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SURVIVE, THRIVE OR DECLINE?

Organisational characteristics for surviving and thriving a once-in-a-century scale of grid transformation

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"There are two ways to be fooled. One is to believe what isn't true; the other is to refuse to believe what is true."

Soren Kierkegaard

Electric sector exceptionalism?

"It won't happen to us..." The famous last words of every sector before it confronts profound disruption. And the perspective always seems so plausible at the time. Perhaps it is especially tempting in the electric sector for utilities and their regulators. A century of operations in a highly regulated and relatively stable environment can reinforce an 'electric sector exceptionalism' that tacitly informs the sector's way of seeing the world.

It is noteworthy, however, that the global transformation of carbon-intensive energy systems is occurring at a time simultaneously called 'the Disruption Generation' and 'the Age of the Customer'. Recent decades have seen whole industry sectors – and massive, highly capitalised incumbents – flounder or completely disappear. [1] Never before have customers enjoyed more choice, decision-making power and autonomy, empowered by digital technologies, market platforms and business model innovations.

"People don't want to buy a quarter-inch drill. They want a quarter-inch hole!"

Theodore Levitt

The forces impacting every part of the economy, and from which the electric sector is not immune, have the potential to progressively erode the viability of traditional monopoly services. These include:

- Expanding customer expectations based on personalised, on-demand services and subscription pricing;
- A shift from scarcity economics to abundance thinking given dramatically lower or zero marginal costs associated with certain platform economy models;
- Democratisation of investment and decision-making power that also erode traditional centralised authority and policy and regulatory influence; and,
- Dynamic business innovation driven by new entrants and business models adapted from other sectors with an almost infinite range of possible variants.

[1] Numerous well documented examples exist such as regulated taxi services, postal services, music stores, print news media, bookstores, land-line telephone services, photographic and video technologies. It's important to note that even the original disrupters also find themselves being disrupted: iTunes by Spotify, Blackberry by iPhone, etc.

As highlighted in the Pacific Energy Institute's A Gambit for Grid 2035 [2] paper, evolving customer needs and aspirations are at the gravitational centre of the transformation. Underpinned by demand-oriented economics and platform technologies, this necessarily involves structural shifts that erode the influence of centralised and deterministic decision making. Similar transformations are impacting every sector of the economy.

Ultimately, the 'nuclear fission' that drives every sectoral disruption was most elegantly summarised by Harvard's Theodore Levitt: "People don't want to buy a quarter-inch drill. They want a quarter-inch hole!" While regulatory systems and regulated sectors have traditionally focused on the efficient provision of specific and standardised services (the 1/4" drill), customers today are increasingly open to – and actively empowered to look for – innovative, customised and outcome-oriented alternatives (a 1/4" hole).

With over a decade of sectoral disruption to learn from, a genuine orientation of customer-centricity and the organisational capacity continuously learn and respond are critical for long-term viability and vitality. As alternative energy options multiply, these attributes become increasingly necessary for both the regulated entities and their regulators if long-term customer interests are truly central and the unnecessary destruction of economic value is to be avoided.

The threat of 'spontaneous deregulation'

In times of disruptive change, new entrants typically combine entrepreneurial passion and organisational agility to skirt complex regulatory minutiae. This often involves operating in the regulatory grey zone and assuming it's easier to ask for forgiveness than permission. While the cohort of 'disruptors' remains small, it presents no immediate threat to the incumbent entities or the regulatory framework. However, where new value proposition 'goes viral', it becomes much more difficult for regulators and policy makers to hold the line. This can drive what has been called 'Spontaneous Deregulation' which has been witnessed across several sectors. [3] [4]

It should be noted that, while analogies from other sectors may provide useful illustrations of sectoral disruption, the electric sector does indeed have some features that may not always directly correlate. For example, electricity is both an essential societal service and can present a life-threatening hazard to human life and property. However, while recognising these factors, it would be foolish to assume that there is nothing to learn from other sectors. Human history is littered with examples of once dominant cultures, nations, sectors and corporations that sincerely but incorrectly believed "It will never happen to us…"

[2] PEI Fellows, A Gambit for Grid 2035: A systemic look into the disruptive dynamics underway, Pacific Energy Institute, 2021
[3] Collier et al, Disrupting Regulation, Regulating Disruption: The Politics of Uber in the United States, Cambridge University Press, 2018
[4] B. Edelman et al, Spontaneous Deregulation: How to compete with platforms that ignore the rules, Harvard Business Review, 2016

Confronting a once-in-a-century scale of change

"You must never confuse faith that you will prevail in the end... with the discipline to confront the most brutal facts of your current reality, whatever they might be."

Admiral James Stockdale

Systemic shifts, not incremental tweaks

Electric power systems are some of the largest and most complex systems created by humanity. Formally defined as Ultra-large Complex Systems [5], globally they are now experiencing perhaps the most profound change since the days of Edison and Tesla in the late 1800's.

For much of the twentieth century, these huge and complex systems, together with their regulatory models, were based on the paradigm of largely predictable and incremental change. This was a world of one-directional supply from centralised, dispatchable, fossil fuel generation to customers that were largely passive. The traditional regulatory framework facilitated the deployment of capital intensive, long-life assets to support a system optimised for the core objectives of safety, reliability, and affordability.

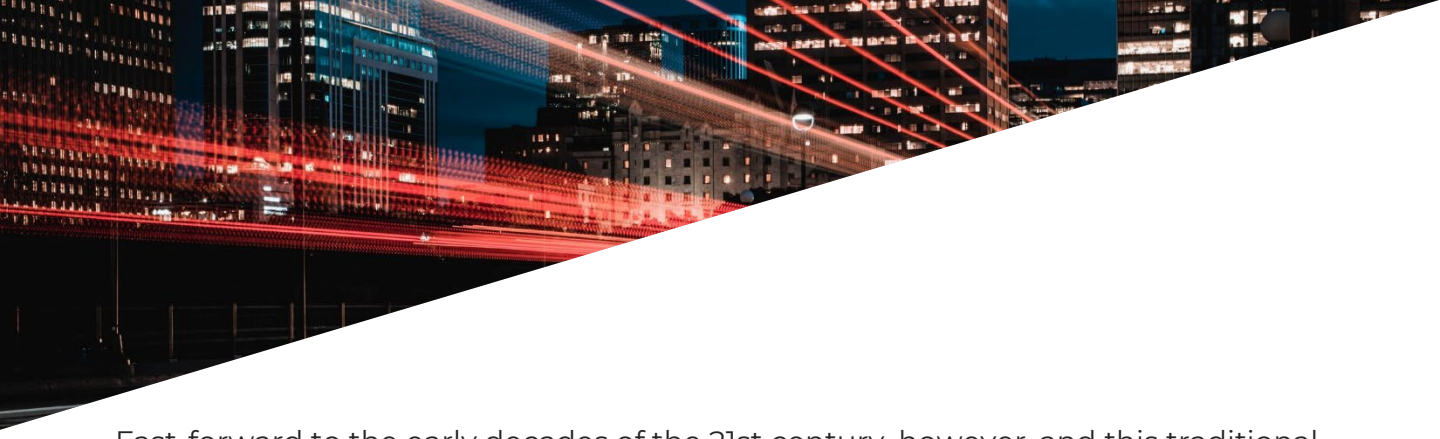
This model has operated successfully for decades in the relatively stable context of:

- long lifespan, capital-intensive investments;
- slow, incremental technological change;
- steady load growth closely coupled to economic activity;
- end-users as relatively passive consumers; and,
- no credible risk of mass 'product substitution'.

Tectonic shifts are moving electric systems from a supply-side dominated architecture to one where the demand-side is as critical to system stability and economic efficiency as the supply-side has traditionally been.

In other words, for much of the last century, the supply side of the electric system was a dominant focus. In this historical context, there was no substantial competitive tension between the historically dominant supply-side system and demand-side alternatives that were absent or immature.

[5] P. Feiler et al, Ultra-Large-Scale Systems: The Software Challenge of the Future, Software Engineering Institute, 2006



Fast-forward to the early decades of the 21st century, however, and this traditional model is being upended in many jurisdictions. Many electric systems in Europe, Australia and the United States are now having to reconfigure technical systems and regulatory processes to efficiently integrate both centralised and decentralised renewables at scale, expand the role of storage, and enable the multi-directional exchange of electricity.

