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Editorial Board: Stephen Rogers, Dr. Jaap Kalkman, David Borras, Rodolfo Guzman, Daniel Monzon, Yotaro Akamine, Michael Kruse, Ilya Epikhin, and Elias Ghantous
Dear Reader,

The global electricity industry is wrestling with its legacy as it undergoes the most significant structural changes since Thomas Edison invented the light bulb in 1879. The forces of innovation and disruption led by technological advances and economic viability of several trends such as decentralized renewable energy, energy storage, digitalization/smartization of networks, electric vehicles, active policy making and regulation, and the influx of new market entrants in the power sector are the main drivers of the current transformation. The aforementioned dynamics in the industry pose both threats and opportunities to the incumbents, which require an agile approach and mindset to generate value.

We at Arthur D. Little are at the forefront of this transformation, assisting several clients to re-think and adapt their business model to be future ready; leading insights are presented in the 2018 Utilities Journal spanning a host of topics relevant to players across the value chain.

This year we begin with the future of batteries, as storage continues to evolve; we present our market and technology view within this transforming landscape. We also look at the prospects of energy storage for a grid operator and analyze the future role, drivers, and barriers to the adoption of energy storage in major markets. Invariably, the energy transition has led to regulators putting pressure on network operators to deliver sustainable outcomes - a huge cultural and operational shift that requires them to rethink their business model.

Next, we look at how the widespread adoption of renewable energy (distributed and utility scale), and the impending boom in energy storage and electric vehicles presents new opportunities and challenges alike for utilities across the globe. We also discuss various business models for utilities to exploit the growth in electric vehicles.
As the race for building fiber infrastructure accelerates globally, utilities are increasingly seen as new credible players. In the most convincing cases, utilities step in and play a complementary role in national fiber development. We detail how utilities position themselves for national fiber development, and how they can be engaged. We also explore the subsequent convergence of electrical utilities and the telecommunications industry.

Finally, we look at the role of aggregators in optimizing electricity generation and demand through virtual power plants in the provision of flexibility.

We truly hope you enjoy our perspective and insights on the wide range of topics addressed in this year’s Utilities Journal, and would be delighted to hear your thoughts and engage with you in a lively exchange.

Happy reading
Warm regards,
Dr. Jaap Kalkman
Executive Summary

Battery technologies are central to delivering significant advances in a wide range of industries, from electric vehicles to renewable power. This has catapulted battery technology to the top of the priority list for many players, leading to a huge boom in investment, as companies try to build key positions in the market.

However, this investment frenzy threatens to lead companies to rush forward without asking themselves key questions. What will the landscape look like when the dust settles? Which technology will dominate the battery space in the future, and what are the potential scenarios for future growth? How do I (as a chemical company, utility, investor, battery manufacturer, automotive manufacturer, mobility provider or government / regulator) prepare for the future and position myself to benefit?

There is no simple answer to these questions, as they depend on a range of factors, from the speed of new innovation to the ability to reduce costs of existing technologies.

Achieving market dominance in a wide range of electrifying industries, from automotive to electronic devices, will require companies to build and defend successful battery technology positions together with hosts of larger and smaller partners. If they lose that battle, they may lose the war. Risks are high, and not all players will be successful in terms of technology choices, their positions in the value chain and partnering strategies.

This study aims to provide a guide to the current state of the market and future scenarios, analyzing the various battery technologies and mapping them to the unmet needs of specific applications. The findings and conclusions mentioned in this report are the result of Arthur D. Little analyses on a wide range of sources which we have not all listed separately for the sake of readability, unless indicated otherwise.

From this study we outline the three most likely potential scenarios and outcomes in terms of the winning technology of the future, and explain the implications for industries and players either dependent on battery technology or looking to benefit from its evolution. In particular, we believe the ultimate winners of this game will be companies that orchestrate the best innovation ecosystems in battery technology.
Key insights

1. Despite uncertainty, demand for battery storage will continue to grow across a wide variety of markets and applications. Each of these has different unmet needs that offer enormous potential to innovative players. (See Chapter 2.)

2. While a vast number of next-generation technologies are in development, with large potential markets, it is easy to bet on the wrong horse. Ultimately, many of today’s new entrants and investors will be disappointed. (See Chapter 3.)

3. Entrants to the battery space face considerable risks, which vary dependent on their positions in the value chain. It is therefore vital to understand how these challenges impact your business. (See Chapter 4.)

4. Arthur D. Little believes that no single company will be able to come out on top without the support of an intricate and dynamic innovation ecosystem made up of partners, start-ups, institutes, etc. These bring complementary technologies, application know-how, and access to captive markets. Master the critical parts of your ecosystem – or lose. (See Chapter 4.)

5. Whatever their positioning or strategies, companies will need to carefully understand and monitor the technology and ecosystem landscapes as they evolve to navigate effectively and capture their shares of battery technology’s enormous potential. (See Chapter 4.)
Battery technologies are an essential catalyst to unlock growth and new advances in sectors such as electric vehicles (EVs), electronic devices and battery energy storage (BES) for renewable energy. The increasing reliance on battery storage is driving enormous demand – overall, battery applications are expected to become a $90 billion-plus market by 2025, up from $60 billion in 2015.

This is driving unprecedented growth in battery supply, from a wide range of existing – and new – players.

However, current technologies are not enough to unleash the full potential of applications such as power, renewable energy, consumer electronics, and mobility. Innovation is required to drive a step-change in performance and price for subsidy-free, mass-market adoption of products such as EVs. For example, Arthur D. Little estimates based on industry expert assessments, that to make EVs price-competitive with vehicles with internal combustion engines (ICEs) on an unsubsidized basis, EV battery packs need to fall to a cost of $100/kWh. Currently, lowest-cost estimates are in the range of $190–$250/kWh. The same is true for energy grids – for regions with high renewable penetration, such as Texas (where wind covers roughly 25 percent of demand), battery prices need to drop by 50 percent in order to switch back-up from gas-fired units to battery storage.

The future size of markets and their importance to overall trends such as mobility, renewable energy and digitalization are shown by the multi-billion-dollar investments that have been announced across the ecosystem. These come from existing battery manufacturers, vehicle makers, chemicals companies, energy suppliers and others, with many businesses moving outside their traditional comfort zones.

The last two years have seen over $13.7 billion of battery-related investments and acquisitions. This frenzy of spending has seen many organizations move beyond their traditional specialisms. For example, Total acquired battery manufacturer Saft, home appliance company Dyson bought disruptive technology start-up Sakti3 as part of its planned $1.4 billion battery investment, and Tesla announced a “gigafactory” to produce batteries for EVs and energy storage in conjunction with Panasonic.

Due to these investments the world is seeing a rapid build-up of vast and intricate ecosystems of existing and new players. Patent filings have increased threefold since 2010 – particularly in the area of joint filings, often between organizations in very different sectors. Examples include research institutions, companies developing battery technology, and businesses using
battery technology within applications, such as automotive, electronic devices and utilities. Players in the market therefore need to manage their way through these complex ecosystems if they are to thrive in the market.

**Figure 3: Patent ownership map**

![Patent ownership map]

Co-owning of patents between sectors

There is no “God Battery”

We believe that no single technology will dominate the industry at large. Each of the five key battery storage markets (described in detail in Chapter 2) has very different requirements on factors such as power density, capacity, cycle lifetime, energy density, capital cost, charging time, reliability and safety.

Winning solutions remain unclear, and success will require a combination of next-generation innovation and improvements to current technologies to meet evolving needs.

Each technology has intrinsic limitations to their technical and economic windows of operations, whereby extending one performance feature (energy density, say) quickly goes at the expense of others (such as safety or costs).

Existing technologies, such as lithium-ion (Li-ion) batteries, have seen rapid improvements in performance and cost due to a combination of greater economies of scale and research and development. However, there are still burning unmet needs to be solved. Next-generation technologies are required to deliver a step-change in performance of key battery characteristics.

Much of the development in this area is being led by ambitious start-ups, working in both the Li-ion market (such as on silica anodes, solid-state electrolytes and advanced cathodes) and in alternative technologies, such as flow and zinc-air batteries.

![Table 1: Relative performance requirements of major battery applications]

<table>
<thead>
<tr>
<th>Applications</th>
<th>Capital cost</th>
<th>Safety</th>
<th>Cycle lifetime</th>
<th>Energy density</th>
<th>Power density</th>
<th>Charging time</th>
<th>Reliability</th>
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<tbody>
<tr>
<td><strong>SLI</strong></td>
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<tr>
<td>Start-stop</td>
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<tr>
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<td><strong>ED</strong></td>
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<tr>
<td>Electronic devices</td>
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<td>○</td>
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<tr>
<td>High frequency, short discharge</td>
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<td>○</td>
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<td>○</td>
<td>○</td>
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<tr>
<td>High frequency, long discharge</td>
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</tr>
</tbody>
</table>

1 Measured as low-temperature performance;
2 Battery Electric Vehicles include 100% battery powertrain and long-range PHEV;
3 Exclusively e-buses due to their dominance in the electric commercial vehicle segment;
4 BES low frequency includes back-up/uninterrupted power supply, high frequency short discharge is mainly frequency regulation & renewables stabilization, high frequency short discharge is mainly residential and grid peak shaving and load shifting.

Source: Arthur D. Little analysis
Not since the first rechargeable battery was invented back in 1859 has there been so much focus on battery technology. Yet, so far, return on this investment has been slight, demonstrating that caution is required from both incumbents and newcomers. Many new technologies are still in their infancy, and there is likely to be a significant time overlap between technologies entering the mainstream and their final replacement of incumbents. For example, Li-ion batteries currently dominate the automotive battery market. Despite this, production of NiMH batteries (the previous leader) is predicted to continue for five to 10 years. We expect that a similar time frame will drive the introduction of next-generation solid-state batteries. Players in the market must therefore take a long-term view and, at the same time, ensure they are focusing on the right technologies and business models for their organizational success.

Although the large influx of investments signals an attractive and growing market, new entrants should beware, as there are considerable risks. These differ dependent on their positions within the value chain:

- For component suppliers reliant on scarce metals such as cobalt, there are considerable risks in securing these raw materials. Additionally, the race for an ever-more powerful battery is continuously raising component performance, resulting in innovative new chemistry which could make current technology obsolete. But despite these risks, the component space offers attractive financial returns, generally yielding 10–30 percent EBIT margins.

- Due to overcapacity among battery cell manufacturers and their desire to lock in automotive OEMs on long-term contracts, margins have been squeezed. Not only has significant additional capacity been announced and built, but battery plants are of much greater scale, depressing prices ever further. Together with the need for “big battery” manufacturers to form early, strong partnerships with automotive companies, this pushes gross margins down to zero and below in the hope that greater rewards can be reaped later on. Bosch’s recent decision to abandon electric-vehicle battery manufacturing (while maintaining its position in other parts of the value chain) underscores the challenges facing players in an increasingly crowded battery-manufacturing market.

- Besides value chain-specific risks, an overarching hurdle is that the battery industry is extremely conservative. There are long development cycles across every step of the value chain. This implies long payback periods and slow scale-up for those interested in entering the market.

So, amid all the announcements and investments, which technologies will triumph, and which players will prosper? This study aims to inform those within the battery technology ecosystem, and help them set their strategies and unlock value moving forward. It focuses on battery components and cells, rather than battery packs, which will be covered in Arthur D. Little’s next report.

The analysis and insight in this study leverage Arthur D. Little’s extensive engagements and one-on-one discussions with leading industry players, academia and start-ups.
The global battery market is made up of multiple applications of battery technologies with slightly different needs and requirements, which leads to each being best served by specific technologies. Next-generation innovation will impact each of these applications in different ways, serving currently unmet needs and helping improve performance. The five major battery applications that comprise the bulk of the battery market are:

- Starter, lighting & ignition (SLI) batteries for internal combustion engine (ICE) vehicles
- Electric vehicles (xEV)
- Electronic devices (ED)
- Stationary battery energy storage (BES)
- Other (aviation, drones, power tools, etc.)

By analyzing the specifics of these applications we can understand the drivers of battery R&D and outline predictions on future trends.

1. Starter, lighting & ignition (SLI)

   This is the oldest (and still largest) application area. An SLI battery is used in every conventional vehicle with an internal combustion engine (ICE), and serves to start and ignite the engine, as well as to provide electricity to the rest of the car when the engine is not running. Starting an engine requires very large currents for a short period – up to 300 amperes for only a few seconds. In comparison, a washing machine only requires 10 amperes. This makes power density a key requirement for such batteries. Additionally, it needs to be able to operate reliably across a wide range of temperatures and environments, while recent advances in "start-and-stop" systems, in which the engine shuts off automatically when waiting for a traffic light, are also placing an increasing burden on the cycle lifetime of SLI batteries.

2. Electric vehicles (xEVs)

   The fast-growing xEV market is made up of major groups of EVs, each with a distinct set of requirements: hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), full electric vehicles (EVs) and commercial electric vehicles (CEVs).

   HEVs are conventional ICE vehicles for which the propulsion systems are combined with smaller electromotors driven by batteries, which are commonly charged by regenerative braking. The smaller relative capacity of the batteries makes energy density and capital cost less relevant. However, as the battery is charged and discharged frequently and powerfully through braking, it has to have a high power density, extremely short charging time, and long cycle lifetime, which requires thousands of cycles.

   Compared to HEVs, a PHEV has a battery that can also be charged by plugging into an external electricity source. These batteries typically have much larger capacity, enabling the vehicle to drive fully electric for short distances. This leads to requirements for lower capital cost and better energy density, while power density and cycle lifetime are of less concern.

   “Full” EVs no longer have ICEs, and thus require much larger batteries to deliver sufficient range for drivers, which makes capital cost and energy density their most important needs. EVs also require batteries with high reliability (as the vehicle can no longer fall back on the ICE) and good cycle lifetimes of around 1,000 cycles, which enable them to last for the same mileage as the rest of the car components.

   Commercial EVs such as e-buses typically have increased safety needs as the battery systems are large and the impact of a thermal runaway (battery meltdown) can be severe. Cycle lifetime is also of more importance than in PHEVs and EVs, as the buses are charged at least daily. In the case of buses for which fast charging is required, they can be fully charged multiple times a day, which makes cycle lifetime even more important.

3. Electronic devices

   Batteries for electronic devices are used mainly within laptops and mobile phones, as well as for tablets, e-readers and other devices. All these applications have similar requirements, with volumetric energy density by far the most important. They need to provide the largest-possible amount of energy in the most compact form. As most applications have low drain, power density is typically not an issue. Battery costs are relatively small in comparison to the end product, and as the willingness to pay
for high-performance batteries is generally high, cost is of secondary importance.

4. Stationary battery energy storage (BES)

Stationary battery energy storage (BES) is a vital part of smoothing the supply and demand around power generated from wind and solar sources. Essentially, it ensures that electricity from renewables can be stored for use when the wind isn’t blowing or the sun shining. Also, it ensures that peaks in consumption can be absorbed and backup is provided without having to temporarily rely on fossil fuel power plants (such as diesel generators).

Figure 4: Global annually installed capacity of renewable energy sources

Arthur D. Little extensively covered BES in its previous report, “Battery storage: Still too early?”, which identified multiple types of operating models for batteries in energy-storage applications, including at grid scale and for residential storage, in which it can be linked to wind turbines and rooftop solar panels. Based on their needs from batteries, these operating models can be divided across two axes: 1) frequency of discharge and 2) length of discharge. The applications and key needs of each quadrant are shown in Table 2.

One interesting example of this is Italian electricity transmission operator Terna, which is combining multiple technologies for different applications: high-energy (long-discharge) technologies for congestion avoidance in its mainland grid, and high-power, lower-frequency technologies to secure uninterrupted power supply on the islands of Sicily and Sardinia.

5. Others

Many other applications exist, with their own sets of needs, e.g., drones, power tools, electric scooters, electric bikes, aviation, fork lifts. As they have a minor market share, they are not considered in this overview.

Next-generation technologies on the horizon

Li-ion batteries have improved dramatically over the past 25 years, enabling improved performance in consumer electronics and the introduction of new applications such as drones and EVs. However, to accelerate these and other applications, new innovation is vital – a step-change in performance is required.

As table 3 below demonstrates, there are still major unmet needs in each application – such as:

- Cost, reliability and charging time for EVs
- Cycle lifetime and cost for high-frequency stationary battery energy storage
- Safety across multiple applications

Table 2: Summary of key needs per application in battery energy storage

<table>
<thead>
<tr>
<th>Application</th>
<th>Key needs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulation/</strong></td>
<td>Peak shaving</td>
</tr>
<tr>
<td>stabilization of:</td>
<td>Load shifting</td>
</tr>
<tr>
<td>– Frequency</td>
<td>Self-supply &amp; TOU</td>
</tr>
<tr>
<td>– Voltage</td>
<td>Congestion avoidance</td>
</tr>
<tr>
<td>– Renewables</td>
<td></td>
</tr>
<tr>
<td><strong>Low cost per cycle</strong></td>
<td>High energy</td>
</tr>
<tr>
<td><strong>High power</strong></td>
<td>Low cost per cycle</td>
</tr>
<tr>
<td><strong>Fast charging</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Low capital cost</strong></td>
<td>Uninterrupted power supply</td>
</tr>
<tr>
<td><strong>High energy</strong></td>
<td>Black start</td>
</tr>
<tr>
<td><strong>Frequency response</strong></td>
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<tr>
<td><strong>Uninterrupted power supply</strong></td>
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</tr>
<tr>
<td><strong>Black start</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Low capital cost</strong></td>
<td>Low capital cost</td>
</tr>
<tr>
<td><strong>High energy</strong></td>
<td>High energy</td>
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<tr>
<td><strong>Low</strong></td>
<td></td>
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<tr>
<td><strong>High</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Length of discharge</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: Arthur D. Little analysis


Table 3: Summary of key needs per application in battery energy storage
A lot is happening in next-generation technologies. A host of battery technologies using alternative materials are being developed by ambitious start-ups, while there is increasing innovation within the Li-ion space primarily focusing on three areas: silica anodes, advanced cathodes and solid-state electrolytes.

Silica has higher energy capacity than graphite, the normal material for anodes. This is leading to it being blended through graphite anodes, with the aim of eventually moving towards full silica anodes. These can offer theoretical increases in energy density of up to 40 percent. However, for this to happen, issues in cycle lifetime have to be overcome, in which the anode pulverizes itself upon its 300 percent volume expansion while charging. Ongoing innovations use only minor silica concentrations, limiting potential density increases to 10–20 percent.

Many advanced-cathode chemistries exist that have higher energy capacities and voltages, such as lithium nickel manganese oxide (LNMO). These high-voltage cathode materials are currently facing issues with the liquid electrolyte used in common battery systems, which breaks down at voltages above 4.5 V.

The third and strongest contender for innovation is a solid-state electrolyte. This replaces the current electrolyte system that is made of organic solvents, dissolved lithium salts and polyolefin...
separators by one thin, ion-conducting membrane. It is often seen as one of the technologies with the most disruptive potential inside li-ion, unlocking the use of new cell components and delivering four benefits:

1. A solid-state electrolyte makes the safe use of pure lithium anodes possible, readily increasing the energy density of a cell by 40 percent.

2. It unlocks new types of cathodes. The oxide-based solid-state electrolyte no longer breaks down at 4.5 V, allowing the use of 5 V cathodes and further increasing the energy density by 10 percent.

