Market Resiliency Transformation

A Background Brief / White Paper

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by John Cooper
CEO, nextenergi, inc

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I. Introduction: Evolution v Revolution

This white paper describes a problem desperate for the world's attention: energy & environment - two areas essential to our survival that now experience too much change, too fast. Societies and economies find themselves at an inflection point at the end of the second decade of this new century, where we must preserve the good aspects of a monopoly energy sector and promote the future of an emerging market energy sector, for both resiliency & environmental purposes. Aligning trends demand our attention to preserve our reliable, affordable energy economy while shifting to a more sustainable path. This challenge comes into focus when we choose how to invest – preserve the old, promote the new, something in between? In the next few years, investment decisions that we make (or don't make) will have far reaching impacts on our personal and collective futures. In this white paper, we suggest three scenarios and develop an argument for the third.

1. **Steady Evolution.** In this *prudent* path forward, we continue to invest in utility infrastructure to gradually green the energy supply & make the grid more resilient.
2. **Renewable Revolution.** At the polar extreme of Steady Evolution, independent vendors deploy energy alternatives deployed in competitive markets, regardless of their impact on incumbents.

To understand how these two scenarios engage with each other, it's critical to understand the scope of the problem, which may be described as the *Pace Problem*. Oriented to preserve system reliability and constrained on multiple fronts, electric utilities constrained both by nature and necessity, move only slowly to adapt to the challenges presented by new technologies and climate change. In contrast, technology companies and consumers, far less constrained and oriented to contest the status quo with innovative approaches to problems, embrace change, even seeking to accelerate the pace of change to their advantage. Utilities risk falling further and further behind in this bipolar emerging market, if they're not able to accelerate their adaptations to change.

Here an examination of the Pace Problem in relation to the imperative to change is helpful to gain a deeper understanding of the necessary steps that will hasten the advent of a more market-oriented, resilient energy ecosystem. Then an exploration of the incumbent monopoly by way of the utility perspective provides insight into the *Monopoly-to-Market Transformation* already underway, but seldom discussed in such detail. A shift to an evaluation of the potential for DER to integrate with the utility model to enhance resiliency follows, where a shared path emerges and takes shape. In conclusion, a brief introduction of the third middle scenario, **Market Resiliency Transformation,** suggests creative, innovative integration of new technologies and business models that promote rapid market adoption and enhanced resiliency, while supporting our collective, historic investment in grid infrastructure.

II. Energy Sector Adaptation: *A Wicked Problem*

As we consider these scenarios, we must acknowledge that modern society faces a *wicked problem* with regard to the energy sector: collectively, we must both decarbonize the sector & embrace new clean energy technologies while maintaining both economy & reliability/access - the twin pillars of our current energy economy. As with any wicked problem, diverse stakeholder perceptions on change priorities complicate the process of finding solutions – by definition, there are no easy ways out. A key to addressing any wicked problem is to reach some agreement on base level assumptions, then work in collaboration to identify a shared path forward. In this rational approach, successive projects shrink the wicked problem down to size. With collaboration, stakeholders agree on a mutually beneficial approach to reach their objectives.

One preliminary objective in resolution of this wicked problem must be to agree on a desired End State that is "a clean, resilient path that we all can agree on." Such foundational agreement focuses stakeholders on defining the collection of intermediate steps along the way, and appropriate measures to structure mutually agreeable priorities for the transition. A key challenge in the US is some agreement on the disposition of the fossil fuel economy – a shared reality including associated constraints and opportunities.

With that fundamental issues in mind, this brief examines Scenario Three, a hybrid state as a transition mechanism featuring practical adjustments to accommodate new realities that foster an emerging market orientation. Market-based building blocks thus represent the fundamental underpinning to support transformation, winding down reliance on the old system while stimulating an emerging market, and integrating new power systems that improve both end user outcomes and incumbent operations and economics. Incumbent pursuit of grid resiliency is one side of the coin, disruptors' pursuit of power continuity the other side. Thus, Market Resiliency offers a common language to promote collaboration and identify priorities for moving forward.

It shouldn't come as a surprise that incumbents and those who would disrupt the status quo with a competing offer have differing perspectives on change. Less than a decade ago, decentralized energy resource (DER) solutions like rooftop solar power systems were expensive, so incumbent utilities could move deliberately to address change with small trials and accommodating policies like Net Metering. But as prices continue to fall and technologies just keep getting better, DER is not only here to stay, it has become a force to be reckoned with – a more engaged strategy is needed on DER Integration. So today its natural for incumbent utilities to describe DER as "market disruption" and challenge change as moving "too fast," highlighting the need to preserve investments in the grid as utilities sort out how to address this disruptive vector. It is equally natural for outsiders to view DER as a "market development" with multiple positive aspects and challenge the pace of change as "too slow," impatiently embracing the potential of the future. Incumbents must find ways to transform their operations and business model. Outsiders must overcome market maturity challenges and institutional discouragement. These competing paradigms of market disruption and market development challenge all of us to look at the market more pragmatically, asking ourselves "What is the appropriate pace of change and future direction of this emerging market?" This white paper begins with a look at the issues that characterize the current state of affairs, to establish a common baseline for a discussion on likely futures and the pathways we may take to shape those futures for our common good.

III. The Transformation Imperative

Societies and economies today face an array of challenges and constraints in the face of disruptive trends. Some of these challenges are outlined below.

1. **Accelerating Change and Complexity.** Change is accelerating and the new, highly dynamic and unpredictable environment represents a monumental challenge for societies and economies to become more flexible and adaptive, i.e., the *Pace Problem*.
2. **Climate Change.** The nations of the world have aligned behind the objectives of the Paris Agreement and now consider the steps that will be needed to meet their mutual objectives. While pockets of resistance remain (not the least of which is US government plans to withdraw from the Paris Agreement in 2020), there is now near universal agreement that we must decarbonize our energy and transportation sectors to achieve our environmental goals.
3. **Empowered Buyers, Innovative Solution Providers.** A mature Internet economy has empowered buyers, who now gather in social networks and routinely leverage internet procurement to buy commodities at the lowest price. In response, successful sellers seek to avoid such a *commodity trap*[i] by becoming innovative solution providers and getting active on social networks to maintain margins and profitability.
4. **From Consumer to Prosumer.** New technologies and innovative business models drive the creation of new products and services, which enable consumers with increasing autonomy and control. As consumers mature, they become producers as well, i.e., *prosumers*.
5. **Decentralization.** Our historical economy organized centrally, with distributors serving consumers. But newly empowered consumers benefit from technology change that puts value "out at the edge," i.e., *decentralization*. As our economic foundation increasingly leverages on-site elements, driving new operating paradigms that allow decentralized and centralized resources to coexist.

6. **Disintermediation.** As entrepreneurs and large companies outside the electric industry take advantage of new tools and business approaches to insert themselves between existing businesses (incumbents) and their long-term customers, they use value as a wedge to upend long-established relationships, i.e., *disintermediation*.
7. **Supply/Demand Side Equivalence.** As utilities (supply) and energy consumers (demand) each seek to optimize their condition, the opportunity for market equivalence emerges. A *co-optimization* approach begins with each side pursuing their objectives with the goal of minimal disruption to the other side, but ultimately evolves when the two sides actively seek synergy and leverage.
8. **Digitization driven by Technology Maturity.** Historically, electric utilities managed the complexity of the electric grid in a low information environment with analog processes and educated guessing by their most experienced staff. Moving forward, the entire supply chain is being transformed by new processes that leverage digital sensory feedback, rich troves of timely data, data analytics, and data processing both at the edge and in the cloud.

Decentralization and *disintermediation* have historically acted to create disruption, largely independent of incumbent control. In so doing, these trends have driven progress in a maturing IT world, as we moved from vacuum tubes to transistors to integrated circuits, then on to a series of information processing devices like calculators, computers, laptops, video games, smart phones and tablets.[ii] Understanding cross-industry patterns in technology creation and adoption is vital to understanding decentralization and disintermediation. A review of this history of the digital economy[iii] reveals three key capabilities employed to drive progress: 1) *research and development (R&D)* creates new technologies and new capabilities; 2) *innovation* crafts new products, services and business models to leverage new capabilities; and 3) *marketing* commercializes new approaches, educates buyers, stimulates uptake, and achieves economies of scale that drive costs down and market share up. Electric utilities are certainly engaged in such activity today, but as monopolies in a stable industry they have not historically invested in these categories to make them core competencies, certainly not to the degree that their likely market competitors have. This relative difference places utilities at a competitive disadvantage in a time of change.

The telecom industry offers the most cogent example to describe the challenge of rapid change facing the electricity world: how to successfully adapt and transform from infrastructure delivery of commodities (i.e., utility) to creation and delivery of value added products and services (i.e., service company). While there are myriad differences in these two industries, they are quite similar - from the business model perspective in general, and for this transformation challenge in particular. In fact, it would not be a stretch to describe power delivered by electric utilities today as *"dial-tone" electricity*, in so much as reliable, affordable grid electricity delivered to wall outlets so closely resembles the reliable, affordable *dial tone* delivered to phone jacks and wall phones by telephone utilities 30 years ago. Describing it this way is in no way a knock on grid power – to the contrary, universal access to reliable affordable power, and universal telephone services have each become hallmarks of modern societies and economies around the planet. In fact, high reliability and low cost have made dial-tone electricity the quintessential commodity of our modern lives.

But this widely accepted definition of the utility value proposition – providing highly reliable, low cost power – also constrains our collective imagination of what may be possible with new energy technologies; limited to thinking only in terms of lower cost and greater reliability, we may remain blind to the potential of new value added energy services. And if we are to learn from what happened to telecom utilities and apply those lessons to the electric industry, we must start here: imagination is vital to innovation. It would have been a stretch in 1982 to imagine the rapid mainstreaming of the platform/applications economy featuring the Wi Fi/internet-enabled iPhone or iPad 35 years later. Lacking the advantage of that vision, telecoms had to learn by painful trial and error, adapting to new technologies and external pressures over the decades, first with mobile telephony and soon thereafter with the Internet and data services (and now Big Data is leading the telecom industry into yet another massive transformation). In the same vein, while it is nearly impossible from our limited perspective at the beginning of 2018 to conceive what the corollary of a future of personalized energy services might be over the coming decades, it's not hard to see the value in becoming innovative and adaptive in order to manage the transition to that future. It's not hard to imagine this trend line that someday will transform electricity like it did information and telecommunications. And it's only good business practice to evaluate how to improve on our predecessors in the face of similar technology changes, rather than learning the same lessons all over again the hard way. Today we have object lessons to build on.

Just as new services associated with mobile and data telecommunications pushed voice telephony to the sidelines, new forms of energy production, delivery, storage and consumption promise to bypass the grid and offer *non-wires alternatives* to grid plug power for monopoly-bound consumers. The few telephone companies that managed to evolve into telecommunication service providers adapted by replacing declining POTS (plain old telephone service) revenue with new cell phone and internet service provider revenue based on new technologies and value added products and services. In a process that took decades to unfold, the ultimate winners – in the US, that would be ATT and Verizon – swallowed their sisters (i.e., Bell South, Ameritech, NYNEX, PacBell, ATT Long Distance, etc.) to create larger, successful, sustainable telecommunications giants. Traditional telecom didn't go away in the face of technology change; rather, the strongest companies in the sector transformed themselves into something altogether new, shifting from reliable telecom utilities that provided an affordable, universal commodity service – dial-tone voice connectivity – to innovative service companies providing innovative value added services. Notably, many of the less successful telephone companies are no longer around, and therein lies a valuable lesson for electric utilities as industry transformation unfolds: there are no guarantees going forward.

As value added energy products and services mature with new technologies and business model innovations, the electricity industry is most likely to follow a similar path to that experienced by the local and long-distance telephone industry over the last 30 years. Value-added product and services revenues will gradually displace traditional revenues that utilities earn through rates for providing reliable kWhs over the grid. Individual ratepayers will invest in energy efficiency and third party on-site energy solutions to lower their bills. Collectively, such activity erodes utility revenues still needed to support long-term grid investments: greater value for consumers becomes an existential challenge for electric utilities.

What seemed like a trickle of innovation a few years ago, a far off phenomenon for utilities in Germany, Hawaii, or California, has already developed into a clear and present threat for electric utilities worldwide, as technology advances and scale economies drove myriad distributed energy resources (DER) to become innovative consumer devices and solutions sold in commercial markets at ever-lower prices. These trends, whether they take two years or ten, are clear and distinct. Our individual and collective choices at the industry and company level today will determine whether electric utilities in the future remain relevant with new, more dynamic roles to play, or whether they are relegated to a supporting role, leaving new DER-based service companies to enjoy the major growth in energy services because they are better able to offer innovative value using new technologies and new business models.

In this future of increasing uncertainty, we all have a vested interest in the continued health of the electric utility sector. It is vital that electric utilities acquire the flexibility and adaptability to address emerging threats and seize opportunities as they arise, because we need the grid to remain strong. We will need affordable and widely accessible plug power for decades to come, industries will continue to need intensive power that is not possible from DER, and we need all of our new site-based power systems to be connected in a wired network. Electric utilities are ideally designed to provide these types of economic value over their grids. But to stay competitive, electric utilities will need to divide their focus in two directions simultaneously: first, they will need to modernize both grid operations and the utility business model; and second, they will need to harden their grids to become more resilient to coming disruptions, which may be described as a *transformation imperative*.

