EXECUTIVE SUMMARY

20 FOR 20

The technologies with the greatest potential to transform the world over the next decade

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INTRODUCTION

What technologies will you be following this year that have the greatest potential to transform the world over the next decade?

Each year, we ask our analysts this question. We also investigate the same question using the Lux Intelligence Engine data platform. This report highlights our findings and provides a jumping-off point into much more in-depth information on the Lux member site via dedicated Tech Pages and other research.

In 2020, we continue to see a lot of changes and new technologies making the list. We take a step back to think about the significance of *this* group of 20 technologies topping our rankings, exploring the key themes from the list. We also check in on techs that dropped off the list from 2019 and take a data-driven look at what's more overhyped right now. We hope you enjoy, and let us know what you think!
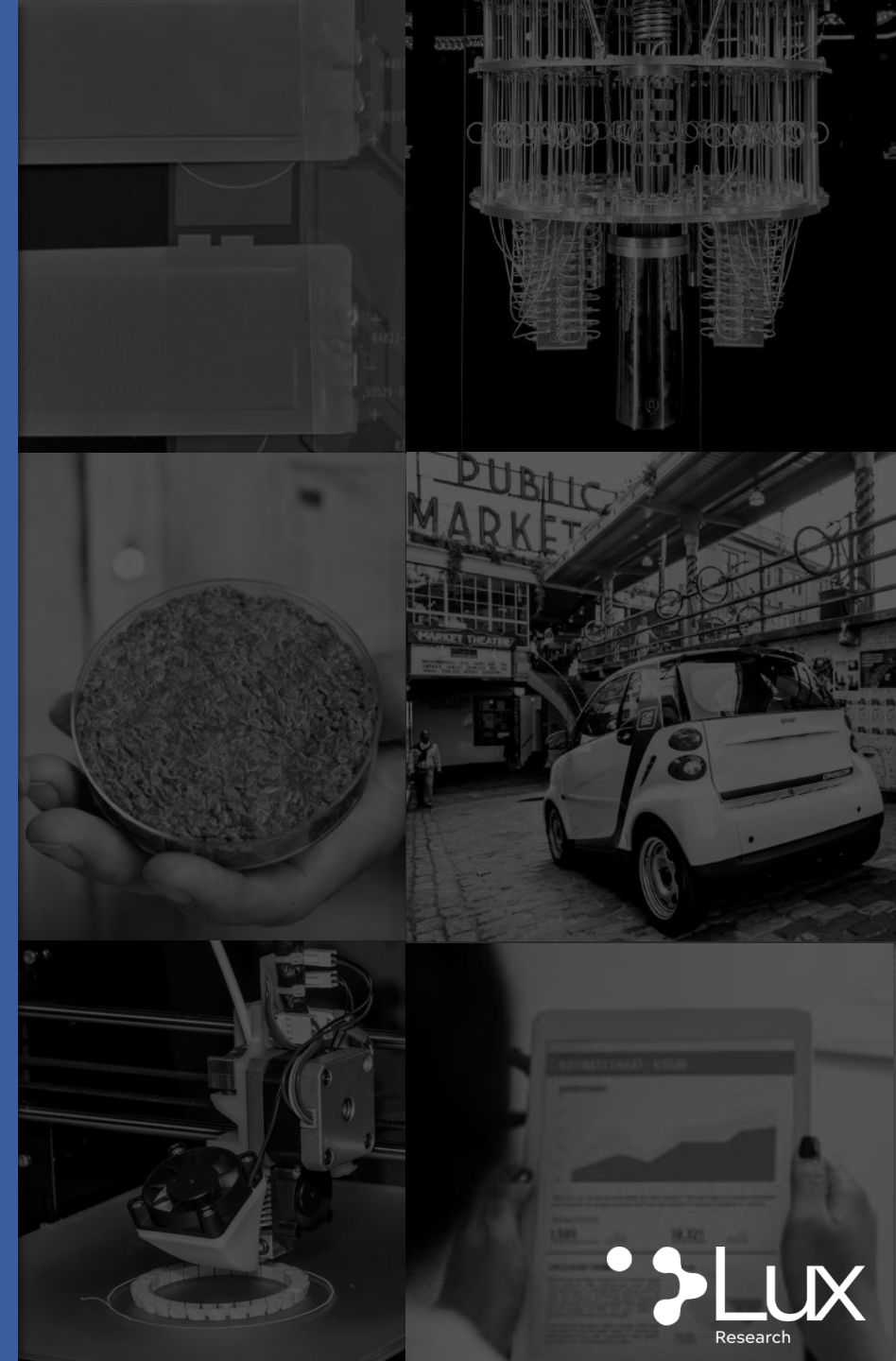
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The Top 20 Transformational Technologies for 2020

