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Creative Destruction and the Natural Monopoly 'Death Spiral': Can Electricity Distribution Utilities Survive the Incumbent's Curse?

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Abstract

The study examines how disruptive technological innovations are likely to impact electricity distribution network utilities and identifies several factors that threaten to inhibit incumbent efforts to adapt and survive. Unlike previous studies of incumbents in competitive markets, this qualitative multi-case study examines 18 electricity distribution network utilities who operate as regulated monopolies. Three important findings emerged from the study: firstly, that disruptive technologies in distributed electricity generation and storage are likely to trigger the creative destruction of existing natural monopolies and render incumbent business models unsustainable. Secondly, the task of adapting to disruptive technologies is made more challenging by the additional requirement to simultaneously transition from a monopolistic to competitive marketplace. Thirdly, incumbents face the risk of inertia and paralysis due to a broad range of rigidities and inhibitors which threaten to undermine their efforts to adapt, survive and avoid succumbing to a death spiral scenario.

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Abstract

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Keywords:

Creative destruction, disruptive innovation, monopoly, rigidities.

Introduction

We know from the works of Schumpeter (1950), Christensen (1997) and others that 'creative destruction' is an ongoing cycle of innovation and renewal and that disruptive technological innovation can lead to firms and industries being substantially reshaped or eliminated entirely. Drucker (1994 p.xv) argues that "in periods of rapid change the best - perhaps the only - way a business can hope to prosper, if not survive, is to innovate. This is the only way to convert change into opportunities.". However, we know from the literature (Henderson & Clarke, 1990; Henderson, 2006; Tushman & Anderson, 1986; Utterback, 1994; Christensen & Bower, 1996; van Moorsel et al, 2012) that incumbent firms often find it difficult to respond to disruptive technological innovation for a variety of reasons and this phenomenon is sometimes referred to as the 'incumbent's curse' (Chandy & Tellis, 2000) or 'innovator's dilemma' (Christensen, 1997). Nevertheless, we also know from the literature that whilst some incumbents decline and die, there are numerous examples of firms that have adapted and prospered in the face of disruptive technologies and change (O'Reilly & Tushman, 2008). One such example is IBM who successfully transitioned from the manufacture of mainframe computers through the era of PCs and is now predominately a provider of technology services (Hill & Rothaermel 2003; Ansari & Krop, 2012).

Electricity distribution network utilities in developed nations are currently facing significant challenges as the industry undergoes a substantial transformation. This upheaval is being driven by a range of global factors including the move to low-carbon energy systems, changing electricity usage patterns, government energy and environment policies and significant disruptive technological advances in distributed renewable electricity generation and delivery technologies. With the value of electricity distribution networks generally measured in the tens of billions of pounds, and electricity being an essential service in a modern energy dependant world, the question of whether incumbent electricity distribution network utilities survive or perish in light of these developments is of great significance, not only for the firms themselves, but also for governments, consumers, business, industry and society in general. In fact, Schumpeter (1950) himself, recognises the potential implications of such an event, stating "there is certainly no point in trying to conserve obsolescent industries indefinitely; but there is a point in trying to avoid their coming down with a crash and in attempting to turn a rout into an *orderly retreat"* (Schumpeter 1950, p. 90).

Drawing upon theoretical concepts from a detailed review of the broader literature, the broad aim of the study was to examine how incumbent firms respond to the emergence of disruptive technologies and avoid 'the incumbents curse' (Chandy & Tellis, 2000). In specific terms, this is reflected in the following two research questions:

Research Question 1:

What are the potential impacts on electricity distribution network utilities from emerging disruptive technological innovations?

Research Question 2:

What factors are likely to be influential in determining whether incumbent firm efforts to adapt and survive are successful?

A qualitative multi-case study approach was used and data was primarily collected through 46 semi-structured interviews, supplemented by a review of relevant participant archival documents and publically available information. Data was analysed and emerging themes categorised using a Technology, Markets, Organisational Capabilities (TMO) framework to examine the interplay between technological developments, evolving market structures and organisation capabilities of study participants (Hajek, Ventresca, Scriven & Castro, 2011).

The study found that disruptive innovations (Christensen, 1997) in distributed electricity generation and storage technologies are likely to continue to develop and improve in accordance with S-curves theory (Foster, 1986; Chandy & Tellis, 1998) and the cyclical model of technological change (Anderson & Tushman, 1991; Tushman & Rosenkopf, 1992). This will eventually lead to 'grid parity' which is the equilibrium point at which electricity prices for consumers from renewable generation sources are equal to electricity sourced from the traditional electricity network (i.e 'the grid') (Simshauser & Nelson, 2012). Estimates of when 'grid parity' will occur vary but most estimates range from 3 to 10 years. At the point of 'grid parity', barriers to entry will be low and competition is likely to intensify as further new entrants emerge (Porter, 1985). This may trigger a migration of consumers away from traditional incumbent utilities to competitors who offer new and improved 'off grid' electricity technologies. This migration will lead to further electricity price rises by incumbents to reallocate a greater portion of the fixed costs to those consumers who remain. This in-turn will lead to further consumer losses and price increases, in what is referred to as the 'death spiral scenario' (Severance, 2011; Simshauser & Nelson, 2012).

Consistent with Schumpeter's (1950) process of 'creative destruction', it is likely the traditional business model of electricity distribution utilities will prove unsustainable once competition intensifies. Incumbent utilities will need to undergo significant transformation to survive the paradigm shift in how electricity is generated and delivered. The task of simultaneously adapting to the disruptive technologies whilst also transitioning to a competitive market has increased the complexity and difficulty of the challenge, particularly for the publically owned utilities who have historically and culturally viewed themselves more as an essential public service rather than a commercial profit motivated business. Furthermore, many incumbent firms face a range of core rigidities and inhibitors which, in combination, threaten to undermine their efforts to adapt and survive. The factors, to be discussed in more detail later in the report, include the lack of incentives to innovate, structural inertia, capability and knowledge gaps, bias towards exploitative over exploration, myopic learning, poor absorptive capacity, internal politics and turf wars, resource and path dependence, management commitment, risk tolerance, managerial cognitive biases, unsustainable business models, limited customer facing capabilities, public ownership impacts, organisation culture, resource allocation processes and a lack of R&D.

