Converging on the Future

Arthur D. Little

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The Prism Board

PRISM is published biannually by Arthur D. Little, the global management consultancy.
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Dear Reader

Convergence seems to be everywhere in the business world these days. It covers a wide range of factors which can come together to change the status quo in an industry or value chain. Think of food and healthcare in functional foods, or telecoms and energy in smart grids. Digital technology has been a huge enabler of convergence.

Nearly all our articles in this edition of Prism are linked in some way to convergence and what it might mean for the future of particular industries. Convergence poses significant threats and opportunities: threats of disruption to established markets and business models, as well as new opportunities to leapfrog the competition through innovation. The bad news is that, by definition, convergence implies the need for companies to master new capabilities, so you either have to develop them internally, or strike up partnerships with others who have them, or both.

In our lead article we shine a light on a major global industry that has an impressive, but often overlooked, history of value creation: chemicals. We show how, through embracing and harnessing the opportunities of convergence, chemicals and other asset-heavy industry players can find new growth and turbocharge their valuations.

Autonomous vehicles are a classic example of convergence between the automotive, ICT and transport domains. Major social, economic and environmental benefits are anticipated when the change to autonomous happens, but how likely is it that these benefits will be realized? The answers in our second article may be surprising.

In our third article we look at the now-common practice whereby large companies set up in-house start-up incubators as a means of

driving growth in new and converging business areas. It sounds like a good idea, but how often does it deliver the scale and speed of growth companies were expecting? We look at some newer incubation vehicles that are much more likely to be successful than the conventional model.

Our next two pieces address different aspects of convergence in the energy and transport sectors. In a future scenario of increased demand from electric vehicles and intermittent renewable energy sources, are we going to risk blackouts, as some commentators are suggesting? And how should energy companies respond to the needs of digitally empowered energy consumers in the coming years? Our experts provide some insight.

Finally, we focus on healthcare, particularly the far-reaching effects of new, one-off curative therapies replacing ongoing lifetime treatments for diseases previously thought to be chronic or untreatable.

To manage convergence, companies need to be excellent at anticipating the future, innovating beyond the core, and transforming their capabilities. This is what we help our clients with at ADL. Enjoy the issue!

Rick Eagar
Chief Editor, Prism
Arthur D. Little

Breaking the mold – Using the power of convergence to accelerate growth

Dr. Michael Kolk, Koji Uchida, Marc de Pater

Despite an impressive record of value creation and its central importance to meeting mankind's future "mega-needs", the chemicals industry is undervalued by investors, which holds back its strategic freedom to grow. Focusing on four key trends to power transformation, this article looks at how this challenge can be overcome by embracing convergence, through lessons that can also be applied to other high-capital-investment, asset-heavy industries.

The chemicals industry has been the world's most successful in terms of shareholder returns over nearly the last 20 years. However, this excellent performance is not recognized by investors, with company valuations lagging behind other, less successful, sectors. This holds back freedom to invest and take a longer-term, more strategic view. Looking forward, the chemicals industry's ability to help solve the world's mega-needs continues to position it well for the future, but to truly obtain industry-leading valuations, the chemicals industry needs to capitalize on the convergence of four independent trends – digital technology, technology transfer from one sector to another, new management approaches and new business models. As this article explains, when these trends are brought together in a holistic way, chemicals firms, as well as those in other asset-heavy industries, can attain the valuations and consequent freedom they deserve, as initial innovators already demonstrate.

The chemicals industry – What's not to like?

Unbeknownst to many, the chemicals industry has an impressive history of value creation. Even during the financial crisis, the chemicals industry outperformed other industries. (See Figure 1.) And the difference in value creation is substantial: where a $100 investment in telecoms in 2000 would have returned a meager $164 by 2018, the same investment in chemicals would have returned over $500. Clearly, being asset-heavy is no impediment to good returns; this is shown by other industries, such as oil & gas and basic resources, although perhaps to a less stellar extent.

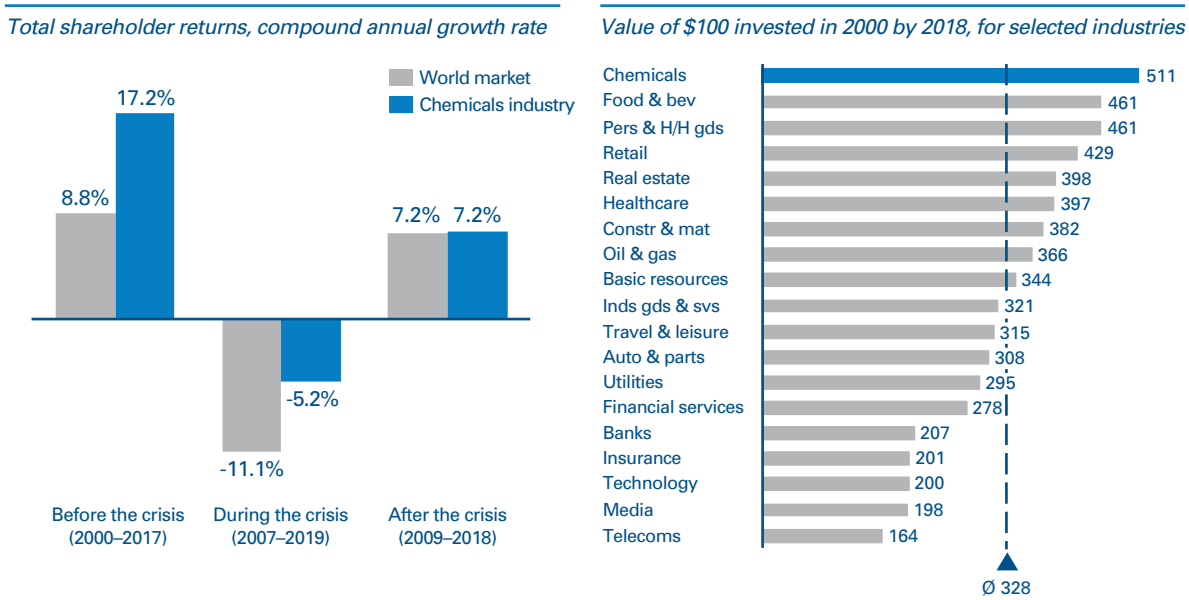

Figure 1: Chemicals industry performance 2000–2018 (mid-December data)

Note: Inds gds & svs = industrial goods & services; Constr & mat = construction & materials; Pers & H/H gds = personal & household goods

Source: Thomson Reuters, Arthur D. Little

A glance into the future alludes to even more good news for the chemicals industry. Chemicals-based solutions will play a pivotal role in solving the world's most important challenges, or "mega-needs". (See Figure 2.)

Mega-need	Megatrend	Chemicals-based solutions required	Example companies[1]
Energy & environment	Changing energy mix	■ Energy storage (battery materials) ■ Next-generation biofuels ■ Purification and scrubbing technologies	Umicore Novozymes Clariant
	Resource shortage	■ Materials recycling ■ Bio-based catalysis ■ Precision fertilization	Umicore Johnson Matthey Yara
	Climate change	■ Power-to-chemicals/hydrogen ■ CO_2 as raw material (carbon capture & use) ■ Preventing spread of infectious diseases	Nouryon[2] Covestro Sumitomo Chemical
Social & health	Demographic shift	■ Next-generation digital infrastructure materials ■ Medical applications of biomaterials ■ Medical applications of advanced materials	Air Liquide Toyobo 3M
	Urbanization & mobility	■ Light-weight performance polymers ■ Novel construction materials ■ Alternative vehicle fuels	Solvay DowDuPont Gevo
	Health & wellness	■ Personalized nutrition ■ Nutrition-based illness prevention ■ Air purification	DSM Christian Hansen BASF

Figure 2: Selected megatrends and their requirements for chemicals

1. Illustrative examples of chemicals companies active in this field
2. Formerly known as AkzoNobel Speciality Chemicals

Source: Arthur D. Little analysis

This has not escaped the notice of many chemicals companies today, whose websites and investor presentations invariably stress their commitment to these causes and associated growth potential. An industry that consistently creates value and is essential to addressing mankind's most important "pain and gain points" surely should appeal to everyone.

Investors are not impressed

A glance at its valuation suggests that the chemicals industry's strong performance and potential to solve society's future challenges do not come across to investors. While the chemicals industry outperforms all others in terms of historical shareholder returns, its perceived future potential (measured in terms of average EV/EBITDA multiple) is underwhelming (Figure 3). Although focused specialty chemicals companies tend to fare slightly better than diversified chemicals commodity businesses, overall, the industry is undervalued. It is important to note that other asset-heavy industries seem to suffer similar fates.

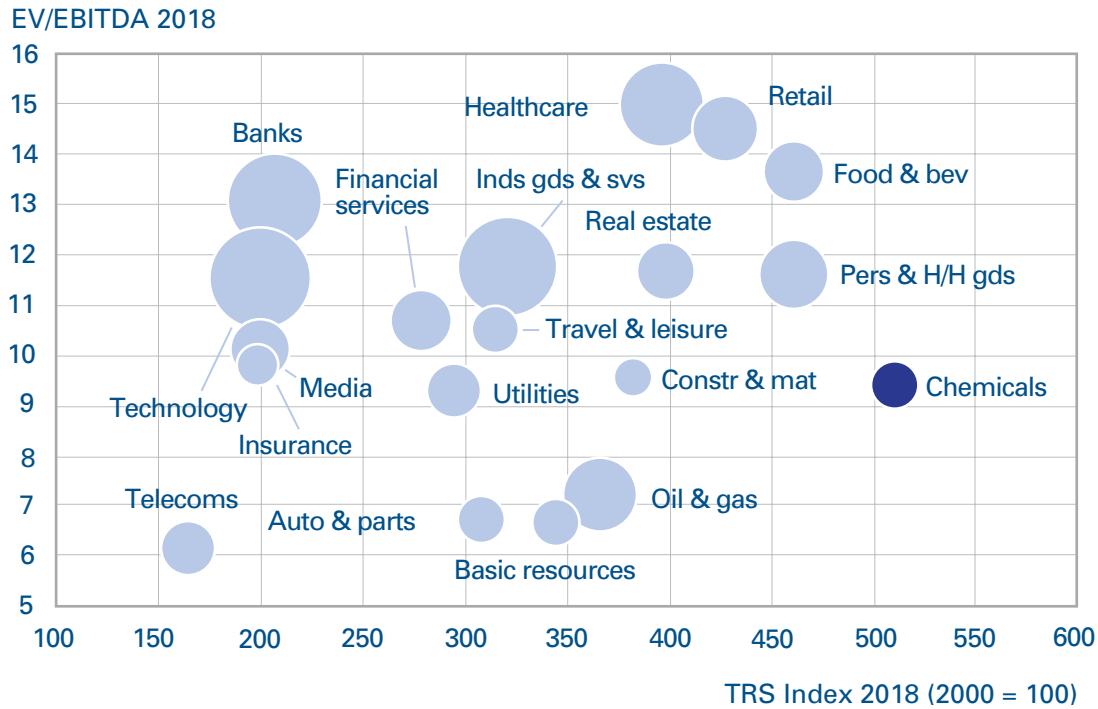

Figure 3: Industry valuations versus performance

Bubble sizes represent relative 2018 industry revenues
Source: Datastream, Arthur D. Little

This valuation matters not only financially, but also strategically. For an industry known for long product life cycles, the chemicals sector's relatively low valuation and "impatient" shareholders decrease the strategic options available to companies looking to grow. Our consulting work offers countless examples of chemicals companies underfunding or even abandoning promising initiatives because they will not "move the needle" in the short term. Furthermore, a casual observer may be forgiven for concluding that there are too many inherent challenges for chemicals firms to change this status quo anyway. Typical chemicals industry issues, such as locked-in assets, long development times, slow adoption of new technology, and low appetite for innovation, may confine the majority of chemicals companies to their current habitat as suppliers of "molecules". This leaves to others the (profit-generating) creation of ultimate "solutions" to the world's needs.

Enter convergence

To be clear: there is nothing wrong with the status quo, as Figure 1 clearly shows. While it is difficult to expand beyond "today's molecules", it is also hard to get in as an outsider. The complexity of profitably dealing with the technology, safety, and business intricacies of the chemicals industry is very hard to copy.

But remaining as they are seems unattractive to many chemicals firms for a number of reasons. Most chemicals firms aspire to do more than sustain the status quo. And for specialty chemicals firms, the risk of being sucked into "commodity hell", as one of our clients puts it, is a fate best avoided. Moreover, it would be a missed opportunity if chemicals firms were to stand by and watch as firms from other industries (Amazon, Google and the like) delivered solutions to the world's most pressing "mega-needs". There is no law of nature that states today's technology giants should be the primary beneficiaries of creating tomorrow's solutions. Instead, given the prevalence of chemicals-based solutions, we believe there is a sizable opportunity for chemicals firms.

Capturing this opportunity would require embracing convergence – the coming together of various independent developments (technological, economic, societal, etc.) to generate a tipping point in, for instance, performance levels, customer acceptance and economic feasibility. We believe the potential for convergence in the chemicals industry is often underestimated, and should receive much more attention than it gets today.

Convergence in the chemicals industry

We believe there are four important trends that enable convergence in the chemicals industry, and indeed, other high-capital-investment, asset-heavy industries.

1. **Digital technology:** Digital technology poses a threat to any company using innovation to command a premium over commodity grades – unless it gets its act together soon enough. For example, what will happen to formulators of coatings, detergents or plastics once Amazon or Google is able to instantly "calculate" the optimal recipe for any customer? The flip side is that even if chemicals companies are unlikely to dominate any particular digital technology, the value of such technologies lies in their application to the "chemicals complexities" that only chemicals firms truly master today. The rewards for such an accomplishment can be enormous; chemicals companies estimate that the success rate of breakthrough innovation projects can be tripled by implementing the right digital solutions, and over 90 percent of companies estimate that digital innovation is transformational (www.adl.com/digitalage). On top of this, digital technology further enables other important trends.

2. **Technology transfer:** We see some very interesting "molecular" technologies coming to fruition in industries adjacent to traditional chemistry. Smart materials are being explored by players such as AkzoNobel, which is looking for enhanced functionalities such as self-cleaning or self-healing surfaces and coatings. Synthetic biology, another example, holds the promise to produce industrial-equivalent products with significantly enhanced benefits in terms of production efficiency, carbon footprint, feedstock flexibility, and replacement of hazardous processes. This was, for example, why Cargill acquired OPX Biotechnologies' fermentation technology.

3. **New management approaches:** Complementary to technology advances are new approaches to managing innovation, such as start-up collaboration, ecosystem innovation and the use of (external) incubators. We see more and more companies taking a holistic view of all possible "innovation vehicles" (R&D, partnering, corporate venturing, M&A, licensing, etc.) and using whatever best fits their goals. At Arthur D. Little, we have been able to do exciting things for our clients following our Breakthrough Incubator approach – essentially a "build-operate-transfer" model applied to breakthrough innovation opportunities.

4. **New business models:** It is hard to think of true breakthroughs, at least in any recent times, which were not built on new or improved business models. And yet, in the chemicals industry, the concept of business model innovation has long been seen as something more conceptual than of strategic relevance, with the notable exception of a few players, such as Umicore. Umicore is now reaping the returns of years of perfecting its double-revenue business model of spent material recovery in catalysts and battery materials, which allows charging for waste material collection and selling of the recovered products.

Business model innovation is becoming more mainstream, with several interesting approaches being pioneered. One such example is the concept of "molecule leasing", whereby a chemicals producer retains ownership of its products while they are in use by its customers. This ensures closed-loop economics that will need to become the standard, rather than exception, in a low-carbon world. This model was pioneered in specific niche markets such as the noble metal catalyst industry, but may well become a more widespread practice driven by new or improved technologies, such as chemicals recycling, as was recently announced in initiatives by companies including BASF and SABIC.