Across the world, as highlighted in Australia and US, more systemic change has occurred regarding decarbonisation policy, electricity resource composition and location in the last 10-years than the previous 100-years. A common feature of these different transformations is the shift from a wholly supply-side dominant system to one that is increasingly hybridised. It involves tectonic shifts that see the demand-side of the system becoming at least as critical to whole-of-system efficiency and reliability as the supply-side of the system has traditionally been.

For much of the 20th century, the most successful economies were built on incrementally optimising both economies of scale and supply chain efficiencies. As noted earlier, the 21st century is seeing a similar revolution, but this time it is on the customer or demand-side of the economy. While each jurisdiction will emerge differently, the future may include some or all of the following features:

- generation and storage will be provided by an increasingly diverse range of technologies including centralised and decentralised, variable renewable and fossil fuel, dispatchable and non-dispatchable sources;
- in the order of 25 – 50% of annual electricity volume (GWh) will be generated at the polar opposite end of the system from its original design;
- the falling cost of clean energy technologies is 'democratising' both investment and participation in the production, storage and trading of electricity in ways that reshape supply and demand profiles and impact wider system operations;
- periods where variable renewable generation output significantly exceeds regional demand;
- business model and technology innovations continue to accelerate the creation of entirely new ways to meet, exceed and influence customer aspirations;

This is not an evolutionary and incremental process of change; irreversible systemic shifts are now occurring in years rather than over several decades.

- digitisation, platform and sharing technologies reconfigure how customers engage with energy and potentially disintermediate some incumbent roles; and,
- at the same time as the number of active customer-investors and stakeholders increases exponentially, concerns about social equity, fairness and the ability of all citizens to share in the benefits of an evolving electric system also increase.

The emerging operating context set out above represents a profound and irreversible transformation of the electric sector. Rather than an evolutionary and incremental process, it involves structural and whole-of-system shifts. These are now occurring over years rather than several decades.

Underestimating the true nature of what is unfolding, combined with a cultural 'status quo bias', is perhaps the source of a dangerous exceptionalism that imagines 'disruption could never happen to us' in the electric sector.

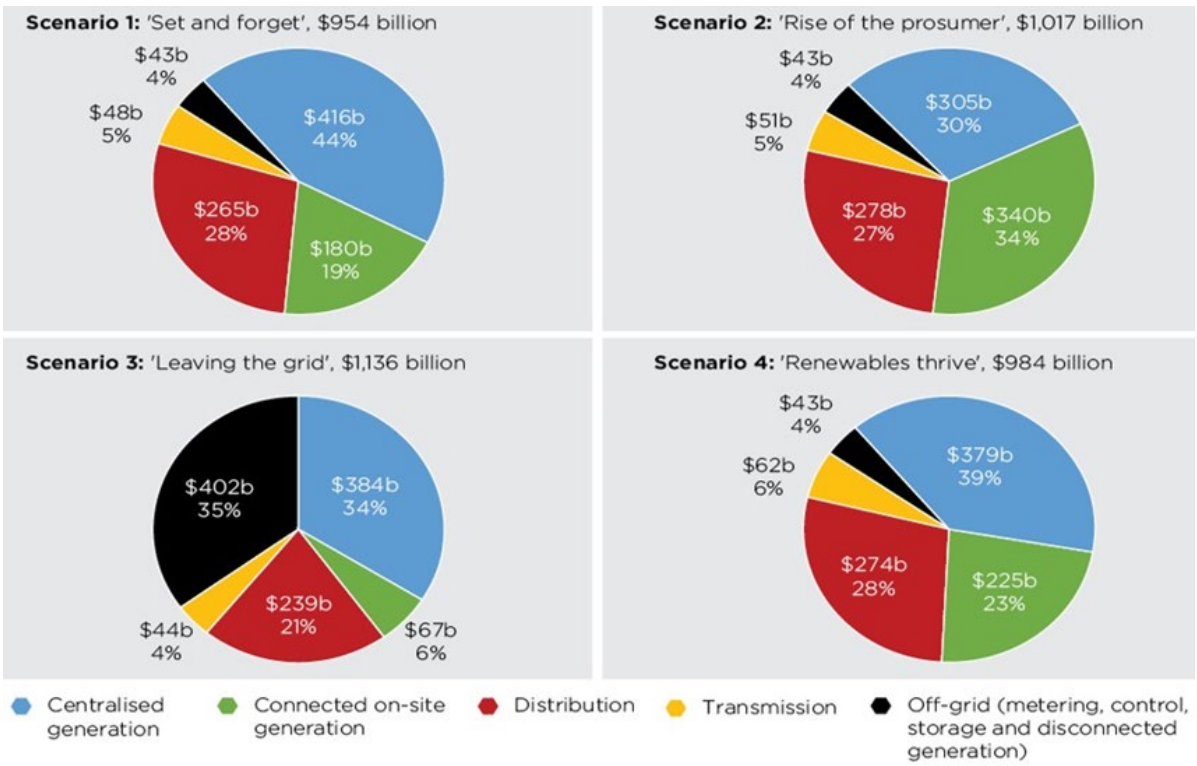


Figure 1: An Australian perspective on how different future scenarios all involve 'democratised' customer-side investment [6]

[6] Electricity Network Transformation Roadmap, CSIRO and Energy Networks Australia, 2015

The ‘DNA’ of systemic transformations

“If you have to plan for a future beyond the forecasting horizon, plan for surprise. That means… planning for adaptability and resilience.”

Philip Tetlock

Understanding how large, complex systems transform

An increasing number of jurisdictions around the world are recognising that we are fast approaching the inherent design limits of the 20th century electric system. The ultra-large ‘cyber-physical-economic’ system that is the electric system necessarily includes its diverse technological, commercial and regulatory systems and the wider industry ecosystem [7].

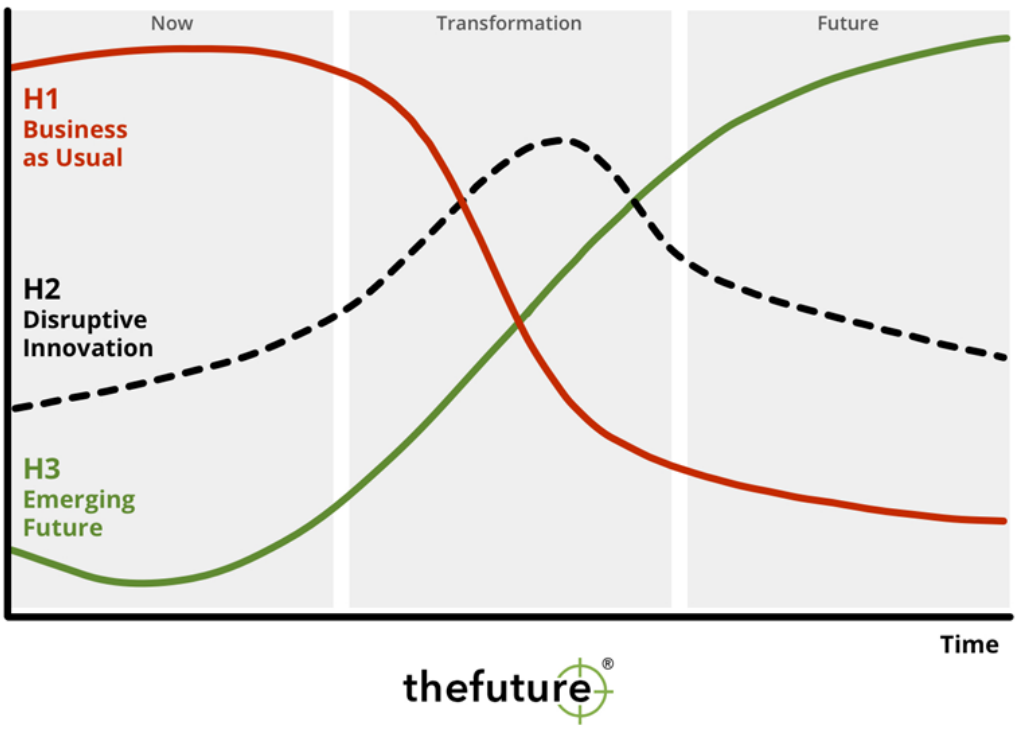


Figure 2: Three Phases of Systemic Transformation [8]

[7] The Electric Industry Ecosystem is examined in detail in the companion paper A Gambit for Grid 2035.
[8] A. Curry & A. Hodgson, Seeing in Multiple Horizons: Connecting Futures to Strategy, Journal of Futures Studies, 2008

Understanding the essential nature of any complex transformation is the first step to selecting the toolkit and approach commensurate to the challenge. As Clayton Christensen noted, similar transformational epochs in other sectors have often witnessed the demise of the strongest incumbents [9]. In significant part, this is because they did not understand or profoundly underestimated the systemic nature of the transformation that was unfolding all around them. As will be discussed later, it is not uncommon for incumbent actors to essentially ignore the unpleasant implications of disruptive transformation until its too late.