3. It enables a new class of conversion cathodes such as sulfur and oxygen, enabling even larger potential increases in energy density. Lithium-sulfur systems have long been produced by companies such as Sion power; however, they suffer from cycling issues due to polysulfides shuttling through the separator to the anode. This is one of the many possible problems that solid-state electrolytes may solve.

4. Improved battery safety – perhaps the largest benefit. Using a solid material instead of a flammable liquid electrolyte prevents the formation of dendrites (lithium slivers living in the electrolyte that can cause internal battery short circuits, which lead to meltdowns) and makes electrolyte leakage impossible (avoiding potential self-ignition). Increased cell simplicity might potentially also lead to decreased costs. Given that safety is one of the primary priorities of virtually all big players, even a slightly higher initial cost of this new technology might be worth their investment.

Given these factors, it is no surprise that the perceived benefits of solid-state electrolytes are of large interest to battery manufacturers as well as users. This is demonstrated by the large amount of well-funded start-ups, investment activity, M&As, and research work/patent filings. Examples include:

- Recent ~$100m acquisitions of the start-ups Seeo and Sakti3 by Bosch and Dyson, respectively
- News from companies including Samsung, Toyota and Bosch, which claim they will be able to produce solid-state batteries before 2020
- Several ~$100m start-ups active in solid-state, with prominent VC and CVC investors including Khosla Ventures (into QuantumScape, Sakti3, Seeo), Kleiner, Perkins, Caufield & Byers (into QuantumScape, Ionic Materials), General Motors and Volkswagen
- Increased research activity and patent filing by large corporates (880 filings in 2015 alone)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Patents filed (2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid electrolyte</td>
<td>1,200</td>
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<tr>
<td>Solid-state electrolyte</td>
<td>880</td>
</tr>
<tr>
<td>Metal-oxide cathode</td>
<td>830</td>
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<tr>
<td>Lithium-air</td>
<td>700</td>
</tr>
<tr>
<td>Lithium-sulfur</td>
<td>565</td>
</tr>
<tr>
<td>Separator</td>
<td>365</td>
</tr>
<tr>
<td>Silicon-based anode</td>
<td>290</td>
</tr>
<tr>
<td>Recycling</td>
<td>35</td>
</tr>
</tbody>
</table>
While there is extremely high potential demand for battery technologies in emerging markets such as EV and BES, the over-riding driver for success is cost. This has led to a concentrated focus on bringing down the costs of Li-ion batteries, such as by scaling up manufacturing, which has brought down prices further than many analysts expected.

Lowering Li-ion prices is a double-edged sword. It helps meet existing demand, but lengthens the commercialization time of new technologies, as they have to reduce costs further in order to cross the "valley of death" (the time between the R&D stage and becoming commercially cost-competitive with current technologies). In turn, this potentially holds back the longer-term innovation that battery-driven markets require.

Based on its analysis, Arthur D. Little predicts that one of three possible scenarios will dominate the mid-term battery technology industry:

1. The current generation of Li-ion prevails
   Likelihood: medium probability
   This scenario assumes a situation similar to that which happened in solar panels – the prevalence of one single technology. As with solar, massive investments in huge manufacturing facilities will further lower the costs of current-generation Li-ion technologies. At these price levels, other existing technologies will not be able to compete, while new innovations will not be able to cross the technological valley of death. Therefore, current Li-ion will become the technology of choice for the majority of manufacturers due to its good balance of technical properties and price.

   However, even despite the huge increase in production capacity of the current Li-ion technology, we do not see this scenario as very likely, for two reasons:
   - Batteries have very diverse applications: certain niche applications for which the willingness to pay is high (such as electronic devices) will drive new technological innovations, and these could later spread to mass-market applications.
   - Further cost reduction will require performance improvements: the recent massive manufacturing scale-up has significantly reduced production costs. To further reduce costs, the focus needs to shift to improving the performance of batteries to make them cheaper on a cost/kWh basis. This cannot come from incremental development, but requires a step-change.

2. A new Li-ion generation emerges
   Likelihood: highest probability
   Essentially, the current generation of lithium-ion technology will keep its dominant position, but eventually, next-generation Li-ion technology will attract sufficient investment to make it a viable alternative.

   We believe this scenario is most likely for three reasons:
   - The current generation of Li-ion technology is hitting its theoretical limits.
   - The development of EVs and consumer electronics are creating further “pull” for better solutions that could be potentially addressed by technologies early in the development pipeline.
   - Applications such as high-end consumer electronics provide attractive markets with their willingness to pay for higher performance, enabling next-generation Li-ion to establish itself before targeting mass-market applications.

   The hottest candidate, the solid-state electrolyte Li-ion battery, will need to surpass multiple challenges besides finding a safe pathway through the cost valley of death. Even when solid-state batteries enter the market in niche applications, current lithium-ion batteries will most likely be produced to cater for the bulk of applications for another 10–15 years.

   We expect solid-state electrolyte batteries to start in high-end consumer electronics, in which the willingness to pay for increased energy density is relatively high and development cycles relatively short. Thereafter, the technology will gradually spread to the majority of other applications, such as EV and grid storage, for which development cycles are typically much longer due to stricter requirements around cycle and shelf lifetime. Alternative technologies, such as flow and zinc-air batteries, will only occupy certain niche applications with very specific requirements. In the energy sector, a range of other
technologies will coexist, depending on the application and driven by the less strict requirements on size and space for stationary systems.

3. Unforeseen technology steals the show

Likelihood: low probability

This scenario sees a completely new technology developed (outside lithium-based batteries) that will have such promising potential that it will attract sufficient capital and become a dominant alternative to existing Li-ion technologies.

As of now, there is no truly viable battery technology with sufficient potential to replace currently dominant Li-ion batteries across all applications. Lithium is the lightest metal around, with the lowest electrochemical reduction potential, making it clearly the most suitable charge carrier for high-performance batteries. Only in grid-storage applications do low-performance and low-cost technologies have potential applications. In EVs, no other battery type stands a chance, which makes only hydrogen fuel cells the only long term threat.
4. The impact for current and future battery players

As our report shows, the battery technology market will remain highly dynamic, delivering both major rewards and large-scale risks over the coming years:

- Tomorrow’s winning innovators should benefit from continued, ongoing growth and have the potential to create tremendous value. However, high entry barriers in current-generation Li-ion markets will prove almost insurmountable to new entrants, while some consolidation among established players seems likely.
- Next-generation technologies show major promise. Despite some industry skepticism, we believe that over time they will eventually replace some, if not all, current-generation Li-ion batteries.
- Improved battery technology performance, especially in areas such as cost and energy density, will make batteries suitable for mainstream applications (such as in cars, cordless devices and grid storage) and in new, high-end uses (e.g., in aviation and military).

- However, some of the much-touted (and heavily invested-in) next-generation technologies will fail to live up to expectations.

Every part of the ecosystem and value chain faces different risks and opportunities. The ecosystem can be broadly broken down into companies that are providers of materials and technology (e.g., chemicals companies, cell and pack manufacturers) and those that are users of battery energy storage (such as automotive OEMs, electronics firms and utilities). And while there are already many established players in both categories, the enormous growth promise of the battery market will remain a strong magnet to new entrants – which will generally have more options but also a longer road ahead than current players.

Where does it leave each one of these groups? Figure 8 below provides an overview of our recommended high-level strategies:

Figure 8: Strategies for battery stakeholders

<table>
<thead>
<tr>
<th>What any company should do</th>
<th>Strategies that depend on the type of company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery value chain</td>
<td></td>
</tr>
<tr>
<td>Providers</td>
<td>C</td>
</tr>
<tr>
<td>A</td>
<td>Define critical performance tipping points</td>
</tr>
<tr>
<td>B</td>
<td>Develop conditional technology and product roadmaps</td>
</tr>
<tr>
<td>C</td>
<td>Define critical performance tipping points</td>
</tr>
<tr>
<td>D</td>
<td>Invest in relevant next-gen “knowledge stakes”</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Arthur D. Little analysis
For all companies in the battery space, three generic high-level strategies are of key importance:

- Managing IP is becoming more important than ever, and not just in protecting licenses to operate. Cross-licensing and co-patent ownership are on the rise, and industry convergence is bringing together companies with very different IP maturity and capacity, such as traditional chemical companies, automotive OEMs and connectivity players. (See Arthur D. Little’s Prism article, “IP management 4.0”)

- Success relies on defining an innovation ecosystem strategy with key research partners, keeping it updated and pursuing it decisively.

- As with any other breakthrough technology, there is always a distinct chance that companies bet on the wrong horse. There is no easy way out on this one but creating a portfolio of options along strategic “competence platforms” is usually a good idea. And last but not least, companies need to ensure that they have the stamina and appetite for risk to continue to do what it takes to win.

- In addition, there are strategic requirements that depend on the strategic importance of batteries for the business, and of the position in the value chain. We distinguish four company situations:

A. Providers with emerging or optional interests

Given the innate conservatism of the battery market, it is futile to enter by offering current-generation technology. Companies are unlikely to switch suppliers unless there is a really good reason to do so (e.g., a price or performance impact of +10 percent). Instead, these new entrants should focus on investing in next-generation technologies. As these are expected to be costly at first, building a strong position will generally start in a niche in which the relative willingness to pay is high for high-performance products. Good examples include Bosch and Dyson, which are directly stepping into advanced solid-state batteries expected to be used in high-end applications. Other options are skipping Li-ion technology completely and launching into other promising technologies such as flow batteries, as witnessed in the cases of Foxconn and Jabil.

B. Providers with established or locked-in interests

Those already active in the battery field should focus on two main themes – relentlessly reducing costs in current-generation technology while innovating by looking for disruptive technology.

Many in the industry believe that current-generation lithium-ion battery is the only feasible technology and no challengers will emerge soon. This feeling has grown thanks to the failure of other battery chemistries (e.g., the sodium-ion battery Aquion) and insufficient breakthroughs in the area of solid-state technology, despite years of focus and investment. While we agree that most other battery chemistries have limited full-scope market impact, we do believe that next-generation solid-state lithium-ion batteries are closer than many industry experts believe. This should be of concern to any established player in the battery field – they should understand strategic scenarios that would allow them to extract maximum value from these new technology trends.

C. Users with emerging or optional interests

Battery performance is continually improving, while costs are becoming ever lower, on both a capital-cost and a levelized-cost basis. This unlocks many new opportunities in a wide variety of applications. Obvious examples include grid storage and EVs, which are gradually becoming cost-competitive with alternatives. However, less obvious examples also exist, such as garden tools shifting from traditional petrol engines to batteries and drones suddenly becoming feasible. Companies should be aware of how a “perfect battery” can impact their businesses and monitor battery price and performance characteristics to see when the tipping point has been reached. Active monitoring is vital, as battery price developments continue to exceed industry expectations year after year.

D. Users with established or locked-in interests

For current users, closely monitoring the evolution of battery characteristics is also of concern. Evolution in current lithium-ion technology is already supplanting other technologies, as it is happening to sodium-sulfur batteries in grid storage. To remain competitive, these users should keep abreast of current battery evolution, and actively invest in next-generation knowledge stakes (know-how, patents, etc.). When the time comes, they should be prepared for next-generation activity, ensuring that they have strong bargaining power when the time comes to secure the best partnerships and supplier contracts.

To maximize their chances of success, we believe that organizations need to start their strategic thinking by focusing on these five questions:

1. Where is the greatest future value creation for my company, and how can I access it?
2. What is the battle that my company needs to win – and what do I leave to others?
3. How do I then stitch together a fitting ecosystem of customers, partners, etc.?
4. Which part of my company will I need to build or transform to make this happen?
5. What, then, are the major uncertainties and risks, and how do I mitigate these?
5. Reference section – battery technology in detail

Following the invention of the first rechargeable battery over 150 years ago, research has led to the wide range of technologies that are now used today. However, each technology has its own strengths and weaknesses – product/technology designers therefore need to choose wisely for their particular applications.

Before discussing each technology, it is important to understand key terms:

- A battery pack consists of battery cells (as you would find in your TV remote control) and a battery management system, which regulates.
- A battery cell consists of multiple components, such as electrolyte fluids and electrodes, which can differ in chemistry, yielding different battery characteristics. This report focuses on battery components and cells.

<table>
<thead>
<tr>
<th>Property</th>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital cost</td>
<td>EUR/kWh</td>
<td>Upfront cost to buy a battery (excluding O&amp;M)</td>
</tr>
<tr>
<td>Safety</td>
<td>-</td>
<td>Resistivity against thermal runaway</td>
</tr>
<tr>
<td>Cycle lifetime</td>
<td># of cycles</td>
<td>Amount of cycles a battery can be discharged from 100% to 20%, until capacity fades to 80% of its original capacity</td>
</tr>
<tr>
<td>Energy density</td>
<td>Wh/kg or Wh/L</td>
<td>Amount of energy which a battery can hold, measured by weight or volume</td>
</tr>
<tr>
<td>Power density</td>
<td>C-rate</td>
<td>Rate at which a battery is discharged relative to its maximum capacity</td>
</tr>
<tr>
<td>Charging time</td>
<td>C-rate</td>
<td>Rate at which a battery is charged relative to its maximum capacity</td>
</tr>
<tr>
<td>Reliability</td>
<td>-</td>
<td>Ability to operate in low temperatures or in extreme conditions</td>
</tr>
<tr>
<td>Others</td>
<td>-</td>
<td>Others properties, such as maintenance costs, shelf lifetime, self-discharge, or charging efficiency</td>
</tr>
</tbody>
</table>

To shed more light upon the complex battery space, Arthur D. Little has developed a framework consisting of seven key performance indicators (Table 4). Arthur D. Little uses this framework to assess the different technologies that currently exist, and to show where the burning unmet needs lie from the application perspective.

1. Lead-acid batteries

The grandfather of rechargeable batteries, lead-acid batteries, was the first rechargeable batteries ever made. While their technology is outdated, they have stood the test of time and are still one of the most widely used types today. Their popularity is due to their low capital cost and ability to operate efficiently even at low temperatures, which often trumps their low energy densities and low cycle lifetimes.

There are two main families of lead-acid batteries. The flooded type has optimal capital cost, dropping as low as $60/kWh for large systems, which is less than one-third of the current capital cost of the lithium batteries used in most EVs. However, its downsides are its low cycle life, low charging rate and maintenance requirements, in which the battery has to be topped up with water to remain “flooded”. The second family, sealed batteries, applies a slightly more advanced design that does not require topping up with water. This eliminates maintenance costs and increases cycle lifetime, but doubles capital costs.

2. Lithium-ion

Lithium-ion (Li-ion) batteries have gained enormous attention in the past decade. While already commercialized in 1991, constant marginal improvements in cost and performance over the past 25 years have unlocked a host of new applications, making breaking news related to batteries a common sight.

The rapid decline in costs is mainly the result of two underlying drivers:

1. Massive increase in scale across all steps of the manufacturing value chain
2. Increase in performance of cells, making new cells cheaper on a cost/kWh basis

The constant search for more powerful battery components has now led to a wide breed of Li-ion battery compositions. While a
perfect battery still remains a work in progress, different variants of the battery’s three main components (anode, cathode, and electrolyte system, Figure 9) lead to specific strengths and weaknesses. In current systems, the cathode limits the power, while the charging is limited by the anode.

Cathode chemistry

Current Li-ion batteries are commonly classified by their cathode chemistry. Five solutions are currently available:

- LCO (lithium cobalt oxide) is the most mature cathode chemistry, which made the commercialization of Li-ion possible. It produces cells with the highest volumetric energy density, but with a downside of low power density and low cycling ability. Cost is proving to be an ever larger issue, as the cathode is entirely made of cobalt. Current innovation efforts are focused on squeezing the last drops out of the battery’s performance by increasing the voltage and energy capacity of the material. Arthur D. Little believes that unless a better alternative comes around (such as solid-state batteries with new cathode types, see below), this technology will remain the cathode of choice in consumer electronics for two reasons: it has the highest volumetric energy density, and willingness to pay is generally higher in these applications.

- LFP (lithium-iron phosphate) batteries take a different approach. The cathode is made out of more abundant iron and phosphate, leading to a lower raw material cost. However, cells produced with LFP have low energy density due to LFP’s inherent low voltage and low energy capacity, eventually making it a more expensive cell when measured on a cost/kWh basis. The cathode material is still favored for its rigid olivine structure, which gives the...
material its extremely high power and high cycle lifetime. This technology is already very near its maximal theoretical performance, giving little room for further improvements besides cost cutting. The cheap LFP production path of using rotary kilns has dramatically grown the Chinese battery industry. Now that other technologies are evolving, higher-performance materials are gradually replacing LFP in applications such as EVs, leaving the market flooded with an overcapacity of cheap LFP. In contrast, high-performance LFP, commonly produced by hydrothermal methods, will maintain a strong position in applications requiring high power (e.g., HEVs and power tools) or high cycle life (CEVs, grid storage).

- **NCA** (lithium nickel cobalt aluminum oxide) is a high-energy cathode material. The current focus is to increase the nickel content further, resulting in higher energy density and simultaneously reducing cobalt usage, effectively bringing down the cost/kWh in two ways. NCA is primarily used by Tesla, while all other EV makers use NCM. (See next bullet point.) That dates back to when Tesla produced its first Roadster (2005). It needed a cheap, high-energy-density cell, and at the time, NCA was the only option, as NCM would not be commercialized until 2009. Tesla is most likely to keep using NCA in its current development cycle, as it is accustomed to using it in a supplied cylindrical cell format provided by Panasonic. However, Tesla has already switched to NCM for energy-storage applications, hinting that a future switch for EVs could soon take place.

- **NCM** (lithium nickel cobalt manganese oxide) is a diverse material dependent on the stoichiometric balance between the nickel, cobalt and manganese. An even ratio (called NCM 1-1-1) is suitable for high-power applications, while higher nickel contents (5-3-2 or 6-2-2) provide higher energy density and simultaneously reduce dependence on cobalt. These are two important reasons the industry is trying to commercialize the nickel-rich NCM 8-1-1 – major producers were expecting to have the first solutions to market early 2018. NCM will remain the cathode material of choice for nearly all EV manufacturers (besides Tesla) until superior 5V cathode materials can be used. Even then, NCM will continue to be used for another five to seven years due to the automotive industry’s long and conservative development cycles. NCM will also be the occasional choice in other applications, such as energy storage, HEVs and e-buses.

- **LMO** (lithium manganese oxide) is similar to LFP, as it can deliver high power and lacks energy density, but is two to three times cheaper. The main issue that prevents its mass adoption is its low stability, as demonstrated by Nissan’s recent shift away from using the technology due to continued battery malfunctions.

This short overview is not exhaustive. Besides the technologies mentioned above, different manufacturers are testing and pushing other solutions, such as pure nickel LNO (lithium nickel oxide) cathodes, manganese-rich NCMs and a host of 5V cathodes.

**Figure 11: Material market projections**

<table>
<thead>
<tr>
<th>Cathode active material market size</th>
<th>Electronic devices</th>
<th>xEV</th>
<th>xEV China</th>
<th>E-Bus</th>
<th>BES</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NCM</strong></td>
<td><a href="#">Graph</a></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>NCA</strong></td>
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<tr>
<td><strong>LCO</strong></td>
<td></td>
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<tr>
<td><strong>LMO</strong></td>
<td></td>
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<tr>
<td><strong>LFP</strong></td>
<td></td>
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</tr>
</tbody>
</table>

Source: Avicenne (2017), Arthur D. Little analysis
Cathode materials including LNMO (spinel type lithium nickel manganese oxide).