IV. The Utility Perspective

The fate of the electric utility sector is largely driven by circumstance and attitude. Utilities now driven by the *circumstance* of a) regulators or legislatures mandating new directions; or b) an emerging competitive environment in California and New York, for instance, have an early opportunity to change and adapt to a new market environment. Likewise, electric utility leadership *attitudes* will drive outcomes: those with an *incumbent bias* will seek to continue in their old ways, promote grid solutions above others, and hold on to monopoly advantages; those with a *disruptor bias* will experiment with new approaches and solutions in order to learn. History is clear which path results in the greatest value over time (hint – usually not the first one). Let us consider the array of challenges facing incumbent utilities, then the corresponding opportunities for adaptation.

A. Constraints & Challenges That Undercut Utility Strengths

1. ***Decarbonization* based on Growing Awareness of Climate Change.** The traditional power system based on combustion of **fossil fuels** (coal, gas, diesel, fuel oil, etc.) is now recognized as less efficient and consequential because of its CO_2 pollution. This challenges applies to the Generation segment of utility operations, highlighting the risk of stranded investment and limitations of long-term capital cost recovery.
2. ***Decentralization* from Onsite Power Maturity.** As onsite power options grow – solar power declines in price, energy storage is bundled, microgrids mature into viability, we see a shift from traditional **remote** power plants and associated power transmission and distribution to decentralized energy resources (DER) positioned onsite next to energy consumption. This challenges applies to both the Generation and Transmission segments of utility operations, highlighting the risk of stranded investment and limitations of long-term capital cost recovery. Transmission risks in particular are compounded when the need for new transmission facilities to transport new remote renewable energy meets investment challenges and public resistance to siting these facilities, characterized by the NIMBY acronym: Not In My Back Yard.
3. ***Decapitalization* in an Atmosphere of Increasing Economic Uncertainty.** The traditional electric business model was to engage monopoly electric utilities with large projects requiring significant **capital** investment (i.e., used and useful). Service Contracts represent a lower risk portfolio approach to accommodating future needs and risk as an alternative to long-term capital investments.
4. ***Disequilibrium* in Resource Planning.** With so much uncertainty, resource and system planning becomes less effective and can no longer extend over long periods of time in a less **stable** environment. Today's planning must be completed in shorter cycles, replaced with practical iterative innovation.
5. ***Derisking* to Achieve Resiliency.** More frequent extreme storms lead to extended outages, highlighting the value of power continuity and challenging traditional perceptions of **reliability**. In a market-based electricity economy, power continuity can transform into a service where energy consumers will pay more for assured power continuity based on how much they want to avoid the potential of power outages or worse, extended power outages.
6. ***Demonopolization* and *Disintermediation* based on New Market Alternatives.** Energy use is flat or declining based on energy efficiency gains. Each DER deployment becomes evidence of a gradual decline in the share of energy from **monopoly** utilities, as increasing options for end users grow into more *non-wires alternatives* like onsite solar power bundled with energy storage, etc. New companies in the electricity sector with advantages not available to **monopoly** utilities, burdened by grid orientation, utility pensions and universal service obligations, lead utilities to evaluate new business models to remain competitive, for instance with platform innovation and emerging value-based services.
7. ***Digitization* of Utility Operations.** Under the term *Smart Grid*, utilities invest in digital sensors to integrate operations technology (OT) in the field with information technology (IT) that manages digital data. Key challenges in Smart Grid include finding ways to pay for these modernization initiatives and accommodating new risks that come with interconnecting formerly segregated components of the grid (i.e., *cybersecurity*).

B. New Opportunities Offer Utility Rewards If Developed

1. ***Operational* Improvements.** As operators of large complex infrastructure systems, electric utilities have their best opportunity in finding creative ways to improve their systems operations. Such improvements will both enhance system resiliency and improve profitability. A list of potential operational improvements includes
    a. **Feeder Resilience.** Individual low voltage circuits (*distribution feeders*) carry electricity to end-use consumers. Using new DER technologies and business model innovations offers the potential to improve the resilience of these facilities in the face of disruptions (see *DER Resilience* section below).

    b. **Feeder Management.** In a similar way, using new DER technologies and business model innovations offers utilities new management approaches to complement or replace central control center management strategies and solutions.

    c. **Right-Sizing (Generation to Grid).** When comparing a large capital intensive generation resource located many miles from the loads that it serves and a portfolio of small onsite DER systems close to loads, we find that the portfolio can achieve a much higher capacity utilization rate. In other words, smaller more flexible local systems can more closely align with expected peaks in energy consumption, providing a complement or substitute to larger remote facilities.

    d. **Service-Oriented Infrastructure.** Support and integration of customer-owned DER facilities is in the best interest of the utility when services from these new resources can be obtained at a favorable rate relative to owning more expensive infrastructure. If utility rules allow buying services in lieu of investing in infrastructure, the utility can address operational improvements more flexibly without the time or money associated with infrastructure investments.

2. **Market-Oriented Improvements.** Active participation in emerging markets, for instance, stimulating the development of competitive non-wires alternatives in their service territory, provides utilities opportunities to earn revenue not available with a monopoly infrastructure orientation. A list of market-oriented improvements includes:
    a. **Electrified *Transportation* Sector for New Revenue.** Electric utilities are best positioned to benefit from any shift from gasoline to electricity. The utility can become the market disruptor, taking aim at gas stations by substituting electricity for gasoline and diesel fuel. Electric vehicles require ready access to charging systems; addressing the chicken & egg nature of this new opportunity is in utility hands. If they should chose to pursue a strategy of revenue growth by embracing EVs, utilities would enjoy a dramatic increase in new revenue, but they would also need to adapt their systems and processes.

    b. **Energy *Storage* System (ESS).** ESS is expensive now, but prices are dropping and technologies are improving. Incorporating ESS will be highly disruptive - current processes assume the absence of economic storage alternatives – but ESS would improve both utility service quality and operational efficiency. Adding ESS in a big way is widely viewed as transformative and a game changer for utilities, enabling new services and revenue.

    c. ***Critical* Energy.** Electricity for critical infrastructure (e.g., water / wastewater plants, public safety stations, hospitals and nursing homes, gas pumps, etc.) benefits from creative onsite power. Providing for *power continuity* for critical energy – is a key component of a resilient power system.

    d. ***Personal* Energy.** Electricity as a service in the future will be based on a more expansive value proposition, as compared to *commodity* electricity where value is simply lowest price. Investment decisions that simply consider *lowest cost of energy* (LCOE) are calculating value based on the old power system. Future value may be found in developing new, innovative forms of energy services.

e. ***Positive* Energy.** Electricity is generally seen as meeting the needs of loads at consumer sites. But when consumers can become prosumers by locating onsite power systems, and can economically deploy systems that generate surplus electricity as part of the design, a positive (surplus) energy scenario opens up merchant capacity and new forms of revenue for prosumers.

f. ***Platform* Integration.** Platforms are a new form for generating value in the digital economy (e.g., Google, Apple, Facebook, Amazon, etc.). New energy companies can use platforms as a way to deliver new value.

g. ***Value* Stack.** When we shift from cost alone to comprehensive value, a way to assess new investments opens up local power as being on par with low cost remote power. Value stacks for local power may include economic development, workforce development, local resiliency, local real estate improvement, none of which are enhanced by low cost remote power.

h. ***Equity* Injection.** Monopoly electric utilities have advantages over new market entrants, including brand recognition, customer loyalty, low cost marketing, and low cost capital. Utilities may choose to invest in local power service providers as a way to participate in new innovative approaches to market resiliency.

C. Monitoring Risk Indicators

In years past, coal miners would traditionally take a canary in a cage down into the mine with them as an early warning device to let them know that air quality was becoming unsuitable to support human life. When the small bird with its rapid respirations collapsed, miners knew it was time to beat a fast retreat from the mine – danger was imminent! What might we consider today to be the "canaries in the coal mine" regarding imminent threats to the electric utility industry? We only have to go back a few years to gather these few examples – there are many more besides those cited below.

1. **DER Rising.** Since publishing a landmark study in 2012 in collaboration with California utility PG&E, the Rocky Mountain Institute has monitored and reported on the deleterious impacts of DER on electric utility business and operations.[iv] That 2012 report concluded that utilities should understand the impacts of DER, adjust rates accordingly, and adapt their business models to increasing efficiency and DER.
2. **Service Business Model.** News in 2013 from Germany, an early and enthusiastic adopter of solar PV, showed that while feed-in tariffs drove rapid adoption of distributed generation to meet green objectives, these tariffs had a significant unintended impact when all that renewable energy, along with high gas prices, made it more difficult to dispatch the power from new gas power plants. German utility RWE opted for transformative change in 2013 by shedding its fossil fuel generation business, shifting focus to a services business model after losing a significant amount of its shareholder value in a short time.[v] Then in late 2014, Germany's largest utility, E.ON, followed suit, announcing that it would divest its traditional utility business to focus on energy services.[vi]
3. **Potential for Rapid Disruption.** In March 2013, a Harvard Business Review article titled *Big Bang Disruption*[vii] described the potential of platform economics to rapidly disrupt existing businesses by introducing new levels of value made possible by maturing technologies and innovative business models. Building on Clayton Christensen's *Innovator's Dilemma*[viii] from the mid-1990s, the authors described a new trend that indicates the need for a new level of concern among powerful incumbents. To survive, incumbents should eschew conventional wisdom, understand the changes coming, and slow the oncoming innovation long enough to beat it. Otherwise, incumbents should expect to be upended, or even driven out, unless they're prepared to radically change themselves if circumstances warrant. *"The good news is that big-bang disruptions hold immense potential for those who can quickly learn the new rules of unencumbered development, unconstrained growth, and undisciplined strategy. Your current business may be replaced by something more dynamic and unstable but also more profitable. And the change will come not over time but suddenly. In other words, not with a whimper—but with a bang."*[ix]

4. **Utilities are Poorly Positioned to Respond to Rapid Change.** Just a few months later, in June 2013, the 35th DRUID Celebration Conference in Barcelona, Spain, included a white paper entitled *Creative Destruction and the Natural Monopoly 'Death Spiral': Can Electricity Distribution Utilities Survive the Incumbent's Curse?*[x] This paper described the risks associated with current technology trends, drawing some alarming conclusions. A survey of 18 electric utilities in the UK and Australia, representing over 80% of those two sectors, concluded that the threat of a *Utility Death Spiral* (see Enterprise Risk below) was real and more likely than many have yet acknowledged. Compounding the threat of disruption is the poor positioning of electric utilities to adapt and respond rapidly to sudden, or even evolutionary fundamental changes. The author documents 13 "Rigidities and Inhibitions" inside utility organizations that make it very difficult for them to rapidly respond to threats that require significant change and innovation. While the utility death spiral has been largely dismissed in the years that followed its open discussion, these underlying risk factors remain.
5. **State Regulators are Initiating Industry Transformation.** Multiple state regulatory bodies are driving industry transformation under their purview (e.g., NY, MA, CA, HI, MD, MN, etc.). Most notable may be the ambitious Reforming the Energy Vision (REV) of the NY State Public Service Commission, launched in spring 2014,[xi] now approaching its 4th Anniversary. REV introduced a pathway to integrate centralized and decentralized energy under the guidance of one or more *distributed system platform providers* or *DSPs*, an innovative market design based on a new energy services platform role for incumbent utilities.

D. New Risks on the Horizon

Together, the "canaries in the coal mine" above expose a trend line of real disruption on the horizon, what we might call a rising *Transformation Risk*, a broad term that includes at least five subcategories, which take their place alongside such traditional energy sector risks as reserve margins, system outages, cyber security, market exposure, long-term planning and capital expenses, etc.

1. **Operations Risk.** Over the past few years, two concepts, the *Duck Curve* in California[xii] and the *Nessie Curve* in Hawaii,[xiii] describe the impact of increasing levels of solar PV on traditional grid operations. Prime examples of Operations Risk, these two concepts evaluate increasing levels of DER on the edge – where the grid terminates at the customer site – that will make the grid increasingly difficult to operate under the current system paradigm, including the new risk of power backflow on heavily loaded circuits.
2. **Enterprise Risk.** The introduction of the phrase *Utility Death Spiral*[xiv] into the mainstream usage 5-6 years ago, introduced above, highlights a second subcategory of risk, where rate increases become necessary when sufficient DER penetration reduces utility revenues. Besides making utility financial statements whole, rate increases also accelerate *grid parity* and enhance the appeal of DER, driving even more penetration, making further rate increases necessary. The end result is a negative self-reinforcing cycle that earns the scary title *Death Spiral*. Sounds like a *Black Hole* – stay away! But not so fast, as most now dispute the nature or even possibility of such an outcome. That said, the risk of flat or declining revenues is real, and reduced revenue constrains a utility's financial ability to respond to changes by becoming more flexible and adaptable.
3. **Organizational Risk.** This next subcategory begins with the well-documented challenge of replacing aging utility workers, but expands when organizational changes in business processes, job descriptions, and business model are contemplated. Slow to change, utility organizations find it difficult to mobilize against threats, discussed as the "Rigidities and Inhibitions" in the DRUID Conference white paper mentioned above. This challenge is compounded when most utilities have been through reorganizations and budget cuts that have left them leaner, but with slim resources to manage necessary changes. As workers take on additional tasks, their core job functions face the risk of disruption.
4. **Market Risk.** The rise of a more mature energy consumer, adopting new consumption patterns and encouraged by energy service companies to leverage DER, creates this next subcategory of risk. Utilities will have to open up to

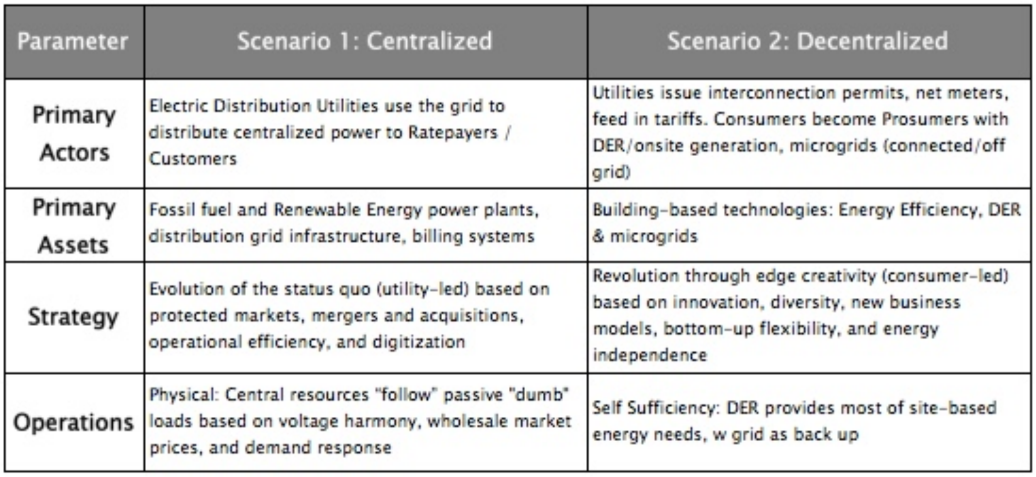
collaborate with a more empowered energy consumer with more demanding expectations of the utility, or risk losing their natural role as local energy subject matter expert to those more willing to engage with energy consumers in new ways, on new terms. And as the utility loses its historic role in the community, loss of revenue opportunities are sure to follow.

