

Transformational Technologies Reshaping the World



Date: January 2018



“What technologies
will you be following
in 2018 that have the
**greatest potential
to transform the
world** over the next
decade?”

We posed this question
to the Lux Research
analyst team.

We also investigated the
same question using our
Lux Intelligence Engine
(LuxIE) data platform.

Here is what we found



18 for 2018

Executive Summary: Top technologies Lux is following in 2018, using data from the Lux Intelligence Engine and analysts' insight

A ranking of the most important technologies to watch, given their potential to transform the world in the next decade

1

Machine Learning and Deep Neural Networks

30% annual increase in machine learning patents

2

3D Printing and Additive Manufacturing

Lux expects 3D printing to be a \$20 billion market by 2025

3

Genome Editing

\$1.2 billion in VC funding to impact industries from food to health care

4

5G Networks

Over 70,000 patents set the stage for 5G network launches in 2018

5

Microbiome

Harnessing the power of microbes for nutrition, agriculture, and more

6

Solid-state Batteries

Safer and better batteries, pursued by start-ups and giants like Toyota

7

Synthetic Biology

A recent \$275 million round for Ginkgo Bioworks highlights the potential

8

Augmented Reality (AR)

Enterprise applications are coming now, on heels of \$4.4 billion in funding

9

Smartwatches

Patents soar from near zero to over 23,000 in less than five years

10

Wireless Charging

Here now for consumer electronics, with R&D pushing for EV uses

11

Materials Informatics

Using IT and AI to break out of slow material development cycles

12

IoT Security

Patents are up 13x as connected devices proliferate

13

Edge Computing

When milliseconds matter, analytics can be local, not in the cloud

14

Energy Distribution System Monitoring

Growing demand and renewables require tech to balance the grid

15

Polyethylene Furanoate (PEF)

Innovation has grown at an 87% annual rate to improve on PET

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Sugar Reduction

Over 162,000 patents to combat health ills from too much sugar

17

Neural Interfaces

Tech to read and stimulate the brain will see growing validation in 2018

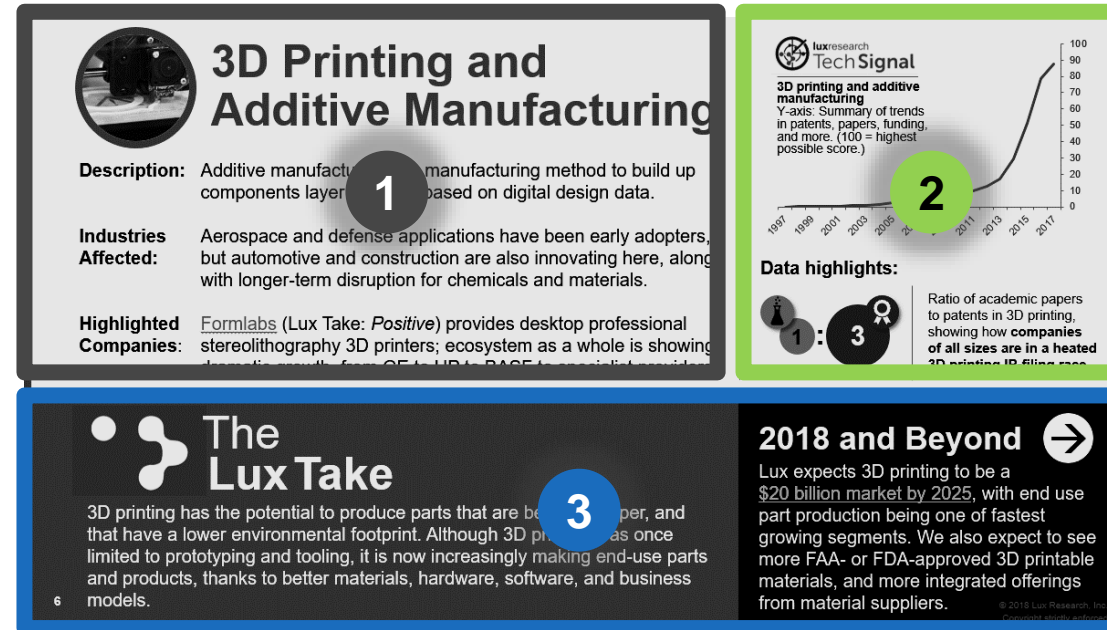
18

Syngas and Power-to-Gas

Producing fuels from CO₂ to drive the energy transition

For each technology, in addition to its ranking, you'll find an overview, our data insights, and our opinion

1 Overview:
An analyst-written summary of the technology, the affected industries, and a selection of highlighted companies.



3 Our opinion:
The “Lux Take” section summarizes our analysis of each technology, while the “2018 and Beyond” section highlights what our analysts expect the future to hold.

2 Our data insights:
The Lux Tech Signal is a composite score, combining data in patents, papers, and funding, plus our own proprietary data. It quantifies the progress of each technology, against a maximum innovation interest score of 100 (for details, see appendix).



Machine Learning and Deep Neural Networks

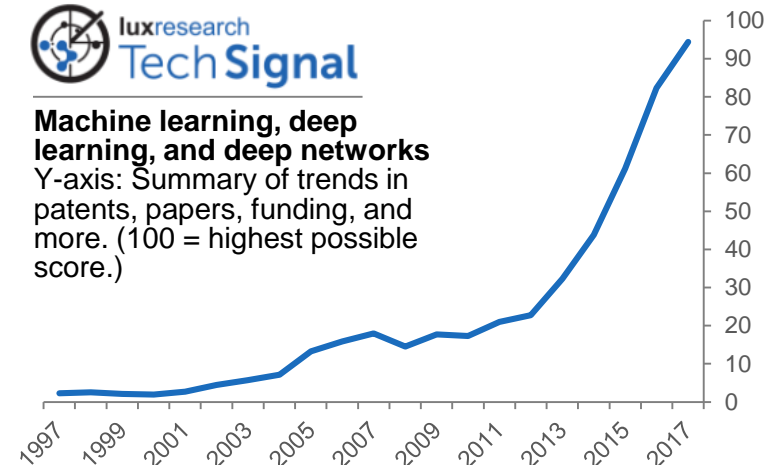
Description: Training a machine so that it has the ability to interpret and derive insights from new data generated in the future – key techniques include deep learning and artificial neural networks.

Industries Affected: Machine learning affects almost every single industry, ranging from agriculture to automotive to pharmaceuticals and retail.

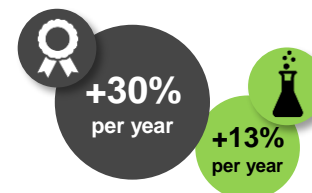
Highlighted Companies: [H2O.ai](#) (Lux Take: *Positive*) has a machine learning platform that's made inroads with many on the Fortune 500 list; also watch massive efforts by the likes of Google, Microsoft, IBM, and Apple.



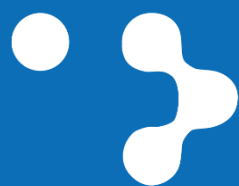
Machine learning, deep learning, and deep networks
Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:



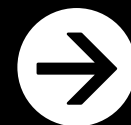
During the past decade, machine learning has had a remarkable rise: **patents filed have grown by more than 30% annually, and academic papers by 13%.**



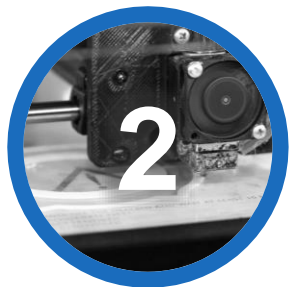
The Lux Take

Machine learning can derive insights from vast amounts of multidimensional data, something that humans are not capable of, meaning it can not only help optimize operations, but also enable some previously unseen products and applications, as well as new business models. Although today IT uses get the most attention, machine learning's impacts will reach into many industries.

