# NEW ENERGY DELIVERY MODELS FOR COMMUNITIES: HOW UTILITIES CAN TRANSFORM THEIR DELIVERY MODELS TO MEET THE NEEDS OF THEIR STAKEHOLDERS, SHORT AND LONG TERM

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ABSTRACT

Society has done little to modernize energy delivery or take advantage of proven, commonly available technology. In the past, change was driven by regulated entities with an exclusive franchise. Today, however, disruptors come from outside of the power sector – a phenomenon that is changing the grid. The grid of the future will provide an open platform, similar to a state-owned interstate that allows access to all. Generation, storage, and load elements will be self-registering building blocks, similar to the concept of all 'Lego' sets being compatible. Elements will be connected by providers or even consumers, they will self-register, and interact with each other optimizing grid performance with respect to economics, efficiency, adequacy, and reliability. The ubiquitous grid will encompass not only electric, gas, and water, but other services that either we've already come to rely upon or haven't even considered yet. Is this farewell to the grid as we know it? The exclusive franchise model that has been around for more than a century might not be as long lived as expected.

*Keywords: Energy Delivery, Smart City, Smart Grid.*

## 1 INTRODUCTION

In the late 1990's industry pundits defined the moniker 'Smart Grid' to describe an approach to modernize electrical distribution that would transform the way that a utility interacted with its customers in order to provide a higher level of service and reliability, put the customer in control of their energy costs, and to achieve energy conservation and sustainability goals [1, 2]. Loosely defined, the Smart Grid included increased automation from the premise to the utility infrastructure, increased use of distributed renewable generation, a high adoption rate of plug-in electric vehicles that could be used to support the need for energy during critical times, and self-healing mechanisms. While slow to be embraced by the industry, at the height of the US stock market rally of 2007, it appeared as though the industry as a whole would be required to invest in the infrastructure to embark on these changes with dispatch. Coupled with efforts to reduce the impact of 'Climate Change' the interest in the Smart Grid was not limited to North America or Western Europe, many Asian and Middle Eastern utilities also embarked on the Smart Grid journey.

Even a cursory review of energy delivery trends reveals that the Smart Grid may have been leap-frogged even before it has seen widespread implementation and operationalization. Utilities are witnessing a convergence of disruptive consumers, political, and technology trends. Even consumers who enjoy government provided services at a low or subsidized price, have a particular disdain for-profit monopolies or parapublic entities that have what are viewed as taking advantage of a privileged position that they do not understand. As a consequence, with the exception of a select few regulatory jurisdictions, primarily Canada

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ISSN: 2056-3272 (paper format), ISSN: 2056-3280 (online), http://www.witpress.com/journals
DOI: 10.2495/EQ-V3-N2-132-143

and Scandinavia where there is an abundance of low-cost hydropower, there is a particular disdain for the exclusive franchises that have been granted to many utilities. With 'Smart' technology, and ready access to information, consumers have transformed into 'Prosumers' [3]. These prosumers question every aspect of their traditional energy provider, from price to reliability to customer service to operational efficiencies. Needless to say, regulatory bodies that are appointed or elected tend to view their obligations on shorter term horizons than the typical investment cycle of a utility: they tend to take a strategy to appease their constituents, and not necessarily take a long-term position. Hence, there is an environment that is favourable to revolutionary change in energy delivery. The third component enable a potential revolutionary transformation is the availability of technology has migrated from other industry verticals to the energy and utility space. This trend is often referred to as the democratization of the energy business or Utility 2.0 [4]. This new model can be described in the following manner: equitable, flexible, low-carbon, and efficient. While being 'Equitable' addresses the prosumer disdain for monopolies or a lack of options, the other characteristics are enabled by disruptive technology change [5]. Figure 1 presents the elements of democratization of energy.

