PERSPECTIVES ON TRANSFORMING UTILITY BUSINESS MODELS

Paper 1 – Horizon Scanning & Forecasting

January 2024

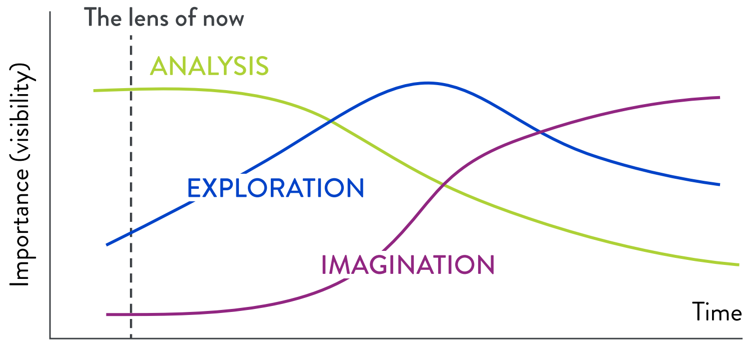
INTRODUCTION

Horizon scanning has been described as a technique for detecting early signs of potentially important developments through a systematic examination of potential threats and opportunities, with emphasis on new technology and its effects on the issue at hand. There is no one definition of horizon scanning since it has application across many sectors and businesses, including academia and RD&D. However, one helpful definition is *'the systematic examination of potential threats, opportunities and likely developments including, but not restricted to, those at the margins of current thinking and planning. Horizon scanning may explore novel and unexpected issues as well as persistent problems or trends.'* A useful visualization of horizon scanning over different timescales is provided by the diagram below.

Horizon scanning is a structured approach for collecting evidence and insights to look beyond a single expected future to a range of possible futures. It can be a self-contained exercise, an ongoing scanning activity, or part of the initial data gathering for a strategic futures programme. Common characteristics of the technique include:

- Looking ahead – gathering information beyond the usual timescales.
- Look across – extending beyond the usual sources of data, exploring different perspectives including across other related sectors; and
- Looking around – beyond the usual technologies and business models, including the important developments that may be occurring at the boundaries between them.

For example, considering the implications of future credible climate change scenarios would be an important long-term 'looking ahead' activity for an electricity utility from both a network physical resilience and future electricity demand perspective. An example of 'looking across' to an adjacent sector would be monitoring emerging developments in transport decarbonization (road, rail, marine and aviation)—in particular the possible future contributions from electrification and hydrogen under different future



Horizon 1: e.g., Current drivers and trends
Horizon 2: e.g., Emerging drivers of change
Horizon 3: e.g., Weak signals of emerging drivers of change

This is described as the 'Three Horizons Model' which considers the strength of influences over time and illustrates the spectrum over which horizon scanning can be applied in terms of current levels of awareness.

scenarios—and hence the implications for future electricity demand. An important 'looking around' example would be monitoring the rapid developments in AI and ML, not only in terms of the threats and/or opportunities they might pose to the secure and efficient operation of the electricity system, but also their potential for revolutionizing the utility business model.

Horizon scanning and forecasting should be regarded as integral components of an organization's business planning process, particularly where their business model is facing significant disruption as seen presently in the energy sector. Identified opportunities should feed into the company's innovation portfolio to explore their potential for value creation, whilst identified threats should feed into to the organization's risk register for consideration of mitigation strategies. It follows that the internal cost of horizon scanning and forecasting should be set against the potential value and threat mitigation they bring. Indeed, inadequate attention to these activities could be seen as a corporate risk itself. The objective of this paper is to summarize approaches to maintaining visibility of future sources of potential business disruption and applying relevant foresight to the overall business planning process.

HORIZON SCANNING AS AN INTEGRATED PROCESS

From the perspective of the energy industry, horizon scanning has always been regarded as an important methodology for 'staying one step ahead' and evaluating whether current strategies, policies and development pathways are sustainable, or whether potentially disruptive elements are becoming apparent which might require adaptation to current direction or even a complete change of strategic direction. However, it is also the case that horizon scanning is often undertaken as a stand-alone exercise with no defined linkage to the wider aspects of modelling, forecasting and business planning. This paper illustrates the role of horizon scanning as an integrated 'front-end' to the entire process of the business cycle from energy policy setting to energy infrastructure delivery.