5. **Regulatory Risk.** Finally, monopoly utilities are still regulated in various degrees, their fates intertwined with regulators as both contemplate transformation. As regulators adjust their thinking and evaluate their options for *industry* transformation, this subcategory of risk for utilities includes managing business transformation inside their organizations and industry transformation expectations of the regulators who set their rates and guide their investments. Utilities must seek to guide industry transformations to be in alignment with their best interests, or suffer actions or inactions by regulators that confound their plans.

V. Steady Evolution & Disruptive Revolution

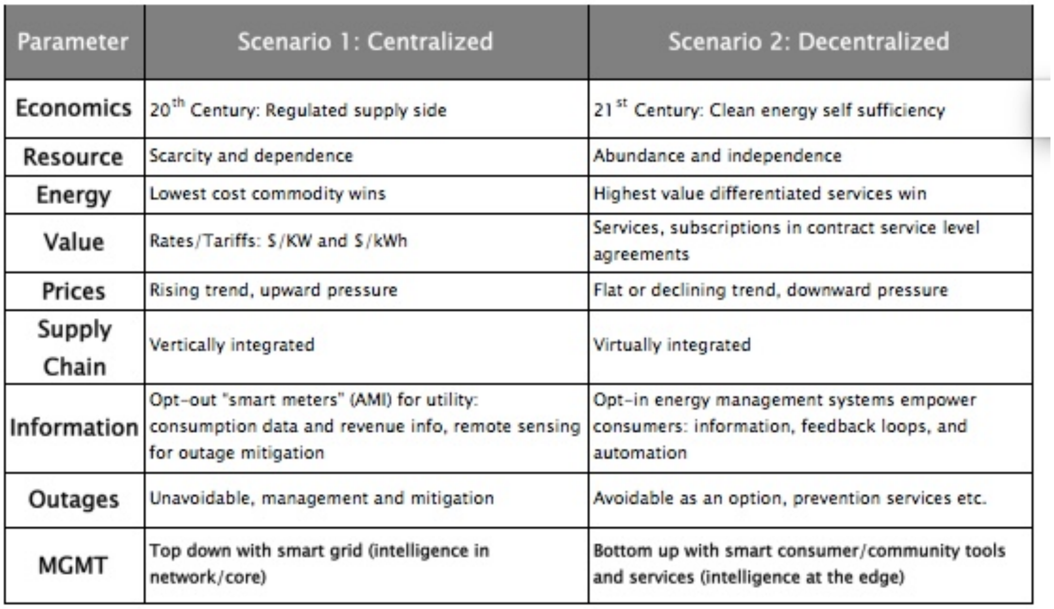
A. Contrasting Centralized and Decentralized Energy

The electric utility arose as an organization whose business model was to distribute a centrally produced commodity, delivered and metered as a kWh by monopolies with prescribed service territories. The rise of decentralized systems, on the other hand, offers consumers a grid alternative, almost a polar opposite, which would-be utility competitors embrace by offering clearly differentiated and diverse energy products and services with added value. The argument presented herein is that to remain competitive, utilities must do nothing less than manage a transition to create a hybrid of Centralized and Decentralized business models, securing their traditional business while developing an answer to the challenges of new competitors – but that's not to say that it will be easy, or that utilities will embrace this imperative by shifting their paradigm.



Parameter	Scenario 1: Centralized	Scenario 2: Decentralized
Primary Actors	Electric Distribution Utilities use the grid to distribute centralized power to Ratepayers / Customers	Utilities issue interconnection permits, net meters, feed in tariffs. Consumers become Prosumers with DER/onsite generation, microgrids (connected/off grid)
Primary Assets	Fossil fuel and Renewable Energy power plants, distribution grid infrastructure, billing systems	Building-based technologies: Energy Efficiency, DER & microgrids
Strategy	Evolution of the status quo (utility-led) based on protected markets, mergers and acquisitions, operational efficiency, and digitization	Revolution through edge creativity (consumer-led) based on innovation, diversity, new business models, bottom-up flexibility, and energy independence
Operations	Physical: Central resources "follow" passive "dumb" loads based on voltage harmony, wholesale market prices, and demand response	Self Sufficiency: DER provides most of site-based energy needs, w grid as back up

These two tables contrast two distinct approaches to an energy ecosystem – one centralized, the other decentralized; one an evolution, the other a revolution. Electric utilities and alternative power providers highlight the polar opposition of these two paradigms on several fronts to make clear the scope of this monumental challenge. With a clear understanding of such differentiated value propositions, utilities may begin to map out their responses to address this disruptive threat. Likewise, a rational understanding of the continuing value of the grid and utilities allows DER vendors to craft collaboration strategies. Recognizing a challenge is the first step to addressing it with creative solutions.



Parameter	Scenario 1: Centralized	Scenario 2: Decentralized
Economics	20th Century: Regulated supply side	21st Century: Clean energy self sufficiency
Resource	Scarcity and dependence	Abundance and independence
Energy	Lowest cost commodity wins	Highest value differentiated services win
Value	Rates/Tariffs: $/KW and $/kWh	Services, subscriptions in contract service level agreements
Prices	Rising trend, upward pressure	Flat or declining trend, downward pressure
Supply Chain	Vertically integrated	Virtually integrated
Information	Opt-out "smart meters" (AMI) for utility: consumption data and revenue info, remote sensing for outage mitigation	Opt-in energy management systems empower consumers: information, feedback loops, and automation
Outages	Unavoidable, management and mitigation	Avoidable as an option, prevention services etc.
MGMT	Top down with smart grid (intelligence in network/core)	Bottom up with smart consumer/community tools and services (intelligence at the edge)

The principal challenge facing the utility industry is not that new players are using new technologies to chip away at utility revenue and to interfere with utility operations and grid stability – they are not victims. Similarly, the principal challenge facing the rising DER sector is not that utilities won't help them to gain markets, but that market maturity challenges (customer acquisition) and value proposition legacies (commodity electricity) prevail. These issues viewed in isolation draw our attention, but they're not the bottom line, rather they're symptoms of a deeper challenge, in three parts, shared by both perspectives – the Pace Problem:

1. **Unbridled Change.** The world is rapidly changing, pushing the utility business model to obsolescence, faster than we might imagine;
2. **Insufficient Response.** Our collective ability to respond is slower than the response the situation demands; and
3. **Decentralized Disruption.** The increasingly decentralized environment is initially characterized by disruption, both gradual and rapid, driven by outside parties using new technologies, which raises the stakes and adds to difficulties in the years ahead.

Put simply, time is no longer on the side of electric utilities and the rise of DERs is accelerating. Both sides have incentives to adapt and work together. **The core challenge for the electric utility is to gain new organizational capabilities and increase flexibility, in order to become more adaptable. The core challenge for DER is to expand the value proposition and mainstream their business model**. In short, both utilities and DER vendors must become more responsive to change. In an increasingly uncertain environment, the ability to anticipate changes, develop scenarios for response, and rapidly craft and adjust strategies will become ever more important. Further, the ability to stay close to customers by leading them in new directions with new services will help to integrate and organize market penetration by third parties, preserving utility revenue and business options, buying more time to engage a managed transition and lowering risk. A positive core focus for utilities is their operations & resiliency, inviting market-based DER vendors to develop the market and channeling market activity in constructive directions that fortify and transform utility operations. A common cause for both sides is Reliability leading to Resiliency.

B. From Reliability to Resiliency

Redefining *reliability* as *resiliency* – going beyond outage *mitigation* or *recovery* to outage *prevention*, will allow utilities to focus and strengthen their operational core competency. For our purposes, DER includes energy efficiency, demand response, distributed generation, energy storage, electric vehicles & charging and microgrids (or nanogrids). Starting with *critical energy users* (i.e., essential operations that must continue during any extended power outage, such as hospitals, police, fire, water, gasoline pumping, etc.) DER will provide high visibility resiliency for foundational infrastructure for both the society and the economy, and also promote long-term sustainability for electric utilities. Attaining outage *prevention* is to become truly resilient, but that's not feasible without onsite energy resources immune to grid outages. DER integration is needed to redefine the core purpose of *high reliability* into *essential resilience* starting with a vision, but continuing with a transition plan.

Historic Monopoly Core Competency: The essential core competency of a monopoly electric utility is to operate a complex, highly-engineered system (i.e., effective grid operations) to deliver reliable, affordable commodity power. These two qualities– affordable rates and high reliability - define electricity and electric utilities today. The grid operator strives to keep the lights on in the face of endless disruptions, from the *trivial* - squirrels and fire ants; to the *infrequent* - drunk drivers & high winds; to the *devastating* – storms, hurricanes, tornadoes, floods and ice storms. Maintaining system reliability by rapidly restoring power after outages is the heart and soul of the electric utility culture.

Affordable Outage Management: Affordability and reliability don't exist in isolation, however. Keeping rates low limits what the utility can do to ensure high reliability. A utility ability to deliver reliability is based on multiple factors, including *age* (how old is the grid?), *weather* (how disruptive is local weather?), and *budget* (how much cost will the ratepayers (and regulators) collectively tolerate for system reliability investments and expenses?). By balancing these factors utilities ensure system reliability as measured in *reliability indices* (e.g., SAIDI, SAIFI, CAIDI, etc.). So, "How Much Reliability?" Financial and physical constraints drive the answer to this question, so that over time a "best-effort" outage management protocol has emerged, where utilities *prepare and react* to external events that damage reliable power service – on a *best effort basis*.

> *Financial* constraints – capital and operational budgetary restrictions – drive system uptime. Under the *regulatory compact*, regulators use rate cases to review plans for normal and crisis operations, balancing the equation between affordable rates and adequate reliability. Thus, capital investments in grid hardening and operational expenses to manage outages have always constrained the ability of grid managers to be prepared to address system outages. A case in point is *tree trimming* – maintenance budgets cut back in good times in the name of efficiency may well be challenged when outages leave utility customers in the dark. In this operating model, spending for reliability always competes with lower rates for ratepayers and higher returns for shareholders/citizens/coop members.
>
> *Physical* constraints – from environmentally-exposed system elements to boundaries in the laws of physics – limit utility operator reactions when it comes to outage mitigation and management. One can prepare for the weather, even predict it with greater and greater accuracy, but an outdoor network will always be exposed to weather-related disruption. Even when burying lines underground, an expensive solution, much of the grid remains above ground, exposed to short circuits from tree limbs and animals, to pole damage from storms and drunk drivers, and to a variety of other environmental threats. In short an above ground distribution network will always be vulnerable. And storms that are more frequent and more powerful only increase this challenge. In the face of increasingly frequent and powerful extreme storms, repairing the grid every time it goes down is becoming an unsustainable strategy.

Reactive, Manual Outage Management: Historically, the grid was the only way to get economical power, so grid operators really had no choice but *reactive* grid outage management characterized by mostly manual processes, only recently adding automated outage management processes. Operators have deployed technologies like sophisticated grid sensors and communication systems as they became available and affordable, first on higher voltage areas then moving out to grid peripheries. Without outage management automation systems like *FLISR (Fault Location, Isolation and Service Restoration)*, many operators still remain unaware of the extent of an outage along distribution feeders at the ends of their network. Without FLISR, these utilities still rely on customer phone calls to pinpoint the extent of an outage, followed by physical line inspections by line crews to locate the fault(s) and determine the extent of an outage, so they can initiate power restoration. In an extensive outage, this manual process can slow recovery, leaving energy consumers without power for extended periods.

Back Up Power: Given the limits of such *best effort* outage management, some customers invested in back up power systems - typically diesel generators paired with fuel tanks - to provide power for a limited time to some or all of their circuits when power went out. Those with greater power sensitivity may also have paired generators with universal power supply (UPS) systems, whose battery banks assured *uninterrupted* power to onsite loads in the event of a grid failure. But either of these back up power strategies has only proved as good as availability of stored fuel. In extended outages as occurred in Hurricane Sandy a few years ago, and in Puerto Rico today, fuel availability and generator operating limitations highlighted the limitations of back up power on its own.

DER Paradox: Adding DER to the grid causes system instability, but only until a certain maturity is reached, when these systems can begin to contribute more to reliability than they take away. How can that be? With more DER, mounting operational instability disrupts operating parameters and imposes risks to system reliability. Intermittent power from solar PV and wind generation requires ample dispatchable power reserves in the event of cloudy weather or a lack of windy conditions. But DER deployed as microgrids and in increasing amounts results in fewer grid outages on a site-by-site basis. In the *DER Paradox*, DER shifts from a disruptor to grid operations to a potential tool to promote greater system stability and improved resiliency. With this new perspective, employing new processes and tools, focusing first on critical use customers, reframes our ideas on system reliability to introduce true resiliency.