Research on this topic is important for several reasons. Firstly, the manner in which incumbents respond to disruptive technologies will determine the shape of the industry and whether firms adapt and survive or decline and die. Secondly, with the size and importance of the electricity industry, the premature decline and death of one or more incumbent firms would have significant ramifications. Thirdly, unlike previous studies which have focused on incumbents in competitive markets, this study involves incumbents who have historically operated as regulated monopolies, without direct competition. Fourthly, the level of industry participation and access to key management in this study is extremely rare and provides a unique opportunity to study this phenomenon. Finally, the study outcomes will assist electricity distribution utilities to better understand the underlying challenges they must overcome in order to adapt and survive the changing industry and competitive landscape.

Theoretical Background

Relationship between Market Structure and Innovation:

Schumpeter (1950) argues that capitalism can only be understood as an evolutionary process of continuous innovation and 'creative destruction' in which new technologies replace the old. In Schumpeter's view, disruptive innovations create major disruptive changes, whereas incremental innovations continuously advance the process of change through variations in existing routines and practices (Damanpour, 1991; Crossan & Apaydin, 2010). Early in his career, Schumpeter (1939) stressed that small entrepreneurial firms were likely to be the sources of innovation. However, he later claimed that large established firms with some degree of monopoly power were likely to be the drivers behind innovation (Schumpeter, 1950). Hill and Rothaermel (2003) provide an explanation for the evolution of Schumpeter's view by suggesting that incumbents are incentivised towards incremental innovations, whereas entrepreneurial new entrants will are incentivised to pursue pioneer radical innovations. Scholars generally agree that organisations need to undertake both incremental and disruptive innovation (Christensen & Raynor, 2003; Terziovski, 2002).

There are competing views regarding the effect of market structure on the innovation performance of firms (Damanpour, 2010). Schumpeter's (1950) later works suggesting that large firms with some degree of monopoly power have a stronger incentive to innovate because they can more easily appropriate returns from innovation efforts. The idea that monopoly stimulates innovation is challenged by Arrow (1962), who argued that organisational inertia, reinforced by the absence of competitive pressures, would dull the incentives for large firms to innovate. Other scholars share this view and argue that monopoly power reduces pressure to search for new and improved solutions, and often leads to complacency toward technological innovation (Scherer, 1980; Dean, Brown & Bamford, 1998; Baldwin, Hanel & Sabourin, 2002). Potts and Kastelle (2010) suggest the incentive to innovate is a very weak force in the context where organisations are not subject to competition, such as a monopoly.

Whilst no clear consensus exists on the question of whether the incentives to innovation are stronger in competitive or non-competitive markets, there does seem to be agreement among scholars that firms in less competitive markets have greater incentives to invest in process rather than product innovations because the benefits from product innovations depend less on the firm's monopoly power than do the returns from process innovation (Cohen & Klepper, 1996). A firm that already dominates its market or is a monopoly has little to gain from introducing new products, whereas process innovation may result in cost savings that increase profits (Scherer, 1983). Similarly, Damanpour (2010) suggests market competition is more positively associated with product than process innovation, whereas the opposite is the case in concentrated or monopoly markets. Product innovations are pursued to satisfy customer demand or to capture new markets, whereas process innovations are pursued with a view to reducing operating costs (Utterback & Abernathy, 1975; Martinez-Ros, 2000; Bessant, Lamming, Noke & Phillips, 2005; Damanpour, 2010).

Theory of Disruptive Innovation:

'Incremental' innovations allow organisations to maintain a competitive edge, improve margins, fix deficiencies or respond to changes in the operating environment (Vyas, 2005). Incremental innovation practices are adequate for equilibrium conditions or non-complex environments, but they are insufficient in highly unpredictable environments (Christensen, 1997). In contrast, disruptive innovation can lead to capability changes of the firm and create

a new operating paradigm that is more long term and strategically focused than incremental innovation (Christensen & Raynor, 2003; Shinn, 2005). Christensen (1997) states that periodically a disruptive event occurs that changes markets and industries and can have a destabilising effect on established firms who tend to do well when faced with incremental innovation but may have difficulties when confronted by radical change. In describing his theory of disruptive innovation, Christensen (1997) states that disruptive technologies cause problems for incumbent firms because the new products do not initially satisfy the demands of even the high low of the market. Because of that, incumbents often choose to overlook disruptive technologies until they become more attractive from a profit perspective. Christensen (1997) states that disruptive technologies eventually surpass sustaining technologies in satisfying market demand but with lower costs. The risk is that incumbent firms who do not invest in the disruptive technology earlier will be left behind. This, according to Christensen, is the "Innovator's Dilemma."

Whilst disruptive innovations can create new market opportunities, they can also simultaneously damage, destroy or transform demand in many existing product markets (Hill & Rothaermel, 2003). This can result in capabilities mismatch and business model conflicts that create a serious challenges in formulating viable strategies to deal with the disruptive technological innovation (Christensen, 1997). It is widely acknowledged in the literature that incumbent firms find it difficult to respond to disruptive technological innovation for a variety of reasons (Henderson & Clarke, 1990; Henderson, 2006; Tushman & Anderson, 1986; Utterback, 1994; Christensen & Bower, 1996; van Moorsel et al, 2012). This issue has been affectionately labelled the 'incumbent's curse' by Chandy and Tellis (2000). Despite this, we know that whilst some incumbents decline and die, others are able to adapt and survive, such as IBM who successfully transitioned from the manufacture of mainframe computers to the era of PCs and beyond. (Hill & Rothaermel 2003; Ansari & Krop, 2012). To better understand the potential impact to incumbents from disruptive technologies, it is useful to first understand how new technologies emerge and evolve.