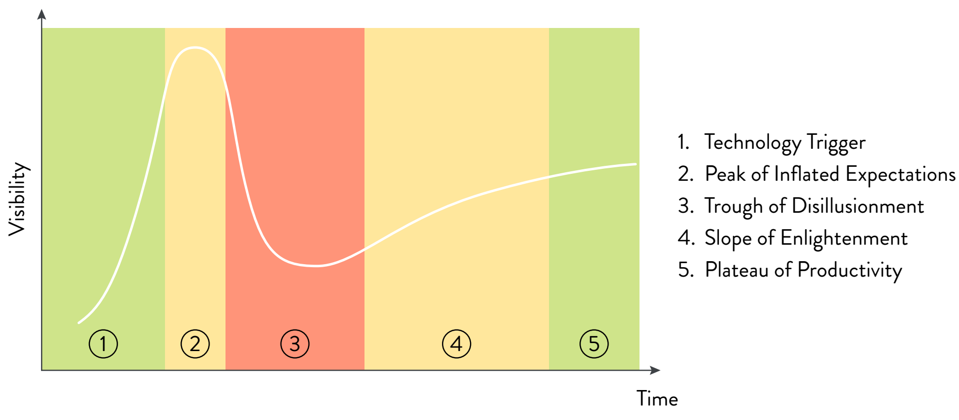
HORIZON SCANNING TECHNIQUES

Several recognized horizon scanning techniques have been developed and documented. However, the focus of this, and other papers commissioned by EPRI as part of this programme, is to examine business models rather than techniques per se. However, awareness of techniques relevant to the energy industry is helpful in providing context. Some of these techniques are summarized here but a more in-depth description can be found in the EPRI paper 'Technology Scouting Signposting Methodologies'.

HYPE CYCLE

The Hype cycle describes a pathway which the majority of technologies follow on the road to maturity and commercial viability. It describes 5 key stages:

- Technology Trigger: the first emergence of the technology with no level of verification.
- Peak of Inflated Expectations: where 'hype' around the benefits reaches a maximum.
- Trough of Disillusionment: following early development where it becomes apparent that a technology is unlikely to deliver all the initial claims or expectations.
- Scope of Enlightenment: the period of core development where a technology begins to mature, and its benefits are understood.
- Plateau of Productivity: the market adoption phase where technology reaches maturity.

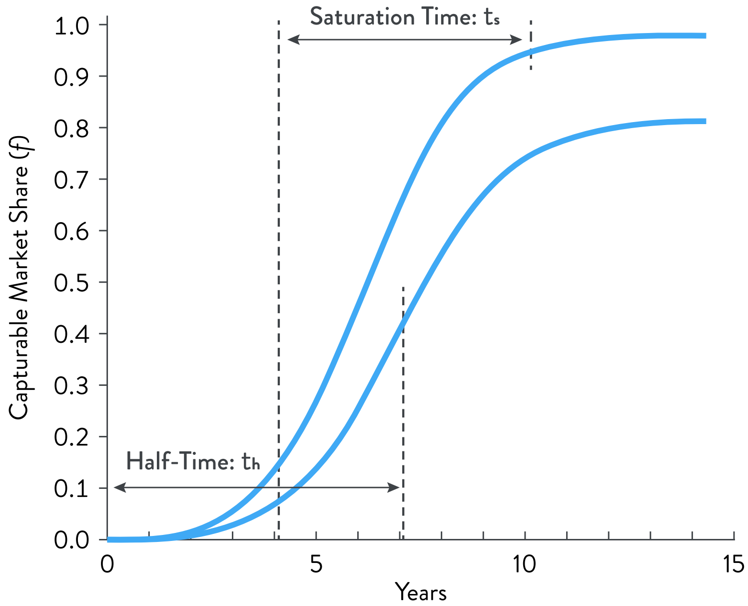


The Hype Cycle is updated periodically to track the speed of development of a particular technology along its development pathway. The key signpost for most companies is the 'Trough of Disillusionment'.

To reach this point the technology has some merit and will probably progress towards commercialization.

S-CURVES

The Fisher-Pry technology substitution model is used to estimate the rate at which the marketplace will adopt a new technology.

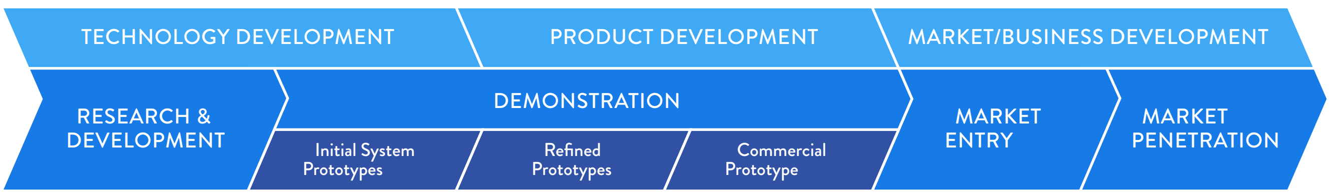


The Fisher-Pry substitution model predicts the market adoption rate for an existing market of known size and is effective in modelling the competitive substitution of one technology by another.