Another business model innovation is represented by the "digital twin" concept. This has been exemplified by Dutch technology provider Celsian, which will pilot advanced simulation models later in 2019, using the input of three separate companies and defining the operational settings of a glass furnace that will produce over 3 million bottles a day. Algorithms will continuously recalculate the strategy for the next production hours, outsmarting human operators.

A final example is a first step in the direction of "asset-free" chemicals companies. Honeywell, a process automation company, recently has taken shared operational responsibility for a German manufacturing location that produces chemical and pharmaceutical raw materials. Honeywell will carry out system optimization, parts management, preventative surveillance and other tasks, way beyond just installing process automation software, which will free the plant owner to focus on other activities.

The circular economy for polymers

Circularity thinking typically focuses on the flow of molecules and energy, but tomorrow's "circular business models" will require more. For example, in addition to intelligent (post-consumer) waste separation and mechanical and chemical recycling technologies, they will certainly need new data exchange and business models, such as certification schemes and blockchain-like technologies, to keep track of carbon content throughout usage cycles. Early examples show how players can work together to optimize the flows of materials, energy, data and finance. For instance, collaborations are beginning between waste management companies (e.g., Suez, HVC), plastic (waste) processors (QCP, Enerkem), chemicals companies (SABIC, Nouryon, Lyondellbasell) and end users (IKEA). Selected investments in this area in north-western Europe alone have amounted to more than $500 million in the last two years.

As in other platform situations, the platform manager will be in the pole position to capture a high share of the value. Chemicals companies, contributing some of the key technologies to the circular economy, will be well placed to take the platform management role.

In isolation, the four trends above might not bring visible results quickly and convincingly enough for shareholders. But when deployed simultaneously in nascent industry intersections and addressing "mega-needs", they can act as powerful enablers and bring to the chemicals industry what the Internet, cheap computing power and agile software development have brought to so many others.

There are already plenty of examples of companies that have been successful in bringing the above trends together. Chr. Hansen combines megatrend alignment (health & wellness), adjacent technology transfer (enzyme engineering), and a powerful innovation machine (as evidenced by its position in the Forbes Innovation Top 100). Investors are taking note; investment analysts have told us that Chr. Hansen

is a good example of a company that has convinced the market it can deliver on its growth projections and capitalize on its technology. It is awarded an EV/EBITDA premium of around 30, comparable to Amazon. Such successes require chemicals companies to bring other industries, companies and capabilities together.

Putting convergence to work

As we have argued, the chemicals industry has a lot going for it. But there are powerful internal and external forces at work that limit chemicals firms' strategic freedom to meaningfully change the industry's course. It is tempting to see this as the inevitable fate of any maturing industry, but we believe there are two important reasons to resist this view. First, the chemicals industry's unique competencies offer a potential gateway to huge future value creation. And second, the power of convergence described above has grown to a point that it may become transformative, even if it does require taking a step back to see the full potential.

Already, most chemicals firms are working at adopting emerging technologies, and many experiment with new business models. Very few companies, however, start with sufficiently holistic reviews of what it would mean to break the mold if the key were to lie in harnessing the power of convergence of several trends, rather than in focusing on just one.

Take artificial intelligence (AI) as an example, which is likely to become an important tool for chemicals firms. Many are building experience, as well as infrastructure, in this new area of research. But AI's main value could reside in domains that are new to them, such as synthetic biology to find new synthesis routes, or behavioral psychology to promote adoption of new ways of working among developers and users of products ("digital nudging"). Again, for chemicals companies to do this successfully, they need to orchestrate other industries and expertise around their own core capabilities.

"Digital nudging" in innovation

"If HP knew what HP knows, we would be three times as profitable". This famous quote by a CEO of Hewlett-Packard is as relevant as ever, and accelerated/automated knowledge capture and learning are becoming a real differentiator to companies innovating in a converging world. Today it is not just about what your own company already knows, but your entire ecosystem. Fortunately, digital technology is coming to the rescue. Software company Dassault Systèmes, for instance, offers solutions that support product developers in optimizing new offerings using artificial neural networks which help predict how final product characteristics will be impacted by raw material properties and process conditions. Engineers are encouraged to limit product and process complexity by identifying similar parts used in any other product or system, based on 3D shape, geometrical features and semantic criteria, thanks to machine learning. And, as a final example, advanced modeling and simulation allow for real-time information and coordination, thus enabling optimization of product, process, manufacturing and conditions over the product life cycle.

Business leaders therefore need to understand how all the pieces of the puzzle fit together over time, and be prepared to make decisions surrounded by more ambiguity and uncertainty than they are used to. Notably, in terms of making convergence work in practice, we suggest there are four areas that require the attention of CEOs in the chemicals and other asset-heavy industries (Figure 4):

1. Emphasis on broad technology "literacy" across their organizations

2. Understanding of the variety of all innovation vehicles available

3. A pre-conception that new business models are an integral part of the future

4. Widely embedded digital technology

	Technology transfer	New management approaches	New business models	Digital technology
What many already do	• Perform deep dives on new technology domains close to the current core in search of direct applications	• Experiment with new approaches (e.g., "garages" and "start-up challenges")	• Make investments in downstream acquisitions and pilot digitally enabled services	• Use a variety of digital tools for specific individual innovation activities
What most don't do enough	• Secure broad and current "technology literacy" across the company's innovation ecosystem • Use this to advance big-ticket opportunities	• Learn to use all available innovation vehicles and configure the optimal mix • Manage this mix in an integrated way	• Assume any significant breakthrough needs a business model change • Build from understanding of value pools and ecosystems in the target market	• Move towards a truly digitalized, end-to-end, tailored innovation function

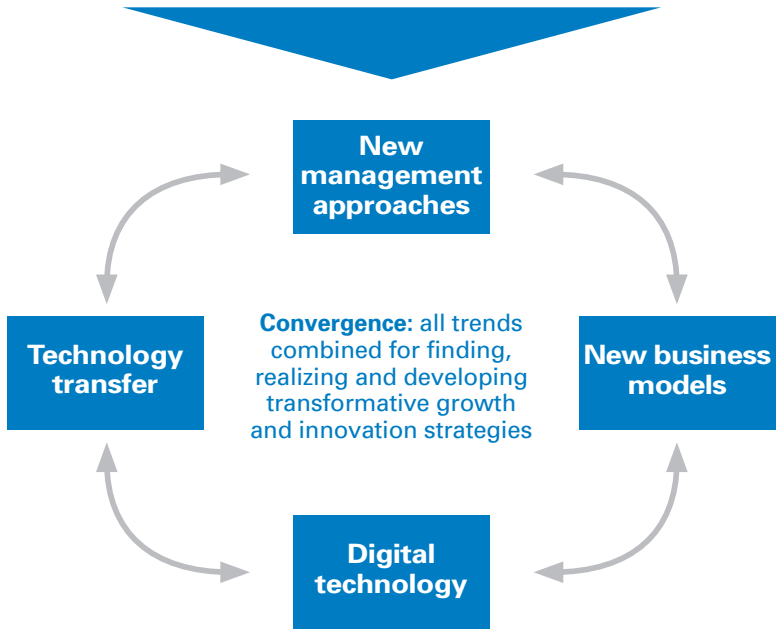

Figure 4: Summary of how to put convergence to work

Source: Arthur D. Little analysis

Bringing all this together is no easy task, and chemicals companies cannot afford to spend as lavishly on breakthrough ideas as a company such as Alphabet can on its "moonshot" programs. A chemicals CEO trying to explain how she plans to invest a billion dollars into a breakthrough innovation program, rather than a world-scale production facility, can expect some very nasty questions at her next shareholders' meeting.

Following the "golden age of chemicals" after the second world war, when one innovation seemed to follow another, access to cheaper feedstock and burgeoning end markets have been the main drivers of chemicals upswings in more recent times.

We believe innovation can once again propel the industry to new heights if it is able to capture the power of convergence: after all, it just takes creativity, the right mind-set, and financial backing to build tomorrow's winning solutions and business models. The earlier-mentioned Chr. Hansen provides a working illustration with its practice of integrating value-chain data into a digital twin and employing advanced (digital) bioinformatics tools to discover new microorganism strains.

Insight for the executive

In a world where listed company valuation is important for strategic freedom, we have shown that very successful industries such as chemicals are not always rewarded for this success; the impressive track record of the chemicals industry and its importance for solving future "mega-needs" are not expressed in shareholder appreciation.

Fully embracing the convergence of current important technology and business trends will allow chemicals companies to accelerate increases in shareholder appreciation, as is demonstrated already by early adopters of convergence. Embracing convergence will allow chemicals and similar asset-heavy industries to capture more value beyond simply selling specification products.

Our advice to chemicals, and other, industry executives who want to discover the benefits of convergence for their businesses would be to:

- Comprehensively assess options for, and impact of, digital technology in their industries and companies, across business functions.

- Investigate broad possibilities for technology transfer from other industries, either for solving existing problems in new, value-added ways, or for offering new solutions.

- Build deep organizational understanding of available innovation vehicles in their industries and for their companies.

- Actively seek out, and rapidly experiment with, new business models.

These four initiatives should be undertaken collectively and not in isolation. CEOs furthermore need to ensure their organizations are streamlined to take on this exciting challenge, and to ready their ways of working and their people for the future. An "ambidextrous" approach to their organizations might be helpful in this respect. (See Prism 2018, issue 1.)

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The march of the robo-taxis

Radical disruption or gridlock?

Dr. Klaus Schmitz, Wolf-Dieter Hoppe, Alexios Seibt, Dietrich von Trotha

Traffic congestion has a major impact on air quality, health and productivity in cities across the globe. Zero-emission vehicles, autonomous driving and new mobility models are billed as providing solutions to this problem, but will they work in practice? Drawing on a unique combination of real-world modeling, consumer research and trend analysis, this article outlines the impact of these developments on drivers, car manufacturers, regulators and public transportation providers.

Traffic congestion is a severe problem in major cities around the world, increasing pollution and adversely impacting health and overall quality of life. The drive for zero-emission vehicles, the rise of autonomous cars, and new mobility models promise to improve air quality and potentially reduce congestion. Autonomous, zero-emission robo-taxis ferrying passengers around the city seem, at first sight, to offer an attractive solution to the problem. But will they work?

Based on detailed consumer research, modeling and analysis, this article provides some surprising conclusions, and sets out the stark implications for regulators, transport providers and automotive manufacturers.

Dealing with congestion and pollution

Cities worldwide are heavily affected by traffic congestion. Time spent sitting in jams varies from over 200 hours per year in the worst-affected locations, such as Mexico City, Rome and Beijing, to around 150 hours in medium-affected cities such as Berlin. Individual journeys in peak hours in heavily affected cities take over twice as long as they should due to congestion.

As congestion affects citizens' quality of life and creates sustainability issues, regulators have developed a large amount of tools to limit car use, which range from congestion tolls and expensive or limited parking to licensing smaller amounts of number plates. This means people are, to a certain degree, already moving away from car ownership and usage in cities, which is heavily impacting the business models of players along the mobility value chain, from vehicle manufacturers to mobility and public transportation providers. Currently, three trends are accelerating transformative change

in automotive: zero-emission vehicles, autonomous driving and new mobility models. Autonomous, zero-emission robo-taxis embody all three of these trends, offering the potential for convenient, personalized transport as an attractive alternative to owning a car or using public transport. However, understanding the impact that robo-taxis would have is not straightforward. Our analysis has looked at three questions:

- What would be the impact of robo-taxis on traffic volumes and congestion?
- What would be the likely consumer demand for robo-taxis?
- What are the implications for automotive companies, regulators and public transport providers?

Robo-taxis will increase congestion unless there are accompanying radical changes in regulation

For regulators needing to pursue the right policies for future urban mobility, vehicles in general currently generate three issues: congestion, pollution and safety, in particular the risk of injury to drivers and pedestrians. While the rise of autonomous, zero-emission vehicles reduces or minimizes the last two of these, it brings other challenges around congestion. Robo-taxis are likely to increase the number of journeys, due to not only their convenience (e.g., no parking problems, no need for a driving license, the ability to drink), but also the empty collecting trips, which would, in theory, more than double the number of journeys altogether. Considering that the capacity of streets themselves is likely to remain unchanged, such a traffic increase would be unfeasible in most cities of the world.

However, robo-taxis also provide an opportunity to significantly increase traffic capacity by reducing safe stopping distances between cars. As robots can react almost instantly, it is reasonable to reduce the enforced safe distance while still expecting higher safety levels.

So what would be the likely overall net impact on capacity and congestion? To explore this question, we developed an in-depth mathematical model to simulate the capacity impact of autonomous cars, based on a representative typical real-life intersection located in Frankfurt. While further research is still necessary, the model does provide meaningful guidance on the magnitude of the impact of autonomous vehicles on a macro scale. The research looked at the traffic capacity in multiple scenarios, based on two factors:

- The percentage of autonomous and human-driven vehicles involved (i.e., 100 percent autonomous versus 50/50 autonomous and human).
- Adaption of traffic rules to maximize capacity for autonomous vehicles (i.e., no adaptation, little adaptation or radical adaptation).

The overall results are summarized in Figure 1 below.

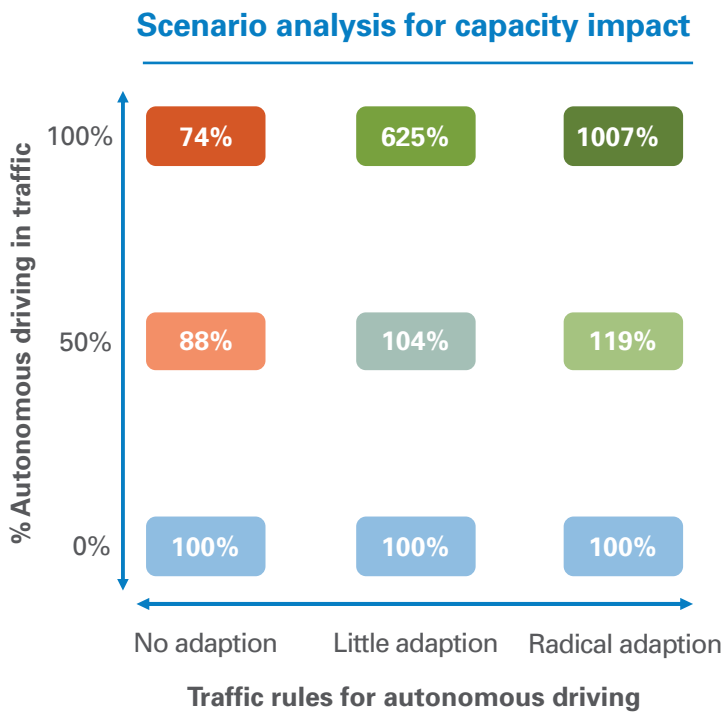

Figure 1: Capacity impact of autonomous driving

As may be seen from Figure 1, the key finding from the simulation was that with 100 percent autonomous driving, along with radical adaptation of traffic rules to suit autonomous driving, capacity would increase by a factor of 10 in most situations compared to today. If we then add in further safety margins, we still arrive at a capacity increase of at least a factor of five.

By contrast, with 100 percent autonomous driving and no rule adaptation, capacity would actually shrink by around 25 percent due to today's rules around safe stopping distances, which are based on human behaviors. Modest adaptation would also increase capacity, but not by as much.

However, in mixed traffic, in which autonomous vehicles and human drivers would share the road, and with current traffic rules, traffic capacity would also decrease. On average, humans tend to drive above the speed limit and maintain safety gaps that are too short. As autonomous vehicles automatically obey the law, this noticeably slows down traffic flow in our dynamic simulation – essentially, they are "bullied" by human drivers. In mixed traffic, traffic rule adaptation would only provide a slight increase in capacity.

In summary, the only way to effectively address street capacity problems with autonomous vehicles is to switch to 100 percent autonomous driving and reduce safety distances between cars. Our findings imply that getting rid of congestion and allowing for the convenience of robo-taxis would therefore be primarily a matter of political and regulatory choice. It would require deep understanding of the mobility profile of the city, existing vehicle density, geography, and traffic systems. Policy decisions would be tough to make. Effectively, the price for getting rid of congestion and enjoying the other benefits of robo-taxis would be to render public transport more unattractive and radically forbid human-driven vehicles, at least in peak time or on peak roads. This would impact the ownership rights and behavior of millions of people.