#	Technology	
1	5G Networks	▲ Up 12 spots from 2019
2	Shared Mobility	New to leaderboard
3	Advanced Plastic Recycling	New to leaderboard
4	Solid-State Batteries	▲ Up 7 spots from 2019
5	Protein Production	New to leaderboard
6	Commercial Vehicle Automation	New to leaderboard
7	Point-of-Use Sensing	New to leaderboard
8	3D Printing	▼ Down 7 spots from 2019
9	Energy Trading Platforms	New to leaderboard
10	Natural Language Processing	▲ Up 6 spots from 2019
11	Hydrogen & Fuel Cells	New to leaderboard
12	Materials Informatics	▲ Up 2 spots from 2019
13	Quantum Computing	New to leaderboard
14	Last-Mile Delivery	▲ Up 4 spots from 2019
15	Blockchain	▲ Up 4 spots from 2019
16	Battery Fast Charging	▼ Down 10 spots from 2019
17	Omics	New to leaderboard
18	2D Materials	▼ Down 9 spots from 2019
19	Flow Batteries	New to leaderboard
20	Vertical Farming	New to leaderboard

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Key themes from the 20 for 20

The 20 technologies we identified are all compelling individually, particularly for companies in industries that are closely aligned to developing and deploying them, or affected by their impact. However, just as important can be the stories they tell as a group. In looking at the 20 for 20, we identified three key common themes among these innovation dynamos – explained in detail on the following pages.

Renaissance technologies

Platform technologies

Breakthrough technologies

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Renaissance technologies are newly relevant

Some technologies on our list aren't necessarily *new*, but are newly relevant. They have been around for a while in some form – some have even gone for a ride or two on the hype cycle in the past; others have just been regarded as stodgy fields not really associated with cutting-edge innovation. But a combination of megatrends, market demand, and new innovations has thrust them into strategic prominence.

PAST EXAMPLE

Artificial intelligence has been an aspiration of computer scientists, and preoccupation of sci-fi writers, for decades. Innovation interest has gone through past surges followed by "AI winters," but in the past five years, new approaches like deep learning combined with the growth of data collection and compute power have made AI a business imperative.

#5 **PROTEIN PRODUCTION CASE STUDY**

Protein production has been part of human economic activity for millennia, but it is seeing an innovation renaissance in response to food security and climate impact concerns. Trendy alternative proteins like plant-based patties from likes of Beyond Meat and Impossible Foods are just the tip of the iceberg, as everything from precision livestock farming to novel fish meal is on the move.

WHO'S CAPITALIZING?
CALYSTA

Calysta's fermentation tech converts methane into single-cell protein feed. Avoiding the land, water, and resource demands of plant protein, it's scaling a viable alternative aquaculture feed along with strong corporate partners.

bp Cargill Thai Union

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Platform technologies' impact is in what they enable

These technologies are growing and will create opportunities for those directly involved in building their infrastructure – but they are of interest not so much for what they do on their own as for how other innovations can piggyback off them. They become the foundation of a new generation business ideas and an enabler for new technologies that leverage this innovation to build even greater capabilities.

PAST EXAMPLE

Smartphones have been the most important platform of the past decade-plus. They've been big business for manufacturers like Apple and Samsung, as well as driving growth for mobile network operators. Their greatest impact, however, has been enabling an all-star list of growth companies, from Uber and Grab to Instagram and Tencent.