The technique can be used for energy technologies which broadly follow a similar trajectory.

LIFECYCLE TRACKING

Through applying the lifecycle tracking method, technologies can be plotted against their development lifecycle to give an indication of where they are in their development. As a signpost, this helps understand the key generic challenges which need to be overcome to move to the next stage.



QUALITATIVE INDICATORS

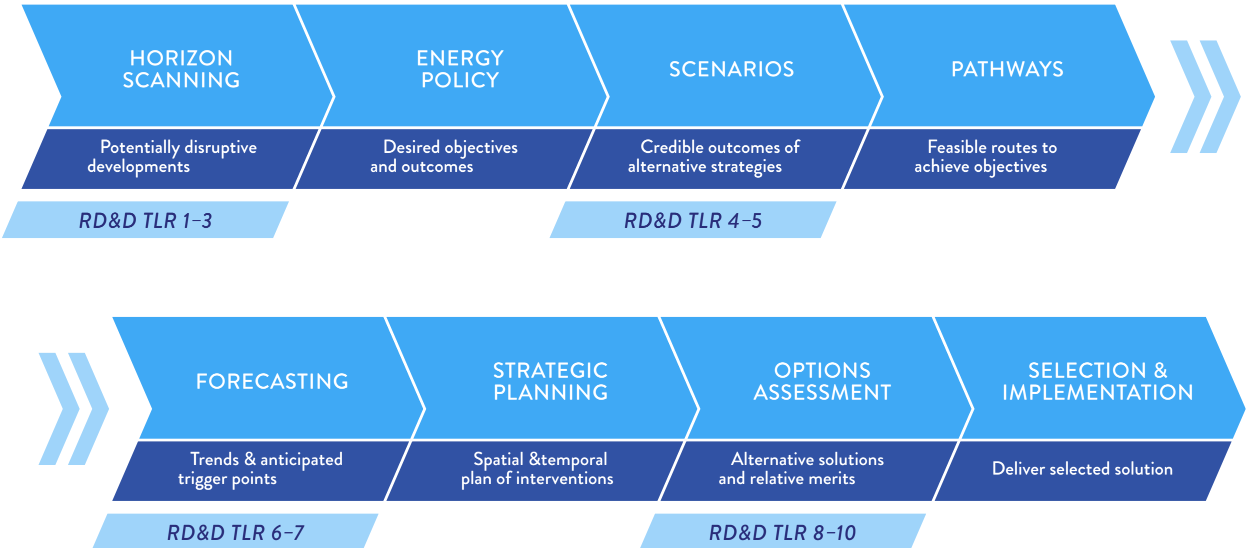
Qualitative Indicators is a more subjective, but highly informed, process whereby key areas of interest are identified along with signposts of progress which are periodically analyzed for evidence that the signposts are broadly being met. An informed judgement is then made balancing opinion as to whether progress is meeting the expected signposts. In some respects, this is analogous to classic risk management techniques but with an equal emphasis on opportunity and risk. The following is an example of how Qualitative Indicators might be applied to monitoring developments in energy storage.

ENERGY STORAGE KEY AREAS TO MONITOR	SIGNPOSTS
• Business case driven by increasing penetration of weather-dependent renewables (especially wind and solar PV) • Intermittency creating real-time system balancing issues for the System Operator • Prolonged wind-drought conditions (note: instances may increase with global warming) leading to a need for long-duration energy storage solutions—including green hydrogen produced during periods of surplus wind generation capacity • Displacement of coal and gas synchronous generation with inverter-connected technologies (IBRs) resulting in declining system strength (fault levels and inertia) • Increasing preference towards BESS connected through grid-forming (GFM) in lieu of grid-following (GFL) inverters which can inject real power in <5ms providing effective synthetic inertia and also black-start capability • Significant deployment of renewables creating both an economic and technical case for energy storage to support capacity markets, frequency response and real-time system balancing • Scope for BESS co-located with onshore wind and solar PV farms to reduce curtailment risk through arbitrage and improve effective generation load factor • Grid-scale Li-ion BESS technology has now reached maturity and both volumes and installation capacities are rapidly growing—installations up to 99MW/198MWh now being connected to European grids • Smart metering and dynamic ToU tariffs creating a business case for behind-the-meter (BTM) storage capacity—especially in conjunction with rooftop solar PV—to help avoid peak demand periods and align consumption with zero-marginal cost generation • Increasing deployment of BEV smart charging and V2G/V2H • Emerging BESS technologies—for example, sodium-ion batteries—which have similar power delivery characteristics (albeit lower energy density), lower manufacturing costs, supply chain security benefit, and enhanced safety characteristics	• Growth in numbers and capacity of grid-scale BESS • BESS cost curves ($ per MWh and $ per MWh) over time and relative to volumes • Growth in BTM static storage (for example, Tesla Powerwall) • Rate of adoption of smart EV charging and V2G/V2H • Deployment of long duration storage technologies: pumped hydro, CAES, LAES, hydrogen, flow batteries