Unfortunately, utilities as a whole have an aversion to risk or change, this is a function of how they need to behave within their existing regulatory framework: quite frankly many utilities do not have a concept of risk-reward and do not know how to behave in an ultra-competitive environment. Publicly traded are certainly not motivated to openly discuss their fears of a changing model. While every region has its own context, moving forward the change is certain as the technology is already in place.

Whereas in the past, utilities controlled the grid, and what was installed on the grid, the future is very different. As disruptive technologies find themselves within the reach of the broader consumer markets electric utilities find that they need to revolutionize their business models or face extinction. The utilities find themselves with many shackles, ranging from regulatory, to stranded investments, to customers who simply want a choice.

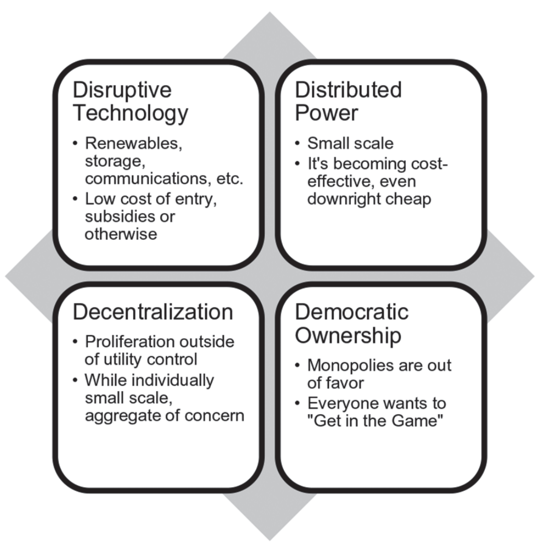


Figure 1: Elements of the democratization of energy.

This paper makes two assertions about the future. First, communities, both formal and informal, will become the key element in the distribution of electrical energy moving forward. Second, utilities and the consumers that they currently supply will have a tenuous transitional period to overcome. This paper will:

- Discuss the future vision for energy delivery.
- Present the disruptive technologies that will impact business models.
- Identify potential transitional states and metamorphic strategies.

## 2 THE VISION

Despite our dependence on electric power, as a society we have done little to modernize energy delivery until relatively recently. Sadly, the advances have not kept up with the values of our society as a whole, or proven, commonly available technology. Whereas in the past change was driven by regulated entities with an exclusive franchise, disruptors will come from outside of the power sector: this is a phenomenon we are already witnessing, with increasing velocity. The grid of the future will provide an open platform, much similar to a state-owned interstate that allows access to all.

Generation, storage, and load elements will be self-registering building blocks, similar to the concept of all 'Lego' sets being compatible. Elements will be connected by providers or even consumers, they will self-register, and interact with each other optimizing grid performance with respect to economics, efficiency, adequacy, sufficiency of supply, and reliability. The ubiquitous grid will encompass not only electric, gas, and water, but as well other services that we've already come to rely upon or haven't even considered yet. In fact, every prosumer may become involved in energy arbitrage as they are able to generate, store, and sell electric power based on automated algorithms. How real is this vision? Consider that most of these components are commonly available or the concepts are in use in other sectors and applications. This is very real and likely within all of our lifetimes. Is this farewell to the grid as we know it? A pragmatist may say we are in a transitional state where not acknowledging and recognizing change will lead to certain obsolescence.

This revolutionary change is similar to what the world has experienced with the advent of crowd-sourced ridesharing. If we use Uber and Lyft as a specific example, they have rapidly gained 55% market share from taxi companies in North America for business travel. It is commonly acknowledged these ridesharing companies were able to quickly this momentum so quickly because they offer convenience, comfort, cleanliness, price, and equality. These are similar to the elements identified in Fig. 1: the utility business is clearly staged to witness a similar transformation. This vision is well documented, and there have already been several attempts at subsidized experiments or pilots [6, 7].