Our calculations show that new robo-taxi models might be cheaper than existing public transport, even if the latter is subsidized. Cities and societies would therefore need to make some difficult choices:

- If robo-taxi fleets would be clean, nearly error free and probably traffic-jam free, aren't they an ideal mobility solution to replace both public transport and regular cars?

- Is a city willing to exploit this potential by embracing the disruption to norms that it would bring?

- If a city is not willing, how would this impact competitiveness in comparison with those that would opt for this type of mobility and accept its consequences?

Robo-taxis have the potential to attract high demand

While the traffic congestion analysis above assumes that there will ultimately be substitution of conventional vehicles by autonomous vehicles, it is important also to understand whether consumers will actually want to travel in autonomous robo-taxis. In 2018, Arthur D. Little conducted a worldwide consumer survey in 13 countries around automotive megatrends, and this unique data set provides a valuable indication of the likely demand. Among the key findings from the survey, we found that:

- Consumers without cars would be likely to use autonomous vehicle-based mobility services to replace journeys by both conventional car and public transport. Nearly half (45 percent) of people without regular access to cars stated they would use robo-taxis instead of public transport, with 25 percent stating they would use them instead of conventional taxis.

- However, for car owners to switch to robo-taxis, they would need to be convinced that robo-taxis would at least match the experience in the key areas of independence, comfort and convenience, which were the top three reasons consumers gave in our survey for owning a car (rated as fairly important or above by 90 percent, 88 percent and 85 percent of consumers, respectively).

Essentially, as soon as robo-taxis are perceived as being more convenient than cars – which they certainly have the potential to be – then the demand for car-based mobility will actually increase.

Robo-taxis will also be a game changer in that they will significantly increase the demand for car sharing. Today's car-sharing usage remains niche, with nearly 70 percent of consumers never car sharing, and only 12 percent more than 10 times a month. This lack of appetite can be explained by the need for journeys to be plannable and reliable, especially journeys to and from work, which account for, on average, half of all car journeys. Robo-taxis could return by themselves from city centers to pick up other commuters during the same rush hour, in the same way public transport does today. However, as well as autonomous driving advances, this will require investment in intelligent-demand fleet management, including dispatching, advanced e-hailing and active demand steering (such as through pricing, as Uber does today), if it is to move car sharing from a niche to the mainstream.

Insight for the executive: What are the implications for automotive companies, regulators and public transport providers?

Automotive manufacturers: Overall vehicle sales impact will be limited, but manufacturers will need a balanced investment approach across new mobility.

A critical question for automotive manufacturers is how the advent of robo-taxis will affect vehicle sales. Using our survey data, we defined a macro model of the traffic of the city of

Vienna based on statistical data, and scaled this to cover the major cities of the world. The impact on global vehicle sales of the advent of autonomous vehicles depends, to a large extent, on how progressive cities will be in their future mobility policies and regulation. For example:

- The proportion of the world's major cities that will impose 100 percent adoption of mobility on demand (MOD) to replace private cars (by MOD, we mean autonomous vehicles, shared vehicles and public transport).

- Whether regulation will favor autonomous vehicles or conventional public transport.

The results of our simulation are shown in Figure 2 below.

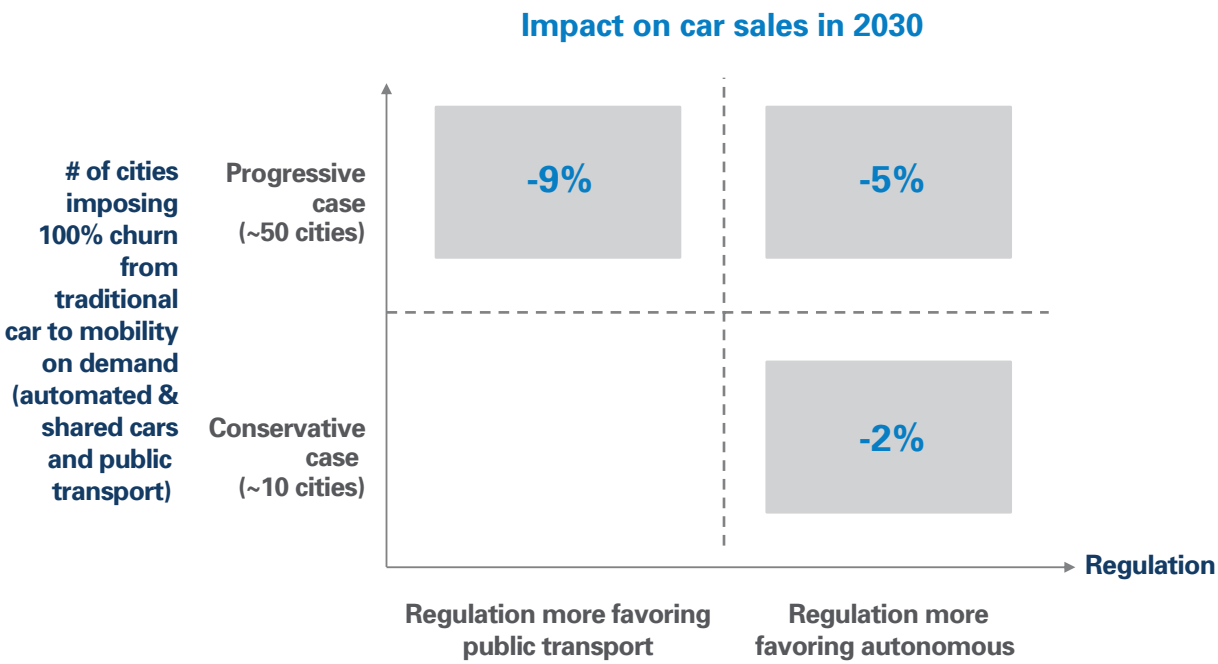

Figure 2: Impact on vehicle sales

Even in the most progressive scenario in our model, in which a high number of cities impose 100 percent MOD, the predicted global sales drop would be only 5 percent if robo-taxis were encouraged by vehicle-friendly regulation, and 9 percent in the case of unfriendly regulation. These limited reductions in volume would likely be compensated for, in any case, by additional growth in the overall automotive market; hence, it is reasonable to conclude that the impact of robo-taxis on overall vehicle sales would be limited.

One of the big challenges facing automotive manufacturers would be how to balance investment between zero-emission vehicles, autonomous driving and new mobility models. Given the scale of the figures involved, and the time and energy required for each of these transformations, which should they focus on most? Could they safely deprioritize one or more of these trends and still benefit?

The most disruptive effect of progressive robo-taxi adoption on automotive companies would be around the shift in buying power from consumers to fleet operators. Today, most car manufacturers sell directly to millions of individual consumers, along with a small number of larger fleet operators, many of which are not in the mobility business. The switch to larger robo-taxi fleets would mean huge buying power would shift to fleet operators, which would also control the customer interface with the end-user/robo-taxi passenger. These operators could be either private sector organizations or existing public transportation players.

This means investment in new mobility models (such as running their own autonomous/car-sharing fleets) would be a requirement for car manufacturers if they were to remain relevant and a key part of the automotive value chain moving forward.

However, our analysis shows that the three investment requirements for car manufacturers – new powertrains, autonomous driving and new mobility – are inextricably linked. New mobility models can only be successful when

clean and autonomous driving is fully in place. That means any upfront investments in new mobility models alone are doomed to failure. An alternative strategy would be to let others make the upfront investments, concentrate on the race for autonomous driving, and then disrupt the mobility market. However, neglecting one part of these requirements risks future revenues, or in the case of new mobility models, the interface with the end user, too. Our top-line advice for car manufacturers is therefore to aim to convince regulators of the sustainability of clean, autonomous and shared vehicles in order to drive vehicle-friendly regulation.

Regulators: With the advent of robo-taxis, regulators need to be prepared to make radical and unpopular decisions to reduce congestion.

As we have seen above, investments in autonomous and new mobility rely heavily on regulatory decisions. If regulation does not adapt driving rules radically in favor of autonomous vehicles and forbid human-driven cars at least at peak times, increasing congestion will lead to an overall decrease in car use. In this scenario, investments in autonomous and new mobility would actually lead to a shrinking market, which would make them counterproductive. Strategically, car manufacturers may be forced to invest anyway, because others, especially disruptors from outside, are doing so. Regulators need to be prepared to make potentially radical and unpopular decisions if they are to reduce congestion and pollution. Do they favor autonomous vehicles over private, human-driven cars? How would they integrate robo-taxis with existing public transport? How would their cities' competitiveness and quality of life be best served?
In any case, the different mobility offerings, ranging from cars to all forms of public transport, need to be integrated and balanced in line with the specific profile of each city. This encompasses sensible regulation, demand balancing, integrated digital journey services, and alignment of schedules.

Public transport operators: Need to engage in careful forward planning with an integrated overall approach.

As shown above, in the case of autonomous vehicle-friendly regulation, public transport operators face losing significant numbers of customers to potentially cheaper and very convenient robo-taxis. Given that they are making long-term decisions today regarding infrastructure and fleet investment, they need to factor this into their thinking now. They need to understand how to counter this threat moving forward. For example, should they decide to run their own fleets of robo-taxis? Automotive OEMs and other vehicle-based mobility providers need to take an active part in this integration. Only if their offerings fit into the overall solution will they find acceptance.

To conclude, what is clear is that autonomous vehicles offer major potential benefits to citizens, but also pose significant challenges. The traditional roles of automotive manufacturers, regulators and transport operators are already starting to be disrupted. It will be interesting to see which cities are bold enough to lead the way.

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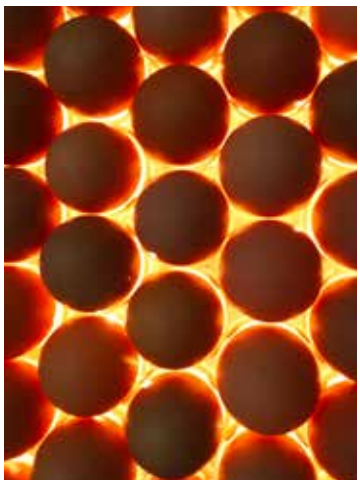
The next generation of corporate incubators

New incubator models to deliver breakthrough growth

Rick Eagar, Phil Webster, Petter Kilefors, Ingrid af Sandeberg

While large organizations have enthusiastically embraced the creation of in-house corporate incubators to identify and support breakthrough growth opportunities with start-ups, the results have been disappointing for many. This article argues that to overcome these challenges and successfully scale up new opportunities, corporates have to embrace next-generation models.

Until recently, start-up incubators were all the rage across large corporates looking for non-core growth through new business creation. Similarly, start-ups saw huge opportunities for access to markets and the potential to scale up.



However, outside digital-native sectors, few corporates have managed to generate the sort of large-scale growth from start-ups that they were hoping for. So, what's the future for corporate incubators? In this article we explore the next generation of incubators, which some companies are already using to drive non-core growth in more systematic and reliable ways.

The trouble with corporate incubators

Over the last five to 10 years, corporates have fully bought in to the idea that growth is driven by newcomers, and this has led to a huge increase in transactions with start-ups. For example, in the US food and beverage industry, the multiple for deals valued at more than $1 billion jumped from 13 to 20 times EBITDA from 2016 to 2017. A recent Arthur D. Little/MatchMaker Ventures (ADL/MMV) survey[1] into corporate/start-up collaboration, which involved more than 300 companies across different industry sectors, found that 98 percent of corporates worked with start-ups in some form.

1. Source: "The age of collaboration II": Joint ADL/MMV survey of corporate/start-up collaboration suggests 98 percent of corporates collaborate with start-ups (to be published in full in June/July 2019)

Many corporates have set up in-house incubators and accelerators as their primary means of start-up collaboration – vehicles to help develop start-ups during their early months or years. These provide facilities, advice, training, funding, and sometimes market access, to help them scale. There was a steep increase in corporate-funded start-up incubators and accelerators up to 2016, with some 70 active programs listed in the corporate-accelerators.net database, although it is likely that the actual number of programs was well in excess of this.

However, of those 70 programs listed in 2016, by 2019 nearly half have closed down, either completely or to be replaced with a different type of vehicle[2]. While some of this is due to an oversupply of incubators and accelerators relative to the number of start-ups, a major factor is dissatisfaction with progress. The ADL/MMV survey found that only 31 percent of corporates considered their collaboration activities successful[3]. Many companies, such as Qantas, Intel, Qualcomm and Citrix, to name a few, have abandoned or downsized their accelerator programs, or else shifted to third-party managed accelerators[4].

So what are the main causes of failure? The most-often-quoted reasons are:

- **Lack of major impact on growth:** While incubators do generate new proofs of concept, often these don't make it past scale-up. And for those that do, the scale of the new business is often one or two orders of magnitude smaller than the core business, especially for established global corporates. For example, a new $100 million business in a peripheral market hardly even registers on the scale for a $20 billion revenue company, however innovative it may be.

- **Misaligned or unclear objectives:** Some corporates launch start-up vehicles without any clear strategic rationale because they see their competitors doing it. Sometimes there is lack of full top management endorsement. Start-ups, too, usually have very specific ambitions and motivations, and are highly invested into specific ideas and concepts. If their aims are unclear or misaligned, or if top management is not supportive, it's unlikely the collaboration will deliver success.

2. Source: Arthur D. Little research
3. "The age of collaboration II": Joint ADL/MMV survey of corporate/start-up collaboration, to be published in full in June/July 2019
4. Nesta/Mind the Bridge, 2018. The status of open innovation in Europe: Corporate start-up collaboration. Report to start-up Europe, pp18

- **Long times required to scale up:** Start-ups often need four or five years to achieve scale, which is typically too long for corporate management teams backed by impatient shareholders – many corporates cancel their programs prematurely, after, say, two years.

- **Inadequate resourcing:** Working with start-ups requires focused management effort and funding, not just to scout, screen and validate potential start-ups, but also to engage and integrate them, as well as to nurture the relationship throughout its life cycle. This is particularly key at the scale-up and commercialization stages, when start-ups themselves often lack the right capabilities and experience. In this respect, corporates are much less able to provide the sort of support that a venture capitalist could offer. A recent Nesta survey found that 33 percent of corporates in Europe identified lack of internal resources as a major barrier.

- **Lack of a systematic approach:** Often companies set up internal organizations for growing new businesses, and call them "new business groups", "special projects groups" or similar. However, frequently these organizations are run as collections of unconnected emerging new-business projects, with little or no systematic approaches to ensure early de-risking and fast-enough "speed to scale".

- **Cultural mismatch:** There are many dimensions in which culture mismatches are possible: for example, start-ups are relatively high-risk investments which are prone to failure, while corporates are naturally more process-oriented and risk-averse. Corporate innovation staff may see start-ups as a threat to their existence, while start-ups may see corporates as a threat to their autonomy, diluting their equity. In the Nesta survey, 53 percent of respondents cited cultures of risk aversion as barriers[5].

5. Nesta/Mind the Bridge, 2019. Open Innovation Outlook 2019: Macro-trends in 2019 for corporate-start-up engagement

- **Lack of a home:** One of the biggest barriers of all is the lack of a home for the new business once it's created, in particular, a pathway for results to be scaled up, implemented and absorbed into the business. Existing brands can be all powerful and dilute or reject new products if they do not fit, or if they are perceived as risks that could cannibalize existing business.

Bring on the next generation

So with all these challenges, is there still a future for the corporate incubator model? The answer is emphatically yes – provided that companies are willing to consider some new approaches to designing and operating the incubator to overcome the challenges. It is also essential that the incubator itself is one part of a broader innovation effort with a diverse and balanced innovation portfolio.

The starting point is to design the incubation vehicle specifically with the intention of delivering major new, scaled-up, de-risked, transformational growth. This is in contrast to the old model, in which the incubator concept relied on running a number of experiments in peripheral business areas, in the hope that one or more proofs of concept might lead ultimately to a viable business.