FORECASTING

Forecasting from an energy sector perspective is generally regarded as the stage at which key metrics such as electricity demand growth (informed by related factors such as economic growth and newbuild forecasts) are built into utility companies' business plans. Similar metrics will also be used by other sector stakeholders such as government energy departments, regulators and original equipment manufacturers (OEMs) to inform policy decisions, regulatory assessments, and production schedules.

Whilst forecasting is generally regarded as the first step in a process leading to options assessments, planning and ultimately implementation, the role of horizon scanning is to provide a basis for monitoring future developments which have the potential to impact the parameters against which forecasts are formed. Horizon scanning techniques can beneficially inform policy decisions by providing insights into potential future emerging risks and opportunities. Horizon scanning will also provide a basis for scenario modelling by informing credible boundaries for future developments, not only in terms of technologies but also in relation to externalities such as potentially disruptive geopolitical and climate change developments. As such horizon scanning is an important precursor to informed and effective forecasting. The overall cycle from horizon scanning through strategic planning to solution delivery can be depicted as follows.



Although the above cycle is depicted as a linear process, in reality the stage transitions will be iterative in nature informed by feedback loops. Moreover, whilst the cycle implies discrete stages, in practice they will overlap. Indeed, the whole process will be live in the sense that variations in outputs from each stage will have a knock-on effect to both subsequent and previous stages. The process will generally be one of continuous refinement. However, in the event that horizon scanning reveals new or unexpected disruptive risks or opportunities, this might trigger a fundamental review of forecasts and strategic plans, and potentially energy policy. The paper later describes how various energy sector stakeholders will typically use horizon scanning, and the future developments, opportunities and risks they will be most interested in. However, the process is essentially similar.

By way of illustration and reducing the overall cycle to its most basic level…

- **Horizon Scanning** will provide the necessary foresight into matters impacting the development of national **Energy Policy** in terms of energy security and resilience.
- Horizon scanning will also inform the selection of **Scenarios** based on credible alternatives to achieving energy policy goals.
- Further evaluation will refine energy policy and help identify credible **Pathways** to achieving energy policy objectives, including by taking account of techno-economic studies—in essence turning scenarios into broadly evaluated delivery strategies.
- **Forecasting** then takes pathways and considers the spatial and temporal aspects of delivery—for example where and when generation will be installed to supply the system, in what capacity and through what technologies, and also how growth in electricity demand will be distributed and in what form.
- The next stage is **Strategic Planning** which broadly determines the necessary infrastructure requirements, in terms of capacity and capability, to transfer generated electricity to centres of demand.
- This is followed by **Options Assessment** which compares alternative solutions to achieve the required infrastructure capacity and capability.
- The final stage (which might involve competitive tendering) is **Selection and Implementation** of the most cost-effective option.

ROLE OF RESEARCH & DEVELOPMENT

The relevance of RD&D is also indicated in the above diagram in terms of developments at each Technology Readiness Level that might typically be considered at each given stage of the cycle. So, for example…

- **Horizon scanning** would be undertaken to reveal opportunities arising due to technological developments ranging from **conceptual to experimental proof-of-concept**, where maintaining a watching brief would be appropriate.
- At the **Pathways** stage consideration would typically be given to RD&D that had matured to **validation in a laboratory or relevant environment**.

- At the **Forecasting** stage greater certainty over outcome would be required, and so RD&D that had matured to a **model or prototype demonstrated in a relevant operational environment** would be most relevant.
- At the **Options Assessment** stage the focus would be on **technologies completed and qualified through test and demonstration or successful operations**, ideally to the extent that performance levels, and failure modes and rates, will have been characterized and documented.

In summary, the benefit of a robust horizon scanning process lies in its ability to identify potentially helpful or harmful disruptive technologies or business models, and similarly climatic or geopolitical developments and their potential impact on delivery of policy objectives. This applies at any stage in the cycle up to and including options assessment. Given adaptive and agile governance, horizon scanning enables potentially suboptimal strategies to be set aside and replaced with more efficient and/or cost-effective alternatives to delivering policy objectives. Alternatively, horizon scanning might reveal insights that suggest a change in policy direction to either counter a previously unidentified risk or exploit a previously unrecognized opportunity.