While the industry is still defining the relationships, components, and economics of Utility 2.0, it is widely accepted that in order to prepare for the future, it is necessary to understand, simulate, and model the future. Similar to the ridesharing revolution, an efficient, tightly integrated technology suite that is cost-justified and reliable is a prerequisite to change. Figure 2 presents a view of the traditional, and prevailing utility model, as well as, the likely 'To-Be' or aspirational model. Figure 2 offers insight into how the technology elements are integrated to enable this potential change. Figure 2 also contemplates value-added, potentially non-regulated services and products into the utility's portfolio. Without a solid technology foundation, future extensibility towards the Utility 2.0 model will be limited. Curiously, this Utility 2.0 vision can be enabled by many of the technology platforms currently in place at utilities.

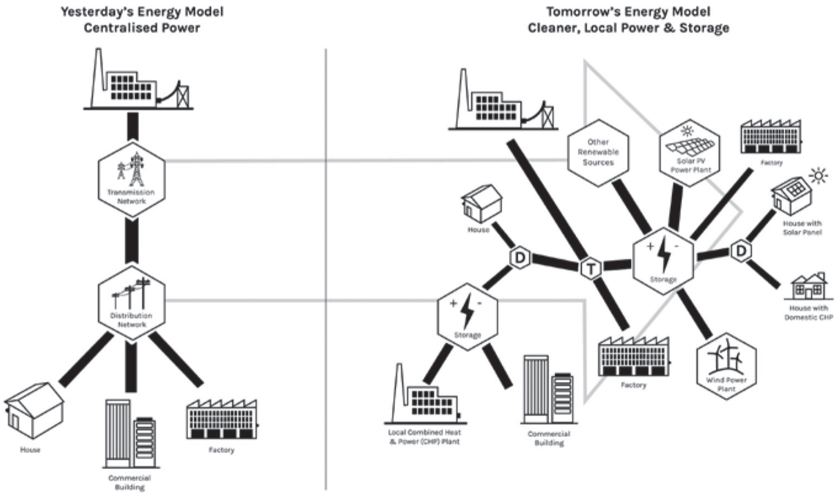


Figure 2: Commonly accepted vision of the future.

From a business perspective, there are many additional factors driving this trend:

- Customer empowerment, e.g. technology that enables a customer behaviour change, in particular 'Smart' technology;
- Energy independence and affordability;
- Energy reliability, security and efficiency;
- Economic development and job security;
- Environmental concerns and impact of climate change;
- Monetization of customer data;
- A thirst to going behind the meter and realize the financial benefits that cellular companies have through data plans;
- Grid optimization and management, e.g. reduction of technical and non-technical losses, improved reliability.

The legacy context does however face challenges:

- Aging infrastructure;
- Renewable and storage integration;
- New market opportunities;
- Domestic resource development;
- Improved asset utilization.

Figure 2 highlights the fact that while we have long had an appetite for democratization of energy, the enabling technology has not been available at a cost that allows the vision to be realized. The ubiquitous presence of relatively low-cost, high latency, low bandwidth, wide area wireless communications has provided a platform to integrate edge computing which places intelligence in the hands of the prosumer. This is key because as a society we take energy for granted, and do not want to find ourselves in a position where we actively need to manage our energy consumption, e.g. we want our energy consumption to be optimized for us, and we do not trust our current providers. With the future state being clearly defined, we will discuss the disruptive technology in order to appreciate the transitional states for the utilities.

## 3 DISRUPTIVE TECHNOLOGY

With the future state being enabled by technology, it is important to understand the disruptive technology trends. Traditionally, energy distribution companies have relied on seven core systems We refer to these as the Fundamental Technology Layer: they are central to most modern utilities and required prior to the implementation of many advanced technologies. These seven Fundamental Technology Layer components are [8]:

- Customer Information System (CIS);
- Geographic Information System (GIS) and graphical design;
- Work Management System (WMS);
- Computerized Maintenance Management System (CMMS);
- Advanced Distribution Management System (ADMS);
- Advanced Metering Infrastructures (AMI), including meter data management (MDM);
- Distribution Automation (DA)/SCADA.