Curry & Hudson's influential work on systemic transition has provided a helpful model for understanding a key aspect of the transformation that is now impacting electric systems. As highlighted in Figure 2 above, three phases of systemic transition are identified. These move from the historic or legacy condition (Past/Now), through a volatile and extended period of change (Transformation) toward the emerging future state where a relative level of new systemic equilibrium is realised (Future).

While each transformation will have its own unique features, this model is instructive as it highlights a dangerous fallacy that assumes large-scale transitions generally move from the legacy condition of the past to the emerging future. By contrast, most transitions are less direct and tend to play out over three overlapping phases of change. Initially the 'business as usual' world (Horizon 1) begins to show signs of gradual decline as disruptive innovations (Horizon 2) erode the legacy system's dominance. This tends to occur in an increasingly chaotic and non-linear manner that is difficult to navigate and can endure for many years. Eventually, this second phase of transformation begins to give way to an emerging future state (Horizon 3) where a relative level of systemic equilibrium is realised for a more extended period of time.

[9] C. Christensen, The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business Review Press, 1997

Structural transformation in the electric sector

With current industry trends, we are nearing the tipping point in the proliferation of large scale and distributed renewables and storage, increasing customer participation in the marketplace, and transportation electrification within this decade. The industry has already entered this transitional period involving structural transformation. This phenomenon is illustrated by technology S-curves in Figure 3 below.

This unfolding transformation is characterised by increasing competitive dynamics on both the supply-side and demand-side. These are being advanced by regulated and unregulated entities, and the most 'economically efficient' combinations of different technologies and applications will not be clear without extensive learning-by-doing. In this new operating context, the efficiencies that regulatory mechanisms seek will, paradoxically, only materialise where the relative 'inefficiency' of agile, emergent learning is accommodated.

In the figure below, the legacy and emergent industry structures are represented by two maturity curves illustrating their respective evolution in terms of performance over time. As these S-curves show, each industry structure involves an initial breakthrough and incremental performance increases until it reaches its limits of what is possible within its structural paradigm.

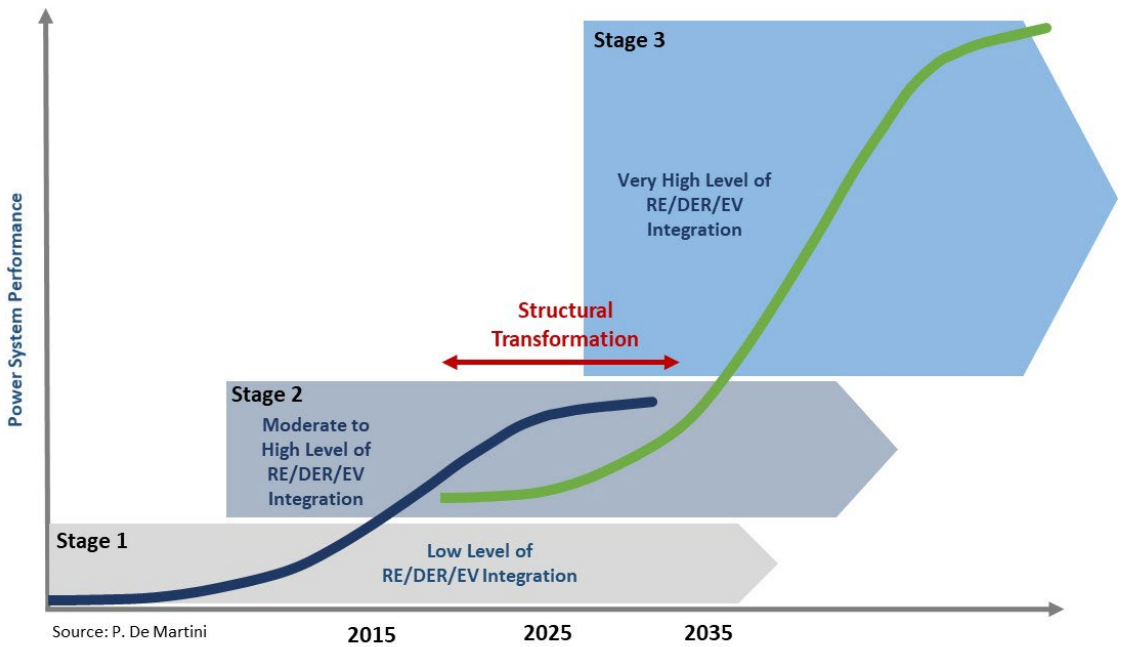


Figure 3: Electric Industry Structural Transformation [10]

[10] This figure is an update on earlier versions developed by P. De Martini depicting a single evolutionary curve. This figure represents a closer view of the industry structural transformation dynamic discussed in this paper.

Today, the growing level of renewable and distributed resources combined with the shift in electrification have begun to signal the need for a step change in power system architecture. The limits of the legacy system have also become clearer under the stress of increasing severity of climate impacts and stochastic variability in electricity production and consumption. In effect, the "Rubicon" is being crossed and the questions cannot simply be about how to maintain the status quo, but how to intelligently move forward. [11]

The critical need for a new culture of shared learning to navigate dynamic change

Given the scale of transformation that is unfolding, both regulators and regulated utilities need to make significant investments that enable more adaptive approaches underpinned by organisational cultures capable of collaborative learning. Unlike the relatively stable operating environment of much of the 20th century, this fast-learning and navigational capacity is expected to be required for the next decade ahead and beyond. As noted earlier, while a relative level of systemic equilibrium may be expected to materialise over time, it is likely that this enhanced agility will be required to exploit opportunities and efficiencies in a long-term future that is inherently more dynamic than the past.

Grounded in insights drawn from other industry sectors, this paper is intended to offer practical insights for boards and executives on some of the key elements required to not only survive but thrive in the emerging future.

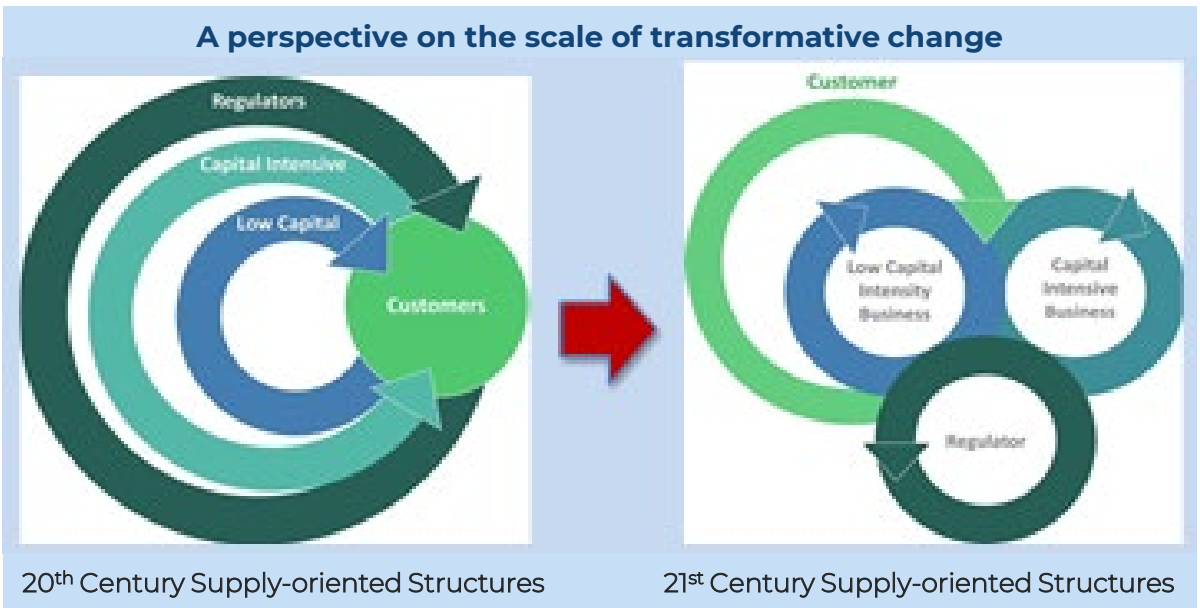


Figure 4: The previous PEI paper discussed the scale of change impacting regulatory and governance structures [12]

[11] PEI Fellows, A Gambit for Grid 2035, Pacific Energy Institute, 2020.
[12] Ibid

Impediments to timely transformation

"Progress is impossible without change; and those who cannot change their minds cannot change anything."