ENERGY SYSTEM STAKEHOLDERS

Whilst utilities are the primary focus of this paper, it is helpful to consider the wider energy landscape and the various stakeholders whose policy decisions, initiatives and operations will impact utilities' business models. Each of these stakeholders will have a need to consider future developments that might present risks or opportunities, and hence the outcomes they should be aiming to achieve. Horizon scanning will therefore be of value not only to utilities but to all stakeholders in the energy sector. The following examples illustrate how some of the key stakeholders might apply horizon scanning. The nature of their role or business will determine the depth and breadth of their horizon-scanning activity.

GOVERNMENT

Governmental departments will be concerned with all future scenarios that might affect or be affected by energy policy. For example, foreseeing potential developments in the future geopolitical landscape will enable governments to assess the extent to which a nation's dependency on imported fuel products might in future become a risk to energy security. Similarly, a dependency on imported goods or materials might present a future risk if the supply chain is vulnerable to political interference in transcontinental markets.

A factor which is now the subject of global interest is climate change and the impact it might have on energy production and the resilience of energy infrastructure. Related to climate change are government commitments to decarbonization and net zero, and the key role that energy policy will play in delivering legally binding carbon (or GHG) emission reduction targets. It follows that horizon scanning has an important role to play in informing energy policy and energy contingency planning. Of the techniques available, this would be a logical application of Qualitative Indicators where geopolitical events and trend indicators, and monitoring of progress towards decarbonization targets, will form the basis of the evidence to determine whether signposts are broadly being met and hence whether any change in direction of policy is indicated.

Traditionally, governments will generally be interested in scanning a wide, but short-to-medium term horizon, reflecting their span of influence and their elected term of office. However, climate change and global warming should now be encouraging governments to adopt a longer-term focus on circumstances and events that might in future impact energy security and resilience. Failure to recognize emerging future as well as nearer-term risks and implement policies and/or contingency measurers to address them, could jeopardize security and/or affordability of energy supply in the longer-term.

ENERGY REGULATORS

Energy regulators, albeit generally independent of government, will nevertheless have a mandate dictated by national government through legislation which broadly sets out their obligations. Invariably the guiding remit of energy regulators will be to protect the interests of existing and future customers by ensuring that utilities (including licensed energy suppliers, system operators and network companies) are efficiently managing their operating costs, cost-effectively maintaining the health and integrity of their assets, ensuring system adequacy in terms both of capacity and capability, and providing a high standard of customer service.

Enabling and ensuring effective competition wherever practicable has been a further objective for energy regulators in respect of generators, energy suppliers and natural monopolies such as network companies. An additional obligation now being considered or enacted is for energy regulators to have a specific mandate towards net zero. Alongside their role as economic regulators, this will oblige energy regulators to ensure that regulated utilities have credible plans in place to effect or enable decarbonization of energy supply and demand.

In terms of their scanning horizon, energy regulators will be interested in tracking developments in regulatory models both in other countries and across different sectors. For example, an energy regulator will typically look at how other countries are developing regulatory mechanisms in response to their net zero obligations and energy decarbonization strategies. They will also typically look across sectors such as water which will also have to address challenges arising from global warming, and telecoms which will need to accommodate higher data traffic volume and propagation speed (latency) requirements to meet the opportunities surrounding digitalization of the energy system, whilst also building-in levels of cyber security commensurate with critical national infrastructure.

In general, the challenge for energy regulators will be in understanding through horizon scanning the future regulatory challenges for the energy sector, and how others are meeting the need to balance their shorter-term obligation as an economic regulator in protecting customers' interests, with the need to ensure sufficient levels of investment in resilient infrastructure to meet climate change challenges and national net zero and decarbonization obligations. This implies a relatively wide horizon but one which also scans short, medium, and longer-term developments. This might reveal opportunities for new regulatory tools and mechanisms which might be tested through regulatory sandboxes providing regulatory relief (for example of a licence obligation) for utilities to test innovative regulatory models through time-limited trials.