Anode chemistry

- **Carbon-based** anodes have been favored since the first commercialization of Li-ion batteries, as they are cheap and have high energy capacity and low voltage versus lithium ions. Multiple subcategories of carbon-based cathodes bring different trade-offs: amorphous carbon has slightly lower energy density but higher charging power when compared to graphite, while silica composites have higher energy but suffer from lower cycle lifetime due to the large volume expansion of silica upon charging. Currently, carbon-based anodes are the mainstream technology, and we do not expect them to be replaced in the near future, until disruptive technologies such as pure lithium and pure silica anodes are commercialized. The current major focus and challenge of carbon-anodes R&D is increasing the silica content while maintaining cycle life.

- **LTO** (lithium titanate oxide) anodes can charge extremely fast, enabling a battery cell to reach full charge in five minutes. On the downside, the anode is expensive and has low energy capacity and high voltage versus lithium ions, resulting in a low voltage cell with low energy density and extremely high capital costs on a $/kWh basis. Its high cycle lifetime, however, can partly compensate for this on a cost-per-cycle basis.

Electrolyte chemistry

The last part of the battery is the electrolyte system. This facilitates the transport of lithium ions from the anode to the cathode. Typically, the transport medium is made of organic solvents with dissolved lithium salts, with a polyolefin membrane between the electrodes (the separator). The separator is a critical element defining the safety of the battery, as it prevents dendrites (metal slivers) from growing from the anode to the cathode. When the separator breaks down, these dendrites form an internal bridge between the electrodes, which shorts the circuit, followed by a thermal runaway (an irreversible meltdown).

This makes the separator the Achilles’ heel of every battery – one that led, for example, to the $5bn recall of millions of Samsung Note smartphones in 2016.

3. Others

Besides the major lead-acid and Li-ion battery types, other technologies are either currently used on a large scale or expected to take significant market share in the future.
Flow batteries are an emerging technology that provides an exceptional lifetime of up to 100,000 cycles. This is more than adequate for their typical application of bulk storage systems, which are designed for an average of two charging cycles per day over a lifetime of 20 years, totaling ~15,000 required cycles.

Flow batteries have two distinct categories – pure flow batteries with all active components stored separately from the cell, and hybrid flow batteries, in which one of the active materials is stored inside the cell. There are further differences based on the types of flow or materials used. Currently, the most mature technologies within pure flow batteries is the vanadium-redox flow battery (VRFB) and the zinc-bromine flow battery (ZBFB) within the hybrid flow category.

While similar in cost, VRFB has a longer cycle life and higher relative energy efficiency. ZBFB technology has higher cell voltage and energy density, but at the cost of high self-discharge rates (up to 33 percent per day) and the risk of dendrite formation.

In general, as flow batteries mechanically pump around highly acidic anode and cathode solutions, they have two drawbacks:

1. Decreased round-trip efficiency
2. Increased need for maintenance

Due to the extremely low energy density (lower than lead-acid), the systems can only be used for stationary purposes. The technology is still in its early stages of maturity, and large manufacturing companies such as Foxconn, Flextronics, and Jabil have only very recently entered the market through partnerships with innovative pioneers. The manufacturing scale-up provided by these players could bring costs down fast enough to unlock a competitive position in the battery energy storage (BES) market.

Sodium-sulfur technology’s high power and energy density, combined with high cycle life, made it one of the most popular large-scale battery storage systems in the past. These characteristics often forgave the operating costs of ~10–20 percent of initial capex p.a. required to keep the system at its 300–350°C operating temperatures. Today it is rapidly losing market share to Lithium-ion, as it struggles to keep up with the massive decreases currently being seen in Li-ion costs.

Nickel-based batteries, once favored for their safety, power and energy, have been replaced by Li-ion batteries in most applications. Originally both Toyota and Boeing invested heavily in using nickel-based batteries for the Prius and older version of the 787 but both companies have now switched to Li-ion-based technologies.

Many other battery technologies exist, which are based on other charge carriers such as sodium-ion, magnesium-ion, zinc, and aluminum. All of these materials are abundant and cheap, but in order to become a viable market option, the technologies need to be able to cross the treacherously deep valley of death – scaling these technologies to competitive levels as currently found in Li-ion requires investments of hundreds of millions of dollars.

These low-cost chemistries generally only appeal to the bulk energy storage market, in which cost is the one and only driver (as opposed to the expensive, high-performance chemistries that can occupy niche areas in the market). This makes manufacturing scale a necessity, a risk fewer and fewer investors are ready to make after a history of bankruptcies in this area.

A recent example is Aquion, a sodium-ion-based battery start-up, which went bankrupt after receiving $190m of funding. With proven technological capabilities and first large-scale orders delivered to its customers, it pulled the plug due to the massive cost reductions in Li-ion.

One possible candidate with sufficient potential to give Li-ion a run for its money is zinc-air technology. Multiple start-ups such as EoS and ZAF Energy Systems are raising millions from venture capitalists, starting pilots with larger utilities such as Con Ed and Engie, and claim to be able to reduce the cost down to $95/kWh by 2020.

Authors
Kurt Baes, Michael Kolk, Adnan Merhaba, Florence Carlot and Yuma Ito

www.adl.com/Futureofbatteries
Agility in managing electricity grids: The case for batteries

Kurt Baes, Florence Carlot, Robin Francis, Adnan Merhaba

Abstract

The deployment of renewable energy over the last decade has created unprecedented challenges for the planning and operation of power systems. Consequently battery-storage technologies have attracted great interest, as they allow utilities and network operators to adopt a flexible and adaptable approach to managing the electricity grid, balancing supply and demand. In this article we particularly examine the potential future role that batteries might play in grid management, and explore the drivers and barriers to greater battery storage use in major markets. We also highlight how this represents new opportunities for industrial companies and investors.

Introduction

The electricity grid is in a state of flux. Low-cost renewables and the increased use of distributed energy generation represent profound challenges to the operation of a grid built on the assumption of power being provided predominantly by large, centralized generation sources, and consumed as soon as it is produced. In particular, the old model of stable baseload power being supplemented by gas and hydro for peaks in demand is giving way to a world where renewables predominate, supported by other, flexible generation assets for when the sun isn’t shining or the wind not blowing. The severe pressures on power utilities in Europe and elsewhere (and their share prices) reflects the magnitude of this transition.¹

To confront the challenge of maintaining a reliable and affordable electricity supply while also providing acceptable returns to shareholders, utilities and network operators must adapt their business models, technology portfolios, and approaches. In particular, they must become more agile, being both flexible and adaptive in how they develop, deploy and manage grid assets.

Energy storage is seen as one key tool for improving the flexibility and adaptability of the grid, for example, by smoothing the output from renewable sources and storing energy in times of high generation for later release, when demand is strong. When it comes to storage, battery technologies have attracted particular interest due to their scalability, efficiency and rapid response. Additionally, there are strong synergies between battery use for energy storage and in other applications such as electric vehicles and consumer devices. However, there are barriers to the implementation of battery storage, such as regulatory uncertainty, commercial arrangements, technology maturity and associated costs.

In this article we examine the potential future role that batteries might play in the management of the grid in different geographies, based on a recently published, multi-client ADL study. We explore the drivers and barriers to battery storage, trends in major markets, lessons for market players and potential business case for batteries for industrials and investors.

**Batteries for grid storage: drivers for use**

Grid battery storage remains a small business today, with less than 1 GW deployed (the equivalent of enough capacity to power 725,000 homes). Nevertheless, several recent developments clearly demonstrate that the sector is taking off:

- Within four years the world’s biggest storage-capacity project in Los Angeles will be delivering over 100 MW for about four hours at peak periods
- In European countries such as Italy and the UK, national transmission service operators (TSOs) are undertaking trial deployments of storage technology, and learning lessons from a technical and commercial perspective

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2See: “Battery storage: Still too early?” January 2017
M&A activity is increasing; for example, Total’s recent acquisition of Saft.

Companies such as Tesla and LG Chem are building huge “gigafactories” to supply burgeoning demand, at least partly from the grid sector.

There are a number of specific drivers for the increased interest in battery storage:

- **Rising renewables penetration** – As the percentage of renewable generation grows, there is an increasing need for flexible capacity that is able to step in/out at short notice (seconds to minutes) due to fluctuating, unpredictable power generation in the network.

- **Increasing decentralization** – As the grid shifts towards distributed generation, there is pressure on the distribution network to accommodate this new and unpredictable generation capacity, especially since much distributed generation is “unplanned” and out of the control of the grid TSOs and distribution service operators (DSOs).

- **Tight flexible-capacity markets** – In many electricity grids, capacity margins have reduced, reflecting low flexibility in the system to accommodate intermittent renewables, and relatively lower capacities of firm supply buffers to be used in case of need on the grid.

- **Poor security of supply** – In some parts of the world aging and/or inadequate grid infrastructure means security of supply is not as high as it should be. This increases the attractiveness of batteries that can “back up” the grid during outages.

- **Rising peak-trough spreads** – Increasing quantities of “must-run” renewables can lead to periods during which supply exceeds demand, leading to very low or, in extreme cases, negative wholesale power prices. Conversely, lack of renewable generation (such as on non-windy nights when solar and wind assets are not active) coupled with high demand can lead to very high prices as expensive back-up generation is pressed into service. Batteries can smooth these peaks and open arbitrage opportunities, in which revenues are generated from charging/buying electricity during low-price periods and selling/discharging during high-price periods.
• **High retail electricity prices** – In some geographies, such as Germany and Japan, high retail electricity prices encourage the storage of self-generated energy (such as from solar) for later use.

• **Cross-industry synergies** – Batteries are, of course, used in many other applications, particularly in consumer electronics and, increasingly, battery-electric vehicles (BEVs). There are strong synergies across these applications in terms of technology performance (in which lithium-ion – Li-ion – technology, in particular, is applied across all three), production (in which volume growth and manufacturing optimization help to drive cost reductions), and usage (most obviously between grid storage and BEVs, in which BEVs can feed back to the grid in times of high demand and charge at times of low demand).

From this list we believe the key factors driving the attractiveness of battery storage are renewable penetration (grid and distributed) and the flexible-capacity margin, which is the proportion by which the total expected firm available generation exceeds the maximum expected level of electricity demand.

A selection of countries have been mapped against these two drivers, allowing the identification of countries with high potential for battery deployment, in Figure 1. Broadly, these fall into two categories:

• Countries with high renewables penetration and moderate capacity margins (Archetypes I and II in Figure 1). Germany is the classic example, although Spain, Portugal and Denmark share similar characteristics. Germany has seen a booming residential-storage market, partly due to policy measures to promote hybrid distributed systems (photovoltaic solar [PV] + batteries). However, the industrial and commercial sectors have so far lagged behind due to an unfavorable regulatory regime and high interconnectedness with neighboring markets.
• Countries/regions with moderate renewables penetration but low firm-capacity margins (Archetypes III and IV in Figure 1). The prime example here is the United Kingdom, although California, Belgium and Greece demonstrate similar characteristics. Recognizing the potentially key role that batteries may play in supporting grid operation, the United Kingdom has begun to make changes to the policy and regulatory landscape to further support the deployment of batteries. National Grid (the UK TSO) foresees the deployment of 1 GW of non-pumped storage by 2020, providing that regulatory barriers are removed.

Figure 1: Regional archetypes
Challenges to the use of batteries

While the benefits of deploying battery technologies for grid management are clear, so far there has been very limited development of the grid-battery market in Europe. Why is this? We see three main reasons: cost, regulations, and alternatives.

1. Cost

The costs of batteries are too high for most grid applications to be viable at present, other than where local regulations incentivize deployment. Typical ranges for battery costs by energy stored and power delivered are shown in Figure 2.

![Figure 2: Battery costs and performance](image)

However, the cost of batteries is reducing sharply. The industry has invested heavily in battery technologies that can also be used within electric vehicles and consumer electronics, such as lithium-ion technology. The cost of lithium-ion battery packs is reducing by 10–15% per year, and if this pace of development continues, they will fall to $100–150/kWh by the early 2020s. At this point many grid applications will become economically viable.
2. Legislation and regulation

At present, in most countries regulatory barriers prevent the deployment of battery storage on grid, except in Italy, where the regulatory framework has been amended. System operators are therefore restrained from developing battery-storage solutions beyond pilot projects because of the regulatory definition of battery storage and the role the regulator expects the system operator to play. The development and ownership of batteries by TSOs certainly raise questions about market distortion and the funding of regulated monopolies, but there seems to be a clear case for their deployment in this way, in markets where conditions are not appropriate for commercial deployments.

It is therefore imperative that clear regulatory frameworks and market mechanisms are established to allow the development of storage assets, with clear targets for deployment. For example, California’s Public Utilities Commission requires utilities to build energy-storage capacity and has clarified the market rules for battery aggregation. Following these moves, Southern California Edison (SCE) bought 261 MW of energy storage by the end of 2014.

Finally, there is a strong argument for providing direct incentives for use of battery storage to catalyze their development and bring costs down, which has worked in the renewables sector. The strong influence of regulation can be seen by contrasting Germany and Spain, two European countries with relatively high renewables penetrations. In Germany the residential storage market is booming because of the incentives provided (such as 30% investment grants and low-interest loans), reducing stress on the grid. In contrast, battery deployment in Spain remains very limited.
3. Alternatives to batteries?

Batteries are far from being the only option for balancing supply in a distributed energy grid with high renewable use. Other important options include interconnectivity, fast-ramping fossil-fueled plant, demand-side response, and other storage technologies.

Interconnectivity
Good regional and international interconnectivity helps in two ways. Firstly, the intermittency of renewables decreases over large areas – it is always sunny or windy somewhere. Secondly, integration over a large area allows for a greater mix of power sources to be utilized. For example, the proposed 1.4 GW UK-Norway interconnector will allow the UK to import predominantly hydro power from Norway, while interconnectors to France can utilize the large amounts of nuclear power there. High interconnectivity is a major reason the German industrial and commercial battery sector has not yet taken off.

Fast-ramping fossil-fueled plant
Fast-start and rapid-ramp fossil-fueled plant has played a key role in meeting peak power-supply requirements for many years and will remain important in the future.

Demand-side response
Demand-side response (DSR) is a further emerging approach for balancing the grid. Demand response refers to the reduction of electricity demand in response to either price signals or automated controls. This is already established in the generation market and, to some extent, in the industrial sector. The business model of incentivizing end consumers to reduce their consumption or switch to “behind-the-meter generators” in response to grid requirements has been widely tested and enabled through regulatory changes. However, the extent to which operators could rely entirely on third-party response and replace assets with DSR has not been fully proven.
Other storage technologies

Other energy-storage technology options under development include compressed-air energy storage, thermal energy storage, and kinetic energy storage (such as flywheels). Pumped hydro storage is mature and will continue to be used where geographic conditions allow. Some companies are experimenting with local pumped storage in combination with renewable sources such as wind.

Battery storage: The case for network operators and utilities

There remains considerable uncertainty in the details, timing and extent of the role batteries will play in grid management. How then should network operators and utilities position themselves to take advantage of the opportunities presented and react to changes in the marketplace? In our view it is essential for industry participants to adopt an agile approach. We see the key lessons as:

- **Adopt a flexible approach to the business model and partnering** – New, more agile approaches and partnerships will be required to fully exploit the opportunities presented by grid battery storage. For example, utilities may contract with third-party aggregators of distributed storage assets to provide back-up for their renewable generation sources.

An extension of this is the virtual power plant (VPP) model, whereby a large number of generation and demand sources are aggregated into controllable power plants. The German, French, Belgian and UK markets have been incubating virtual power plants for the past five years. VPPs have started to become viable, and this evolution will accelerate as battery costs decrease and strong players such as Tesla enter the market.
• **Look to serve multiple applications from the same asset** – Given the challenge of developing a viable business case for a single application at present, a combination of applications is essential to stack revenue streams and build a positive business case.

For example, utilities and generators could use battery storage for a number of complementary applications:

- To decrease exposure to imbalance charges from renewables intermittency
- To optimize asset production and sales in the wholesale market based on market signals (arbitrage)
- To capture revenues from ancillary services and capacity mechanisms. For example, AES recently commissioned a 10 MW battery to provide fast-response ancillary services to EirGrid in Ireland
- To support industrial or consumer groups in avoiding system charges, where these are calculated based on consumption at peak periods, and negotiate to receive a portion of these savings.

• **Develop a portfolio of storage assets and technologies** – Although Li-ion looks to be the most likely technology to succeed, at this point it is not clear which battery technology will win for most grid applications. Market players should look to develop a portfolio of assets and technologies, and not be tied to one particular technology approach. This is the model that Terna (the Italian TSO) followed by testing multiple technologies for similar applications.

Moreover, it is not just about the battery technology. Other technologies, such as sensors, communication and software (for example, for modeling and prediction), and generation will also be important. E.ON, for instance, released its home storage system combining PV, storage, app and tariff in Germany in April 2016.

• **Use storage as a differentiator** – Utilities can leverage batteries as a differentiator in the retail market and a provider of flexibility services to TSOs. Engie is developing its 20 MW / 20 MWh energy-storage park in Belgium to provide R1
ancillary services, initially from different suppliers. It will then develop a pool of batteries that can be rented for applications such as industrial sites, for which it can provide demand response. Benelux utility Eneco has been supplying the Tesla Powerwall to its customers since the start of 2016. It then expanded its services to CrowdNett with the support of Tesla, SolarEdge and Ampard, whose software allows the remote control of residential batteries, facilitating provision of ancillary services. In exchange for the use of 30% of the battery capacity, residential customers receive a guaranteed €450 in compensation over the next five years.

Battery storage: The case for industrials and investors

Industrials and large companies may have a truly compelling case to invest in battery storage, for various reasons:

- Need to cope with power-outage issues (especially in South Asia and Africa)
- Company commitment to sourcing 100% power from renewables (e.g., Google, Apple and Facebook)
- Paying high tariffs for their electricity (such as in Italy)

Industrials have the option of outsourcing their battery-storage operations to power utilities or aggregators, or collaborating with DSOs and TSOs, potentially earning extra revenues by providing ancillary services to the grid (such as voltage stability or black start).

While we see few applications of this business model to date, it can provide a particularly good alternative for system operators that have their hands tied regarding their roles in storage activities.

Battery storage is a relatively young industry, and such projects do not have track records of five or more years of real returns, which makes the bankability for storage a challenge. However, recently, Advanced Microgrid Solutions and Stem raised significant money for new storage project financing ($200mn and $100mn, respectively). This behavior is very similar to the caution demonstrated by investors in early solar projects. However, as more data, in terms of revenues and returns, becomes available from the storage projects under operation, investor confidence will grow.

The emergence of leasing models can also become attractive to different types of investors, as was the case for the meter industry, representing low risks for stable revenues.
Insight for the executive – Fast move for some, wait for others

Battery storage is a much-debated part of the energy market solution, with both energy majors and technology providers investing heavily into research, development and try-outs to create successful business cases. The challenge is not technology: differences in market and regulatory conditions can make identical solutions worthwhile or pointless, as economic viability is determined by the revenue and profit models within the regulated energy industry in individual markets.