2018 and Beyond



We expect to see more widespread adoption of machine learning in the non-IT sector in 2018, as return on investment is proven out. Clients should keep an eye out for announcements of acquisitions and partnerships that involve large non-IT companies.



3D Printing and Additive Manufacturing

Description: 3D printing is a manufacturing method to build up components layer by layer, based on digital design data.

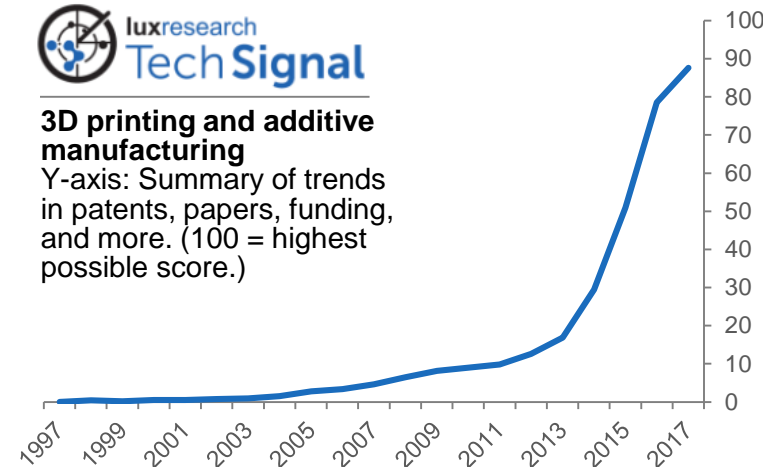
Industries Affected: Aerospace and defense applications have been early adopters, but automotive and medical are also innovating here, along with longer-term disruption for chemicals and materials.

Highlighted Companies: [Formlabs](#) (Lux Take: *Positive*) provides desktop professional stereolithography 3D printers; ecosystem as a whole is showing dramatic growth, from GE to HP to BASF to specialist providers.



3D printing and additive manufacturing

Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:



Ratio of academic papers to patents in 3D printing, showing how **companies of all sizes** are in a heated 3D printing IP-filing race.



3D printing has the potential to produce parts that are better, cheaper, and that have a lower environmental footprint. Although 3D printing was once limited to prototyping and tooling, it is now increasingly making end-use parts and products, thanks to better materials, hardware, software, and business models.

2018 and Beyond



Lux expects 3D printing to be a [\\$20 billion market by 2025](#), with end use part production being one of the fastest growing segments. We also expect to see more FAA- or FDA-approved 3D printable materials, and more integrated offerings from material suppliers.



Genome Editing

Description: Using genetic tools like TALENs and CRISPR to make specific changes to a cell's DNA.

Industries Affected: Agriculture, pharmaceuticals, consumer products, chemicals and materials, health care.

Highlighted Companies: [Benson Hill Biosystems](#) (Lux Take: *Strong Positive*) is developing a gene discovery platform that uses machine learning; other players include Caribou Biosciences, CRISPR Therapeutics, Monsanto, Syngenta, Precision Biosciences, Cibus, and more.

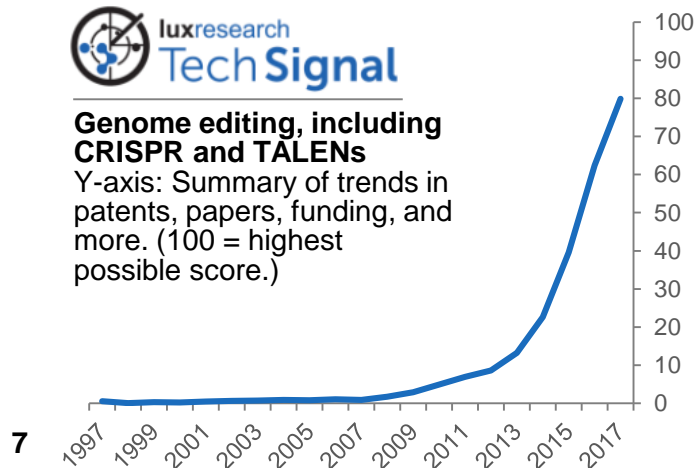


Genome editing has the ability to impact every major life science industry, promising advances like cancer cures and more nutritious crops. Unlike transgenic approaches, genome editing can be faster, cheaper, and offers an easier regulatory path. Its impacts will be felt everywhere, from food to health.



Genome editing, including CRISPR and TALENs

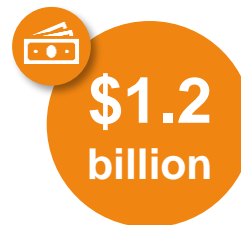
Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:



Number of academic papers is about equal to patent publications, **highlighting key role of both academia and industry in innovation.**



Firms related to genome editing have raised more than **\$1.2 billion in funding, 40% of which came in 2017.**

2018 and Beyond →

Clients should expect initial clinical trials of gene therapies developed using CRISPR to begin in 2018, led by cancer therapeutics. In agriculture, consumer-relevant traits like reduced gluten and increased lycopene content will be most relevant – watch for the reception of genome-edited “Arctic Apples” to gauge how consumers will view the technology.



5G Networks

Description: Fifth-generation mobile network technology spanning new devices, 5G-enabled business models, as well as operators and companies supporting and developing 5G-related innovations.

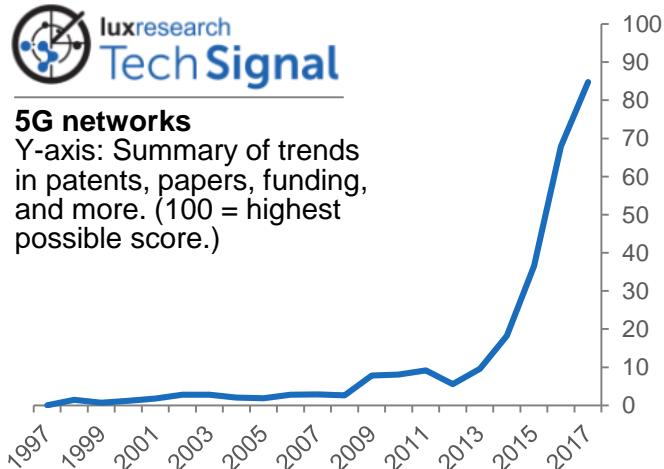
Industries Affected: Electronics and IT will be key beneficiaries, but expect impact to span from automotive to energy to retail to diversified industrials.

Highlighted Companies: [Taoglas](#) (Lux Take: *Positive*) makes 5G IoT antennas; other key players include Verizon, Telia, Deutsche Telekom, AT&T, Nokia, Huawei, Ericsson, Samsung, ZTE, Intel, Qualcomm, and Cisco.



5G networks

Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:

70k

Patents applications and grants referring to 5G networks, led by likes of Samsung Electronics, Intel, Qualcomm, and Verizon.

Top 1%

A boom in both patents *and* academic papers **puts 5G in the top 1% of all tech we track using Tech Signal.**



5G will be critical for internet of things (IoT) uses, with a mix of higher transfer rates, lower latencies, lower battery consumption, higher signal reliability, and support for more simultaneously connected devices – but standards and rollout may be painful, and partnerships and product launches are still needed.