George Bernard Shaw

The challenge of transformation in a highly regulated sector

Regulation has played an important and influential role in the electric sector. This has traditionally involved a strong supply-side orientation focused on stability, predictability and efficiency. Regulatory frameworks largely emerged in a historical context of highly centralised and deterministic decision-making involving a limited number of large stakeholders. [13]

In what is already a highly complex sector, both regulated utilities and the regulators themselves now face new challenges where large-scale transformation is unfolding. Increasingly, technology and business model innovations threaten to outpace regulatory models that were originally designed to protect customer interests in a centralised, monopolistic, and slow-changing paradigm typified by long-life assets and investments.

As the electric system evolves, it is expected that some form of regulation will continue to be required. However, given the rapidly changing competitive landscape for customer self-generation, storage and resiliency options, it is becoming less clear what is needed for utilities and competitive services providers.

Perversely, the systems designed to protect customer interests may unintentionally erode customer outcomes, exacerbate social inequity and accelerate the destruction of economic value.

This is especially critical when legislators and regulators are considering large scale policy initiatives that have the potential – knowingly or unknowingly – are already creating winners and losers. It is equally important, however, where a jurisdiction decides to maintain the regulatory status quo and apply a 'wait and see' approach to disruptive forces, similar unintended consequences may arise. Unlike the past, in today's fast transforming operating environment, to avoid making a decision is ultimately to make a decision.

[13] Decision Structure Dynamics are examined in detail in the companion paper A Gambit for Grid 2035.

Perversely, in either case, the very systems that are designed to protect customer interests may unintentionally hasten the erosion of customer outcomes, exacerbate social inequity and accelerate the unnecessary destruction of economic value.

What got us here won't get us there!

Such periods of transformation in large and complex systems require new capacities to navigate ambiguity and make effective decisions with incomplete knowledge. This is because knowledge for effective decision-making in a transformational period moves through a gradual maturation process that Roger Martin of the Rotman School summarises as the journey from a Mystery to Heuristics to Algorithms. [14]

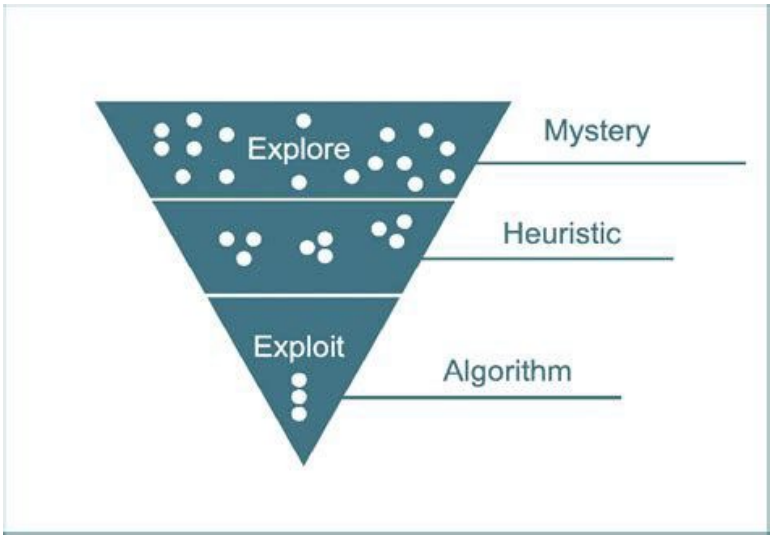
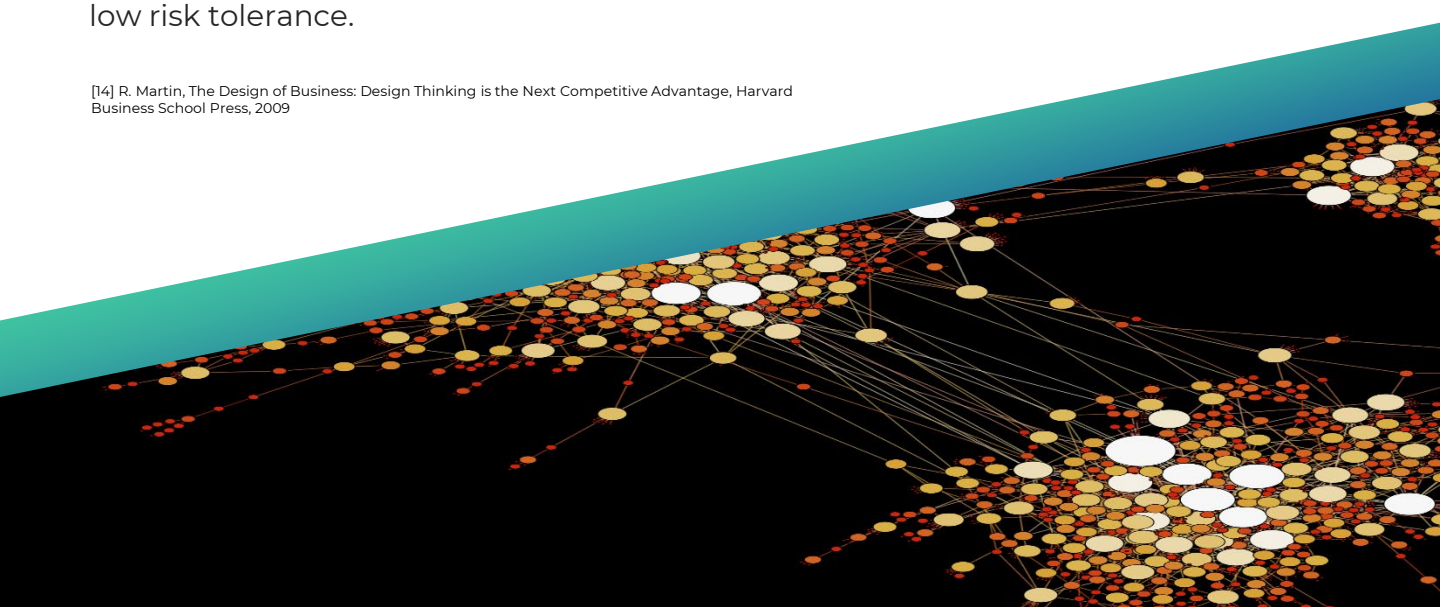


Figure 5: New knowledge in a transformational period moves through a gradual maturation process from Mystery to Heuristics to Algorithms

In transformative environments it is simply not possible to accurately predict all dimensions of the future state or states that will emerge. Nor it is possible to anticipate the range of iterative pathways that technology innovations and business models will traverse as the most efficient solutions become clear. By contrast, the traditional electric sector is well known for its linear and hierarchical structures and low risk tolerance.

[14] R. Martin, The Design of Business: Design Thinking is the Next Competitive Advantage, Harvard Business School Press, 2009



While such organisational constraints may be true of regulated utilities, it is not uncommon to find the same features reflected in the regulatory entities themselves. Where this is the case, slow structural transformation of the relevant regulatory frameworks will have a profound impact on the ability of regulated utilities to respond to continuously evolving customer aspirations.

In a context where – for the first time in a century – the traditional electricity sector is confronting a future where a growing set of customer segments have credible product substitution alternatives, an inadequate pace of regulatory change will likely exacerbate the destruction of economic value.

PART B

Five organisational characteristics for successfully navigating to Grid 2035+

Five organisational characteristics for successfully navigating to Grid 2035+

"In the end, a smart power industry will not be the product of the oncoming revolution in control systems or generating technologies... It will be the result of provisioning the industry for change."

Peter Fox-Penner

Actively navigating sectoral transformation or disruption is extremely challenging. Moving any organisation beyond the natural 'wait and see' posture will test the mettle of even the most seasoned leaders. This may be especially difficult in highly regulated sectors such as energy where the regulatory architecture itself can be perceived as constraining and immovable, even inviolable.