S-Curve Theory and the Technology Life Cycle:

The theory of S-curves comes from the technology management literature and explains the origin and evolution of radical innovations (Foster 1986; Utterback & Abernathy 1975). This theory suggests that technologies evolve along a series of successive s-curves that drive various new product introductions (Chandy & Tellis 1998). The s-curve emerges because a new technology offers few consumer benefits when first introduced, offers rapidly increasing consumer benefits as it develops, and offers slowly increasing consumer benefits as the technology matures.

Expanding upon the concepts set out by Foster (1986) and earlier works by Utterback and Abernathy (1975), Anderson, Tushman and O'Reilly (1997) published their Cyclical Model of Technological Change in which they divide the technology life cycle into four phases: era of ferment, dominant design selection, era of incremental change and technological discontinuity. The era of ferment consists of two processes, namely the design competition process and the substitution process. The era of ferment concludes with the emergence of a dominant design (i.e. phase 2). The era of incremental innovation sees refinements and improvements to the dominant design, but the underlying technology is retained. This era continues until a new discontinuous technology emerges and starts a new technology cycle (Anderson & Tushman, 1991).

Organisational Ambidexterity:

'Organisational ambidexterity' is the ability of a firm to simultaneously explore and exploit (Tushman & O'Reilly, 1996). Levinthal and March (1993 p.105) state that exploration involves "a pursuit of new knowledge," whereas exploitation involves "the use and development of things already known". March (1991 p.71) defined exploitation as "refinement, choice, production, efficiency, selection, implementation and execution," whereas exploration involves "search, variation, risk-taking, experimentation, play, flexibility, discovery, and innovation". Simultaneous exploration and exploitation is difficult to accomplish and to maintain, because they each require distinctively different organisational designs, different incentives, cultures, structures and leadership styles (Benner & Tushman, 2003). The appropriate balance between exploration and exploitation depends on the organisation's mission, strategies and industry conditions (Lavie & Rosenkopf, 2006; March, 1991). Consequently, changes to strategies or environmental conditions require adjustments to the levels of exploration and exploitation (Auh & Menguc, 2005). Innovation success is achieved by organisations which are able to renew their capabilities over time, in line with market requirements (Teece & Pisano, 1994).

Teece, Pisano and Shuen (1997) define dynamic capabilities as ''the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments''. Dynamic capabilities play an important role in helping organisations to be ambidextrous and to compete simultaneously in both mature and emerging markets. For example, an organization's ability to explore is associated with its absorptive capacity (Cohen & Levinthal, 1990). 'Absorptive capacity' refers to an organization's ability to "recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990: 128). Absorptive capacity enables the organization to operate proactively and explore emerging technologies and market opportunities (Cohen & Levinthal, 1990; Lavie & Rosenkopf, 2006; Rothaermel & Alexandre, 2009). Cohen and Levinthal (1990) suggest that a lack of appropriate absorptive capacity may help ex-plain the inability of incumbents to respond to the discontinuity created by a radical technological innovation (Hill & Rothaermel, 2003).

These concepts are useful in the context of this study as they underpin the idea that long-term success for incumbent electricity utilities requires that they possess not only the operational capabilities and competencies to compete in existing markets, but also the ability to recombine and reconfigure assets and organisational capabilities to adapt to emerging markets and technologies (O'Reilly & Tushman, 2008).

Research Methods

Research Setting:

The electricity industry in Australia, United Kingdom and other developed nations are facing significant challenges as the environments in which they operate are being fundamentally and permanently altered. This upheaval is being driven by a range of global factors including the move to low-carbon energy systems, changing electricity usage patterns, government energy and environment policies and significant disruptive technological advances in distributed renewable electricity generation and delivery technologies. The electricity supply chain traditionally comprises of several components, namely power generation, transmission, distribution and retail supply. Prior to the 1990s the entire electricity supply chain was publically owned, but a period of liberalisation commenced and saw the disaggregation and privatisation of most components. All 7 UK based electricity distribution utilities are privately owned, whereas in Australia only 6 distribution utilities are privately owned, with the remaining 9 publically owned by state and territory governments.

Electricity distribution utilities in Australia, United Kingdom and most of the developed world operate capital intensive networks and incur declining marginal costs as output increases, thus realising economies of scale. This gives rise to a natural monopoly structure. The networks are subject to national regulatory frameworks to manage the risk of monopoly pricing and ensure the reliability, safety and security of the power system. The regulatory framework is administered by a national body, the Australian Energy Regulator (AER) or the Office for Gas and Electricity Markets (Ofgem) in the UK.

Case Method & Case Selection:

A comparative-case based research approach was adopted and provides a stronger foundation for testing a theory than single case studies, because the multiple case study research design allows one to confirm or disconfirm the conceptual insights that emerge (Yin, 2009). Replication logic that treats the cases as a series of experiments, allows one to compare and recognize patterns of relationships and underlying logical arguments both within and across cases. This view is supported by Eisenhardt (1989) who states that flexible multiple data collection alternating with 'within-case' and 'cross-case' analysis allows the researcher to take advantage of emergent themes by looking beyond initial impressions. Comparison with confirming and conflicting literature also build external and internal validity and raise the level of theoretical argumentation (Eisenhardt, 1989).