We recommend that executives looking to invest successfully keep in mind these guidelines:

- Tailor the solution (technology, ownership, and revenue model) to the local market conditions, depending on:
  
  - Market characteristics (the amount of renewables penetration, degree of grid interconnectedness, regional electricity generation mix, electricity network topology and system size)
  
  - Regulatory framework (revenue models, operational requirements)
  
  - Incentives and commercial signals

- Explore how to benefit from a combination of applications, as it is essential today to stack revenue streams to build a positive business case

- Influence energy-market design (such as the definition of ancillary services, access to grid services and the possibility of stack services) to make the most of battery storage and enhance the business case

Deployment of battery storage by industrial and commercial customers is likely to remain limited in the short term (two to three years), given its current challenging economics. However, the most promising applications will be grid-scale storage, and investors increasingly have this opportunity on their radar. Indeed, for grid-scale applications, it is time for early adopters to make a move. Power utilities are stepping into the market, and a series of large-scale commercial battery-storage contracts have been announced over the last year. Even if it seems early for big asset investments at this time, it is key for industry players to prepare their strategies now and plan for “rapid deployment” tactics to later embrace the larger opportunities that are currently emerging.
Electric vehicles and electric utilities

*A clear opportunity with many shapes*

**Executive Summary**

While several stakeholders are supportive of the widespread adoption of electric vehicles, we have looked specifically at electric utilities to understand the opportunities that such a change in the transportation landscape can generate, and define the key questions to be addressed in order to embrace them. We have identified four business models – by no means evolutionary – that can be looked at independently, and eventually combined to fit the company’s strategy and the specific market conditions (e.g., regulation, competition, ecosystem, customer readiness). We strongly believe electric utilities are ideally positioned to leverage the opportunities offered by the adoption of electric vehicles on a mass-market scale, but they need to act fast, as many other players are addressing the same opportunity.
1. Demand for electric vehicles grows… and most likely won’t stop

We are in the middle of an EV revolution. Only a decade ago, vehicles with batteries and electric motors felt like a distant sci-fi dream. Today, they are shaping the lives of consumers and the strategies of car producers and governments, showing fast growth.

The global estimated number of EVs in 2016 was 2 million – a number led prominently by the US and China, with approximately half a million EVs each (Figure 1).

Figures for the future vary a lot, as shown in our comparison of several organization and their estimations (Figure 2).

Based on discussions with industry leaders, dedicated surveys, and analyses of market forces, regulations, and industry aspirations, we believe the global light-EV market will represent 5–16 percent of car parks until 2030, translating to 270 mn cars at the high end of the range. The large difference in our estimates comes from the uncertainty around adoption of favorable regulation at the city level, which can favor or curb the growth of EVs.

Figure 1: Growth in EVs led by the US and China

Countries included in the analysis are: Canada, Chile, France, Germany, India, Japan, Korea, Netherlands, Norway, Sweden, United Kingdom, United States, Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Iceland, Italy, Ireland, Latvia, Lichtenstein, Lithuania, Luxemburg, Malta, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Switzerland and Turkey
Figure 2: Scenarios on EV car park up to 2030

Scenarios on EVs’ car park up to 2030

Percentage expresses share of total car park

Cumulative OEMs announcements (estimate)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADL Disruptive</td>
<td>16%</td>
</tr>
<tr>
<td>IEA B2DS</td>
<td>13%</td>
</tr>
<tr>
<td>ADL Regulated</td>
<td>12%</td>
</tr>
<tr>
<td>IEA 2DS</td>
<td>10%</td>
</tr>
<tr>
<td>Morgan Stanley</td>
<td>7%</td>
</tr>
<tr>
<td>Bloomberg</td>
<td>7%</td>
</tr>
<tr>
<td>Paris Declaration &amp;</td>
<td>7%</td>
</tr>
<tr>
<td>ADL Incremental</td>
<td>7%</td>
</tr>
<tr>
<td>OPEC (2016)</td>
<td>5%</td>
</tr>
<tr>
<td>IEA RTS</td>
<td>4%</td>
</tr>
<tr>
<td>Oil Major</td>
<td>3%</td>
</tr>
<tr>
<td>OPEC (2015)</td>
<td>3%</td>
</tr>
</tbody>
</table>

IEA B2DS = below 2 degrees; 2) 2DS = 2 degrees; 3) RTS = Reference Technology Scenario; 4) Paris Declaration on Electro-Mobility and Climate Change and Call to Action
Total car park assumes 0.9bn cars in 2014, 1.6bn in 2030 e.q. to 3% CAGR 2014-40 to reach 2bn cars in 2040.
Sources: IEA, global EV Outlook 2017, Bloomberg, New Energy Finance, OICA, Business Intelligence, BP, OPEC, ADL Little analysis.
2. Four main groups of stakeholders play a critical role in the widespread adoption of EVs

The four main stakeholder groups

Four main groups of stakeholders, displayed in Figure 3, play a critical role in the widespread adoption of EVs, involving different interests and motivations.

Figure 3 – Overview of 4 main stakeholder groups

1. Government entities

Public entities have recently embraced environmental causes, recognizing the importance of taking concrete actions to reduce carbon emissions and air pollution.

In the spirit of fighting carbon emissions, eight major nations – Canada, China, France, Japan, Norway, Sweden, the United Kingdom and the United States of America – signed a Government Fleet Declaration in 2016, pledging to increase the share of electric vehicles in their government fleets and calling for other governments to join them to keep global warming on a less-than 2-degrees pathway.

Countries such as Norway, France and the UK have expressed strong commitments to banning all new petrol and diesel cars and vans latest by 2040 in an attempt to improve poor air quality, which is more and more associated with public health concerns.

We see similar dynamics outside of Europe and North America. India recently set an ambitious target date of 2030 to end sales of new cars with combustion engines. With China’s increased understanding of the effect of pollution on public health (a study done by Nanjing University’s School of the Environment associates toxic smog with one-third of all deaths), the country is considering implementation of a ban on all petrol cars, which could be as early as 2030 or as late as 2040.

In addition to the environmental cause, governments – such China’s – are expected to push EVs in an attempt to exploit the technology to attain championship and support domestic businesses. (China has already managed to accomplish this with photovoltaic technologies.)

2. OEMs & equipment/service providers

Car manufacturers are in a peculiar situation – they need to balance their strategies between regulatory forces and business-model opportunities.

Increasingly stringent emission regulations posed by governments and regulators or competition are driving manufacturers to develop new solutions to avoid fines or loss of market share. Examples such as the reactions of Porsche (Mission E), Audi (e-tron Quattro) and Daimler (EQ) to Tesla’s moves, slowly eating into their high-margin sales segments, are only the tip of the iceberg. The impact will be clear after volume models become consistently electrified.

Manufacturers also have a reason to embrace the EV as an opportunity. Companies can use the faster and smoother acceleration of their low-end torque electro-motors to promote a better driving experience, or to make use of federal subsidies or state rebates.

1 However, the US subsequently withdrew from the Paris Agreements on climate change after the election of President Donald Trump
Battery producers are focusing their R&D to improve both the cost and value of their batteries – as lower price and better performance (higher energy density, better safety and faster recharging cycles) help drive change in the sector. (See the upcoming Arthur D. Little study on battery technologies that will be released in Q1 2018.)

These effects are part of the broader automotive landscape reshaping, in which electric vehicles and autonomous-driving technology will add new ecosystems to the traditional pyramid, offering new mobility players the position at the top of a new pyramid. This will allow them to dictate specifications for the ecosystem, including vehicle-industry incumbents (Figure 4 – for more details please refer to the Arthur D. Little viewpoint, The future of automotive mobility).

Figure 4 – Arthur D. Little Automotive pyramid

![Arthur D. Little Automotive pyramid](image)

3. Consumers

Still, the number of EVs sold is only a fragment of the total sales volume in most global markets. This has two simple reasons: Perceived price and practicability.

A recent Arthur D. Little study that included thousands of consumers in automotive core markets confirmed the main barriers to purchasing electric vehicles. Those are the higher prices compared to traditional vehicles, the limited operating range, and insufficient charging solutions (Figure 5).

Figure 5 – ADL Global Customer Survey

<table>
<thead>
<tr>
<th>Barriers for purchasing EVs</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>64%</td>
</tr>
<tr>
<td>Limited operating range</td>
<td>53%</td>
</tr>
<tr>
<td>Charging takes too long</td>
<td>41%</td>
</tr>
<tr>
<td>Unattractive models</td>
<td>22%</td>
</tr>
<tr>
<td>Less fun to ride</td>
<td>12%</td>
</tr>
<tr>
<td>Other</td>
<td>4%</td>
</tr>
</tbody>
</table>

Source: Arthur D. Little Global Customer Survey

Nevertheless, we expect dramatic improvements on the vehicle side, especially with operating reach, in the next few years. Large initiatives to improve the charging infrastructure are currently being kicked off in leading key markets (e.g., China, the US, Europe), and regulation is further supporting electric vehicles.

EVs are transforming their image – from a choice for prestigious, extremely rich, and extremely green-thinking customers towards the broader mass. With manufacturers such as Volkswagen, GM, Renault Nissan Mitsubishi Alliance and Volvo announcing ambitious plans to develop new EV platforms, we believe mass-marketization is closer than ever.

4. Infrastructure enablers

Among various infrastructure enablers, electric utilities have the potential to increase their presence in the current ecosystem as the main provider of electricity. They can start leveraging the existing infrastructure to find additional sources of revenues or improve the way they manage their energy grids.

In addition to electric utilities, several other players are demonstrating interest in developing the required charging infrastructure – among these are large retailers, which could use it to attract customers; parking operators, which could create extra revenues from their existing businesses; highway operators, which could further leverage their concession
rights; and oil companies, which may be looking to convert or complement their existing fuel-station networks.

In addition, in a world where service boundaries are constantly re-shaping among existing players, OEMs and mobility companies are increasingly interested in the infrastructure business. For example, Ionity, a consortium consisting of four automotive veterans (Ford, BMW, Daimler, and Volkswagen), recently announced the construction of 400 fast-charging stations across Europe by 2020. Didi, the Chinese ride-hauling giant, has created a JV to roll out charging networks for EVs across China.

| “We will offer 80 new models until 2025 – 50 battery-driven cars and 30 other plug-in hybrids. This is a commitment.” | Matthias Mueller, CEO of VW, September 2017 |
| GM believes the future is all electric. (…) It all starts with the Chevrolet Bolt EV. | Mary Barra, CEO of GM, November 2017 |
| “The Renault-Nissan-Mitsubishi Alliance will launch 12 new pure electric vehicles by 2022, utilizing common EV platforms and components.” | Carlos Ghosn, CEO of the Alliance, September 2017 |
| “All new Volvos launched from 2019 will be electrified: either fully electric or hybrids. We aim to launch 5 fully electric vehicles between 2019 and 2021.” | Hakan Samuelson, CEO of Volvo Cars, July 2017 |
3. Electric utilities can adopt several business models to exploit the opportunity

In this viewpoint we have taken a closer look at the role electric utilities can play in light of the EV trends, and identified four business models that electric utilities can execute – some closer to “business-as-usual” operations, and some more courageous and innovative. These business models are by no means evolutionary. Each utility should evaluate the different options, possibly combine some of them, and strategically decide on the future direction.

1. **Energy provider**
   In this most basic business model, the utility sells more energy for charging EVs. In order to foster EV penetration, attain new customers, or partially manage peak loads, utilities can choose to provide EV-specific bonuses, such as a sign-up rebates, free mileage, discounted tariffs for charging at specific times (a basic offer can be introduced to shift some of the demand from daytime to night time, which is cheaper), and guaranteeing that all energy used for EV charging is 100 percent from renewable sources.

   **Example box**
   Good Energy, a UK utility, created a tariff for EV users with a GBP60 annual discount. This translates into more than 2,000 free EV miles, calculated on average Nissan Leaf energy consumption. Good Energy also provides a guarantee of 100 percent from renewable sources.

   While being closest to “business as usual”, utilities need to understand that EV owners have the potential to become much more profitable customers than the regular ones, as they have higher electricity demand (additional 3,000–4,000 kWh/year for an average EV) and lower churn rates. This business

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**Figure 6 – Business model overview**

- **1) Energy provider**
  - Sell energy to EV owners, and try to maximize revenues by fixed or flexible tariffs
  - By perceiving EVs as a “fleet of batteries” on wheels, control their charging and de-charging to balance load or provide ancillary services

- **2) Infrastructure provider**
  - Provide charging points with different levels of infrastructure management

- **3) Load balancer**
  - Provide mobility as a service to the customer, either on a narrow (B2C) or wider (municipality) scope, use cars to optimize RAB

- **4) Mobility provider**
  - By perceiving EVs as a “fleet of batteries” on wheels, control their charging and de-charging to balance load or provide ancillary services

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*Source: Arthur D. Little analysis*
model requires the utility to have a profound understanding of EV market development, customer sensitivity, and implications for the organization. Some questions that should be addressed include the following:

- How does EV demand look now, and how will it evolve?
- What are the potential customer segments, and how can we best target, attract and retain relevant ones?
- What will be the impact on the top and bottom lines?
- What are the implications for the business (e.g., sales, trading, network requirements), and how can the utility best adapt to it?
- How can the utility valorize additional customer data?
- What are the additional cross-selling opportunities with the existing product/service portfolio?
- What are the implications for other parts of the business (e.g., sales, trading, network requirements), and how can the utility best adapt?

2. Infrastructure provider

Addressing the often-insufficient public infrastructure, the utility can become both the enabler and the driver of EV penetration by building, operating, and maintaining charging points.

Example box

In March 2017, ENGIE acquired EV-Box, one of the world’s leading EV-charging services providers, with over 40,000 charging stations in service. By combining ENGIE’s global presence and energy capabilities with EV-Box’s leading technology and thought leadership in the EV-charging market, ENGIE will be in a unique position to offer customers in all segments across the globe innovative, attractive and comprehensive EV-charging and related energy services.

Utilities have multiple options on how to leverage charging points. Some of the many possibilities include: strategic coverage of areas with high-potential customers; cooperation with other entities such as malls, restaurants, and hotels to let customers charge their vehicles while shopping, eating or sleeping (to secure additional revenues from managing these charging points); and using the charging points as a part of their standard service upgrades (i.e., having customers switch and giving them free usage of charging points in their networks).

Even though in many markets it is unclear as of now who will pay for development and construction of a nationwide charging infrastructure, some countries consider charging infrastructure to be a part of the distribution network, and allow it to be included in the regulatory asset base (e.g., Italy, where Enel envisages installation of around 7,000 charging stations by 2020, to reach a total of 14,000 by 2022).

This business model leverages core utility capabilities, but requires the utility to address certain key questions:

- What is possible under the current regulation framework, and what needs to be adjusted?
- Who are the customers, and how to efficiently tap their potential?
- How favorable is the competitive landscape?
- Who is the right partner to team up with, or how to develop new capabilities?
- What is the impact on existing asset infrastructure and operations?
- How to efficiently integrate the new opportunity with the existing product portfolio?
- How to keep operations financially viable, especially in the initial phase, when cars are few and average utilization of charge points is relatively low?
- How to avoid investing in technology today that might be obsolete tomorrow?

3. Load balancer

With the intermittency of wind and solar power, which exacerbates network load balancing, utilities and grid operators are searching for efficient ways to optimize the supply-demand equation and manage the grid load. One possible solution is to take advantage of connected EVs and, based on network requirements, charge and discharge them accordingly.

Provided that the electric utility is granted the right to operate the car battery and the infrastructure is adequate to support a bidirectional flow of energy and communicate with the car system, the utility can save on expensive battery-storage equipment, support development of the EV market, and create
tighter connections with EV owners, leading to customer lock-in. These are only few of opportunities.

**Example box**

In cooperation with BMW, PG&E, a US utility, tested the feasibility of using EVs as a flexible grid resource over 18 months. The project included 100 BMW i3 vehicles in the San Francisco bay area and a battery system made up of reused EV batteries, ultimately providing 100kWh of resources.

The vehicles contributed an average of 20 percent to the target kW reduction, with only a 6 percent opt-out rate in case of a demand reduction event. Ninety-two percent of participants described their roles as passive – without feeling affected in any significant way.

PG&E is counting on 250,000 enrolled EVs by 2030, which will provide an approximate load-drop potential per event of 776 MW.

**Example box 2**

Enel recently acquired eMotorWerks, an advanced energy and e-mobility solutions company and leading supplier of EV charging stations. The acquisition is expected to enrich Enel’s e-mobility offering and integrate a highly sophisticated smart EV charging solution within a portfolio of grid-flexibility services, which includes a demand-response network, distributed energy management systems, and battery-storage solutions.

Before rushing into hunting for technical solutions (e.g., “smart” chargers that allow bidirectional power flow and enable remote management) and requirements for implementation, utilities should start by understanding the environment and potential of this shift:

- Which customers are currently present, and what market change can we expect in the medium-/long term?
- What is the load curve shift potential?
- What are the financial implications?
- What are the required capabilities?

- Who are the right potential partners?
- How to keep the operations financially viable in the initial phase of the initiative?
- How to avoid investing in technology today that might be obsolete tomorrow?
- How to integrate opportunities coming from EV offerings with smart-home services?

### 4. Mobility provider

Certain utilities can even consider extending their businesses into mobility services by providing EVs to customers as a service, while leveraging their potential for grid control and further increasing their understanding of customer behavior by collecting (and potentially providing) advanced data.

In the easiest model, the utility combines fees for energy and car rental into one bill. But utilities can also partner with automotive manufacturers and municipalities to go beyond the usual “car-sharing” scheme. This initiative can ultimately lead to development of urban mobility systems that complement existing public transport networks.

**Example box**

EDF, Toyota, and Citelib are providing 70 EVs and about 30 charging stations in Grenoble, France. Customers use a smartphone app to reserve and pay for the service. EVs are mostly located at tram stops for the first and last kilometers of their transportation.

Besides understanding the technical and financial aspect of this opportunity, utilities should address additional questions such as:

- How to define the whole vision of the project?
- Who are the correct partners?
- How to identify, bring to the table, and align the expectations of all stakeholders?
- What are the largest strategic, technical, and operational challenges that need to be covered?
4. Electric utilities should act fast as many other players are addressing the opportunity

The size of each opportunity is company specific and depends on multiple aspects, such as ecosystem readiness, specific market conditions, stakeholder landscape, and regulatory conditions. Electric utilities should carefully and neutrally evaluate the opportunity in light of the mentioned aspects to identify the best way forward.

While electric utilities remain ideally positioned to leverage the opportunities offered by the adoption of electric vehicles on a mass-market scale, they should act fast, as many other players are addressing the opportunity, including automotive players (e.g., Ionity), mobility players (e.g., Didi) and other infrastructure players (e.g., ChargePoint, Inc.).

Arthur D. Little, facilitating your success

We understand the industry end to end, and are aware of current needs and opportunities across the value chain – we have supported electric utilities, manufacturers, mobility providers, and charging operators/aggregators in identifying and exploiting opportunities arising from the wide growth of EVs. Some examples of our projects include market studies and volume forecasts for charging-infrastructure development; EV technology-roadmap development, charging and mobility business strategies and portfolio development; development of 360-degree e-mobility customer solutions; development and implementation of a commercial plan for the entry of the client into the electric-mobility sector for both B2B and B2C clients; and orchestration of the required activities – from idea detailing to implementation – for the creation of a dense system of charging columns in one of the main metropolitan areas in Europe, in alignment with stakeholders from the OEM and the municipality.