We have seen companies succeed in this new approach using five steps, as illustrated in Figure 1.

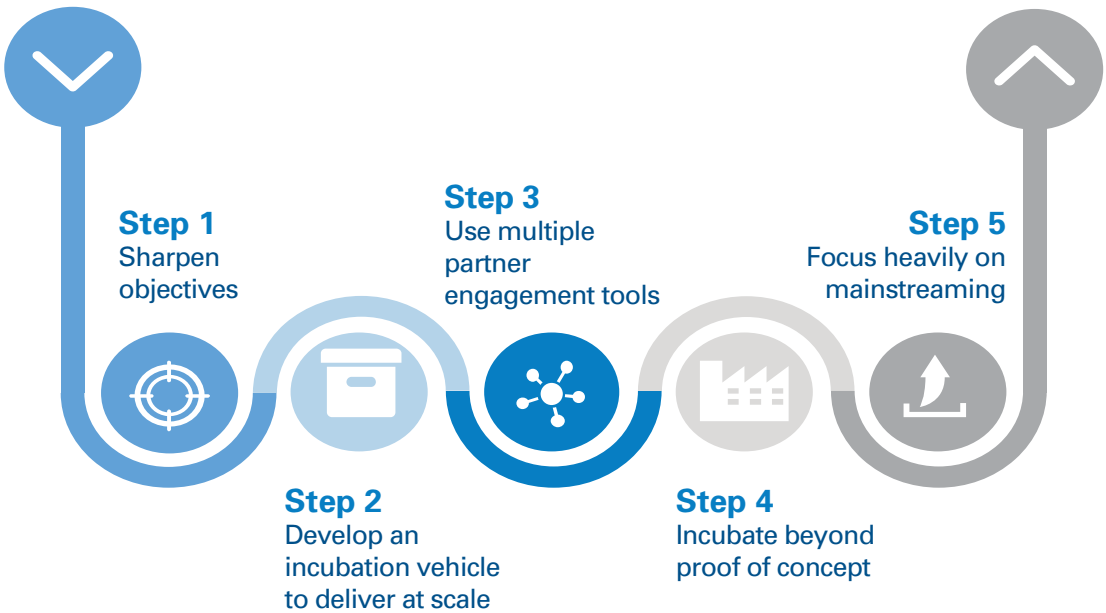


Figure 1: The next-generation corporate incubator: Five steps to success
Source: Arthur D. Little

1. Sharpen objectives: Often, companies looking at non-core or longer-term growth only go as far as defining some broad technology/application domains or themes to guide their innovation efforts. An example could be "artificial intelligence in the supply chain", or perhaps "mobility-as-a-service". Such broad domains are often of little help in prioritizing investment or selecting the right external innovation partners. Companies that are more successful in delivering significant new growth spend much more effort on defining inspiring visions supported by razor-sharp objectives: what are the future unmet customer needs, what challenges need to be overcome to meet them, and precisely how could these be articulated in terms of practical innovation programs?

These discussions are the vital first step in laying the groundwork for mainstreaming of a future new business. Importantly, these objectives should be precise in terms of scope and challenges, but not limiting in terms of possible technological solutions or numbers of experiments that could be undertaken. Once agreed, the objectives should be supported by top management, and championed by those within the organization who will be responsible for implementing the results. They should be managed via an appropriate governance mechanism, which should be cross-functional, rather than just within R&D. Metrics should be tailored to reflect progress with respect to objectives (e.g., number of challenges overcome), not just revenue and profit, which may not be achieved until further down the line.

2. Adopt an incubation vehicle designed to deliver at scale: Some companies are now setting up purpose-built vehicles to incubate and deliver new, scaled-up and de-risked businesses in non-core areas, instead of (or in addition to) conventional start-up incubators. These may be either run from within the corporation or wholly externalized, but whichever route is adopted, these vehicles need to be given strong independence and autonomy from the mainstream corporation. They need to fully leverage the external partner ecosystem, including specialist service providers and established businesses, as well as start-ups (Figure 2).

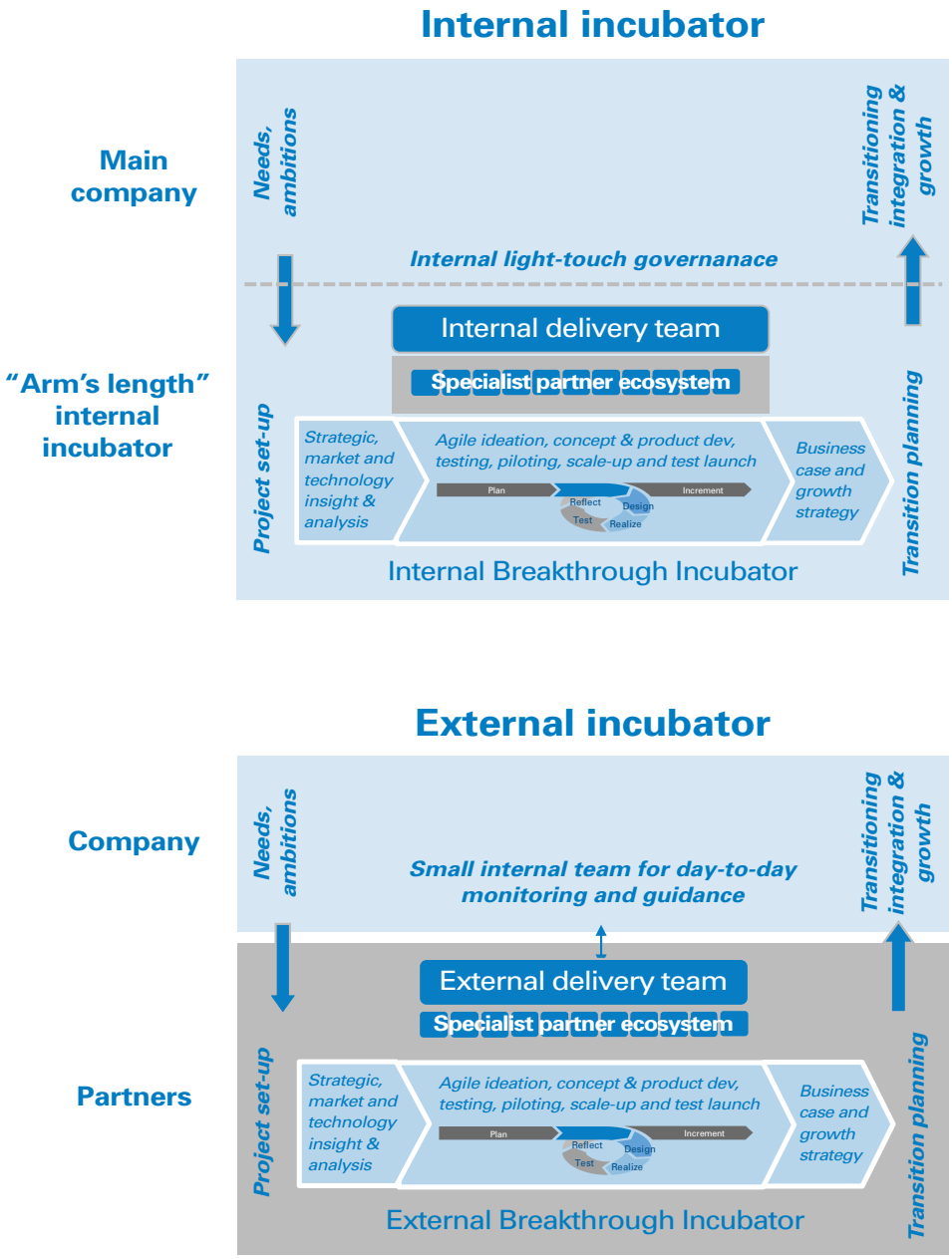


Figure 2: Next-generation corporate incubation vehicles – Internal and external models

These vehicles are distinct from conventional incubators in several key ways:

- They are designed to run a full, end-to-end process from ambition though to launch and scale-up of a new product/service line or complete business.

- They use a single lead delivery team to take full responsibility for achieving the goals, managing the process with a dedicated team, and leveraging input from multiple external partners, which include not only start-ups, but also established firms.

- They adopt an agile approach to new product/service development, integrating technical, commercial, operational and strategic inputs simultaneously, testing early and using more than one solution route. This enables much faster speed to launch, typically one to two years rather than the three to four years needed for a start-up.

They can be run either internally or externally:

- The **internal** model, in which the incubator is managed by an in-house corporate team, means the company maintains close control. However, if the incubator is not fully isolated from normal corporate influences and pressures, constraints and obstacles may slow the process down and stifle true breakthroughs.

- The **external** model[6], which we at Arthur D. Little refer to as the "Breakthrough Incubator", is similar in its end-to-end approach, except that incubator management is fully externalized to an independent lead delivery partner. This model offers great advantages, including maintaining arm's length operations from existing brands to avoid distortion and premature death, maintaining anonymity in the marketplace for first-mover advantage, and improved speed and agility. However, in this model, additional effort is needed to effectively transition the new business back into the company and capture all the learnings. (See step 5, below.) This model was used recently by a large food & beverage company to create major new platforms and product lines in a new market whitespace. (See case study 1.)

6. Refer to Prism S1 2018 "The Breakthrough Incubator – How to create and rapidly launch new step-out businesses"

3. Use multiple partner engagement tools in an integrated way: Many companies already use a variety of innovation tools and vehicles, including start-up incubators and accelerators, corporate venturing, intrapreneur programs and internal R&D teams. However, often these are managed as separate vehicles focusing on different projects and challenges. Companies that are most successful in creating new businesses of scale tend to apply multiple tools and vehicles to address the same challenge in an interconnected way, orchestrating a collaboration culture throughout the organization. For example, a major European utility has found that interconnecting different tools is critical to success for breakthrough innovation: its corporate venturing team identified start-ups in advanced mobility, which were then passed on to the company's equivalent of a Breakthrough Incubator, which also took ideas from the internal R&D teams for the partnership to work on. This helps to ensure that results from a venturing program ultimately give rise to a new business area and ensures engagement with some internal intrapreneurs as part of the process.

4. Go beyond proof of concept (PoC) before integrating into the business: Many great opportunities die at the PoC stage. It is at this "downstream" end of the innovation cycle that most of the barriers lie. Because the new vehicle takes new business opportunities beyond PoC through into testing and scale-up before integrating them into the mainstream business, there is a much higher chance of success. For example, when Orange Spain wanted to create a new disruptive, cloud-only enterprise telecoms operator (called X by Orange, see case study 2), it used an external Breakthrough Incubator model not just to design a prototype for the new business, but also to operationalize and de-risk it before ultimately mainstreaming it – essentially a "build/operate/transfer" approach.

5. Focus heavily on the mainstreaming phase: Regardless of whether an internal or external incubator approach is followed, there is always a point at which the new business has to be either integrated into mainstream operations or killed off. As mentioned above, this phase is one of the most difficult, and because of this, many companies still fail to manage it effectively. A common approach is simply to make one of the existing business units responsible for the new

business, which can often lead to problems of "dilution": watering down the products/services of the new business so they fit more easily into existing operations and/or brands. This can be hugely value-destructive for a new venture.

A much better approach is to spend time to *structure and implement a comprehensive transitioning* or *mainstreaming process*, in order to ensure that the right structure and governance are in place for the new business, and that all the key interfacing functions (such as supply, operations, marketing, commercial and finance) are engaged to support it. It is also key to ensure that valuable lessons in terms of approach and culture are captured and transferred. In the example in case study 1, a food and beverage company spent over six months with some 50 separate touchpoint events to mainstream and transition a newly incubated and de-risked business with a multi-category range of new products, which had been developed and test-launched externally by its incubator function.

Importantly, this needs to be a two-way process, in which the business learns about the new venture and the incubated business adjusts to fit corporate requirements, though it is essential to ensure that the incubator function is sufficiently empowered so the results of incubation are not ignored or diluted. In addition, the handover process can be a valuable way to learn how to adjust the incubation approach in the future, as corporate incubators themselves are experiments to be refined and built on. Mainstreaming is important irrespective of whether the incubator is internally or externally managed.

Case study 1: Breakthrough – end-to-end product innovation for a global food and drink company

A leading food and beverage company set out to target new segments of the consumer population by developing innovative products tailored to their specific needs. It wanted the initiative to be consumer-needs led, scientifically and quantitatively driven, and independent of its existing portfolio of businesses and brands. While the initiative aimed at developing and launching new products and platforms, it was also focused on learning and bringing the organization up to speed on the targeted segments, as they were deemed important future growth drivers.

With the help of Arthur D. Little, the company created an external Breakthrough Incubator outside of its organization with the charter to ideate, create, develop, test, and launch new products that fulfilled the strategic objectives. As the project orchestrator, ADL created and implemented an agile approach using an ecosystem of collaborators that met the needs of every step of the project. ADL also coordinated with the client team on a regular basis to ensure input and buy-in to critical decisions and milestones. In just over two years the incubator delivered three new brands, developed 21 concepts and prototypes quantitatively tested with 4,000 consumers, launched six new product lines, and created 12 strategic platforms and an innovation pipeline with 170 concepts. Collectively, the outputs have multi-billion-dollar sales potential.

A key aspect was transitioning the new business back into the parent business, which took place as part of a comprehensive programme over six months, with more than 50 separate touchpoint events. The insight and learnings about the segments' emotional and functional needs will also form the basis for the development of strategic platforms, around which the company will transform the business to focus on key growth segments of the future.

Case study 2: X by Orange – Developing and launching a new, non-core business using the Breakthrough Incubator model

Orange, one of the largest operators of mobile and Internet services in Europe and Africa, wished to build a new type of cloud-native operator for the enterprise market that would become the blueprint for the future Orange digital offering and operating model. To ensure rapid delivery and maximize innovation without the normal constraints of the corporation, Orange Spain, the sponsor of the project, created an independent external incubator, managed by Arthur D. Little as lead delivery partner, to take the project from conception through to launch and operations. The project was started in June 2017.

The project was conceived from day 1 as a "step-out" approach – a fully owned subsidiary of Orange Spain was created, with ample freedom to hire and contract without the constraints of the corporation. Strategic goals, concepts, scoping and a project plan were developed over six weeks. The business was successfully designed and delivered using

agile approaches within 15 months up to public pre-launch, and a further operational and continuous development phase of 18 months is now in progress. The project resulted in a disruptive, fully digital operator, meeting very aggressive targets on schedule and attracting top-class external talent. It created a new capability to allow Orange to significantly grow its business in its current markets and develop new markets with new business models.

Key to success was the seamless orchestration of the core team with around 100 ecosystem partners, which was coordinated by a small team of three from Orange, five from Arthur D. Little, and 10 associates. Technical, commercial, marketing and operational capabilities were integrated from the beginning of the development and delivery phase.

Insight for the executive

Working with start-ups is seen today as an essential part of any corporate innovation effort, and it is a trend that is here to stay, as companies need to find new growth in mature markets and defend against disruptions. But as experience in working with start-up incubators grows, companies are increasingly looking at new vehicles to create businesses of scale, not just incremental opportunities which are orders of magnitude smaller than the core business. The conventional corporate incubator model is not able to deliver against these requirements.

Companies therefore need to look to next-generation models for start-up incubation. These move away from running a number of experiments in peripheral business areas, towards scaling up and de-risking new businesses. Companies need to sharpen objectives, trust lead teams to deliver against them, release the teams from corporate shackles, and work in an agile way, simultaneously integrating technical, commercial, operational and strategic inputs to ensure de-risked and scaled-up new businesses. Finally, they need to take comprehensive measures to transition their new businesses back into the mainstream, which will enable true transformation.

Continuing to rely on striking it lucky with the right start-up to achieve breakthroughs is not enough. Companies that are able to master these next-generation incubator approaches are likely to be the ones that achieve major growth in new business areas in today’s challenging environment.

