

Thematic Investing

To the Moon(shots)! - Future Tech Primer

Thematic Investing

*This is a redaction of a 152 page report published September 14, 2021***Eureka! The 14 technologies of the future you must know**

6G could have a download speed of 1Tb/s, the OceanTech economy could be as big as Germany's GDP, and thanks to Emotional AI our personal devices will know more about our feelings than our families. If we don't appear at meetings via Holograms, we will get there by eVTOL flying cars and, by the end of the decade, we will spend more time in the Metaverse than 'real life'. These are just a few of the 14 moonshots in this report, i.e., radical technologies that could change our lives and accelerate the impact of global megatrends. And we argue they are not as far into the future as you might think.

Tomorrow may be too late; pace of change to accelerate

Failure to identify future tech today could mean missing out on the next big revolution. The pace at which themes are transforming businesses is blistering, but the adoption of many technologies – like smartphones or renewable energy – have surpassed experts' forecasts by decades, because we often think linearly but progress occurs exponentially. And we haven't seen anything yet: a paradigm shift in the explosion of data (we are generating 2.5 quintillion bytes of data every day which is doubling every 2-3Y), faster processing power (>1 trillion-fold increase since Apollo 11), and the rise of AI (already same IQ as a 6 year old) would bring about the fastest rollout of disruptive tech in history.

Imagine investing in the Internet before dot.com boom

Leftfield technologies will be needed to tackle immense global challenges. Could 5G be unable to handle the exponential growth in data by the end of the decade? Then 6G will need to be rapidly deployed in just 5-6Y. Could scarce natural resources and increasing emissions hold back the planet from decarbonizing and tackling climate change? Then carbon capture storage, nextgen batteries and green mining could be the solution to decrease emissions by 70% and enable access to 3x more rare earth metals. Is health the new wealth post-COVID? Then bionic humans, brain-computer interfaces and synthetic biology could all take us a step further towards the holy grail of 'immortality'.

Disruption always wins: 1.5% generated 100% of net wealth

In the past 30Y, just 1.5% of companies generated all the net wealth on the global stock market, meaning that actually only a handful of disruptors ('superstar firms') really influence long-term financial markets growth. Furthermore, accelerating innovation places incumbents at greater risk of displacement. In 1958, the average company lasted 61 years on the S&P 500; by 2016 this was 24 years and is forecast to be just 12 years by 2027.

US\$330bn mkt today; possibly US\$6tn+ by the next decade

The 14 technologies we highlight in this report represent a US\$330bn market size today (2019-21) growing at an average CAGR of 36% to potentially US\$6.4tn by the 2030s. These moonshots could transform and disrupt multiple industries, contributing to the next big cycle of technology-driven growth.

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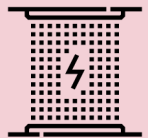










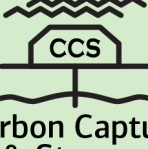
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14 Moonshots: what you need to know

Exhibit 1: What are the next future technologies?

14 disruptive moonshot technologies

| COMPUTATIONAL TECH | HUMAN TECH | CONSUMER TECH | GREEN TECH |
|--|--|--|--|
|  6G |  Bionic Humans |  Wireless Electricity |  Oceantech |
|  Emotional AI |  Immortality |  Holograms |  Nextgen batteries |
|  Brain Computer Interfaces |  Synthetic Biology |  Metaverse |  Green Mining |
| | |  eVTOL |  Carbon Capture & Storage |