Adapting a New Tool for Reliability: A paradigm shift to see DER as one of an array of tools available for grid stabilization is critical to maintaining greater reliability in the face of increasing grid complexity. In a world without DER, best-effort outage management was sufficient for grid reliability, especially when back up power was available. But now that DER is becoming ubiquitous, approaches to reliability must become more versatile, leading to *resiliency*. Utilities can now collaborate with customers for improved system resiliency.

Energy Efficiency: DER now includes a new generation of energy efficiency driven by automation. While passive energy efficiency – for example more efficient light bulbs – is not an active resource the utility needs to worry about, others, such as building and home energy management systems and smart thermostats, cause changes in load that are unknown and unknowable to utilities until after the fact, or through big data analytics that can lead to more accurate forecasting. Again, these technologies reduce system costs, and especially individual customer costs, but add challenges to utility planning and operations.

Demand Response: Demand response (DR) now accounts for five percent of capacity requirements in many markets, with customers responding to a variety of incentives to curtail their load. At the same time, more jurisdictions are deploying time-varying rates causing customers to shift load and take advantage of lower off-peak prices. For example, in California, all commercial customers of the investor-owned utilities are on either peak day prices or time-of-use rates. These actions on the demand side reduce total system costs but introduce complexity in load forecasting and resource planning.

Distributed Solar PV: The *power purchase agreement* or *PPA* was a landmark innovation that allowed small system buyers to get a solar power system for no money down if they agreed to a long-term contract to purchase the electrical output of the system. A falling PPA price based on lower solar module prices and non-panel costs – from balance of system (BOS) equipment like micro inverters, to websites that automate some of the sales and configuration processes to more innovative financing – has turned distributed solar PV from a novel technology to a rising market force, with mainstream adoption and massive penetration on the horizon.

Natural Gas DG: The continuing low cost of natural gas in North America introduces two other distributed generation resources: Micro CHP and Fuel Cells. Natural gas DER as described herein represents a versatile new technology that has the advantage of being dispatchable, leading to a wider array of applications.

MicroCHP: Micro turbine units paired with combined heat and power (Micro CHP) use natural gas and other fuels, operating at high speeds to produce electricity with a dynamo, much like their full-sized cousins in industry and at utilities. These high speeds create "waste" heat, which can be repurposed to heat or chill water for domestic heating or cooling. When the waste heat is used, these units become highly efficient and ideal for a boiler or chiller substitution in a building where there is a consistent need for hot water, heating or cooling.

Fuel Cells: Fuel cells use natural gas as a source of hydrogen, then make electricity through ion exchange. The modular nature of this technology and the low cost of natural gas make this technology increasingly attractive, although price points remain higher than for other types of distributed energy.

Energy Storage: Factors that drive storage growth projections include advances in material science research, economies of scale that lower costs (e.g., Tesla PowerWall), and business model innovations. Two reports by Rocky Mountain Institute found that in many parts of the country, solar plus battery home systems will be the most economical choice sometime in the next decade or so for customers of many utilities.[xv]

Electric Vehicles & Chargers: EVs offer a tantalizing combination of energy and transportation that could be disruptive to electric utilities, petroleum companies and automobile manufacturers and dealers. It is interesting to contemplate that of all the different types of DER, EVs are unique in that they offer a potential large increase in grid electricity demand. But integration of EV charging stations and accompanying modification of distribution feeders, transformers, etc. promise to add significant costs to grid operations as well, suggesting clustering strategies to minimize grid upgrades.

C. A New DER Perspective: From Liability to Asset

Defending Reliability: Focused on system disruptions and preservation of grid stability, most utilities have reacted conservatively to the prospect of adding significant quantities of DER onto the grid. As with any other new technology that might be added to the grid, DER represents a threat to reliability until proven otherwise. Perhaps the two best depictions of the impact of high amounts of DER on the grid are the Duck Curve,[xvi] describing the *potential* impact on the California grid and the Nessie Curve,[xvii] describing *actual* high PV penetration on the Hawaii grid, with challenges including a significantly higher upswing in peak demand in the late afternoon/early evening, and power back flow along high penetration circuits. In the face of this experience, grid operators have viewed advancing DER first and foremost as a challenge to be managed, if not an actual liability to system reliability.

Economic Impacts: Beyond operational impact is the potential negative impact of DER on utility costs and revenues. For vertically integrated electric utilities, DER represents dilution of revenues due to potential "load defection" when energy users substitute on site power for grid power. Wires only local distribution companies (LDCs) may not share a risk concerning lost revenues from alternative generation, but DER still represents potential cost increases for interconnection and other operational issues. Rates themselves must be adjusted, given that increasing DER risks a concentration of system cost recovery on a smaller rate base of customers – fewer and fewer customers paying for the fixed costs of grid operations.

A New Tool: As DER becomes more commonplace and seemingly inevitable, the argument of positive impacts emerges as a new consideration. DER may provide ancillary services, for instance, with the advent of smart inverters, storage and integrated microgrids. DER may have the impact of reducing grid congestion, thereby deferring the need for system enhancements like expanded or new substations. When DER can encourage energy users to reduce grid consumption during peak operations, it can act like Demand Response and become a substitute for tapping supply side solutions. Islanded microgrids have proven to be a durable resource in times of grid distress in Hurricane Sandy, in particular.[xviii] The exploration of DER as a new tool for system resiliency is an emerging area with significant potential, suggesting further study to quantify costs and benefits.

Resiliency Strategy: For DER to enhance reliability, it will be necessary to evaluate each technology on its merits and apply creativity to current problems in grid operations that impact system reliability. As DER becomes more commonplace, the argument of positive impacts emerges. With the advent of smart inverters, for instance, DER may become a provider of ancillary services. DER may have the impact of reducing grid congestion, thereby deferring the need for system enhancements like expanded or new substations. EPRI has begun a process to examine this important issue with the release in 2014 of a report introducing the concepts of grid integration.[xix]

Business Integration: The integration of DER from a business perspective poses interesting regulatory policy and utility strategy questions. Does the proscription for wires-only LDCs from owning generation apply in cases where DER is used to enhance reliability? How is storage to be treated, as a generation resource (when discharging) or a load (when charging)? Will storage require new categories and rules? DER as a new tool for system resiliency is an emerging area with significant potential, suggesting further study to quantify costs and benefits. In July 2015, a second EPRI report tackled the costs and benefits of DER integration.[xx] The analysis below sidesteps many of these questions that will no doubt be debated for years to come in regulatory and legislative arenas. Instead, this white paper proposes two simplified perspectives in looking at DER from a business perspective: for cost containment and reliability enhancement in a regulatory context and for value added services in an unregulated context.

D. DER for Grid Resiliency Enhancement

DER is a tool to enhance grid resiliency, whether deployed by regulated utilities or by private sector third parties. Viewed in neutral fashion, DER presents an opportunity for grid engineers to reconsider their protocols for reliability and outage management, when more and more of these new technologies are deployed within the service territory.

Interconnection Process & Fees: The grid interconnection process for DER systems has been described by DER vendors as an area for potential cost reduction and simplification. Reform in this area could potentially benefit utilities, vendors, and customers alike. But as DER grows more prevalent, regulated utilities must understand obligations and motivations when it comes to interconnection processes that ensure reliability but do not add unnecessary costs. Interconnection fees may prove to be a tool for driving reliability outcomes on the grid, as described in Reliability Pricing below.

Cost Recovery: Regulated utilities are likely to seek assurances from regulators for prudent costs associated with DER interconnection to be allowed full cost recovery going forward. Along with direction on interconnection processes and fees, cost recovery is paramount for regulated utilities when considering DER.

Location Matters: When spread throughout a distribution territory in discrete amounts, DER could remain innocuous and unthreatening. But when concentrated in clumps, the potential to cause disruption increases considerably. Incentivized by utility rebates and investment tax credits, early DER systems gravitated to higher end neighborhoods where disposable income enabled the purchase of higher priced systems. Thus far in the history of DER implementation, the location of DER has been more a matter of market adoption than utility control. With regard to reliability, location matters when it comes to DER: irregular distribution drives higher risks.

Resiliency Pricing: The irregular clumping evidenced in DER deployments results, in part, from a lack of price signals to customers deploying DER. What may be termed "resiliency pricing" attached to DER interconnection fees that follow certain conceptual guidelines[xxi] has the potential to affect the distribution of DER in a service territory, providing utilities with the hope of directing the dispersion of DER in their service territories. For example in a carrot and stick approach, DER deployments may be promoted with lower interconnection fees to stimulate deployment in congested areas of the grid, enhancing resiliency. Likewise, where DER deployments aggravate present or trending areas of high DER penetration, higher interconnection fees may moderate deployment. In fact, regional transmission planning organizations do something similar when they use *congestion pricing* and *nodal* approaches to drive decisions by generators.[xxii] In addition, the public utility commissions in New York and California now evalutate locational pricing in the distribution system to send appropriate price signals for locating DER investments. Any fee differential would of course need to be both equitable and significant enough to drive desired behaviors in siting, which may or may not be feasible.

Continuous Dynamic Distribution Plans: But how would a utility know just where to influence DER locations to improve system reliability, if it were to be afforded that opportunity with new reliability pricing or other alternatives? In a new more dynamic environment, where DER deployments routinely change the capacity of distribution grids and impact daily operations, distribution system planning must become much more detailed, deliberate and frequent. Dynamic DER-oriented resource planning will become a part of new *distribution resource plans (DRPs),* for instance, offering guidance to enable a utility to take control of a heretofore-organic market process driving DER adoption and deployment.

E. DER for Resiliency Services

DER may become an unregulated service offered by utilities to provide energy consumers with power continuity – enhanced resiliency as a service. In a market environment, those who seek it are likely to choose higher reliability if offered, all the way up to seeking guarantees of power continuity regardless of circumstances. DER by design affords such new types of value.

Unregulated DER Services: It may be that some electric utilities choose to pursue a less constrained set of opportunities when it comes to DER. In fact, the solar PV power purchase agreement (PPA)[xxiii] provides ample evidence of the potential of adjusting a business model, shifting from a commodity approach of selling rooftop PV systems to a value-added service approach of selling electricity from those systems. The rapid uptick of residential solar PV adoption is closely correlated with the introduction of PPAs around five years ago. Prior to PPAs, customers mostly bought rooftop systems with long-term payback periods. When PPAs became available, they rapidly spread to become the predominate form of residential participation in the distributed PV market. Perhaps the biggest driver for utilities to opt to pursue an unregulated business in DER is the advent of widely successful third-party DER vendors introducing DER in their service territories. Proscribed from offering DER retail services through their regulated distribution companies, utilities may consider unregulated DER services as a high-growth competitive alternative to their regulated business, as well as a means to remain competitive to new DER vendors. Irrespective of being offered by utilities or third party vendors, this section explores the potential of DER as a service both to support power continuity for individual consumers and to improve system resiliency.

On Site Generation/Storage as a Service: Onsite generation and/or energy storage hold great potential as a new value added service. Natural gas fuel cells, micro turbines and smaller reciprocating engine generators offer an attractive opportunity for natural gas subsidiaries of electric utilities in particular to extend their supply chain, expanding the value of a natural gas connection to afford power continuity. When combined with energy storage, solar PV can offer a degree of power continuity not possible with solar PV alone. These two solutions merely sample the endless variety of value added services possible by combining different DER technologies with innovative business models.

Microgrids as a Service: The full expression of power continuity via DER may be found in the microgrid, a robust combination of multiple DER technologies with a management system to enable *islanding* - operations made independent from the grid by connecting and disconnecting at will. Microgrids have grown popular as technology has improved, prices have come down, and extended grid outages have become more common. When offered as a service in a long-term PPA with a management contract, microgrids become a new tool with tremendous potential to support power continuity for commercial, industrial and municipal consumers. Should microgrid operators choose to collaborate with grid operators, microgrids would offer tremendous opportunities for greater system resiliency. Microgrid target segments traditionally include campus facilities, such as military bases, college campuses and corporate campuses. Shifting the definition away from a collection of buildings enlarges the market to include emerging commercial market segments such as sensitive manufacturing facilities, lodging (e.g., hotels/motels), and retail facilities.

Critical Energy User Services: For some energy users the use of energy is critical not only to that organization's purpose, but also to society itself. This group of *critical energy users* includes at a minimum, water/wastewater systems, public safety (police, fire, EMS, etc.), public health (hospitals, nursing homes, etc.), telecommunications and information technology (server farms, internet data centers, telecom switching centers, etc.); traffic signals, certain street lighting, and gasoline pumping facilities. Critical energy users have historically ensured their own power continuity with onsite back up power systems. By shifting from back up power to microgrids as a service, these facilities may collaborate with electric utilities to mitigate the negative societal and economic impacts from the extended service outages increasingly associated with extreme storms and in so doing, show the way for other less-critical energy users.

F. Integrating DER & Grid

Beyond contemplating new approaches and uses of DER from a resiliency perspective, utility planners and grid operators must incorporate new decentralized energy resources with their system designed around centralized resources. DER integration remains an open issue, a widely recognized challenge without clear guidelines yet from regulators and industry groups.