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Demystifying the charging challenge

A driver for convergence and new business opportunities

Alexander Krug, Andreas Schulze, Kai Karolin Hüppe, Johannes Herr

The combination of a growing need for electric vehicle charging and an energy industry increasingly reliant on renewable generation has led to many prophesizing power cuts and blackouts as current infrastructure struggles to cope. However, this charging challenge will instead open up new opportunities for the energy and automotive industries as the two converge. We explore how this will transform both sectors.

There is a widely held view that the combination of rising energy demand from electric vehicles (EVs) and the shift to fluctuating renewable power generation will lead to inevitable blackouts and power cuts. However, given the rapidly developing technologies and emerging business models in energy and mobility provision, how likely is this to happen in practice? In this article we provide an optimistic view of the future, in which we see the charging challenge as more of an opportunity than a threat for those mobility and energy players that can best exploit the new business prospects offered by the convergence of these two domains.

The charging challenge: Will EVs and renewables put energy grids under pressure?

In recent years, zero-emission transport and renewable energy have left their niches and become mainstream market drivers.

In 2017, we passed the first remarkable milestone in the EV market, when global EV sales passed the 1 million mark[1]. Since then the EV market has been gaining further momentum, driven by greater consumer acceptance, greater availability of infrastructure and favorable regulatory change. Countries across the world have set deadlines for ending sales of petroleum- and diesel-engine vehicles – for example, Norway in 2025, Sweden in 2030, and the UK, China and France in 2040. Consequently, automotive manufacturers have been focusing on a zero-emission future, boldly shifting investments towards vehicle electrification. Volkswagen Group, the world's largest automobile maker in terms of sales, plans to invest €44 billion by 2023 in electric vehicles and related digital services[2].

1. http://www.ev-volumes.com/news/global-plug-in-vehicle-sales-for-2017-final-results/
2. https://www.reuters.com/article/us-autoshow-detroit-volkswagen/volkswagen-to-invest-800-million-build-new-electric-vehicle-in-u-s-idUSKCN1P81R1

At the same time, renewables are becoming central to energy supply. Germany produced enough renewable energy in the first half of 2018 to power every household in the country for a year. In 2019, more than half of the UK's power has come from renewable sources. As of 2020, California will be the first US state to make solar panels on new buildings mandatory, which will support its goal to be CO2-neutral by 2045[3]. To meet climate change targets, legislators are looking to decrease harmful emissions from fossil fuel power generation, amid ambitious targets to reduce CO2 levels.

The automotive and energy industries have grown and developed independently of each other over the last decades. Each has faced its own separate opportunities and challenges. However, now, thanks to EV and renewables trends, they have begun to substantially affect each other. On the positive side, the electrification of cars and the shift from conventional to renewable energy generation have led to improved air quality by decreasing emissions. At the same time, they also put traditional energy networks under pressure – electric vehicles on the demand side and renewable energies on the supply side, as shown Figure 1.

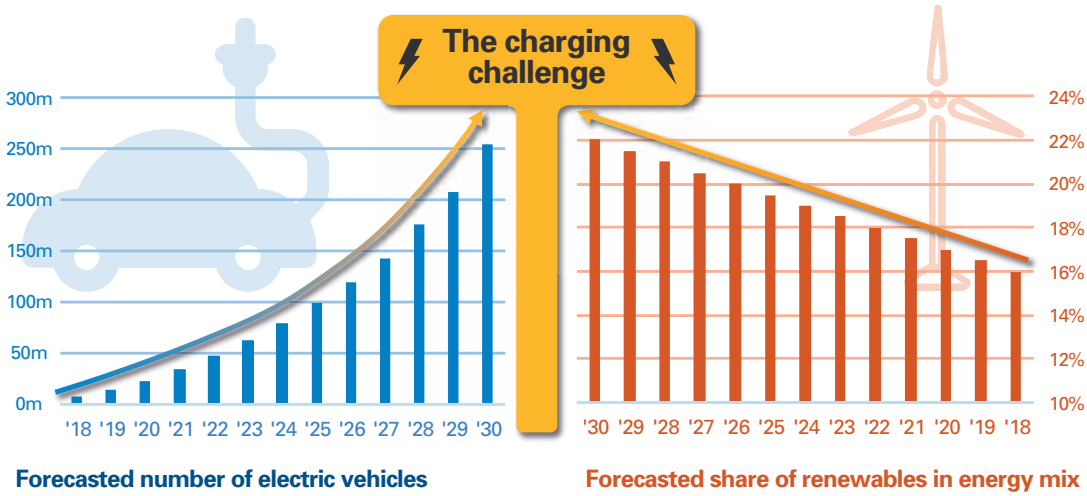


Figure 1: Global EV and renewables forecast until 2030: Pressure from the charging challenge[4]

Source: Arthur D. Little, IEA, DBS

3. https://www.erneuerbareenergien.de/archiv/kalifornien-fuehrt-solarpflicht-ein-150-436-108001.html
4. https://www.iea.org/publications/reports/globalevoutlook2019/, https://www.dbs.com/aics/pdfController.page?pdfpath=/content/article/pdf/AIO/082018/180820_insights_2030_energy_mix_marching_towards_a_cleaner_future.pdf

Increased volatility: Coping when the wind doesn't blow or the sun doesn't shine

Increasing energy generation from renewable sources threatens the stability of grids due to their time- and location-dependent availability. Wind is hardly predictable, and shows high fluctuations in power generation due to varying weather. Solar power may be more predictable, but is still volatile and only available during the daytime. It is also localized – in the case of Germany, most wind energy stems from the North of the country, while solar power is predominantly generated in Southern areas. Given that the German government has set a target of renewable energies meeting 65 percent of German power demand by 2030, this will lead to a supply-side challenge for electricity grids[5]. Similar grid challenges will arise in other countries, such as China, the world's biggest energy consumer. The government there has increased its original renewables target from 20 to 35 percent by 2030, which will lead to enormous expansion of fossil-free energy generation[6].

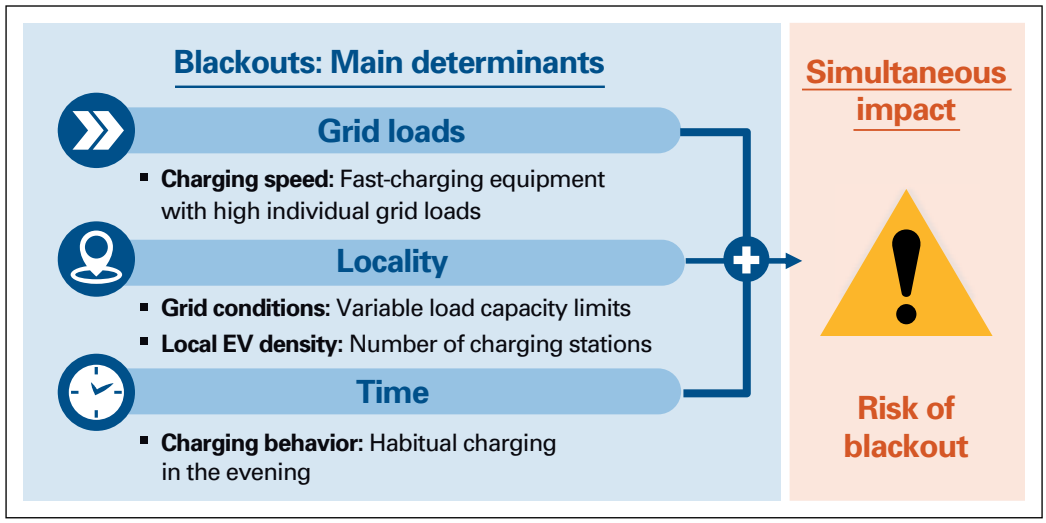
From a demand-side perspective, vehicle electrification will substantially increase electricity requirements. The combination of greater consumer acceptance, regulatory targets and more affordable vehicles will lead to growing market uptake, especially in Europe. From a cost perspective, by 2022 EVs will be on par with, or even drop below, the costs of internal combustion engine (ICE) vehicles in Europe, according to a recent study by Bloomberg New Energy Finance. This decrease in cost is mainly driven by the drop in battery prices. In just a few years this will make choosing an electric car over its ICE equivalent a matter of taste, not one of cost[7]. By 2040, 54 percent of new-car sales and 33 percent of the global car fleet are forecast to be electric, with China, the US and Europe making up over 60 percent of the global EV market[8]. Consequently, consumers' electricity demand will be significantly changed, in terms of not only electricity volume, but also charging power.

5. https://www.bmwi.de/Redaktion/DE/Dossier/erneuerbare-energien.html
6. https://www.bloomberg.com/news/articles/2018-09-26/china-sets-out-new-clean-energy-goals-penalties-in-revised-plan
7. https://www.bloomberg.com/opinion/articles/2019-04-12/electric-vehicle-battery-shrinks-and-so-does-the-total-cost
8. https://data.bloomberglp.com/bnef/sites/14/2017/07/BNEF_EVO_2017_ExecutiveSummary.pdf

These two trends contribute to the same critical challenge – putting the electricity grid under pressure. They are often seen as leading to a potentially bleak outlook for maintaining a secure power supply.

The threat of electricity blackouts

So how real is the threat of local blackouts as energy networks are pushed beyond their maximum capacity? First of all, it is important to realize that this would not be a continuous problem: with EVs accounting for less than 10 percent of total electricity demand by 2030, the challenge is more around the time and local impact of charging. What happens if more fast chargers with higher load capacities are installed? What happens when every EV owner in a suburban residential neighborhood charges their vehicle at exactly the same time? Figure 2 illustrates the main determinants of potential blackouts: grid loads, locality and time.



Source: Arthur D. Little

Figure 2: Main determinants of potential blackouts: Grid loads, locality and time

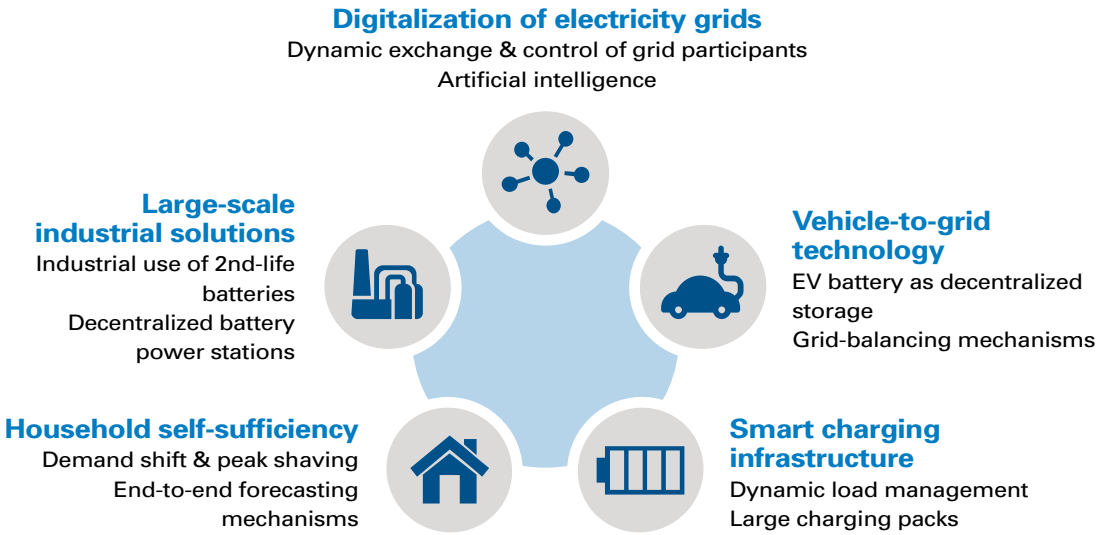
Many studies have discussed this threat and forecast nightmare scenarios that range from short-term local power outages to nationwide blackouts. The often-repeated message is that electricity grids cannot cope with forecasted vehicle electrification and renewable energy development at the same time. And it is very true that if grid infrastructure remains in its current state, blackouts and energy shortages will become a reality even before 2030.

However, in our analysis, this scenario will only be valid if energy and mobility providers follow the same patterns and business models that predominate today. In practice, we believe this is unlikely, as mobility and energy players have strong drivers to evolve their business models, and ample time to respond to the new opportunities afforded by technological convergence of electric vehicles and renewable energy applications.

Why the charging challenge will be overcome

The key reason for optimism is that all market players still have some time to adapt to changing requirements and transform their operations. EV penetration is an evolutionary, rather than revolutionary, process. Although electricity demand for charging EVs is expected to double by 2022, this still accounts for less than 1 percent of total electricity generation. Given that the major uptake of EVs, and therefore greater electricity demand, is only expected from 2025 onwards, providers have time to prepare.

Five key technologies and trends will support their transformation:



Source: Arthur D. Little

Figure 3: Key trends and technologies relevant for the charging challenge

1. Digitalization of electricity grids

Energy providers are increasingly investing in intelligent networks that will help to prevent grid instability and blackouts. Smart grids, which enable the exchange of information between different players within the network, are key to balancing electricity supply and demand. For example, the Trans-European Network for Energy facilitates transport of electricity over long distances across Europe, which lowers the risk of electricity blackouts. Current technology developments such as artificial intelligence, vehicle-to-grid/-home and dynamic load management will further support the development of intelligent and stable grids. Today, the building blocks for smart grids are already being put in place. In multiple countries, smart meters are becoming mandatory for businesses and end consumers with high electricity demand. In addition, electricity network providers are investing in intelligent transformer stations that contain metering and control functionalities. By making it possible to constantly monitor and steer voltage, current and frequency, these intelligent transformers also allow bidirectional flow of energy.

2. Vehicle-to-grid technology

Expensive infrastructure updates can be avoided with vehicle-to-grid technology that uses the batteries of EVs as a storage mechanism, which stabilizes the grid. If there is a surplus of electricity, EV batteries can be charged and serve as local storage. In case of electricity shortages, they can then feed energy into the grid or, alternatively, reduce their charging rates to keep the grid stable. The essential vehicle-to-grid technology to deliver these capabilities is still in its infancy and requires further development, but it is the focus of cross-sector research and studies that are building the pillars to exploit this new technology. Different players, including network operators, energy service providers and automobile manufacturers, are launching joint pilot projects. For example, Renault has begun piloting the first large-scale vehicle-to-grid charging project with electric vehicles in the Netherlands and Portugal. In the UK a consortium of players with different expertise, such as Nissan Motor Manufacturing UK, Energy Systems Catapult and National Grid ESO, are exploring both near-term and large-scale opportunities for vehicle-to-grid to play a role in a flexible energy system[9].

3. Smart charging infrastructure

The nightmare scenario of all EV owners plugging in their vehicles at once should be mitigated through the installation of smart charging infrastructure. Communication features and in-built load management will allow energy providers or charging infrastructure owners to flexibly control the charging process at one or more connected charge points, which will smooth electricity demand peaks. For example, even if every EV owner begins charging their vehicle at the same time every evening, the process doesn't need to be simultaneous. Dynamic load management enables the charging volumes to be distributed across the entire night, which will significantly reduce grid load.

Today, there is already a lot of smart charging infrastructure installed, which allows for communication and load management. In this major area of focus, we expect rapid maturing and expansion of more sophisticated load management systems, in both private and public charging infrastructure.

9. https://es.catapult.org.uk/wp-content/uploads/2019/06/V2GB-Public-Report.pdf

In addition to private households, larger energy consumers such as charging parks and other business facilities can benefit significantly from intelligent steering of charging processes, as it allows them to reduce demand peaks and thus avoid cost-intensive infrastructure expansion.

4. Household self-sufficiency

In 2018 there was a record number of installed photovoltaic (PV) solar panels combined with home battery storage, and this is predicted to grow in the future[10]. These households with battery storage have the potential to reduce grid loads and provide flexibility by shifting demand and lowering the need for electricity supply to their properties (and vehicles). Smart management of these electricity sources and consumer needs will provide an endless range of new applications and business models. For example, AI algorithms could evaluate driver profiles, weather forecasts and electricity consumption patterns to flexibly connect individual electricity sources to consumers, which will minimize energy cost, ensure high customer satisfaction, and limit the impact on local grids. In fact, home batteries are already being used to balance grid volatility due to the rise of renewable energy.