Nevertheless, the transformational forces that impact industry sectors also impact the regulatory regimes that govern them. In learning from the expanding history of sectoral disruptions, it is worth considering several of the characteristics that tend to be important in the organisations that secure a successful and vibrant future in a transforming sector.

Five key characteristics of such organisations are now briefly explored below, namely:

1. **Executive Priority Focus:** Navigating the next decade of dynamic change is a 'mission-critical' priority of leadership

2. **Futures-competence:** New organisational-foresight capabilities for exploring 'future-back' perspectives are embedded

3. **Adaptive Structures & Strategy:** Innovative structures and fit-for-purpose strategy models foster agility, innovation and alignment

4. **Shared-learning is Prized:** A culture where fast and continuous shared learning is valued as foundational to competitive advantage

5. **Complexity is 'Tamed':** New tools are integrated to help 'tame' the deep technological complexity inherent to industry transformation

1. **EXECUTIVE PRIORITY FOCUS:** Navigating the next decade of dynamic change is a 'mission-critical' priority of leadership

The decision for any organisation to confront the pace and scale of change facing the energy sector has wide-ranging implications. As with transformations in other sectors, breaking out of deeply ingrained cultural and cognitive inertia can prove too much for many once great organisations.

Whether a regulated utility or regulatory body, the strategic resolve, urgency and resourcing required for incumbents to reinvent themselves for long-term success cannot be outsourced. To be commensurate with the scale of transformation unfolding, explicit ownership and resourcing by the leadership team is essential. Given the comparatively hierarchical nature of many energy sector organisations, this is especially critical.

As noted earlier, the transformation of the energy sector is also occurring the 'Disruption Generation', otherwise known as the 'Age of the Customer'. Never before have customers enjoyed more choice or decision-power in almost every sector, enabled by digital technologies and business model innovations. Only the entities that do the hard work of becoming truly customer-centric have any hope of longevity. This will require new capacity to deeply understand and anticipate emerging customer needs and aspirations, and to proactively develop solutions that are ready as market demand emerges.

One major barrier to the necessary urgency and decisiveness in economics and engineering-dominated sectors is the propensity to demand near perfect knowledge to enable future decision making. This may be a reasonable approach to decision-making during periods of slower, more linear change that can depend primarily on historical data. It is entirely inadequate, however, where change is accelerating, increasingly non-linear and historical data provides limited if any insight about the emerging future.

In transformative circumstances, the goals of securing and growing shareholder value and/or avoiding the unnecessary destruction of economic value require new levels of strategic intelligence and decision. It is a sobering realisation that history provides few examples of incumbents that successfully navigate sectoral transformation with a navigational approach that is fundamentally 'Wait and see'.

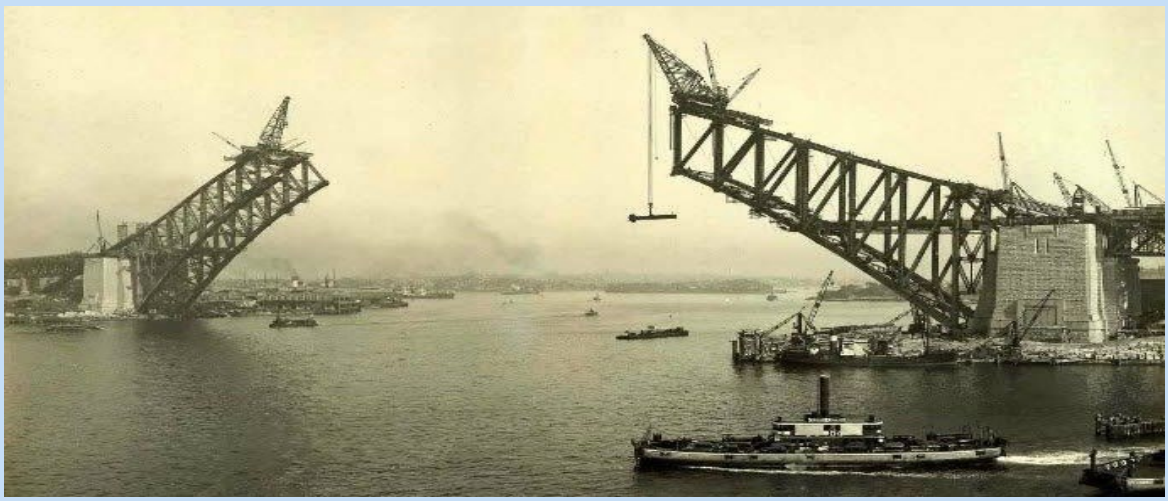
2. **FUTURES-COMPETENCE:** New organisational-foresight capabilities for exploring 'future-back' perspectives are embedded

A common trap at times of large-scale transformation is that humans – and therefore organisations – primarily comprehend it from a 'present-forward' mindset. This largely unconscious framing operates on a tacit assumption that the future will be largely like the past, perhaps with some minor modifications. While this may work in times of comparatively slow, incremental change, it is deeply flawed at times of transformative change.

Where industry sectors enter periods of volatile change, traditional present-forward thinking must be complemented with – and constructively challenged by – 'future-back' perspectives. [15] The former respects historical precedent and practices while the latter highlights the forces of dynamic, non-linear change. This combines current state realism with the freedom to interrogate plausible futures that some might otherwise feel are unthinkable, even 'heretical'.

Bridge building and Futures-competence

The Sydney Harbour Bridge, built in the early 20th century, provides a working metaphor of how present-forward and future-back thinking can function together. This engineering masterpiece was simultaneously constructed from the south bank and north bank of the harbour, with both spans ultimately meeting in the middle.



During times of transformative change, the bridge's construction process illustrates the need for both present-forward and future-back perspectives. Continued enhancements to the legacy system (south bank) and the simultaneous envisioning of the most plausible futures (north bank) are both critical. This combination and creative-tension of thought is key for navigating turbulent change in a manner where the 'two spans' have the best chance of meeting in the middle.

[15] M. Johnson & J. Suskewicz, Lead from the Future: How to Turn Visionary Thinking Into Breakthrough Growth, Harvard Business Review Press, 2020

As Steve Jobs noted: *"You can't connect the dots looking forward. You can only connect them looking backwards."* Navigating periods of transformative change requires new skills and capabilities, and embedding strategic foresight disciplines in the organisational and cultural toolkit becomes key. Beyond one-off specialist consultant assignments, this will ideally involve a structured uplift of leadership team capability to at least a basic level of competence with relevant futures-thinking tools. Some examples may include regular scanning for weak signals, trend analysis, thinking in multiple-horizons, 'diverge-converge' analysis and the establishment of customer trend and technology radars.

The aim is not to 'predict' the future. Rather, the increasingly rich set of future-back insights will complement and help stress-test present-forward perspectives. This will expand the range of options considered and support decision-making that is more resilient to alternative futures. It will also help avoid leadership thinking that is unconsciously constrained by past precedents or any single or 'authorised' view of the future which, by definition, is inherently uncertain.

In summary, strategic foresight disciplines are key to fostering a new level of intellectual plasticity and organisational adaptivity. Both are critical in times of profound change. Regulators may also find this increasingly valuable for anticipating and 'war gaming' alternative futures in which different regulatory treatments and/or expanded market competition may be required.

