# Distributed energy platforms: Who will lead the next electricity revolution?

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## Abstract

Climate change is forcing rapid change in the energy landscape. Two opposing paths represent plausible futures for the US power sector: centralization vs. distribution. Without trying to predict its likelihood, this thesis explores the implications of one of these paths, a distributed energy future. My objective is to investigate who could become the leader of this revolutionized industry. I specifically explore the potential role of three types of actors: privately-owned *Utilities*, energy-software *Startups*, and *Large Tech* companies, whom many do not yet factor into their assessment despite what I consider to be their vast scope to shape outcomes.

A literature review establishes the broad contours of a distributed energy future. I find that existing scenarios predict a more complex energy system and that intermittency would become a significant issue. I consider the role of distributed energy resources (DER) as a viable solution if built on digital platforms. To draw out the implications of these observations, I conducted nine in-depth interviews with executives. The analysis yielded four key insights: a distributed system would be a revolution for the industry; *Utilities* are under much pressure, putting their leading position at risk; *Startups* are in a position of dependency and cannot take the lead alone; *Large Tech* are much closer to playing an active role than it looks at first glance.

I sketch out comparisons with recent history to suggest that *Large Tech* companies should be considered as serious contenders for the leading role of a decentralized energy industry. I extend my analysis to the unique case of Tesla, also in a position of strength in this plausible future. I conclude this thesis by estimating that the answer depends on how utilities will act in this future, either by transforming themselves fast enough or letting *Large Tech* companies take over.

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It is an understatement to say that I did not expect this year to be like this. I got the call from Rod Garcia telling me that I was accepted for the MIT Sloan Fellow program MBA on February 12, 2020. I had less than ten days to enjoy that news before the first lockdown in Italy that made me understand that nothing will happen as hoped. However, I was certainly among the luckiest during this first year of the pandemic. I was still able to join MIT and engage in the transition I was hoping for. Obviously, like everyone, I had to adapt to this new reality, and this thesis is a part of that process. In a “normal” world, I do not think I would have found the time and the energy necessary to achieve this. So, even if I do not thank the pandemic for anything, I wanted first to acknowledge that.

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A punch in the face but a real eye-opener.

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# Table of Contents

# Chapter 1 - Introduction

Pressed by climate change and other critical issues, the global energy landscape faces major disruptions (IEA, 2020). Energy production is growing faster than many expected and shifting to new sources, driven by major economic, environmental, and geopolitical factors (IEA, 2019). With the rise of devices and services that use electricity to replace manual and mechanical energy--consider everything from temperature control to transportation--residential customers are developing a taste for new uses of electrical power. At the same time, thanks to small-scale home solar systems, residential customers are producing more of their own energy, putting them into the new role of “prosumers” whom both draw on utility-generated electricity when needed and share excess electric power with others via the grid (Immonen et al., 2020).

Public attention tends to focus on energy sources, putting electricity generation at the top of their concerns about the impact of energy use. But the electric power system cannot function without the electric grid. These grids are composed of different, sometimes fully independent, networks. Observers note that the level of investment needed to maintain the grid already poses what may be an overwhelming constraint, especially in mature countries like the United States (EBP US & ASCE, 2020). At the same time, the system needs to evolve to offer more flexibility and bespoke services (e.g., load following, ramping, regulation, peak shaving) (Hillberg et al., 2019), changes that will call for even more investment.

Finally, wholesale and retail markets evolve to face new needs and new challenges, creating complex situations that introduce further questions and uncertainty. Many remember the 90’s-era shift to electric power deregulation in the US. It provides an excellent example of how much this market can evolve--and unfortunately also revealed that market shifts could precipitate new crises, such as the “2000–01 California electricity crisis” (EIA, n.d.) or the “Enron scandal” (FBI, n.d.).

Thought leaders from public institutions like the Intergovernmental Panel on Climate Change (IPCC) to private companies like Royal Dutch Shell (Shell) have developed plausible scenarios to depict what could happen in our future when we account for such trends and shifts. Their scenarios cover the entire energy industry on a global scale where the rise of new consumers will reshape energy markets, technical systems, and climate impacts. But the shifts that will play out in advanced economies could be equally momentous, as we will see. Two countervailing forces seem poised to fight each other for the next stage in the evolution of the power sector: centralization vs. distribution.

Centralized systems dominate the US power system today. If we continue on the centralization path, electricity production capacity would be managed by large plants. An essential component of such a system is its transmission and distribution infrastructure. A more centralized energy future would entail networks linked together by an increasing number of long and efficient transmission lines, along with transformers and controllers, to bring power to customers when they need it. Those lines would be deployed between states and neighboring countries to share the strengths of different regions and help limit the impact of extreme events, making the system more resilient. This path could also present potential efficiency on the production side due to scale effects and would rely less on expensive and potentially environmentally deleterious energy storage. Some actions currently taken in the industry indicate that this is one plausible future.

This thesis focuses on the other path: a distributed system. In such a future, power generation would not be the sole purview of large plants but would also include more and more small assets installed everywhere. From solar panels on rooftops and parking structures to relatively small onshore wind turbines, the electricity generation would become highly decentralized. Besides, actions to manage and optimize electricity consumption would be pushed forward, thanks to heat pump installation, building insulation, but automated appliances that would avoid peak periods. Finally, local storage would also become an essential part of this future, thanks to electric vehicles and home batteries.

In such a world, electricity markets would shift, potentially dramatically, to a platform-based model. As consumers and producers become more intertwined, the number of exchanges would increase, not only in volume but also in complexity. The market would have to handle buys and sells from millions of points on the grid in real-time. To manage such exchanges, new roles would have to appear, in turn demanding new business models, and of course, new limits. The number of platforms, their interoperability, and their reach could vary a lot, but this would create significant changes to the current situation.

The point here is not to establish *whether* this "distributed energy platforms" future would be better or even if it appears to be more probable than the centralized alternative. Instead, my goal is to explore its implications. As I have argued, a distributed future is plausible. Yet because the arrangement of producers and service providers in such a world would look very different from what we know today, a worthwhile goal is to develop a clearer picture of what such a future could look like, concretely. Such an analysis would explore questions that my research suggests do not appear to be sufficiently examined by current decision-makers. For example, few existing scenarios take on the question of *who*--which players--would shape the market in this potential future world.

Examining a platform-mediated distributed energy future also calls into question the type of changes such a shift would entail. If we consider this future to represent not just an evolution, but possibly a revolution, from the current state, it is logical to assume that the current leaders of this industry could lose their top position. Indeed, history is full of technical and operational changes that led to significant reconfigurations of the actors who had previously dominated their sectors, like the car industry a century ago or what is currently happening to the entertainment industry.

So, the main objective of this study is to investigate who could become the leader of the energy industry in a future built around a distributed path and explore what that might mean for the industry. Specifically, I seek to answer the following questions:

- How are the industry's current leaders positioned to face, and even shape, this plausible future?
- Which other actors could enter this market by providing essential services to enable distributed energy? Might such new entrants even take the lead?
- What significant changes among those actors could we expect in the industry if this future indeed happens?

Instead of putting the spotlight on specific companies that could change in the short term, I chose a wide-angle view to explore these questions. Accordingly, my research examines three categories of actors: *Utilities*, *Startups*, and *Large Tech* companies.

➔ ***Utilities***

Electric utilities are the current leader of the power sector. These large companies know how to handle major infrastructure projects and are currently responsible for almost all access to electricity in our modern societies. They manage the generation of electricity and work with or are directly in charge of the transmission and distribution of the electricity to their clients.

Even though many utilities are publicly owned, cooperatives, or nationalized entities, "[i]nvestor-owned utilities served 72% of U.S. electricity customers'' (Darling & Hoff, 2019). In this category, I will be focusing my research only on those private companies, as I suppose they will be more inclined to react in a decentralized future.

➔ ***Startups***

The energy sector, impacted by the development of renewables, is generating some noticeable interest from *Startups*. Their goal is often to bring either new technology or a new offer to the market. But, individually, they are very focused on their "bet" and cannot work on many different projects or markets.

In 2019, “climate tech startups” gathered $16.3 billion of funding from venture capital companies, compared to only $418 million in 2013 (Herweijer & Azha, 2020). This trend is significant. However, the *Startups* focused on the energy sector represent only a tiny portion of this total, less than 10%, the most significant part dedicated to mobility startups, more than 60%.

But despite this mixed financial situation, considering the increasing need for innovations in this industry, it is possible for the *Startups* currently working on this specific future to take a significant role. Besides, as we already saw it happened in other industries, like during the digital revolution, it is not impossible to see some *Startups* taking leading positions.

➔ ***Large Tech* companies**

*Large Tech* companies' involvement in the energy sector mainly comes from the major energy needs of their data centers, for which the energy bill is, in general, the main operating cost. They are also firmly pushed by public opinion to decarbonize their activities and tend to take positions in favor of all aspects of sustainability.

Rather than considering in this thesis only the “Big Tech”, which represents a finite group of companies, I choose to consider more companies in this category, named *Large Tech.* This category includes tech companies with activities worldwide, managing tens of thousands of employees and generating tens of billions of US dollars in annual revenue. Therefore, the “Big Tech” are included in this category but are not the only ones.

Industry observers might not think to put *Large Tech* firms at the top of their list entities to consider in their analysis of the electric sector, but their role in reshaping entire industries in recent years suggests that they could exert tremendous influence--and come to control much of the economic activity--in this sector too.

The considerations I have laid out in turn frame what I will argue are the key considerations for not only the *Utilities* that currently dominate the industry but also for would-be entrants--and ultimately for the communities and organizations they serve. The growing burden of climate change also suggests that the upshot matters to the entire planet.

With these implications in mind, I built my study around the three categories of actors I have identified as the potential shapers of the next electricity revolution. To map out the contours of a distributed energy future, Chapter 2 starts with a literature review and a broad discussion of the context, motivating the qualitative interviews that follow. Chapter 3 moves into a discussion of my interview design and sampling strategy. I present the interview results in Chapter 4, weaving in quotes that convey leaders' perspectives from all three types of organizations, then discuss their implications in depth in Chapter 5. As I argue in the concluding chapter, my insights could inform the people and companies who have the power to shift how the electric system operates. They may even help to deliver better solutions for the world.

# Chapter 2 - Literature Review

I reviewed the literature to identify key considerations for understanding the industry's transition and the next challenges it will have to face in the near future. Indeed, this helped me get a sense of the urgency of the situation and the pressures to change that the actors I am considering could feel.

Then, I considered the question of "platform-based" models and how it is currently linked to the energy industry. Again, the goal was to understand better how the current actors are involved in the digital transformation and what unexpected paths could appear to best frame my interviews and support the analysis and discussion of the results.

# 2.1. The Energy transition

## 2.1.1. Inevitable transition

### 2.1.1.1 The end of an era

Over the past century, a few large corporations have been mandated by the State to provide electricity to residents, businesses, and industries (Pomp, 2000). Before the beginning of the deregulation of the sector in 1997, competition was nonexistent. The best way to manage this situation was to build large, long-lasting power plants with unidirectional transmission and distribution routes to deliver electricity all over the country. Prices were “cost-based, not market-based” (Pacific Northwest National Laboratory, 2002, 5.1); the values sought were security and stability.

But now, external constraints are prompting a new energy transition. Several major factors have pushed this transition. In a widely-cited study, Solomon and Krishna (2011) summarize supply, cost, technological innovations, and pollution as factors that “stimulate a transition from reliance on one major energy resource to another”.

For example, the recent transition away from coal-fired power in the US has been firstly motivated by the development of shale gas technologies. Thanks to new technical developments that made horizontal drilling and hydraulic fracturing possible, shale gas became an abundant and cheap source of energy. As a result, proponents advocated for shale gas as an efficient and plentiful replacement for coal, even as the potential reduction of CO2 emissions has been questioned (Lueken et al., 2016). In China, some coal power plants were also closed in favor of renewables, but the main reason was mostly to fight air pollution in major cities, especially Beijing, and not directly fight climate change (Inskeep & Westerman, 2019).

#### 2.1.1.2. Renewables strike back

After two centuries ruled by fossil fuel energy, renewables are becoming central again. Since 1990, the annual average growth rates are 37% for solar and 23% for wind, compared to a 2% growth rate of the world's total energy supply (IEA, 2020). But, again, without even the consideration of CO2 emission, thanks to the latest innovations and developments in solar panel and wind turbine technology, renewables have now several advantages against non-renewables that are certainly driving their current growth:

- Their availability, in new geographies, allows some countries to develop their energy independence, which was previously impossible for them, lacking mineral resources to do so (Global Commission on the Geopolitics of Energy Transformation, 2019).
- Their financing structure is more straightforward than big power plants, needing less capital and presenting fewer risks, especially considering low capital cost, high discount rates, and very high incentives. Indeed, for several, often political reasons, renewables are highly incentivized, thanks to tax credits in particular (IEA, 2019).
- The rate of technological improvement has been high, fueled by research, innovations, and startups. It allows those technologies to improve quickly, inducing better competitiveness and a strong feeling of high potential among their defenders and investors in general (IRENA, 2017).
- And finally, excluding hydropower, their operational risk level is also low. Contrary to any other power plants, wind and solar farms present a low risk for the population (Sovacool et al., 2016).

Today, of course, the evolution of the climate worldwide is starting to be worrying enough for everyone to consider that the decarbonization of our activity should be a priority. The Paris Agreement, adopted by 196 Parties at COP 21 in 2015, is evidence of the growing acknowledgment of looming environmental concerns (United Nations Framework Convention on Climate Change, 2015).

#### 2.1.1.3. Financial motivations

This transition requires many transformations. The energy sources like solar panels and wind turbines are only a piece of it, meaning that the financial needs of this transition are even more significant. Indeed, to support new energy sources, the entire infrastructure may have to evolve or be reinvented (Blackmon, 2020). Furthermore, with new infrastructure, we also need new systems to manage it, from the rules that we apply to the automation needed to pilot it.

*Utilities* have always been capital-intensive sectors, and enduring such a large transition means that "strong financial partners will play a critical role in providing funding" (McKinsey & Company, May 2019). And funding is already flowing into renewable energy and low-carbon technologies. Last year, despite the pandemic, we committed $501.3 billion of investments worldwide to decarbonize our economy. This budget represents a 9% increase compared to 2019 (BloombergNEF, 2021).

Considering those factors, the conclusion is that the current energy transition from fossil energy sources to renewables cannot be avoided. As Ernest J. Moniz, former U.S. Secretary of Energy, posted on his Twitter account in December 2016, "Climate change may have inspired the clean energy revolution, but price has made it inevitable".

### 2.1.2. Long-term scenarios

#### 2.1.2.1 Below 2°C

Facing this inevitable transition, we can try to grasp the numerous impacts we will have to cope with in the coming years. Projecting the implications into plausible scenarios has always been an effective way to imagine better solutions. Companies, groups, and institutions regularly develop scenarios about plausible futures focused on climate change and its interaction with the energy industry.

Those scenarios highlight strict and demanding actions regarding emissions reductions. In 2015, the IPCC adopted a group of "Representative Concentration Pathways (RCP)", that describe "different 21st century pathways of GHG emissions and atmospheric concentrations, air pollutant emissions and land use" (Climate Change 2014 Synthesis Report, 2015).