There are currently 22 electricity distribution network utilities operating in Australia (15) and United Kingdom (7). Eighteen of those are participating in this ongoing doctoral thesis study which is expected to concludes in late 2013. This sample represents 80% of Australian electricity distribution network utilities and 86% of UK utilities, with the combined asset value of participants exceeding exceeds €62 billion (Australia €39.92 billion and UK €22.36 billion) (AER, 2012; Ofgem, 2012). The aim of sampling strategies was not statistical representativeness but rather to identify specific groups who possessed characteristics relevant to the phenomenon being studied (Barbour & Kitzinger, 1999). However, with most utilities eager to participate in the study, the sample is substantial.

Data Collection, Coding & Analysis:

Adopting grounded theory methods for data collection and analysis, theory emerges from a process of comparing and contrasting cases in a recursive manner, while considering the link to extant literature (Glaser & Strauss, 1967; Van Maanen, 1979; Strauss & Corbin, 1990; Miles & Huberman, 1994; Eisenhardt & Graebner, 2007). Data was primarily collected through 46 semi-structured interviews (which were recorded and transcribed, with the permission of the interviewees) and supplemented by the review of relevant participant archival documents (including annual reports, corporate strategy documents, innovation program materials and selected materials that were publically available from the official website of the regulatory bodies (AER & Ofgem). Between 3 and 5 interviews were conducted at each organisation with interviewees being members of senior or middle management with responsibilities for corporate strategy and regulation, human resource management, field operations and network design. This data was analysed using NVivo and emerging themes were categorised using a Technology, Markets, Organisational Capabilities (TMO) framework and allowed a subsequent exploration of the interplay between technological developments, evolving market structures and the organization capabilities of incumbent firms (Hajek, Ventresca, Scriven & Castro, 2011).

Technological Findings & Discussion

This section discusses the existing and emerging technologies within the context of the theories of disruptive innovation (Christensen, 1997), technology s-curves (Foster, 1986; Utterback & Abernathy, 1975), and technology life cycle (Anderson & Tushman, 1991). The enables an informed discussion of the likely evolutionary path for each technology and provides input for the subsequent discussion of market dimensions to follow.

Theory of Disruptive Innovation:

In accordance with Christensen's (1997) theory of disruptive innovation, the global transition to low carbon emissions energy systems has seen changes to government policy and regulation and incentives for new entrants to develop and implement alternative energy technologies based on renewable energy technologies. Investment growth in renewable generating technologies continues to increase year-on-year. In 2010, global investment in renewable energy totalled $243bn, a 30% increase on the 2009 result (Bloomberg 2011). Although the unit price a consumer pays for a kilowatt hour is currently lower if sourced via an existing electricity distribution network, compared to off-grid micro-generation, nevertheless, government subsidies to drive consumer take-up has been significant in increasing rates of diffusion across both Australia and United Kingdom and the take-up rate is expected to escalate steeply from 2015 onward (AEMO, 2012; NationalGrid, 2012).

Christensen (1997) states that disruptive technologies cause problems for incumbent firms because the new products do not initially satisfy the demands of even the high low of the market. Because of that, incumbents often choose to overlook disruptive technologies until they become more attractive from a profit perspective. As shown in Figure 1, existing grid based technologies are indicated by the letter 'A' and disruptive technologies in off-grid electricity generation are indicated by the letter ‘B’. The red line indicates the current point in time and reflects that disruptive technologies have recently reached the point where they meet the needs of the low end consumers.

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Figure 1: Trajectory of ‘Grid’ and ‘Off-Grid’ Electricity Technologies

S-Curve Theory:

The theory of S-curves explains the origin and evolution of disruptive innovations (Foster 1986; Utterback & Abernathy 1975). This theory suggests that technologies evolve along a series of successive S-curves that drive various new product introductions (Chandy & Tellis 1998). The S-curve emerges because a new technology offers few consumer benefits when first introduced, offers rapidly increasing consumer benefits as it develops, and offers slowly increasing consumer benefits as the technology matures. Figure 2 shows the s-curves for the existing ‘grid’ emerging ‘off-grid’ electricity technologies and shows that the existing ‘grid’ technologies (indicated by the letter ‘A’) are in the incremental change phase with considerable emphasis by incumbents on incremental improvements such as smart grids, demand management, remote switching etc. The second s-curve represents the status of ‘off-grid’ generation technologies (indicated by the letter ‘B’) and ‘off-grid’ battery storage technologies (letter ‘C’). By examining the respective s-curves, we see that emerging technologies are likely to improve to the point where they become the dominant design technology and at this point we should see a comparative decline in the fortunes of the existing ‘grid’ based technologies, despite the fact that further incremental improvements to the existing technologies will occur prior to the onset of decline.

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Figure 2: S-Curve for 'Grid' and 'Off-Grid' Electricity Technologies

Essentially, what we are seeing is an old technology paradigm which is in the 'era of incremental innovation', whilst significant investment in distributed renewable electricity generation and battery storage technologies are still in the 'era of ferment'. The emergence of a dominant design will subsequently lead to lower manufacturing and improved efficiency will then follow. 'Grid parity' will inevitably follow and drive a new era of incremental change and innovation. Using these theoretical concepts, we can see how the threat to incumbent utilities from emerging technologies is likely to increase rather than decrease.

Electricity Distribution Network as Large Technical System:

The way electricity networks are engineered and designed has not changed significantly over the last 50 years. They are designed principally around a model whereby bulk electricity is transmitted at high voltage from large power stations, generally located some distance from major cities and end consumers (Smith, 2010). Electricity supply systems are capital intensive, incorporate a broad range of technical components and there is a high degree of interdependence between the various components (Markard & Truffer, 2006). They also characterized by particular technical standards, social norms and organisational practices. Consequently, electricity supply systems are strongly path dependent and innovation is generally incremental rather than disruptive. Scholars suggest considerable barriers, in the form of prevailing standards and technologies, act as deterrents for disruptive innovation to such an extent that a 'lock-in' phenomena exists (David, 1985; Markard & Truffer, 2006).