OEMS

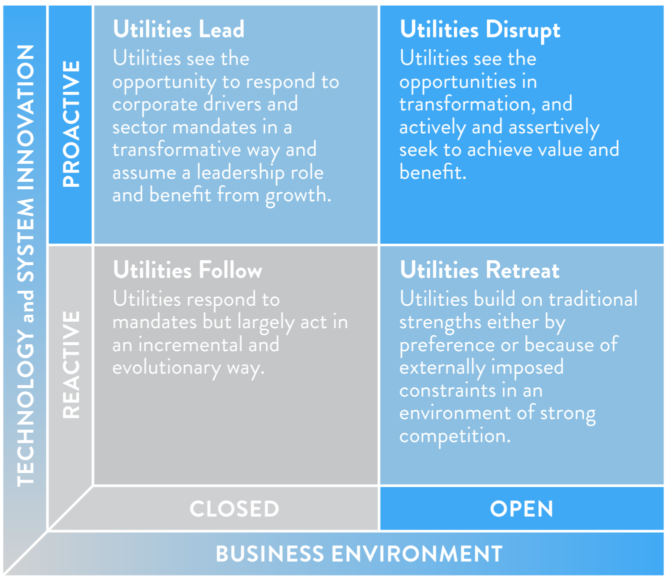
Equipment manufacturers, particularly those in the energy sector, operate in an increasingly competitive global market where business sustainability, let alone growth, depends on being able to embrace emerging opportunities and/or counter emerging threats, and stay ahead of (or at least keep pace with) the competition. OEMs will need to continuously review, and where necessary adapt, their business models, not only to ensure they are able to serve customers' changing needs but also to ensure they maintain focus on their company's core strengths and competitive advantage. The outcome of horizon scanning might be a decision to either expand or consolidate their product offerings. For example, companies might see their best way forward being to focus on their core strengths to serve either emerging niche or mass markets through consolidation, or alternatively to adapt their product offerings through development and expansion.

From the perspective of an OEM, horizon scanning has a key role not only is respect of the technologies surrounding the company's products but also its supply chain, manufacturing, marketing, and delivery methods. For example, the pace of technological evolution in automation, digitalization, communications, computerization, and AI has the potential to disrupt product development, manufacturing, and supply chain logistics, all of which have the potential to increase profitability (or survivability) provided the company and its management are responsive and sufficiently agile to embrace the opportunity. Similarly with respect to communication and marketing, AI and ML can be very effective in predicting potential markets and volume sales based on emerging trends.

It follows that the depth and breadth of horizon scanning for OEMs will depend largely on their business model. Those seeking to consolidate around their core product and/or service strengths will have a relatively narrow and medium-term horizon whereas those seeking to expand their business and/or product range, including through mergers and acquisitions, will have a wider horizon. Others which have a stronger eye on business sustainability and longer-term growth will have a longer-term horizon to identify emerging opportunities where through creating appropriate development plans now, including through research and product development, they will be more likely to be able to secure a future market-leading position. For OEMs, tracking RD&D across all TRLs will be a key focus for horizon scanning along with evolving markets. This suggests a role for Hype Cycle, S-Curve and Lifecycle Tracking approaches.

UTILITIES

A traditional definition of an electricity utility is a company in the power industry (often a public utility) that engages in electricity generation, supply and distribution of electricity. However, as a consequence of deregulation/privatization, decentralization and democratization of the energy sector, the concept of a 'utility' has tended to give way to greater specificity in the roles of power system stakeholders, whilst traditional vertically integrated structures have been largely dismantled. One consequence of this is that, in addition to the traditional roles of Electricity System Operator, Generator, Network Operator and Energy Supplier, new entrants, including Energy Storage Operators, Aggregators, VPPs and Virtual Lead Parties[1], Distribution System Operators, Independent Network Operators and Energy Communities have emerged and gained inroads into what have been historically regarded as national or regional monopoly businesses. This also extends to businesses that focus on 'behind-the-meter 'or 'grid-edge' aspects of the electricity supply chain, including home generation, energy storage and flexible demand, commonly described collectively as consumer energy resources (CER).



Technology and system innovation breakthroughs can create new business opportunities that utilities and others are able to exploit.

Conversely, stronger (or more restrictive) regulation, stressed financial markets, energy policy uncertainty and/or weak policy support might see utilities take more of a follow and retreat approach.

Where any given utility sits on the matrix will be determined by their business culture (reactive or proactive) and environment (closed or open).

This paper considers four categories of utility, each of which will have a business-specific perspective on horizon scanning and forecasting, whist recognizing that other 'non-utility' businesses will also play a role in the services, and even the infrastructure, that these traditional utilities have historically provided. In each case the reach (how far into the future) and breadth (scope) of horizon scanning activity will depend on where the utility positions itself in terms of its interest in exploiting technology and system innovation, and its appetite for business consolidation or expansion, or alternatively their appetite for trading-off risk and reward according to their business culture. An EPRI report: Toward Net Zero - The Evolving Utility Business Model and Possible Future Scenarios[2] suggested that utilities could be differentiated according to where they position themselves on the following matrix.

Taking each of the above four quadrants in turn…

Utilities Follow

A utility that is positioned in the bottom-left **'closed -reactive'** quadrant of the above matrix will generally use horizon scanning to seek opportunities to maintain, rather than grow, its market position with a focus on compliance rather than expansion. Its focus will be on evolutionary rather than revolutionary opportunities, preferring to adopt a lower risk strategy by following rather than leading the competition. It will also use horizon scanning to identify potential business threats, due to either statutory, regulatory or market developments.