Source: BofA Global Research

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Exhibit 2: Moonshots 101

Overview table of the 14 future technologies

| Moonshot | Description | Milestones |
|----------------------|--|--|
| 6G | The next generation of telecom networks that is faster than 5G with 1TBps download speeds | 2028: data volumes reach capacity of 5G networks |
| BCI | Connecting brains with computers to augment humanity cognition / thoughts | 2021: human trials in progress |
| Emotional AI | Affective/Cognitive Computing capturing, analysing and responding to human emotions with AI | 2020s: increasingly pervasive in everyday life |
| Synthetic Biology | Harnessing nature by redesigning organisms through genetic engineering to have new applications | 2030: most people will have eaten, worn, or used synbio |
| Immortality | Breakthroughs in health/ biotech, anti-ageing drugs for radical life extension that 'disrupts death' | 2029: humans could become 'immortal' and live forever |
| Bionic Humans | Technology that augments physical human capabilities e.g. exoskeletons, biohacking, implants | 2021: world's first artificial cornea implanted |
| eVTOL | Electrical vertical take-off and landing vehicles that provides alternative mobility to road transport | 2023: three eVTOL certified for commercial launch |
| Wireless Electricity | The use of magnetic fields or radio waves to transmit electricity wirelessly without cables | 2025: 10 connected devices per person that needs charging |
| Holograms | Light imagery projections without headsets for digital interactions not requiring physical presence | 2021: world's first hologram dining experience |
| Metaverse | Virtual worlds universe that interoperate with each other superseding the internet/physical world | 2030s: spending more time in virtual world than real world |
| Nextgen Batteries | Next EV technologies after lithium-ion batteries such as solid state, sodium ion, vanadium flow etc | 2020: one million mile battery pack breakthrough |
| Oceantech | Blue Economy where technology is deployed in the sea (ocean energy, precision fishing etc) | 2030: global ocean economy equivalent to 2010 German GDP |
| Green Mining | Climate change is metals intensive requiring sustainable mining (sea, agro, wastewater, asteroid) | 2024: commercial deep-sea mining set to start |
| CCS | Negative emissions technologies that captures and stores CO2 before release into the atmosphere | 2040/50: \$1 trillion in cumulative capex investments in CCS |

Source: BofA Global Research

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Sectors and Industries impacted – tailwinds / headwinds

Exhibit 3: Industries impacted by Future Tech

Beneficiaries are Technology, Healthcare vs Challenged are Autos, Commercial Real Estate