2018 and Beyond



The first publicly available 5G networks are coming: Telia is launching the first public 5G live network in Europe with Ericsson and Intel, and Verizon plans to soft-launch 5G in 2018. Moreover, Verizon and Intel are working on developing 5G systems-on-a-chip (SoCs) that could soon make their way into next-generation mobile devices.



Microbiome

Description: Microbes (and their genes) that can be used as ingredients, therapeutics, and diagnostic tools across a wide range of industries.

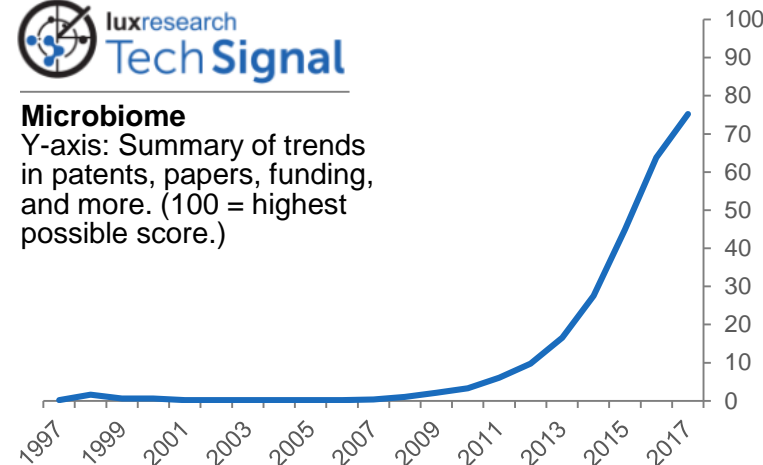
Industries Affected: Agriculture, consumer products, health care, and the pharmaceutical industry.

Highlighted Companies: [Ganeden](#) makes functional ingredients for foods, beverages, livestock, and personal care (Lux Take: *Strong Positive*). Also watch the likes of Novozymes, Danone, Day Two, and Unilever.



Microbiome

Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:



Ratio of academic papers to patents in the microbiome, highlighting the stage of **fundamental research is still very much alive here.**



Consumers are more frequently seeking microbiome-focused products and services, and academic research is reaching a critical mass in understanding the impacts of microbes on a number of diseases. This technology area has the potential to unlock a new layer of personalization across food, personal care products, and medicine.

2018 and Beyond



Improved understanding of how microbial communities contribute to (or detract from) human health, enabling the development of tools to manipulate the microbial communities, to drive things like increased crop yields, improved livestock health, and reduced diabetes.



Solid-state Batteries

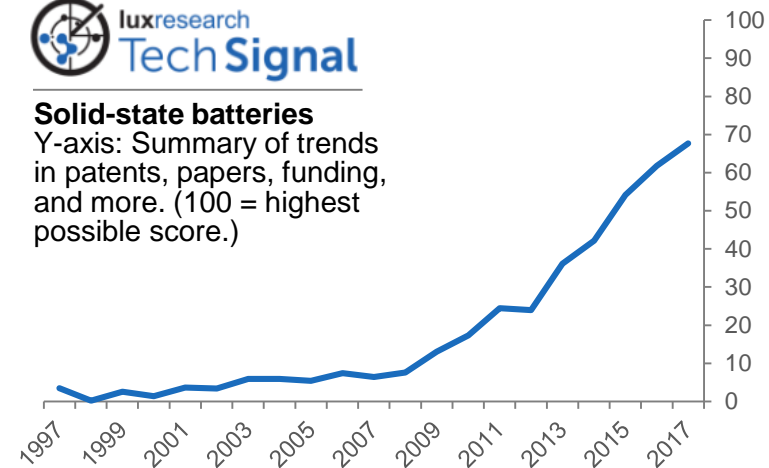
Description: New, safer, higher-energy battery chemistry that replaces conventional liquid electrolytes with solid materials.

Industries Affected: Automotive as well as consumer electronics, with possible impacts to energy utilities and oil and gas incumbents.

Highlighted Companies: [Ionic Materials](#) (Lux Take: *Strong Positive*) develops solid polymer electrolytes for solid-state batteries. Incumbents to watch for their emerging work on solid-state batteries include Panasonic, Toyota, Bosch, and Volkswagen.



Solid-state batteries
Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:



Patent publications referring to solid-state batteries **exceeded 1,000 per year for the first time in 2017**, with Toyota Motor leading the way.

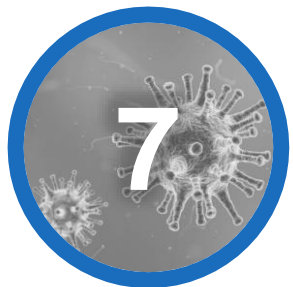


Solid-state batteries are the only next-generation battery technology that currently has traction in the energy storage space. Despite challenges in cost and manufacturing, they are the industry's best chance at displacing incumbent lithium-ion batteries with something that is higher-energy, safer, and potentially lower cost – but they will take time to commercialize.

2018 and Beyond



Solid-state batteries are approaching market introduction. Toyota is planning to use solid-state in 2020, and Samsung plans to introduce such batteries in its devices within the next two years. The latter should lead to announcements of production capacity in 2018.



Synthetic Biology ("Synbio")

Description: Technologies to create new organisms – including microbes and plants – with valuable capabilities for various applications.

Industries Affected: Chemicals and materials, consumer products, food & beverage, agriculture, and pharmaceuticals.

Highlighted Companies: [Ginkgo Bioworks](#) (Lux Take: *Positive*) develops an automated, high-throughput platform for engineering microbial strains. [Zymergen](#) (Lux Take: *Positive*) is worth watching for its work using robotics and machine learning to engineer microbes.



Synthetic biology companies have been well-funded during the last two years, with notable deals including Ginkgo Bioworks' \$275 million Series D. The new leaders here are developing technologies to accelerate organism development timelines, bringing them to commercial relevance faster.

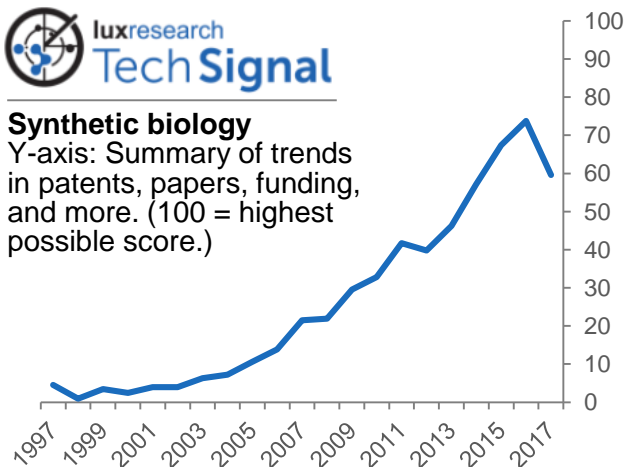
2018 and Beyond →

2017 not only saw continued funding, but also new partnerships highlighting new target markets, such as microbiome development for agriculture and medical applications. We expect to see progress with these new applications, as well as other new target markets in 2018.

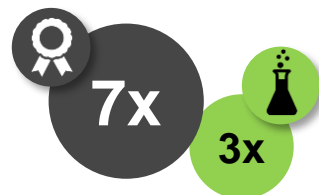


Synthetic biology

Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:



The rate of **patent publications per year** has **increased 7x** during the **past decade**, albeit from a smaller base than papers.



Ginkgo Bioworks' recent Series D, including money from **Y Combinator**, **General Atlantic**, and **Bill Gates**.