Arthur D. Little is uniquely positioned to support electric utilities in:

- Bringing diversification opportunities to the board
- Identifying business models and developing business plans
- Formulating value propositions towards customers or the ecosystem at large
- Identifying possible partners and negotiating terms and conditions of the agreement between the parties
- Identifying financing strategies in compliance with regulatory constraints
- Identifying governance models between utilities and other parties
- Supporting technology decisions to avoid early obsolescence
- Creating realistic implementation plans with a draft of the PMO structure required to execute the project
- Supporting the implementation with dedicated PMO teams

Authors

Carlo Stella and Michal Koza

www.adl.com/EVBusinessModel
Generating business value from data

Safeguarding reputation and improving efficiency through data-driven risk models

With advances in technology, companies are now collecting far greater quantities of data about their business processes and assets than before. However, existing assurance processes rarely benefit from this data, which limits access to richer insight and may lead to false assurance on performance. There is also the potential for legal implications following an accident, in which a company may be judged to have failed to act on data that indicated an accident was foreseeable. Data-driven modelling approaches better exploit the value of these new sources of disparate data and are readily transferrable into multiple industries, such as utilities, transportation and oil & gas. This viewpoint describes the successful application of this approach in the utility sector, which has led to improved business efficiency by better allocation of limited assurance and operational management resources.

Data usage challenges

Current advances in technology enable companies to capture large volumes of previously unavailable data about their businesses, such as asset conditions and deviations from expected performance by assets or employees. However, the existing assurance processes in some companies often do not exploit these richer sources of data and, as such, can provide a limited or potentially misleading positive report that risks are low. Such data can be overlooked, or seen as too complex to understand or not directly linked to business risk. As such, these remain unused in databases, providing no value.

The collected data is often distributed across multiple databases, with no individual having a holistic view. There is therefore a challenge in turning the data into information to provide insight into the business performance and enable more robust decision-making to improve productivity and risk management. There is further reputational and legal risk, should an accident or other loss event occur: that the business will be perceived as having had access to the data (i.e., knowledge of the precursors of the event), but failed to act upon it in order to prevent the incident (“guilty knowledge”). Such foreseeability can be a pivotal argument in prosecutions. Using multiple databases also creates inevitable consistency issues. One database might show employee productivity, while another shows driving telematics data for the same group of employees, but employee identification records cannot be cross-referenced. In our experience, this can be a symptom of managers in different functions working in silos, with limited cross-functional engagement across disparate databases.

Development of a data-driven risk model

We have developed a four-step approach for building a data-driven risk model, which accounts for multiple databases and addresses the data challenges raised in this paper. For example, it can reveal inconsistencies between databases, highlighting the value to be gained by operational and support functions working together.

Step 1: Review available data from databases across multiple business functions, paying particular attention to that which the assurance function previously overlooked.

Step 2: Analyze correlations between data and the undesired acts or events, and unpick components of the data to find parameters with strong predictive ability.
Step 3: **Develop and validate a multi-variable risk model** based on these correlations, rather than a traditional model that uses only two or three sources.

Step 4: Create a set of principles for **adjusting the model** regularly when more data become available. Brief senior management on the model outputs and how they can use it to drive actions that generate benefits such as business-efficiency enhancement and cost reduction.

This is a scalable approach. Modern analytical techniques can encompass practically unlimited amounts of data and data sources.

**Application in a utility company**

**Project background**

Our client was the metering business of a large European utility company. It is responsible for replacing and installing hundreds of thousands of gas and electricity meters every year, relying on a limited, sample-based inspection approach to gain assurance that the installed assets are safe for the public.

The client had completed an internal audit of its assurance process and found that the actual defect rate in its meter installations was 11 times higher than what had been indicated by its own assurance activity.

**The assurance process was found to underestimate the defect rate by more than a factor of 10**

Such defects expose people and property to risk. For example, electrical-wiring defects introduced during installation can cause overheating, fire or electrocution, and gas leaks have the potential to lead to serious fires or explosions. Such high-risk (HR) defects may not always be apparent from a visual inspection, and can be present for long periods without any disruption to a customer’s supply. This leads to the potential for significant impact on a company’s reputation in the event of an incident, due to the residential nature of many locations.

Our diagnostic revealed two key underlying causes of this discrepancy. Firstly, prioritization of inspection activities was not effective, which made it difficult to identify meter technicians (MTs) likely to leave (or who had already left) defects in their work. Secondly, underlying management issues, such as limited cross-functional engagement, were negatively influencing their operational performance.

The underlying causes were addressed by developing a new data model that allowed the company to better prioritize its use of assurance resources and improve business efficiency.

The model also provided a better predictive capability than the company’s existing assurance regime had to identify both meter technicians who were likely to have already left defects, and those likely to leave defects in the future.

**Data-driven risk model development**

The four-step approach described above was used to develop the risk model. All available data from different sources across multiple business functions was reviewed, which formed the initial basis for the new risk model. This considered both a “modeled risk” and a “recorded risk” to predict which meter technicians were more likely to leave high-risk defects:

- Recorded risk represents a company’s existing risk measure, and is based on observed defects that its assurance function has found.
- The modeled risk relates to a composite measure based on our analysis of factors that have a demonstrable correlation with defect rates.

From the analysis, seven key parameters showed strong predictive ability and demonstrated high levels of correlation with meter technicians who were likely to leave high-risk defects in meter installations.

Using these parameters, a method for classifying meter technicians based on recorded risk and modeled risk was developed. This was presented as a visual mapping of the risk for every meter technician on a 10-by-11 matrix, split into four geographical regions.
main groups that required appropriate line management and assurance focus.

Further development of the risk model followed a three-step process:

- Define high-, moderate- and low-risk boundaries of relative risk for each of the seven parameters.
- Weight these parameters based on the strength of the correlation and their influence on defect rates by assigning values to each parameter – the sum of these gives the modeled risk.
- Test and validate the model.

To define initial risk-category boundaries for each individual parameter, the range of quantitative values was split into low-, moderate- and high-risk categories based on quantiles of meter technicians.

Next, these seven parameters were weighted based on the strength of the correlation and their influence on defect rates by assigning values to moderate and high-risk technicians for each parameter. These weightings were then adjusted using sensitivity analysis to ensure that the new risk model differentiated sufficiently between the technicians with the greatest risk factors, so that the client could focus its assurance and operational management attention where it would provide the greatest benefit.

The effectiveness of the model was validated by comparing the distribution of technicians on the new risk-model matrix who had left defects with that of technicians who had not left defects in the analysis period, under two different scenarios. The two scenarios were analyzed using an independent data set. The results showed that the new risk model was approximately twice as effective as the company’s existing assurance process in finding technicians who were likely to leave defects in the future.

Risk-model outcome

The risk model outputs supported more effective and focused management interventions:

- Defining clear responsibilities for both operational and assurance functions to facilitate cooperation in acting on the model’s results.
- Focusing monitoring effort on high-risk assets when a business’s physical assets are spread across a wide geographic area, making comprehensive assessments or checks impracticable.
- Requesting additional support from operational management for known high-risk assets.
- Increasing monitoring and inspection of physical assets that are at risk of developing unsafe conditions.

Potential application in other industries

The type of model discussed here is relevant to other industries that have asset profiles similar to those in utility companies. For example:

- Assets spread over wide geographic areas in uncontrolled environments (e.g., bridges, earthworks, railway signaling equipment, tank farms and pipeline pump stations).
- Assets with useful lives measured in decades that can go long periods between inspections.
- Assets for which inspections may not consistently detect certain types of latent defects or problems.
- Assets for which the delivery capacity of work is much higher than for the resources available to assure that work has been completed properly.

Such industries also usually have a significant amount of data available on both physical assets and people, which are spread across different departments and often not used to their full effect. This data contains information that could be used to further develop risk-based approaches to either asset inspection or employee/contractor performance. This would be consistent with the move away from time- or sample-based inspection approaches that has occurred in some industries over recent years.
The most applicable areas in similar industries in which this quantitative, data-driven approach can be used are likely to be those for which:

- The nature of the work being completed makes it hard to check (e.g., due to geographic spread or number of assets), and defects are not easily found with a visual inspection.
- Behavioral factors play a large role in the development of unsafe conditions, such as those caused by employees and contractors missing out steps of procedures.
- Work completed is not always checked by third parties, or there is a large element of lone working.
- Good-quality records of assets, employees and contractors are available, even if these are spread across different departments or business functions.

Critical to the success of any risk model is the management arrangements that support its use. Clear responsibility and approaches to managing individuals in each category of risk need to reinforce messages that are in line with a company’s overall approach to asset management.

**Conclusion**

Arthur D. Little developed a data-driven risk model for a utility-sector company, leveraging observable and measurable data from a range of sources and databases to predict high-risk employees and assets. This data-driven approach to risk modeling provides executives with actionable management information that can generate higher business efficiency. The success of the risk model relies on high-quality input data from databases overseen by different departments or business functions, and requires a collaborative approach between individual managers and moving away from operating in discrete silos. The key benefit is enabling increased business efficiency through better use of resources already available to managers, without significant additional expenditure on assurance or inspection activities.

This data-driven approach to risk modeling also has strategic business importance in protecting businesses’ reputations. By failing to use such data and its associated insight, companies may be unable to prevent asset failures. Any avoidable incidents that endanger lives of employees and/or the public can cost a business more than replacing a member of staff. It might also involve fines, reduce sales and profits, and generate negative public opinion that is hard to reverse or irreversible. It takes time to recover from such events, but it is relatively easy to prevent damage to business reputation by implementing an effective risk-control model and program.

The model has direct applicability to multiple industries with infrastructure assets, including utilities, transport, and oil & gas. These sectors share many common properties, such as large, geographically dispersed asset bases, and assets installed and maintained by lone workers. With our experience in strategic business management and risk modeling, we can help you to develop a customized risk model that safeguards your business reputation and improves your business efficiency.

**Authors**

Stephen Watson, George Simpson and Wenwen Li
“E-lectric” customers

Understanding customers’ online engagement with their power and gas utilities: The case of Spain

Executive Summary

“Utilities, brace for the online impact.”

The shift to online channels has long since ceased to be a current topic among companies in retail and banking, for example. These companies have redefined the customer relationship model, not only in their industries, but in other sectors as well. The utilities industry, which has traditionally not been engagement intensive, is being affected by this model redefinition and progressively moving to digital channels. The rise of purely online players, increasingly blurred market boundaries as utilities offer additional services, and new customer experience requirements have made this online move both challenging and critical.

In this viewpoint, Arthur D. Little analyzes Spanish online utility customers to understand how they engage with their utilities, highlighting the existing relationship between engagement, satisfaction and value and focusing on the growing relevance of online engagement. Furthermore, it points out the important gap that exists between challengers’ and incumbents’ online channels and engagement, reinforcing the call for urgent action.

Engagement, satisfaction and customer value are deeply intertwined. Assuring engagement and satisfaction is especially relevant in a market as dynamic as Spain’s, with over 14 percent of customers having switched suppliers over the past year. Online switching still represents only a fraction of those who switched, but several indicators point towards its growth in the near future. The relevance of the online channel for searching and comparing and the potential limitations to doorstep selling are just two examples of these drivers, as experience in other markets has shown.

In this growing online reality, new online challengers are being quicker and more effective in catering to evolving customer tastes, while incumbents’ online channels are still lagging behind. Not only do incumbents’ customers engage less often with their suppliers, but when they do, it is mostly to generate non-value-adding interactions. On the other hand, challengers generate more value-adding interactions across both their physical and online channels.

Incumbents are faced with an urgent call for action. They must adapt their online channel offerings to ensure customer satisfaction and retention, and to position themselves for the new wave of online switching. This adaptation will involve a complete overhaul of their existing marketing and sales budgets and reconsideration of their commercial strategies, in order to differentiate the service offering and the company positioning, and to defend the margins in an ever-more-competitive marketplace.

The utilities industry has reached a tipping point. Now is the moment to decide which way to go.
Introduction: Welcome to Spain

Arthur D. Little’s survey and analysis illustrates Spanish customers’ online engagement with their utilities and the implications of this relationship.

An evolving market perspective requires incumbents to rethink and adapt to new realities

New offers and services, evolving consumer attitudes and competition are some of the main trends and changes affecting the utility-customer relationship in most European markets.

Currently, most of these changes come from online channels and digitalization, which have major impact on aspects such as engagement and switching behavior, and are setting the “new norm” in terms of service and availability.

While the Spanish power and gas market is still largely a “physical channels” market – i.e., door-to-door and branches are still the most relevant in acquiring new customers – online players have already established significant presence. However, given the magnitude of the implications of online relationships with customers and the speed of online adoption that is observed, utilities should seriously consider the dynamics in the online segment.

Three elements point to a rapid and substantial change in the coming years:

1. Spain is “digital ready” and “digitally engaged”

The Spanish market’s digitalization level is in line with the EU’s average and above that of other countries such as Italy and France, according to the European Union’s Digital Economy and Society Index (DESI). DESI evaluates each country’s digitalization in five main dimensions: connectivity, human capital, use of internet, integration of digital technology and digital public services. Although in line with the EU’s average,
Spain’s level of digitalization still lies below that of the UK, Germany and Belgium, among others.

2. **Spanish customers are among the most dynamic**

   In addition, as measured by churn rates, the Spanish retail electricity market is one of the most dynamic in Europe, with 14 percent of power customers changing suppliers each year.

3. **Online adoption can gain momentum and speed up… fast**

   Some examples can illustrate the astonishing speed of adoption of online channels. In the UK, according to Ofgem, online customer switching changed from 21 to 48 percent in three years. In Spain, the retail-banking sector has massively restructured its physical branches, reducing the number by more than 22 percent since 2012, as consumers have progressively shifted their interactions online.

   In such an evolving context, Arthur D. Little has researched (see details in the annex) the online retail electricity customer segment in Spain to understand its basic drivers of value, the relative positioning of the existing players, and how to prepare for such a change.
The more customers engage with their utilities, the higher the satisfaction levels and the lower the switching risk

The need to build strong relationships with customers becomes evident when analyzing how engagement relates to customer satisfaction.

Figure 2: Customers who have considered switching

According to internal Arthur D. Little benchmarks, the marginal channel used to win back lost customers costs utilities today ~€150 per acquisition. For a utility with an average customer satisfaction score of 5–8, around 12 percent of its customers are considering switching. This means that for every million customers, this 12 percent of switchers will cost the utility more than €18 million to win them back into their customer bases. It is important for utilities to realize and monetize the actual impact of a satisfied customer base, and to understand the existing relationship between satisfaction and switching.

Additionally, those customers who state they never contact their utilities have significantly lower satisfaction levels than those who do. The gap also exists between those who contact the utility through offline rather than online channels. These differences can be seen in Figure 3 below.

For those customers who decide to switch companies due to various reasons, online is gaining traction as one of the channels of choice

Spanish customers are quite active in terms of switching suppliers, with 35 percent of customers stating that they have...
switched suppliers at least once over the past three years and more than 14 percent stating they have switched over the past year. (See figure 4.)

One of the most interesting conclusions drawn from the Arthur D. Little survey conducted to utility customers is related to the growth of online channel usage. Customers are using it more and more to gather information on utilities, compare offers and, finally, switch utilities.

**Figure 4: Switching metrics**

| Customers who are aware of the possibility of switching supplier | 98.4% |
| Customers who considered switching over past year | 47.5% |
| Customers who switched supplier over the past year | 14.4% |

Source: Arthur D. Little survey and analysis

The growing usage of online channels is especially becoming evident in some activities prior to switching, such as searching for information. More than four out of every five customers state that they compare before switching, and over 87 percent of customers who search for information state that they use the online channel to do so (either exclusively or in combination with other channels).

**Figure 5: Online searching and online switching**

<table>
<thead>
<tr>
<th>Switching channels</th>
<th>2011</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online</td>
<td>21%</td>
<td>33%</td>
</tr>
<tr>
<td>Phone</td>
<td>14%</td>
<td>32%</td>
</tr>
<tr>
<td>Salesperson</td>
<td>11%</td>
<td>27%</td>
</tr>
<tr>
<td>Other</td>
<td>33%</td>
<td></td>
</tr>
</tbody>
</table>

Source: Arthur D. Little survey and analysis

This impressive proportion of “online searchers” is beginning to materialize into online switchers. Already, 6 percent of those who switched over the past year did so through online channels, while the majority of customers still prefer face-to-face interactions.

This dominance of the online channel for searching for information (well above the telephone and office), combined with the growing digitalization of the Spanish population and considering the similar evolution of other European countries, hints that the Spanish consumer will also move to “digital switching” in the near future.

An interesting example of how fast digital switching can occur is the United Kingdom. Between 2011 and 2014, the number of online switchers grew 27 percentage points, moving from the 21 percent who switched electricity suppliers online in 2011, to 48 percent in 2014.

**Figure 6: Online switchers in the UK in 2014 vs 2011**

Out of % of switchers

<table>
<thead>
<tr>
<th>Switching channels 2011</th>
<th>48%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online</td>
<td>21%</td>
</tr>
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<td>Salesperson</td>
<td>11%</td>
</tr>
<tr>
<td>Other</td>
<td>27%</td>
</tr>
</tbody>
</table>

Source: Arthur D. Little analysis, OFGEM

This online growth coincided with the banning of doorstep selling in 2012 after the Competition and Markets Authority (CMA) found that customers were paying higher bills when signing up to tariffs via direct sales. Although such a decision has not been taken yet in Spain, a similar debate has already begun, especially in certain areas such as Catalonia, one of the main regional markets. The local government has begun evaluating the possibility of banning telephone and door-to-door sales.

There are multiple reasons explaining how and why online adoption is happening at such a fast rate in different markets.
Some of these reasons come from the demand side, while others arise from the supply side.

One of the triggers of this shift is that online channels are where some of the “best-priced deals” are found, in both electricity and gas. Customers’ main online comparison tool is the search engine, and comparison websites are also spreading rapidly in Spain, with over 40 percent of customers who search for information online already using them. These two elements will require utilities to reconsider their commercial approaches.

Although there are several drivers for this shift, the conclusion is clear. Utilities need to get ready to manage substantial shifts in their channel mixes.

As our research shows in the next section, Spanish incumbent players are not yet ready for the radical changes ahead, and must prepare for action.

Figure 7: Channels used for comparing

% over respondents who compared information

<table>
<thead>
<tr>
<th>Channel</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Search Engine</td>
<td>69.4%</td>
</tr>
<tr>
<td>Company Website</td>
<td>50.0%</td>
</tr>
<tr>
<td>Comparison Page</td>
<td>39.5%</td>
</tr>
<tr>
<td>Social Media</td>
<td>2.4%</td>
</tr>
<tr>
<td>Online</td>
<td>87.3%</td>
</tr>
<tr>
<td>Telephone</td>
<td>21.1%</td>
</tr>
<tr>
<td>Office</td>
<td>7.7%</td>
</tr>
<tr>
<td>Word of Mouth</td>
<td>14.8%</td>
</tr>
<tr>
<td>Others</td>
<td>5.6%</td>
</tr>
</tbody>
</table>

Source: Arthur D. Little survey & analysis
2. A wake-up call for incumbents

In a context where digital is becoming the norm, new challengers are threatening incumbent utilities by adapting their customer experiences and online channels to the evolving customer requirements not only faster, but also better.

**Strengthening the online channels as consumer habits evolve will allow incumbents to increase engagement, optimize costs and capture additional customers.**

This ability to adapt to the evolving consumer behavior becomes evident when analyzing contact frequency among incumbent and challenger utility customers.