Among the main versions of the IPCC scenarios, "RCP2.6" is the only one that may limit global warming below 2°C by 2100, and that is therefore aligned with The Paris Agreement. But even to have a chance to achieve this result requires a steady decline of CO2 emissions starting in 2020 to reach net-zero worldwide by 2100, as well as cutting by half methane emissions and almost all sulfur dioxide emissions. It also requires negative CO2 emissions by developing more natural sinks, which would only be possible if the world decides to invest in carbon capture and sequestration (CCS) technologies.

#### 2.1.2.2 Plausible pathways

Plausible climate futures include a range of difficult-to-contemplate cases that would pose severe challenges for much of the world for an energy industry that would want to comply with their conclusions. The company Royal Dutch Shell (Shell) started working on scenarios and plausible futures in 1965. In 2018, Shell released its latest scenario for the industry, called "Sky". They described it as "a technically possible, but challenging pathway for society to achieve the goals of the Paris Agreement" (Shell International B.V., 2018).

Shell's *Sky* scenario is built on a set of internally consistent assumptions that would define a new low-carbon energy future in which very known low-carbon technology is implemented rapidly at its full potential. Governments and institutions would, in the *Sky* world, take aligned action to enact efficient and targeted policies to promote the right actions. They would discourage, even forbid, less climate-beneficial policies and actions. Assumptions underpinning this scenario include:

- General electrification of the world, with electricity exceeding “50% of end-use energy consumption” by 2070, “compared with less than 20% in the 2010s”.
- Complete divestiture of coal everywhere globally, including in developing countries, and fast decline of fossil fuels as a source of energy by 2070, with “solar meeting over half of the global electricity needs in 2070”.
- Nuclear reliance is multiplied by 3 in the next 50 years.
- Innovation and economy of scale leading to notable price drops by 2030 of “battery storage technology, CCS, and advanced biofuels”.
- Aligned actions from every government to put “legislative frameworks to drive efficiency and rapidly reduce CO2 emissions”.
- Implementation of a carbon price everywhere in the world, reaching almost $50 on average per tonne of CO2 in 2030, nearly $150 in 2050, and $200 in 2070, applied to every activity.
- Transition from oil and gas to hydrogen “as a material energy carrier” by 2040, to reach “10% of global final energy consumption by the end of century”.
- A third of all passenger vehicles in the world would be either electrics or using fuel gas, and more than 80% by 2070.
- Same “levels” of changes in all other GHG emitting sectors, like agriculture, industrial processes, urbanization, and real-estate.
- No more net deforestation by 2060, everywhere in the world.

The introduction by the scenario overview indicates clearly that the “relevant transformations in the energy and natural systems require the deployment of disruptive new technologies at mass scale within government policy environments that strongly incentivise investment and innovation”. Considering the extent of the assumptions indeed made, this assumption is certainly not made lightly.

Based on this observation, and even if we fail at limiting global warming to 2°C, let alone the 1.5°C target, the energy transition the world is starting to experience will probably not

be straightforward. It will much instead require a complex mix of significant transformations of all parts of our current system.

## 2.1.3. A major limit: intermittency

### 2.1.3.1. From load to generation

Unfortunately, this transition is not without drawbacks. Renewable energy sources present many advantages over fossil fuels, but they still offer the same characteristic that made humanity choose to abandon them: intermittency.

Energy intermittency, also referred to as variability or uncertainty, is a big issue that we, consumers, are not ready to accept. All our societies are built on “available-when-you-want” energy and cannot be reconfigured to be fully dependent on the sun radiations (directly in the case of a photovoltaic panel or indirectly in the case of a wind turbine). “The need for generation to occur at the time of consumption has been a long-standing feature of electricity networks” (Rowe et al., 2016, 136).

Therefore, this issue cannot just be accepted, and a solution needs to be found. We need to transform our entire electric system from load-focused to generation-focused. And for that, the electric transmission and distribution networks, commonly designed together as “the Grid”, are a central part of the solution.

### 2.1.3.2. The Grid

This colossal system, sometimes called the “biggest machine on Earth” (Martin et al., 2020), is almost invisible to all, except when all of a sudden, a line has to be built in your backyard. No one cares about it since it is a “by-product” (or “sub-system”) of the big power producers born in the “fossil-fuel era”. Owned by them, or built for them, the companies that are now in charge of the grid, either private and highly regulated or plain simply public, share a similar burden.

In the US, the grid is still working on the same technical principles developed more than a century ago. This infrastructure, estimated to be worth more than $1 trillion (Martin et al., 2020), costs every customer between $700 and $800 every year, at least for customers served by investor-owned utilities (Fares & King, 2017). In the last decade, to keep the price of electricity low, the tendency regarding operations on the grid was to become leaner, with few redundancies or lines not buried where it could be necessary (Rueda & Clark-Ginsberg, 2020).

Even relatively new concepts like “Smart grid technologies” are not driving increasing investments, declining since 2016 (IEA, 2020). In the meantime, on the other side of the planet, China announced a plan to invest “$900 billion in the next five years to help further develop the country’s power grids” (Reuters, 2020).

Unfortunately, as the grid has been designed to accommodate a centralized and stable energy production, managing only a one-way transport of the electricity is not ready to face the ongoing energy transition.

#### 2.1.3.3. Signs of failure

Indeed, it is not just a question of maintaining the grid’s current state, which is already a complex task, generating more issues. Those we saw in California during the summer of 2020 (St. John, 2020) and the one in Texas during the winter of 2021 are two examples that demonstrate “the vulnerability of power grids to shifting weather patterns that come with climate change” (Harvard Kennedy School, 2021).

In 2016, the MIT Energy Initiative study “Utility of the future” (Pérrez-Arriaga & Knittel, 2016) highlighted several requirements necessary to build the electric system of the future that illustrate the importance of the changes we are considering here:

- Building the entire energy market on real-time, granular prices
- Creating a data platform to store and share data relative to the industry, like productions or consumptions, and act as a trusted intermediary.

- Modifying regulations and policies to push and help distribution utilities to improve their efficiency, both short term, and long term, while avoiding conflicts of interest.
- Integrating distributed resources and operational constraints into the wholesale market.
- Improving the usage rate of all existing assets to maximize the potential of economies of scale and return on invested capital.
- Finally, dealing seriously with new cybersecurity and privacy issues created by the considered evolutions.

To handle the new reality of tomorrow's electricity will require significant transformations, technological of course, and organizational and even systemic. All players will have to evolve, including the regulators, at every level. Yesterday we had a simple distribution corridor; today, we need an exchange platform.

## 2.2. Distributed energy platform

### 2.2.1. Distributed generation

#### 2.2.1.1. Distributed versus Centralized

Until now, power generation has been centralized into a small number of "utility-scale" power plants. A power plant is designated as utility-scale when it has a capacity of at least 1 MW. It can reach several GW of capacity, as is the case, for example, with the "Grand Coulee Dam" in the US (6.8 GW) or the "Bruce Nuclear Generating Station" in Canada (6.4 GW). In the US, as of December 31, 2019, we count 10,346 utility-scale power plants (U.S. Energy Information Administration, 2020), meaning that there are only 3.15 power plants per 100,000 population.

This centralized approach relies on the transmission systems necessary to carry the electricity produced by those power plants to consumers everywhere. For example, those systems are also centralized into three networks for all the US: the Western

Interconnection, the Eastern Interconnection, and the Electric Reliability Council of Texas (ERCOT) (Union of Concerned Scientists, 2015).

However, the industry is now considering an alternative approach: a distributed generation system. This approach relies on “non-utility-scale” distributed energy assets, considering power-generation assets but also electricity-consuming assets. A big step was made in that direction last year by the US Federal Energy Regulatory Commission, with Order 2222, which enables “distributed energy resource (DER) aggregators to compete in all regional organized wholesale electric markets” (FERC, 2020).

Among the power-generation assets, solar panels and wind turbines are the most important ones. Still, some technologies like combined heat and power (CHP) or fuel cells could also become noticeable in the near future.

Among the electricity-consuming assets for commercial and residential customers, HVAC systems, water heaters, lights, appliances, and electronic devices constitute the main ones. For industrial customers, the situation is different, where electricity-consuming assets are mainly electrical drives and some electrochemical processes (United States Environmental Protection Agency, 2013).

Finally, we have to consider assets that could be included in both categories: batteries. Either as local energy storage or included in electric vehicles, batteries will indeed consume electricity at some point to deliver it later. Thus, it is an excellent opportunity to amplify the flexibility of a distributed system. Those two markets’ current trends indicate that batteries could indeed take a significant role in this transition. As reported by the U.S. Department of Energy, “The global stationary and transportation combined annual energy storage market [...] is projected to increase fourfold by 2030 to more than 2,500 GWh, from a 2018 baseline” (U.S. Department of Energy, 2020, 6).

Properly managed together, those assets could provide essential services to the grid, making this distributed approach a viable solution in a renewables energy future (EnergyHub Inc., 2021):

- Demand response, fighting the “duck curve” (which represents the difference in electricity demand and available solar energy during a typical day) and extreme weather events.
- Frequency and voltage support, compensating renewables and distributed assets’ weaknesses.
- Load shifting limits the overall capacity.

More than that, distributed energy could save the US $473 billion by 2050 compared to a more standard clean energy transition scenario and could create two million additional jobs, according to a recent study of Vibrant Clean Energy (Clack et al., 2020). This work shows that, contrary to the usual position in the industry to consider large solar farms less expensive than small farms or roof panels, it was not the case when taking more variables into account, especially the transmission and distribution costs. The whole point is to avoid having some grid capacity, and peaker plants, only used a few days per year but costly every day.

#### 2.2.1.2. Data and automation

For distributed assets to provide those services and reach a size that could impact the entire electric system of a region, we need the capacity to aggregate and manage them with “speed, accuracy and scalability” (Enbala, 2018). Indeed, energy resources have to react in real-time to all the constraints put to the energy system, with a near-perfect service. Scalability is a condition to comply with those two components.

But scalability means that managing assets one by one is impossible. Automation solutions, relying on data analytics and machine learning algorithms, are therefore necessary. Some

*Startups* and *Utilities* are currently developing a "Distributed energy resources management system" (DERMS) to fill this role.

Greentech Media defines a DERMS as a "software that can integrate the needs of utility grid operators with the capabilities of flexible demand-side energy resources at the edges of the grid" (St. John, 2017). The market for DERMS is still nascent, reaching only a global revenue of about half a billion USD in 2019, but projected to grow "to nearly $5.7 billion in 2028" (Navigant Consulting, 2019). As often with new markets, much confusion still exists, with difficulties getting a widely accepted definition and clear value propositions from vendors and involved companies.

As this market grows, reaching the right "speed, accuracy, and scale", the aggregation and automated management of distributed energy resources are allowing the constitution of what is now called "virtual power plants" (VPP). One of the significant advantages of VPPs is that they can become part of the system without perturbing it, being always available, ensuring the system's reliability, and at a regular energy price, ensuring its cost efficiency (Deign, 2020).

#### 2.2.1.3. Customer involvement

So far, the notion of distributed systems is primarily developed in computer science. Maarten Van Steen and Andrew Tanenbaum propose the following definition (2019): "A distributed system is a collection of autonomous computing elements that appears to its users as a single coherent system". We already saw that relying on data and automation is necessary to make a distributed system viable. In that case, the other major component of this definition is the "collection of autonomous computing elements".

Transposed to the energy industry, the computing elements are called customers. Indeed, it is impossible to consider a distributed generation system of electricity without considering that those customers must have an active role in it. The US Department of

Energy acknowledges the term “prosumers” as relevant to the energy industry to design this new role for customers (Office of Energy Efficiency & Renewable Energy, 2017).

As in the definition we saw of a distributed system, all energy customers, residential, commercial, or industrial ones, are autonomous. Therefore, one of the challenges of this plausible future is transforming them into active components of the system.

Industrial customers often care a lot about their energy consumption. The big ones are important clients with dedicated offers or who even have recourse to power purchase agreements (PPAs). We can assume that they are already involved actors and would be willing to make their role evolve if it would bring them more value.

Commercial and especially residential customers are harder to engage. For example, a study made by The Brattle Group showed that only 3% of residential customers enroll themselves in time-varying pricing programs when they are proposed by utilities (2017). So, even if customer engagement has become a strong interest for the industry, energy is still just a commodity for most clients. Their relationship with their energy provider should just be the shortest and as efficient as possible to ensure that they can switch on whatever they want whenever they want (Costello, 2017).

However, a new relationship built on distributed assets and genuine partnership between utilities and their customers could solve this engagement issue. By taking an active role, customers will be more in control of the service they get, either, for example, lowering their bill or improving the reliability. Besides, they could find gratification in being part of the solution facing climate change and environmental issues.

## 2.2.2. Platformization of the energy market

### 2.2.2.1. The current energy market

When considering the plausible revolution of distributed energy and the platform economy could have on this industry, it is essential to note some of the specificities of the current electricity market that could have noticeable impacts on this transformation.

The first primary specific attribute of this market is linked to the nature of the product itself. Indeed, electricity is impossible to stock and has to be consumed instantaneously when it is produced. Ways to transform electricity into another form of energy that can be stored and then converted again in electricity exist and are developing quickly. However, it is still a major constraint in this market (Office of Electricity Delivery and Energy Reliability, 2015). This fact has two noticeable implications:

- Electricity must be transported from its production point to its consumption point as soon as it is produced. It is impossible to use a multi-usage transport system, as is the case for all the other goods or commodities we produce. As we saw, the Grid, with its transmission and distribution lines and the numerous sub-stations to make it work, occupy this role. It is, therefore, unique.
- The variations of the demand and supply curves for this commodity are hard to predict. Indeed, this market has to reflect every change affecting the production and electricity consumption, which creates many imbalances to control and optimize.

The second important specificity of this market is the high variability of the short-run marginal cost, and therefore, the price (Joskow, 2019). Indeed, for one unit of electricity, for example, a kilowatt-hour, the marginal cost could vary between zero and an almost infinite value, leading to prices that could surge more than 100 times in a brief period. Both extreme situations have different causes:

- In the case of the production of electricity from renewable energy, at the moment, this energy is present, and if the installation, transmission, and distribution

capacities are sufficient at the time of the consumption, then the marginal cost is zero. In the case of other energy sources with low fuel costs, like from a nuclear plant, the marginal cost could also be low, as long as we stay below the system's capacity of production and transportation.

- But, in the case of electricity consumption when the Grid is already overloaded, or the maximum production capacity of all accessible power plants is reached, it is impossible to deliver the requested electricity. In this situation, "peaker plants", most of the time using inefficient gas turbines, will be started to respond to at least a part of the demand, but at a very high cost. Besides, the Grid would still be at risk and could prevent the delivery of the electricity anyway, leading to shortages or even blackouts.

An example of an extreme occurrence of this specificity was the winter storm of February 2021 in Texas that generated an increase in prices of 450 times overnight (McWilliams, 2021).

Finally, the last specificity we need to consider, even if this one is less uncommon than the other two, is that it is a highly regulated market. Moreover, regulations vary a lot by region. Thus, from one country to another, even from one state or county, policies in place could push actors of this market to adapt their entire activity to comply, creating an external force that needs to be considered when envisioning a plausible revolution.

#### 2.2.2.2. Platforms everywhere

If we take a bigger perspective on our economy, platforms are not a new concept anymore. We are in the middle of a significant period of changes, called by some the "Fourth Industrial Revolution" (World Economic Forum, 2016), also designated "Digital Transformation". In this context, we already saw several industries, complex ones, transforming themselves quite a lot in the last couple of decades.