#12 **MATERIALS INFORMATICS CASE STUDY**

Materials informatics applies machine learning to structure and property data of chemicals and materials, allowing it to recommend new compositions, formulations, and processing. Chemical and material companies, and their customers, can use these capabilities to streamline R&D and create new impactful products – but also to build new business models.

WHO'S CAPITALIZING?
Evonik's Coatino platform taps into an extensive database on paints and coatings and applies machine learning to make targeted recommendations for additives and formulations, facilitating sales and boosting customer relationships.

EVONIK
POWER TO CREATE

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Breakthrough technologies are creation with unclear impact

Some technologies are pure bursts of tech innovation brilliance. It might not be entirely clear what all the applications will be, but the surge of innovation interest and the way they've captured the imaginations of entrepreneurs and visionaries around the world makes them impossible to ignore. The risk is that they are just "tech push" without market pull, but when they can align to an unmet need or demand, the result is explosive.

PAST EXAMPLE

Wearable electronics came onto the scene as a novelty, with experiments like the Pebble watch Kickstarter campaign prompting early adopters to begin experimenting. Now, valuable practical applications are being established for both consumers, such a providing critical health alerts, and industrial users, such as worker safety and productivity boosts.

#15 BLOCKCHAIN CASE STUDY

Blockchain followed the rise of bitcoin's price to prominence, along with a predictable array of half-baked ideas and outright scams. However, large companies and serious tech developers are exploring how the concept of a distributed ledger can enable legitimate new businesses. It's not certain yet which approaches and applications will work out, but some will likely go on to have great impact.

WHO'S CAPITALIZING?

centrica

nationalgrid LO3ENERGY

U.K. utility Centrica has created a "local energy market" (LEM) in Cornwall, allowing solar and other distributed asset owners to engage in peer-to-peer energy trading – including "power hedges" on LO3 Energy's blockchain platform.

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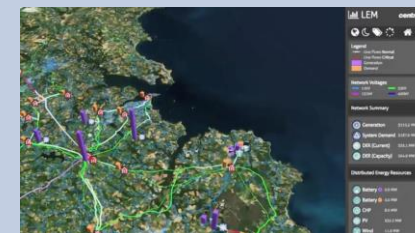
#1 5G NETWORKS

Fifth-generation mobile network technology, with higher bandwidth, more connections, lower latency, and longer battery life.

LUX TAKE

Why it's important: 5G will be critical for internet of things (IoT), enabling applications in fields from robotic surgery to connected cars. 5G devices will also demand enabling tech from <u>advanced substrates</u> to novel creations like <u>metamaterials</u>.

What you should do: 5G will provide greater data collection, increasing transparency into operations, enabling autonomy, and creating new business models like flexible manufacturing. Clients should take care to align timing to 5G's staged rollout, where different capabilities will emerge from different components of 5G that mature at different times.

Michael Sullivan

Lux Tech Signal

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

— Average
— 5G Networks

81
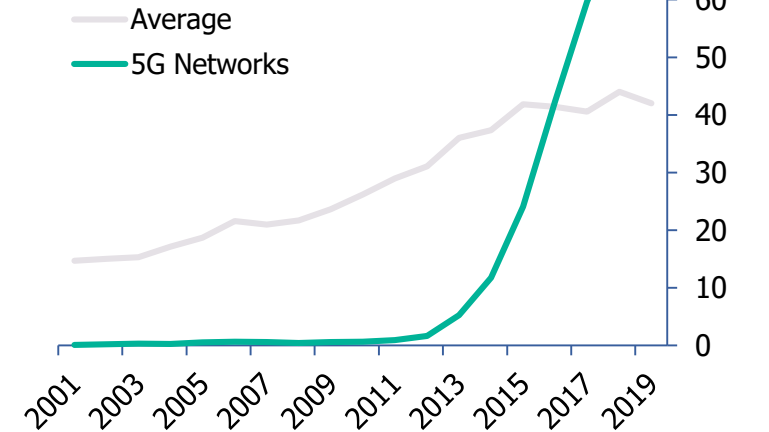
DATA HIGHLIGHTS

2,200

Patents trailed academic publications until 2018 – but patents have shot past and are set to top 2,200 in 2019.