It is interesting to note that these Fundamental Technology Layer components are largely supporting inward facing functions for the utility, e.g. they do not enable the democratization that we identified a need for in the Vision or Utility 2.0. In fact, Fig. 2 does not explicitly call out these components. This is a significant change for a utility, e.g. they are no longer in control of their own grid.

When considering the future state of utilities, the first consideration is an architecture that is very similar to that of an industrial Internet of Things (IoT). Some describe this architecture as Fog Computing. Figure 3 identifies the premise of Fog Computing as a multi-tier architecture. In Fig. 3, data intensive applications and sensors make decisions at the lowest level of interaction with the consumer and distributed energy resources. These devices can be described as 'Smart' in that they manage human and device interaction with storage,

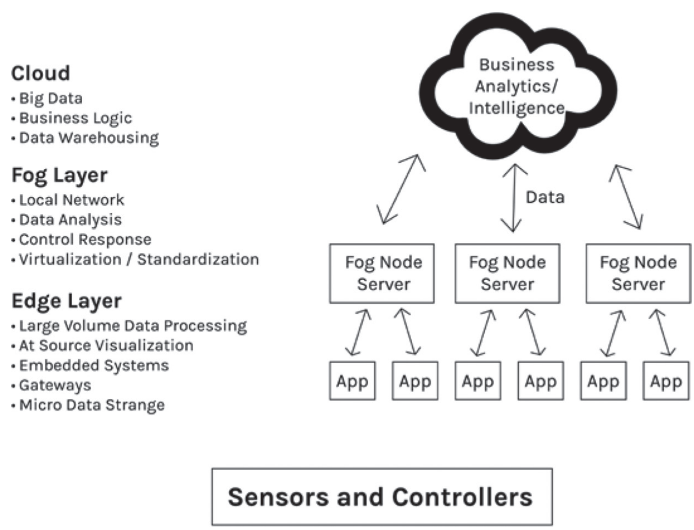


Figure 3: Fog-computing.

generation, and the grid: this is a completely decentralized model. The Fog layer represents substation, medium and high voltage level control and optimization. This is the layer where many of the decisions will be made through machine learning algorithms that balance reliability, energy efficiency and energy arbitrage. The Cloud layer represents a system wide view of grid as a whole. Over time, this layer will occupy the role of an automated air traffic controller, integrating self-subscribing generators and consumers of energy. This is all enabled by the low cost of data storage, and the presence of a wireless communications infrastructure. We anticipate seeing more interaction between electric, water and wastewater, and gas commodities in this scheme, as well as, other smart or sustainable city sensors and infrastructure. The presence of this architecture is the first disruptive technology element. By all regards, this architecture is considered the decentralization and digitization of the grid. By decentralization, we imply:

- The handling of decentralized assets will change and utilities will need to share assets with other companies and public entities to develop joint projects with different players.
- The scale changes as does workforce qualifications and the revenue structure.
- New entrants will likely fragment market and offer low, initial strategic pricing. This will set expectations for future pricing.

By digitalization, we imply:

- Energy systems in the future may be able to identify who needs energy and deliver it at the right time, in the right place and at the lowest cost. But getting everything right will not be easy.
- Safety, productivity, accessibility and sustainability of energy systems are inherently being improved. Digitalization is also raising new security and privacy risks. It is also changing markets, businesses and employment. New business models are emerging, while some century-old models may be on their way out.
- Policy makers, business executives and other stakeholders increasingly face new and complex decisions, often with incomplete or imperfect information.
- Adding to this challenge is the extremely dynamic nature of energy systems and fast pace of technology change which is diametrically opposed to our existing model, which is built on large, long-lived physical infrastructure and assets.