An essential part of this transformation is related to the evolution of business models and the effects of what we call now the platform economy. The concept of platforms in the economy is relatively new, as the first academic work on the subject is less than 20 years old (Rochet & Tirole, 2003). To find a generalized definition of a platform, we have to wait another five years, with the work of Baldwin and Woodard (2008), that define a platform as "a set of stable components that supports variety and evolvability in a system by constraining the linkages among the other components". Even if this definition could seem very theoretical, it captures the central element of a platform: a common ground.

Thanks to this common ground, this universal language, this shared set of rules and processes, actors from both sides of an exchange can be free to change and innovate. "The combination of stability and variety [...] makes it possible to create novelty without developing a whole new system from scratch. Thus platform systems are evolvable." (Baldwin & Woodard, 2008).

Digital platforms have now become more than successful. In 2014, Libert, Wind, and Beck wrote an article for the Harvard Business Review reporting a study they conducted in collaboration with Deloitte. They compared the financial performance of the S&P 500 companies based on their business models: "Asset Builders", "Service Providers", "Technology Creators", and "Network Orchestrators". Although these researchers don't directly refer to platforms, this last business model is similar, as they defined it by creating "a network of peers in which the participants interact and share in the value creation." They also give example companies that we are now directly calling platforms companies, like Visa, Uber, or Alibaba. Finally, they conclude that "Network Orchestrators outperform companies with other business models on several key dimensions", including two to four times higher valuations.

In particular, they find that "[f]ewer than 5% of companies are Network Orchestrators". That point seems fundamental to understand this transformation. Platforms are now almost everywhere, but each sector that has undergone this transition contains very few

platforms. And without geography or clear customer segmentation issues, we could argue that only one platform would exist per industry. Indeed, “there are network externalities and near-zero marginal cost on the internet, resulting in a potential pattern for the economy platform: the natural monopoly” (Yang & Ji, 2016).

This “Digital Transformation” has already impacted the electricity industry in many ways. In 2016, the World Economic Forum wrote a white paper in collaboration with Accenture indicating that “[t]he platform revolution will offer an opportunity to develop an entire system for electricity and beyond, spanning the digital and physical worlds” (World Economic Forum & Accenture, 2016. This paper describes a set of digital initiatives already accomplished or considered by the industry, representing together more than USD 1.3 trillion of producer surplus and USD 2 trillion of consumer surplus. Among those initiatives, several of them are directly linked to the concept of distributed energy platforms, highlighting some case studies like the virtual power plant built by the company Next Kraftwerke in Germany 12 years ago, in 2009.

More recently, we can even witness some startups working on very young technologies, like the Blockchain, to impact the energy industry. For example, EnergyWeb, a nonprofit organization, is working to build a common trusted platform, trying to bring all actors of the ecosystem on board (https://www.energyweb.org/).

This concludes my literature review, as it goes back to my initial question: who are, or would be those “actors”? Indeed, looking at those major changes, from the energy transition to the plausible disruption of distributed energy and digital transformation, I wonder more and more who would be part of this future.

# Chapter 3 - Method

A future built on distributed energy resources is plausible. To face the challenges posed by renewable energy sources, mainly intermittency, one efficient solution could be to rely on a distributed network based on an open and automated platform.

As stated in the introduction, if we consider that, at least in the US, the industry will develop more DER capacity in the near future, one question would be to know who will be more involved in this transformation. A simple approach to get the first answer is to ask directly professionals and experts already involved in it, fully or partially. Therefore, I decided to do in-depth interviews with executives working for relevant companies to obtain their exact point of view toward this question. In addition, I also gathered their opinion about the threat represented by other categories of actors viewed as potential competitors.

This research aims not to survey the entire industry or gather public opinions of renowned experts. Instead, it is to get access to more personal and “unfiltered” perspectives from the experts who are working directly toward this plausible future. To this end, the interviews focused on the potential collaboration and codependency between each group to become leaders of this new energy future.

This chapter is divided into four sections. The first one explains the chosen population to be interviewed, the second one details the interview process in itself, and the third one presents the method I used to analyze the data. Finally, I present some of the limits and biases of this study and how I control some of them.

## 3.1. Study subjects

To define the population I sought to interview, I first decided on lists of relevant companies. I defined companies to be relevant because of their active work in the energy transition at a world scale. Those companies have been selected based on the following criteria:

- For the category *Utilities*, I focused my selection on international power companies, with significant activities in the US and investing massively in renewable energies. I started by selecting all companies cited in the article "The energy giants are renewables companies" (Bloomberg Green, 2020). I also searched on the Internet for "best renewable energy utility company in 2020" and "most innovative energy company in 2020". Finally, I added to those results companies with dedicated operations in the US or Canada and more than 5,000 employees in 2020.
- For the category *Startups*, I focused my selection on small software-based companies working in the US, on products and services related to distributed energy. I used the Crunchbase search engine (https://www.crunchbase.com/), with the following criteria:
    - Description Keywords: "distributed energy" or "der" or "platforms" or "smart grid"
    - Headquarters Location: "The United States", "Canada"
    - Industry: "Energy"
    - Total Funding Raised: Minimum of "$5,000,000"
- Finally, for the category *Large Tech*, I kept the definition of this category presented in Chapter 1, based on three criteria:
    - International activity on every continent
    - Number of employees > 50,000
    - Annual revenue > 20,000 USD

My final list of companies contained 15 companies; 7 *Utilities*, 8 *Startups*, and 4 *Large Tech* companies. I used LinkedIn (https://www.linkedin.com/) to find relevant contact among those companies. I defined contacts to be relevant because of their noticeable level of responsibilities, expertise, and experiences among my targeted companies. The inclusion criteria were:

- Currently working in the considered companies and based in the US or Canada.

- As high as possible in the organization structure, ideally members of the C-Suite or at a VP level. The minimum considered level will be the director level or equivalent.
- Example of functions or roles targeted for the employees that will be contacted and interviewed: CEO, Managing Director, Managing Partner, CFO, CTO, CDO, VP/Director of Strategy, VP/Director of Business, VP/Director of Marketing, VP/Director of Innovation/New markets, VP/Director of Renewable energy/Storage/Smart Grid, VP/Director of Strategic projects (linked to the considered subjects in this thesis), VP/Director of Digital Business/Digital Transformation.

For each company, I selected two to three persons that I prioritized based on their rank in their company, starting with the highest in the organization structure. Then, based on this prioritized list of people, I contacted all people with a top priority using the "InMail" message function of LinkedIn.

I recontacted these targets one week after my first message for those who did not get back to me. Without an answer in the next 4 to 5 days, I contacted the next person in terms of priority in the considered company and repeated the entire process. I informed the new contact of the colleague already contacted during my previous attempts. As soon as I received answers, I started to set a 45 minutes interview based on the interviewee's schedule. All interviews have been done in a two-week timeframe after the first response from interviewees.

After 40 contacts made, I was able to complete nine interviews, with the following distribution by categories of actors as defined in my introduction:

- *Utilities* = 3 interviews
- *Startups* = 4 interviews
- *Large Tech* = 2 interviews

Each interview's duration was between 30 minutes and 1 hour and resulted in an average of four pages of notes.

## 3.2. Interview process

Interviews were conducted by telephone or video conference software. The first five minutes were devoted to an introduction, first of myself and my background, then on the research subject. Then, I indicated that the interview was fully confidential and not recorded and that I will ask by email for consent if I needed a direct quote from the interview.

This choice of confidentiality was important, as it helped gather more unfiltered information. In some instances, especially for interviewees working in large companies, it was even mandatory. Indeed, despite their position, they were not allowed to make any official comment in the name of their company, and therefore, they could not accept being recorded. However, I indicated to interviewees that I would take extensive manual notes to gather the data I needed for this research.

After the introduction, the interview process was built around three phases:

- A "definition phase", with questions oriented around the work of the interviewee's company, their definition of the concepts considered in this research, and their professional opinion toward them.
- A "simulation phase", where I stated that in the following questions, we would consider that a decentralized future for the energy industry will happen. The questions were oriented around the possible impacts on the interviewee's company and their reaction to that position.
- Finally, a "competition phase", with questions oriented toward the competition, current and in the considered future. Particular attention was made to the possible evolution of relations between all groups of actors involved.

Please see Appendix A for a complete description of the interview plan. However, it is essential to note that I adapted each interview to the situation, especially to the interviewee. This plan was therefore used as a generic framework, with interviewees orienting the discussion as they wanted.

## 3.3. Data analysis method

To answer my research question, I chose to conduct a thematic analysis of the data gathered by the interviews, as described by Braun & Clarke (2012), to highlight relevant themes.

After reviewing my transcripts, I generated initial codes for relevant sentences and adapted them at the end of each transcript. I then looked for themes among my codes, and by a recursive process, I defined several sub-themes that I finally group into main themes.

My initial goal was to limit the number of themes to a maximum number of six to focus on the analysis of the data. However, after considering the sub-themes I had, it seems pertinent to me to create only four themes.

Besides, I decided to add an extra theme before analyzing the data, focused on climate change and environmental issues. Considering the importance of those subjects, it appeared impossible not to highlight the relative gathered content, even in a situation where I would judge its volume to be too low compared to the other themes. Please, see Appendix B for more information about the themes and their related sub-themes I defined based on this analysis.

Based on that thematic analysis, I planned to highlight in Chapter 4 the quotes I judge relevant for each theme from all my interviews. The goal was to give me enough perspective to consider several findings that would then help answer my problem statement for this thesis.

## 3.4. Limits and biases

Finally, it is essential to note some limits and biases in the method I used for this research that has impacted the gathered data.

First, the principal limit of this method is that the data I gathered is not representative. As I noted, although study informants represented a mix of perspectives, my sampling was not designed to represent companies that make up the entire industry comprehensively.

Second, the interview method also presents a strong limit as the engagement asked interviewees is noticeable. They had to read a message from me, an unknown person, arrange a meeting with me, and spend almost an hour of discussion. Therefore, even within my selected sampling, only willing respondents have participated in this study.

Third, while I followed a semi-structured protocol in conducting each interview and a systematic coding and analysis approach, my findings rely on self-reports. My analysis draws on my own summaries of the key themes revealed in each interview.

Last, my personal view of the subjects discussed in this research is a strong bias, even if I tried to stay as neutral as possible during the interviews. To give the reader a better understanding of this bias, I will define my personal position briefly:

> *I firmly believe that fighting climate change and environmental damages should be our utmost priority as a species. I also think that humanity will not keep the temperature increase to a sustainable level during this century, forcing us to work more on resilience and adaptation than prevention. Therefore, I believe that, in general, decentralized networks are better solutions than centralized ones, as they tend to be more resilient and adaptable. I think this is also true regarding the energy industry and hope the plausible future considered in this study will indeed happen.*

By relying on in-depth interviews and a structured methodology analysis, I have limited the impact of this bias, but it seemed important for me to point it out before presenting my results.

# Chapter 4 - Analysis and Results

My interviews investigated a potential future in which distributed energy resources play a central role in the US power industry. The nine respondents were executives in companies that could shape this transformation: three of the biggest renewables-focused *Utilities* in the world; four successful *Startups*; and two *Large Tech* companies. Although such technology companies are currently not seen as key in the electric power industry, my investigation sought to examine whether they could become key participants in the sector.

My goal is not to predict. Rather than addressing if this distributed-energy future is more probable than alternatives, my study sought to explore the relationship between those actors should this future materialize. For example, would one firm dominate the entire industry? Might companies develop new forms of partnerships? Would one of them become irrelevant?

The interviews were confidential and not recorded to allow more freedom in the exchanges. In each case, I took extended notes and captured as many direct quotes as possible. I then developed a thematic analysis of this qualitative data, coding almost every part of it. The content analysis revealed the four following key themes, plus the added theme as indicated in the methodology (3.3):

1. **Focal technologies**, which contains quotes related to technological subjects.
2. **Business challenges**, which contains quotes related to business considerations.
3. **Digital platform**, which contains quotes related to digital transformation and platforms.

4. **Key players**, which contains quotes related to the categories of actors I considered in this research.
1. **Climate change**, which contains quotes related to climate change and environmental issues.

## 4.1. Focal technologies

Technologies are clearly central to any investigation into the future of the energy industry. In keeping with my focus on distributed energy resources, every respondent offered detailed thoughts on the technologies that could shape the future structure of the energy system. All of them were confident that DER would take a major role.

> *"I definitely think DER are a part of the future and our whole business is largely predicated on distributed energy and behind the meter flexibility"* (Utility executive)
>
> *"Distributed energy, you can say we are all in."* (Another *Utility* executive)
>
> *"A lot of these technologies are awesome and they're gonna be necessary to the energy transition. What you're seeing a lot of times is just these massive power companies who are just kind of resistant to change. But they're coming around."* (A third *Utility* executive)

One would expect such views from *Startups* I interviewed, as I only selected startups working on DER, but it was a welcomed confirmation from those working for the *Utilities*.

And this was often linked first of all to the flexibility and resiliency offered by those resources.

> *"Our business model is specifically to enable demand flexibility."* (*Startup* executive)
>
> *"[DER] is the future. It's a big part of resiliency and the need for having alternatives to purely centralized functionings of these markets. Having on-site both generation and just flexibility of how they manage their load and and the costs."* (*Utility* executive)

The discussion often turned to the evident opposition between a centralized and a decentralized system. This point is central to the present analysis: a centralized system is easier to manage, and therefore, does not need complex, real-time and fully automated controls.

> *"The fact that renewable energy companies are focusing on big wind and solar farms, that's very opposite to this decentralized vision of the grid."* (*Large Tech* executive)

> *"In terms of where the capital will go, more capital will go into centralized, because it's more capital intensive, and there is more opportunity to do it on a centralized basis."* (*Utility* executive)

However, stated in the last quote, this opposition appears to me to be linked more to financial considerations, rather than to technological ones, as I would have expected it. The complexity of a decentralized system was not discussed, but seemed less appealing for *Utilities*. We will discuss more in detail some financial considerations in the next chapter, but DER seemed to be considered as a threat to *Utilities* by the two other actors.

> *"Regulated utilities are faced with an interesting challenge because let's say you're vertically integrated, these distributed resources are being deployed by your customers which means that they're going to consume less of the energy that you produce for them which means less revenue for you."* (*Startup* executive)

> *"However you're asking a company whose primary job has been over the last hundred year is to keep the lights on at all costs even if it means building carbon intensive coal plants, that's all they've been asked to do, but now you're saying second of all you can't do carbon anymore and also you got to figure out a way to create new services and generate new revenue to offset the volumetric sales of distributed generation because you're not going to have that."* (*Large Tech* executive)

Some new technologies involved in this revolution were also considered to be great opportunities for utilities by other actors, especially energy storage and electric vehicles (EVs).

> *"What is going to be a huge impetus to actually do that: EV charging, because that's the best opportunity a utility has ever had to add load. That's the best opportunity they can have and it's going in the right direction regarding climate change fighting. People will start to schedule their charging where you charge at certain times a day because the electricity is cheaper So that's actually a great way to engage customers."* (*Startup* executive)

It is true that EVs in particular have been considered by some as one of the biggest opportunities for *Utilities* to see their total market size grow quickly in the coming years. In 2019, BCG estimated "that the rise of EVs could create $3 billion to $10 billion of new value for the average utility" (Baker et al., 2019). However, it did not seem so simple for the people working for *Utilities* I interviewed, as they were more considering storage and EVs as additional complexities than clear opportunities.