DETAILS For key player analysis, full data, case studies, and more, see our **5G Networks Tech Page.**

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5G NETWORKS

1 MATERIALS

ROGERS CORPORATION	isola	Laird TECHNOLOGIES	DUPONT	Kaneka
kuraray	muRata INNOVATOR IN ELECTRONICS	AGC	HRAI	JFE

2 CHIP MAKERS

QUALCOMM	intel	SKYWORKS	BROADCOM	QORVO all around you
XILINX	HUAWEI	MEDIATEK	SAMSUNG	UNISOC
PIVOTAL COMMWARE		METAWAVE	taoglas antenna solutions	movandi

3 NETWORK GEAR

NOKIA	HUAWEI	ERICSSON	SAMSUNG	ZTE
CISCO	Hewlett Packard Enterprise	DELL EMC	PHAZR	

4 MOBILE NETWORK OPERATORS

verizon	AT&T	T··Mobile	Sprint	vodafone
中国电信 CHINA TELECOM	China unicom中国联通	中国移动 China Mobile	SK telecom	kt
LG U+	SoftBank	docomo	orange	T··

5 DEVICE MAKERS

(Apple)	SAMSUNG	LG	OPPO	mi
hTC	SONY	Microsoft	Google	

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#2 SHARED MOBILITY

Innovations in mobility outside of conventional ownership, such as car-sharing, ride-hailing, autonomous taxis, and other business models.

LUX TAKE

Why it's important: Megatrends like urbanization and a rising global middle class mean urban mobility is increasingly important, but conventional car ownership models are failing to meet this growing need. In their place, new companies and ideas are emerging in the automotive value chain to make mobility cheaper, more convenient, and more efficient.

Chris Robinson

What you should do: While the ride-hailing space is fiercely competitive, there are a huge number of possible business models that stand to disrupt traditional sales, including car subscriptions and microtransit services.

Lux Tech Signal

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

— Average
— Shared Mobility

67
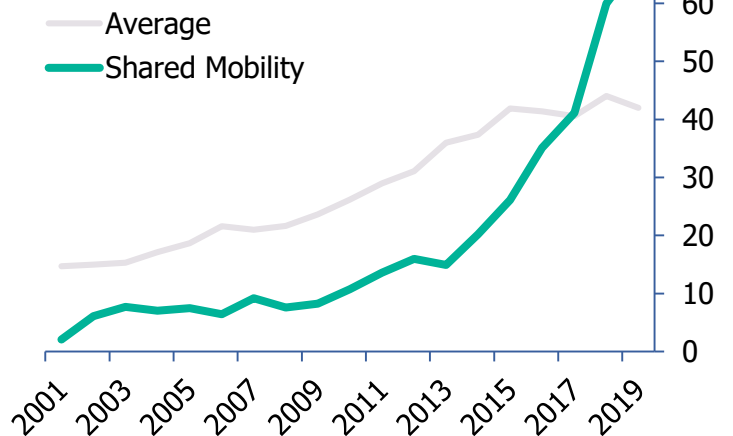
DATA HIGHLIGHTS

$10 billion

Amount of funding being poured into the shared mobility space *each year*, including in 2017, 2018, and 2019.

DETAILS For key player analysis, full data, case studies, and more, see our **Shared Mobility Tech Page**.

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#3 ADVANCED PLASTIC RECYCLING

Innovations that can convert plastic waste into a variety of valuable products, enabling a circular economy and avoiding pollution.

LUX TAKE

Why it's important: Regulations like single-use plastic bans and waste reduction commitments from brands are shaking up the plastics value chain. Plastic waste recycling is becoming mission-critical for companies from CPGs to chemicals.

What you should do: Companies need to develop waste collection and sorting and help scale up conversion technologies like pyrolysis and chemical recycling. Look for those collecting and converting to present new competition for oil, chemicals, and materials companies in the new circular value chain.