Augmented Reality (AR)

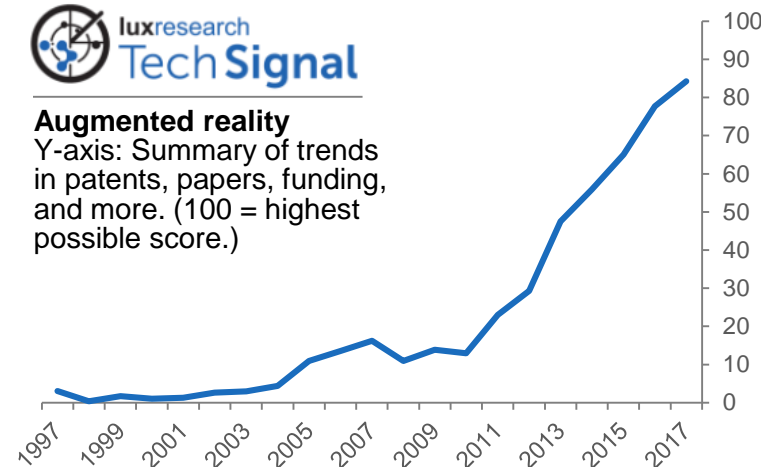
Description: AR is any digital content that is placed over the real world to inform or enhance the viewer's experience.

Industries Affected: Consumer products, oil and gas, transportation and logistics, health care, agriculture, aerospace and defense, and more.

Highlighted Companies: [Vuzix](#) (Lux Take: *Wait and See*) develops smart glasses and video eyewear for enterprise uses. Others to watch include Atheer, Ubimax, Daqri, Apple (via ARKit), Google (via ARCore), Lumus Vision, and Vuforia.



Augmented reality
Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:


\$4.4 billion

Funding going into AR has exceeded \$4.4 billion, led by [Magic Leap](#)'s raise of more than \$1.5 billion across various rounds.



AR has proven ROI in the enterprise, especially with complex tasks where a human operator is necessary. It is also emerging on the consumer end, with use cases like allowing a more engaging automotive sales and marketing experience, as well as finding its place in some products such as BMW's new 7-Series luxury vehicles.

2018 and Beyond



Expect to see more widespread use of AR in the enterprise with its incorporation into enterprise tasks such as remote assistance, maintenance, assembly, quality control, and prototyping and design.



Smartwatches

Description: Mobile wrist-worn devices offering connectivity and sensors with touchscreen displays, and sometimes acting as a proxy for smartphones.

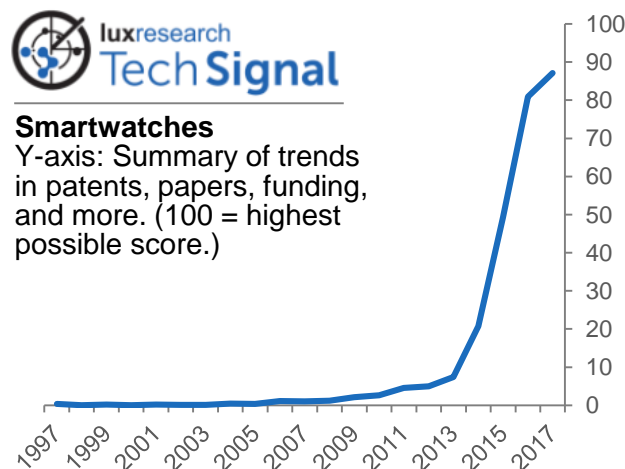
Industries Affected: Consumer products, electronics and IT, health care, pharmaceutical, and retail.

Highlighted Companies: A wealth of companies are innovating in the space, including AliveCor, Apple, Fitbit, Fossil, Huawei, LG, Polar, Samsung, Sony, Xiaomi, Garmin, Google, Amazon, and Qualcomm.



Smartwatches

Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:

23k

Smartwatch innovation has been largely patent-driven, going from near zero to more than 23,000 in just five years.



Since 2013, a very strong rise in innovation interest puts smartwatches in the top 1% of all we track using Tech Signal.



Smartwatches continue to incorporate new capabilities in enterprise, consumer, and medical applications. These can be new sensing capabilities, such as blood pressure monitoring, or the ability to connect to the large IoT ecosystem, integrating with the connected home and car.

2018 and Beyond



Smartwatches used to focus on notifications and fitness tracking, but are finding their way into other uses like medical heart rate evaluations and clinical studies. These applications are enabled by improvements to existing sensors and the analytics used to process the data. As costs decrease and functionality is added, adoption will increase.



Wireless charging

Description: Charging batteries without plugging in, for everything from small consumer electronics to electric vehicles.

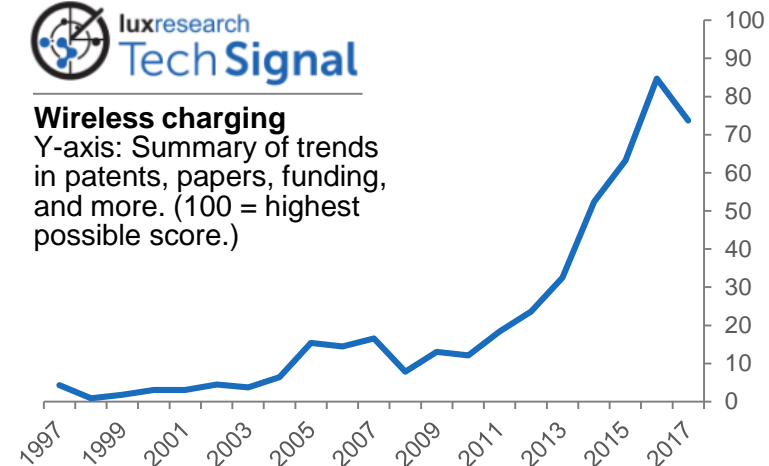
Industries Affected: Automotive, consumer products, electronics and IT, energy and utilities, oil and gas.

Highlighted Companies: [Solace Power](#) (Lux Take: *Wait and See*) makes wireless charging systems using resonant capacitive coupling. Larger players to watch include Apple, Samsung, Qualcomm, Nissan, and Daimler, as they look to impact electronics and automotive applications.

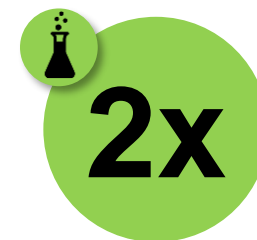


Wireless charging

Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:



Innovation in wireless charging is seeing activity in both papers and patents, with **rate of papers per year increasing twofold during the past decade.**



Wireless charging is being applied already for small devices like smartphones. Meanwhile, developers are working on applying the technology for electric vehicles, with a dream of charging on the fly so that vehicles will have near-infinite ranges given the right infrastructure – though this dream vision is far from coming to fruition.

2018 and Beyond



Significant market adoption in electronics, while automotive OEMs will invest in development of wireless charging for parking lots. Look for milestones in new product releases, standards work, and more demonstrations.



Materials Informatics

Description: Applying data science and artificial intelligence methods to materials science and engineering to better understand the use, selection, development, and discovery of materials.