> *"Another major constraint is the cost of energy storage. We would have a lot more dispatchable assets if energy storage was cheaper. And the constraints on the fleet vehicle side are on that, and the availability of electric vehicle supply."* (*Utility* executive)

> *"It's been a tough business especially like development of batteries and where to site them and just all the complexities that go into a contract around having a third party install a high capex piece of infrastructure on the customer site it can be pretty complex"* (Another *Utility* executive)

I was actually surprised by this differing perspective between *Startups* and *Utilities*, as at least one executive from a startup had a clear opposed position.

> *"Storage is so cheap that anyone can buy it right now. I think people deploying storage still do rely on some level of federal incentives so financial is certainly a consideration but it's fast becoming not the most important consideration."* (*Startup* executive)

Of course, smart devices targeting residential customers were also discussed quite a lot, not as exciting new technology, but definitely as an important part of this DER revolution. However, on this one, both *Utilities* and *Startups* seemed to agree, indicating that their deployment was still limited for now. Indeed, the most common smart devices in houses are smart thermostat and smart light bulbs, but it is still a niche market. The consulting firm McKinsey indicates for example in their current dedicated "connected home" page that "Despite the proliferation of devices, we're still far from the vision of seamlessly connected homes. We have yet to see explosive growth in the market" (McKinsey, n.d.). The interest is here, for some *Startups*, it is their main business, but the scale remains too small presently to create a major value for the industry.

> *"It's interesting conceptually if we can connect all those devices and as those devices become smart in the home, and there's companies that can control that, there's definitely opportunity. But right now at least, it hasn't been on a scale where it makes sense relative to the costs of helping to monetize that."* (*Utility* executive)

> *"Because some of these technologies are still expensive. Let's take like a Nest thermostat as an example of how widespread this is. California from a cultural perspective is probably the most likely to adopt these kinds of technologies but doesn't mean that there's a smart thermostat in every home in California. […] Maybe there are some cultural barriers as well, like thinking about their energy bills is probably not the most important thing for most people."* (*Startup* executive)

The last citation made by a startup executive raises the important point of the position of where residential customers stand on smart home devices. As indicated by this person, the cost of those products, but also some cultural barriers, as well as lack of consideration for the energy consumption could be some possible reasons for this situation.

To conclude this first theme, all the persons interviewed seem to have a quite clear vision of the role of technology in this plausible future, with a high confidence that smart devices, energy storage, electric vehicles as well as, of course, wind and solar generation, would become the main components of our power system.

> *"If you think about our vision of a future energy sector it's going to be some nuclear, a bunch of wind and solar, more energy storage before battery electric and then it's gonna have a ton of demand flexibility built in there as well, and that will provide not only carbon benefit with this system but we believe it can maintain or actually improve resilience and we believe that it can actually be more effective than a solution without demand flexibility and it can be more cost effective than any other portfolio out there."* (*Startup* executive)

On a side note, none of the persons interviewed talked to me spontaneously of blockchain technologies or related applications. When asked directly, the reactions I had were often mixed, evasive, or even strongly negative.

> *"Blockchain is just too slow and clunky today. Now maybe, if tech continues to deliver higher bandwidth and faster blockchain technology quickly enough, and that you're not doing the settlement on blockchain but just watching prices."* (*Startup* executive)

I would have expected more enthusiasm on the possibilities offered by blockchain technologies, like smart contracts, in particular from the *Startups* I interviewed.

## 4.2. Business challenges

As we saw in the previous theme, DER may be considered as a perturbation of the current state of the industry, bringing opportunities but also creating a lot of risks. The *Utilities*' business model appears indeed to be challenged by DER, as stated by both a startup and a utility executive.

> *"Utilities don't have to own the asset which is very against the typical utility business model, which is regulated return on employed capital."* (*Startup* executive)

> *"The DNA of the company was all C&I, commercial and industrial focused business and that's just where you obviously, by definition of their size and how much electricity they use, get more scale with those types of companies."* (*Utility* executive)

Several points were made related to the potential of DER to make building new large assets, like power plants and transmissions lines, irrelevant, or at least, not as efficient as it was a few years ago.

> *"For parts of the world now, distributed small-scale solar is now the most cost effective option. And we know that, as customers continue to come down, it's going to be increasingly true. So the old economy of scale is no longer true."* (*Startup* executive)

The entire business model of some of the *Startups* interviewed is actually focused on replacing new assets that Utilities would have to build otherwise.

> *"We don't need to build a sophisticated model to figure out the value we're delivering to utility where utility has a formula that says for every kilowatt I don't have to generate or don't have to install it's worth X and as long as my price comes in under X I'm delivering value to the utility."* (*Startups* executive)

On the other hand, some interviews reminded me that the energy industry is, or was until recently, a very specific industry, focusing on supplying all the demand, at production cost. Of course, we can imagine the long-term impacts it has created in the selection and then training of the decision-makers for the industry.

> "*When I got into the energy industry 15 years ago, the demand curve was irrelevant. The only thing that mattered strategically was understanding the supply curve. Demand was going to be what demand was going to be because energy is a requirement and enables much more higher value economic activity. You just let demand do what it's going to do*

*and instead you focus on supply and just, you're basically trying to compete on the supply curve. Essentially what it was 15 years ago and the industry, still, is run by people who only understand that.*" (*Startup* executive)

Both on the *Utility* and *Startup* sides, some agreed on the importance of the entry barriers for this industry, and therefore, the difficulty for outsiders to penetrate the market.

*"Access to the energy market in general it's really really hard, as the connections on both sides are actually very complicated."* (*Utility* executive)

*"I would say energy, like healthcare, it's the barrier to entry. To be able to do this is much higher than what it is in other industries where we see massive disruption. The amount of regulation, having to work with public utilities, commissions, etc. Plus, there are regional rules, market rules, being able to operate in different sorts of regulatory environments. This is not like a "Oh we can enter here easily and disrupt this industry"."* (*Startup* executive)

Several interviews confirmed that entry barriers seem indeed to exist, indicating that *Utilities* still have some market power.

However, despite that potential market power, some *Utilities* appeared to consider the current situation as more and more risky, on several factors (financial, regulatory, and even safety), limiting their growth.

*"In terms of what's hindering the growth, there's a lot of risk in these deals in terms of pricing risk, regulatory risk, credit risk and safety risk. Risk is a big part of the contract negotiations and I just think that risk transfer and who holds risk and who's comfortable with what parts of the risk equation and how does that all bubble up into the economics you need is, especially for that behind the meter distributed energy, that's probably one of the biggest things I see."* (*Utility* executive)

This could lead to business projections that are considered, for example, too optimistics.

> *"A lot of players participating or building battery assets for example are taking on more and more risk. Then, when things actually get developed and they see the outcomes, there's gonna be a little bit of a reckoning in terms of the real world not bearing out the way this forecast was predicted."* (*Utility* executive)

Another utility executive had the same consideration regarding financial risk, indicating actually that all the low risk projects, from a financial point of view, were already made in the US. Therefore, to continue to build new projects, their focus is currently on finding ways to manage higher financial risks.

> *"The biggest problem there is that we haven't figured out how to address the sub-investment grade, like the subprime, if you will, commercial real estate market. And that's problematic because we generally judge investment grades based on S&P credit ratings, and we ran through those investment grade credit-worthy companies extremely quickly. There are like a thousand. After you hit that thousand, you're not gonna continue to get investment-grade rated companies. "* (*Utility* executive)

Some *Startups* seem actually to work on this issue, but the person I interviewed was not satisfied by this approach, leaving the situation without a clear solution.

> *"There are some companies that are trying to solve that with insurance tech, but that's grossly too expensive, too confusing, and risky."* (*Utility* executive)

Regarding growth, another utility executive indicated that they are trying to find other ways to develop their business. The focus is made on batteries and EVs in particular, as it was pointed out already in the previous part.

> *"We have a big demand response portfolio. We're increasingly working with batteries and somewhat with electric vehicles. We've, for now at least, steered from smart devices and have focused more on C&I applications but I'm trying to develop new things for the business and to find ways to grow and new products and services."* (*Utility* executive)

Another major subject that was discussed during the interviews related to the business was the customers, and in particular residential customers. Two startup executives were very clear on the fact that customers do not care about electricity, leading to the necessity to build a relationship with them from scratch.

> *"People think about their utility bill four minutes a year or something like that."* (*Startups* executive)

> *"There have been high acquisition costs [in this industry] because customers don't want to think about energy consumption. For the most part they just want, when they flip the switch, the lights to come on."* (Another *Startup* executive)

But some also pointed out that two new factors impacted this observation. First, the development of EVs and home chargers are leading to more conscious and educated customers related to energy consumption.

> *"if you own an electric vehicle you are very comfortable with off peak charging."* (*Startup* executive)

Besides, climate change impacts have been the second factor discussed, that is leading residential customers towards a more active role in the industry. Indeed, facing limitations in their access to energy, high revenue customers now have the capacity to invest in individual generation and storage resources.

> *"There's the climate instability that's affecting residential customers, whether it's fires in California or like a blizzard in Texas, it doesn't matter. Ultimately, you're energy-insecure. There are going to be customers who have the ability to buy a battery and install it. Those may be some of your richest customers. If they start consuming less of your energy then they are no longer gonna cross-subsidize your low income customers that you have which becomes like a downward spiral."* (*Startup* executive)

It is interesting to note that, as pointed out in the previous quote, this transition from a status of simple customer to a role of prosumer could actually lead to imbalance in the business model of the entire industry. If prosumers stop participating in the infrastructure cost, it could increase the lack of investment, in particular in the grid, that we saw in chapter 2 (2.1.3.3. Signs of failure).

Again, engaging with those prosumers was a recurring subject for startup executives.

> *"Utilities have to engage these prosumers and there's a big push to do that for example someone sitting at Texas after the blackout that happened they're going to say that they need a battery or some way to be able to secure their energy source because they can't rely on the grid the entire year"* (*Startup* executive)

> *"Utilities have a network of customers that are deploying distributed resources. How do I aggregate the flexibility of all this and monetize it in the market? So they will require a solution to be able to manage all of this."* (Another *Startup* executive)

I note that, from my perception of the interviews, this subject was more important for *Startups* than for *Utilities*. Indeed, one startup executive was very critical regarding the customer journey offered by *Utilities* to their customers.

> *"How to create a connected customer journey? The utilities have no capability for that. They're the worst of any business enterprise I've had to talk to and deal with customers like, they're a horrible customer experience."* (*Startup* executive)

But this strong position could have been generated by the motivation to show the quality and importance of the services offered by their startup, as the next quote indicates.

> *"Therefore we are the ones who provide customer journeys in order to allow customers to make better decisions and deploy all this technology that is going to be more demand flexibility in a more resilient and climate related approach."* (The same *Startup* executive)

It was finally a way to put forward their vision of partnership between *Startups* and *Utilities*, around customer relationships, indicating the will to avoid losing it in favor of other Big Tech companies like Apple.

> *"We cannot just give consumer engagement to Apple. We're going through proving that utility can have a role in delivering these benefits. We're gonna prove that the utility can contract and together we can create great customer experiences and then we're gonna advocate incrementally for changes that eventually result in this evolution to where we have a system that's optimized for all. We need to deliver clean, green and consumer empowered energy."* (The same *Startup* executive)

Another startup executive also talked about the importance of Tech companies in the daily life of customers. They expected an increasing role of this relationship based on energy related subjects, mostly because of their link with confort. For them, it is a reason for alignment between *Large Tech* companies and *Startups*.

> *"Tech companies are all down reaching in your life. They're being a touch point for everything related to your life, whether that's like providing information in data or making it easier to buy things. In energy, it's almost like comfort, so their role will just expand and get a little bit more alignment with what we're doing. Some of those tech companies are working on enabling more efficient understanding of options, providing more information and data to make decisions, enabling transactions more efficiently to customers. So I see that alignment with what we're doing, much better than with utilities."* (Another *Startup* executive)

To conclude this theme regarding business challenges, a startup executive made a comment on the uncertainty of the timing that would lead to more DER in the energy industry.

> *"The primary challenge of operating in the distributed energy industry is knowing when that tipping point is going to happen. Because we see a lot of players who are interested*

*in using our platform, to deploy a large number of distributed energy resources on sites and with customers that they have access to. From a timing perspective it's hard to be able to say when things are really going to just scale up to the point that it feels inevitable to everyone."* (*Startup* executive)

This last point made me think about the possibility that this tipping point would never be reached. As already stated, the point of this work is not to measure the probability of a future for the energy industry relying on DER, and indeed, even for actors directly involved in it, it is still not a certainty.

## 4.3. Digital platform

Several of the *Startup* executives interviewed were naturally very aligned on the fact that, in order to exploit and rely on DER, one or several digital platforms would be required.

*"When you think about a platform provider, what they do is to help manage the flexibility associated with [DER]. Just because you're deploying large amounts of solar and storage doesn't solve the inflexibility. You have to connect and control these assets, especially during critical periods, peak periods, or an alternate problem, which is happening a lot in Australia for example where you actually have sometimes excess generation and not enough demand."* (*Startup* executive)

*"Even if the demand is coming from utilities, whether they build this technology platform internally or they use someone like us, you need a technology platform to be able to manage these resources. So that's where I feel like players like us come into play."* (Another *Startup* executive)

One startup was considering themselves as the future platform, or "hub", to manage this entire distributed system, on all legal, financial, operational and technical missions.

*"We are the hub that facilitates contractual economic operational and technical interactions between all those entities."* (A third *Startup* executive)

Another had an interesting position to see themself not as the platform, but as an application that would run on the future platform. They, however, considered the fact that this platform does not currently exist properly.

> *"We're not the platform, we're the app. But the issue is that utilities are not leaning in on virtual power plants, wires alternatives and other applications, because you need both the platform and the app. The Apple app store is useless without the app."* (*Startup* executive)

And indeed, as we saw in chapter 2, no one, *Utilities* included, has developed yet a real platform for the energy industry. One *Large Tech* executive pointed to the fact that this situation could be due to the lack of data available on the current network of the industry, which is the Grid. With data, for them, *Utilities* would have already built platforms.

> *"But the utilities would have been in the position to be that platform, for all this new cool stuff, if energy had the ability to take data coming right off the grid into their platform. The services they could offer would be direct to the customers and be much more valuable. Today they do it through cloud-based data acquisition, not necessarily real-time grid-based, and I think the real-time component is important."* (*Large Tech* executive)

And, according to them, based on new computing power and artificial intelligence, a platform based on two-way flows of power and data would then allow the development of new applications and services.

> *"So the area focused for us is to push advanced server class computers to the margin of the grid, like in the substations, that would allow for almost autonomous real-time load balancing based on AI. That computer power does not exist today. It didn't need to exist because all of it was flowing power, making sure no one got electrocuted, and there was no catastrophe. Once that compute platform is built and installed at the edge, then you have the ability to take all those new data streams that you're collecting from your solar panel, your EV charger, your building management system, take all that data and then*

*federated out to the application development world to create all these new services around who knows what they will come up with."* (*Large Tech* executive)

In my opinion, a very interesting comparison was made between the energy industry now and the telecom industry in the 80s and 90s. A *Large Tech* executive pointed out the fact that incumbents which developed the infrastructure, were actually not those which developed the platforms afterwards. And in this particular case, the platform owners became, a few decades later, the biggest companies in history.