| Sector | Beneficiaries/Challenged | Future Tech Comments |
|--|--------------------------|---|
| Communication Services | | |
| Telcos | Beneficiary | 6G should benefit telco equipment providers with denser networks, telco service providers will have to cope with sooner than expected 5G to 6G migration |
| New Media & Entertainment | Beneficiary | Gen Z will drive shift towards Metaverse and Holograms, greater content creation for virtual worlds, more leisure time in the very long term could benefit sector |
| Big Tech Platforms | Beneficiary | Leading pioneers in multiple moonshot technologies (Emotional AI, Brain Computer Interfaces, Bionic Humans, Immortality, Holograms, Metaverse) |
| Consumer Discretionary | | |
| Autos | Mixed | eVTOL could be disruptor for road passenger vehicles, Nextgen Batteries and Green Mining is an opportunity and risk for shift towards EVs |
| eCommerce / Retailing | Beneficiary | Metaverse could drive the next retailing wave like eCommerce with the rise of Social Commerce and virtual worlds shopping |
| Energy | | |
| Oil & Gas – Majors & Refining | Mixed | CCS the last 'earthshot' technology for fossil sector to remain relevant, otherwise increased stranded assets risks from EV reducing oil demand, growth of renewables & energy storage |
| Real Estate | | |
| Data Center, Telco Tower | Beneficiary | Sector benefits from 6G creation which will accelerate demand for even more data intensive services like holograms, metaverse, emotional AI, brain computer interfaces, eVTOL |
| Offices | Challenged | Hologram technology could accelerate the WFH trend even more with people interacting more in virtual offices in the Metaverse |
| Commercial/Malls/Residential/Lodging | Challenged | Metaverse could be the next big thing on par with eCommerce disruption with consumers shopping more and more in virtual worlds |
| Health Care | | |
| Biopharma & Biotech | Beneficiary | Immortality breakthroughs' sector could drive next big cycle of healthcare innovation eg. anti-ageing drugs, senolytics, geroscience, life extension medicine |
| Life Sciences Tools/Diagnostics | Beneficiary | Synthetic Biology could be as big as CRISPR as we enter the next stage of genomic engineering with biofacturing, LST sector will be a key beneficiary as the enablers of the SynBio revolution |
| MedTech / HealthTech | Beneficiary | Bionic Humans exoskeleton will drive growth in robotic surgery, implants, wearables etc that benefits the sector, other human tech like immortality and synthetic biology could also provide tailwinds |
| Industrials | | |
| Capital Goods | Beneficiary | Collaboration between humans and robots (cobots) will be a key driver of Bionic Humans, sector however could be disrupted if Wireless Electricity theme mainstreams and put pressure on cabling / voltage companies |
| Commercial Aerospace / Transport | Mixed | eVTOL innovation being driven by incumbent A&D companies, however with Holograms and Metaverse there is a risk of long term decline in demand for commercial aviation via corporate / business travel as people WFH |
| Materials | | |
| Metals & Mining | Beneficiary | Green Mining, Nextgen Batteries, Oceantech benefits sector, climate change decarbonization is positive for metals eg. EV demand for lithium, cobalt, nickel, gold, copper |
| Chemicals | Beneficiary | Synthetic Biology could unleash wave of new materials/chemicals innovation and Nextgen Batteries likely to benefit sector as enabler of EV materials |
| Information Technology | | |
| Semiconductors | Beneficiary | Among the biggest beneficiaries in Future Tech with Moore's Law as the key enabler of 6G, Brain Computer Interfaces, Emotional AI etc |
| Tech Software / Cloud | Beneficiary | Another big beneficiary of future tech that will power Holograms, Metaverse in the future supported by tech hardware |
| Tech Hardware / Cybersecurity | Beneficiary | World of future tech will need strong cyber privacy solutions to protect businesses from the next global black swan |
| Utilities | | |
| Renewables / Integrated Utilities / IPPs | Beneficiary | Green Tech beneficiary from innovation in Wireless Electricity, Oceantech, Nextgen Batteries, Green Mining and CCS along with existing tailwinds in solar, wind, EV charging, energy storage etc |

Source: BofA Global Research

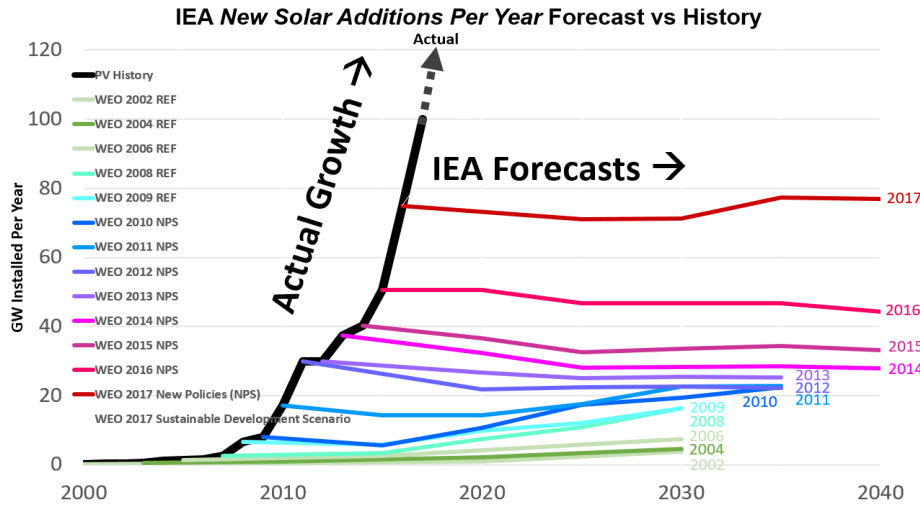
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New tech is consistently underestimated

The pace of transformation continues to accelerate, meaning that long-term, distant technologies are approaching ever faster. However, humans continue to underestimate this acceleration, failing to accurately assess the near-term potential of new technologies and their disruptive impact on society. In this report, we highlight 14 new technologies that could prove disruptive and yet have barely been considered by investors and wider society.