*Figure 8: Contact frequency with utility supplier*

<table>
<thead>
<tr>
<th>% over total utility customers</th>
<th>Incumbent Utilities</th>
<th>Challenger Utilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 2 times/year</td>
<td>12.3%</td>
<td>16%</td>
</tr>
<tr>
<td>1-2 times/year</td>
<td>74.2%</td>
<td>52%</td>
</tr>
<tr>
<td>Never</td>
<td>13.6%</td>
<td>32%</td>
</tr>
</tbody>
</table>

+2x vs incumbents: 28.6% vs 16%

+2x vs challengers: 13.6% vs 16%

While with incumbents, 48 percent of the time a customer contacts the utility in a non-value-adding interaction (regarding a problem with the reading or bill), this percentage is reduced to just 34 percent among challenger utility customers.

With challengers, value-generating interactions (new sales, information about a service) and administrative activities (change of contract or payment method and others) are performed the remaining 66 percent of the time.

*Figure 9: Contact reasons*

<table>
<thead>
<tr>
<th>% over total responses</th>
<th>Contact reasons incumbents</th>
<th>Contact reasons challengers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem with the bill</td>
<td>48%</td>
<td>13%</td>
</tr>
<tr>
<td>Value-adding interactions</td>
<td>16%</td>
<td>32%</td>
</tr>
<tr>
<td>Problem with meter reading</td>
<td>32%</td>
<td>21%</td>
</tr>
</tbody>
</table>

Nevertheless, it is noteworthy to state that these non-value-adding interactions represent a critical touch point and, if not resolved correctly, will greatly damage customer experience.

Overall, telephone remains the preferred channel for contacting utility companies, with 59 percent of customers choosing it.

When contacting the supplier due to problems with the meter reading or bills, telephone appears to be the natural choice for most customers (~70 percent), while the online channel is just used 23 percent of the time.

**Incumbent utilities have less value-generating interactions than challengers do**
Usage of the online channel increases almost 10 percentage points when customers want to perform activities involving changing contract details or payment method, and its usage reaches 35–40 percent for activities such as obtaining information about a service or signing a new service contract.

**Incumbents’ online channels are lagging behind those of challengers. In order to bring them up to speed, they must meet a series of customer “must haves”**

Similarly to engagement levels and customer satisfaction, challenger utilities’ online channels are consistently outperforming those of incumbents:

The latter achieve an average Net Promoter Score® (NPS®) for their online channels of -46.9 percent, while challengers achieve a +50 percent NPS®.

Challengers’ online channels appear to be more adapted to customers, allowing them to perform several different actions through a more convenient and responsive portal. This difference with respect to incumbent utilities becomes evident when analyzing some key online engagement metrics.

Concerning the number of visits per month per customer to their websites, Spanish challenger utilities greatly outperform incumbents. These utilities’ visits per month per customer are,
Challengers’ presence on social media, which greatly contributes to generating speedy, timely and useful interactions, is also more significant than that of incumbents. Although anecdotal, it is interesting to point out that while the average incumbent achieves around two Facebook page likes per 1,000 customers, an average challenger reaches more than 680 likes, once again highlighting the great differences that exist in engagement levels between incumbents and challengers. A similar analysis performed with other European challengers suggests that Spanish challenger utilities have better engagement metrics. However, although it is evident that there is an important gap between incumbents and challengers in terms of their online channel capabilities, it is also true that this gap is by no means insurmountable.

Beyond these particular numbers and ratios at a given point in time, the important conclusion is to realize the tie that exists between engagement, satisfaction and value. The goal for utilities, therefore, is to unlock that customer value by translating engagements into sales.

The key to do so lies in deep understanding of their customers: who they are, what they want and how they want it. These topics will be addressed in the following section.
3. Prepare for action

Even if the way of contacting and engaging evolves, customers will still want what they have always demanded of their utility contact channels: speed, convenience and a hassle-free service. However, with an online switch forecasted for the next years, utilities must prepare themselves if they want to be “part of the game.”

In the described circumstances, utilities and other players willing to have significant roles in the online energy retail business must “get their acts together”

The current utility market’s boundaries are blurring more and more every day. Whether automation, security or comfort for the home, utilities are offering all sorts of products and services beyond “energy.”

The online customer is also becoming used to new standards of service that are not set by regulators, but rather by players such as giant online retailers, which, for instance, offer extremely fast and convenient customer service.

Just as it has occurred in other industries, such as banking and insurance, the online channel in utilities is evolving from a niche or complementary channel to one of the main contact gateways for many customers.

In this sense, there are several key implications that utilities should consider, the main of which are:

- Understanding which customers to target digital channels to and what their needs are, in order to define a better value proposition
- Rethinking the commercial strategy and how to acquire, retain and generate engagement and loyalty with customers in the new digital environment

Customers are willing to switch to online channels, but they still do not perceive that those of incumbents meet their required needs. However, 66 percent either agree or strongly agree that if incumbents made their online channels more agile, they would use them more often.

As changes in customer habits and attitudes unfold, with a greater demand for speed, agility and convenience, many interactions will “switch on,” moving from traditional offline channels to online ones.

In an industry in which interactions between customers and utilities are generally very sporadic (companies with the highest engagement levels do not register more than two to three interactions per year per customer), it is essential for companies to assure a seamless online channel experience that delivers a consistent service level and meets customer requirements. With few opportunities to interact with customers, companies must ensure they “do it right” every time.

Figure 13: Customer disposition to use online channels

Among some of the main “must haves” of online channels, customers mainly demand:

- Convenience: over 25 percent of customers who do not use their utilities’ online channels state that the main problem is quite basic: the channels do not allow them to perform the desired action
- Speed: Channel responsiveness, intuitive and user-friendly interfaces, and reliability are essential if online channels are to be used
Additionally, among those customers who do not use the online channel, 56.5 percent state that it is the lack of human contact that mainly discourages them to do so.

Even if this is an intrinsic trait to online channels, utilities could explore different ways to mitigate this barrier, such as introducing virtual chat rooms or video calls with agents for customers requiring additional assistance or complex tasks to be performed.

Although speed, convenience, clarity, trustworthiness and efficiency, among others, are all attributes that customers demand for the online channel, it is important to note that these are also essential attributes for any contact channel between the utility and its customers.

Furthermore, although this viewpoint has focused on understanding the growth of the online relationship between utilities and their customers, companies should not forget that although it is developing, the online channel is still in an embryonic stage.

There is an additional consideration for incumbent utilities related to their customer bases. For many years, these companies were the only available suppliers, and captured the whole of the market. With the development of the market and the surge of challenger companies, part of that customer base left the traditional incumbent utility, searching for better deals and attracted by challengers’ online offerings. The rest of that customer base, including price-insensitive customers who did not want to face the administrative burden of switching, stayed with their traditional utilities.

This diverse customer pool forces incumbent utilities to adopt a comprehensive approach in designing distinct value propositions for each of their different customer segments.
Similarly, through observation and analysis of comparable industries such as insurance, the launch of an insurance company with a purely online value proposition can cost up to ~€30 M per year in advertisement investment.

Although this does not imply that utilities should commit to such investments, it helps to understand the investment ranges that should be considered to achieve different goals in terms of online presence.

However, although investing in online presence is necessary, it is important to keep in mind that if the actual online channels are not functional and adapted to customers’ needs, this investment will have little or no impact.
As the utility market’s boundaries become more and more blurred every day, customers’ digital tastes and demands evolve, and new online competitors enter the market, incumbent utilities must react now.

Our study highlights how increasing engagement (especially online) with customers, not only by contacting them more often, but also by generating value-adding interactions, will increase value and reduce churn. Currently, incumbents in Spain are lagging considerably behind local challengers in terms of engagement with their customers and effectiveness of their online channels.

Time is of the essence in the digital world, and utilities must brace for the challenging task ahead. Otherwise, they will risk losing considerable market share.

As these dramatic shifts unfold, some major questions arise in terms of what initiatives and budgets need to be prioritized by senior management. As in any business facing such a situation, yearly targets need to be met, which require investing substantial amounts of money in the existing commercial model, as well as management attention. At the same time, building new capabilities in new channels, services and customer mind-sets to target these new emerging segments is crucial in order to continue to be competitive in the near future.

Most power companies have put digital teams in place and are investing in their tools and capabilities. However, as this research highlights, this might not be enough. Beyond digital tools and specific digital initiatives, utilities need to reconsider their commercial strategies in order to differentiate the service offering and the company positioning and defend the margins in an ever-more competitive marketplace.

Arthur D. Little has broad experience in these fields and is currently working hand in hand with its clients to solve these challenges in the utilities industry.

For further details on our analysis and perspectives, please do not hesitate to contact us.
Annex: Methodology & analysis

Aware of the deep changes and digital transformation ahead in the utilities industry, Arthur D. Little prepared this viewpoint in order to help utilities understand the depth of these changes and capture the opportunities derived from them.

In order to achieve this goal, the viewpoint was devised through three main pillars:

- Understand how customers interact with their utilities
- Analyze customers’ attitudes towards switching companies and searching for information
- Focus on the “online side” of all of these aspects

This viewpoint is the result of analysis of the answers of more than 500 representative respondents, as well as additional investigation and prior Arthur D. Little utility industry expertise. In order to reach the conclusions showcased in this viewpoint, four main data sources and partners were used:

- A comprehensive survey to utility customers (through an expert market research company)
- In-depth utility website analytics (through online-traffic analysis software)
- Extensive desk research to analyze challenger and incumbent utilities
- Similar international reports on the utilities industry prepared by regulators

Although the viewpoint represents only a selection of the performed analysis, the survey data has allowed Arthur D. Little to obtain a vast amount of data and generate several detailed analyses, including:

- In-depth satisfaction levels of each utility’s customers
- Online usage characterization of customers (not only for utilities, but also in other industries, such as banking, telco and insurance)
- Understanding of the main reasons for switching or not switching
- Percentage of customers from each utility who would recommend their supplier

Arthur D. Little has produced a viewpoint that illustrates the current situation of the customer-utility relationship in Spain. It points towards the future and supports utilities in understanding the challenges and opportunities ahead.

Authors
David Borràs, Pedro Fernández-Olano, Rocío Castedo and Iñigo Merino

www.adl.com/ElectricCustomers
Energy hand in hand with telco

Is a wave of merging electric utility and telco assets imminent?

Executive Summary

Liberalization of telco and energy sectors incentivized traditional telco and energy companies to look for new revenue sources beyond their traditional business scope. Telco companies have started to sell energy, gas and heat while energy companies often offer telco services. Simultaneously, we experienced fast development of internet and related services. Nowadays, broadband internet connection is an essential part of infrastructure and precondition for prosperity even in developing countries. Therefore, in multiple countries governments, both legislatively and financially, support providing households with broadband internet connection. Given the support, energy and telco companies in many countries cooperate with government, municipalities and regulators on deployment of next generation telco infrastructure. All in order to secure cost efficient network construction while avoiding any competition disrupting measures.
1. Liberalization and technology advances stimulate industry sectors to converge

For a long time ago, services a company provided were simply based on the core industry in which it operated. However, as markets in traditional industries become mature and saturated, companies are finding it difficult to grow their revenues further. In these markets, it is becoming increasingly difficult for traditional companies to find room for cost reduction or significant quality improvement of their goods and services, as they have been doing this for a long time. Instead, ever-present market liberalization continues to invite more and more competitors into their market, which increases pressure on their profitability.

In order to overcome these challenges and grow their revenues, companies are starting to look into entering other industries that are distinct from their core businesses, but at the same time, will still allow them to leverage some of their current capabilities. The primary driver that enables companies to enter new industries is advancing technologies. Therefore, it is not surprising that convergence started in the industry sectors most related to the new technologies. It has been some time since hardware companies such as IBM noticed that in order to grow, they would need to expand into software and IT services, while software companies such as Microsoft and Google entered the hardware market segment to build digital ecosystems of their own goods and services.

With ongoing market liberalization, next in the line were telco, information technology and media companies. It now seems natural that you can subscribe to TV media content via your telco operator. Similarly, although in the past traditional landline companies were the only providers of telephony services, nowadays, thanks to advanced information technologies, IP-telephony services can easily be bought from internet providers. However, industry convergence doesn’t stop here. For instance, telco companies are looking to enter the banking sector by offering products such as loans and insurance, and the energy sector by bundling energy products with their telco services. Another example is retailers trying to enter the telco industry by offering mobile services packaged with their retail purchases. The telco industry is especially attractive to new entrants, as current players often have margins at 30–40 percent, which isn’t the case for many other industries. The list of examples of industry convergence is only expected to grow in the upcoming years due to ever-advancing technologies and eagerness of companies to grow in spite of significant challenges in their core markets.
2. New political set up squeezed wholesale prices causing energy companies’ value to drop

Nowadays, the energy sector is facing challenges that significantly change energetics as we know it. For instance, although fast development of new technologies allows cheaper renewable-energy generation, it also raises demands on the stability of the electricity supply to end customers and decreases, or even nullifies, profitability of investment into traditional sources of energy. The supply stability becomes problematic when using renewable-energy sources, as customers also want to spend energy when the wind is not blowing or the sun is not shining. However, no currently available technologies allow efficient storing of surplus energy. Therefore, operation without energy from traditional sources still is not possible. On the other hand, governments are massively subsidizing energy generation from renewable sources, while traditional sources have to finance their operations on their own in a situation in which renewable-energy generation growth increasingly limits the potential production volume of traditional energy sources.

Moreover, the whole energy infrastructure was originally set so that electricity plants would be sufficiently utilized, which is the only way the investment spent on their construction can be profitable. Furthermore, integration of renewable energy requires substantial additional investment into transmission, and especially distribution networks, in order to secure supply stability and prevent blackouts. The economic formula of securing profitability of past and current investments has been disrupted. It can be seen with the decrease of spot prices of electricity, e.g., in Germany, where the prices fell from €90/MWh in June 2008 to €23/MWh in January 2016 (although the bill for end customers was unaffected). In January 2017 electricity was traded for €29.20/MWh. This trend did, of course, significantly decrease share prices of energy companies.

Therefore, similar to other industries, CEOs of energy companies are also intensively looking for solutions related to new business models, changes in strategy, reorganization and improvement of their companies’ performances. One of many possible strategic solutions is maximizing revenues from existing customer bases and offering new services. Energy companies already have connections with end customers, and know how to address them and handle billing or communicate with them using existing customer relationship management (CRM) systems. Therefore, in addition to energy products, they can offer non-energy services such as telco and insurance.

Figure 1: Decrease of spot price of electricity and share price development of chosen energy companies

![Graph showing decrease of spot price of electricity and share price development of chosen energy companies](image-url)
Another challenge that energy companies will face in the upcoming years is smartification of their power grids into so-called “smart grids.” Smart grids use Information Communication Technologies (ICT) solutions within all components of the power grid, from generation plants to end points at customers’ premises, to monitor and control electricity transmission and distribution. Energy companies can thus use them to improve energy efficiency, avoid black-outs (or at least reduce their duration), and optimize power delivery to customers, including management of input from intermittent renewable power sources such as solar plants. Furthermore, smart-grid components installed directly on customers’ premises allow energy companies to monitor customers’ energy use and outages or report power quality. This information can be sent in real time to the energy company, or even directly to the customer’s smart device. If interested, customers can subsequently use this information in various applications to optimize their own energy consumption and management.

However, despite all the positives it brings, implementation of a smart grid might be very challenging financially. In order to function properly, a smart grid needs a robust and flexible communication network. This network might consist of several technologies, such as mobile data services, Power Line Communication (PLC) technology or fiber-optic infrastructure. Although the fiber-optic solution is the most expensive to deploy, it also has substantially better-quality characteristics, which are necessary in some parts of smart-grid infrastructure.

Energy companies have three basic options for acquiring necessary infrastructure. They can use services of external telco players, build it themselves for purely internal use, or build it themselves to also use for external telco business purposes. As the deployment of an extensive smart-grid network requires substantial investment, building such an infrastructure purely for own internal purposes may not be viable. On the other hand, once the energy company operates its own communication network, it can realize significant synergies with the proposition of external telco services (either wholesale or for end customers).
Not long ago, voice and data services were provided exclusively by vertically integrated telco companies. Standard telco operators used to own telco infrastructures, be in charge of their operation and maintenance, sell and distribute voice and data services, and have big ambitions to produce new services and applications with added value (the applications we currently have in our smart phones). Globalization of the sector and entry of new players into the traditional telco value chain, especially in the provision of services with added value, such as Apple, Google, eBay and Yahoo, led to vertical disintegration. The present disintegrated model is divided into so-called infracos, netcos and servcos.

- **Infraco**: Owner of the infrastructure, which secures construction of the telco network and its rental
- **Netco**: Network operator managing active network components and providing wholesale capacity and coverage for service providers
- **Servco**: Telco operator or provider of applications that sells services on the network infrastructure to which it has access

Moreover, the disintegration of the traditional telco model has led to “commoditization” of such services as broadband internet connection. For instance, a White House report (US) about broadband connection issued in September 2015 states: “Broadband internet connection is now starting to stand side by side with traditional commodities such as water, heat, electricity and sewage.” According to this report, “the broadband internet connection is now a completely essential part of infrastructure of municipalities.” The European Union is aware of this, and provides several measures that should support construction of optical networks to the premises of end customers. In 2010, the digital agenda for Europe was approved, and its targets are binding for all EU member states. The primary target is to achieve 100 percent household coverage of broadband internet with a minimum speed of 30 Mbit/s, and 50 percent household coverage with a minimum speed of 100 Mbit/s. For the period...
2014–2020, the EU devoted over €20 bn to the construction of so-called next-generation access networks (NGN or NGA networks). At the same time, in addition to financial subsidies, several other measures are being taken to support deployment of NGN/NGA networks and save investment costs. Some of these measures are:

- **Maximum utilization of existing passive infrastructure** – this means utilization of existing energy, transport and telco networks
- **Reduction of the bureaucratic burden** on projecting and construction of new networks in the form of, e.g., easier obtaining of building permits and easements
- **Improvement of the transparency and coordination** of deploying new engineering networks in the form of, e.g., obligation to inform owners of telco licenses about planned excavation works
- **Definition of clear rules for construction of NGA/NGN access in new buildings**

What role can utility companies (energy, gas, oil, etc.) potentially play in the construction of next-generation access networks? For instance, traditional energy companies usually own extensive telco infrastructure, including backbone networks of optic fibers. They use these networks for operation, monitoring and management of transmission and distribution networks of power plants. Furthermore, requirements for own energy telco networks are even higher. Ongoing integration of distributed production and always-increasing requirements from regulators for reliability of electricity supply require investment into monitoring systems and automated or remote-control network elements within implementation of smart grids.

At the same time, a significant portion of energy companies’ infrastructure is usually a part of national critical infrastructure. Therefore, special security measures, including substantial cybersecurity requirements, have to be followed when an energy company wants to deploy additional communication infrastructure on its power grid. These trends lead to higher demands on own telco networks and require considerable investment in them. Hence, as energy companies will probably not avoid substantial future investments into their telco infrastructure, it’s only natural that they might be interested in also using this investment for external business purposes.