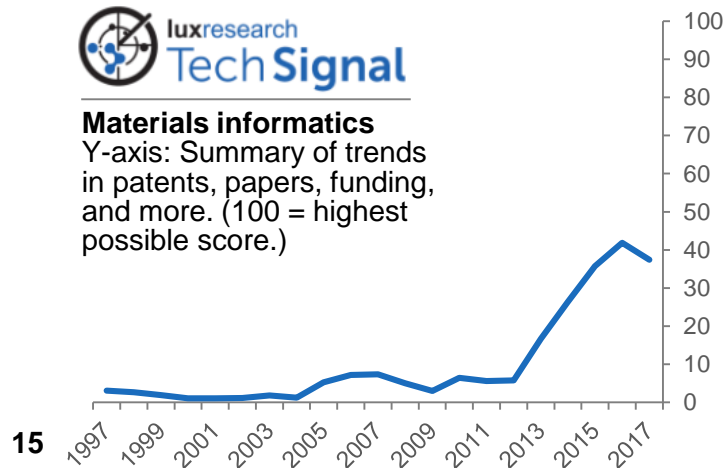
Industries Affected: R&D labs of materials developers, product manufacturers, and academia will feel impact first. More broadly, it will impact everything from automotive to health care to construction.

Highlighted Companies: [Nutionian](#)'s (Lux Take: *Positive*) AI modeling platform for big data; as well as Citrine Informatics and IBM Accelerated Discovery Lab.

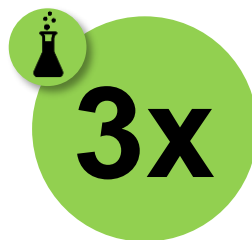


Materials informatics

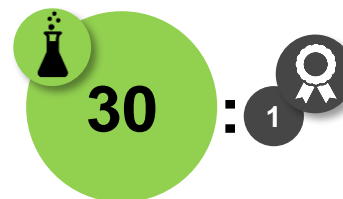
Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:



The number of materials informatics **papers per year** has increased threefold during the past decade.



Ratio of papers to patents in materials informatics, showing the field is still **ripe for fundamental technological advances**.



Materials informatics tools are beginning to disrupt the R&D and manufacturing spaces, accelerating materials and chemicals research and product development timelines, extracting additional value from existing experimental and computational data, and leveraging past R&D spending.

2018 and Beyond



Fundamental technological advances, as well as more prevalent investment: Piggy-backing off of machine learning advances more broadly, materials informatics start-ups will use research progress in AI for commercialization efforts. Expect more investments, increasing the number of start-ups in the field.



IoT Security

Description: Technologies and approaches for preventing, identifying, and addressing cyberattacks on internet of things (IoT) devices.

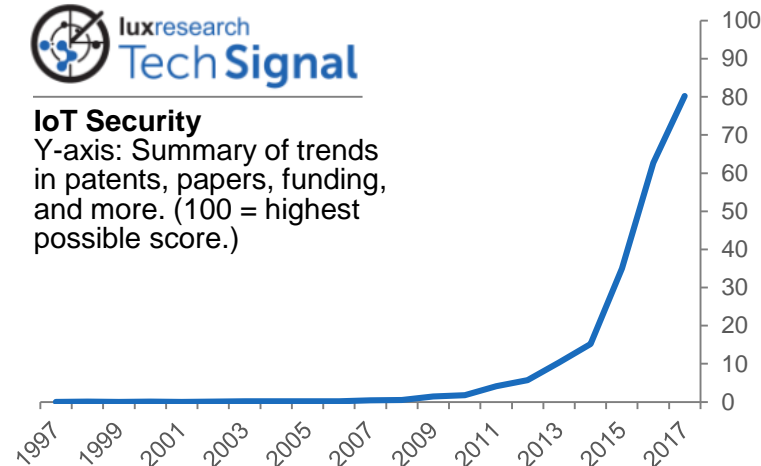
Industries Affected: Energy and utilities, oil and gas, government, defense, and industrials are key stakeholders, as are electronics and IT.

Highlighted Companies: [Nozomi](#) (Lux Take: *Positive*) offers cybersecurity for industrial control networks and has gained impressive traction; others include Symantec, Accenture, Cisco, Splunk, Stanford Secure IoT Project, IoT Security Foundation, and Online Trust Alliance.

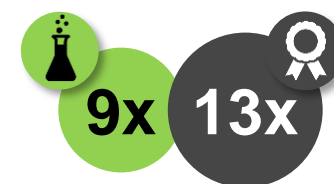


IoT Security

Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:



Just during the past three years, the number of papers and patents that touch upon **IoT security** have grown by **9x** and **13x**, respectively.



Booming IoT deployments introduce a plethora of new attack surfaces that are particularly vulnerable, and poorly-secured cyber-physical systems have been the cause of numerous catastrophic and embarrassing attacks. Cybersecurity is a critical component of IoT stack optimization, and both IoT developers and IoT adopters are responsible for its effectiveness.

2018 and Beyond



Today is still the Wild West of IoT security; consortia have yet to align the industry around standards, and problems continue to grow. Watch for the emergence of products that use novel security approaches like AI and blockchain.



Edge Computing

Description: Technologies that can do analytics and derive insights right where the data is generated, rather than by uploading data to the cloud for further analysis.

Industries Affected: Automotive, aerospace and defense, electronics and IT, transportation and logistics, energy and utilities, and more.

Highlighted Companies: [AlphaCs](#) (Lux Take: *Positive*) simplifies AI chip design for gaming, IOT, and wearables; also see [Graphcore](#), [Coolfire Solutions](#), [Neurala](#), and watch work by the likes of Google and Apple.



Edge computing is being pushed by key trends including data privacy, current bandwidth limitations, and diverse experiences, plus latency: In our "here-now" world, it is not enough to do analytics on the cloud and derive insights later. In mission-critical uses, milliseconds make all the difference.

2018 and Beyond



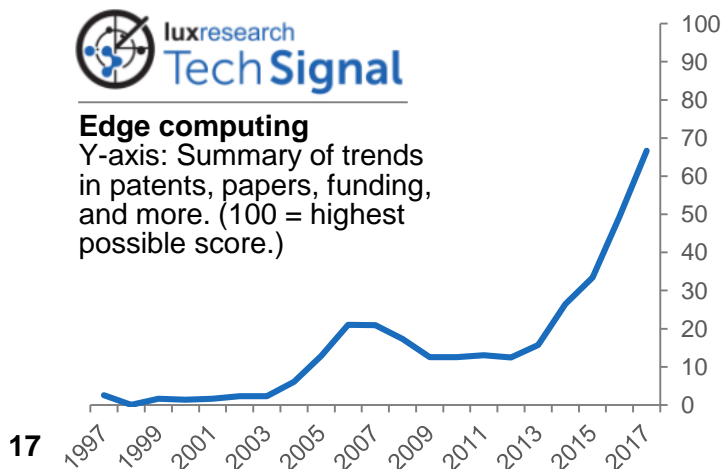
Introduction of initial products will continue as leading developers bring more edge computing offerings to market. Many of the companies mentioned here have released some preliminary architectures/solutions. These products will solidify over time, and lead to more mature offerings in the growing marketplace for edge computing.

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Edge computing

Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:



Of all technologies we track using the Tech Signal, partly thanks to a recent boom in patents.



More patent publications related to edge computing than just five years ago, with leaders including the likes of IBM and Microsoft.



Energy Distribution System Monitoring

Description: Monitoring and intervening in the power grid for the purpose of optimizing the load.

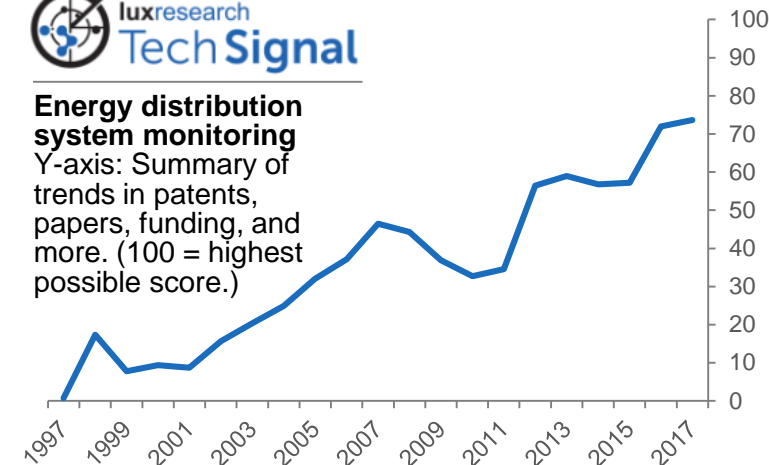
Industries Affected: Energy and utilities, automotive, oil and gas, and the electronics and IT industries.