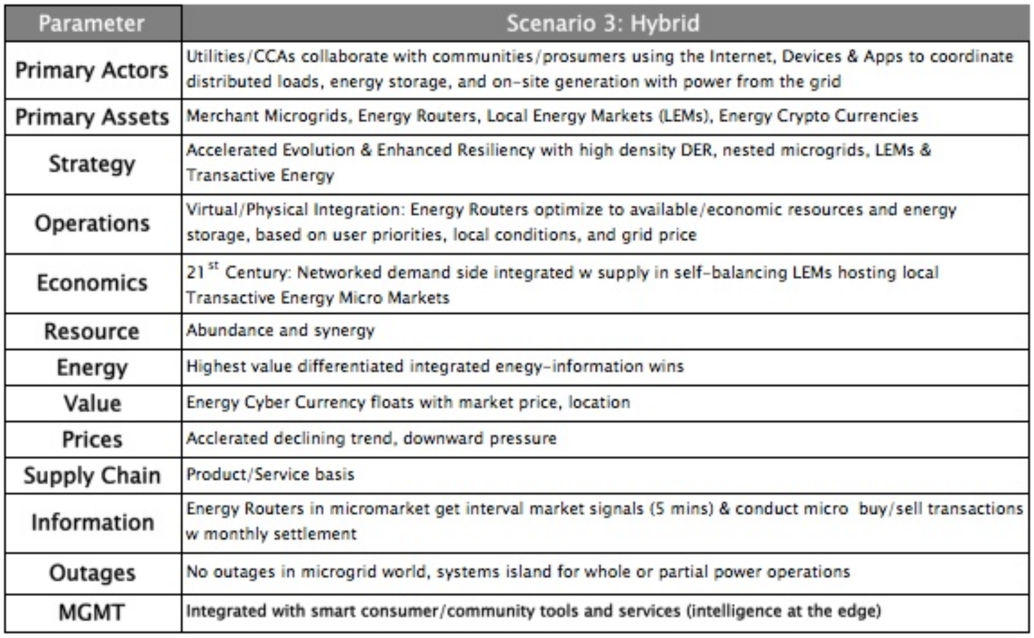
Integrated Strategic Planning: DER changes everything, including planning protocols. The environment of a distribution utility has simply grown much more complex over the past decade. On the one hand, DER is destabilizing unless planned and designed for – ideally, DER will be dynamically integrated into system operations and planning. On the other hand, more extreme storms promise more environmental disruption – more frequent, more extensive, and longer system outages. The Integrated Strategic Planning process is comprised of two parts: Integrated Business Planning followed by Combined Resource Planning. An integrated business plan starts with a vision supported by a set of explicit assumptions, to inform a corporate plan highlighting key business objectives. A combined resource plan starts with traditional Integrated Resource Planning (IRP), accounting for centralized utility resources, combined with a transmission plan and a distribution plan that incorporates DER. The value of this explicit approach is to inform all elements of strategy and deliberately acknowledge the complicating elements of DER and unpredictable, more destructive weather patterns.

DRP and Dynamic Distribution Planning: A conventional distribution plan may be drawn up based on historic usage data and current weather reports. In today's more dynamic environment, a more detailed, complete, and frequent plan is required to evaluate both predictable resources and influencers, and resources recently added to the grid. Under AB 327, the comprehensive energy law in California that addresses the rise of DER, the California PUC required regulated electric utilities to file Distribution Resource Plans (DRPs).[xxiv] More dynamic planning will be needed to complement such massive system planning to reflect DER as it is added to the grid.

Business/Technology Convergence: In more predictable times, technology decisions could legitimately be made without considerable integration with business decisions. From the outset, smart grid has been about information (IT) and operations (OT) technology. More recently, smart grid planning includes determining how these two types of technologies may work together. But in today's more complex, dynamic climate, it is vital to consider the business more holistically and over a significant planning cycle. A deliberate planning process must consider business capabilities, aspirations and then identify gaps. By understanding business to this detail, technologies may be identified as tools to accomplish defined business objectives according to a coherent strategy. In this way, the business can methodically address dynamic technologies and change, with both the foresight and flexibility it will need to achieve its business objectives.

Transmission/Distribution Convergence: The transmission and distribution environments are converging. A call for *Independent* Distribution System Operators (DSOs) in the US,[xxv] underscored this convergence and future joint operations. Transmission business planning and system operations offer a model for the changing distribution grid environment, which must now address multiple generation resources and two-way power flow. With the proliferation of DER, the role of the distribution grid operator is changing, and operations and planning will both be affected.

VI. Market Resiliency Transformation



Parameter	Scenario 3: Hybrid
Primary Actors	Utilities/CCAs collaborate with communities/prosumers using the Internet, Devices & Apps to coordinate distributed loads, energy storage, and on-site generation with power from the grid
Primary Assets	Merchant Microgrids, Energy Routers, Local Energy Markets (LEMs), Energy Crypto Currencies
Strategy	Accelerated Evolution & Enhanced Resiliency with high density DER, nested microgrids, LEMs & Transactive Energy
Operations	Virtual/Physical Integration: Energy Routers optimize to available/economic resources and energy storage, based on user priorities, local conditions, and grid price
Economics	21st Century: Networked demand side integrated w supply in self-balancing LEMs hosting local Transactive Energy Micro Markets
Resource	Abundance and synergy
Energy	Highest value differentiated integrated enegy-information wins
Value	Energy Cyber Currency floats with market price, location
Prices	Acclerated declining trend, downward pressure
Supply Chain	Product/Service basis
Information	Energy Routers in micromarket get interval market signals (5 mins) & conduct micro buy/sell transactions w monthly settlement
Outages	No outages in microgrid world, systems island for whole or partial power operations
MGMT	Integrated with smart consumer/community tools and services (intelligence at the edge)

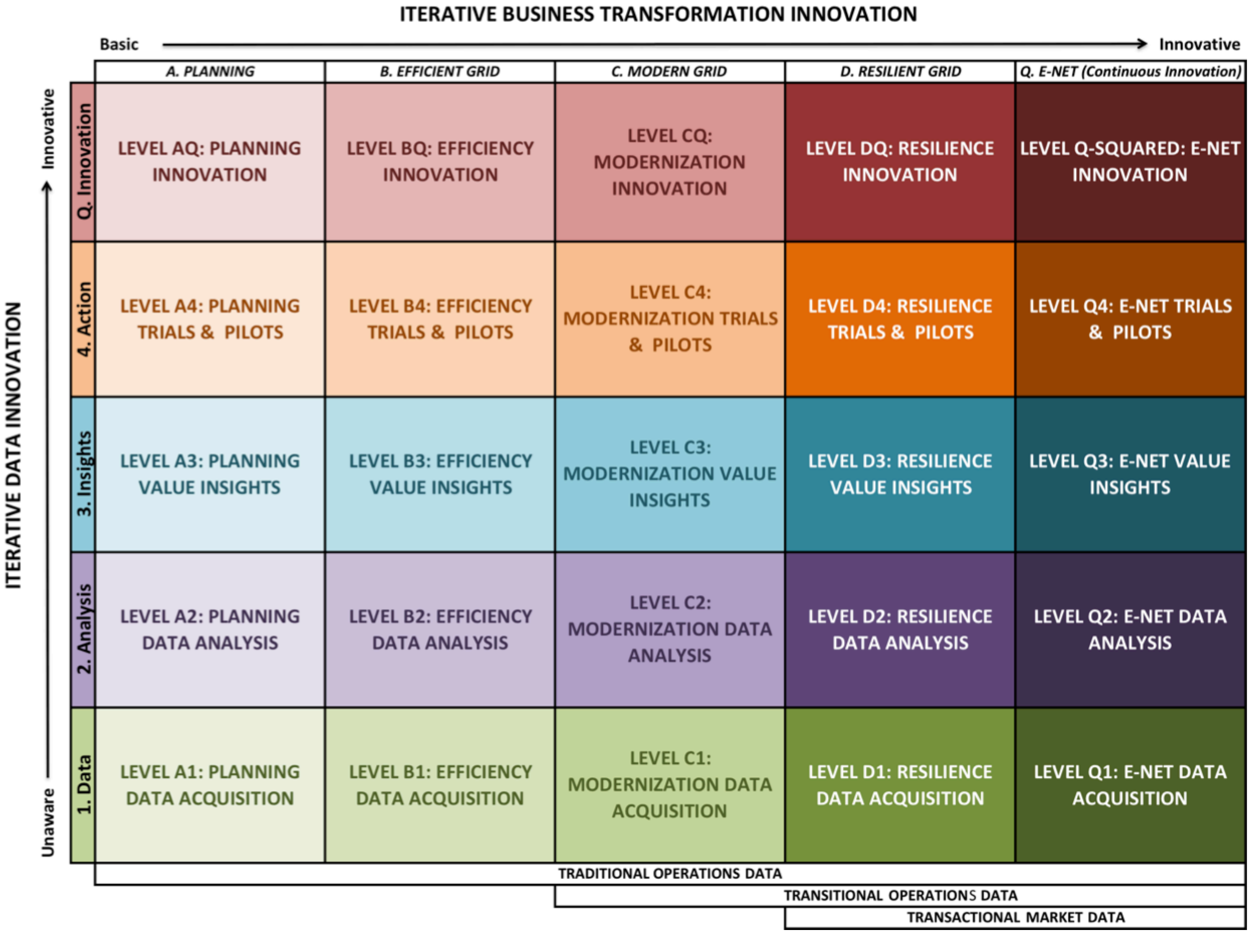
The multiple factors limiting extension of monopoly hegemony and demanding a focus on resiliency signal a single path forward for long-term sustainability: to proactively embrace changes that lead us into the future. A strategy of embracing the future while preserving the best of the past promises a novel value proposition for the twenty-first century: the creation of a new business and operating paradigm for resilient energy. Executing the hybrid *Market Resiliency Transformation* will require regional industry transformations and individual business transformations likely to take decades to accomplish. Organization into incremental stages enables a *managed transition* from old to new that minimizes disruption & optimizes value.

New rules needed for this new energy economy follow these parameters. First, **Urgency & Redesign:** today's grid was designed for a 20th century economy, not for the internet-driven, digitally disruptive, value-oriented economy of the 21st century. Redesign and repurposing is both *urgent* and necessary; Second, **Iterative Innovation:** redesign must be *iterative* to maintain and improve critical operations as we learn the best ways to adapt to new needs and as technologies and stakeholders mature to take on new roles; Third, **Core Principles: resiliency -** expanding system reliability to adaptability and flexibility; **decarbonization -** systematic elimination of carbon from the supply chain; **collaboration -** inclusive of utility industry, technology, third party vendors and energy users; and **DER:** the modular tool for system redesign.

A. The Energy Internet's Primary Actors: Grid Integrated Onsite Energy

When we consider an emerging hybrid (Scenario 3) as an alternative to either of the polar extremes "winning" a battle for definition of the new energy sector (Scenarios 1 & 2), we're informed by contemplating the model of an emerging Internet 25 years ago. In such an emergent *Energy Internet* (sometimes referenced as the *Enernet* or the *Intergrid* – let's use a shorter abbreviation - the "*eNet*"), the changes described in the chart above enable a more rapid evolution than either of the two poles to answer the urgent need to address pressing energy and environmental challenges. In this new, more open and collaborative *market* environment, the grid is repurposed for economic transactions and resiliency, rather than delivery of commodity remote power from large power plants. Focus on grid resiliency invites local and regional market groups, most prominently

Community Clean Energy (CCE) regional power procurement organizations formed under the Community Choice Aggregation Laws (CCA) found in only seven select states (CA, IL, MA, NJ, NY, OH, RI). Industrial, Commercial, Residential & Government – familiar ratepayer classes in Scenario 1 – are transformed into independent consumers in Scenario 2, empowered with new onsite energy as *prosumers*, wearing two hats as both consumers and producers. In Scenario 3, these prosumers shift to a market orientation and engage in new market activity introduced by DER ubiquity and market orientation to resiliency. In this shift, the *low cost* benefits of large-scale renewable energy (i.e., solar/wind farms) combine with the *high value* benefits of local DER to produce the resiliency equation that underlies Scenario 3.



	A. PLANNING	B. EFFICIENT GRID	C. MODERN GRID	D. RESILIENT GRID	Q. E-NET (Continuous Innovation)
Q. Innovation	LEVEL AQ: PLANNING INNOVATION	LEVEL BQ: EFFICIENCY INNOVATION	LEVEL CQ: MODERNIZATION INNOVATION	LEVEL DQ: RESILIENCE INNOVATION	LEVEL Q-SQUARED: E-NET INNOVATION
4. Action	LEVEL A4: PLANNING TRIALS & PILOTS	LEVEL B4: EFFICIENCY TRIALS & PILOTS	LEVEL C4: MODERNIZATION TRIALS & PILOTS	LEVEL D4: RESILIENCE TRIALS & PILOTS	LEVEL Q4: E-NET TRIALS & PILOTS
3. Insights	LEVEL A3: PLANNING VALUE INSIGHTS	LEVEL B3: EFFICIENCY VALUE INSIGHTS	LEVEL C3: MODERNIZATION VALUE INSIGHTS	LEVEL D3: RESILIENCE VALUE INSIGHTS	LEVEL Q3: E-NET VALUE INSIGHTS
2. Analysis	LEVEL A2: PLANNING DATA ANALYSIS	LEVEL B2: EFFICIENCY DATA ANALYSIS	LEVEL C2: MODERNIZATION DATA ANALYSIS	LEVEL D2: RESILIENCE DATA ANALYSIS	LEVEL Q2: E-NET DATA ANALYSIS
1. Data	LEVEL A1: PLANNING DATA ACQUISITION	LEVEL B1: EFFICIENCY DATA ACQUISITION	LEVEL C1: MODERNIZATION DATA ACQUISITION	LEVEL D1: RESILIENCE DATA ACQUISITION	LEVEL Q1: E-NET DATA ACQUISITION

Figure 5. Quintessential Innovation: Q^2i Platform & Apps Model for *Utilities*
Source: Future of Utilities, Utilities of the Future –
Chapter 5 The Innovation Platform Enables the Internet of Things, by Cooper, 2016

The Q^2i platform, in Figure 5, is designed to enable this modular approach to accelerate problem solving by inviting utilities and third parties to share, and profit from, their innovations in the form of Apps. A current challenge for utilities suffering with the Pace Problem is the adherence to a service territory definition of the provisioning of commodity kWhs. Locked into relatively small markets, utilities have a small base on which to apply their innovations.[xxvi]

B. Urgency & Redesign

A distribution electric grid may be repurposed as a highway for energy commerce in the emerging eNet, when new market functionality is added to existing distribution grid segments to complement original distribution functionality. Given the conservative nature of utilities and the primary orientation on system *reliability* and soon, system *resiliency*, this grid repurposing can begin with individual circuits – distribution feeders – as they are converted for eNet operations with a focus on DER integration and system resiliency. In this way, two market introduction scenarios are presented. First, progressive utilities in progressive regions (CA, NY, IL, MA, Ontario, etc.) may choose to pilot single circuits and test new operating models that promote, rather than discourage DER introduction. As concentrations grow and DER is integrated into grid dispatch models, the hybrid unfolds and new options for grid operations based on resiliency may be tested. Alternately, after massive hurricanes like Harvey, Irma and Maria this year, grid reconstruction can include one or more test circuits in devastated regions, where grid restoration now includes grid repurposing. In this way, innovative third parties may contribute to grid restoration to not simply restore the system as it was before the storm's destruction, but to make it better and new.