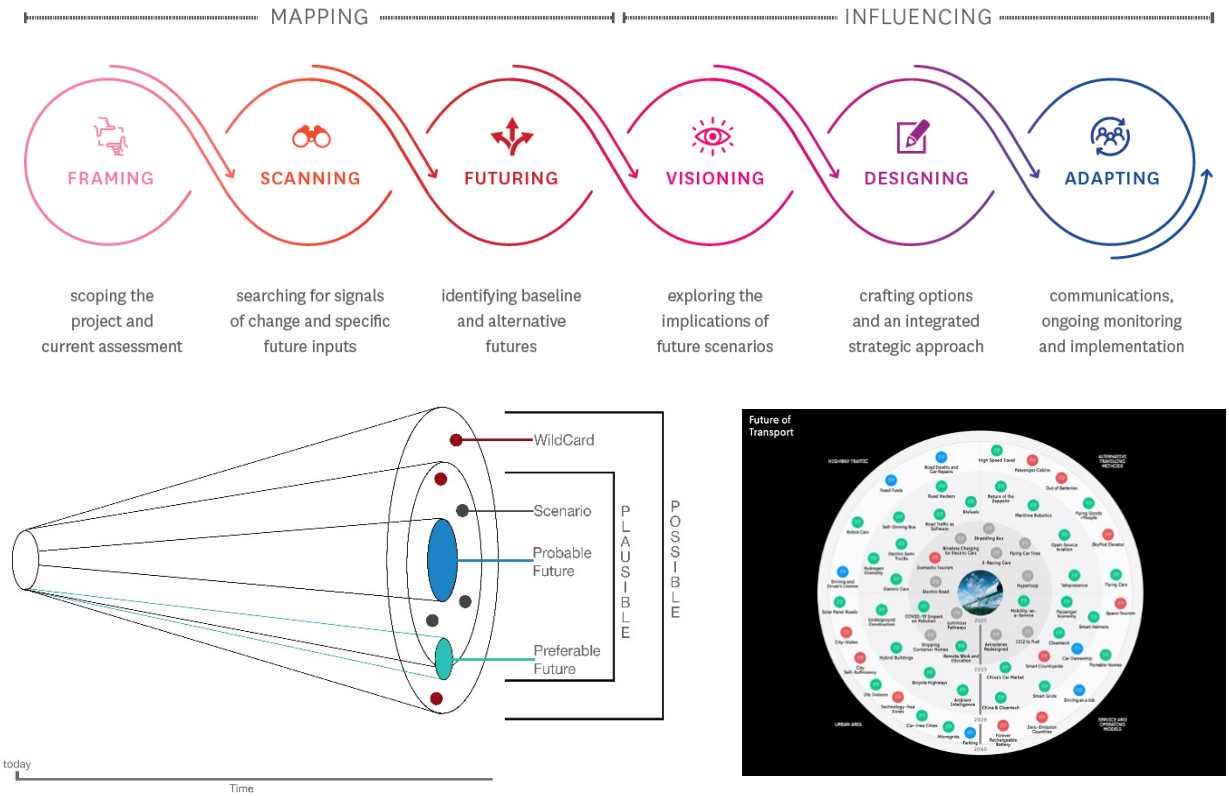
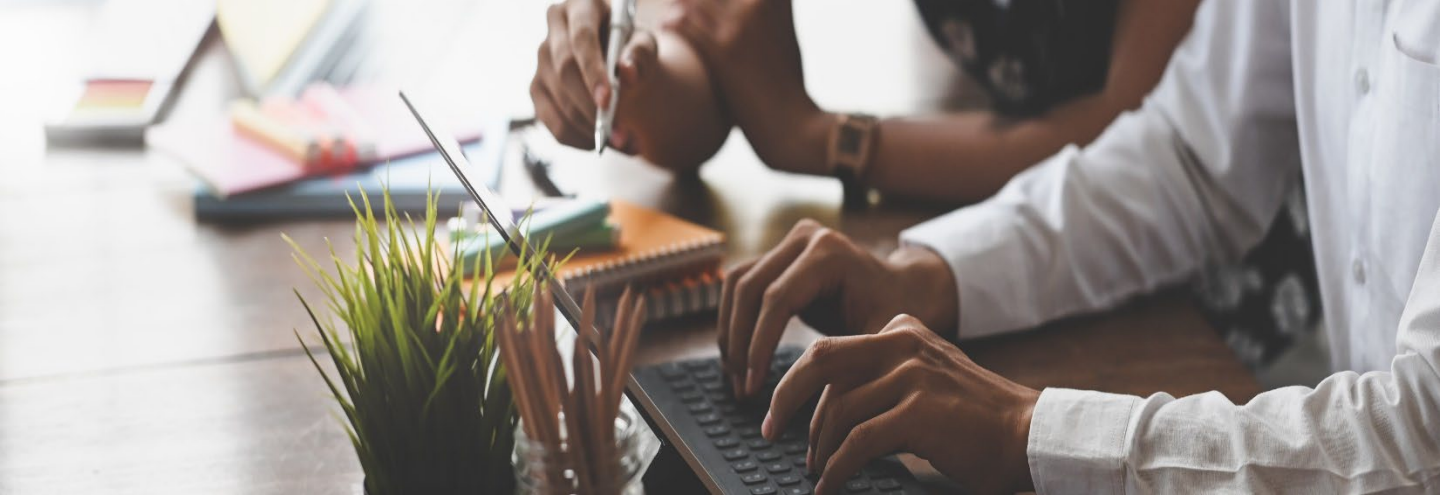


Figure 6: Strategic Foresight provides robust tools and methodologies for building futures-competence



3. ADAPTIVE STRUCTURES & STRATEGY: Innovative structures and fit-for-purpose strategy models foster agility, innovation and alignment

Traditional governance structures in the power sector are typically based on long-standing knowledge and driven by conventions, rules and historical data. Similarly, more conventional approaches to strategy formulation have matured over decades of relatively slow change and in a comparatively stable context.

A particularly challenging reality for governance structures and strategy formulation over the next decade is the sheer scale and rate of volatility and change. In addition, various categories of 'disruptive innovators' have already made a clean break from the past in their thinking. Many are not only playing the old game very differently but actively seeking to invent a new game!

At the same time, informed by historical and personal experience, we can think about strategy formulation as a type of planning that remains quite linear. Examine the context, consider the options, define a goal and document a step-by-step plan to get there over the next three to five years.

It is noteworthy, however, that the electric sector is fortunate to benefit from the documented experience of disruptive forces that have impacted other sectors over the last two decades. One such lesson is that the traditional linear and hierarchical systems that have effectively regulated and managed the electric sector will face increasing challenges in the decade ahead due to its contextual volatility.

As Harvard's Professor John Kotter notes, each organisation has existing structures and processes that together form its 'operating system'. In a context of such transformational change, he notes these traditional structures do not *"identify the most important hazards and opportunities early enough, formulate creative strategic initiatives nimbly enough, and implement them fast enough."* [16]

[16] J. Kotter, Accelerate! Harvard Business Review, 2012

A key part of the solution advanced by Kotter is the development of a 'dual operating system'. This is distinct from but complementary to the organisation's traditional hierarchical structure and governance mechanisms. Day-to-day operations continue to be effectively managed by the traditional mechanisms. The parallel operating system provides less constrained navigational insights that can be progressively injected into the traditional governance processes.

A related lesson is that some contemporary approaches to strategy formulation, quite appropriate for a slower-change environment, may no longer be fit-for purpose. As Reeves, Haanaes and Sinha note:

> *"It's not that we lack powerful ways to approach strategy; it's that we lack a robust way to select the right ones for the right circumstances. The five-forces framework for strategy may be valid in one arena, blue ocean or open innovation in another, but each approach to strategy tends to be presented or perceived as a panacea."* [17]

In other words, an organisation's strategy development process itself needs a strategy! In a fast-evolving context, determining the right strategy approach – classical, adaptive, visionary, shaping or renewal – will require a co-creative process involving key stakeholders. [18]

Together, innovative structures and fit-for-purpose strategy models can function to enhance both organisational direction setting and dynamic decision making. Given that we likely face at least a decade of transformational change in the power sector, investments to build these capabilities are likely to deliver significant returns.

[17] M. Reeves, K. Haanaes & J. Sinha, Your Strategy Needs a Strategy: How to Choose and Execute the Right Approach, Harvard Business Review Press, 2015
[18] Ibid

4. **SHARED-LEARNING IS PRIZED:** A culture where fast and continuous shared learning is valued as foundational to competitive advantage

In a context where ambiguity and incomplete knowledge are common, continual assessment of the external context and the ability to respond with greater insight and speed are key.

Each of the above three organisational characteristics provide the basis for an expanding culture capable of asking 'the hard questions' without fear. This is perhaps especially important in any sector that has benefited from a robust historical body of engineering, economic and regulatory knowledge. This has served the electric sector well for much of the 20th century but it can also create new risks where contextual change is accelerating.

In such highly analytical and knowledge-rich sectors, it is not uncommon for professionals to avoid any admission that they don't know something. Often borne of a risk-averse culture, this can exacerbate emerging risks that are inherent to sectoral transformation, and in which ambiguity and incomplete knowledge are unavoidable.

It is important to note that new knowledge emerges in three basic phases: from *'Mystery to Heuristics to Algorithms'*. [19] In other words, 'learning by doing' becomes essential, and this requires the space for intelligent risk taking. To navigate these three phases of knowledge formation, supportive cultural norms, psychological safety and modelling by leaders will be required.