Within the context of the current study, the technological paradigm which exists within the electricity supply industry (in both Australia and United Kingdom) heavily influences the direction of exploration and search activities by incumbent electricity distribution firms and constrains their level of technological variation within certain boundaries. The prevailing technical paradigms represent a barrier for disruptive technologies to emerge from within these incumbent firms. In other words, large technological systems, such as the electricity supply system, are characterised by a high degree of stability and inertia (Markard & Truffer, 2006).

Market Related Findings & Discussion

Building upon the previous section on the likely evolution of emerging technologies and the eventual decline of existing technologies, this section provide conclusions with respect of the market impacts of these disruptive technologies over time.

Investment Megacycle Driving Pric*e Rises and 'Death Spiral' Risk:*

As stated previously, electricity distribution networks are capital intensive and incur declining marginal costs as output increases (i.e. economies of scale). Electricity distribution utilities are regulated by way of „'revenue equivalence' which mean that if energy demand decreases by 5%, (holding all else constant) then network prices are raised by 5% or are '*rebalanced'* the following year to ensure future annual revenues are maintained against their substantial asset base. Therefore, falling energy demand results in higher tariffs because the industry's heavy fixed costs will be spread across fewer units of output (Simshauser & Nelson, 2012).

Australia and the United Kingdom electricity networks are currently undergoing an investment megacycle which has been a key determinant of recent rises in electricity prices.

Australia also has a problem with 'peak load' which is not such an issue in the UK. Since 2005, peak demand growth in Australia has been running at twice the growth rate of underlying or energy demand (AEMC, 2011). This raises the potential for a 'death spiral scenario', the term used by Severance (2011, p13) who states:

> *"The unspoken fear of all utility managers is the "Death Spiral Scenario". In this* nightmare, a utility commits to build new equipment. However, when electric rates are raised to pay for the new plant, the rate shock moves customers to cut their kWh use. The utility then raises its rates even higher – causing a further spiral as customers cut their use even more... In the final stages of that death spiral, the more affluent customers drastically cut purchases by implementing efficiency and on-site [solar PV] *power, but the poorest customers have been unable to finance such measures..."*

According to Simshauser and Nelson (2012) continuing price rises will lower barriers to entry and attract competition from emerging technologies. Faced with genuine choice for the first time, customers will begin to migrate to new competitors. This loss of customers will mean the traditional utilities will be required to pass a greater portion of fixed costs on to those customers who remain. This leads to more prices rises, and inevitably, more customer losses, in what we now refer to as a 'death spiral' for traditional electricity distribution network operators.

What Severance (2011), Simshauser and Nelson (2012) fail to comprehend in their discussion of the 'death spiral' scenario is that once 'grid parity' is achieved within the next decade (i.e. electricity cost per unit is the same for grid and off-grid sources) then it won't only be the 'more affluent customers' who are able to migrate to off-grid generation, but all consumers will feasibly have this choice. On that basis, it is reasonable to conclude that the 'death spiral' scenario is more likely than first envisioned. Consequently, the question that is central to this debate relates to the rate of diffusion of new technologies or in general terms, what level of revenue losses (i.e. consumer migration to competitors) can be tolerated before the business model, which assumes economies of scale, fails and the 'death spiral' begins? Ironically, new entrants may find that in some geographic markets 'crossing the chasm' (Moore, 2002) is less difficult than envisaged, depending on the pain threshold of utilities.

Underestimating the Market Impacts of New Technologies:

A common theme which emerged through interviews was that participants generally assess the threat from distributed electricity generation in isolation from other technologies. By doing so, people take comfort in the knowledge that renewable generation technologies (Solar, wind) are subject to intermittency, which simply means the sun and wind are not always available. Interviewees generally felt that consumers will always need to be connected to the electricity grid to overcome the intermittency problem. This assumption fails to acknowledge that the threat from distributed generation, in combination with distributed battery storage is far greater than distributed generation alone, as it provides the consumer with greater choice to 'opt out' of the traditional electricity network paradigm entirely. Whilst battery technologies have not progressed the levels required to support such a scenario, billions of dollars of investment is being channelled into R&D, looking at ways to expedite the diffusion of electric vehicles. The lack of battery life is generally regarded as the main barrier to electric vehicle adoption. If we acknowledge that breakthroughs in battery technologies will be achieved at some point in the future, then we can see how this would have spin-off benefits for distributed battery storage in a residential setting.

Organisational Capability Findings & Discussion

I have shown how disruptive technologies in the form of distributed renewable electricity generation and storage will lead to the 'creative destruction' of incumbent natural monopolies and the introduction of competition in electricity supply markets. In this section I will focus on the organisational capabilities that will influence whether incumbent efforts to adapt and survive succeed. The findings suggest electricity distribution network utilities will face a range of significant challenges and survival is by no means certain. Whilst it is difficult to predict how each firm will fair in their efforts to adapt and change during to period of transition, at an industry level it is possible to highlight a suite of common challenges shared by many of the participants. The significance of the challenge is reflected in the words of Terry Effeney, CEO ENERGEX Limited, who states:

> *"The industry is at such a crossroads… in the next 20 years we will see quite a large transformation in the way the energy model evolves… The journey is going* to be an *enormous challenge."*

Despite the extensive literature, no common innovation theory exists and there is no universal solution for improved innovation performance (Tidd, 2001). Hansen and Birkinshaw (2007) suggest that a good starting point for managers need to take an end-to-end view of their innovation efforts to identify areas requiring improvement. The following is a summary of preliminary from the analysis of the initial round of interviews.