C. Iterative Innovation

Iterative Innovation will enable local communities and the utilities that serve them to maintain and improve critical operations even as they experiment with new approaches and learn the best ways to adapt to emerging needs, changing technologies and maturing stakeholders better able to take on new roles. Iterative Innovation is best described using the Quintessential Innovation (Q^2i) Model as shown in the graphic above.[xxvii] As more data is gained in pilots, it leads to insights & innovation (data-analysis-insights-action-innovation). Concurrently, pilots, insights & innovation lead an organization, company or community through a transformation process that also ends in innovation (planning-efficiency-modernization-resiliency-innovation). This process is designed to enable rapid incremental change with the least risk.

D. Core Principles

Four core principles stand out in Market Resiliency Transformation. First, **Resiliency** is the *visionary* principle, the focus and centrality of stakeholders in the emerging energy ecosystem, where activities support expanding system reliability into resiliency (i.e., adaptability and flexibility). Second, **Decarbonization** is the *ongoing energy sourcing* principle, with opportunistic, systematic elimination of carbon from the supply chain. A key strategy to implement this principle is to steadily grow local clean energy capacity with two shared acceleration goals: 1) closure of legacy fossil fuel plants; and 2) conversion to an electricity-based transportation economy. Third, **Collaboration** is the *stakeholder organizing* principle, where activity is pursued *inclusive* of utility industry, technology, third party vendors and energy consumers/prosumers in a transparent, fair manner. Fourth, **DER** is the *implementation* principle, the tool for redesign. Modular DER enables tailored solutions (i.e., networked microgrids/nanogrids) for specific needs with energy consumers subsidizing cost/deployment.

E. Market Resiliency Vision: the eNet

The primary assets of market resiliency start with a transformation to microgrids as the predominate form of DER (see Appendix 2. It's a Microgrid World Now.) For microgrids to emerge as the predominate form of DER, they must shift from today's highly complex, unique and expensive project-driven power systems to standardized commercial energy products, which can be deployed readily and acquired by a mass market of energy consumers searching for greater value and enhanced resiliency. For the marketplace to grow, targeted marketing will be needed to convert consumers of commodity electricity (kWhs) into prosumers of energy services measured by unique value. As the energy ecosystem transforms from a monopoly into a market, market segments that view energy differently will be audiences for new forms of energy marketing.

With ubiquitous DER, microgrids and nanogrids that are networked create local energy markets, preparing the distribution grid to become an *overlay* eNet. A key challenge will be to network disparate elements so that they may operate in synchrony as an organized market, without the need for a monopoly utility to act as a unifying grid services provider. By networking non-utility devices and enabling them to register transactions (information exchange), a new local energy market can host independent facilities that seek to import/export energy (electricity) using the repurposed commercial grid.

VII. Conclusions & Recommendations

A. Key Conclusions

Scenario One – Steady Evolution. Utilities have sufficient motivation and opportunity to engage a Market Resiliency Transformation, but only a rare few appear ready to do so as yet. Further, the *complexity* and *cost* of the necessarily *rapid* transformation are overwhelming to many utilities faced with flat or declining revenues. Other challenges slow utilities down and make them less adaptable: 1) utility *cultures* remain relatively risk averse; 2) utility *leadership and teams* remain deeply committed to a core mission of maintaining grid stability through traditional means, which may manifest as resistance to change; 3) utility *business models*, until forced to consider alternatives, remained oriented on large-scale capital asset investment and monopoly grid operations to deliver lowest cost commodity power; 4) utility *strategic decision-making* is generally closed, with community engagement only to review decisions already made; and 5) utility *ownership structure*, by and large, is concentrated in the hands of institutions and governments, and so is less flexible than the mix of small, medium and large market-oriented energy companies.

A principal conclusion is that **most utilities are either unwilling or incapable of moving at the appropriate pace to address the demands of accelerating energy and environmental trends**. Certainly, smaller electric utilities and those owned by municipalities may be better equipped to keep pace with motivated non-utility stakeholders. That said, Scenario One. **Steady Evolution is simply too slow to meet the demands of the Pace Problem**.

Scenario Two – Renewable Revolution. This alternative is too slow as well, and without the weight of an engaged utility sector, market disruption is disjointed and less effective. As the disruptor in the face of a slowly mobilizing incumbent industry, renewable energy companies suffer from under capitalization and difficulties in awakening a market long-oriented on low cost commodities. Electric utilities have worked so well in modern economies that a large share of the electric consumer market is simply not motivated to seek alternatives. Those that are so motivated are slow to adopt new beneficial clean energy technologies, waiting for further price drops. It is true that the prices of Renewable Energy (RE) and DER are steadily declining - remarkably so - but the organic nature of market progress requires significant acceleration in order to meet the timetable dictated by Climate Change. To halt the warming that is driving extreme weather and sea level rise, the transition to a full electric energy economy and retirement of fossil fuel resources like coal power plants and oil-based transportation, must be at a far more rapid pace than we have ever achieved so far. To do that, we need to accelerate market development and adoption of clean energy resources like RE and DER.

A principal conclusion is that **market-based DER in the absence of utility sector cooperation will proceed too slowly to meet the needs of Climate Change**. All the nations of the world now stand behind the Paris Agreement (although the US has indicated a desire to withdraw as soon as it can, in 2020) tacitly acknowledge this challenge by consistently edging up predictions associated with CO_2 airborne concentration and global temperature rise. Absent a change in core conditions, we may face the supreme irony of solving the problem, but being too late to stop much of the calamity associated with Climate Change.

Scenario Three – Market Resiliency Transformation. While utilities are unlikely to lead a transformation as described herein, their cooperation remains highly beneficial to change, so they should be recruited to engage at the planning and pilot level in response to overtures from communities in their service territory. This appears to be the opening for interested communities: to engage utility representatives as stakeholder participants in planning and piloting new approaches, in order to prepare them to take more significant actions as time progresses and their situation evolves.

Establishing a shared objective – system resiliency on the one hand, power continuity on the other – engages both polar extremes in a synergistic process that can tap the good points about Scenarios One and Two. The established grid and market power of utilities can be adapted to a new purpose with the help of the innovative, creative market players so motivated to engage a revolution. This process should follow local community leadership as described in the

Recommendations section below. The opportunity is for motivated local communities to step up and pioneer new approaches to become more resilient and more energy self-sufficient. Breaking up the *wicked problem* introduced at the beginning of this document into manageable bites through stakeholder consensus and collaboration is possible with local community leadership and an approach that can be improved upon, so that a Best Practices regimen can be established.

The principal conclusion with regard to Market Resiliency Transformation is that **while the necessary elements to realize this scenario are all now available, what is missing is a programmatic shift in priorities and marshaling of the necessary resources to address the Pace Problem**.

B. Recommendations

1. **Planning**
   a. **Begin Immediately with Strategic Community Energy Planning.** There's no time like the present to start this long journey, and each journey starts at the local community and/or regional level. Communities with strong local interest who are ready should initiate a process of Market Resiliency Transformation with Community Energy Planning, which can begin in many different ways: 1) Identify local stakeholders for broad community representation; 2) Gather to discuss the formation of a Community Energy Planning group; 3) By *listening first* and by *seeking to understand* different perspectives, the community will seek to identify *win-win scenarios* and *synergies*, avoid subsequent conflicts, and create a *more effective plan* that supports *community coherence* and *long-term value creation*.
   b. ***Wicked*** **Workshop/Work Program Process.** The Initial Workshop, ideally facilitated with a subject matter expert, identifies those energy planning issues and challenges most relevant to the local situation; gathers local stakeholder perspectives; identifies strengths, weaknesses, opportunities and threats (to produce a SWOT analysis); and prioritizes challenges.
   c. **Leadership Vision.** A key output of Strategic Community Energy Planning is a Shared Community Vision based on the concepts of Market Resiliency Transformation. This vision may be seen as a public launch of the strategy planning effort, with initial widespread acceptance at the leadership level, and communication to the broader community.
   d. **Orientation Workshop.** An initial documentation of strategic threats and risks may be assembled with the information gathered and organized from the Initial Workshop. Significant data points may be identified and processed into an Interim Report to lead workshop participants in an Orientation Workshop focused on a guided discussion on creative solutions with two key objectives: 1) **Holistic Perspective.** Open up the gathered stakeholders to competing objectives and priorities in order to craft a shared perspective and plan based on what is best for the community as a whole; and 2) **Value Acceleration.** Seek out synergies between the different parties that will accelerate the value proposition for the entire community.
   e. **Initial Demonstration Project.** At this point, it may be helpful to engage in a Market Demonstration. An initial pilot or demo can serve as an object lesson to focus public attention and raise the level of public involvement.
   f. **Business Model Aspirations.** New business model alternatives should be evaluated to determine the best fit to meet the community's objectives. This process is helpful to create an objective understanding at a comprehensive level of the interactions of channels, product, pricing, etc. Tools such as the *Business Model Canvas*[xxviii] are well suited for this step and a facilitated workshop is also helpful, producing a Draft Business Plan to guide stakeholders.
   g. **Change Readiness Assessment.** Assess the readiness of community stakeholders to begin a Market Resiliency Transformation process. A Community Marketing Program including educational tools to ensure widespread awareness of the issues associated with change helps to communicate the group's findings and to set up a successful community survey or town meeting process. To the degree the assessment reveals gaps in readiness, it is appropriate to consider delaying the planning process to focus on readiness gaps.

   h. **Platform Evaluation.** The community should consider technical alternatives to leverage a platform for management of disaggregated DER elements, but also engagement of DER vendors and potential partners at this stage of the planning process.
   i. **Strategic Roadmap I.** Crafting an initial rough draft of a long-term plan provides a *qualitative* understanding of new business models, capabilities, and aspirations, including technology integration. This rough initial plant will also evaluate any necessary regulatory challenges, community impacts and change readiness, and external stakeholder alignment and mobilization (e.g., electric utility engagement).
   j. **Strategic Roadmap II.** With agreement on the first qualitative plan, a more detailed *quantitative* plan may be outlined, including an assessment of costs and benefits of a transformation program. The objective of these two initiatives is to produce a value-based Market Resiliency Transformation Roadmap (MRTR).

2. **Implementation w Pilots**
   a. **Long-Term Partner.** Agreement on a well-defined transformation plan (MRTR), allows the community to identify and engage one or more long-term partners with the necessary subject matter expertise, experience, and resources to assist with the transformation.
   b. **Program Management Office (PMO).** Having agreed to begin a Market Resiliency Transformation, it is time to establish the Program Management Office (PMO) to guide the long-term implementation of the MRTR, with a focus on consistent value creation and logical, progressive skill attainment to add back to local communities.
   c. **Integrate with the Host Utility.** With each pilot, the host utility may become further integrated with the local community and onsite energy systems. As an engaged stakeholder, the role of the host utility is to support the community process and contribute where it can.
   d. **Form a CCE.** A key measure for those states that have a CCA law in place is to begin the process of regional cohesion with the formation of a Clean Community Energy non-profit organization for identification and financing of clean power resources, whether large-scale remote (i.e., RE) or smaller scale local resources (i.e., DER).
   e. **Deploy Local Microgrids and Nanogrids.** Following a demonstration microgrid (Step A5) a program of intensive onsite power system deployment should begin by a) starting with critical infrastructure then move on to b) ensuring that shelters have sustainable power systems, then filling in with c) deployments to drive towards the renewable energy goal, ideally 100 percent. By mapping out these stages over the local community, initial resiliency steadily improves with each onsite system deployment.
   f. **Program Refresh.** Plan to refresh the strategic roadmap and the initial SWAT analysis regularly to accommodate growing community maturity (changing strengths and weaknesses) and a dynamic external environment (new opportunities and threats).
   g. **Form Local Energy Markets.** Sufficient DER density opens to local energy market formation.
   h. **Engage an Energy Currency.** A local market benefits from a specific energy currency.

3. **Expansion & Integration**
   a. **Expand Local Energy Markets.** As local energy markets are launched, they expand with DER density and market activity.
   b. **Connect Local Energy Markets.** The interconnection of vibrant local energy markets is the realization of full resiliency, sustainability and energy optimization driven by a healthy ubiquitous eNet.
   c. **Grid Integration.** The overlay energy network based on onsite energy production and consumption, i.e., the launch of the eNet, when combined with the repurposed distribution grid, becomes the new Hybrid Energy System.