Highlighted Companies: [PXiSE](#) (Lux Take: *Wait and See*) makes fast-response control systems for managing intermittent renewable generation. Larger firms to watch include E.ON, P66, Singapore Power, BNP Paribas, Engie, Total, Tennet, EDF, RWE, and Vattenfall.

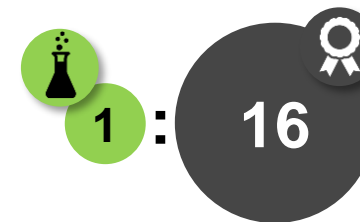


Energy distribution system monitoring

Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:

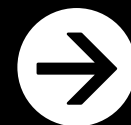


Patents dominate the innovation landscape here, with 16 patent publications for every one paper on this topic.



With the steady increase of loads on the grid, like plug-in vehicles, and the strong growth of intermittent renewables, the limits to current grid resilience are approaching. Grid operators are searching for technology to stretch those limits without investing in additional hardware. Energy management services provide new business opportunities for utilities and oil and gas companies.

2018 and Beyond



2018 is the year where the first real solutions may appear for peer-to-peer electricity trading. Look for incidents indicating increasing stress on the grid and for initial offerings to clients (consumers or business) of demand-side management special rates.



Polyethylene Furanoate (PEF)

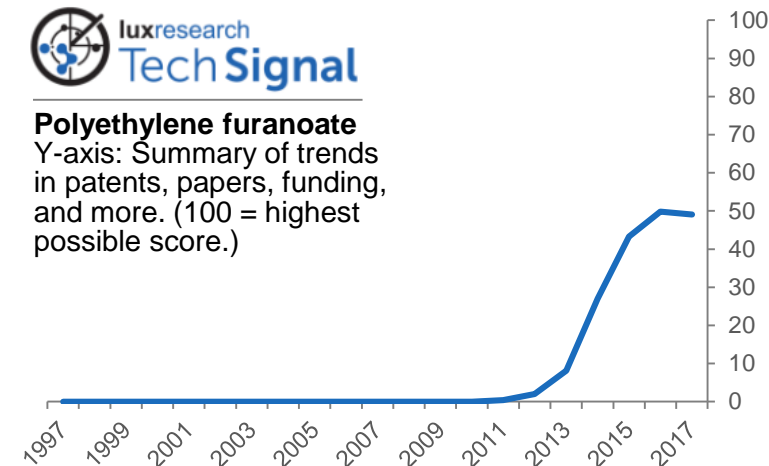
Description: Bio-based polyester with improved mechanical and barrier properties over incumbent polyethylene terephthalate (PET).

Industries Affected: Consumer products will be affected by PEF's development, with implications for the chemicals and materials industry.

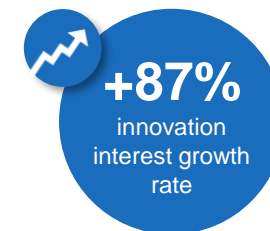
Highlighted Companies: [Avantium](#) (Lux Take: *Positive*) develops furanic building blocks for renewable chemicals and fuels, working with BASF via a joint venture called Synvina. Others to watch include Mitsui, DuPont, ADM, Corbion, and Origin Materials.



Polyethylene furanoate
Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:



PEF's five-year growth rate on our Tech Signal benchmark is an amazing **+87% per year, in the same league of interest as blockchain and neural networks.**



For a new material, PEF is well-primed for success. It has similar processing ability but improved properties over the commodity it aims to replace, PET. The most important factor in PEF's favor, though, is the vast support from brand owners: Coca-Cola, Danone, LEGO, and Nestle are some of the key players vested in this new plastic, often motivated by sustainability.

2018 and Beyond



The first commercial-scale plant (a 50,000 tpa facility led by Avantium/BASF JV) for PEF's key monomer, FDCA, should come online by 2024. We anticipate further progress from other players in the space – Corbion and DuPont in particular.



Sugar Reduction

Description: Reduction and substitution of sugar (sucrose) within food and beverages.

Industries Affected: Consumer products, food & beverage, agriculture, as well as chemicals and materials.

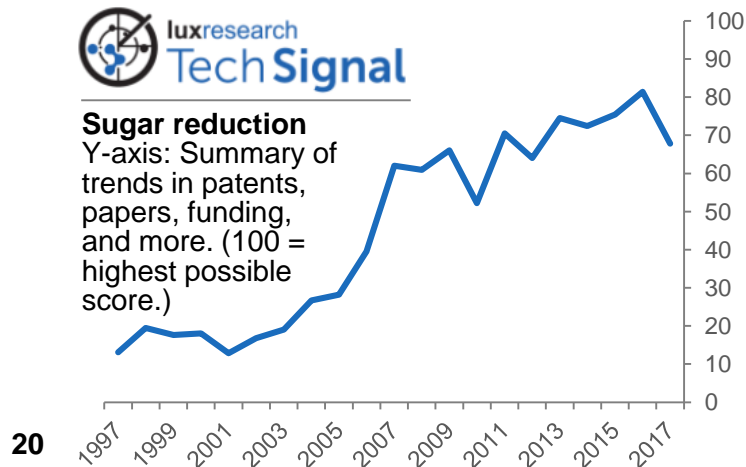
Highlighted Companies: [Bonumose](#)'s (Lux Take: *Positive*) enzymatic technology platform produces rare sugars from starch-based feedstocks. Others to watch include Nestle, Coca-Cola, Cargill, Tate & Lyle, Ingredion, PureCircle, GLG Life Tech, DouxMatok, Evolva, and Manus Bio.



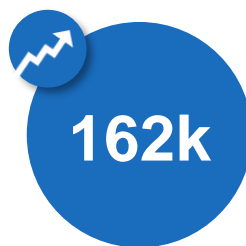
Sugar consumption has increasingly been linked to ill health. Pressure from public health, government, and consumers alike has initiated a flurry of both short-term and long-term sugar reduction goals by many global consumer packaged goods (CPG) companies.



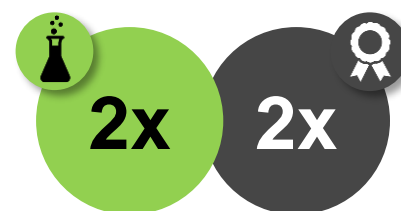
Sugar reduction
Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:



With **162,000 papers and patents** touching on sugar reduction, the field has strong momentum.



During the past decade, the rate of **yearly patents and research papers** around sugar reduction have **doubled**.

2018 and Beyond →

Reducing and substituting for sucrose has been a decades-long effort. 2018 should be an exciting year in the pursuit of the holy grail of sugar replacements – look out for product launches from Nestle using its hollow-sugar crystals and Coca-Cola with its refined stevia, as well as scale-up progress from rising stars like Bonumose and DouxMatok.



Neural Interfaces

Description: Neural interfaces are technologies to read and stimulate the brain, with potential to manage disease, enhance performance and wellness, and facilitate communications.