**Figure 3:** Energy companies participated in mobile market growth and are currently entering the broadband market

<table>
<thead>
<tr>
<th>Local utilities operate optic fibers at regional level</th>
<th>Energy companies establish telco subsidiaries</th>
<th>Participation in mobile market growth</th>
<th>Start of broadband data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enel 1996</td>
<td>Energy companies set up telco subsidiaries</td>
<td>Energy companies or their telco subsidiaries obtain GSM licenses and utilize the potential of their optic networks - mobile operators</td>
<td>Enel OpEn Fiber 2012 – deployment of 1,500 km FTTB, investment of €3.7bn</td>
</tr>
<tr>
<td>Enel OpEn Fiber 1997</td>
<td>Small energy telco companies look for partnership options or joint ventures to utilize their optic networks</td>
<td>Energy companies or their telco subsidiaries obtain GSM licenses and utilize the potential of their optic networks - mobile operators</td>
<td>2016 – deployment of FTTB, investment of €3.7bn</td>
</tr>
<tr>
<td>75% sold, 1998</td>
<td>Energy companies or their telco subsidiaries obtain GSM licenses and utilize the potential of their optic networks - mobile operators</td>
<td>Mobile market is getting saturated and mobile operators are being bought by global telco players</td>
<td>2015 – deployment of FTTB, investment of €0.45bn</td>
</tr>
<tr>
<td>1991</td>
<td>Small energy telco companies look for partnership options or joint ventures to utilize their optic networks</td>
<td>New opportunity for energy companies to join national digital agendas for deployment of ultra-fast broadband</td>
<td>Toshiba 2012 – deployment of 1,500 km FTTB</td>
</tr>
<tr>
<td>Fibernet 2004</td>
<td>Energy companies or their telco subsidiaries obtain GSM licenses and utilize the potential of their optic networks - mobile operators</td>
<td>Increasing pressure to include energy networks in national digital agendas</td>
<td></td>
</tr>
<tr>
<td>Company established</td>
<td>Participating in mobile market growth</td>
<td>Mobile market is getting saturated and mobile operators are being bought by global telco players</td>
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<tr>
<td>Company sold</td>
<td>Energy companies or their telco subsidiaries obtain GSM licenses and utilize the potential of their optic networks - mobile operators</td>
<td>New opportunity for energy companies to join national digital agendas for deployment of ultra-fast broadband</td>
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</tr>
<tr>
<td>Enel OpEn Fiber 2012 – deployment of 1,500 km FTTB, investment of €3.7bn</td>
<td>2016 – deployment of FTTB, investment of €3.7bn</td>
<td>2015 – deployment of FTTB, investment of €0.45bn</td>
<td></td>
</tr>
</tbody>
</table>

Notes: 1) UFB – ultra-fast broadband, minimum speed of 100 Mbit/s; 2) IoT – Internet of Things; 3) PE – private equity
Source: Arthur D. Little
A lot of energy companies are already engaged in telco business in the form of “servcos.” Energy companies usually provide telco services as mobile virtual network operators (MVNOs) or directly own mobile operators. At the end of the 1990s, energy companies started to set up subsidiary telco companies, participated in the fast growth of the mobile market and, after the saturation of the market, sold their shares in these companies to global telco players.

For example, in 1997 Italian electricity company Enel established Wind Telecom S.p.A, which became the third mobile operator in the Italian telco market, right after Telecom Italia Mobile and Omnitel (now Vodafone Italy). In 2005 Enel sold Wind for €12 bn. Another example can be seen in Austria. Austrian telco Tele.ring was established in 1997 by Verbund – the country’s largest electricity provider – Austrian railways (ÖBB), and so-called “Stadtwerke” Citykom Austria. At the beginning, Tele.ring provided fixed telco services and internet. After the capital entry of German mobile operator Mannesmann Mobilfunk, it added mobile telco services. Later, Vodafone acquired Mannesmann Mobilfunk, but subsequently sold it to American Western Wireless International, and in the end Deutsche Telekom bought the whole company for €1.3 bn in 2006. Currently, the former Tele.ring is part of T-Mobile Austria.

Nowadays, similar development is being repeated as energy companies build on their previous experience and engage in deployment of NGN/NGA networks and massive growth of broadband internet.

Overall, telco business is still an opportunity for energy companies

Altogether, it can be concluded that the telco business is an interesting opportunity for energy companies to grow. First, it represents potential to substantially grow revenues while using synergies with current capabilities such as CRM, billing systems and existing large customer bases. Moreover, diversification of sources of revenues is an attractive proposition for investors, especially when it targets rapidly growing market segments such as broadband data. Additionally, engagement in telco services can also benefit their core businesses. Telco infrastructure can be used for smart-grid purposes, which could significantly improve efficiency and reliability of power distribution, as well as give customers the possibility of better managing their own electricity consumption.

Hence, companies can save money on better power distribution while having more satisfied customers and better churn rates. In the future, engagement in telco business would consequently also improve the value propositions of utility companies towards customers for smart homes, and towards cities for smart-city projects. Therefore, capturing all these synergies by merging utility and telco assets appears to be a very likely scenario in the near future. Nowadays, the most attractive telco business area for energy companies appears to be deployment of fiber-optic networks for broadband internet. The participation of energy companies in the growth of the broadband market through deployment of fiber-optic networks is elaborated in detail in the Arthur D. Little viewpoint “Utilities’ contribution to national fiber development.”

Authors
Radek Svoboda, Jaap Kalkman and Dean Brabec

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Utilities’ contribution to national fiber development

How utilities and telecom operators can cooperate to accelerate fiber deployment

Executive summary

As the race for building fiber infrastructure accelerates globally, utilities (especially electrical utilities) are increasingly seen as new credible players. In the most convincing cases, utilities step in and play a complementary role in national fiber development. Engagement of utilities in fiber development can result in a win-win situation for national agencies, the utilities themselves and telecom operators. From one side, utilities can exploit some advantages in fiber development, leading to accelerated fiber deployment and less spending of national funds on network expansion. The utilities themselves stand to benefit through the diversification of their revenues and enhancement of their core businesses. From the other side, telecom operators benefit from the ability to reach hitherto unprofitable customers. In this article, we detail how utilities position themselves for national fiber development, and how they can be engaged.
1. The ultra-broadband demand-supply balance remains an unsolved equation

Globally, the race for fiber infrastructure has been accelerating in the recent past. The number of countries that achieved 95 percent fiber-to-the-home (FTTH) coverage increased from 1 in 2012 to 6 in 2016. Similarly, the number of countries that achieved higher than 50 percent coverage has increased from 10 in 2012 to 14 in 2016.

The growth is driven by commercial purposes (the business case for fiber is sound), as well as national development agendas, which consider ultra-high-speed broadband a critical enabler of economic growth. Several countries globally have plans to increase the coverage targets for high-speed fiber broadband.

Countries seriously willing to deploy FTTH now (e.g., Qatar, New Zealand and Sweden) can achieve full coverage in less than 10 years. In markets where fiber deployment started earlier (e.g., European markets such as the UK and Germany), the expected time frames rise to 15 to 20 years due to operators’ network strategies, competitive dynamics and regulatory uncertainties.

Nevertheless, despite demand and push from national entities, only 11 countries in the world have achieved fiber penetration\(^1\) equal to or higher than 25 percent.

So far, the reasons for slow fiber deployment vary by country, but – generally speaking – can be explained by the fact that user application requirements in terms of bandwidth and latency have remained moderate, leading to low take-up rates. These requirements could be satisfied more competitively with alternative technologies such as DSL later augmented with vectoring, bonding, etc., or even 4G/4G+ mobile broadband, which are less investment intensive and hence more suitable for areas that are not highly populated or digitalized. However, more recently the demand for 1Gbps products is increasing, and assumed to be 10 percent of fixed-broadband market demand.

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\(^1\) Defined as Households connected (HHc) over Households served (HHs). Source: FTTH council
To further exacerbate this situation, operational and regulatory risks generally offset the strongest willingness to invest, as obtaining permits and rights of way from regions or municipalities can turn into a nightmare. This is especially true when operators plan to adopt vertically integrated models in which the retail exploitation of the built fiber asset is exclusive to the infrastructure owner.

As a result, national broadband plans suffer from structural voids, as few rational investors are ready to commit to covering more than 50 percent of their countries without public support, be it direct (financial subsidy) or indirect (demand subsidy and regulatory certainty).

Figure 3: Households connected, 2016e

Figure 4: Launch of 1 Gbps offers, timeline

Figure 5: Return profile for fiber investments

Source: Euromonitor, IDATE World FTTx market June 2016, Arthur D. Little analysis

Source: Publicly available information, company websites, IDATE World FTTx market June 2016, Arthur D. Little analysis
2. Several utilities are contributing to national fiber development

As alternative network providers, utilities are well positioned to play a complementary role in national fiber development. We have seen several utilities around the world stepping in and trying to fill the gaps left by telecom players.

Utilities have more reasons to be confident now, as the current business context seems more favorable to these initiatives, compared to the bust of the original tide of alternative players in early 2000:

- Rising demand for ultra-broadband among consumers, especially in light of newer applications such as 4k, 8k, VR and AR;
- The accepted role of fiber companies or wholesale-only players in the competitive arena;
- Higher availability of public funding or government-led infrastructure initiatives;
- Incumbents mainly focused on the most lucrative areas;
- Fiber specialization offering better risk/reward balance;
- Significant unrealized value of the left-over ducting and pole capacity among many utilities.

Figure 6: FiberCos set up by Electricity Utilities

<table>
<thead>
<tr>
<th>Utility</th>
<th>Fiber Venture</th>
<th>Trigger for FTTx</th>
<th>Business model</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>EPB Fiber</td>
<td>Business diversification</td>
<td>Retail</td>
</tr>
<tr>
<td>Ireland</td>
<td>SIRO</td>
<td>Market opportunity</td>
<td>Wholesale</td>
</tr>
<tr>
<td>Norway</td>
<td>Altibox</td>
<td>Business diversification</td>
<td>Retail</td>
</tr>
<tr>
<td>Italy</td>
<td>Open Fiber</td>
<td>National policy</td>
<td>Wholesale</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Northpower Fiber</td>
<td>Public funding</td>
<td>Wholesale</td>
</tr>
<tr>
<td>Basel, Switzerland</td>
<td>IWB Net</td>
<td>National policy</td>
<td>Wholesale</td>
</tr>
<tr>
<td>Bavaria, Germany</td>
<td>M-Net</td>
<td>Market opportunity</td>
<td>Retail</td>
</tr>
<tr>
<td>Denmark</td>
<td>14-utility partnership</td>
<td>Business diversification</td>
<td>Retail</td>
</tr>
</tbody>
</table>

Source: Arthur D. Little analysis
Utilities have inherent advantages

As alternative network providers, utilities have some inherent advantages in rolling out fiber networks, with some overrated and others underestimated.

1. Scope to lower the build cost, but be aware

The infrastructure deployed by a utility to offer its core electrical services is very similar to the fiber network architecture. In particular, the hierarchy of an electrical network follows the same hierarchy as that of an FTTH network, but is much denser (up to three times). Therefore, the fiber network can theoretically reuse the electrical infrastructure while optimizing its path to avoid redundant and unnecessary infrastructure deployment, thereby lowering the overall cost of fiber network deployment.

Utilities could lower the cost of fiber network deployment through the reuse of spare infrastructure, depending on the area to be covered and the existing infrastructure of the utility.

The effective savings highly depend on the areas to be covered, which could be largely classified as greenfield versus brownfield, while the electricity infrastructure could be classified as underground versus overhead.

However, in the absence of suitable infrastructure, the cost savings will be minimal, as infrastructure reuse is limited.

**Greenfield areas**

Greenfield areas are those where the utility has not established electrical feeder networks, but plans to do so in the future (this can be a large part of the new fiber deployment in many fast growing countries, such as Middle East). Utilities can achieve significant cost savings in these areas compared to new deployment by telecom operators. Civil works form nearly 60 percent of the total cost of a new network deployment. Utilities deploying electrical networks to reach new developments dig trenches, lay ducts or install poles to provide electrical services. The same infrastructure can be used for deploying a fiber network simultaneously – resulting in 80–90 percent savings on the civil costs, when compared to new telecom deployments by third parties.

**Brownfield areas**

Brownfield areas are built-up places where electrical feeders already exist to the customer premises. The ability of utilities to lower the cost of fiber deployment in brownfield areas largely depends on the nature of existing infrastructure. Potential elements that can be reused by electrical utilities in brownfield areas include ducts, poles, transmission towers, overhead cables, and substations for colocation of fiber equipment.

In areas with existing overhead electrical networks or ducted underground networks, the cost reduction achieved for fiber deployment is close to those in greenfield areas. This is because it requires limited additional work, such as deploying fiber on...
existing poles below electrical lines or installing fiber in subducts within existing ducts.

In this respect, Open Fiber (Italy) announced the possibility of achieving a cost advantage through Enel’s existing power infrastructure, providing the equivalent of duct access for total reusability of ca. 55–67 percent, which has been estimated to reduce build cost by approximately 25 percent.

Similarly, Altibox (Norway) is said to enjoy significant cost advantage over Telenor, with average build cost estimated at approximately €2,500 per home (vs €3,400 for Telenor).

However, our experience is that such synergies are more complicated to achieve on the ground:

- Reusability of an electrical network must be proven, and initial estimates may lead to effective synergies less than 20 percent;
- Aerial infrastructures have high potential for reuse, but they may be associated with sparsely populated areas where wireless solutions may fit better anyway;
- Beyond reusability, lower-cost figures may be achieved by adopting innovative business practices, such as 50 or 60 percent sign-up requirements in new areas, or asking customers to dig their own trenches (inverting the concept from “last mile” to “first mile”).

2. Faster deployment through privileged rights of way

Utilities can ease several constraints related to rights of way and civil works, as they have access to public areas, even in well-developed parts of cities. On the other hand, without privileged access and optimized procedures, the process to obtain right-of-way licenses could take two to four months in certain countries and municipalities. In areas where construction standards are not defined, telecom operators could take two to three years to enter new developments.

Electricity and water utilities are the first service providers to reach new developments and, in most cases, dig trenches and lay ducts or install poles to provide their own services. By deploying fiber on the same infrastructure, utilities can ensure that fiber connectivity is available in homes even before the houses are occupied.

Utilities typically have well-defined processes for coordinating with various public agencies and private owners to obtain rights of way. This helps them reduce unexpected delays and interruptions in rolling out the fiber network. They also have access to the manholes or poles in their existing infrastructure, which helps them interconnect or extend networks from different points in cities.

On the contrary, utilities also face their own challenges. Examples include generally overloaded and lengthy internal processes, as well as developing safety procedures with electrically competent contractors for installing fiber networks with minimum interruption of core electrical services – especially in brownfield areas with overhead deployments.

3. Availability to play as neutral telecom wholesale players

In many of the recently launched initiatives, utilities deploying fiber networks prefer to operate as neutral wholesale providers for passive (GPON) or active (bitstream) services. This enables all telecom service providers to focus on retail operations, while limiting their upfront investments in fiber deployment.

Such competitive plays are quite unique, though it is the norm in Sweden, as it prevents fiber infrastructure duplication while creating a level playing field in areas where single telecom
operators may struggle to achieve the minimum take-up rate to make the infrastructure investment viable.

Regulators generally mandate this neutral competitive positioning. This is the case in Europe, wherever the infrastructure player, be it a utility or a telecom infrastructure operator, enjoys support from public funding. Several utilities have started offering not only passive services, but also active wholesale or bitstream access, thereby enabling ISPs to offer services to customers.

As an example, Northpower and Ultrafast Fiber in New Zealand have implemented the active wholesale model, and now have more than forty-five service providers on their networks, offering various services such as voice, broadband, TV and home security. Open Fiber in Italy seems to be following the same approach.

Finally, utilities are exempt from the typical cannibalization dilemma suffered by telecom operators with extensive legacy fixed networks (e.g., copper). In such cases, utilities act as accelerators for national broadband plans, even exercising positive competitive pressure on telecom incumbents.

Eventually, utilities can help to extend the reach of telecom operators to areas that were previously considered commercially unfeasible.

4. Attitude towards long-term investments

Investing in infrastructure is quite different from investing in a vertically integrated retail business. This applies to telecom businesses as well.

Access network fiber, with an open access model, is a quasi-monopolistic infrastructure; we rarely find overlapping fiber infrastructure around the world. As a consequence, utilities might be ready to accept payback time frames of more than seven years, provided that clarity and stability of regulation will be in place.

This will especially hold true in areas of market failure where telecom operators are typically reluctant to invest.
Utilities have a variety of reasons to diversify into fiber business

Reasons utilities diversify into fiber business largely vary by country. Sometimes there are prominent and contingent reasons, while more often, the overall decision is driven by a combination of factors, such as electrical business stagnation, soundness of the business opportunity itself, smart-grid upgrade, political call, and/or contingent availability of public funding.

First and foremost, fiber development gives utilities an opportunity to diversify their revenues. As seen from mature markets, a utility could make up to 20 percent of its revenues from fiber business, depending on the chosen business model. Retail business models are richer in revenue contribution, but not necessarily in profits.

Utilities that already have fiber assets deployed on their long-haul networks (i.e., transmission networks) have generally opened them up to third-party use, but they could monetize their assets better if they deployed complementary fiber-access networks.

Influencing factors:
- Competitive situation
- Demand maturity
- Year of entry
- Business model
- Service offering (e.g., wavelength, IP services)
- Network footprint
- Asset utilization and monetization

1 Group revenue denotes total revenue of parent co. including utility, telecom, and other sources
Source: Arthur D. Little analysis

Figure 10: Drivers for electricity utilities to go for fiber

<table>
<thead>
<tr>
<th>Business opportunity</th>
<th>Smart meter/ Smart grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active equipment</td>
<td>Civil Works</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference cost</td>
<td>Utility cost</td>
</tr>
<tr>
<td>15%</td>
<td>85%</td>
</tr>
<tr>
<td>76%</td>
<td>36%</td>
</tr>
</tbody>
</table>

Competitive advantage
Low latency and high availability

Cost synergies
Availability of substantial funding
Demand for accelerated fiber

Figure 11: Telecom revenue as % of utility revenue

Table: Telecom revenue as % of utility revenue

<table>
<thead>
<tr>
<th>Player 1</th>
<th>Player 2</th>
<th>Player 3</th>
<th>Player 4</th>
<th>Player 5</th>
<th>Player 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet</td>
<td>Internet</td>
<td>Internet</td>
<td>FTTB</td>
<td>FTTB</td>
<td>FTTB</td>
</tr>
<tr>
<td>TV</td>
<td>TV</td>
<td>E2E data</td>
<td>Infrastructure</td>
<td>GP</td>
<td></td>
</tr>
<tr>
<td>Telephone</td>
<td>Telephone</td>
<td>Telephone</td>
<td>FTTH</td>
<td>FTTH</td>
<td>FTTH</td>
</tr>
</tbody>
</table>

Source: Arthur D. Little analysis
Additionally, utilities deploy fiber to achieve independence for their internal telecom needs and benefit from the fiber infrastructure for their own internal use.

There is an increasing need for making utility networks smarter and equipped with high-bandwidth communication and more important, there is a need for very low latency and high availability, as demanded by certain internal applications such as tele-protection.

However, deploying fiber purely for internal use is not commercially feasible. Sharing the costs of deployment between internal and external purposes makes the investment more attractive. For example, utilities in the US, Germany and Ireland have benefited from rolling out fiber, as they reserved a few fiber strands for their own internal use while counting on external monetization to recover the initial investment.