Exhibit 4: Humans and even expert forecasters are prone to underestimate exponential growth

IEA each year has forecast linear growth of solar additions/year while actual growth of new solar GW installed per year has been exponential

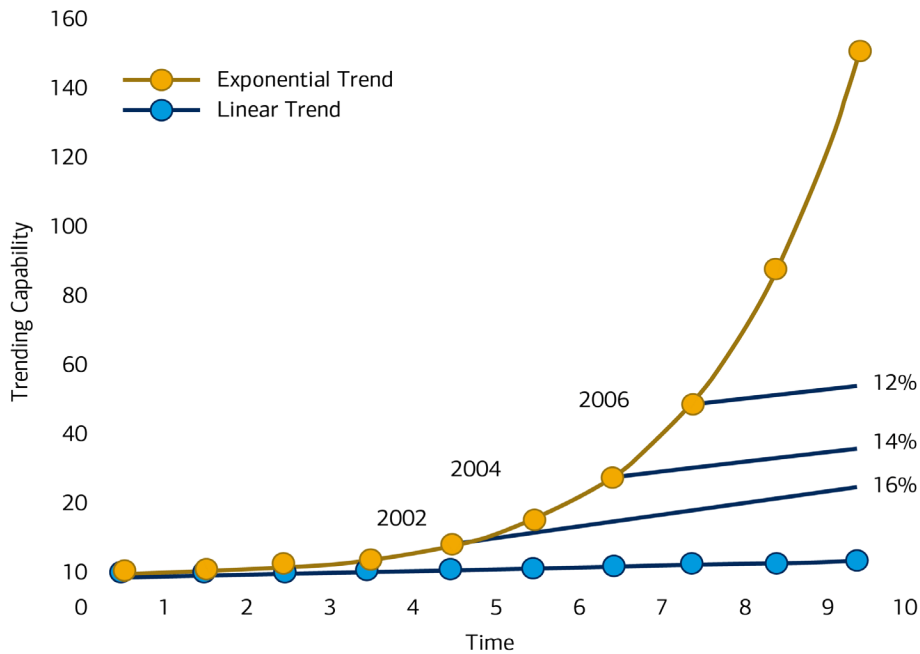


Source: Visual Capitalist, IEA

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Exhibit 5: History doesn't always repeat itself.... but it rhymes...

Trends that seem linear often surprise to the upside and grow exponentially



Source: Ramez Naam

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Why do we keep underestimating tech? Exponential development

At our New York 2021 (Virtual) Transforming World Conference, futurist Ramez Naam highlighted 6 key steps that define and characterize the exponential development of technologies. Beyond digitization of a product, he notes that we tend to be deceived by the rate of development of tech. Having seen slower development to begin with or even disappointment, individuals can underestimate the rate of development of various technologies.

Exhibit 6: How does exponential technology change the world?

The 6D's framework: digitised, deceptive, disruptive, dematerialised, demonetised, democratised

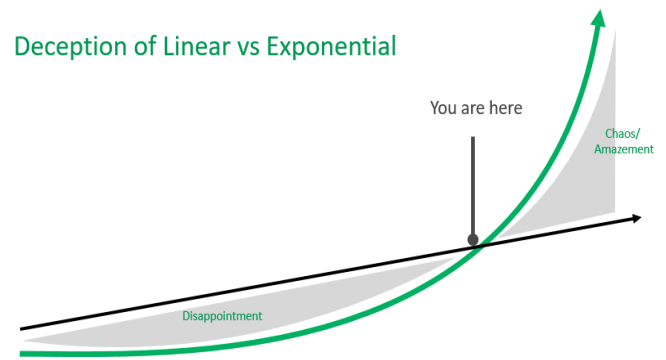


Source: Ramez Naam

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Exhibit 7: Why is exponential growth often mistaken for linear?