*"Back in the telecommunications transition, maybe 30 years ago all those companies that built that infrastructure that we used today were not the companies that made the money. All the telephone companies that put product broadband infrastructure out and we started using it, the Googles, the Apples, the Facebooks of the world out there, were the ones that used all of that infrastructure and made tons of money by creating services around the data collected from those new networks. Same exact thing is happening here. The utilities, there's this great platform they developed called the electric grid to serve electric vehicles, solar panels, all these new distributed energy services that consumers are buying."* (Same *Large Tech* executive)

However, from the utilities' point of view, some said that they were already developing software to manage DER. They did not identify those software applications as a platform, but respondents were clear on their strategic importance for their business. One was particularly confident about the technical superiority of their softwares compared to those developed by others, including specialized *Startups*.

*"We already work on DER softwares, because we had to, to monetize our assets, and other software solutions are just way too expensive and not that much better. In fact, our core system, which we developed internally, we found that it was better than the platforms being developed externally, and it's a positioning competitive advantage. If I own the assets, why would I mortgage a way that competitive advantage to someone else."* (*Utility* executive)

> *"All of this is driven by optimization softwares and control softwares. So we do that ourselves. We've done ground softwares so we don't really partner with startups on that kind of stuff."* (Another *Utility* executive)

Several startup executives disagreed, claiming that *Utilities* were not software companies, and would not be able to become ones, in particular because of their impossibility to attract the right talents.

> *"I can't really think of any utilities who have tried to develop or successfully developed a competing software product. Once in a while a utility will say "oh we're going to use yours for a while but you know eventually we're going to develop something ourselves to replace you". Between you and me nobody takes that seriously. A utility is not a software company. Out of my list of top 10 competitive stresses of the company, a utility replacing us with a software platform is not on it."* (*Startup* executive)

> *"Utilities are going to struggle in some ways to be able to attract the type of talent necessary to build good softwares, because that type of talent likes operating in [a more agile] environment. So unless you have a proliferation of that type of talent available, where utilities are also able to attract them, they could not build [good softwares] internally."* (Another *Startup* executive)

This consideration is indeed a common idea to explain the difficulty for certain types of companies to succeed in their digital transformation, based on the concept of the "War for Talents" developed by the consulting firm McKinsey in 1997 (Keller & Meaney, 2017).

Finally, some people talked to me about the potential role in this platform play of outsiders, especially Google, based on their presence on the smart home market, and their capacity to operate data platforms.

> *"You can foresee a future where utilities have APIs that publish prices and Google goes and grabs that price, brings it down and then just orchestrates your whole house. That's the only way, to me, for real time variable pricing to work."* (*Startup* executive)

> *"I know Google is thinking about connecting all the devices using their central platform."* (*Utility* executive)

> *"Where you will see Big tech companies play a lot is actually in the "Nest type" of products. They're going to expand the number of products and services that allow them to directly work with the end customers because that's very aligned to their existing business. You're going to start to see them provide more smart devices to the end customers and be able to utilize and monetize that data that they're getting from these devices."* (*Startup* executive)

Of course, from the startup point of view, tech companies would not be able to do it properly, as their technology is not energy-specific. *Startups*, however, would be best positioned for that role.

> *"Can [tech companies] take some of their own internal technology tools and expand it for the purposes of managing [distributed energy] resources? Possibly, yes. But it's not like you can take some of the core technologies that are being used for completely different applications and just copy and paste it. You have to make it energy-specific and the energy domain knowledge, understanding how the markets work, understanding how to, what the data models need to look like for these types of resources, etc., the skill you need to have, basically a combined expertise of people who understand the energy industry very well and then also understand how to build software right, is really hard."* (*Startup* executive)

Indeed, according to this executive, they would count these two expertises in their rank, ie. energy-industry knowledge and software development skills.

> *"That's where energy software startups may be differentiated, because we are building software specifically for this purpose. Our teams are made up of data scientists and energy domain experts who bring these two skill sets together and say okay, now if we have to manage a network of distributed energy resources and you're getting data*

*telemetry from these resources at a particular way, you're getting large amounts of data from a large number of these assets that have been distributed so it becomes a big data problem in the sense that you have to figure out how to process this large amount of data in real time and at scale to be able to manage the demand and supply adequately."* (the same *Startup* executive)

Finally, talking about their vision of the future, a *Large Tech* executive used the term "transactional grid", not just as a technical concept, but really as a grid that would be smart enough to make a virtual aggregation between data and electrons.

*"You're really going to create a true kind of transactional grid where the highest and best used electron is consumed regardless of where it comes from. In a flat grid, the electron produced flows easily to the point of consumption regardless of what some customers may choose: green or lowest price for example. There's lots of different services and pricing if you could create an easily verified flow of electrons so the electron from the rooftop solar at your house flows easily to your neighbor's EV because that's what consumers chose. The grid is far away from being smart in that way but it's not that sci-fi though."* (*Large Tech* executive)

For them, it would be a way for *Utilities* to take control of this transformation, by opening the platforms where *Startups* could then develop applications.

*"To make a startup stand up by itself, it's really a question of access to data and right now the utility is the controller of so much of the data. I think that once utilities recognize that there's a platform play here and that they can open up a platform to the app development world, you'll start to see some startups do well."* (*Large Tech* executive)

Unfortunately, I did not have as clear position as this one from utility executives regarding their potential role in the platformization of the energy industry.

## 4.4. Key players

During the interviews with *Utilities* and *Startups*, I witnessed several times an opposition between them. One utility executive was very clear on the fact that collaborating with *Startups* was not a smart move on a long term, or for any strategic project.

> *"I had a discussion with a friend of mine that worked at an energy startup. I tried to explain why it would never make strategic sense for a utility like us to be a customer. There are probably other companies that have made strategic mistakes and become a customer. But just like auto companies, the competitive advantage now is in making the batteries. If they can operate better batteries, they can operate better than their competitors. That's why Tesla, Proterra, others in that class have done so well at creating a better vehicle."* (*Utility* executive)

Besides, each side was often dismissive of the potential of the other, regarding their capacity to develop efficient and qualitative softwares.

> *"I don't think any vendor right now is, like, at the apex of that software development. It's very early stage for all these companies, many of are like five years old, maybe a little bit more in terms of development but actually even less time in terms of actual experience"* (Utility executive)

> *"Utilities are not software companies, they never will be. They use software but they're not built to develop software. And when they do develop software, I would argue they develop fairly shitty software. I think that is like oil and water and we've experienced that drum clay and it really just comes down to IT policies. They manage risk, they're like professional risk managers, that's their role, not to develop software."* (*Startup* executive)

I had the impression that *Startups* were a bit less aggressive towards *Utilities* than the *Utilities* were, but it could be due to the fact that, for now at least, *Startups* need *Utilities*, not the other way around.

Considering *Large Tech* companies, they could actually be a way for *Utilities* to bridge the gap that the *Startups* seem to identify, ie. they are not software companies. One *Large Tech* company executive was clear on the fact that their role is to empower *Utilities* in front of this energy revolution.

> *"What we are trying to do is work with those utilities to develop solutions that allow them to use their grid as a platform for the delivery of the new services. But that vision [Ed: of relying on DER] scares the hell out of the utilities because think about it: you've just intermediated them. You've taken their biggest asset which is that coal or nuclear plant, and you're starting to discount it. It's not valuable anymore and every customer that signs on and does transactional energy in the market, you don't need that anymore. So they're scared to death and they should be! But I also think they should be excited because I think there's big opportunities for the utilities. That's my main point actually."* (*Large Tech* executive)

The same *Large Tech* company executive highlighted a sad example of the current inefficiency of our energy system related to the 2021 Texas electricity crisis. Based on this example, they expressed the fact that, in their opinion, *Utilities* are afraid of the potential revolution in the industry.

> *"The thing that happened in Texas, if we had a real smart grid with scalpel-like precision, we could have turned off bill boardings where people couldn't even get to because the roads were frozen and you couldn't even drive. But the power was still on all of downtown in Austin, all the lights were still on. No one was there while the neighborhood right next door was turned off. It is crazy and it's not science fiction. The technology is available today but it's like letting one little piece out. Utilities are afraid that opens up the whole thing. If they go in and do that type of load balancing then it makes their other assets less valuable because oh wow we don't need that power we can do it over here."* (*Large Tech* executive)

Disruption facing this revolution, rather than simple improvement, was also a subject discussed in some interviews. A *Large Tech* company executive estimated that real disruption compared to what *Utilities* are currently doing would be a way of success for *Startups*, allowing them to become independent players of the industry.

> *"[Some large customers] are gonna come in saying I don't need any power from the grid, don't give me your power, I don't want to be connected to you anymore because it's a threat to my business. I'm gonna create my own. [Some other big companies, like Oil & Gas for example] will come in the project, will finance it and migrate into a smart system. I definitely see that. So the startups that would be successful in my mind would be the disruptors, that don't want to be acquired, that want to compete."* (*Large Tech* executive)

> *"I think a lot of the startups get acquired because they're trying to work with utilities. But companies that I would see disruptors were the ones that are creating alternatives. Energy services that replace the existing ones."* (The same *Large Tech* executive)

Regarding the potential success of *Startups*, a utility executive highlighted the growth of the market, for example with the apparition of energy storage projects, as an important way to explore. Indeed, energy storage projects are riskier than generation only or generation and storage projects, and their profitability rely a lot on the management software performance.

> *"As you see more developers getting into the energy storage space, then yes, you will see more of those developers who maybe don't want to invest in the software. I think that the bright spot for energy software startups."* (*Utility* executive)

But, as said before, I was more under the impression that the utility executives I interviewed were just considering *Startups* as small companies trying to get acquired by *Utilities*. The following quote is a perfect illustration of that feeling.

> *"Startups get acquired, I don't think they're planning to go public. I think this is the end game. They are trying to get pilot projects with a bunch of their potential acquirers, to get enough growth before selling."* (*Utility* executive)

However, from the *Startup* point of view, selling to a utility did not appear to be the goal, even if it seemed easy, according to one *Startup* executive.

> *"Our focus is really more on the impact and the scale of that impact as opposed to solving for a specific outcome like a sale. Now that being said, an acquisition along the way is highly likely. It's an outcome but our focus is really building a great business and then out of that, you have options. I think a utility would love to acquire us. I don't think it would be the right fit."* (*Startup* executive)

One *Large Tech* executive agreed on that position, indicating that *Startups* that were acquired by *Utilities* would usually disappear.

> *"I don't think the utilities that buy these startups are buying them to get them out of the game. I haven't seen one real successful utility acquisition of a startup that grew into a commercial enterprise. Most of them die."* (*Large Tech* executive)

One startup executive cited the neutrality of their position between *Utilities* and the final customers as an important strength for *Startups*, that they could not have obviously if they were part of a *Utility*.

> *"There's so much power that we've experienced having it when we go to a customer and say we don't care what you do. We just want you to solve your goal or your objective in the most efficient manner and we're all about transparency. We're the arbiter of truth, our interests are aligned with yours. I think it really changes the dynamic of the conversation."* (*Startup* executive)

Finally, related to *Startups* acquisition, another startup executive indicated that, if the cultural fit with *Utilities* would be difficult to get, it could be better with a tech company.

> *"A good, more rational, acquisition would probably be a tech company or data company who maybe has experience in the marketplace side once, and wants to get into the energy opportunity. One of the most important things is that alignment of interest."* (*Startup* executive)

*Large Tech* companies, and especially the "Big Tech", were perceived sometimes as potential competitors, although not on a short term.

> *"We work with Tesla, Google, big ambitious companies, who could in the future decide to compete more directly with a utility than they do today. I think that it's definitely a longer term play but that it wouldn't surprise me if someday one of them would launch some directly competitive energy products."* (*Startup* executive)

> *"Even cable companies, Comcast or somebody like that, could decide to become an energy retailer and start to compete more directly with utilities for customers. A lot of these companies will say that's interesting because there's such a massive market for electricity. But when they actually dig into it a bit and they look at some of the regulatory hurdles and others, it becomes a little less appealing. But I think that you could see that happening long-term, somebody could figure that out."* (*Startup* executive)

> *"I can see that, over time, the potential is there, as more and more devices get connected, they [Large Tech companies] could start developing a control software [product]."* (*Utility* executive)

But, for several persons interviewed, *Large Tech* companies were considered only to be customers, at least for now.

> *"The Tech companies, they are customers mainly, and that's because they aren't as good as building things, like infrastructure assets. They don't even know about their data centers, they operate the software and they've got really good at that. They own direct distribution centers now, they're looking to replicate a model where they own the*

*distribution center which makes sense for their business model, but largely they are customers."* (*Utility* executive)

One startup executive was considering *Startups* in general as the balanced actor, between *Utilities*, that get the energy-related knowledge, and tech companies, that get the technological skills.

*"When you look at it from a tech company's perspective it's like do you have the market knowledge, the energy domain specific knowledge, and the regulation and all of that? When you're looking at it from the utility perspective it's like okay do you have the technology knowledge? Ultimately you actually do need intersection of these skill sets. You need someone who has been working in the electric power industry for long enough to understand how that world works. And then you need someone who understands which is why we're kind of uniquely positioned in the sense that we're in we are investment into the product has been driven by players in the utility industry but our core skill set, we draw from basically silicon valley and that talent pool to be able to build up the software right."* (*Startup* executive)

Another one was more considering the collaboration between actors, based on a common platform, developed by one of them.

*"Each group of players has a role to play in this distributed energy picture. And a platform provider, whether it's us or anyone else in the space, also has a role to play for sure."* (*Startup* executive)

However, the specific business model of *Utilities*, based on large investments, appeared to be a problem for considering partnership with *Startups* that are focused on a P&L approach.

*"Their business model is not driven on maximizing revenue and minimizing cost. It is actually based on a set return cost of service basis. There's a need for utilities either to align on this vision of the future or for us to take the business."* (*Startup* executive)

*"We're not there yet because the incumbents are providers of the old business model and have influenced the way the market is evolving now."* (*Large Tech* executive)

One *Large Tech* executive indicated that the transformation that seems to be expected from *Utilities* is major, and cannot be handled quickly and easily..

*"What you're asking them to do is to remake their company. The transfer of value is enormous and they're holding on to it as long as they can. They're trying to hold on this through regulatory and policy [means]. In the US, it's a little different in every market, but it was all built to protect the natural monopoly of the utility, because no one's going to build competitive utilities. There was only going to be one wire company. So they used that natural monopoly protection of regulatory policy to help influence and slow down the market transformation to a point where they can figure out how to, how to be nimble enough, and adjust, and take advantage of the new opportunities."* (*Large Tech* executive)

Indeed, talking about smart grids and DER, a *Large Tech* executive told me an interesting story, illustrating according to them, the current position of *Utilities*.

*"Two years ago in a big energy conference, I asked the audience, mostly utilities and some technology providers, the same question. I said "Is this an evolution or a revolution? If you think it's an evolution, raise your hand". Almost every utility in the room raised their hand. They were thinking "It's an evolution, in other words, it's under our control. It'll happen on our terms, will happen on our platform, when we decide it". And then a small group at the back of the room said "No it's revolution".And I think right now, it would be hard to argue that it's not a revolution."* (*Large Tech* executive)

Finally, *Startups* did not seem to show confidence in the capacity of *Utilities* to adapt to the new situation and requirement, especially linked to climate change.

*"So one of the biggest challenges we have is trying to get decision-makers to understand that supply and demand are now different, that there's a fundamental difference in how*

*the energy sector should be set up, who understand that climate change is now, leading to new resilience and reliability imperatives, and safety imperatives. Most utility executives are out of that."* (*Startup* executive)

According to this *Large Tech* executive, the protection obtained from regulation in the past is considered as an important reason for the confidence of *Utilities*.