The other technology elements that are considered disruptive at the present time include [9]:

- Distributed and Community Renewables;
- Electric Vehicle's;
- LED lighting;
- Energy efficiency;
- Storage;
- Big data and Predictive Analytics;
- Machine learning leading to automated system response;
- Transactive energy.

There are numerous perspectives of which of these disruptors plays the greatest influence of the change we're witnessing, it is likely the alignment of these in conjunction with prosumer and political trends that will lead to this change and impact the timing.

### 3.1 Distributed and community renewables

The energy supply is diversified, and the increasing efficiency of renewables is driving many independent power producers to feed electricity into the grid. More and diverse power of various qualities, with different environmental impacts, is produced. No power source is comparable to another, and every power source has to be treated in a very special and proprietary way. The grid cannot match demand and is far more difficult to control as it has many of bidirectional players. Grid operators are split between efficiency, low costs and accepting various inputs from very diverse players, ranging from nuclear power plants to solar panels. The share of renewable energy is growing and will soon reach 30–40% of total energy production. These intermittent sources have their own industry-specific challenges. The diversity of renewable energy is increasing, and almost every source has different technical characteristics and uses new technologies which have to be quickly understood by utilities.

Monitoring new entrants and their business models in order to develop defence strategies or/and strategies to prevent the effects of disruptive innovations. The future utility market will abound in disruptive innovations. Utilities will be crucially faced with the continuous improvement of its algorithms, business models and dealing with rapid change. Defining and shaping a more customer-centric approach and experimenting with new approaches to developing a customer base will be a defining factor for competing utilities. Today, small scale distributed generation is compact, efficient, reliable, and affordable. As the technology continues to evolve, it becomes even more attractive and disruptive.

### 3.2 Electric vehicles

Simply stated, EV's have the potential to be 'better' vehicles. Range, battery life, and cost are constantly being improved upon, while price is falling dramatically. Widespread adaption will tax the existing grids from the perspective of capacity, topology, and coordination. At a local energy level, there will be an opportunity for using EV batteries as grid storage (V2G). All of these factors promote further decentralization of the grid, and a loss of control on the part of the utility.

### 3.3 LED lighting

Lighting accounts for almost 15 percent of US electricity demand. LEDs, which rely on semiconductors, benefit from rates of improvement dictated by Moore's Law. Software increases the value in LEDs by adjusting their energy use based on needed lighting levels. For example, a 100-lumen LED bulb cost $20 in 2011, down from $50 in 2009. The price dropped to between $8 and $10 for a 170-lumen bulb by 2015, which would render incandescent and compact-fluorescent bulbs obsolete. LED lighting currently accounts for approximately 30 percent in 2015 and 80 percent by 2020. Global consumers saved more than $50 billion annually to 2015 and more than $100 billion annually by 2020, which could enable a 1.5 percent decline in US electricity demand per year, the equivalent of more than 30 base-load power plants. Increasing the adoption of LED lighting will lead to erosion of utility margins.

### 3.4 Energy efficiency

Simply stated, both residential and commercial and industrial facilities are becoming very efficient. Electrical consumption per capita is falling for the first time in history. More efficient electrical energy usage, improved devices with less energy consumption are impacting industrial and residential consumption. For example, in 2011, Nest introduced its self-learning Wi-Fi enabled and remotely controlled thermostat that saves energy. By early 2018, Nest was allegedly selling 100,000 thermostats per month, and sales are forecasted to increase. Energy efficiency technologies will go beyond thermostats to all household appliances and electronics. These efficiencies make local generation and storage more realistic, with the potential for complete disconnection from the grid or community level energy.

### 3.5 Storage

The availability of storage was long viewed as the catalyst for making renewable energy work on a large scale. Today, materials technology has evolved considerably, many of the advances due to lessons learned from EV development: the materials technology today may in fact have the biggest impact on the grid overall. The batteries available are smaller, have a larger capacity, support a high number of charge and discharge cycles, and are available at a more reasonable price point, in particular when coupled with financing. When used in conjunction with distributed renewables, storage can be used to improve reliability, optimize system performance, and conduct energy arbitrage, or a combination of all of these. Currently the industry is overcoming the challenging of optimizing at the level of the grid as a whole.