Initial disappointment of exponential tech leads to linear belief and chaos/amazement as growth exceeds expectations



Source: Ramez Naam

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This underestimation can be seen in multiple technologies from mobile phones and clean energy to biotech. Forecasts, at each point in time, have assumed linear growth into the future similar to the growth at the time. Instead, realised growth has continued exponentially, exceeding all forecasts. In the case of solar, for instance, the exponential decline in cost has meant that today's solar prices are ahead of IEA forecasts from 2010 by 50-100 years.

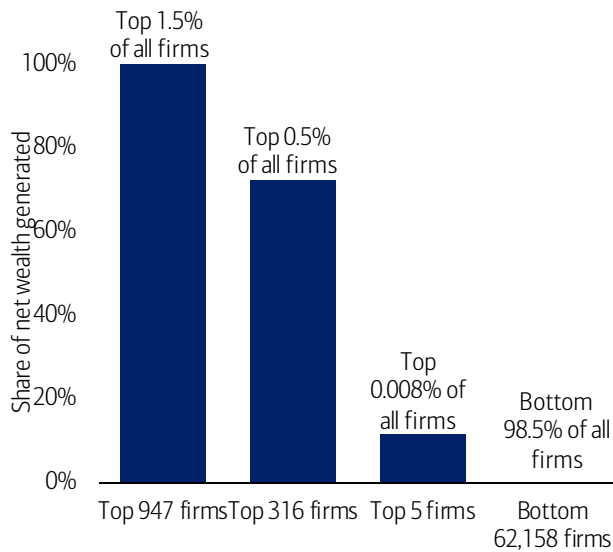
Why does understanding tech properly matter? Just 1.5% of companies create all wealth

Consequently, understanding technologies that may arrive much sooner than expected and distinguishing which will become disruptive is key for a financial industry. Especially given that the financial industry is driven predominantly by the returns of a very small share of disruptive companies. In fact, between 1990 and mid-2020, the global stock market generated US\$56.2tn. However, just 1.5% of companies accounted for all of that wealth creation. The majority (56.6% of US stocks and 61.3% of non-US stocks) underperformed one-month US Treasury bills (source: H Bessembinder, Arizona State University, 2020). Globally excluding the US, the picture is even starker, less than 1% of firms actually accounted for US\$20.1tn of the net wealth creation. This trend of concentrated wealth creation by a small number of companies is actually accelerating in 2016-19, just 5 companies accounted for 22% of net wealth concentration.



Exhibit 8: Just 1.5% of all stocks have generated net wealth in the global markets since 1990

Share of net wealth* generated by stocks between 1990 & mid-2020

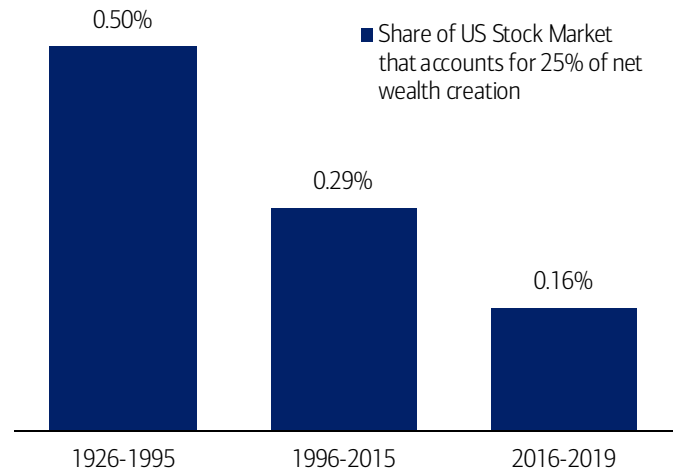


Source: H Bessembinder, Arizona State University 2020, *net wealth accounts for wealth generated above the performance from one-month Treasury bills

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Exhibit 9: What share of the US stock market has accounted for 25% of net wealth concentration over time?