Culture constraints on exploration and ambidexterity:

Organisational culture is the 'primary determinant' of innovation according to Ahmed (1998). Culture has a profound effect on innovation within incumbent firms via the value it places on tradition versus change (Hargadon, 2003). Strong cultures such as those which exist within electricity utilities exhibit a cultural bias which favours exploitation and limits the ability to explore, observe and respond to identity-challenging environmental threats (Sorensen, 2002). Utilities have historically been incentivised to incrementally innovate to improve their systems and processes within the boundaries of the existing technological paradigm. The technological discontinuities now require utilities to be ambidextrous and as such rebalance innovation focus toward exploration. Cultural aspects are impeding progress and may require a separate company structure (with its own culture) to achieve what is required.

Risk tolerance:

Studies suggest the willingness to take risks and experiment is a characteristic exhibited by innovative firms (Saleh & Wang, 1993; Thomke, 2001). Hansen and Birkinshaw (2007) suggest that whilst organisations need to have the courage to experiment and to take calculated risks, the key is to fail often, early and at minimal cost. The consensus view of interviewees was that culturally their organisations were extremely risk averse and had no tolerance for failure. One indicative example related to a proposal to fund a portfolio of experimental R&D projects, recognising that while some would fail, the success of others could lead to significant successes. The idea was dropped when executive management stipulated that only experiments guaranteed to returning an NVP in excess of 20% would be funded. Management seems not to have grasped the idea that experimentation implies that results are uncertain.

Competing priorities and time horizons:

Any discussion of corporate strategy must be cognisant of the broader organisational context and industry landscape. In this regard, interviews with key managers indicated the threat from disruptive technologies was only one of many challenges that compete for the time, resources and attention of strategic decision makers. Given the impacts from disruptive technologies were not expected to fall within the immediate time horizon, none of those interviewed saw this as a priority in the short term.

Path dependence:

What an organisation can achieve and where it can go in the future is a function of its current position and the path it has travelled (Teece, Pisano & Shuen 1997). Consequently, when responding to the current changes, incumbent utilities are to some extent held back by their previous investments (in the electricity distribution network) and the existing routines, skills and capabilities which are designed with the current technological paradigm in mind (van Moorsel, et al, 2012).

Public ownership impacts:

Publically owned organisations often exhibit higher levels of beaurocracy than privately owned organisations which can inhibit innovativeness (Damanpour, 1991). Evidence of this was observed during interviews with management from publically owned utilities who recounted stories of government directives and interventions that served the political interests to the detriment of organisation. One example, was the directive that employee remuneration packages not include 'at risk' component to be paid subject to achieving pre-determined performance outcomes. This was in response to negative press critical of the bonus paid to the CEO. The performance incentive bonus scheme had been a crucial tool to incentivise employees and managers in a time of considerable transition and change.

Formal innovation strategy documentation:

An explicit innovation strategy is an importance tool which helps to align innovation goals with the strategic objectives of the firm (Tipping & Zeffren, 1995). Only 3 Australian utilities had developed an innovation strategy document, with 4 others in progress. Very few Australian utilities explicitly referred to innovation as a strategic enabler. In contrast, in the UK Ofgem regulations require utilities develop a strategy and submit an annual report detailing innovation efforts and results. Despite this, only 2 UK based utilities published the document across the broader organisation, preferring to retain it within the innovation unit. UK utilities have generally not sought to embed a culture of innovation more broadly across their organisation.

Organisational politics:

Electricity utilities are characterised by individuals and groups who compete for power and influence and act in ways that reinforce their own importance (March 1991). Major changes in strategy and structure lead to the redistribution of power and influence and trigger political behaviours and turf battles (Hill & Rothaermel, 2003; Van Moorsel et al, 2012). Many examples of such behaviours arose during interviews including, organisational functional silos preventing information exchange and cross functional problem solving. Also, at the time of conducting interviews, industry reviews were underway in 4 Australian states (impacting 7 participant) and there was speculation about possible restructuring, and privatisation. Interviewees indicated this had lead to some degree of inertia as people waited for clarity and direction.

Managerial cognition:

Organisational actors have limited cognitive and memory capabilities to process complex, ambiguous and incomplete information and this leads them to develop filters or mental models which help them to make sense of the environment (March 2006). These filters can also prevent the organisation from detecting emerging technologies and threats (Tripsas & Gavetti 2000). Leonard-Barton (1992) points out that today's core capabilities can become tomorrow's core rigidities, particularly if electricity utilities cling to the old ways of doing things and are reluctant to change. Manager bias toward exploitation may cause electricity utilities to deploy existing competencies persistently at the expense of exploration (Lavie, Stettner & Tushman, 2010). This is an example of how institutionalised capabilities may lead to 'incumbent inertia' in the face of environmental changes.

Resource dependence:

Strategic commitments made by electricity utilities in the past can constrain their ability to respond to disruptive change (Hill & Rothaermel, 2003). Electricity utilities exhibit ‘technological inertia’ because of their previous investments in the electricity network and this raises the issue of asset obsolescence (Ghemawat, 1991). Creative destruction can lead to obsolescence and discarding of capital assets even though their original functionality remains intact (Erumban & Timmer, 2012).

R&D missing-in-action:

Schumpeter (1950) argues that monopoly favours the development of R&D as it provides the necessary cash flow to invest in such activities. However, the regulation regimes in Australia and UK generally incentivise utilities to reduce operating costs and maximise capital expenditure on which their returns are based. Given that R&D is usually accounted for as an operating cost, R&D expenditure by electricity utilities (as a percentage of revenue) has fallen to less than 0.1% in 2003 (Ofgem, 2003). Jamasb and Pollitt (2008) suggest the decline in R&D by distribution utilities is a global trend.