5. Large-scale industrial solutions

Advances in battery technology and rapidly decreasing kilowatt hour prices will provide larger-scale solutions to help with grid stability. Stand-alone battery power stations will be installed as significant local power resources, while smaller energy storage systems can ensure distribution grid stability. The growth in availability of dedicated power station batteries, as well as the increasing reuse of EV batteries, will feed this trend. For example, the second-life EV battery[11] market is expected to grow to $4.2 billion by 2025, with 70 percent of the market value originating in China and 16 percent in South Korea[12].

10. https://www.eupd-research.com/aktuelles/detail-ansicht/tesla-und-sonnen-als-mavericks-der-globalen-heimspeicherbranche/
11. Reuse applications for EV batteries after they are no longer fit to their original purpose (e.g., in stationary storage systems)
12. https://www.pv-magazine.com/2018/08/03/second-life-ev-battery-market-to-grow-to-4-2-billion-by-2025/

Audi has recently installed stationary energy storage with capacity of 1.9 MWh in Berlin. Fortum, as well, is piloting different second-life battery solutions, testing new business models. In India, for example, Fortum is developing a leasing model in which auto rickshaw owners can give back their used batteries for recharging and receive full batteries in return[13].

Taking them together, we expect these trends to enable grids to cope with the charging challenge despite rising vehicle electrification and renewable energy use. Batteries and smart charging infrastructure will provide **flexibility**, while intelligent networks and connectivity allow for **decentralized energy management.** Finally, **monetary incentives** across all applications will ensure market attractiveness. Some utilities have already started to introduce such tariffs, especially for B2B customers, while reduced grid connection costs for interruptible consumers such as EVs allow for short power cuts in case of grid instability.

Both utilities and e-mobility providers have explicit interest in supporting these developments, to prevent unnecessary costs for grid extensions and ensure a flawless customer experience for EV users. Other players, too, are entering the market; often these are mobility service providers emerging from the start-up landscape with strong digital focus. In these rapidly converging industries, we expect a new competitive landscape to quickly develop on the base of new business models.

13. https://www.fortum.com/second-life-lithium-ion-batteries

Incumbents, challengers and new business models – Which will win the battle?

Potential new business models will arise from the charging challenge, for both established energy market incumbents and challengers such as automotive manufacturers and mobility service providers. Energy companies will heavily invest in public charging infrastructure to provide viable alternatives to home charging, while e-mobility players extend their offerings to support grid-stabilizing mechanisms. Each of these players brings different core competencies to the table:

- Automotive manufacturers have global retail and brand experience at their disposal.
- Energy incumbents build on vast energy technology and regulatory expertise.
- Smaller mobility players are able to take on specific niches at high speed and with advanced digital skill sets.

When it comes to successfully introducing new business models, all these strengths can be crucial. Which players will emerge as the winners? Three aspects are likely to be important: margins, customer access and technological capabilities.

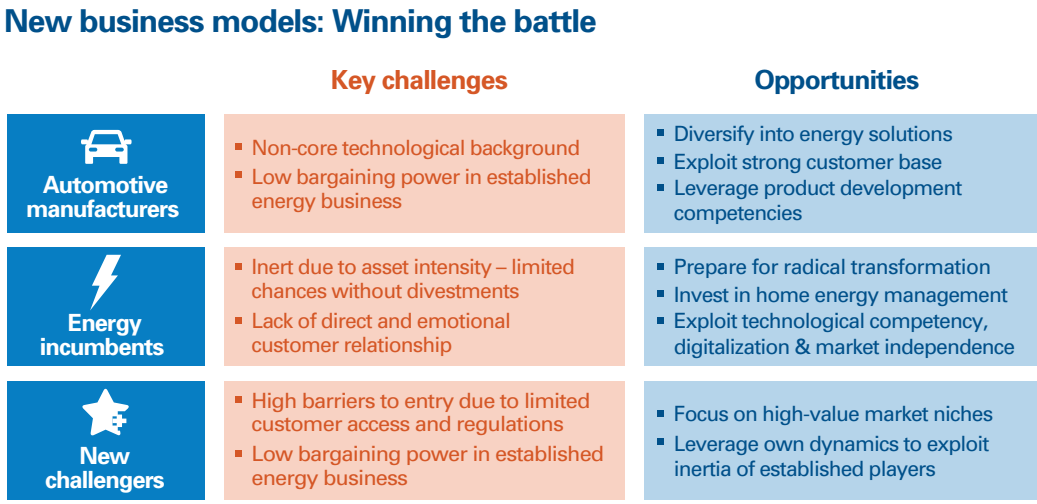
- **Automotive manufacturers**, with well-established B2C and B2B customer bases, as well as command of vehicles, will enter the charging challenge from a position of strength and are likely to have the initial advantage in generating enough margins. Clearly, their products are focused on the vehicle, with little or no reach into customers' households. They do, however, hold the advantage in terms of their experience in emotionally charging products and building brands. We therefore expect manufacturers to extend their offerings towards the "energy solutions" business by making use of their EVs, brands, and market access. For example, Volkswagen Group founded Elli, an energy and charging solutions provider, in 2018. Elli aims to offer a seamless and holistic energy and charging experience for electric car drivers and fleet managers.

- **Energy incumbents** have a greater challenge due to their traditional focus on energy provision as asset-heavy and cost-driven Enterprises. However, those players that are able to move away from central generation, transform their infrastructure, digitalize their businesses and refocus on the consumer[14] have good chances of success. This trend is already well under way, as shown by, for example, the splitting of E.ON into E.ON and Uniper, and RWE into RWE and Innogy. Continuous investment from Engie in customer energy management and demand response players is another example. Smart home appliances allow energy players to gain access to customers' homes. They can also use their independence from automotive brands as a unique selling point, especially with corporate customers. In addition, existing energy players will have networks of installers, which will provide an advantage when it comes to deploying relevant hardware.

- **New challengers**, such as mobility and energy service providers, pose a serious challenge, given their speed, strong focus on the customer, and digital capabilities. While many corporates make use of internal incubators to create these capabilities, start-ups with technology focus are likely acquisition targets. For example, Shell has been investing heavily in energy and mobility service start-ups such as Sonnen and NewMotion. Amazon is leading a $700 million round of investment in Rivian, a potential rival to EV manufacturer Tesla, as well as investing heavily in customer energy management providers[15]. Well-known automotive players, similarly, are investing in high-potential e-mobility companies such as Rimac. This Croatian company develops EVs with advanced battery and control technology, and was able to attract investments from Porsche, Hyundai and Kia[16]. These challengers will address specific "high value" spots in the value chain where they are likely to have the upper hand over the industry giants, at least initially.

14. See also companion article "Getting ready for the energy consumer of the future" elsewhere in this issue of Prism
15. https://www.handelsblatt.com/unternehmen/industrie/investment-in-rivian-amazons-700-millionen-dollar-wette-auf-elektroautos/23993148.html?ticket=ST-4042233-xkh9h2mcV4engxygsNW4-ap2
16. https://cleantechnica.com/2019/05/15/hyundai-kia-make-an-80-million-euro-investment-in-rimac/

Figure 4 summarizes the positioning of players entering the charging challenge and opportunities for new business models.



Source: Arthur D. Little

Figure 4: Charging challenge business models: Opportunities and challenges

Insight for the executive

The competition has begun around future energy business models. The charging challenge is unlikely to lead to blackouts or instability, given the strong drivers for new business models, the potential of converging technologies, and the availability of sufficient time for key players to adapt. On the contrary, the rise of EVs will very much prove to be an opportunity. In converging industries, the charging challenge will enable new business models, which will see established and new players competing. We expect energy and automotive incumbents, as well as new challengers – often smaller mobility players and energy service providers – to open up these new areas.

Today, these players start from different positions with their individual sets of capabilities. With smaller players as likely acquisition targets, both of the giant industry environments of energy and mobility promise to drive consolidation as

competencies converge. This can be seen in the automotive industry, as alliances have become increasingly popular to fund the significant investments required for new e-mobility capabilities. In the meantime, energy players themselves have been consolidating, and will be further driven to demerge asset-heavy and cost-intensive electricity generation businesses.

Realizing margins within these new business models is based heavily on gaining substantial market shares, which means we expect a "volume-driven game" to emerge in these areas. Currently, automotive manufacturers seem best equipped to succeed in this competition, but the challenge requires all players to change and adapt if they are to drive long-term success.

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Getting ready for the energy consumer of the future

Aurelien Guichard, Paola Carvajal, Carl Bate, Greg Smith, with contributions from Michael Kruse, Matthias von Bechtolsheim, Felix Keck

The energy sector is undergoing radical transformation as formerly passive consumers take control over their energy consumption and procurement. Based on the five stages of this transformation, we explain how it impacts the energy value chain and outline the capabilities that traditional providers must embrace if they are to meet the needs of the energy consumer of the future.

Today's consumers expect convenience as a matter of course – and want greater control over everything they buy and do. This trend is now spreading from sectors such as retail and transport to energy, with customers moving from being passive consumers to playing a more active role in managing their energy consumption and procurement. And as digital technology, electric vehicles and distributed power generation all increase, these trends will accelerate and expand in scale. This will inevitably lead to a reorganized energy value chain and drive the emergence of new business models. What is the impact on incumbent energy providers in the oil, natural gas, power, and utility industries? Who will win the race to attract the energy consumer of the future? This article aims to map potential pathways and provides a framework to help business leaders develop the new essential capabilities.

The evolving energy consumer

Within retail and transportation, consumers have already embraced the platform-based Amazon and Uber models, increasing their control and ensuring they get what they really need, when they need it, without the time and friction of going through intermediaries.

The same trends are moving into the energy world, where customers will increasingly adopt and adapt digital systems. These digital tools will enable customers to better meet their own needs, which will lead to new business models that will allow them to personalize their energy requirements. Based on our research and analysis, we see in Figure 1 a path that

takes energy consumers globally through five main phases. Depending on local energy market development, some consumers in advanced countries are already ahead in this evolution.

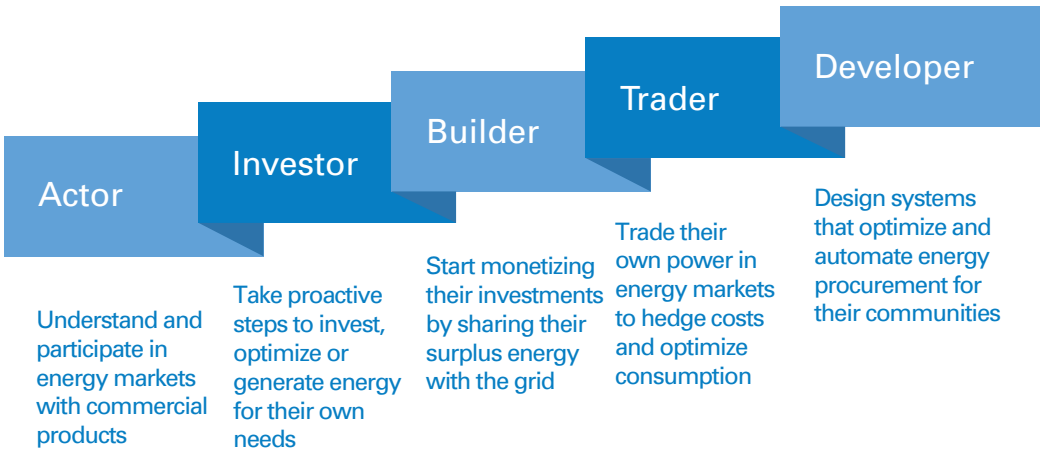

Figure 1: Evolution of the energy consumer

Actors: Initially, consumers take advantage of energy efficiency and demand response programs in order to reduce their costs and carbon footprints. In certain US and European markets, they are aware of the unbundling of power generation and energy retail, which means they switch energy providers according to their preferences. They invest in smart devices that connect to their smart homes and cars to learn and understand their behaviors. They transact individually through digital channels with their energy providers, although they have limited ability to influence products and rates.

Investors: With increasingly energy-efficient and environmentally friendly behaviors, consumers put the focus on services that allow them to optimize their energy consumption. They install methods of distributed energy resources (such as photovoltaic solar panels on their rooftops and battery/energy storage on their side of the electric meter) and produce energy for self-consumption and for the grid. This is a fundamental change for utilities that means they have to rethink, and reverse, their unidirectional contracting strategies with their customers. As the gap in the total cost of mobility

between electric and gasoline-powered vehicles narrows, consumers also assess which provides their best option for transport. This means traditional fuel retailers and suppliers need to transform their customer service as they start to compete with utilities. In advanced gas markets, consumers assess electric versus gas as an energy choice.

Builders: Consumers optimize their dependency on energy products. From a power perspective, customers make their spare supply available to their neighbors and transact with each other when needed, which offsets and reduces any reliance on grid services. This challenges the business models of incumbent utilities, which have traditionally invested in centralized, capital-intensive assets funded by utility customers. In terms of mobility, customers prefer not to spend time driving to, and waiting at, the gas station anymore, and this therefore threatens the relevance of this traditional value chain.

Traders: With the rise of battery systems and electric vehicles, consumers have turned into virtual traders. They start balancing – essentially hedging – their energy consumption with their own production. They tailor and schedule their activities to commercially advantageous times of the day and night. Even commercial and industrial consumers trade energy on digital platforms to the extent that they need to keep their core business operations running. Their energy consumption and generation systems are nimble and respond to surge pricing events, which further disintermediates incumbent power and fuel providers.

Developers: When these behaviors spread to entire communities, consumers work together to design energy systems that optimize resilience and cost for their own communities. In doing so, they build total systems that cover heating and cooling, building automation and smart neighborhoods, telecoms and broadband, and transportation and mobility. Utilities and oil and gas companies provide reliability and safety through their existing infrastructure, but they are no longer the sole providers of value-added services to consumers.

Preparing for the energy future

Building on the convergence of new technologies and business models, the energy consumers of the future are connected, commercial, and autonomous, virtually making (and transacting) power within an "Amazon of energy". Consequently, they will play the leading role in the future world of energy – and incumbent players need to react now to be ready.

In order to adapt to how consumers use and produce energy, we see three ways in which businesses can respond, each of which will have radical impact on the energy value chain. These are shown in Figure 2. Equally, they will need to develop new capabilities to power this transformation, which we describe in the next section.

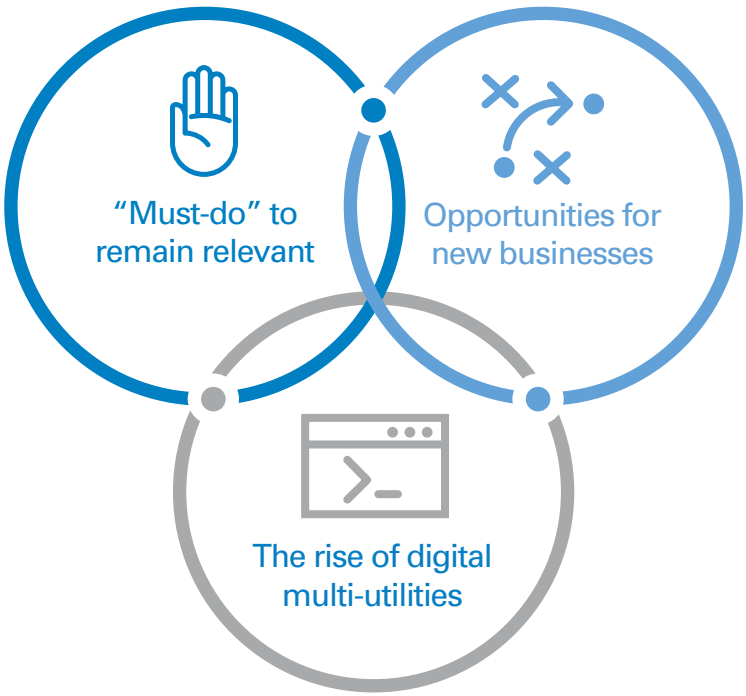

Figure 2: Business responses to evolving consumer behaviors

"Must-do" to remain relevant: Incumbent energy companies need to embrace the consumer-driven model and develop **new digital businesses** that offer convenience and new services around the delivery of their existing products to customers. They need to move from "sign in to your account" websites and "locate your nearest gas station" apps to interactive and personalized customer portals. Examples range from E.ON's Energy Manager in Europe to Duke Energy's Power Manager in the US and Diamond Energy's bill reduction offer with Reposit Power in Australia. They need to focus on personalizing their products, including rethinking consumer-to-utility contracts, based on extensive investment in the customer experience and greater consumer understanding. Input from consumers further drives this personalization, which results in a new demand dynamic for energy generation and consumption.