Share of US stock market that has accounted for 25% of net wealth concentration in each 3 year period since 1926 has declined and accelerated recently



Source: H Bessembinder Arizona, State University, 2020

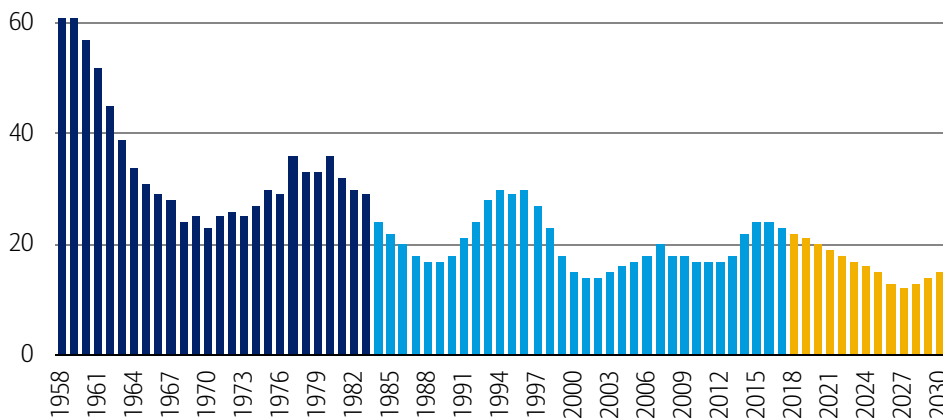
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Life expectancy of incumbents keeps falling

What's more, the displacement of incumbents is only growing. In 1958, the average 7-year rolling lifespan of a company on the S&P 500 was 61 years; by the 1980s it had dropped to 30 years and by 2016, it was just 24 years. In 2017, 26 companies dropped out of the S&P 500. If we continue on this road, by 2027, companies could last just 12 years as they become increasingly disrupted (source: Innosight, S&P 500) – see Chart 1.

Chart 1: Incumbents are getting disrupted quicker

Average company lifespan on S&P 500 Index (year, rolling 7 year average)



Source: Innosight

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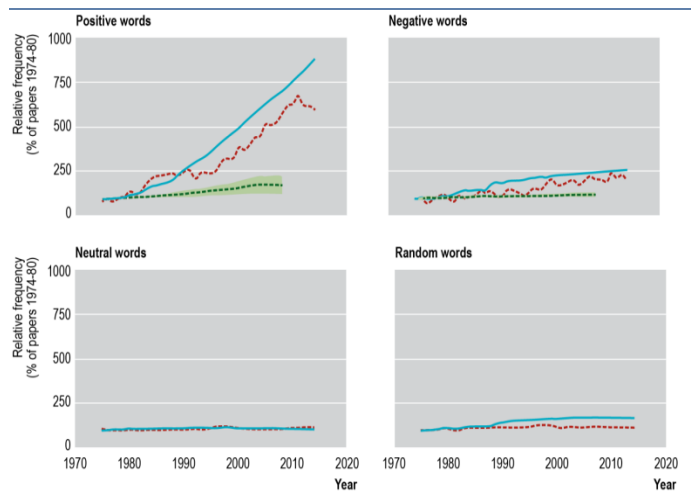
How does Next Tech succeed? Economics, adoption, regulation

From cryptocurrencies to meme stocks, trends can be susceptible to hype and over-exaggeration as excitement takes hold. To pick out the meaningful technologies that that result in disruptive success, three key elements are needed:

- 1. Technology** – the innovations enabling the Next Tech must have the potential to be economical and cost-competitive (e.g. 99.999% fall in the cost of genome sequencing, smartphones enabled by exponential progress in computing power).
- 2. Mass adoption** – new products must address a gap in the market, such as more convenience, solve a key problem such as climate change or improve quality of life (smartphones providing convenience by combining a phone, internet and camera).
- 3. Governmental support** – regulation providing a favorable environment (subsidies enabling renewables to reach cost effectiveness, EVs gaining from autos emissions regulations in the EU).