Charles Willard

Lux Tech Signal

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

— Average
— Advanced Plastic Recycling

52
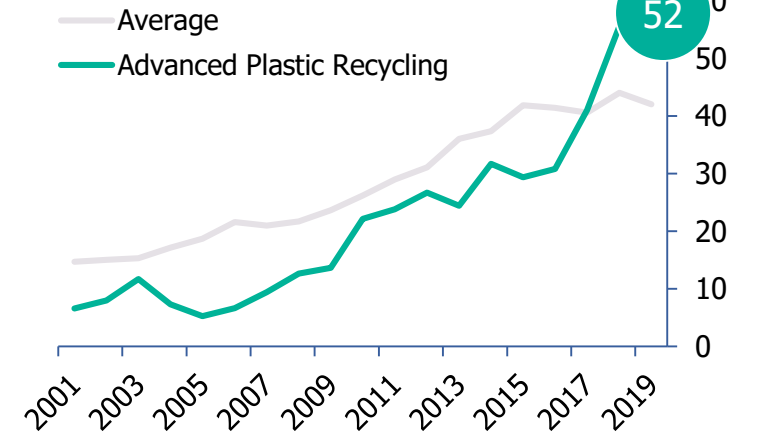
DATA HIGHLIGHTS

55%

China's taken a commanding lead in IP activity, with more than half of global patents since 2015.

DETAILS For key player analysis, full data, case studies, and more, see our **Plastic Recycling Tech Page.**

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![Lux Research logo] ADVANCED PLASTIC RECYCLING

1 PYROLYSIS
Waste to oil

PLASTIC ENERGY	nexus FUELS	PyrOil	Recycling Technologies	RES POLYFLOW
VADXX PLASTIC TO ENERGY	ReVital POLYMERS	Polymer Research Technologies Ltd.	PYROWAVE CLOSING THE LOOP	TECHNOLOGIES
RENEWLOGY	QUBE ENERGY	LEITNER		Arqlite Innovation for the planet
urjas		WasteCapital	PRI	

2 CHEMICAL RECYCLING
Waste to chemicals

Ioniqa Technologies	CARBIOS Reinvent Polymers Lifecycle	grEn	CUMAPOL POLYESTER UPGRADING	loop INDUSTRIES
QCP QUALITY CIRCULAR POLYMERS	PRT PET REFINE TECHNOLOGY Co.,Ltd.	GARBO your innovative partner		

3 MECHANICAL AND SOLVENT-BASED RECYCLING
Waste to materials

APK	cleyond	PURECYCLE TECHNOLOGIES	M	saperatec back to values
ZENROBOTICS		SADAKO TECHNOLOGIES		

DETAILS For key player analysis, full data, case studies, and more, see our **Plastic Recycling Tech Page.**

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What happened to the dropouts – the technologies that were on the 19 for 2019 but no longer appear here?

Technologies that dropped off the 2019 list aren't suddenly losers or busts – they're just not quite suitable for selection to the top 20.

Tech innovation is dynamic and rapidly changing, with many closely matched technologies vying for commercial impact. The reality is that there are dozens more transformational technologies that can be (depending on your industry and role) worth following closely. The exercise of highlighting the top 20 hardly means that others are unimportant.

Generally, technologies that dropped from the list did so in one of three ways, as laid out at right, with slightly different implications for executives planning their innovation strategies. The following slide takes a look at each.

WENT MAINSTREAM Machine learning, microbiome, cybersecurity	Some techs have become such standard practice in relevant industries that there's less value and relevance to including here
CHANGED FORM Wearable electronics, genome editing, precision medicine	Other techs are related to or form one component of bigger-picture technologies that are still included in the 20 for 20 this year
FELL – RELATIVELY AR/VR, drones, perovskite solar, generative design	These techs are still relevant and even growing in innovation interest, but are no longer growing as rapidly as those on the list

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Comparing hard innovation data versus social trends' additional signals

Most of this report focuses on "hard innovation data" sources, specifically patent grants and applications, academic papers and conference proceedings, venture capital funding, and government grants. We also include subject matter experts' reports and insights.