Myopic learning:

Levinthal and March (1993) suggest learning activities often exhibit a bias towards knowledge that has proximity to what is already known (i.e. 'within the same temporal and spatial neighbourhoods'). This can partly explain why organisations prefer 'exploitation of old certainties' over 'exploration of new possibilities' (March 1991). Within the context of electricity utilities this implies that the acquisition of new knowledge and the exploration capabilities of the firms will not come easily to incumbent utilities how have a long tradition and commitment to a particular body of knowledge which will not continue to serve their interests in the longer term.

Open innovation:

According to Chesbrough (2003), a paradigm shift is underway in how companies manage and organise their innovation activities, with firms shifting from a closed to an open innovation model. Many of the electricity utilities interviewed suffered from a 'not made here' mentality which is largely a product of their culture and historical evolution. An 'open' approach to innovation will require utilities to have a porous boundary in order to build networks and absorb external knowledge and capabilities (Hansen, 1999; Chesbrough, 2003). Absorptive capacity consists of the 'capabilities to recognise the value of new information, to assimilate it, and to apply it to commercial ends or to evaluate and utilise outside knowledge'

(Cohen & Levinthal, 1990; Zahra & George, 2002). According to von Hippel (1988) there is a direct relationship between a firm's absorptive capacity and innovation performance.

Lack Customer facing competences:

The task of simultaneously adapting to the disruptive technologies, whilst also transitioning to a competitive market, has increased the complexity and difficulty of the challenge. In particular, electricity distribution network utilities have very limited customer facing staff (other than call centre staff who deal with customer connection and power interrupting issues. There is a complete lack of any sales related personnel and capability within these utilities.

Conclusions

Drawing on the influential literature ranging from disruptive innovation (Christensen, 1997), creative destruction (Schumpeter, 1950), core rigidities (Leonard-Barton, 1992), s-curves (Foster, 1986), Technology Cycles (Utterback & Abernathy, 1975), the 'incumbent's curse' (Chandy & Tellis, 2000) and many other important scholarly contributions the study has sought to undertake an holistic examination of the forces that conspire against incumbent firms as they face the prospect of significant change in response to disruptive technological innovation.. By combining the exploring the key theoretical constructs with the structure provided by a Technology-Markets-Organisation Capability (TMO) Framework I have been able to obtain credible evidence which supports a diagnostic assessment of the risks and challenges facing one of the more significant industry sectors in the world today.

The evidence suggests that disruptive innovations in distributed renewable electricity generation and storage technologies are likely to continue to develop and improve in accordance with S-curves theory (Foster, 1986; Chandy & Tellis, 1998) and the cyclical model of technological change (Anderson & Tushman, 1991; Tushman & Rosenkopf, 1992). This will eventually lead to 'grid parity' where the cost of electricity sourced from these new technologies will be the same as electricity sourced from the traditional electricity distribution grid (Simshauser & Nelson, 2012). This will most likely trigger a migration of consumers away from traditional electricity distribution networks (i.e. incumbents) to competitors. This migration will lead to further electricity price rises by incumbents, to reallocate a greater to portion of the fixed costs to those consumers who remain. This in-turn will lead to further consumer losses and price increases, in what is referred to as the 'death spiral scenario' (Severance, 2011; Simshauser & Nelson, 2012).

Consistent with Schumpeter's (1950) process of 'creative destruction', the scenario described above suggests the traditional business model of electricity distribution network utilities is unsustainable and so incumbents will need to undergo a significant transformation if they are to adapt and survive the paradigm shift in how electricity is generated and delivered to consumers. Despite the challenge, it is apparent that incumbent firms possess many relevant resources and capabilities which provide strategic options to adapt and survive in the new competitive landscape.

The task of simultaneously adapting to the disruptive technologies, whilst also transitioning to a competitive market, has increased the complexity and difficulty of the challenge. Furthermore, many incumbent firms face a range of core rigidities and inhibitors which, in combination, threaten to undermine their efforts to adapt and survive. The factors, to be discussed in more detail later in the report, include the lack of incentives to invest in disruptive innovations, structural inertia, capability and knowledge gaps, organisational routines which favour exploitative rather than exploratory innovation, myopic learning, poor absorptive capacity, internal politics and turf wars, resource dependence, path dependence, senior management commitment, low risk tolerance, managerial cognitive biases, unsustainable business models, limited customer facing capabilities, public ownership impacts, employee engagement, management commitment to innovation, resource allocation processes and little or no historical R&D.