Exhibit 10: Hype in science is growing

Relative frequency different types of word in PubMed science abstracts 1974-2014

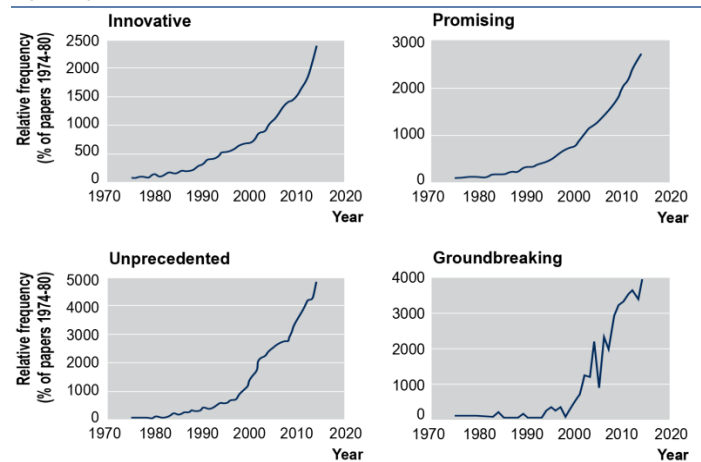


Source: Vinkers et al, BMJ, 2015

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Exhibit 11: Science is getting excited, 'unprecedented', 'ground-breaking'...

Relative frequency of specific positive word in PubMed science abstracts 1974-2014



Source: Vinkers et al, BMJ, 2015

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So what are these new technologies?

We examine the moonshots, comparing risks, market sizes, CAGRs, catalysts and timelines, to give a comprehensive overview and assessment of what technologies could take hold next – either transforming the computational world of data, changing humans and their capabilities, affecting the new consumer or solving the problem of climate change.

- **6G:** The next generation of telecom networks will be needed in less than a decade as data continues to grow exponentially and 5G reaches its upper limit capacity.
- **Brain Computer Interfaces:** As we reach a point where humans are unable to keep up with computers and AI, brain computer interfaces could help 'level up' humans with computers. Shorter term, brain computer interfaces hold solutions for paralyzed individuals and promise a new wave of innovation in gaming.
- **Emotional Artificial Intelligence:** Emotional AI (EAI), also known to as "Affective Computing" and "Cognitive Computing" is designed to capture, analyze and respond to human emotions and simulate human thoughts. EAI can potentially collect, analyze and respond to completely new varieties of data and situations and predict or simulate human thought, leading people to take action.