However, *another* potential source of innovation data is social data, which ranges from social platforms like Twitter and Facebook to search engines like Google. Many of these datasets are not publicly available due to privacy concerns and controversies like the Cambridge Analytica scandal, making social trends difficult to analyze.

Our team nonetheless was able to programmatically analyze thousands of technologies on the Google Trends platform: **On the next slides, we highlight technologies that are trending on the world's largest search engine and provide our take and additional data on these innovations.**

MILD HYBRIDS

Cars that use improved small batteries alongside conventional internal combustion engines to bump up fuel economy slightly.

LUX TAKE

Is the social signal relevant? Not for innovation purposes. Mild hybrids have been covered by Lux Research for more than a decade as an incremental step on the road to vehicle electrification. Much of the innovation has already been done. Now, carmakers are instead turning their innovation attention to full electrification – although the Google Trends data indicates that consumers may finally be coming around to interest in mild hybrids.

What you should do: Note the gap between technical innovation (green curve) and customer interest (yellow curve) – this is typical of many hard innovation problems associated with long product development times like cars.

Google Trends vs. **Lux Tech Signal**

Mild hybrids
Interest based on data from:

— Google Trends (left y-axis)
— Lux Tech Signal (right y-axis)

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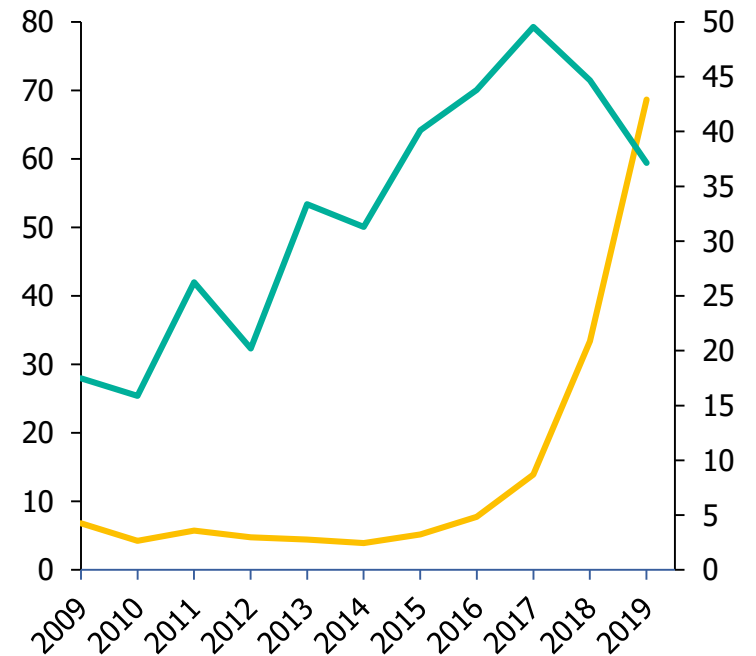
# How active should your organization be in pursuing each of these 20 transformational technologies?

For most companies, aggressively pursuing all these technologies won't make sense. But which to focus on? Each company has its own innovation approach and risk appetite, and technologies have different consequences for different industries – so there's no one-size-fits all strategy.

However, as a guide, clients can align the 20 for 20 to their industry based on two factors:

1) **Maturity** – How close the innovation is to broad adoption in their industry

2) **Impact** – Whether the results of adoption of this innovation in their industry will be marginal, major, or truly disruptive

Clearly, disruptive technologies that are near or past market launch should be a priority for everyone, but each company can evaluate how far it should go in pursuing innovations that are less mature or that will have less momentous impact. How does this look for *your* company? Contact us to see how we can help with your roadmap.