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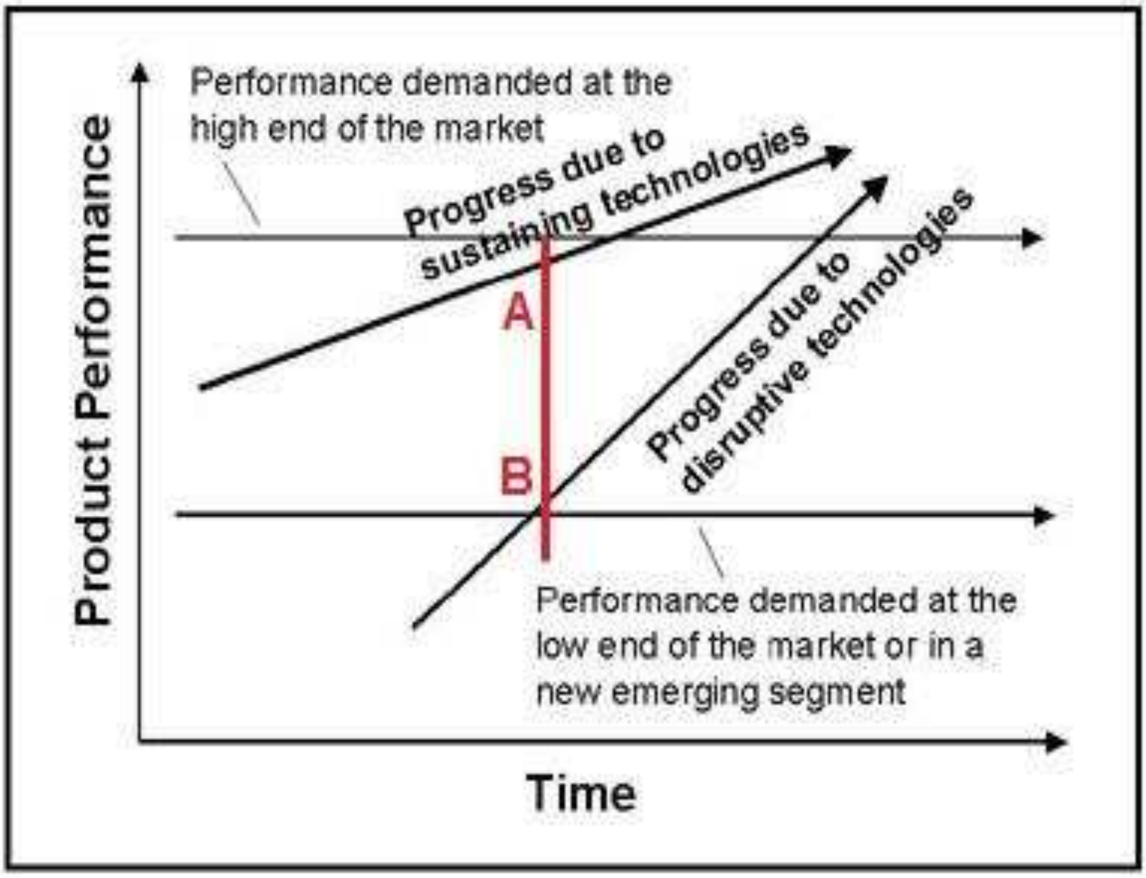
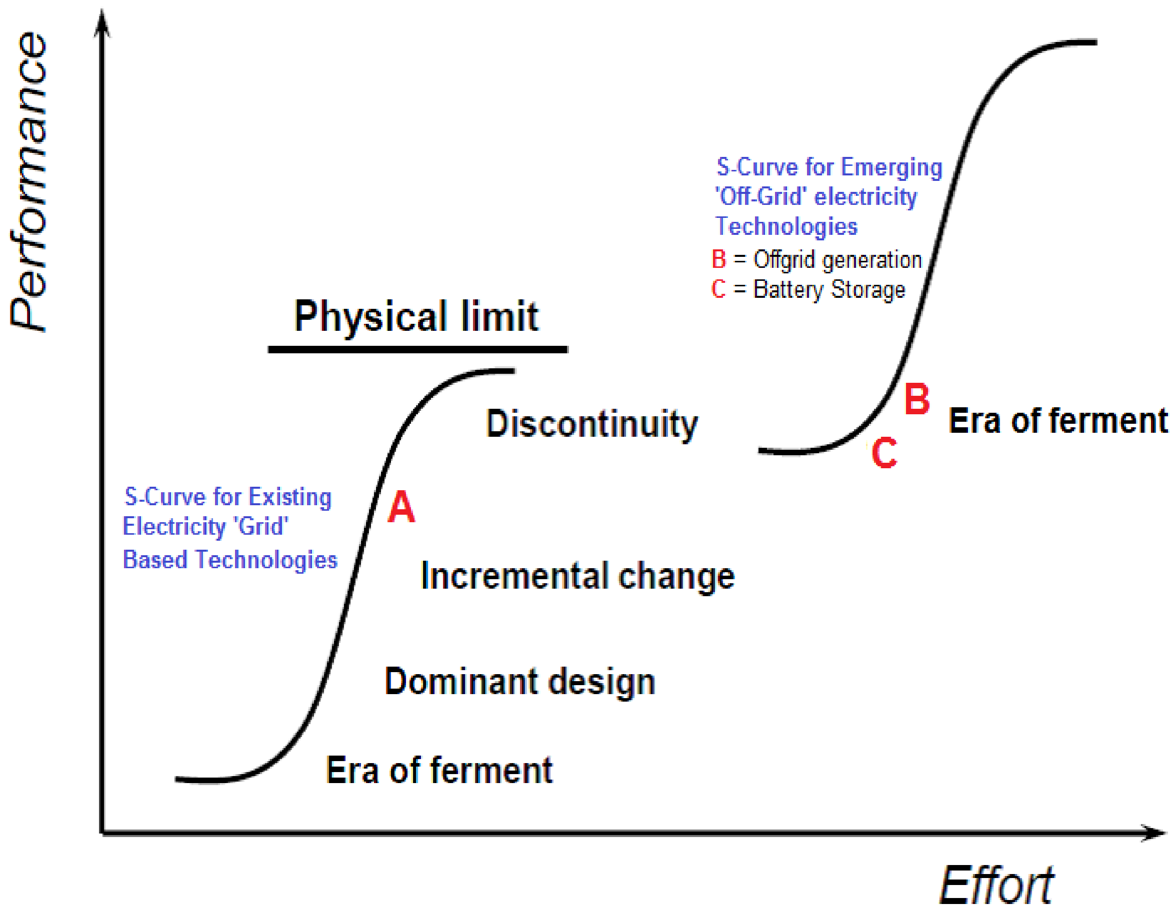
Figures:

Figure 1: Trajectory of 'Grid' and 'Off-Grid' Electricity Technologies



Source: Adapted from Christensen (1997, pp xix)

Figure 2: S-Curve for 'Grid' and 'Off-Grid' Electricity Technologies



Source: Adapted from Foster (1986)