Utilities Retreat

A utility positioned in the bottom-right **'open-reactive'** quadrant will be more open to business growth opportuni-

1 In Great Britian, VLPs are able to participate in both the Balancing Mechanism and Replacement Reserve market.
2 https://www.epri.com/research/products/000000003002025745

ties revealed by horizon scanning but limited to activities falling within its 'comfort zone' or constrained by virtue of limitations imposed through its licensed activities (for example a network operator may not be permitted to build and operate grid-scale energy storage). It will focus on its core strengths rather than taking risks with new or radically different business models or technologies, or previously unexplored markets. Horizon scanning will also be used to identify the emergence of competition that could threaten its market share.

Utilities Lead

A utility positioned in the top-left '**closed-proactive'** quadrant will have a greater appetite for transformational change rather than relying simply incremental change—but continuing to operate and grow within the bounds of its statutory or regulatory limitations. Horizon scanning will be used to seek technological or market developments which might currently be relatively immature, but which might potentially create opportunities for growth or higher returns, provided the company is prepared to manage the risks involved in taking a leading position, for example in developing a technology from (say) TRL6 to TRL9.

Utilities Disrupt

A utility positioned in the top-right open-proactive' quadrant will use horizon scanning to seek out both established and relatively immature technologies or business models that have the potential for the company to expand its activities into new as well as existing areas of operation. For example, a utility might see an opportunity for a revolutionary change to energy system architecture, a radical overhaul to its business structure, or a chance to create a separate (possibly unregulated) business that is able to promote new technologies into existing or new markets. The most open and proactive utilities might consider the option to expand into other energy vectors, or even other related sectors.

The remainder of this paper provides some specific examples of how electricity utilities, including both traditional utilities such as Electricity System Operators, Generators, Network Operators and Energy Suppliers—and new-entrants such as Energy Storage Operators, Aggregators, VPPs and Virtual Lead Parties, Distribution System Operators, Independent Network Operators and Energy Communities—might undertake horizon scanning through the Qualitative Indicators approach.

Three complementary aspects of horizon scanning are considered: electricity system operational management, electricity markets, and regulatory frameworks. Although these examples relate to the electricity sector, similar aspects of horizon scanning will apply to other energy vectors.

ELECTRICITY SYSTEM OPERATIONAL MANAGEMENT

KEY AREAS TO MONITOR	SIGNPOSTS
• Overall growth in zero-carbon generation capacity (wind, solar PV, SMR/AMR, hydrogen, and CCUS abated CCGTs • Scale and rate of displacement of synchronous generation with inverter-connected wind and solar PV to meet net-zero and other environmental targets • System balancing: – Requirement for intraday supply and demand-side flexibility services – Availability of demand flexibility services to reduce demand under tight system margin conditions – Requirement for inter-day and seasonal flexibility • Frequency control – requirement for new dynamic frequency response services: – To continuously maintain frequency within operational limits – To respond to sudden changes in generation output or demand – Post-fault to contain rate of change of frequency • Constraint and curtailment management mechanisms – To curtail excess generation output (from self-dispatching plant) – Flexible demand response services to maintain system security of supply obligations – To prevent network overloads or voltage management issues arising from reverse power and/or reactive flows due to distributed generation • System restoration capability: – Sufficiency of emergency demand reduction provisions to contain post-fault frequency collapse – Ability to create stable power islands when rebuilding the system though sufficient fault-level contribution and reactive control – Ability to overcome cold pick-up and latent demand due to loss of embedded generation and demand diversity • Requirements for grid-forming capability to maintain system stability and provide system restoration capability (including through distribution system connected anchor generators) • Short and long-duration grid-scale energy storage capacity for system balancing and ancillary services • Scope for BTM storage, smart EV charging, and V2G/V2H to support system balancing and network constraint management services • Reactive power capability to maintain voltage within operational limits and prevent over-voltage issues due to increasing system shunt capacitance and reverse VAR flows • Interconnector capacity to provide system security and balancing services • System perturbations – for example, oscillations due to control interactions of inverter-based resources (IBR)	• Annual demand (TWh) • ACS peak demand (GW) • Minimum system fault levels • Minium inertia levels • Harmonic levels and voltage depressions • Dispatchable generation capacity • System margins • Reactive flows • Reactive injection and absorption capability • Coordination of procured flexibility services (including common platforms) • Growth in BTM storage and levels of adoption of smart EV charging and V2G/V2H • Availability of short and long-duration energy storage capacity: BESS, pumped hydro, CAES, LAES, hydrogen • Ratio of GFM:GFL inverter based resources (IBR)