In a few markets (such as Switzerland) and cities (such as Chattanooga, Tennessee), utilities are controlled by local municipalities, and their decisions to invest into fiber are aligned with the vision to improve the standard of living in the city or to boost the local digital economy. Therefore, the utility may be rolling out fiber to improve the local quality of life and make its territory a more attractive investment destination.
5. Three business models can be adopted

Utilities engaging in fiber development have been observed to follow one of three notable business models, as listed below:

1. **Wholesale operator with telco partner**
2. **Wholesale operator, state-triggered or co-owned**
3. **Independent retail/wholesale telecom operator**

In the first case, the option to partner with telecom operators to diversify into fiber business is straightforward. The utility offers wholesale services (active or passive) to telecom operators, which provide retail services on the fiber network. Telecom partners share the initial investment risk, especially in the case of large roll-outs, by guaranteeing purchase commitments and minimum utilization of the network. Sometimes, telecom partners also bridge gaps in skills, such as network design, network deployment and geo-marketing, and gaps in telecom systems such as Operations Support System and Business Support System.

Though the utility may partner with one or more telecom operators, it typically retains the right to offer wholesale capacity to any telecom operator to augment its revenues from the deployed infrastructure. IWB is a good example of such a model. IWB and Swissscom co-invested in deploying fiber in Basel. Swissscom has committed to a long lease of a few fiber strands to offer telecom services to retail subscribers, while IWB remains free to wholesale the other fiber strands to other telecom operators or use it for its own purposes.

In the second case, the state-aid component could be in different forms – a subsidy, a zero-rate long-term loan, setting up a joint venture with the state, etc. The availability of the state aid typically mandates that the utility follows the wholesale model in order to promote service competition. An example of this business model is Oman Broadband Company (OBC), which was set up as a joint-stock company wholly owned by the Government of Oman. OBC is focused on the deployment of a broadband infrastructure, providing equal and open access to telecommunication service providers on a wholesale basis, enabling end users to efficiently leverage high-speed fiber connectivity in Oman. OBC partners with government-run utilities and ministries, such as the Public Authority for Electricity and Water, the Ministry of Regional Municipalities and Water Resources, and Haya Water, to reduce the cost of civil works. The company has covered 23 percent of the Muscat Governorate, and aims to achieve 85 percent coverage by 2020.

Northpower Fiber and Ultrafast Fiber in New Zealand are other examples of utility-led fiber roll-outs set up with government funding to cover rural areas. In contrast, Open Fiber in Italy started as an autonomous initiative by Enel (it was initially called Enel Open Fiber), but ended up as a joint venture with Cassa Depositi e Prestiti (CDP, an Italian government fund) after the merger with Metroweb (a historical fiber company active in a few cities in Northern Italy). In our view, SIRO is another example which operates under Model 1, but also has the potential to move to Model 2 for selected areas.

In the third case, utilities play the role of full-fledged telecom operators. M-Net in Germany and electrical companies such as OptiLink and EPB in the US engage in wholesale and retail services. This is often the case for those utilities that decided to diversify into telecom business early, around 2000.

Though this business model helps utilities to capture a larger part of the value in the fiber broadband market, it is extremely challenging, as it demands a strong build-up of commercial and technical telecom capabilities. Further, telecom operators are not incentivized to procure wholesale services from the utility, due to the direct competition threat at retail level.

Recently, utilities taking up the role of stand-alone wholesale operators is not widely observed. (It is more the case for utilities that started this diversification process in the early 2000s). The utility may not be able to achieve extensive coverage through this model, as some areas are not feasible without state funding. Further, the utility carries the risk of upfront investments in areas where telecom operators may not be interested in offering retail services.
The retail model: EPB case (US)

The case of EPB is exemplary in showing how far diversification into telecom services can go, and the hurdles and criticism that utilities may encounter along the way.

As early as 1996, EPB decided to invest into telecoms and connect its electrical assets (e.g., substations), backed by its main shareholder, the municipality of Chattanooga, Tennessee. The project was resumed after stagnation in 2000, after the company obtained a license to offer non-electrical services and take out loans in non-electrical business.

EPB’s expansion into telecom services was met with lawsuits from incumbent ISPs claiming that EPB was illegally cross-subsidizing its communications services with revenue from its electric business. EPB only decided to invest into FTTH in 2007, and gained permission to operate in 2008.

EPB Fiber was successfully launched, and the fiber networks now cover a footprint of 170,000 homes, schools and enterprises of Chattanooga. EPB Fiber is now profitable, yet highly leveraged, and advertises its products as the “nation’s fastest internet” by proposing internet access ranging from 100Mbps to 10Gbps.

The case of a municipality entering the telecom space and allowing the local electrical company to compete against telecom giants such as Comcast and AT&T has raised much discussion and criticism so that plenty of literature and news can be found about this case.

Critics of the government-backed project argue that private utilities are at an unfair disadvantage in competing against a government utility that gets extra federal funds and doesn’t have to generate a profit for its owners. It is argued that Chattanooga cannot be taken as a model for other municipalities to replicate the building of fiber networks for several reasons. Firstly, this particular network arose out of the unique circumstances of access to a federal grant. Secondly, Chattanooga residents are not entirely shielded from liability stemming from the debt required to build the FTTH network. Finally, “the exclusively public nature of the Chattanooga fiber network not only contradicts the city’s established preference for using PPPs to improve local economic conditions, but the high upfront and recurring costs associated with running the fiber network divert critical resources from local government priorities.” (From “Chattanooga Case Study” by Charles M. Davidson.)

However, backers of EPB Fiber insist that the investment has already paid off in a smarter electric grid which generates savings and greater quality, better telecom services and more economic development in Chattanooga.

Learnings

Fully fledged telecom retail models can offer up to 20 percent revenue diversification for utilities, but ignite serious debates on fairness and the nature of such a competitive value proposition.
The wholesale model: SIRO (Ireland)

ESB is the electrical utility in Ireland, engaged in power generation, transmission and distribution. ESB has a long-distance fiber network across its high-voltage electrical footprint, established over 15 years, partly for internal use and partly to serve external customers. Further, ESB has a dark fiber network in Dublin, which hosts many data centers and large technology companies. Major cities in Ireland already had high-speed broadband. However, roll-out in regional and rural areas was limited despite the demand for high-speed broadband, due to the high cost of network roll-out.

ESB set up “SIRO,” a 50/50 joint venture with Vodafone, to roll-out and market the access fiber network in regional and rural areas of Ireland, with an investment of €450 mn. SIRO was set up with the vision of establishing the first 100 percent fiber network in Ireland, with a target of passing 450,000 premises.

The partnership limits the investment and risks for ESB, as it assures monetization of the new network via Vodafone. ESB could leverage its electric-network infrastructure for the deployment of a fiber network and monetize it by offering wholesale open access to all telecom operators. For Vodafone, the largest fixed-mobile operator in Ireland, the partnership lowered the cost of reaching customers.

SIRO started the program to launch the network in the first 50 commercially viable towns. It consciously targets regional and rural areas, where there is limited competition from telecom operators. The rural focus has led to SIRO being shortlisted by the Irish government as one of three potential network providers for two geographic areas of the country under the government’s National Broadband Plan.

A key criterion for SIRO in selecting cities for the roll-out has been the reusability of the electrical infrastructure of ESB. Roll-out is prioritized based on multiple factors, including:

- Limited competition from telecom operators
- Customer concentration: preference for areas with high densities of housing
- Reusability of electrical infrastructure, based on the cost and effort required, with preference for overhead and ducted or vaulted areas.
Due to the safety considerations for building a fiber network in the vicinity of an electrical network, SIRO leverages electrical contractors supported by telecom contractors for fiber deployment, after ensuring that they have the necessary authorization, certification and training.

SIRO offers a managed-access service to retail telecom operators, ISPs and other entities that are licensed to offer retail telecom services within Ireland. Though Vodafone acts as the anchor customer, SIRO offers services to any operator demanding wholesale service. Apart from FTTH/B access, SIRO offers multiple points of interconnection across the country and backhaul to mobile towers.

It should be noted that ESB continues to offer long-haul services and international backhaul services to carriers on its own network, independent of the SIRO business.

Learnings
SIRO is a good example of utility, telecom operators and government coming together to accelerate fiber deployment at a national level.
6. Fiber development does not come without challenges

Though there are many examples of utilities rolling out fiber successfully on their infrastructures, it does not come without challenges.

Firstly, utilities should know if conditions exist (e.g., existence of specific policies which support the development of strategic infrastructures in the country) to ensure the bankability of the project with adequate internal rates of return their overall business plan objectives and growth priorities. For example, utilities should confirm the existence of specific policies that support the development of strategic infrastructure in their countries, as well as the availability of a favorable competitive landscape (presence of cable operators with upgradeable networks can limit the opportunity for utilities).

Secondly, utilities should take into account the requirements mandated by the regulators on their core activities, in order to tap (business) synergies for both the power grid and the telco business without compromising regulatory compliance. For example, the role of fiber optics as a reliable communication infrastructure used for grid management should be clearly formulated in a mid-term network development plan and communicated with the regulator.

Thirdly, utilities should set up a business model (ownership, operation, transfer of rights to entities involved, including pricing) which complies with various regulatory requirements such as license conditions, cyber-security and tax regulations.

The business model should also enable a clear split between regulated and commercial business in terms of CAPEX and OPEX.

Utilities should build telecom capabilities in the areas of planning, design, construction, operations and maintenance. Even if the utility plans to outsource most of the activities, it should be able to develop the fiber-network architecture, identify areas for roll-out, monetize the deployed network and plan to reduce the gap between investment and revenue generation. It will also need to define the process, procedures, standards and specifications that the contractors will adhere to.

Utilities should collaborate with construction contractors to define procedures which will minimize the outages required and qualify them accordingly.

Utilities should also collaborate with telco operators and their contractors to develop operations and maintenance procedures which will allow to operate in the proximity of dangerous equipment, taking into consideration the service-level requirements of both electricity and telecom networks.

Lastly, utilities should manage regulatory constraints on the telecom side. In developing regions such as the Middle East, the deployment of fiber and monetization methods (such as wholesale and retail) are tightly regulated.
7. **Arthur D. Little is the ideal partner to support both utilities and telcos**

Arthur D. Little is uniquely positioned to support utilities and telecom operators in:

- Bringing diversification opportunities to the Board
- Identifying possible partners and negotiating terms and conditions of the agreement between the parties
- Assessing the reusability of assets
- Identifying business models and developing business plans for fiber development
- Identifying financing strategies in compliance with regulatory constraints
- Identifying governance models between utility and telecom units
- Developing processes, procedures, standards and specifications for fiber infrastructure deployment (both overhead and underground)
- Assisting with the definition of IT system requirements

We have extensive project experience in fiber development, and have worked for both utilities and telecom operators. We have also worked with ministries and regulators in developing their national broadband plans, gaining a holistic view of fiber development strategies across all relevant stakeholders.

Our internal experts combine extensive fiber experience with local insight and industry expertise.

Our extensive network of external experts ensures that each client will leverage the best-possible expertise, in line with the challenges and the context the company is facing.

**Authors**

Andrea Faggiano, Lokesh Dadhich, Jaap Kalkman and Carlo Stella

www.adl.com/NationalFiber
Virtual Power Plants – At the heart of the energy transition

Energy utilities are evolving towards greater reliance on flexibility to respond to an increasing supply-and-demand imbalance. In that context, the role of aggregators has become predominant in optimizing electricity generation and demand through virtual power plants (VPPs) and complementing traditional power plants in the provision of flexibility. Meanwhile, aggregators face strong competition from traditional retailers: these are developing similar demand-side response (DSR) solutions, leveraging their portfolios of customers and generation assets or acquiring promising aggregators altogether. In our broad project experience, we have supported utilities and investors in addressing the question of how to build up a successful aggregator model.

VPP development was, until now, facilitated by regulation and opening of energy markets to flexibility

Regional and local regulators are encouraging and facilitating participation of demand response and aggregators in all organized energy markets. In parallel, transmission system operators (TSOs) in some countries have redesigned their market rules to accommodate DSR in the system. This has generated a broad range of mechanisms and programs in recent years, allowing aggregators to ramp up revenues over short periods in order to benefit from acceptable market conditions (e.g., minimum bid size, no consent from final customer’s supplier required, technology-agnostic market rules) and get access to real-time price signals. The combination of favorable regulation and opening of energy markets has led to a proliferation of aggregators across the globe in the last years. In the UK alone, around 20 players have developed aggregation activities.

Although some markets, such as the UK, France and Belgium, are very dynamic for favoring DSR flexibility development, substantial efforts still need to be made in other regions of the world, such as Germany and Spain. Conditions of participation in lagging markets are often quite strict, and therefore limit the aggregated load to compete with traditional generation assets.

Market consolidation is ongoing

The Demand Side Management (DSM) market is facing significant consolidation and attracting large investments from utilities and private equity firms. Some recent acquisitions of aggregators by retailers in Europe and the US were the results of win-win searches for synergy (e.g., EnerNOC was acquired by Enel, ReStore by Centrica). This demonstrates great interest from retailers in integrating agile start-ups and technical solutions into their own large, complex organizations. Aggregators on their side can directly benefit from market access offered by retailers through their customer portfolios, which become potential flexibility sources.

Meanwhile, the business climate for aggregation becomes more sophisticated and less stable, creating multiple effects. Capacity auction results in the UK demonstrate the volatility of expected revenues for energy asset investors and aggregators. Record-low clearing prices for capacity market auctions (£8.40 per kW in 2018 T4 auction) raises questions over the sustainability of the mechanism and the level of incentives developers can expect for new-generation assets.

On top of revenue instability, energy suppliers and aggregators (and distribution system operators in some markets) are competing for access to flexibility from the same pool of...
customers, with higher cost of customer acquisition for aggregators.

Finally, the DSR market is constantly evolving, with the introduction of new mechanisms and existing ones being rationalized and simplified. This drives the need for VPPs to be on top of each of their regional market dynamics and ahead of any upcoming developments.

The ongoing consolidation trend is likely to be confirmed in the next months if uncertainty of revenues occurs, making the business model less stable for aggregators.

**Different levels of maturity across aggregators**

From a commercial and technical perspective, aggregators are spread along a maturity spectrum, based on geographical footprint, scope of services, portfolio of customers and technology.

We distinguish three types of European and US players:

1. **Embryonic**: These typically focus on either aggregated generation or load control. Due to their early developmental stage, flexibility is sourced from a limited number of assets and geographic expansion is opportunistic, with no deployment of sales force abroad. Partnership with retailers is key for their development, to open market potential and access to portfolios of customers.

2. **Active and developed**: These demonstrate capacity to generate profit in a short time with ambitions to geographically expand their activities. They are usually perfect targets for acquisition by large-scale energy companies.

3. **Self-sufficient**: These firms have considerable capacity under management, sizable presence around the world and developed flexibility portfolios composed of broad varieties of buyers and assets, ensuring ability to supply all types of flexibility needs.

Recent acquisitions show that each of the three categories of companies are potential targets for investors as a function of the investor’s need.

Illustrations of recent acquisitions and investments

<table>
<thead>
<tr>
<th>Source: Arthur D. Little</th>
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<tbody>
<tr>
<td><strong>Acquisition of RESTORE by Centrica for €70m</strong></td>
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<tr>
<td><strong>£3m funding by Statkraft into Limejump</strong></td>
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<tr>
<td><strong>Acquisition of EnerNOC by Enel for €200m</strong></td>
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<tr>
<td><strong>Acquisition of minority stake by Eneco in Next Kraftwerke</strong></td>
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<td><strong>Inflexion, private equity, has invested in UK Power Reserve</strong></td>
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Key success factors: What is required for aggregators to survive in this rapidly evolving and hyper-competitive environment

We distinguish multiple key success factors to thrive in this business. On top of developing a large scope of services to offer flexibility to users, the combination of the right skills and technology solution constitute the key differentiator to be a “winning market player”.

1. Extended scope of activity and offering
The analysis of the aggregator landscape shows a concentration of players offering full DSR scope (load and supply aggregation), as illustrated by the figure below. In some cases, their aggregation offerings are complemented by energy services. Only a limited number of providers can offer this large offering spectrum, unless they have strategic partnerships with energy retailers or were acquired by one of them.

Mapping of aggregators against go-to-market strategies and scope of offering (selection)

<table>
<thead>
<tr>
<th>Independent aggregator</th>
<th>Partnership with energy retailers</th>
<th>Aggregator within an energy retailer</th>
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<tr>
<td>Aggregate load</td>
<td>Aggregate supply (including VPP)</td>
<td>Full DSR scope (load &amp; supply)</td>
</tr>
<tr>
<td>Aggregate load</td>
<td>Aggregate supply (including VPP)</td>
<td>Full DSR scope + energy services</td>
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<td>PeakGen</td>
<td>Activity</td>
<td>Energy Pool</td>
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<td>UK Power Reserve</td>
<td>AutoGrid</td>
<td>Yuso</td>
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<td>Open Energy</td>
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<td></td>
<td>Flexibility</td>
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Increasing scope

1. Extended scope of activity and offering
2. Reactiveness and flexibility
3. Diversification
4. Innovation and technology
5. The right skill set
6. A low-cost solution

Outlook
The role of aggregators in the VPP/DSR market is on the rise in the US and Europe, where market design and regulation are increasingly favorable to supporting this flexibility source in the energy system. Our research and project experience in this area highlight the attractiveness of Europe, especially the French and UK markets, for their maturity and continuous willingness to improve conditions for DSR to participate in the flexibility market. Flexibility monetization is ongoing in Asia, with the Japanese market as an example of how a new DSR market is being shaped based on US and EU learnings. Although some other geographies are still lagging behind, we anticipate increasing supply and demand for flexibility, driven by most of the energy market players.

On the provision side, we expect that renewable generation, battery storage and load from industrial and residential segments will increasingly provide flexibility in the coming years. Conventional generation has been the single source of flexibility for years, and related provision volume is
expected to stabilize, as investment for that category of asset is limited (except for gas-fired flexible conventional generation).

**Current and future flexibility trends – Breakdown by provision and consumption types**

**Demand outlook**

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<th>Flexibility providers (1)</th>
<th>Flexibility users (2)</th>
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<tr>
<td>Current share</td>
<td>Expected trend</td>
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<tr>
<td>Conventional generation</td>
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<td>Renewable generation</td>
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<td>Stored capacity</td>
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<td>Flexible consumption</td>
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**Current and future flexibility trends – Breakdown by provision and consumption types**

On the consumption side (2), system operators will constantly need more flexibility since development of intermittent generation is still growing. On the retail side, more and more energy retailers are developing or integrating aggregation activities into their businesses; therefore, we do not expect them to still need intermediaries in the future to get access to flexibility.

The flexibility market, and more specifically, VPPs, present opportunities on different fronts. Some geographies start shaping their markets based on key learnings from more mature markets and should open theirs to aggregators soon. In parallel, in markets where aggregators are successful and more or less established, consolidation is happening, mainly driven by utilities looking to complement their businesses with VPPs relying on proven technologies. Finally, private investors will carry on leveraging the ongoing market consolidation, pushing additional revenue streams (such as “software-as-a-service”) in these maturing flexibility markets.

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Arthur D. Little

Arthur D. Little has been at the forefront of innovation since 1886. We are an acknowledged thought leader in linking strategy, innovation and transformation in technology-intensive and converging industries. We navigate our clients through changing business ecosystems to uncover new growth opportunities. We enable our clients to build innovation capabilities and transform their organizations.

Our consultants have strong practical industry experience combined with excellent knowledge of key trends and dynamics. ADL is present in the most important business centers around the world. We are proud to serve most of the Fortune 1000 companies, in addition to other leading firms and public sector organizations.

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