### 3.6 Big data and predictive analytics

Society has learned many lessons in the value of data from companies such as Alphabet, Facebook, Amazon, etc. Utilities have largely ignored these lessons. As more third-party suppliers enter the home, e.g. alarm companies, and offer additional products and services, including energy management, the utilities monopoly will erode rapidly. While many utilities currently employ data scientists, they largely seek to optimize system operations or asset performance. The real opportunity is for utilities to venture behind the meter, an area that they aren't well equipped to venture to. In the ecosystem identified in Fig. 2, data will be by far the utilities' greatest asset. The traditional utilities competitor will be expert at mining data with the view of monetizing the information.

### 3.7 Machine learning leading to automated system response

Credited to Arthur Samuel in 1959 Machine Learning is a concept that espouses rather than teaching computers everything they need to know about the world and how to carry out tasks, it might be possible to teach them to learn for themselves [10]. Based on a system of probability, e.g. the data fed to it, a computer is able to make statements, decisions or predictions with a degree of certainty. The addition of a feedback loop enables 'learning' by sensing or being told whether its decisions are right or wrong, it modifies the approach it takes in the future. In the new paradigm identified in Fig. 2, Machine Learning enables automated system response, removing the need for a distribution or system operator and allowing an increasingly complex environment with more components acting independently. In fact, automated system response has demonstrated its competency in automotive and defense applications already. This effectively becomes the 'Smart' aspect of consumer applications, such as Nest

Thermostats or Rachio sprinkler controllers. Many utilities still struggle with the concept of auto-dispatch where a crew is dispatched to work without human intervention. As the number of points and devices to manage in the IoT increases, human control will no longer be possible, further reducing the utility's value proposition.

### 3.8 Transactive energy

The Transactive Energy Association defines transactive energy as: 'Transactive Energy engages customers and suppliers as participants in decentralized markets for energy transactions.' [10, 11]. Brooklyn Microgrid, for example, is a peer-to-peer marketplace for excess energy, where residents can harness excess energy and sell it to other tenants in the building or to neighbors across the street utilizing blockchain ledger technology [7]. As well, in Australia, a blockchain-based peer-to-peer energy trading platform enables consumers and businesses to sell their surplus solar power to their neighbors without an intermediary. As the case studies of these Transactive Energy continues to grow, coupled with the more accessible renewables, storage, and the Fog computing platform, the elements for fundamentally changing the utility business model are ever present.

### 3.9 Alignment of context and technology

With the favourable environment, and technology elements readily available, the natural tendency of the free market structure will drive us towards the revolutionization of energy delivery. The momentum is driving the change to the local or community level. Innovative market design will drive the following fundamental changes:

- Utilities will transform from commodity vendor to service provider.
- The diversification of regulatory risk will present a serious challenge to all energy delivery asset owners as they are less able to sell commodity and recover their investment.
- Politics will become more populist, less rational, a less utility-friendly approach may be taken by governments and authorities.
- The new breed of global utility managers will have to cope with fresh demands from local and national governments and to learn to react to 'meddling' politicians.
- While currently, utilities act independently, moving forward they will need to interact with other utilities, and service providers.
- More non-utility companies will enter the market and provide various service alliances between telecommunication companies, software companies and utilities.
- Reversing classic utility inertia in deploying new technologies and new assets based on bottom-up approaches, while focusing on today's unpredictable and unstable regulatory environment.

An example of this change that has already take place is in Germany. The German electricity market, with its 590 billion euros sales revenue, is the biggest in Europe. The Big Four Utilities, RWE, E.ON, Waterfall and EnBW, currently amount for 74% of the market. However, their share is sharply declining, some 1.5 million corporations and individuals produce energy, with the number ever increasing. For a utility in a regulated environment reduction of top line sales of 5–10%, while retaining an obligation to maintain infrastructure is not economically viable long term.