> *"We cannot solve our problems with the same thinking we used when we created them"*
>
> Albert Einstein

In practice, this will involve the empowerment of professional staff and the most senior decision makers to acknowledge they simply don't know something. Such a culture honours the pursuit of excellence while also recognising humility, honesty and continuous learning as hallmarks of true professionalism. In this environment, shared learning, enquiry and constructive debate are highly prized.

[19] R. Martin, The Design of Business: Design Thinking is the Next Competitive Advantage, Harvard Business School Press, 2009

At a practical level, this involves creating structured platforms for collaborative problem solving. This will involve constructive debate and the expression of different perspectives. It should also include a diversity of stakeholders, both internal and external, who have important and even uncomfortable insights on the matters under consideration.

In reality, this represents a profound shift from traditional cultural norms of many regulated utilities and their regulators. It is comfortable with more iterative and non-linear problem solving. It requires a level of professional humility that some may initially find unnatural. However it represents a truly mature model of organisational life where the most credible professionals are recognised by their propensity to:

> *"... view their own ideas as hypotheses in need of testing. Their aim is not to convince their teammates of their own expertise, but to encourage their teammates to help them falsify their own notions."* [20]

[20] D. Epstein, Range: Why Generalists Triumph in a Specialised World, Riverhead Books, 2019

‘Wing walking’ and the transformation of regulatory systems

For a growing number of electric sector regulators, there is recognition that the institutions they are leading are ill-suited to tackle the complex challenge of today – let alone the increasingly complex and multi-dimensional challenges of tomorrow. Notwithstanding this recognition, for the reasons articulated herein, most regulators continue to operate necessarily from a principle of wing walking when it comes to novel, innovative approaches, and organisational change.

Wing-walking was the practice of getting out of the cockpit of a biplane (while someone else served as pilot) and staggering along the wing holding onto struts or wires. It was a thrill show for onlookers at air shows and barnstorming events in the 1920s and 1930s in the United States. But for the wing-walker individual, the experience was likely terrifying. It was tempting to just freeze up and hold on. If you were going to move, you had to be careful to make sure you were holding something substantial enough to take your weight in the face of wind blowing nearly 100 miles per hour. The “first rule” of wing-walking, according to observers, went something like this: “Don’t let go of what you’ve got until you get hold of something better.”

Stated differently, most regulators and institutionalists in the electricity industry today firmly believe that a regulatory theory or approach should not be abandoned before there is substantial evidence in favor of an alternate framework or option set. Much like an individual would not let go of one’s grip on the wing of a flying plane unless there is something better or more secure to grab onto, regulators are often reticent to abandon the relative comfort of the status quo unless a superior handhold has been first provided.

Considering this dynamic, as an industry collective, we must help provide wing-walking colleagues a better handhold – or at a minimum help foster the conditions for the creation of such. To that end, there is an imperative to embrace regulatory innovation in a deep and systemic manner, to enable a material shift to a focus on forward-looking system outcomes, compared to backward-looking prudency reviews. These no longer hold true with the expanding market dynamics and are unfit for resolving exponentially complex issues which require evidence-based learning through processes that favor collaboration over prescribed process and litigation.

Innovative approaches and processes represent a break from the status quo. Innovation is about something new – something unique. As such, innovation, by its very nature, is almost always in tension with regulation. Innovation requires testing unproven concepts and technologies, taking risks, and pursuing ideas that often fail. These tenets of innovation, though, are at odds with both the traditional obligations of electric companies (which are encouraged to avoid risks for safety, security, and reliability) and the duty of regulators to ensure a well-run and efficient electricity system. The question then is: what steps can be taken to enable innovation with a regulated industry?

For one recent, discrete example of this concept in practice, we look to the regulatory sandbox approach, which was developed to address the uncertainty inherent in innovation. Regulatory sandboxes are effectively a limited waiver from normal regulations and requirements, allowing companies with new innovative ventures to test their products or services in a constrained and safe environment – that is, the sandbox.

Having this flexibility is especially critical for the introduction of new customer offerings. It is not market responsive to conceive of a new customer solution and then wait a year or more for an adjudicated decision, for example where the new potential solutions don't fit neatly within historical regulated frameworks. In the time that traditional process takes place, the customer will, in many cases, find another solution. This same dynamic occurred in the telecom industry as competition increased for the incumbent and, in many cases, monopoly energy utilities. [21]

[21] The 'Wing walking' and the transformation of regulatory systems' section was kindly provided by Matthew McDonnell, Managing Director US Consulting, Strategen

5. COMPLEXITY IS 'TAMED': New tools are integrated to help 'tame' the deep technological complexity inherent to industry transformation

Modern power systems are complex cyber-physical-economic systems. They are arguably the largest and most complex 'machines' ever created by humanity. As noted earlier, even our 20th century grids were formally defined as Ultra Large-scale complex systems. [22]

With energy systems in deep transformation, it is vital to recognise that what we refer to as 'the power system' (singular) is, in reality, seven inter-dependent structures (plural) that have evolved gradually over the last century.

This web of structures include the: (1) electricity infrastructure; (2) digital infrastructure; (3) operational coordination layer; (4) markets / transactional layer; (5) industry / market structure; (6) regulatory structure; and, (7) sector couplings.

It is also noteworthy that these structures variously map across and influence the vertical layers of the grid, including the bulk power, transmission, distribution, retail and DER aggregation functions. And, changes to one structure will typically impact the other structures – in both intended and unintended ways.

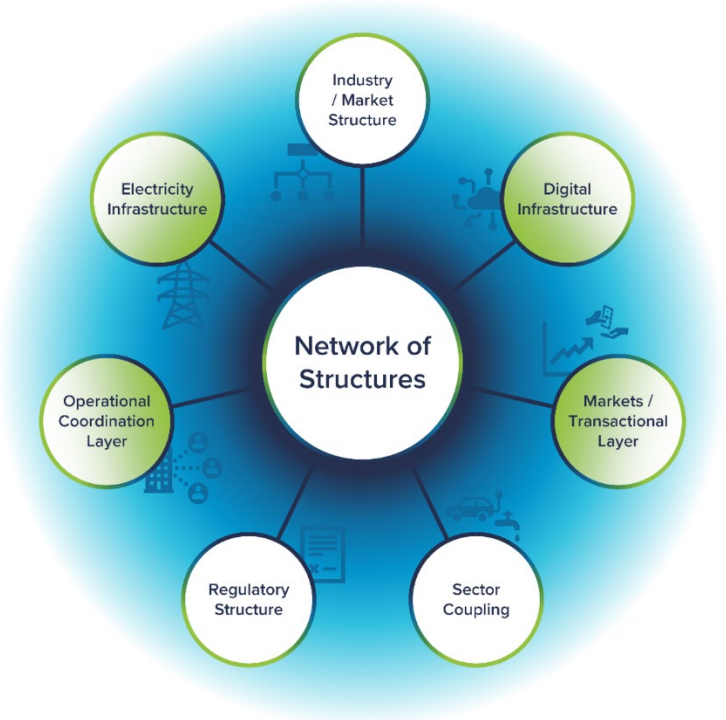


Figure 7: Like the modernising aerospace sector before it, a decarbonising power sector faces rapidly expanding systemic complexity [23]

[22] P. Feiler et al, Ultra-Large-Scale Systems: The Software Challenge of the Future, Software Engineering Institute, 2006
[23] Image: Strategen Consulting, informed by the Network of Structures model developed by Pacific Northwest National Laboratory (PNNL)