ELECTRICITY SYSTEM MARKETS

KEY AREAS TO MONITOR	SIGNPOSTS
• Wholesale – possible transition to zonal or nodal pricing • Capacity Markets – trends in capacity charges during a transition to inflexible zero marginal cost/zero carbon sources • Contracts for Difference – trends in strike prices across allocation rounds • RAB mechanisms – level of deployment to support capital-intensive technologies (for example, nuclear) • Transmission and Distribution Use of System Charges – potential for regional pricing • System Balancing – including progress with wider access arrangements extending to non-licensed VLPs • Ancillary Services – degree of coordination in services provided to ESO and DSOs • Network Access Charges – connection charge boundaries for demand, generation, and energy storage • Environmental and social obligations	• Impact of zonal or nodal pricing on traded prices • Cost of flexible generation capacity • System balancing costs • Constraint payments • Ancillary service cost reductions due to coordination • TUoS/BSUoS/DUoS trends

ELECTRICITY SYSTEM REGULATORY FRAMEWORK

KEY AREAS TO MONITOR	SIGNPOSTS
• Trends in use of incentive-based/rate of return/revenue cap/RPI-X/RIIO mechanisms • Assumed cost-of-capital – debt and equity (nominal gearing) • Capitalization rates • Business plan incentives (customer value propositions and cost justification) • Anticipatory investment allowances • Reliance on re-openers/uncertainty mechanisms • Innovation incentives and funding mechanisms • System and network performance incentives • Customer service incentives • Network connection performance incentives • Asset stewardship assurance (asset resilience/condition/utilization) • Cost-efficiency and sharing incentives (shareholders/customers) • Provision for competition • Energy efficiency and flexibility mandates/incentives • Priority and vulnerable customer registration provisions • Environmental and net-zero provision • Whole system cross-funding mechanisms	• Actual CoC • Overall Capex and Opex (Totex) efficiency savings • Extent of triggering uncertainty mechanisms • Quality of supply trends (CAIDI/SAIFI) • Storm resilience performance • Customer satisfaction surveys • Asset utilisation indices • Asset health/risk indices • Connections performance and competition levels • Losses performance • NPV benefits of deferred investment through flexibility

CONCLUDING OBSERVATIONS

An integral part of the business model – horizon scanning and forecasting should be seen as an integral component of an organization's business model. Identified opportunities should feed into the company's innovation portfolio to explore their potential for value creation, whilst identified threats should feed into to the organization's risk register for consideration of mitigation strategies. The internal cost of horizon scanning and forecasting should be set against the potential value and threat mitigation they bring, particularly for those organizations facing significant disruption, as seen presently in the energy sector.

Utility business model evolution – the future may see the boundaries of the utility redrawn, innovative technologies deployed, new players delivering new services, and the competitive landscape altered. In this context, one key area that utilities must consider is the impact on current business models and how these may need to evolve in response to the challenges and opportunities that low carbon energy transformation presents. The objective of this paper has been to provide a concise overview of the role and value of horizon scanning for energy (and specifically electricity) stakeholders in both informing and continuously refining energy policy and business planning.

Value to wider energy system stakeholders – the value for utilities lies in the use of horizon scanning as an input to their overall business planning cycle from future energy scenarios modelling, through pathways and forecasting, to strategic planning, options assessments, and solution delivery. However, whilst the focus of this paper has been to consider horizon scanning primarily from a utilities perspective, examples have been included to demonstrate that horizon scanning is of potential value to all energy system stakeholders, including government, regulators, and OEMs.

Horizon scanning as an integrated element of strategic business planning – Whether applied as a 'front-end' to technological development of system architecture or as part of managing an evolving business strategy, the greatest value of horizon scanning is obtained when conducted on a regular basis as opposed to a one-time (or annual) exercise and when it is incorporated as an integrated element of strategic business planning and as an input to a companies' overall business risk management. Various tools and approaches are available, some of the more common of which have been described by this paper.

Forward visibility of evolving market and regulatory frameworks – the role of horizon scanning in tracking technological developments is well understood and has been covered comprehensively through earlier EPRI reports. However, by focussing on electricity utilities and closely associated stakeholders (who will have the primary responsibility for developing and delivering a national energy system consistent with legally binding decarbonization and net-zero commitments) it has been possible to demonstrate that there is a value-adding role for horizon scanning in business planning, system operational management, and in providing forward visibility of evolving market and regulatory frameworks. Applied in that context, through the application of horizon scanning and the associated tools and techniques this paper has described, utilities and energy system stakeholders will be better placed to both exploit the opportunities and manage the emerging threats surrounding an inevitably rapid transformation of national energy and especially electricity systems.

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