy has been sapped so I'm off to recharge my own batteries.

Over and off.