*"If you've lived in a market where policy regulation and legislation have protected your position, I can see how you could get that way. "I hear all that stuff that's going on but I'll be fine". It's not true anymore."* (*Large Tech* executive)

However, this person indicated that it does not seem to hold anymore.

## 4.5. Climate change

As explained in Chapter 4, this theme is different, as it was added to my list of themes before the analysis of the data. The following quotes represent almost all references I had in my transcripts of subjects related to climate change and environmental considerations.

What appeared to me to be the most important focus during the interviews about this theme was the growing external pressure on *Utilities*. Decarbonation was indicated as a source of this pressure. A *Startup* executive thought that *Utilities* would just have to accept that and move toward the platformization of the system.

*"What the utilities are starting to see is pressure from the market, from consumers, from governments, from Wall Street, to decarbonize."* (*Large Tech* executive)

*"The grid operators also have to contend with the fact that most governments are trying to decarbonize. So they'll have to figure out a way to do this. All of it then comes down to having smarter and more dynamic ways to manage the grid than they have been doing in the past. This again comes down to a platform or some sort of software system that*

*actually is able to do this in an intelligent and scalable way. I think from a timing perspective there is just the ability for these technologies to scale."* (*Startup* executive)

Some *Startups* appeared to be clear on the importance of fighting climate change, and positioned themselves as a solution, permitting *Utilities* to transition from the role of "villains" to "heroes" in this fight.

*"We believe solving the climate is an imperative. We furthermore believe that we are one of the core and critical ways that utilities will go from being the villains to becoming the heroes in the climate change story. We are very specific on a business model that is for utilities to drive to decarbonization."* (*Startup* executive)

However, one *Large Tech* company executive emphasized the fact that the drive to move forward in sustainability was, first of all, financial. Indeed, according to them, as the finance sector is including sustainability concerns into their risk analysis, it would lead to difficulties to get financing and higher interest rates for those that are considered non-sustainable.

*"The corporate sustainability goals announced by [utility] companies, it's not because they feel good, it's really the show Wall Street or Brussels. Companies like Black Rock made some pretty bold statements recently about auditing companies footprints as part of their investment decisions. It sent a big signal out. If I can't get an investment or my interest rate is higher because I'm considered riskier because of my carbon footprint, it's my bottom line. And I'd better be doing something to show my shareholders that I'm addressing this, because it's costing us all money. They'll say "Oh yes, we're doing this for the planet, we're doing this for whatever, but it's exactly what it is, and I'm fine whatever motivates them"."* (*Large Tech* executive)

On the other hand, some utility executives were critical regarding the position of *Large Tech* companies regarding climate change subjects, indicating that they were not, and would not be soon, carbon neutral.

> *"Big Tech, and C&I companies in general, including consumer goods, retail, industrial, like anyone consuming really large amounts of energy, data centers obviously, they're leading the way, as their investors are pushing them to, from an ESG front, and thinking more about how to lower their carbon footprint."* (*Utility* executive)

> *"The world is realizing how much it is a fallacy to say that they are entirely powered by renewables. Google has been the leader on this, they say they are 100% renewables, they are signing virtual PPAs on the desert somewhere, for putting that project online and purchasing their power. It's really just a hedge transaction, a financial transaction. They said they are technically 100% renewables on a net basis but 5 times a day, they are not even close, as they have data centers that are running 24/7."* (Another *Utility* executive)

To conclude, as said before, climate change fighting was not a major subject in all my interviews, despite my personal bias as the interviewer. However, the following quote from an utility executive was a relief to me, as they clearly emphasized the bigger mission they are trying to accomplish.

> *"Especially at a company like us that has a positive impact. You get reminded constantly of why you got into energy to begin with and I think no matter how, you're still gonna have that somewhere in the back of your mind."* (*Utility* executive)

On a side note, I wanted to point out that, among my transcripts, I have no reference to other climate change related issues, like the consumption and waste of natural resources or the impact on the preservation of biodiversity, despite the fact that they are particularly relevant when considering renewable energy generations.

# Chapter 5 - Findings & Discussion

This study starts by considering one potential future for the power industry: a future in which distributed energy resources (behind-the-meter generation sources, energy storage,

electric vehicles, and even controlled loads like smart devices) would play a much more significant role in the entire energy system than they do today. Such a shift, I argued, would push our system to rely on decentralized platforms. To better understand this future, I assess the relationships between different categories of actors who may be involved in such a future. I sought experienced managers and leaders from three types of firms:

- Innovative *Utilities* currently focused on renewable energy.
- *Startups* dedicated to smart grid and DER projects.
- *Large Tech* companies that may take a more active role soon.

To investigate how current or potential industry participants see such a future, I conducted nine in-depth semi-structured interviews with executives working in the US for companies of each of those categories, then analyzed the results using a thematic approach.

This chapter first presents the inferences I developed from the interviews I conducted. I then summarize my findings and map out the considerations that will inform my responses to the study's focal problem statement. Finally, to develop the insights further, I examine these findings in the light of what I consider similar situations in other industries to provide some recommendations for the current actors of this plausible future.

## 5.1. Interview findings

The quotes I highlighted in the previous chapter provide a rich set of ideas to inform the analysis presented here. Four notable themes emerged: The DER revolution, *Utilities* at risk, *Startups'* dependency, and *Large Tech* companies, credible competitors.

### 5.1.1. The DER revolution

We tend to think of evolution as a gradual change of a system over time. It is, therefore, slow. In contrast, a revolution is a radical change that we imagine as happening fast. Industry observers have tended to see the shift to renewables as a slow and gradual

change. For example, a 2016 report by the consulting firm McKinsey and Company lays out the case in the title itself: “Renewable energy: Evolution, not revolution” (Nyquist & Manyika, 2016). Of course, if one were to assume that renewables were a pure substitute for fossil fuels and the centralized system were to remain in place, such a perspective makes sense. But what if the electric system were to decentralize as our reliance on renewables grew? As I have argued, the rise of renewables makes a decentralized, distributed system possible. It may even trigger a shift in the system. In such a case, **the advent of distributed energy resources would represent a revolution**.

None of the experts I interviewed dismissed a decentralized, distributed future. As we saw in part 4.1, DERs were a key topic during the interviews. Respondents identified DERs as a solution to two of the most critical problems they foresaw in the unfolding energy transition: flexibility and resiliency.

But managing new resources in a system focused on supply, rather than load, in turn, calls for platforms. Platforms that are smart and efficient, relying on artificial intelligence and automation to match supply and demand, would reshape the role of producers and consumers and make possible a new market-making position that would unleash a real revolution. *Startups* are betting on a revolution to come, hoping to be, at worst, an important actor, and at best, the leader in its aftermath. They want to become the winning platform, or in other cases, to become the next unavoidable application sitting on it.

For now, however, it is clear that no platform with the right reach exists or is even in development. Two-way flow grids based on real-time pricing, a concept sometimes called “transactional grid”, are discussed among experts but tend to be seen more like a vision than a near-future reality. *Startups* are worried about the timing of this transition, or even if this will ever happen on a large scale. An evolution plays out gradually, but its incremental nature means that it could well be irreversible as funding flows, investments, mindsets, regulations, contracts, and formal relationships co-evolve in alignment with technology, producers, and consumers. Might a more rapid change--the revolutionary shift we have

been examining--turn out to be reversible? Despite the signs pointing toward the future of DER, it is still an uncertain future.

The deciding factor could be residential customers. Long neglected, hidden behind more profitable commercial and industrial customers, their role changes quickly, as we saw in Chapter 2. First, residential customers are increasingly mindful of the source, cost, and impact of the energy they use, not least because the growth of electric vehicles makes them aware of the variability in the price of electricity. Second, the negative impacts of climate change on their day-to-day life are increasingly dire. As DERs will become cheaper and easier to use, more residential customers could decide to leave the current centralized energy system in favor of decentralization. This could pose an existential challenge to *Utilities*' existing business models.

### 5.1.2. *Utilities* at risk

As of today, power utilities are unquestionably the leaders of the power industry. And considering the current and inevitable energy transition we discussed in chapter 2.1, *Utilities* focusing on renewable energy are well-positioned to take first place among their peers sooner than later, when it is not already the case. However, based on the interviews I did for this research, it appears that ***Utilities* are perceived to be at risk by some experts of the industry**.

This risk takes many different shapes. Financial risk is the one that has been the most salient, in my opinion. *Utility* executives highlighted it often, some arguing, for example, that all the low-risk projects have already been made in the US, pushing them to take higher financial risks on new projects. They also consider that they have to face more regulatory and even safety risks, all of which already limit their growth.

The risk related to residential customers is also seen as more and more critical. As discussed in part 2.2.1.3 of this research, with a growing customer-first culture in many industries and the digitization of services, they expect more from their providers.

Unfortunately, several experts are very critical of the current customer journey offered by *Utilities*.

Besides, the rise of prosumers in the energy industry brings many new risks, like an imbalance in the finance of infrastructures, as we saw in the previous inference and also discussed in part 2.2.1.3. The transition from a centralized to a decentralized system is considered by *Startups* and *Large Tech* companies to be a threat to *Utilities*, as building new large assets could become irrelevant. Indeed, the business model of *Utilities* is currently based on large capital expenses, whereas *Startups* and tech companies work on an operating expense model. Discussions about this "OpEx" trend first appeared a few years ago, even in the industry. For example, Schneider has been focused on "the rising shift in investment strategy from CapEx to OpEx" (Gershman, 2019).

Moreover, several executives emphasize a cultural risk, where *Utilities* have to face the digital transformation discussed in part 2.2.2.2. Aligned with the transition from a CapEx to an OpEx business model, becoming a "software" company for an entity built on physical assets is complex. *Utilities* claim that they are way ahead on this path, developing cutting-edge software and platforms to manage, among other things, distributed resources. Yet, *Startups* and *Large Tech* companies are not aligned with this assertion and ascertain that *Utilities* are not "software companies". The "War for Talents", mentioned in part 4.3., is not helping *Utilities* to succeed in this transition either.

To summarize, *Utilities* are currently facing growing financial stress due to the rapid growth of renewables, the change of behavior and role among customers, and a pressing digital transformation, with impacts on cultures and business models. If we had that, external pressures related directly and indirectly to climate change, their status of leader seems to me, at least, to be contested.

However, several major opportunities exist for *Utilities* if they can grab them fast enough. Energy storage and electric vehicles are the best way for them to increase their market size, which is more than rare in mature industries. And the digital transformation, although

difficult, could provide an entirely new market for *Utilities*, where *Startups* would develop applications based on *Utilities'* platforms. But for that, a genuine partnership between those *Utilities* and *Startups* would be necessary. Such new partnerships will prove challenging to develop. Experts I interviewed from both sides were not very confident that partnerships easily emerge.

### 5.1.3. *Startups'* dependency

If the *Utilities* are considered at risk by the experts, their position regarding the *Startups* working on DER and digitalization of the industry, in general, is not more encouraging. Indeed, during the interviews, executives in all three categories indicated that ***Startups* are fully dependent on *Utilities* and are most likely either targeted to be acquired by them or, if possible, replaced by internal products**.

As we saw in Chapter 4, oppositions exist between *Startups* and *Utilities*. Firstly, some *Startups* do not consider *Utilities* to be able to develop qualitative software. Yet, at the same time, some *Utilities* think that *Startups* do not provide the advanced software needed in this sector. Not surprisingly, *Utilities* do not want to allow *Startups* to take this strategic advantage. Secondly, some *Startups* also point out the cultural gap between them and *Utilities*. For them, that is a noticeable handicap when they try to hire employees associated with the "startup culture" and, therefore, would not choose to work for a utility. Based on that consideration, some startup founders presented the possibility of being acquired by a *Large Tech* company as more desirable.

But, even if a startup manages to be acquired by a *Large Tech* company, if its offerings involve the electric grid, it would still need to work with or through *Utilities* to deliver value. Any startup seeking to innovate in the electricity sector cannot avoid being highly dependent on the leading players in the industry: the *Utilities*. First, and more importantly, they need to get access to the market, which requires partnerships, especially with *Utilities*. Second, they are not in a position to develop strong relationships with regulators. *Startups'*

weak position vis-a-vis regulators creates a difficult barrier to entry and scale. Finally, like any new company, they do not have the financial solidity to last long alone and need external funding, most likely from *Utilities* or energy-related investment companies.

A company called Uplight provides a good illustration of this finding. The company was created in 2019 from the fusion of six *Startups,* each working on subjects related to energy efficiency, DER, and energy platforms. They describe themselves as "the leading provider of end-to-end customer-centric technology solutions dedicated solely to serving the energy ecosystem" and indicate that they are working with "[m]ore than 80 utilities around the globe" (Uplight, 2021). Recently, Uplight announced a new round of funding, pushing their valuation to $1.5 billion (Uplight, 2021). As of today, this is undoubtedly a great success for a startup. However, among the lead investors in this company and this last round, we can find the utility AES Corporation and the tech energy-focused company Schneider Electric.

History showed us that *Startups* could take leadership positions in new markets several times, despite competing with big companies. It was, of course, the case with many of the markets created by the invention of the Internet. However, based on the interviews I conducted, I am not convinced that *Startups* could lead alone in a DER future.

### 5.1.4. *Large Tech* companies, credible competitors

The power sector is often considered a challenging sector to get in because of major entry barriers: regulations pose onerous requirements, capital needs are extensive, and technical considerations make scaling up and management difficult as there is no room for learning from experimentation. As I saw during the interviews, these factors lead incumbents to perceive the threat of newcomers to be low. *Startups* share this perception of high barriers to entry.

However, none of these barriers are entirely insurmountable, and this study took on the very question of potential new actors getting into this sector. I indeed found that ***Large Tech* companies are seen by some industry experts as highly credible competitors.**

To mitigate this inference, they are not considered as a short-term threat and are more considered as customers for now. Some startup executives indicated that they do not have energy-specific technology for now and that applying their knowledge to this sector would be hard. However, they could be strongly biased, as the entire value proposition of their companies is to provide energy-specific technologies. Admitting that this is either not as hard or not as specific would not serve them well.

The reasons that *Large Tech* companies are considered to be a threat were highlighted in multiple interviews. First, their capacity to build digital platforms at a large scale and for many different industries would become a major asset should the energy system become more complex and decentralized. Second, their expertise in data and automation is unparalleled, especially compared to *Utilities*. Finally, those companies are, by design, customer-centric, and some are already proving that they have direct relationships with residential customers regarding their energy consumption, thanks to smart home systems. But, again, as it was pointed out during the interviews, *Utilities* are not recognized for this particular expertise either.

Besides, in parallel to their current known activities around the energy activities, focused on managing and improving their own energy consumption, **two of the "Big Tech" just announced recently that they are working on virtual representations, also called "digital twins", of the energy grid.**

- On April 23, 2021, Alphabet subsidiary X announced its "moonshot for the electric grid". Their goal is to explore "whether creating a single virtualized view of the grid — which doesn't exist today — could make the grid easier to visualize, plan, build and operate with all kinds of clean energy". To lead this project, X hired Audrey Zibelman, previously the CEO of the Australian Energy Market Operator (AEMO) (Teller, 2021).
- Two weeks later, on May 6, Microsoft presented its "Energy Grid Ontology for Digital Twins". Following their work on a cloud digital twins platform last year, they

> developed this ontology to "bootstrap solution development and enabled developers to quickly model and create sophisticated digital representations of connected environments like buildings, factories, farms, energy networks, railways, stadiums, and cities, then bring these entities to life within a live execution environment that integrates IoT and other data sources" (Ravi, 2021).