## 4 TRANSITIONAL STATES

While the current state of utilities is well understood, and there are a plethora or articles about the final state as depicted in our interpretation of Fig. 2, there is little consideration for the potential uncertainty created during the transitional state. Figure 4 depicts the belief that as the disruptive technology becomes more accessible and the socio-economic becomes more favourable to the democratization of energy, we will tend towards a movement from today's utility model to that of the target of Fig. 2. It is important to note that we define Technology Accessibility to include all of the following aspects of the Disruptive Technologies identified in Section 3: physical size or form factor, life expectancy, reliability, ease of use (e.g. is it 'Smart'), availability of installers and service providers, financing schemes, cost of energy and total cost of ownership. The mass market appeal of these technologies will attract a large number of product and service providers, all hoping to gain sufficient market share for a roll-up event: this is consistent with the market behaviour we have seen to date. The further detail of the transitional state which is between these is further described in Fig. 5.

Within Fig. 5, we display the fact that assuming that the current socio-economic trends continue, as the price of Disruptive Technologies decrease, the utility top-line revenue, and margin will erode which will turn the utility business model upside down. As the cost of the Disruptive Technologies approaches the cost of service offered by the utility, an inflection will occur which promotes wider scale adoption of the Disruptive Technologies to the utility's detriment. Simply stated, the utilities will not be able to maintain their distribution and services as their margin is eroded. Some studies indicate that consumers will pay up to a 20% premium to gain control of their own energy needs and eliminate their reliance on a monopolistic utility. The primary technologies that will need to be in place to enable the transformation of Fig. 5 are the platform identified in Fig. 3, small scale renewable energy generation and storage, and smart controls to assist in the autonomous management of the system as a whole.

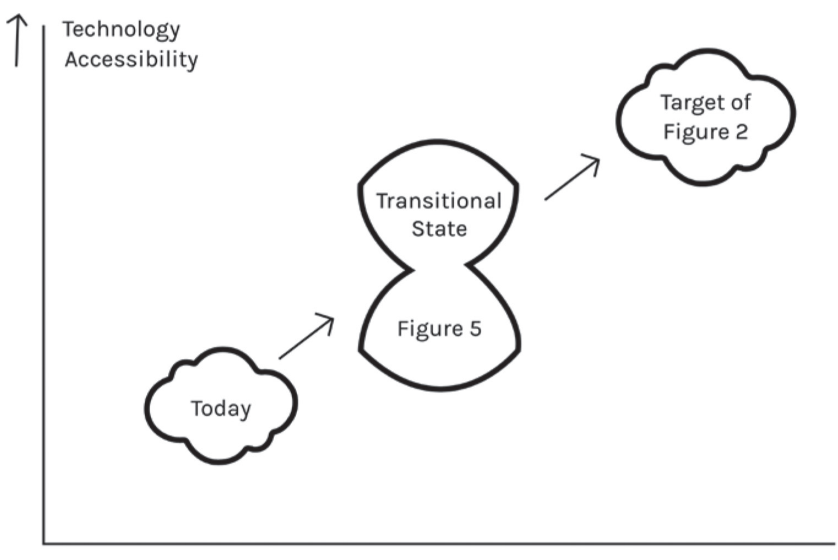


Figure 4: Accessibility and socio-economic pressures.