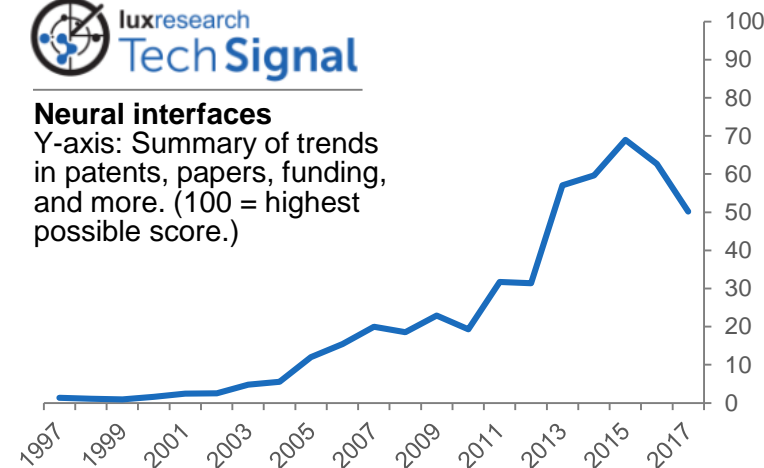
Industries Affected: Consumer products and health care are the two industries where we expect to see neural interfaces' impact first.

Highlighted Companies: [Fisher Wallace](#) (Lux Take: *Positive*) makes wearable electro-stimulation devices for treatment of depression, insomnia, and anxiety. Larger players include GSK, Facebook, and Samsung.



Neural interfaces

Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



Data highlights:



Ratio of academic papers to patents in neural interfaces, showing the **mix of ongoing research alongside the start of commercial traction**.



With increased focus on neurological health, recent advances in technology to understand how our brain works, and buy-in from pharma companies like GSK and less-expected giants like Facebook and Elon Musk, some of the promises associated with neural interface technologies will begin to materialize in the not-too-distant future.

2018 and Beyond



Clients should watch for clinical validation of neural interfaces technologies; introduction of new, more diverse applications for neural interfaces; buy-in from more giants; and advancement of already-announced initiatives to commercialization.



Syngas and Power-to-Gas

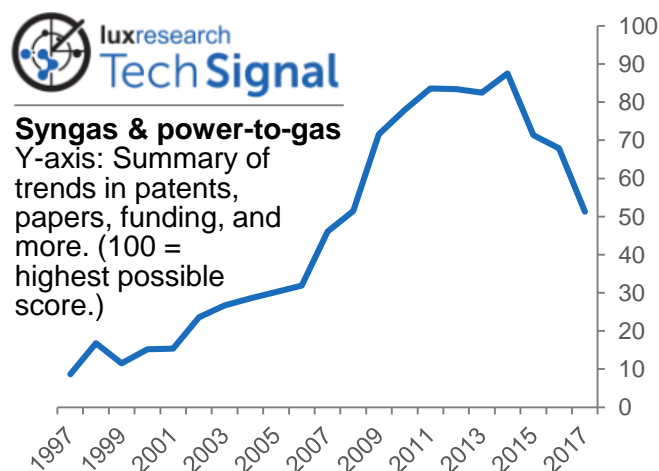
Description: Using hydrogen and CO₂ to produce chemicals and fuels.

Industries Affected: The oil and gas, chemicals, and steel industries are among those most affected.

Highlighted Companies: [Dioxide Materials](#) (Lux Take: *Wait and See*) develops catalysts for electrochemical conversion of CO₂ into fuels and chemicals. Meanwhile, larger companies to watch include Halder Topsoe, Mitsui, Covestro, Dow Chemical, Arcelor Mittal.



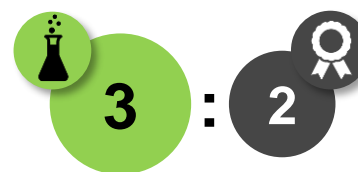
CO₂ utilization and carbon recycling (from waste) have steadily been gaining attention and are now on the verge of reaching first applications. They provide options for addressing some of the harder-to-solve issues in the energy transition, such as how to replace aviation fuels or chemical feedstock.



Data highlights:



Academic papers and patent publications touching on this area both **exceed 10,000 per year.**



The ratio of academic papers to patents is about 3:2, highlighting **innovation in both research institutes and companies.**

2018 and Beyond →

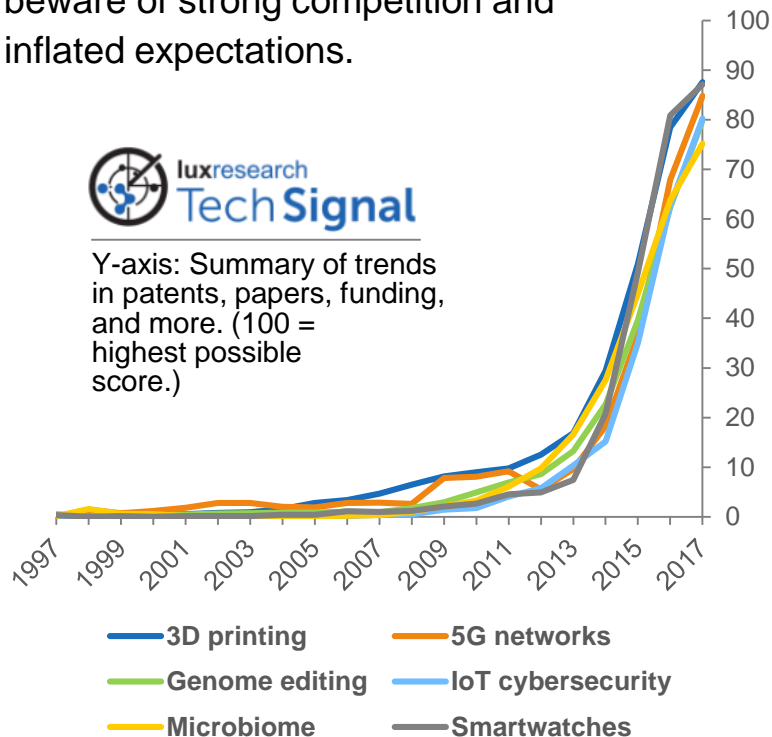
Expect new developments in electrochemistry for CO₂ and new syngas chemistry developments. Watch in particular for partnerships forming between the chemical industry and steel or waste companies (e.g., AkzoNobel might announce an investment in its partner Enkema's site in the Port of Rotterdam).

18 for 2018

Outlook: Transformational technologies fall into three categories based on their maturity, Lux Tech Signal score, and analyst evaluation

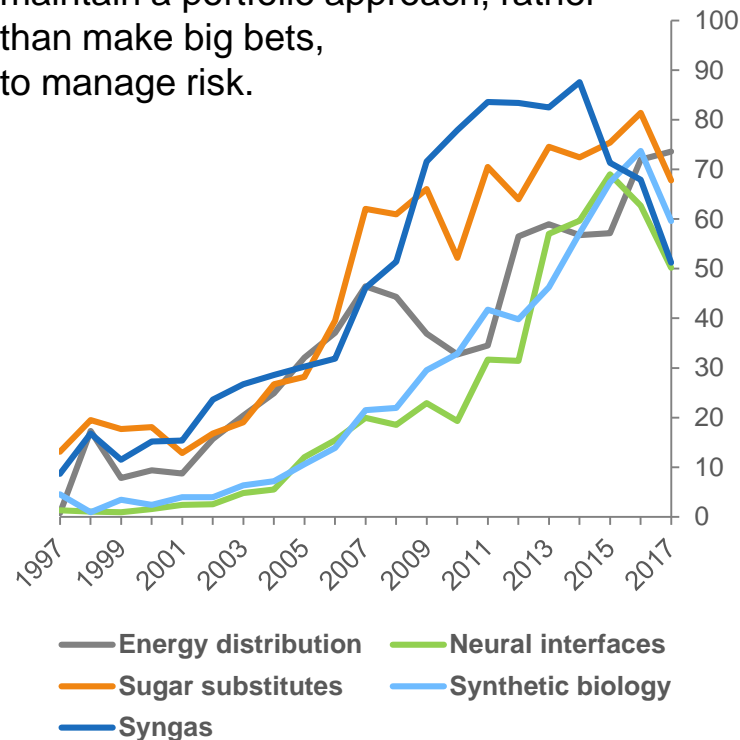
The current rock stars of innovation:

Rising stratospherically during the past few years, these are technologies where there is substance. **A strategy for each of these technologies is a must-have for any company** in relevant industries – but beware of strong competition and inflated expectations.