The similarity and the timing of the two announcements are striking. It is a clear sign of the growing interest of *Large Tech* companies in the energy industry.

Of course, despite those strengths and interests, the entry barriers of this industry are still here. It is, therefore, now a question of assessing the resistance of those barriers. This research can not answer that; nonetheless, it is interesting to ask ourselves if regulation, financial, and tech issues could provide even any meaningful resistance when *Large Tech* companies would decide to march against them actively. It is also interesting to ask ourselves what could decide them to make this move.

## 5.2. Assessing the threat posed by *Large Tech*

### 5.2.1. Will history repeat itself?

Based on that last finding, is it the natural conclusion that Tech companies could become direct competitors to *Utilities* in the energy industry? It might seem implausible, considering, as we discussed, the strengths of the entry barriers, as well as the differences in the business models between those categories of companies.

But if we take a step back from the power sector to look at other industries during the last decades, we can find a pattern that may be relevant to our current problem. Consultancies and industry experts across varied sectors have made the point that companies that followed a strong digitalization strategy and developed their own platform or "ecosystem" have higher business performance. Lending credence to their arguments, academic researchers are uncovering evidence about the value of embracing digital strategies. See,

for example, the wide range of studies presented by the MIT Center for Information Systems Research (https://cisr.mit.edu/).

To get beyond the hype, and further than part 2.2.2.2., we can simply take a look at several of the most influential industries in today's advanced economies to observe that there have been many occasions where tech companies took the lead despite robust, old, and entrenched competitors:

- **The Retail industry** was one of the first major industries to be completely modified by the Internet and the platform economy. Amazon has taken the lead of this industry, ahead of Walmart, founded 32 years before. Like Amazon, but on the other side of the World, Alibaba and JD.com are also becoming giants, aggregating all the other industry actors on their respective platforms. Walmart, and some other traditional incumbents, are certainly reacting to this change, some with great success, but it is a shame to wait to lose its first place to start moving seriously.
- **The Entertainment industry** went from mass media companies, physical movie theaters, and physical supports to subscriptions "on-demand" models, streaming, and curated content in less than two decades.
    - Several platforms have already replaced most of the main actors of this industry, despite a considerable brand effect on the general public. Example of leading platforms: Youtube (Alphabet), Netflix, Amazon Prime Video, Apple Music, Spotify, Steam (Valve)
    - Some incumbents have recently made strategic moves into the platform economy, some with great success, like Disney, with the recent launch of Disney+, or Warner, with HBO Max.
- **The Financial Services industry** is particularly interesting. Banking incumbents are still leaders, and the sector did not evolve toward platform systems, as online banks are only "digitalized competitors" or still *Startups*. The situation is identical for insurances.

    - It is first noticeable to see the number of new actors that entered this industry with great success during the last two decades despite the numerous entry barriers that they had to fight (financial, regulation-related, and technical).
    - Second, the part of this industry that is now fully working on platforms is payment. Examples of leading platforms: Paypal, Apple Pay, Google Pay, Amazon Pay, Square, Stripe.
    - Finally, let's note that blockchain-based services, with crypto-currencies and smart contracts, could be a way to "platformize" our financial systems, but the timing for that is undoubtedly not short-term.
- **The Hospitality and Tourism industry** has been strongly impacted by the platform economy, and the leaders of this industry are now new tech companies.
    - Airbnb, founded in 2008, now proposes 7 million listings worldwide and has reached a market capitalization of almost $100B. Marriott International, the largest hotel company by market cap, founded in 1927, has around 8000 properties, containing 1,5 million rooms, for half the value of Airbnb (around $47M).
    - Booking, founded in 1996, has revolutionized the travel agency business, making almost all competitors irrelevant. Its market capitalization is also just under $100B. Its main competitor in this market, Expedia, also a tech company, has a market value of $25B. In 2019, Thomas Cook, one of the oldest and most prominent travel agency companies in the world, founded in part in 1841, went into compulsory liquidation, despite a valuation that reached $2.3B in 2018.

Other industries are under massive transformation based on their digitalization and transition on a platform-based model. Leaders have not yet emerged in all sectors, but in many industries, the landscape is clearly different from 20 years ago.

What is happening in the healthcare industry with telemedicine platforms is an interesting example of this dynamic as it plays out in early 2021. For now, it is hard to say that one platform, in particular, will take the lead in this industry, and one cannot be confident that a single winner will emerge. However, it is clear that the growth of this business is strong and was not visible a few years ago, putting the current actors of this industry at risk.

We can also look at what is happening within the education industry, as, in my opinion, its situation a few years ago bears similarities to the current situation of the healthcare industry. Top universities and public systems are still the education leaders, but platforms like Udacity are challenging this domination.

However, in that case, the incumbents are evolving quickly, working on new education offers and models. Some industry leaders, such as Harvard and MIT, created their own platform, edX, in 2012, in anticipation of these new competitors. As of today, this platform is a major success, with courses from many other universities, real degree programs, and, above all, content from other universities. This kind of collaboration is rare but is highlighting a very relevant path for the energy industry.

*Note: The given examples of "platformization" are all from what we call the "services sector". No clear example exists from the "industrial sector", where we currently put the energy industry. However, I would argue that, for this research, as we consider a plausible future of distributed energy resources, the industry would be closer to some of the industries I took as an example than those from the traditional "industrial sector".*

### 5.2.2. Do entry barriers stand a chance?

By looking at those examples, and based on the findings of this research, saying that *Large Tech* companies could become future competitors or even leaders of the energy industry does not seem so silly. Based on the inferences made during the interviews, I concluded that the last question left to answer was about the strength of entry barriers. Those barriers are relative to regulation, finance, and tech issues. But from my perspective, all

those barriers could not represent a significant problem if *Large Tech* companies decided to fight them.

They have the resources to deal with any problems they could face relative to regulation, as some have demonstrated in many other industries. For example, Amazon launched Amazon Pharmacy last year for the US, having to deal with the complex regulations depending on each state. Despite many potential problems linked to that move, putting Amazon "squarely in several enforcement agencies' sights" (Lee & Holland, 2020), this entry barrier did not hold the company outside this industry.

The financial requirements of the energy industry, in my opinion, do not represent at all a barrier for those companies if they would judge the investment to be strategic. It can be simplistic, but I find it still relevant to look at orders of magnitude to get a basic idea about this situation. A middle-size innovative energy utility like, for example, AES corporation has a current market capitalization of $17B. But more importantly, they reported in 2020 a total of owned and managed assets of almost $35B (AES Corporation, 2021). I could take other examples, but I would say that the order of magnitude of total financial size of energy *Utilities* is about several tens of billions of dollars.

I will not try to compare the financial size of energy *Utilities* and *Large Tech* companies, as it would be irrelevant, but we can look at some of their investment plans in the US. For example, Apple announced a plan to invest $430B in the US over the next five years. This plan includes many "physical" activities, like investments in infrastructures and plants (Apple, 2021). Therefore, the order of magnitude of those plans would be more around hundreds of billions of dollars, confirming my position toward these entry barriers.

Finally, tech issues should be considered as two different barriers. The first one is more related to industry-specific knowledge that would be related to processes and software. This barrier can be easily passed by poaching talented people from the energy industry. Therefore, it would be only a question of the pay scale, job interests, and work environment's quality between the tech and the energy industry. The winner of this match

is also easy to define, and the fact that the energy-related teams among *Large Tech* companies are growing rapidly tends to confirm that they do not have difficulty hiring experts who will bridge that knowledge gap.

The second "tech" barrier is more related to hardware than software in the sense of building physical assets. Indeed, the energy industry relies heavily on complex infrastructure projects, and *Large Tech* companies are, by design, software companies. However, I would argue that they developed much expertise around physical assets during the last two decades. It started in the '00s when they had to build their own servers. One day, Google was announced to be the second manufacturer of servers in the World, where everyone was convinced that they were doing nothing else than a search engine. The incredible part was that they had only one client: themselves. Now, Google actually owns shares on more than 63,000 Miles of the submarine cables, representing 8.5% of the total worldwide Internet cables, and they are even the full owner of 1.4% of those cables, thanks to the Dunant subsea cable project (Google Cloud, 2021). So, the Big Tech companies are indeed developing massive infrastructures to support their data centers worldwide. And, thanks to the cloud, as those data centers are supporting a big part of the activity of the entire humanity, saying today that they are only software companies is clearly misled.

### 5.2.3. What motivations to move further?

Even if I conclude that the entry barriers of the energy industry are not strong enough to keep the *Large Tech* companies away, one more question is still present to solve our problem. Why would they do that? What motivations would push them to make this move?

Indeed, the energy industry is not known to be a lucrative industry with high margins. On the contrary, the margins are either controlled and based on cost in regulated markets. They can even be smaller in deregulated markets, where competition is bringing new competitors that will try to gain market shares and new projects at "any cost". As already

evoked, a clear indication of this low financial rewards industry compared to the tech industry is the difference in market capitalization between those companies.

So, *Large Tech* companies will not be attracted by the potential of easy financial gains. However, those companies are so massive now that they have no choice but to consider entire industries as their possible next strategic moves. They cannot just accept a nominal growth on their core businesses, resulting in a substantial decrease of their market value, which is only based on “hyper-growth”. As we saw, Big Tech, notably Google, Amazon, and Apple, occupy already several industries and are trying to take noticeable market shares in new ones.

Besides, we have to consider that they may not even have a choice if they want to be really serious about fighting climate change. Indeed, they are now taking some serious commitments that may push them to act if nobody else does. For example, Google has committed to “operated carbon-free” by 2030 (Google, 2020). They did not commit to a simple “carbon-free” equation based on buying on a simple matching of their consumption with renewable production. Instead, they committed to a full 24/7 carbon-free energy for all their operations, including their offices, data centers, and manufacturing plants, and all of that in less than nine years! Reaching this goal will undoubtedly be incredibly difficult. Nevertheless, they are saying that they will “continue [their] work with governments, *Utilities*, and policymakers to deploy those technologies and drive system-level change”. The power utility AES, based in Virginia, actually just announced their first agreement with Google to provide 24/7 carbon-free energy to their data centers based in the state (AES Corporation, 2021).

But could this move happen everywhere? What would happen if those “governments, utilities, and policymakers'' would not move fast enough? The transition in the US may evolve fast enough, but if we think, for example, now about the situation in Asia, where we are still seeing coal generation growing, will it be easy for Google to procure the renewable resources they need there? In that case, and it is only a personal opinion, I would argue

that they could be pushed to take a more active role in building those resources. And by gaining forced experiences in one part of the world, it would be definitely easy to do it elsewhere.

The remaining question regarding the active involvement of *Large Tech* companies in the energy industry is, therefore, not why they would do it, but instead, would they have the choice to stay away from it? And the answer, in my opinion, is entirely dependent on what the *Utilities* will do.

## 5.3. Outsiders

To finish this discussion, I wanted to highlight two different outsiders that I chose to exclude in my initial exploration of the landscape of a decentralized energy future. However, based on some very recent events, I think it is now essential to keep them in mind before concluding this research.

### 5.3.1. Tesla, the Big Bad Wolf

In 2003, the founders of what was called Tesla Motors, Martin Eberhard and Marc Tarpenning, laid out a goal to build "a car manufacturer that is also a technology company" (Bloomberg Businessweek, 2007). So the idea to link the tech industry with another, older, and physical industry, was already there, but at the outset, energy was not the target.

It was not until 2017 that the company changed its name to Tesla and marked its entry into the energy industry. This move followed the launch of their energy storage offer (named "Powerwall" for residential customers and "Powerpack" for C&I customers) in 2015 and the acquisition of the solar company SolarCity in 2016.

Today, Tesla's mission is to "accelerate the world's transition to sustainable energy" (Tesla, n.d.). The car itself is not central anymore. Energy is. They indicate proudly that they build "infinitely scalable clean energy generation and storage products". Their goal is also clearly

linked to the energy transition, as they believe that the transition away from fossil fuels needs to happen as fast as possible.

This position is why I think it is essential to include Tesla in reflecting about the future leader of a DER future. Tesla's vision of the energy industry is clearly decentralized and is based on distributed resources. As they are saying themselves, "[e]lectric cars, batteries, and renewable energy generation and storage already exist independently, but when combined, they become even more powerful – that's the future we want." (Tesla, n.d.).

Besides, since the recent major success of their car manufacturing activity, they have a huge financial capacity to accomplish their goals. Today, Tesla has a market capitalization of almost $650B, but more importantly, it is reporting strong and fast-growing financial results, with annual revenue for 2020 of $31.5B (+29% YoY) and $52B of total assets. Thus, as discussed in part 5.2.2., their financial size is already in the same order of magnitude as a mid-size energy utility.

However, we could argue that they did not do much into the energy industry until now and kept their focus on the automotive industry. But, in my opinion, it is not a question of if, just a question of when.

In an April 26, 2021 earnings call for the first quarter of 2021, Tesla CEO Elon Musk announced (The Motley Fool, 2021):

> *"[W]ith a whole bunch of Powerwalls and houses, we can actually buffer the power. And so if the grid needs more power, we can actually then, with the consent, obviously, of the homeowner and in partnership with the utility, we can then actually release power onto the grid to take care of peak power demand."*

This is a perfect description of what a DER company could do, using an efficient platform to manage distributed resources based on a partnership with *Utilities*. But one sentence later, he said:

> *"[T]he Powerwalls can operate as a giant distributed utility. This is profound. I'm not sure how many of you will actually understand this but this is extremely profound and necessary."*

He clearly expressed the possibility for Tesla to become a utility in a distributed future, in opposition to his previous statement. Notably, Musk's language--the "extremely profound" shift he mentions--invokes the notion of a revolution in keeping with the ideas explored in 5.1.1.

Musk highlighted his belief that utilities would not be able to react fast enough without Tesla's DER proposition, leading to more catastrophic events for the general population.

> *"[I]f this is not done, the utilities will fail to serve their customers. They won't be able to do it. They won't be able to react fast enough. And we're going to see more and more of what we see, say, in California and Texas of people seeing brownouts and blackouts and the utilities not being able to respond because there's a massive change going on with the transition to electric transport. And we're seeing more extreme weather events. This is a recipe for disaster."*

He concluded this segment of his presentation by arguing that if we do not rely on DER in the near future, *Utilities* will have to upgrade all their infrastructure. That would, in turn, pose major challenges, and in final, impose costs on customers.

> *"[I]t needs to occur both at the local level and at the utility level. If it doesn't occur at the local level, what will actually be required is a massive increase in power lines in power plants. So they have to put long distance and local power lines all over the place. They'll have to increase the size of the substations, [which] is a nightmare."*

For him, and therefore, for Tesla, DER is the only possible future for the energy industry, and they will be a big part of it.

> *"This must occur. There must be solar plus battery. That's the only way."*

In the present research, I tried to contact several people at Tesla to include the company in my interviews. Although I did not manage to obtain a one-on-one interview, the line of thinking revealed in this call transcript was detailed enough to paint a vivid picture of the company's thinking and to underscore the dramatic transition its leaders envision.