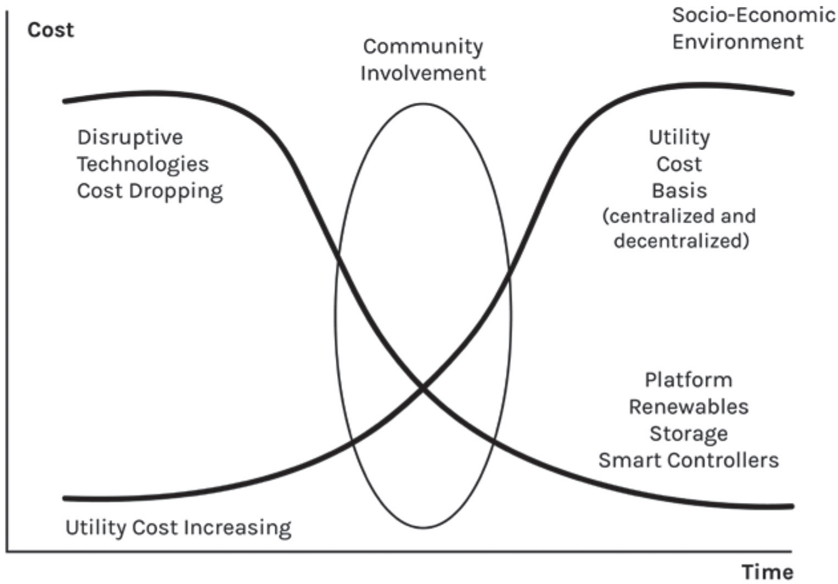


Figure 5: The tipping point to attain the transitional state.

It is during this Transitional period that communities will be forced to assume responsibility for the Fig. 3 platform that enables both communication and delivery of energy. While some utilities and associated organizations espouse their ability to provide this platform, there are many reasons why they simply aren't suited or welcome in this role. Utilities are not suited primarily because telecommunications providers already have higher speed wireless or RF networks already in place, and because of the disdain and lack of trust for utilities that is almost omnipresent. This will likely be similar model to broadband companies offering subscribers Wi-Fi routers as public hotspots. The question that will need to be answered is how utilities may be compensated, or if they are compensated, for their assets should they decide to exit a particular service area. Larger utilities with a diversified service territory will find that certain portions of their service territory will be susceptible to this change sooner than others. A public private partnership model may be of interest in these situations. The following factors can be viewed as accelerants to getting to this inflection point:

- A rapid increase in the price of oil or carbon-based fuels, e.g. 100USD/BBL.
- Advent of further disruptive technology, e.g. innovation from Asia.
- Further disruptive technology price deterioration.
- Increase in cost of maintaining utility infrastructure, e.g. aging assets.

Inhibitors to this trend include:

- Rapid change in utility behaviour vis-à-vis consumers and distributed energy resources, e.g. they become market makers and anticipate changes.
- Regulatory measures that identify decentralization as a potential national security issue.
- Global economic slow-down that removes incentive for change.
- Protectionist tariffs that prevent the entry of lower cost hardware and innovation from low cost countries.

## 5 CONCLUSION

Even though we do not understand how the disruptive technologies will align with a market demand to change the utility business model, it is apparent that the crowd sourcing schemes we have seen successful in many industry verticals will place a significant impact on utilities. All of these changes favour community energy, be it formal communities with some political definition or informal communities that represent an aggregate of consumers who buy and sell energy from each other, through third parties. In our forward-looking view, we see the introduction of a self-healing grid or potentially no grid at all. In this model, utilities no longer have a monopoly on energy delivery or even the wires. In this state, the monopoly is redefined.

While the end-goal or vision as identified in Fig. 2 may represent a utopia, the transitional state will be or primary concern to utilities, their shareholders, and in fact consumers overall. In the transitional state, we will see erosion of gross revenues at the utility. Unfortunately, the associated erosion of net income will disproportionately biased towards those defectors. Typically, the defectors represent the largest and most lucrative loads for the utilities, and of course the greatest source of revenue. In many cases, these defectors also have the greatest apathy for any form of monopoly, e.g. regulated business, which they believe has taken advantage of them over decades. This transition is likely to be accelerated in developing countries where reliability is low and cost is high. This transformational state is where community or public private partnerships will be necessary to take consumers successfully through the transition.

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