Sample alignment of some of the 20 for 20 to the automotive industry

17
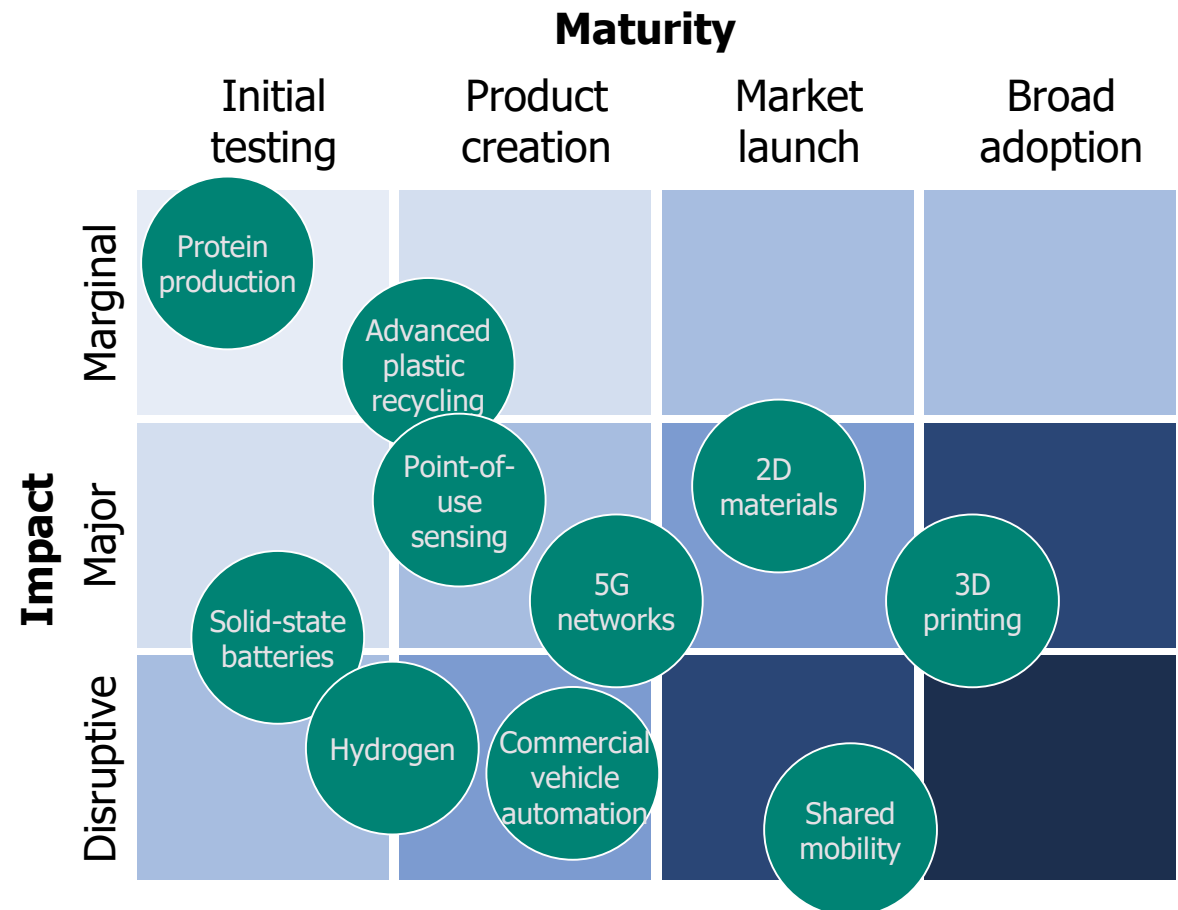
What to look for beyond the top 20 – and what to expect going forward

1 **Have data-driven as well as expert-led monitoring in place.** As the renaissance technologies show, innovation areas that seem to have fizzled can return to prominence – so it's not enough to assess an area once. Ongoing monitoring is essential, and data science approaches can be particularly useful for areas where past disappointments might bias individuals against them.

2 **Cast a wide net to catch enabling platform tech**. The next great innovation to impact your industry might come from well outside it – but if it provides a tech platform on which to build high-value applications for your company, it's vital not to miss. Most innovation organizations are fairly adept at monitoring and surface innovations from within the industry, but a wider view is critical as well.

3 **Be prepared to think imaginatively about breakthroughs.** When a new technology comes onto the scene, the impacts often aren't immediately obvious – not least because many of the initial proposed uses are foolish and doomed to fail. Maintain a realistic view of the technical limitations but don't dismiss possibilities too easily – and rely on data to help keep grounded, without getting swept up in the hype or deflected by naysayers.

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