### 5.3.2. Octopus and other underdogs of retail electricity

Finally, I consider it important to highlight another kind of actor that is very different from those we have already considered: retail electricity companies. Also called energy suppliers, these companies are much smaller than utilities and could be regarded as startups. But contrary to the software *Startups* studied in this research, they are not focusing on providing additional technical solutions but rather becoming intermediaries between the utilities and their customers, primarily residentials. Most of the time, they do not own any infrastructure or generation plants. Their strategy is to focus on customer relationships and lower operational costs to provide a better service while keeping it profitable. In that sense, they are opposed to the "low price, low margin, low service" position that we often see among utilities.

As energy markets get deregulated, this category of actors is growing fast, counting already hundreds, or maybe thousands of companies. As they are not explicitly dedicated to DER or even renewables, I did not focus my work on them and instead considered them simple "interfaces". They are, by default, fully dependent on utilities that own the assets they need and do not appear as plausible strong competition.

We just got a clear example of the level of dependency of those retail electricity companies with the case of Griddy. In December 2020, everything seemed to be going perfectly well for this company. They were announcing new management and a financing agreement that would "help the business reach its tremendous potential". Griddy's leadership went so far as to announce that they would focus on developing "[s]olutions to combat price volatility, including a "price lock" feature for peak periods'' (Griddy, 2020). Just three months later,

following the 2021 Texas power crisis, whose origins the company had nothing to do with (Giberson & Moore, 2021), Griddy filed for bankruptcy. Texas has now banned any other retail electricity company that would provide similar offers (Chediak, 2021).

However, we can also find examples of companies in this category that suggest that some could represent a real threat to utilities in a decentralized energy future. The case of Octopus Energy provides a telling example of this possibility. This company was established in 2015 in the UK by two founders with no prior experience in the energy industry but with an extensive background in technology and design. Octopus started with a strategy similar to that of other retail electricity companies, focusing on customer experience. But they quickly expanded their services, thanks to acquisitions and investments, putting them into a position where they could become an independent utility in their market. This independence appears to be revealed by how the founders spoke of their competition:

> *"The energy industry in Britain is ruled by a handful of complacent dinosaurs peddling fossil fuels, pricing trickery and poor customer service. In 2016, Octopus entered the market to disrupt the status quo with energy that's good for the planet, good for your wallet, and, honestly, good for your soul."* (Octopus Energy, 2021)

The language is rather disparaging. Octopus appears to be out to challenge the status quo. And what is even more interesting to me is Octopus' proposition related to electric vehicles. First, via their subsidiary Octopus Electric Vehicles, they are proposing electric car leasing. Some utilities are already offering such services, but most often do so through a partner. Octopus goes even further by managing charging installations at consumers' homes and providing the "most cost-effective tariffs" (Octopus Electric Vehicles, 2021a).

Second, in a rare move among competitors, in late April 2021, Octopus announced the launch of their newest offering, a "Vehicle-to-Grid" system, called "Powerloop" (Octopus Electric Vehicles, 2021b), the culmination of months of testing. With that, in my opinion, they are positioning themselves as a credible full actor of the DER future and a plausible competitor to *Utilities*.

# Chapter 6 - Conclusion

## 6.1. Summary

When I started this research I was motivated by a question that has driven me throughout my career: “What will happen in the future?”.

The extensive research I undertook in conceptualizing, developing, and conducting this study led to a new understanding of our shared future. I have come to see **the energy industry as the heart of human civilization**. Without it, almost nothing can work, almost nothing can move, and human activity would grind to a silent halt.

I am convinced that we are at a moment in our civilization that necessitates major systemic changes. I am also convinced that the right changes will shift our systems--whether they are political or physical--towards decentralization. Why do I see distributed solutions in our future? Apart from the value placed on self-determination and local control by communities everywhere, there are technical reasons to value decentralized options. My training and experience in computer science has taught me that decentralized systems outperform their more brittle centralized counterparts: they are more responsive, more flexible, and adapt to innovations and challenges over time. Today, thanks to an ever-increasing amount of data that until even recently would be unimaginably difficult to collect and analyze, we can develop systems that connect activities across large networks in real time, enabling coordination, facilitating exchange, and addressing needs as they emerge--all without needing constant human intervention.

I set out to consider a decentralized power sector based on distributed energy resources running on platforms. And in this new landscape, I wondered who would be present. Would it be the same participants that we are seeing today? Would some of them disappear? Would new ones appear? Who would stay, fight, and maybe even win?

My core question:  in this plausible future of distributed energy platforms, who will lead the next electricity revolution?

With my literature review, I started my study by looking at the current energy transition. I concluded that this transition, pushed mainly by financial motivations, is inevitable. I also noticed that future scenarios developed to examine how the impacts of climate change rely on using all the technological solutions we know. This would therefore lead to a much more complex energy system than the one we know nowadays.  Finally, I highlighted that, by pushing more renewable sources into the system, we will have to deal with new issues, in particular, short and long term intermittency, that our current grid could not manage without large investments and a global digital transformation.

Then, I looked more specifically at distributed energy resources, based on a decentralized system, and concluded that it could indeed represent a viable solution facing those constraints. However, I noted that this solution would rely on two fundamental pillars: intensive use of data and automation, and the active engagement of all customers, including residential ones. It led me to consider the necessity of one, or a few, digital platforms to manage this energy industry of the future.

Based on those primary conclusions, I conducted in-depth interviews of executives at some of the most innovative renewables *Utilities* and software *Startups* of the power sector in the US, as well as a few *Large Tech* companies. I gathered qualitative data that revealed four key insights

- If the industry would evolve toward a distributed system, it would not be just an evolution but rather a revolution, leading to many, hardly predictable, changes.
- *Utilities*, even the ones that appear to currently lead the energy transition, are already under a lot of pressure, putting their leading position at risk.
- *Startups* are in a position of dependency, and cannot take the lead alone.
- And finally, *Large Tech* are much closer to playing an active role in the energy industry than it looks at first glance.

Finally, I examined these findings, particularly the last one, from the perspective of my own experience and observations. Indeed, Tech companies are now everywhere, in our daily life, at the top of our financial markets, at the forefront of innovations. To make sense of the situation the energy industry could face, it is useful to compare it with what we have learned from the recent history of other sectors. My prior experience in software and my recent study of technology strategy suggest that *Large Tech* companies could step into key roles in the electricity sector and shape its future far more actively than they currently do as powerful concerned customers. Perhaps the most telling example is Tesla, a company with the means to fight the entire market, and the will to do it.

Now, it is time to reach a conclusion.

## 6.2. Conclusion

This research aimed not to evaluate the probability that distributed energy resources would dominate the energy industry's future. Although my literature review highlighted arguments in favor of a decentralized system, far more data and analysis would be required to arrive at a specific credible prediction. Yet, I am confident in concluding that a decentralized platform-mediated electric power sector is at a minimum plausible. Furthermore, I find that enough of the elements are in place for distributed energy to represent a viable path for the industry.

My study focused on the key questions that ensue when you follow this line of thinking. Which types of actors could most influence this future market? Who will have the means and the innovation capability to create the next iteration of our electric energy system? Might we see the same kind of actors we see today, the same to lead it? Or would we see new entrants in this revolutionized industry?

Of course, these are somewhat rhetorical questions. Any attempt at a definitive answer would rely on conjecture. Nonetheless, my findings led me to a set of working conclusions that apply to the three categories of actors considered in my framework:

I. First, I estimate as highly unlikely that more than a very few *Startups* will gain complete independence and become either a new utility or a new *Large Tech* company. However, I estimate as highly probable that many *Startups* will get acquired from both other categories of actors and will, therefore, at least partially, succeed.

II. Second, I estimate as highly probable that some *Large Tech* companies will take a full role in this new decentralized landscape. However, as they are not in an aggressive stance yet, I estimate that the effective content of their role will be dependent on what the *Utilities* will do in the near future.

III. Finally, I estimate as highly probable that if *Utilities* do not transform themselves fast enough to become actual tech companies, then *Large Tech* companies will have no other choice than to become direct competitors for *Utilities*.

While these are my own working conclusions--informed, of course, by the research presented in this study--I think they could prove useful spurs to strategic thinking for current firms and would-be entrants in the sector. I imagine that stakeholders could use these ideas to refine their mapping of potential energy futures and identify potential risks and rewards for investments, partnerships, alliances, and on-going industry research.

That said, my last point bears emphasis as it seems to be the most important of my insights. With the right direction, I think that many *Utilities* could indeed succeed in their digital transformation and become sufficiently capable in their use of software technology to retain and defend their current leadership position. And because I am convinced that it would benefit consumers to limit the industry concentration that major technology firms have created in other sectors, I very much hope that *Utilities* will continue, or begin, to take the challenges of DER seriously.

## 6.3. Recommendations

I began this study intending to develop ideas that could be helpful to the people and companies who have the power to shift how the electric system operates. I would like to end with some recommendations designed to do just that.

My first recommendation could be considered commonplace, even platitudinous, but it is still necessary to articulate it: all non-digital companies should be "full steam ahead" towards digital transformation. It has been 20 years since the world started to talk about digitalization and the resulting transformation of organizations. My own professional experience over more than a decade has given me a front-row seat to both the challenges and the opportunities that digitalization brings. Yet, I observe companies everywhere, every day, where this process is not finished. We can too often see companies that outsiders would consider to be under threat from competitors, but nevertheless invest little in assessing the demands of digital transformation. Some even disdain the imperative. However, I am convinced that, without mastering digital transformation, organizations will not face the challenges that await them.

My second recommendation is related to the reason that motivated this research in the first place: climate change. I observed during my interviews that this consideration is not always central in the strategies and actions deployed. The seriousness of the impacts of climate change, and even more importantly, its concise time frame, do not allow for any wasted time and immobilism. Given the lead time of any impactful project in this industry, it would be a mistake, in my opinion, to wait for a market-based solution. I would therefore recommend that all companies engage in strategic plans to, at least, resist and adapt, and at best, fight against climate change.

Many concrete actions should be done based on those two recommendations, like launching proper experiments to stay flexible and ready, and keeping an eye out to seize the perfect timing on when to act on the positive results. However, I would prefer to emphasize a subject that is often marginalized in transformation plans: education.

I am not talking here only about continuous skill training, which is undoubtedly necessary , but definitely not sufficient. I am talking about serious education, for everyone, from the most junior employees to all the executives and board members. Without spending a tremendous amount of effort to learn and think about what is going on around us, I don't know how it could be possible to plan and act effectively. And without everyone around us having the same knowledge and understanding of the reality, I don't see how it could be possible to achieve exceptional success.

I took a full-time year in the middle of my career to learn at MIT, and I only scratched the surface. This journey is harrowing, sometimes dark, but for the sake of all, we cannot back down.

# Appendix

## Appendix A - Thesis Interview Plan

### [T+0 min - PHASE 1 - Introduction]

This study explores the landscape of actors that could take the leadership of a future where the power sector would evolve toward a more distributed way to produce energy. In this future, we imagine the apparition of one or several platforms that could manage the electricity in itself and energy markets.

Our first goal is to understand how this industry's current leaders, startups, and other innovative companies, are positioned to face this plausible future. Our second goal is to define what significant changes we could expect in the industry relative to those actors if this future indeed happens.

We are therefore looking to learn from your perspective what your current view is considering distributed energy and the emergence of platform models in the industry and what you think will be your strategy to approach this future. We are particularly interested in potential opportunities and challenges that you could presume.

This research-driven study will be developed into a thesis this spring that MIT Sloan could publish. This conversation will not be recorded and will stay confidential. However, I would like to take extensive manual notes during this interview, in order to be able to gather quotes. But as I said, you will not be identified as a respondent, and I will not attribute you any quotes I will use. I will only indicate for each quote I would use which category of company you're working for. You can refuse the current conditions if you want to, at any time, during or after the interview.

This interview should last 45 minutes in total, including this 5 minutes introduction and 5 minutes at the end to discuss any further questions you may have. Are you ok with what I said, or do you wish to discuss anything relative to the interview in itself?

[Manage potential questions before starting the interview]

Great, I will then ask you the first question.

## [T+5 min - PHASE 2 - Definitions]

1. Could you please give me a quick presentation of your company and your role?

- [Probe if no reference of the competition] And who are your main competitors?

2. Would you be able to classify those competitors in a few categories, and what would they be?

3. Could you tell me what would be your definition of "distributed energy"?

- [Probe] What activities does your company do related to distributed energy?

4. If we now talk about "Distributed energy platforms", what would be your definition of this concept?

- [Probe] Do you think it is a known concept in the industry?
- [Probe] What is your professional opinion on "Distributed energy platforms", and what future do you see for it?"
    - [Probe if positive reaction] Why do you think this?
    - [Probe if negative reaction] What other future do you imagine in this case?

## [T+15 min - PHASE 3 - Simulations]

5. Now, let's admit this future is the direction we will take. What problems or difficulties do you think the industry will have to overcome?

- [Probe if too many constraints given] Could you try to categorize them into groups of constraints?

6. [Not later than T+20 min] In this plausible future, how would your company be impacted?

- [Probe if necessary] What would you need to change to face this new reality?

7. How would you manage the difficulties we talked about?

## [T+30 min - PHASE 4 - Competitions]

8. Who would be your competition in this scenario?

- [Probe if the answer is the same as the one given at the beginning of the interview] Do you think that new actors would appear, and if yes, who could they be?"

9. [Not later than T+35 min] Considering the difficulties we talked about, how do you think your new competition would manage them?

10. Before the end of this interview, let's assume another alternative future, where the energy industry becomes a more centralized system. Do you think it is more probable than a decentralized future?

- [Probe if yes] How are you and your company preparing yourself to face that future?

- [Probe if no] Why do you think it is less probable?

## [T+40 min - PHASE 5 - Conclusion]

Great, this interview is now over, and it was very insightful. Thank you again for your participation in this study, and I hope it was also interesting for you. I repeat that it is

confidential and any quotes I will use based on my notes will be anonymised. The only information I will use is the category of the company you're working for.

We can take a few minutes if you want to answer any question you may have on the subject of the interview or the process in itself.

# Appendix B - List of themes and subthemes

Here is the list of related sub themes for each theme defined by the thematic analysis of the interview transcripts.

1. **Focal technologies** - This theme contains quotes from my transcripts related to technological subjects, and in particular the following sub-themes:
    a. Physical constraints (including references to grid & infrastructure, flexibility, resiliency and intermittency)
    b. Distributed generations
    c. Smart devices
    d. Energy Storage
    e. Electric vehicles
    f. Blockchain
2. **Business challenges** - This theme contains quotes from my transcripts related to business subjects, and in particular the following sub-themes:
    a. Electricity market
    b. Entry barriers
    c. Business model
    d. Financial considerations and risks
    e. High capex projects
    f. Customers
    g. Future growth and opportunities
3. **Digital platform** - This theme contains quotes from my transcripts related to digital transformation and platforms, and in particular the following sub-themes:
    a. Software
    b. Role of Data and applications
    c. Building a Platform
    d. Open vs closed platform

4. **Key players** - This theme contains quotes from my transcripts related to the categories of actors interviewed, and in particular the following sub-themes:
    a. Opinions between actors
    b. Competition
    c. Collaboration (including references to *Utilities* investment in startups)
    d. References to *Utilities*
    e. References to *Startups*
    f. References to *Large Tech* companies
    g. References to Oil and Gas companies

**Added theme: Climate change** - This theme contains quotes from my transcripts related directly to climate change and environmental issues. Considering that I decided to add this theme before analysing the data, I did not follow the method of aggregating codes into sub-themes. Therefore, there is no sub-theme for this theme.

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