Appendix 1. Glossary of New Energy Terms

1. **Building Energy Management Systems (BEMS).** *BEMS* is a class of technologies, processes, products and services whose purpose is to address energy efficiency in commercial buildings. BEMS includes energy management technologies, sub-metered systems and software to provide building managers with energy usage data and feedback, but also lower tech solutions energy efficiency solutions as spray foam and double-paned windows.
2. **Combined Heat and Power (CHP).** *CHP* describes a power generator whose heat exhaust is channeled for productive value by the end user. Previously referred to as cogeneration, CHP is the simultaneous production of power and the capture of exhaust heat to provide thermal energy, to be used, for instance, to heat water for a district energy plant. Natural Gas turbines, in particular small scale turbines, (i.e., *Micro CHP*) – spin very rapidly and produce high heat, so they are typically associated with the use of exhaust heat. (See also *Distributed Generation (DG)* and *Distributed Energy Resources (DER)*).
3. **Community Choice Aggregation (CCA).** CCA is US innovation substitute for power provisioning, replacing investor owned utility (IOU) electric sourcing with local (e.g., county or multi-county) non-profit entities. Under CCA law, these organizations aggregate the buying power of individual customers in their service territory to secure alternative energy supply contracts, almost exclusively with the goal of securing green power contracts, whether from large remote farms or from local DER facilities. CCA customers default IN, so that they must actively opt out if they do not wish to be supplied by the CCA entity. Seven states have CCA laws (CA, IL, MA, NJ, NY, OH & RI), but only California has a comprehensive, active CCA marketplace to date.
4. **Community Clean Energy (CCE).** CCE is an alternative name for a CCA entity (e.g., East Bay Community Energy, Silicon Valley Clean Energy, etc.).
5. **Community Energy Storage (CES).** *CES* is the application of energy storage technology to support a small number of residential or commercial load centers, akin to a neighborhood energy storage facility, considered by some to be the sweet spot for immediate application based on current technology maturity, capabilities, and price points.
6. **Community Solar.** *Community Solar*, sometimes referred to as a *solar garden*, is a mid-sized solar PV system (100-500 KW) that produces energy for use by a group of individuals (community).
7. **Critical Energy User (CEU).** A ***Critical Energy User (CEU)*** is an energy consumer for whom energy is of critical importance to its mission and to society. When a power outage disables such a user, society and the local economy suffer significant to catastrophic impacts. Historically, CEUs have used diesel generators & UPS as customer-owned power backup resources.
8. **Demand Response (DR).** *DR* is a change in the power consumption of an electric utility customer at the request of the utility to better match power demand with power supply. The electric grid requires demand and supply to be in balance from moment to moment, given the lack of economical energy storage options. Historically, utilities throttled power plant production to keep demand and supply in balance, ramping generators up or down, or importing power. DR represents an alternative means to balance the grid. DR systems consist of a remote control unit connected to a wireless network, used to automate load curtailment as an alternative to dispatching additional supply resources.
9. **DER Resiliency*.** New *DER* technologies capabilities and business models enable dramatic improvements to service reliability including partial or full avoidance of outages. *DER Resiliency* describes the transformation of the distribution grid by leveraging new DER capabilities and business models to ensure power continuity for *critical energy users* during outage events.

10. **Dispatchable.** Utility operators traditionally *dispatch* power from central generation resources to keep the grid voltage levels in balance. A challenge to renewable energy resources like wind and solar energy is that the power they produce is intermittent, due to the nature of wind and sunlight. Consequently, the power renewable energy resources produce is not considered "dispatchable" by grid operators and must be backed up by gas or coal generation resources in the event they suddenly become unavailable. In Smart Grid terms on the distribution grid, DER resources will be deemed dispatchable generation resources if they are equipped with communication devices and micro inverters and grid operators can dispatch them similar to the way they dispatch central power today. DR resources may also be considered as dispatchable generation resources if they consistently curtail on demand with a record of that curtailment.
11. **Distributed Energy Resources (DER).** Alternately, *Decentralized Energy Resources – DER* is a relatively new umbrella term for technology-driven onsite-power devices and systems that includes *Energy Efficiency* (including *Home Energy Management Systems (HEMS)* and *Building Energy Management Systems (BEMS)) Demand Response (DR), Distributed Generation (DG); Electric Vehicles (EV)* and *Electric Vehicle Supply Equipment (EVSE)* and *Energy Storage (ES).*
12. **Distributed Generation (DG).** *DG* describes small, diverse onsite power generators that operate to meet individual loads near to the load that they serve and/or provide power directly onto the distribution grid. DG includes such clean energy technology as rooftop *solar PV* systems, micro gas turbines using combined heat and power (*micro CHP*), as well as less common micro wind turbine systems and more traditional portable gas and diesel generators.
13. **Distributed Solar Photo Voltaic (PV).** *Distributed solar PV* is small energy production system that uses solar panels to produce energy at a site where the energy is consumed, stored, or sold over the grid, typically sized under 100 KW.
14. **Distribution Feeder Microgrid*.** As a distribution feeder – a "last mile" circuit on the distribution grid providing retail service to end users through revenue / net meters - gains ever more energy self sufficiency, it starts to comprise a unique new energy ecosystem with new capabilities – a *Distribution Feeder Microgrid.*
15. **Distribution Power Producer (DPP)*.** The rise of Positive Energy Buildings, other DER and microgrids enable the potential to export power directly onto the low voltage distribution feeder in a deliberate merchant capacity as a *DPP,* a term that applies the IPP concept to onsite power production that powers a particular distribution feeder.
16. **Distribution Resource Plan (DRP).** A DRP applies the IRP concept to include resource activity inside the distribution grid ecosystem to accommodate new *distributed energy resources (DER)* and more frequent, dynamic planning cycles.
17. **Electric Vehicles (EV).** *EV* is an expanding umbrella term for vehicles that make use of electric batteries, including *hybrids*, which combine energy storage and an *internal combustion engine (ICE)*; *plug-in hybrids* (typically have a small onboard generator) or 100% *electric vehicles (PEVs)*; *battery electric vehicles (BEVs)* such as specialty equipment in warehouses and airports; and electric buses. EVs are widely viewed as the most likely replacement for vehicles that depend on fossil fuels (e.g., ICE). (See also *vehicle to grid (V2G)* and *vehicle to home (V2H)*).
18. **Electric Vehicle Supply Equipment (EVSE).** *EVSE* is the charging system complement to the electric vehicles in the EV category used to describe individual chargers as well as networked chargers that will comprise a large overlay network onto the power grid. Charging stations are likely to be deployed at residences and businesses, as well as at public locations including charging stations available to the public at curbside, parking garages, and parking lots.

19. **Energy Consumption v. Energy Demand.** A distribution grid is designed and built to service a projected system peak load – the time during the year of maximum energy consumption, when all generation units are operating at full capacity to meet demand and the distribution grid is at peak capacity as well. Energy consumption, measured in kWh, is the cumulative amount of energy represented by the area under the load curve over a specific amount of time. Energy demand, measured in kW, is the highest point of the load curve over a specific amount of time. Residential consumers typically are charged only for consumption, while commercial and industrial consumers pay for both consumption and demand. This is because rates are designed to recover both capital and operational costs. Electric utilities invest capital for generation, transmission, and distribution assets – capacity to meet peak demand, but also operational expenses such as fuel costs to produce energy.

20. **Energy Efficiency (EE).** *Energy Efficiency* or *EE* is a focused on the demand side of the energy equation, on energy consumption. The *built infrastructure* – buildings and homes – consumes approximately 70 percent of electricity, so focusing on eliminating wasteful consumption becomes a way of operating a more efficient system. EE may be divided into passive strategies, principally focused on sealing the *building envelope* as a more effective container of heat or cold (insulation, radiant barrier, etc.) and on upgrading energy appliances to the most efficient models and technologies (replacing incandescent light bulbs with *CFLs* and *LEDs*, switching *HVAC* to a higher *SEER* rating). EE may be low-tech (turning off light bulbs when leaving the room, sealing cracks around doors and windows) or high-tech (spray foam insulation, programmable *HEMS*).

21. **Energy Self Sufficiency*.** *Energy self sufficiency* (ESS) and freedom from loss of service (i.e., electricity outages) are two of the principal benefits from becoming a *prosumer*, one who gains energy independence with onsite production and expanded capabilities.

22. **Energy Service Purchase Agreement (ESPA)*.** An *ESPA* is inclusive of power & devices that when viewed as a package provides a service (e.g., comfort, lighting, hot water, etc.) … an ESPA enables "as a service" value-adds as an innovation to deliver more value than can be found from the separate purchases of an energy appliance (device) and the electricity to run it (kWhs). The ESPA "locks-in" a portion of the monthly energy bill in a long-term contract (service level agreement or SLA), reducing rate-based kWhs. An ESPA may be seen as a *Load* strategy to preserve grid service, where rate-based kWhs transform into a cost input into a service contract.

23. **Energy Storage (ES).** *Energy Storage* may be fixed or mobile, as in the case of EVs. Fixed ES comes in different sizes, ranging from personal ES serving one home or building, to community ES serving a neighborhood or group of homes or buildings, to utility-scale ES, as a component of the distribution grid used for energy balancing, ancillary services, renewable energy integration, or arbitrage. Principal types of energy storage include 1) mechanical – hydroelectric (pumped hydro), compressed air energy storage (*CAES*), flywheels, etc.; 2) electrochemical – lead acid batteries, advanced lead acid batteries, sodium sulfur and flow batteries, fuel cells, etc.; 3) electrical – capacitors, super capacitors, ultra capacitors; 4) thermal – ice, molten salt, etc.; and 5) chemical, biological, etc. ES holds great potential as a disruptor to the current electricity paradigm, which has generally been a just-in-time system, designed and operated in real time without the capacity for managing peaks with the benefit of stored energy.

24. **Energy Service Purchase Agreement (ESPA)*.** An ESPA is inclusive of power & devices that when viewed as a package provides a service (e.g., comfort, lighting, hot water, etc.) … an ESPA enables "as a service" value-adds as an innovation to deliver more value than can be found from the separate purchases of an energy appliance (device) and the electricity to run it (kWhs). The ESPA "locks-in" a portion of the monthly energy bill in a long-term contract (service level agreement or SLA), reducing rate-based kWhs. An ESPA may be seen as a ***Load*** strategy to preserve grid service, where rate-based kWhs transform into a cost input into a service contract.

25. **Grid Parity.** *Grid Parity* described a time in the near term, when new types of electricity, typically renewable energy and DER, achieve the same or lower levelized cost of energy than traditional – typically, fossil fuel-based –

forms of electricity. At grid parity, the incumbent advantages of traditional electricity generation fall away and replacement with new clean electricity becomes predominate. Many believe we have now passed this point.

26. **Heating, Ventilation, Air Conditioning (HVAC) systems.** *HVAC* systems manage temperature and humidity environment for buildings and homes, so the term includes heaters, boilers, air conditioners, chillers, refrigeration units, etc. For Smart Grid purposes, HVAC systems matter because they are often the largest single energy-consuming appliance inside the building or home. For DR, HEMS units interface with the HVAC, providing feedback on energy consumption, but more importantly, direct control to cycle the HVAC on and off to reduce energy consumption during peak periods.
27. **High Penetration PV (HPPV).** *HPPV* describes efforts to load up a single distribution circuit on the grid with higher concentrations of PV facilities than current standards allow. An initial rule of thumb was that a single distribution feeder could only handle about a 20 percent penetration of PV, beyond which the potential for intolerable risk and instability to grid operations sets a boundary. The intermittency of production and the potential for excess power to reverse the power flow on distribution feeder lines pose a threat to upstream utility equipment. HPPV anticipates new technologies and processes that will enable the distribution grid to safely accommodate ever larger concentrations of DER.
28. **Home Energy Management System (HEMS).** *HEMS* is an acronym for a new class of consumer devices that combine equipment and software to provide consumers with a feedback mechanism to better monitor and manage their in-home energy consumption. Closely related to *home area networks* or *HANs*, HEMS may include a connection to the Smart Meter, drawing revenue data from the meter via ZigBee connectivity. HEMS will enable DR services to the degree that they automate or facilitate consumer decisions to curtail power during peak periods at the request of the utility.
29. **Independent System Operator (ISO).** The FERC directs the formation of *ISOs* for individual states, but also sometimes regions, as a coordination and monitoring mechanism to provide oversight and direction to regional electric grids for *reliability* purposes. An ISO may also have the purview over market operations of the wholesale power market in a region as well, overseeing power dispatch and grid balancing, but also providing a market clearing function.
30. **Independent Power Producer (IPP).** An *Independent Power Producer or IPP* was introduced with the PURPA electricity reforms in the 1970s, whereby third party (i.e., non-utility) producers own and operate power plants and sell power onto the transmission grid and to end users (large power producers).
31. **Integrated Resource Plan (IRP).** An *Integrated Resource Plan (IRP)* is a term coined under the PURPA laws (circa 1978) to move beyond generation planning focused on utility-owned power plant investments to more diversity in energy resources (e.g., energy efficiency, etc.) and more inclusive of third parties (independent power producers – IPPs and energy service companies – ESCos).
32. **Investor Owned Utility (IOU).** *IOUs* are one of three principal classes of electric utilities in the US. IOUs are owned by private investors and are typically larger than the other two types of utilities, municipally-owned utilities (*MOUs*) and electric cooperatives (*Co-ops*). IOUs are regulated at the state and federal level. The Edison Electric Institute (EEI) is the industry body most closely associated with IOUs.
33. **Kilowatt (kW), Kilowatt Hour (kWh).** A *kW* is a term to define energy generation *capacity* equal to 1,000 watts, whereas a *kWh* is a common unit of measurement for electric power *consumption* equal to 1,000 watts in one hour or 3.6 megajoules. The kW is used as a billing unit by electric utilities for *energy demand*, whereas the kWh is used to measure and bill the amount of *energy consumed*.