Opportunities for new businesses: Companies may also venture out of their current business models and invest in developing **new transformative products** that respond to consumer desires for greater energy efficiency. Companies can incrementally extend their scope and reach to provide services further up and down the energy value chain. Some may engage in M&A transactions (for example, Swiss utility BKW acquiring 40-plus service businesses in engineering and building technology), while others will grow organically (for example, electric utility Southern Company offering fiber-optic solutions, as well as Shell venturing into mobile fueling services with TapUp). As a result, they augment their customer value propositions by pushing new products to their markets.

The rise of digital multi-utilities: New, disruptive intermediaries may become the ultimate digital multi-utilities, aggregating consumer needs, social preferences, energy availability, partner ecosystems, and delivery service optionality to fuel the consumer's entire personalized energy lifestyle. As seen in other industries, such as media and travel, these businesses ingest and process massive amounts of data across various information sources and make consumer

predictions based on artificial intelligence. In addition, the network platform effect allows consumers to monetize their assets across electricity, heating/cooling, and mobility fuels. By being independent from incumbents, this **"energy-as-a-service"** response provides the most personalization, convenience, and value-add, which we believe will offset the higher acquisition costs of implementing consumer digital technologies. This is also the most disruptive response for traditional energy providers, as it reduces the relevance of the historic energy value chain and forces oil and gas companies and electric utilities to collaborate (or compete) with each other.

There are already some good examples of how competitors in the industry are responding, as seen below.

How competitors are responding to the energy consumer of the future

Traditional energy companies

Large energy companies are already taking significant steps to shift their focus, as previously discussed in "Shaping the oil company of the future" in Prism issue 1, 2019. Many existing utilities struggle with lack of **direct engagement with local consumers**, although some are aiming to bridge this gap. For example, EDF Luminus offers flexibility, energy assets (solar panels, battery packs, electric vehicle chargers), and services beyond traditional gas and electricity. Overall, major oil and gas operators invested $3–4 billion in low-carbon energy solutions in 2018 – slightly over 1 percent of their capital budgets. Given that 2018 global investments in distributed energy and clean technology overall totaled more than $300 billion, oil and gas companies are not the only players.

Consumer products companies

On the consumer products side, smart home vendors are helping customers control the temperature in their houses, reduce their energy usage, and make significant savings on their bills. There is a fierce battle raging for control of the smart home between market leader Google Nest, followed by Ecobee, Honeywell, Samsung, and Amazon's Alexa platform. All are investing massively in order to own the new smart home, managed via apps and voice control. This is just the beginning – companies such as Ecobee are leveraging artificial intelligence to **listen, learn, and respond to consumer behavior and market pricing**, automatically adjusting energy consumption based on real-time weather and electricity rates and acting as virtual batteries for energy. In the mobility space, companies are starting to penetrate the consumer energy market with offerings that directly affect energy consumption – for example, Volkswagen's Elli, a webshop for green power supply and charging solutions for electric vehicles.

New energy companies

New entrants are seizing specific opportunities, based on in-depth knowledge of generation and consumption patterns. Companies such as LO3 Energy and GridPlus in the US, Power Ledger and GreenSync in Australia/the UK, and Vandebron and Powerpeers in the Netherlands are beginning to reshape how energy is distributed across the grid by allowing **consumers to transact energy** with one another. In Germany, digital platforms for B2B power and gas procurement are emerging. Players such as enPortal, e.less, enermarket, and Verivox for retail, as well as tender365 and enmacc for wholesale, support fully digitalized, end-to-end buying and selling energy capabilities. While they connect buyers with utilities today, they will become pure P2P trading businesses in the next five years. On the gasoline side, start-ups such as filld.com and startyoshi.com began by providing delivery to individual cars, and are now expanding to bundle maintenance services and offer discounts on retail gasoline.

The spark for action

As energy consumers favor and adopt offerings from integrated, digital multi-utility and energy-as-a-service business models, the global energy value chain is finding itself on the cusp of being fundamentally disrupted. Traditional gas and electric utilities, as well as liquid-fuel providers, certainly have a valuable set of competitive advantages across customers, products, and logistics, but these are being challenged by new entrants.

We believe the businesses that are able to listen to their customers' behaviors across multiple platforms and rapidly offer them tailored energy solutions will be successful in the long term. Incumbent energy providers therefore need to take steps to build new communication channels, foundational product capabilities, and the advanced analytics necessary to remain the suppliers of choice. We show five key capabilities that are fundamental to achieving the necessary transformation in Figure 3. Many of these are new to established companies' mind-sets:

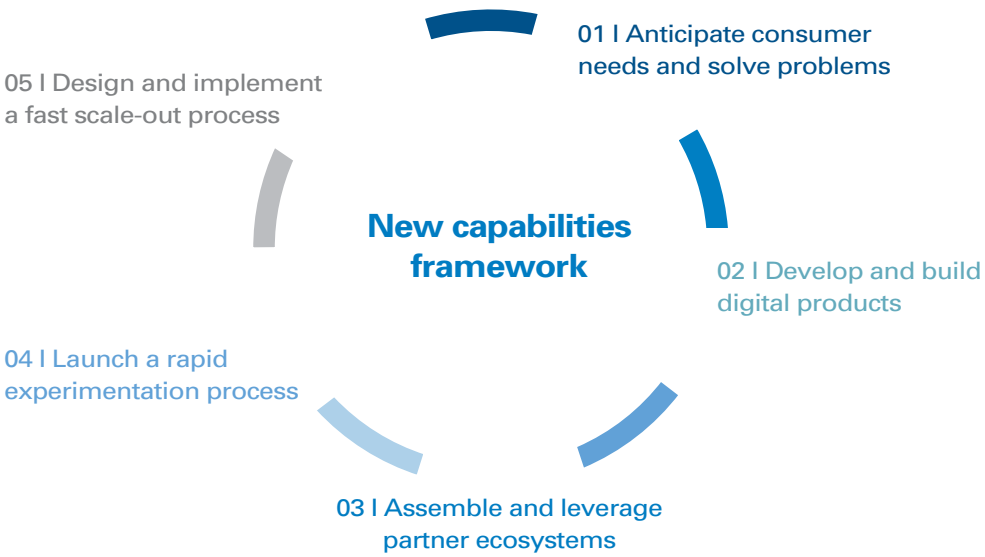

Figure 3: New capabilities framework

01| Anticipate consumer needs and solve problems: Based on specific local market conditions, energy companies need to leverage issue-centric problem solving to avoid implementing today's "best" practices, and instead craft their consumers' "next" practices. Previously, energy providers followed best practices to solve relatively predictable consumer problems that were flagged to them. In the more fluid future market, they will need to move to convergence-driven problem solving. They need to anticipate new, future needs and actually identify solutions to problems before consumers realize there is an issue. This can only be achieved by adopting consumer anticipation-based design thinking and aggressively expanding direct consumer engagement, so they can understand and incorporate consumer insight into design and innovation processes.

02| Develop and build digital products: Players need to invest boldly in the resources and skills which allow their teams to develop and fine-tune their digital technologies and offerings. The objective should be to align energy product offerings with energy customer priorities as they evolve. Technologies that capture energy customer behaviors and patterns spanning multiple information channels will be the most relevant investments for energy providers to personalize their solutions. The capabilities to strategically design, engineer, and architect digital businesses will be key to unlocking digital opportunities.

03| Assemble and leverage ecosystems of partners: Business leaders need to actively develop and maintain networks of partners that bring unique and complementary capabilities to their organizations. Energy-as-a-service means that customers play the central role in the transformation of the industry value chain. Traditional power utilities, oil and gas producers and retailers, technology developers, and start-ups, among others, should be able to leverage synergies to satisfy energy customer expectations. Beyond traditional supplier partnerships, companies also need to manage technology ventures that can be monitored, evaluated, and scaled up

once de-risked, as well as corporate-start-up collaboration platforms such as accelerators and incubators, to bring in new, breakthrough thinking.

04| Launch a rapid experimentation process: To compete in the fast-paced digital environment, leaders need to implement comprehensive processes that let their organizations iterate to tangibly measure – and learn – from testing and experimenting with new products and business models before engaging in pilots and commercialization at scale. Managing technology pilots requires rigor and discipline – and a broad view of the business. So the company needs a structure to enable teams to ideate, a process to guide the incubation stage, and a system to link the learnings back to the overall business.

05| Design and implement a fast scale-out process: Energy companies have been traditionally strong at managing projects, infrastructure, and commodities through multi-year and decade-long cycles. For the future energy consumer, they will need to transform their established value propositions and at a much faster pace. Their capabilities to scale out solutions to their markets will become critical. The key strength and competitive advantage will therefore rely on a nimble, yet effective, commercialization process and go-to-market approach, which will require an agile mind-set for change and collaboration across multiple corporate functions.

Equipped with this capabilities framework, business leaders can start setting the new direction for their companies in line with the requirements of future energy consumers, and therefore take leading roles in the future ecosystem and value chain.

Insight for the executive

The energy consumer of the future will adopt and adapt digital systems that will enable them to control their energy footprints, which will lead to new business models of energy-as-a-service. Energy companies will face multiple disruptions to their businesses, and need to act in new and different ways to remain ahead:

- Develop new digital businesses that offer convenience and personalized options for delivery of their existing energy products to customers.

- Launch new energy products to respond to particular customer desires, strengthening their offerings as broader energy service providers.

- Transform their businesses towards digital multi-utilities that can offer integrated and optimized total energy solutions to their customers.

The energy transition is also opening the door to new players such as smart device manufacturers and network developers, which are focusing on interacting with customers and understanding their needs to provide personalized solutions. These new ecosystems represent not only challenges, but also opportunities, for incumbent energy companies. Ultimately, incumbents need to shift their core engineering capabilities from infrastructure assets to software platforms and digital assets. Such a transformation requires significant effort to develop new capabilities:

- Anticipating consumer needs and solving problems
- Developing and building digital products
- Assembling and leveraging ecosystems of partners
- Launching a rapid experimentation process
- Designing and implementing a fast scale-out process

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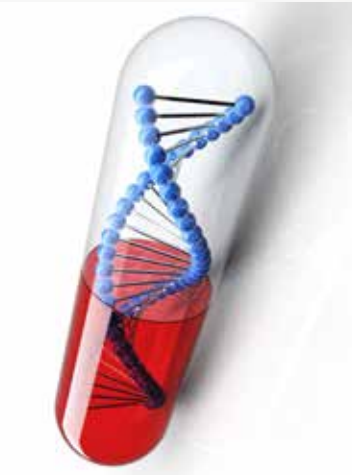
Transforming healthcare – How curative therapies will disrupt the market

A paradigm shift for health

Craig Wylie, Rebecka Axelsson Wadman, Dr. Thomas Unger, Vikas Kharbanda, Dr. Ulrica Sehlstedt, Satoshi Ohara

The combination of scientific advances, increasing patient expectations, emergence of new technologies, and growing concerns around cost are driving an unprecedented level of change encompassing whole healthcare systems across the globe.



One key part of this is the shift towards curative treatment for conditions that were previously considered chronic or untreatable. Essentially, patients that previously had to rely on ongoing medication can now be cured through specific, time-limited courses of treatment, which transforms their lives. This will disrupt the entire healthcare ecosystem. With curative treatments, payers' expenditure drastically shifts from ongoing, long-term and relatively low-cost drugs to large, front-loaded therapy costs. Revenues for therapy providers will also shift, focusing around when they are introduced to the market. This transformation will lead to a number of consequences for patients, policy makers, payers, providers, and pharma companies alike. In this article, we will take a deeper look at what those consequences are, and what can be done to address them.

The shift to curative treatments promises to transform the entire healthcare ecosystem. Patients whose conditions were previously managed through ongoing, long-term medication can now be cured through specific courses of treatment. This transforms their lives – but, as this article explains, it also has a disruptive effect on the wider market, shifting payers' expenditure, increasing the importance of first-mover advantage for pharmaceutical companies, and changing care models for healthcare providers.

What are curative therapies?

Our definition of a curative therapy is a time-limited treatment that removes the symptoms of a disease through permanent (or semi-permanent) correction of the underlying condition. In contrast, a pill that a patient needs to take for the rest of their life to manage symptoms or disease progression is not curative.

From our analysis, we have defined three archetypes of curative treatments:

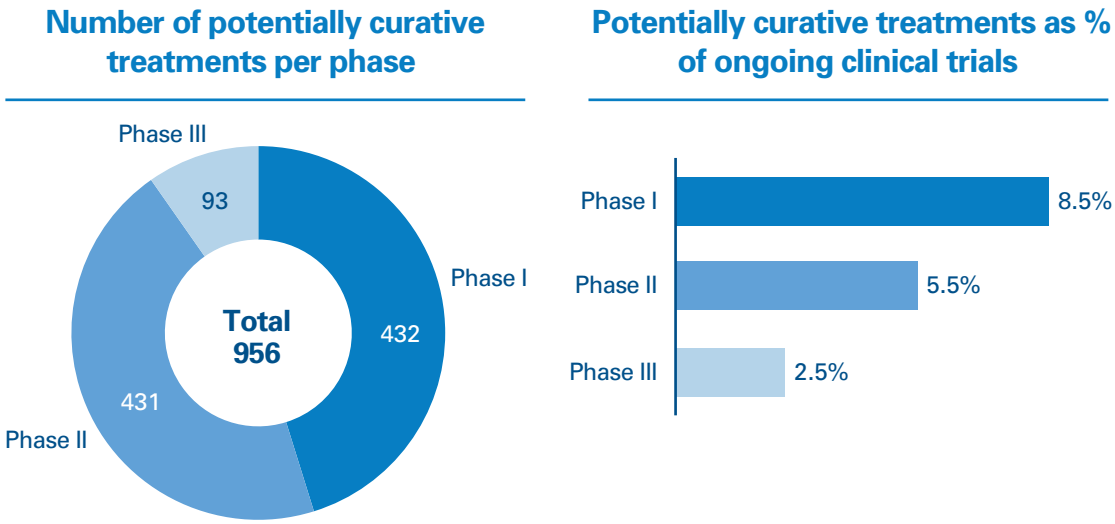
- A biology-modifying drug is one that targets a particular mechanism that contributes to, or is responsible for, the underlying disease. An example is the hepatitis C virus (HCV) treatment Sovaldi (Gilead Sciences), in which a nucleoside analog interferes with viral replication, thereby curing the patient of hepatitis.

- Gene therapy addresses underlying causes of a disease by correcting the missing or mutated genes. It can be divided into somatic and germ-line therapy, with the latter treatment curing not only the current patient, but also their future offspring. Examples include Luxturna from Spark Therapeutic, for patients with inherited retinal diseases (IRDs).

- Genetically re-engineering cells, such as CAR-T and stem-cell treatments.

The number of curative treatments is increasing. Analysis of the clinical trials pipeline undertaken by Arthur D. Little shows that approximately 5 percent of all drugs currently registered as active in clinicaltrials.gov are potentially curative[1]. The highest share of potentially curative treatments can be observed in phase I (the earliest testing phase), which indicates that we will see a significant increase in the number of curative treatments reaching the market over the next 10 years.

1. Based on high-level analysis of clinicaltrials.gov data for interventional trials of gene therapy and cell therapy that were ongoing (recruiting) as of May 28, 2019.