- **Synthetic Biology:** This is a field of science that combines features of molecular biology, genomics, chemistry, engineering, machine learning, and computer science. At its core, “synbio”, as the field is commonly referred to, takes advantage of the vast diversity of nature to make biomolecules that traditional chemistry cannot
- **Immortality:** Breakthroughs in healthtech, biotech and anti-aging drugs could result in radical life extension that ‘disrupts death’. Traditionally, aging has not been viewed as a disease that can be treated but this is changing. Actors in this space are increasingly looking to tackle the hallmark of aging via pathways such as ‘genomic instability, telomere attrition, mitochondrial dysfunction, and cellular senescence’ among others.
- **Bionic Humans:** Augmentation technology that seeks to extend and expand (physical) human capabilities. This could be invasive (e.g. implants) or non-invasive (e.g. exoskeleton). Biohacking is also an associated field which is essentially applying DIY biology to boost oneself e.g. RFID chip in hand for contactless payments
- **eVTOL:** Electrical vertical take-off and landing vehicles that could provide an alternative mobility transportation solution to outdated infrastructure and overly stressed roads in urban settings.
- **Wireless Electricity:** As the IoT takes off, automating and creating near continuous charging solutions could provide convenience for consumers, while solving charging problems for the rollout of EVs and secure electricity supplies for remote communities.
- **Holograms:** A technology capable of creating a simulated environment through light imagery projections that will allow everyone to come together in one virtual room, without having to leave their physical location. Unlike virtual / augmented reality, it does not require users to wear glasses or head mounted devices (HMDs).
- **Metaverse:** describes the concept of a future iteration of the Internet, made up of persistent, shared, 3D-shared spaces linked into a virtual universe. It could comprise countless persistent virtual worlds that interoperate with one another, as well as the physical world and transforming markets such as gaming, retail, entertainment etc
- **Nextgen Batteries:** Whilst lithium batteries are the major EV technology, this does not necessarily need to stay true with alternatives such as solid state, vanadium flow, sodium ion etc provide promising additional attributes, such as faster charging, greater energy densities and better reusability.
- **OceanTech:** aka Blue Economy is the advanced technology industry focused on products that work in or use the ocean. It seeks to answer: ‘How do we increase sustainability of the ocean economy while harnessing its benefits?’ Solutions could include ocean energy, land based aquaculture, and precision fishing using AI, etc.
- **Green Mining:** Transitioning away from a carbon-intensive economy will mean moving to a metal-intensive one. Green mining solutions like deep-sea mining, agromining, mining of wastewater and asteroid mining could provide less polluting and destructive solutions as the green economy’s thirst for metals grows.
- **Carbon Capture & Storage (CCS):** All current zero-carbon pathways require some form of CO2 removal. CCS, alongside other geoengineering solutions, could act as part of the solution with long-term permanent removal of CO2 vs afforestation.

Emerging tech: addressable market vs. industry adoption

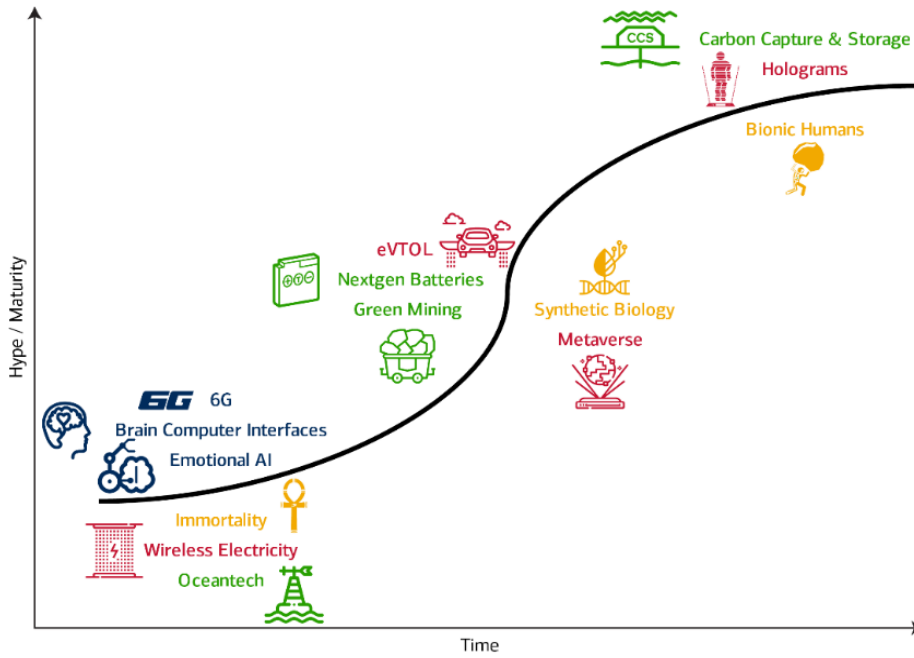
The next disruptive technology’s importance depends on the potential total addressable market (TAM) size, where it currently fits in the technological hype cycle as well as its



ability to penetrate the space and achieve wide market adoption (e.g. partnerships, customer licensing deals).

Exhibit 12: Moonshot Future Tech S-Curve Adoption Trajectory

6G, BCI still in the early stages, eVTOL, Nextgen Batteries reaching the inflection point, CCS late stage



Source: BofA Global Research

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