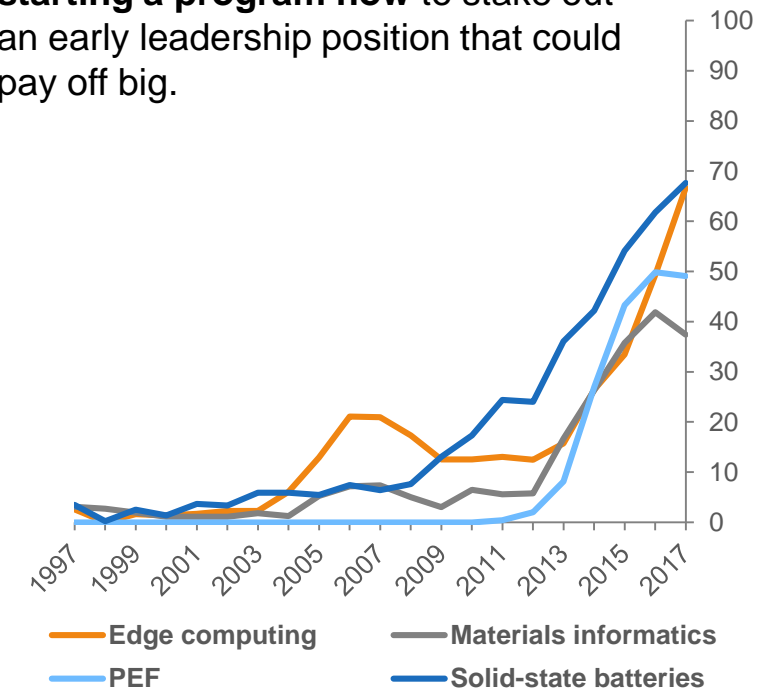
Hard problems that remain relevant:

These technologies continue to attract attention due to their massive potential impact, but have had a tough road to commercial impact so far. **Clients need to monitor closely at a minimum**, but maintain a portfolio approach, rather than make big bets, to manage risk.



Hidden gems:

A bit more under the radar, these technologies do not yet attract much innovation attention in absolute terms, but they are at the beginning of what could be a meteoric rise. **Companies should consider starting a program now** to stake out an early leadership position that could pay off big.





Michael Holman, Ph.D.

VP of Intelligence
+1 (646) 723-0161
michael.holman@luxresearchinc.com

Cosmin Laslau, P.hD

Director, Research Products
+1 (857) 284-5699
cosmin.laslau@luxresearchinc.com

Rachel (Brecher) Daricek, MEM, MBA

VP, Marketing & Product Strategy
+1 (508) 878-0913
rachel.daricek@luxresearchinc.com

Understanding the Lux Tech Signal (LTS)

OBJECTIVE, HOLISTIC MEASUREMENT

The Lux Tech Signal provides a holistic picture of how much innovation is happening in a given technology or product and how it changes over time, objectively and consistently measured by our composite score called “**Innovation Interest.**”

ADVANCED ANALYTICS + ANALYST EXPERTISE

Lux analysts select, curate, and analyze a variety of datasets, ranging from public data such as patents to proprietary analyst-generated data. Custom-built software taps into our massive (and frequently updated) data lake, querying, processing, and combining results from these datasets into the overall measure of innovation interest.

A LEADING INDICATOR

Our analysts use the Lux Tech Signal to complement their expert evaluation in a number of ways, including identification of promising (or declining) technologies and validating/informing viewpoints on commercial prospects for different technologies.

[Contact us](#) to discuss how it might assist you and watch [this webinar](#) demonstrating the effectiveness of the LTS.

Lux Tech Signal (LTS) methodology

The Lux Tech Signal is based on our analysis of innovation data including:

- Patents
- Academic papers
- VC funding
- Government funding
- Lux proprietary data

The **Innovation Interest** score is calculated by analyzing multiple, diverse datasets weighted based on our evaluation of the role innovation sources play in each stage of commercial technology development; empirically tested and validated against real world historical data.

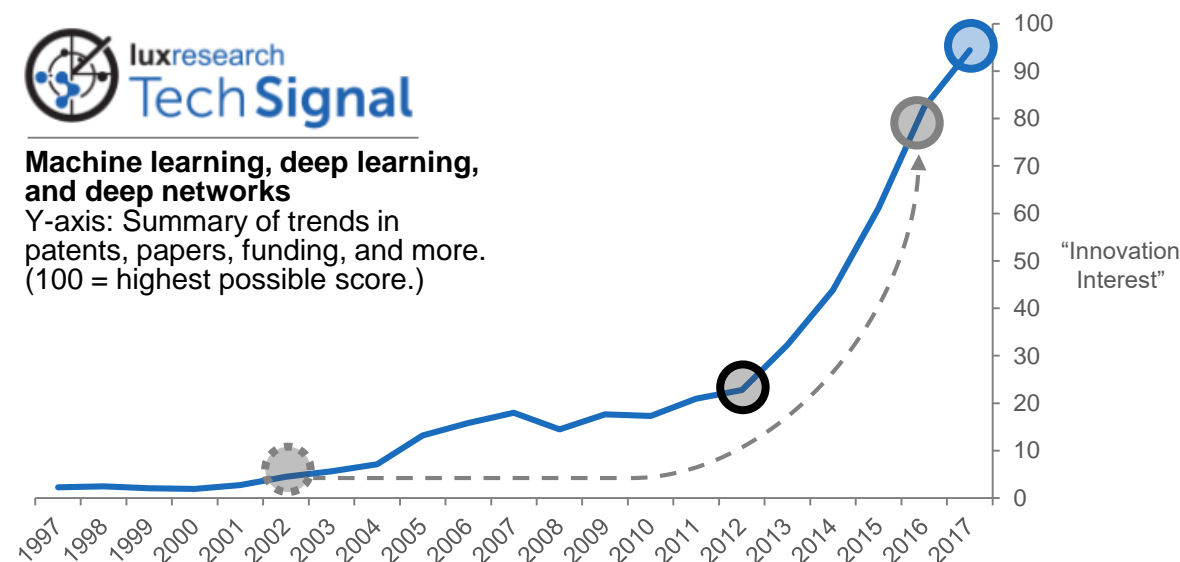
The maximum possible score is 100, indicating the highest observed rate of research, patenting, funding, etc.

EXAMPLE:



Machine learning, deep learning, and deep networks

Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



- **Changes over time** signal growing (or shrinking) innovation interest.
- **Inflection points** may point to commercial opportunities or challenges ahead.
- **Current value** indicates innovation maturity, distinguishing established technologies from those that are still emerging.