Source: Clinicaltrials.gov (June 2019); Arthur D. Little analysis

Figure 1: Potentially curative treatments in clinical trials

Implications for care provision

Curative treatments have the potential to lower the overall impact and cost that particular diseases have on healthcare systems, as they eliminate the need for long-term chronic care. This will change the way we treat patients and impact how healthcare providers organize care and its delivery.

The sales and upfront cost profiles of these new treatments will have an immense impact on payers and providers. It will demand development of new models for payment and reimbursement in order for their introduction to be affordable.

This impact is already being seen. Many one-payer health systems have observed significant increases in drug spending directly attributable to the introduction of Sovaldi, which costs $84,000 for a three-month course of treatment. For budgetary reasons, England's National Health Service (NHS) tried to delay its availability (along with next-generation therapy Havoni) to patients, and looked to cap the annual number of patients receiving the treatment.

In the US, some state Medicaid programs and private health insurers restricted access to curative therapies, which led to warnings from federal officials and lawsuits from patients. Medicaid programs in 29 states said Sovaldi was the first or second most costly pharmaceutical outlay that they had to make. While payers recognize that drugs such as Sovaldi lead to bigger medical savings later on – for example, if Hepatitis

C is left untreated, it can lead to cirrhosis, liver failure or liver cancer – its immediate financial impact has a profound effect on the current budgets of insurers and payers. And this is for a drug that is relatively low cost compared to some other curative treatments.

In contrast, imagine the cost and operational impact on a cancer center if multiple expensive curative treatments were introduced in the same year. This higher variability in costs makes it increasingly difficult to plan and budget – aspects that are key to healthcare systems given that they are under continuous cost pressure.

Implications for pharma companies

The revenue models for curative treatments are radically different to those for existing drugs. Traditionally, new therapies tend to show a modest bump in sales when introduced, which then stabilizes and remains steady until patent expiration. This delivers predictable revenues and requires stable, ongoing drug production. Curative therapies, however, are one-off treatments. Once a patient has been treated, they will not require any further treatment. That means peak sales will appear earlier and be higher than for traditional therapies, as the populations of eligible patients will all be treated in short spaces of time. However, sales will then drop off much faster once this pent-up demand has been met. Figure 2 compares revenues for a traditional therapy versus a curative one.

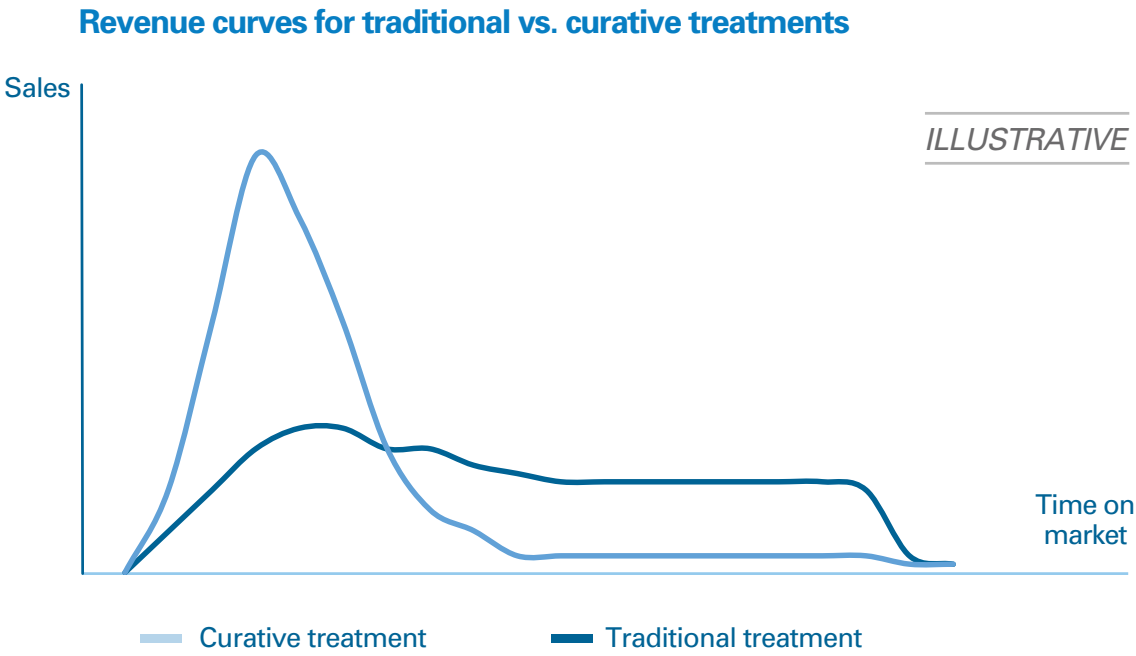


Figure 2: Revenue curves for traditional versus curative treatments (illustrative)

Case study: Sovaldi

A recent example of the shift in sales patterns is Sovaldi, which was launched in 2013. This is the first curative treatment that effectively cures 99 percent of Hepatitis C virus cases.

This new model represents a clear break from typical pharma sales profiles, which will, in turn, impact the way the pharma organization needs to be set up and function. Manufacturing needs to be able to deliver large-scale production in the short term, but once the peak has passed, it needs to be scaled down to more modest, "steady-state" production volumes. The same is true for marketing and sales.

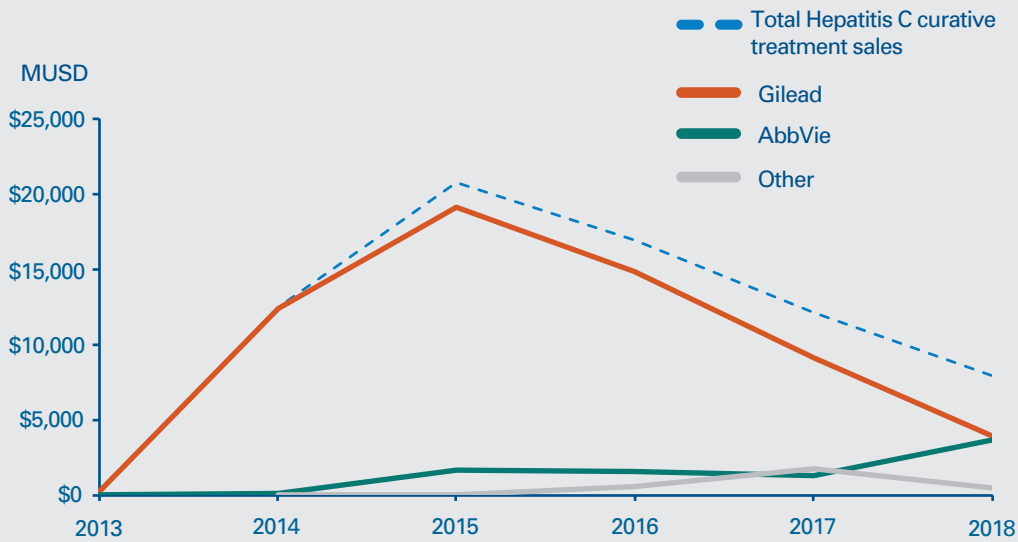


Figure 3: Sales for Hepatitis C curative treatments

This also affects competitive products. When there is already unmet demand, the first mover really does have a significant advantage. It can effectively eliminate any market opportunities for competitors by curing the backlog of patients either waiting for treatment or receiving chronic care. The only remaining need will then be from newly diagnosed patients.

When competitors entered the market in 2014, a large share of patients had already been treated. Based on its successful record, Sovaldi was the natural first choice for prescribing to new patients. To demonstrate the importance of first-mover advantage, when AbbVie launched its first Hepatitis C drug about 12 months later, sales were disappointing. However, in 2018, it launched a significantly improved follow-up drug, Mavyret, which is currently the leading treatment for new patients. While this has managed to gain AbbVie a strong long-term market position, the company clearly missed out on the lion's share of treatment revenues.

The unusual sales profile shown in Figure 4 had a clear and unexpected effect on Gilead's share price. Even though investors understood that Sovaldi was a curative treatment, shareholders weren't expecting the peak and consequent drop in sales, which led to the share price slumping as sales naturally slowed down. This demonstrates that pharma companies will need to anticipate this issue and either educate the market or, more likely, try to balance product portfolios to counteract potential large swings in sales.

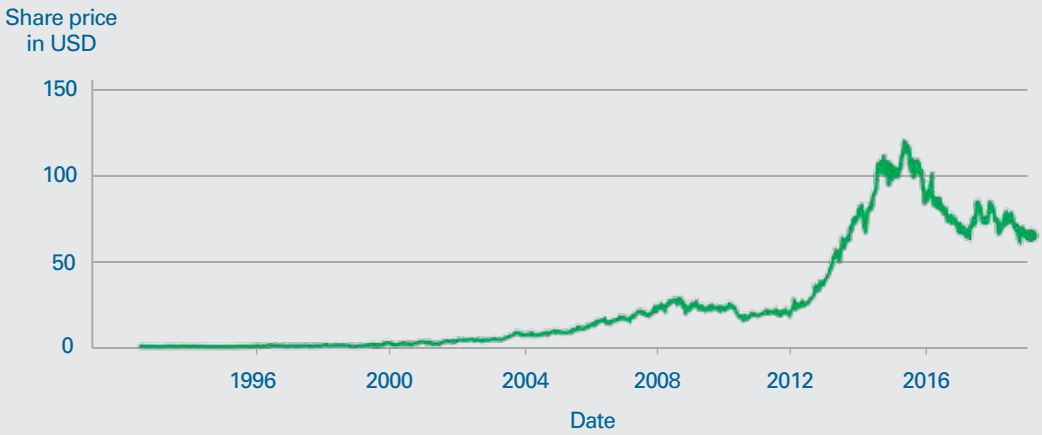


Figure 4: Gilead share price movement

Key factors to consider in anticipation of curative therapies

Curative therapies have the potential to disrupt the healthcare market, and most importantly, to dramatically improve the lives of patients struggling with significant, long-term conditions. A number of questions need to be addressed by the pharma companies providing treatments, care providers, payers, and policy makers in order to control the market disruption caused by curative treatments while also maximizing their positive impact.

Payers and policy makers

In a world of limited resources, tough decisions need to be made. What diseases should be treated over others, what curative treatments should be funded, and for whom? These are ethical questions that need to be answered, and the answers will have significant impact on patients and their health.

The timing of costs also needs to be controlled, with the financial impact of new treatments evened out to reduce cost volatility. There are a number of potential payment model options that could be used, either alone or in combination, to address this:

- **Survival/outcomes-based payment** – The treatment is only paid for when successful. This shifts part of the risk of unsuccessful treatment to pharma companies, effectively lowering the risk that payers will have to fund both expensive treatments and continued treatments for chronic conditions.

- **Interim payments** – Payments are spread out over longer periods. This aligns the cost profile much more closely to that of a chronic/long-term treatment and reduces the immediate cost for payers.

- **Companion diagnostic-based payment** – Treatments are only approved when a companion diagnostic has shown that the patient is highly likely to respond to the treatment. This also serves to limit the number of patients subjected to ineffective treatments, which, by extension, also reduces costs for payers.

If the payer is a private insurance company, its models for calculating risks and costs, as well as for pricing, will need to be changed, as past actuarial data will no longer be accurate. In addition, payers and policy makers will need prior warning when new curative treatments are about to hit the market, so they have time to accurately plan, budget, and adapt policies.

Care providers

Care providers are facing a multitude of changes due to the increase in curative treatments. They will need to rethink their organizations and infrastructure from chronic care and surgery to curative treatments.

Care providers will need to shift their financial models, as well as their operating models, to better account for swift changes in standards of care. A key component here is training of staff – as new treatments are introduced more often and for shorter time spans, training models will need to be adapted to focus on faster learning and higher degrees of staff specialization.

Pharma companies

Ensuring first-mover advantage is key for any pharma companies that operate in fields in which curative treatments can potentially be introduced. They need to focus on market intelligence and build portfolio decision-making models that take into account the unique properties of curative treatments. They will need to understand if the new treatments they are developing are curative, if products being developed by competitors are curative, what their own time to market is, and whether they can gain first regulatory approval and be first to market. If first approval is possible, but they face competition, they should assess how they can accelerate time to market to beat rivals. If first approval is not a possibility, they need to be prepared to significantly revalue potential market revenues, move away from the project, or be convinced that their products are superior to the competition.

Pharma companies also need to rethink their reimbursement models. The greater the certainty that a treatment will be curative, the greater its worth, and this enables it to command higher prices. If a specific patient type is responsive, the company needs to ensure that there are diagnostics in place to demonstrate this. Pharma companies will need to adapt pricing depending on the certainty of the treatment working and thus reducing long-term costs, or leverage the use of contingent payments to allow care providers to pay over time or when results have been achieved. This makes it hard for anyone else to break into the market.

Companies will also require a proactive approach to portfolio management. They must understand the timing of revenues and plan for dealing with revenue cycles that are radically different from the pharma industry standard. Finding a way to balance revenue either through portfolio management, business/price model changes, or financial planning could help avoid large share-price fluctuations. Factoring companies could become important players in the industry by financing peak manufacturing costs, and then taking upfront revenue and paying it out to the pharma company over time, thus helping to manage peaks in costs and revenue.

Case study: Luxturna

Luxturna (voretigene neparvovec) from Spark Therapeutic is the first FDA-approved gene therapy for patients with inherited retinal diseases (also called inherited retinal degeneration, or IRD) caused by mutations in both copies of the RPE65 gene.

Patients suffering from IRD risk partial or complete blindness, and while current treatments can help slow down the advancement of IRD, they cannot stop disease progression.

Luxturna carries a list price of $850,000 (or $425,000 per eye) – a high cost for payers to bear, despite there being a limited number of patients.

To address this, Spark set up a payment agreement with Harvard Pilgrim Health Care, the first health plan to cover the treatment. Under its terms, Harvard Pilgrim Health Care will only need to pay for patients who are successfully treated.

The outcomes-based contract pays Spark in full only if the drug works after 30 months, with an interim payment based on preliminary effects at 30–90 days.

Before being treated, patients need to undergo genetic testing to confirm the gene mutation, and it must also be confirmed that the patient has enough viable retinal cells to restore or preserve vision.

Insight for the executive

An increase in curative treatments will lead to tremendous clinical progress and drastically improved quality of life for affected patients. It will also, however, put significant pressure on healthcare systems, as well as change revenue models for pharma companies providing such treatments. High initial sales caused by the treatment of large backlogs will lead to distinct first-mover advantages and large fluctuations in production volumes.

In order to prepare for this major change, there are a number of concrete items that policy makers and executives in the healthcare industry must focus on:

- New payment and reimbursement models need to be put in place. Pharmaceutical companies developing curative treatments need to engage with care providers, policy makers, and payers to develop financial models that are sustainable for all parties. Engaging with payers and providers early on will also help them plan and prepare for implementation of new treatments. In order for patients to fully benefit from the new developments, healthcare provider operations need to be able to accommodate rapid changes in care practices. Training, education, facilities management, and executive decision-making processes will all be impacted.

- Policy makers, payers, and care providers should start to build up better analytical capabilities tailored to assessment of new curative treatments and their implications. These must focus on quantifying the value of the new therapies, in terms of both the value to patients (improved quality of life, increased life span) and the financial side (the upfront cost of treatment versus the long-term costs of managing the disease, as well as the cost of treating medical issues caused by the disease). Models for quantifying and analyzing treatment impact should be used to make qualified decisions around treatment funding and prioritization. This will enable balancing expectations around treatment access and overall cost and value.

- Pharmaceutical companies need to review their drug pipelines, portfolio management practices, and launch plans (marketing, sales, manufacturing) to accommodate the different properties of curative treatments, so they can proactively push for first-mover position or adapt their strategies if that isn't possible.

Developing these new capabilities across the healthcare system will be essential to ensuring that new therapies can be brought to market and implemented in clinical practice in an efficient and sustainable manner, prioritizing high-value treatments to the benefit of patients.

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