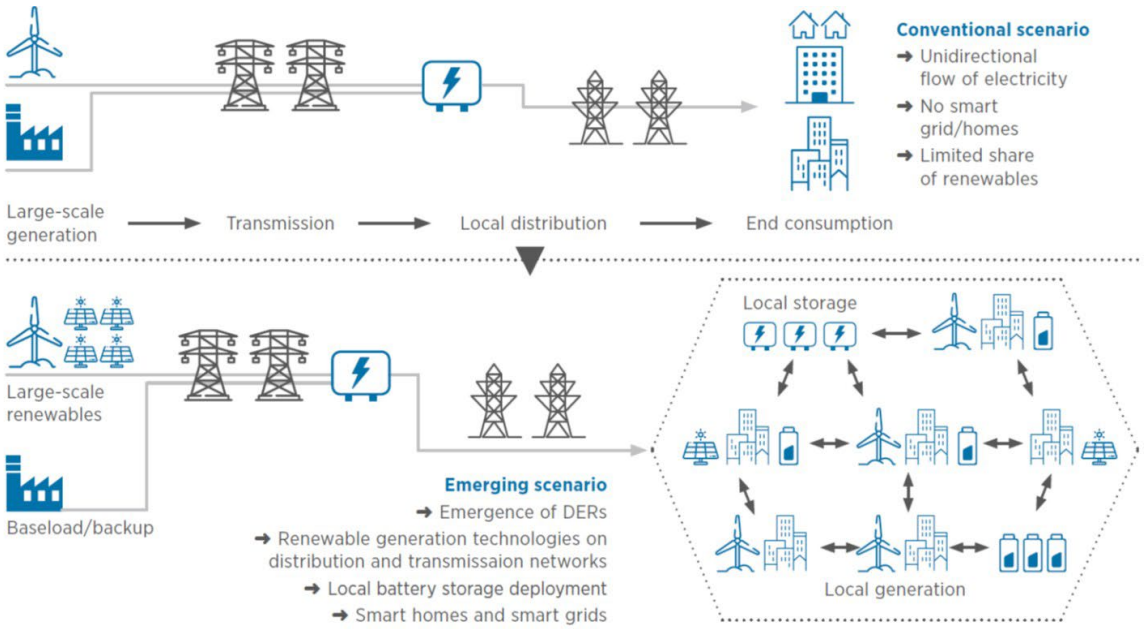


Figure 8: A whole-of-system perspective on the emerging power system is critical for navigating the transformation and identifying new opportunities [24]

In many cases, power systems are now transitioning from hundreds to tens of millions of participating resources. This includes deep dependence on Variable Renewable Energy (VRE) generation sources which are both transmission and distribution-connected. In this context, the decades-old structural settings of our power systems must be provisioned for levels of systemic volatility unimaginable to their original architects.

In a comparatively steady-state environment, regulatory and governance processes and technology pilots may readily focus on matters framed as discrete initiatives. In large-scale transformation, however, this becomes increasingly problematic because of structural impediments and the amplification of 'feedback loops' from each individual change. Time-tested assumptions about how the wider system will respond to changes risk breaking down as the underpinning structures of the system itself are impacted. As the Oxford Energy Institute recently noted:

"In a system, all parts interact, so you can't change one part without changing the whole system." [25]

The successful navigation of large-scale transformation, therefore, requires not only a knowledge of the discrete elements but also a growing appreciation of the 'systems architecture' of the whole. While relatively few in the sector have been trained in these disciplines, remaining ignorant of them is no longer a credible option if the aim is secure and least cost outcomes for society.

[24] Image: IRENA System Operation Collection, 2020
[25] M. Keay, Glimpses of the electricity future, The Oxford Institute for Energy Studies, 2022

While the full capability of Systems Architecture disciplines is beyond the scope of this paper [26], in the midst of a once-in-a-century scale of change, they provide organisations with new levels of valuable strategic insight. For example, a recent, internationally co-authored IEEE report [27] similarly noted the role of such methodologies for helping objectively address several key topics, including:

- Distribution System Operator (DSO) model designs and extensibility;
- Transmission–Distribution Interface design;
- Consideration and assignment of future roles and responsibilities across the full power system; and,
- How the 'Operational Coordination' of the power system will occur as it transition from hundreds to tens of millions of participating energy resources.

The underpinning structures of any complex system – how all the elements and actors are formally linked together – has a disproportionate impact on what the system can safely, reliably, and cost-efficiently do.

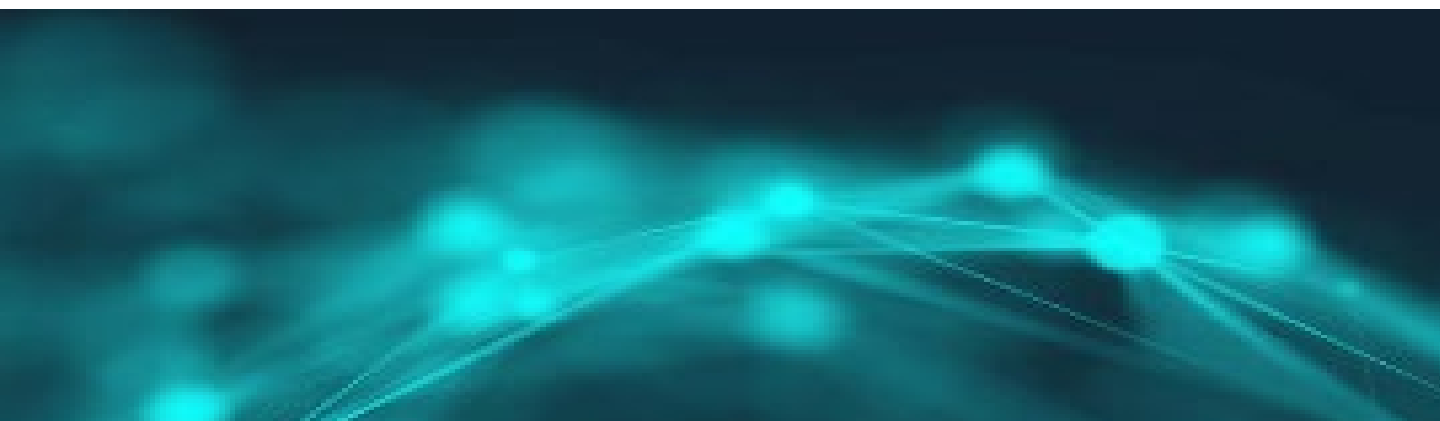
This is because the underpinning structures of any complex system always have a disproportionate influence on what the system can safely, reliably, and cost-efficiently do.

Ultimately, no amount of change to the individual elements of a system can approximate the benefits of timely and targeted structural adjustments when the system is experiencing transformational change [28].

[26] For more information on Power Systems Architecture refer to https://www.strategen.com/gpst-psa-report

[27] Transmission & Distribution Grid Modernization to Mitigate Impacts from and Adapt to Climate Change, IEEE Power & Energy Society, 2022

[28] E. Crawley et al, System Architecture: Strategy and Product Development for Complex Systems, Pearson, 2016



Conclusion

With many examples of sectoral transformations up-ending other industries, there is much the power sector can learn for navigating its own transformation.

Like the modernising aerospace sector before it, a decarbonising electricity sector faces unprecedented new levels of whole-system complexity that now exceed many of its traditional tools, navigational approaches and organisational biases.

New levels of strategic imperative, futures-competence, structural agility and organisational learning, coupled with best-in-class tools for 'taming' the inherently complex, will all be key to the organisations that shape the future.

Such an unparalleled scale of transformation will likely play out over the next decade or more. Investments made now to equip organisations and build the human capital for navigating volatility can be expected to deliver a healthy return on investment.

Survive, thrive or decline? The choice is ours.

The Author

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Mark is a globally-connected energy system transformation leader with over 25-years of experience in technology strategy, power systems architecture and thermal and fluid systems. He is known for his expertise in leading the collective navigation of complex and contested issues, systems thinking and the co-design of transformation pathways that build social licence and deliver future-resilient outcomes.

Mark's theoretically robust but pragmatic approach is grounded in applied technology origins and Engineering, Business and Master of Enterprise qualifications. He has been formally trained in Systems Architecture & Engineering disciplines at Massachusetts Institute of Technology (MIT), Strategic Foresighting methodologies developed by Europe's EDHEC and Power Systems Architecture methodologies developed through the US Department of Energy's Grid Modernisation Laboratory Consortia.

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[1] Numerous well documented examples exist such as regulated taxi services, postal services, music stores, print news media, bookstores, land-line telephone services, photographic and video technologies. It's important to note that even the original disrupters also find themselves being disrupted: iTunes by Spotify, Blackberry by iPhone, etc.

[2] PEI Fellows, A Gambit for Grid 2035: A systemic look into the disruptive dynamics underway, Pacific Energy Institute, 2021

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[10] This figure is an update on earlier versions developed by P. De Martini depicting a single evolutionary curve. This figure represents a closer view of the industry structural transformation dynamic discussed in this paper.

[11] PEI Fellows, A Gambit for Grid 2035, Pacific Energy Institute, 2020.

[12] Ibid

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