34. **Levelized Cost of Energy (LCOE).** *LCOE*, measured in kWh or MWh, is a way of comparing energy from different generation sources, using such measurements as initial capital investment, ROI, operating costs, fuel cost, and maintenance costs.
35. **Light Emitting Diode (LED).** An *LED* is an electronic device that produces light using semiconductor chips, a technology that has advanced over nearly 50 years to become an alternative to incandescent light bulbs and compact fluorescent light bulbs. Advantages of LEDs are numerous: lower energy consumption, longer life, smaller size, faster switching, and greater durability and reliability. The principal advantage of LEDs is their low operating costs, but that is offset by their still relatively high upfront costs, although the price is in rapid decline. LEDs are increasingly in use in small form factors such as flashlights and decorative holiday light strings.
36. **Megawatt (MW), Megawatt Hour (MWh).** A *MW* is a measure of energy capacity, a million watts, and is generally the measurement used to describe the capacity of large generators. In contrast, a *MWh* is a power measurement, multiplying the capacity over a period of one hour. A 100 MW generator produces 100 MWh in one hour. Collectively, 1,000 homes consuming 1,000 kWh each month consume 12 MWh over one year.
37. **Meter Data Management (MDM), Meter Data Management System (MDMS).** *MDM*, is a new requirement for data coming from digital Smart Meters, which will dramatically increase as more and more AMI systems are deployed, making management of that data a new critical skill for utilities. The raw data that comes from the Smart Meters is stored in head end servers, processed, and then used for digital billing and other analytical purposes. *MDMS* is the term for the system that performs the MDM function. MDM is a vital component of the value production of Smart Grid, given that data will feed the variety of applications inside a utility to drive processes and deliver desired outcomes.
38. **Microgrid.** A *microgrid***,** in its original definition, is a campus of buildings that have access to multiple onsite energy resources, energy storage and managed loads to enable independent operations (i.e., "islanding"). As microgrids become more common, moving from concepts to reality, the concept is used to describe variations (e.g., see also *Distribution Feeder Microgrid*, *Nanogrid*, *Proximity Microgrid*, etc.)
39. **Microgrid Management System (MGMS)*.** An *MGMS* enables the efficient operation of a microgrid, balancing system resources, loads, and energy storage.
40. **Municipally Owned Utility (MOU).** Community-owned utilities, known in the industry as *MOUs*, are city departments operated by city employees with direct or indirect board oversight by city government (city councils or independent boards). Local, hometown decision-making is a critical element supporting MOUs, as well as ensuring access to a stable supply of electricity while protecting the environment. About two-thirds of these utilities do not generate their own electricity, but instead purchase wholesale power to distribute to their citizens/customers.
41. **Nanogrid*.** A *nanogrid* narrows the microgrid concept from a campus down to a single building, whose multiple onsite energy resources, energy storage and managed loads work together to provide energy self-sufficiency.
42. **Nanogrid Management System (NGMS)*.** A *Nanogrid Management System (NGMS)* enables the efficient operation of a nanogrid, balancing system resources, loads, and energy storage.
43. **Net Energy Metering (NEM).** With the addition of onsite power production systems, utilities developed a new type of meter to enable onsite systems to be connected to the grid. First, the NEM differs from standard revenue meters by registering the net consumption (grid power minus onsite power). Generally, this would produce a reduced bill. But if onsite power were to exceed grid power in a given billing cycle, then the excess would be accounted for by a utility payment to the system owner. Second, the NEM ensures worker safety by cutting off the onsite power production when the grid loses power (without a NEM, utility workers restoring power after a line or system outage would risk mistaking power lines still energized by onsite power systems for dead ones and suffering harmful or

fatal power shocks). NEM has become a political football recently. Favored by third party system providers because it eases integration of onsite power systems, utilities have begun to challenge the NEM system in regulatory proceedings, claiming that NEM metered consumers constitute a new privileged class of energy consumers, driving up system costs because of interconnections, receiving payments for excess production, but consuming less grid power and so contributing less to the system in rate payments – effectively shifting the burden of maintaining the grid to non-NEM consumers. This remains an open, contentious issue with more and more utilities seeking to add a fixed charge for NEM consumers, while others advocate for a full accounting of the value of distributed generation with new Value of Solar Tariffs (VOSTs).

44. **Net Zero Energy Home (NZEH).** A *Net Zero Energy Home* produces sufficient energy over the course of the year to balance out its annual power consumption for a net zero impact. Navigant predicts total NZEH units in NA will grow to nearly 27,000 in 2025.
45. **Pace Problem*.** Oriented to preserve system reliability and constrained on multiple fronts, electric utilities move slowly to adapt to the changes presented by new technologies. In contrast, technology companies and consumers, oriented to challenge the status quo with innovative approaches to problems and far less constrained, embrace change, even seeking to accelerate the pace of change to their advantage. Utilities risk falling further and further behind if they are not able to accelerate their adaptations to change.
46. **Non-Transmission Alternatives.** *Non-Transmission Alternatives (NTAs)* are transmission-related NWAs (see below) that specifically targeted at the grid's transmission sector. Opportunities for NTAs are identified through more deliberate least-cost planning and action, one geographic area at a time.
47. **Non-Wires Alternatives.** *Non-Wires Alternatives (NWAs)* are electric utility system investments and operating practices that obviate the need for specific transmission and/or distribution projects. Key advantages are lower total resource cost and specific targeting of transmission congestion or distribution system constraints at times of greatest need in grid operations. A more comprehensive analysis reveals advantages for both NWAs and NTAs for managing electricity supply and demand using a wider variety of solutions than traditionally used in planning, including DER on the demand side and rate design on the utility side.
48. **Personal Energy*.** *Personal Energy* expands on the traditional energy concept, whereby a commodity (i.e., *grid power, dial-tone power*, as kWhs, BTUs, etc.) is purchased from a third party in an industrial context and delivered over a network, often under regulatory authority. *Personal Energy* redefines energy from the individual perspective, oriented to services and added value (i.e., energy self sufficiency, comfort as a service, lighting as a service, etc.) purchased from a competitive marketplace of service providers, generally without regulatory oversight, as a complement to self-produced value.
49. **Personal Energy Purchase Agreement (PEPA)*.** A PEPA is any combination of PPAs and/or ESPAs marketed to an end consumer/prosumer by either a utility or a 3rd party service provider. A PEPA is a concept not yet available, but likely to emerge as the market matures to focus on higher value-added services. A PEPA may be offered that totally replaces the monthly energy bill (e.g., comfort, lighting, and hot water LPAs reduce energy bill by 60% and solar PPA with energy storage covers the remaining 40%).
50. **Photo Voltaic (PV).** *PV* panels and film systems create electricity directly from sunlight and its interaction with the materials in the PV system. Silicon chips are mounted in solar cells on solar panels in rigid frames, while PV film has the active substance *printed* on a substrate (film) that can be applied to a variety of building materials (roofing tiles, wall panels, windows, etc.) to create *building integrated PV (BIPV*).

51. **Plug In Hybrid Electric Vehicle (PHEV).** In contrast to a pure EV, which runs strictly on electricity, a *PHEV* has a gas tank and internal combustion engine (*ICE*) as a complement to its electric batteries and power system. PHEVs have longer range, but produce more greenhouse gas emissions. (See also *EV*, etc.)

52. **Positive Energy Building (PEB)*.** A *Positive Energy Building (PEB)* produces more energy than it consumes on a daily basis, *by design*, introducing the potential of creating a dependable, long-term income stream based on an on-site energy investment. A PEB enables the potential to export power directly onto the distribution feeder as a *Distribution Power Producer (DPP).*

53. **Power Continuity.** *Power Continuity* ensures power availability for the end user regardless of the state of grid power. In a short or long-duration power outage, traditional power continuity strategies like back up power (e.g., diesel generators or UPS/battery banks), and dual-feed distribution circuits and new strategies like onsite power (e.g., microgrids, fuel cell arrays) address the need for continuous power for such critical energy users.

54. **Power Purchase Agreement (PPA).** *Power Purchase Agreement or PPA* is long-term (e.g., 10 year minimum) contract to buy 3rd party power. The PPA has proved to have a dramatic impact on the adoption of new technology, particularly on market penetration of rooftop solar PV, which saw a dramatic rise with the introduction of PPAs as an alternative to the purchase of expensive systems with long payback periods. A PPA may be seen as a *Resource* strategy**,** providing alternative energy to the transmission grid (w/a utility) or directly to a site on the distribution grid (w/a consumer, e.g., solar PPA as above).

55. **Prosumer.** Where a *consumer* purchases energy to use as an input to create added value (light, power, comfort, convenience, security, etc), they become a *prosumer*, one who not only purchases but also produces energy to create expanded value.

56. **Proximity Microgrid*.** A *Proximity Microgrid* shifts the microgrid concept from colocated buildings on a single campus to co-located buildings on a specific segment of a distribution feeder that may be isolated for islanded operations.

57. **Resilient Feeder*.** As DER capacity is steadily added to a distribution feeder, it may be considered by grid operators to have become a *resilient feeder*, supporting local power continuity.

58. **Resilient Substation***. When multiple resilient feeders extend from a distribution substation, enabling it with new capabilities during an outage, it may be referred to as a *resilient substation*. Feeder-by-feeder, substation-by-substation, a distribution grid becomes more resilient in stages under such a transformation scenario.

59. **Solar Photo Voltaic (Solar PV).** See *Photo Voltaic*.

60. **Solar Garden vs. Solar Farm.** A *solar farm* is a large installation, generally with capacity measured in MWs, also called *utility-scale solar*, feeding its output onto a high voltage transmission system. Smaller than a solar farm, *solar gardens* have capacity measured in KWs. These ground-mounted systems have recently gained popularity as “right-sized” energy systems suitable for cooperative sharing or for community energy purposes. (See also *Community Solar*)

61. **Strategic Positive Energy Collaborator (SPEC)*.** A *Strategic Positive Energy Collaborator (SPEC)* harnesses the potential of a prosumer and a positive energy building or site that operates as a nanogrid. Such new capabilities enable a new business model whereby a strategic positive energy collaborator exports power in a manner to complement or enhance the operations of the connected grid and the surrounding energy ecosystem to create synergy and added value not possible without collaboration.

62. **Positive Energy Building (PEB)*.** A *Positive Energy Building (PEB)* by design produces more energy than it consumes on a daily basis, introducing the potential of creating an income stream.

63. **Power Purchase Agreement (PPA).** A long-term (e.g., 10 year minimum) contract to buy 3rd party power. The PPA has proved to have a dramatic impact on the adoption of new technology, particularly on market penetration of rooftop solar PV, which saw a dramatic rise with the introduction of PPAs as an alternative to the purchase of expensive systems with long payback periods. A PPA may be seen as a ***Resource*** strategy**,** providing alternative energy to the transmission grid (w/a utility) or directly to a site on the distribution grid (w/a consumer, e.g., solar PPA as above).

64. **Prosumer.** A consumer who begins to produce the commodity or service consumed may be referred to as a *producer/consumer* or *prosumer* for short. In the case of electricity, a consumer becomes a prosumer by adding the ability to produce electricity onsite.

65. **Resilient Feeder*.** As DER capacity is steadily added to a distribution feeder under such a transformation, it may be considered by grid operators to have become a *resilient feeder*, supporting local power continuity.

66. **Resilient Substation*.** When multiple resilient feeders extend from a distribution substation, it may be referred to as a *resilient substation*. Feeder-by-feeder, substation-by-substation, a distribution grid can become more resilient in stages under such a transformation scenario.

67. **Strategic Positive Energy Collaborator (SPEC)*.** A SPEC harnesses the potential of a prosumer and a positive energy building or site that operates as a nanogrid. Such new capabilities enable a new business model whereby a strategic positive energy collaborator exports power in a manner to complement or enhance the operations of the connected grid and the surrounding energy ecosystem to create synergy and added value not possible without collaboration.

68. **Vehicle-to-Grid (V2G), Vehicle-to-Home (V2H).** These two terms are used to describe the transfer of power from an EV to the grid or to the home (or building), where the EV becomes an alternative energy storage device acting as a power supply.

69. **Virtual Power Plant (VPP).** *Virtual Power Plant* or *VPP* describes a demand-side alternative to accommodate growth in peak demand to the traditional supply-side alternative of adding a natural gas power plant, commonly referred to as a *peaking unit* or a *peaker*. In its most expansive definition, a VPP combines an array of rooftop PV systems with localized energy storage and aggregated DR capacity (e.g., HEMS appliances equipped with direct load control – commonly, smart thermostats – or some combination). Such a system provides a utility the capacity needed to meet its peak needs without adding a power plant.

Appendix 2. It's a Microgrid World Now: *The Emerging Microgrid Paradigm Shift*

By John Cooper
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Abstract

- As DER technologies become ever more affordable and capable, they become well suited to be repurposed as components of higher value systems, to support the shift from cost-to-value embodied in *Personal Energy*.
- A *microgrid* is a defined technology concept of an *islanded* system – one that can connect and disconnect from the grid. A simplified definition for microgrids unlocks greater market potential.
- Microgrid-as-a-Service (MaaS) expands the promise of microgrids by removing financial capital obstacles and increasing value options.
- When innovation is applied to new business models for these innovative microgrids, value is enhanced.
- When individual innovative microgrids are interconnected into larger networks – *nested microgrids* – then network platforms with remote management and control help to align these systems with the needs of incumbent power systems – still more value is added.
- A *microgrid paradigm shift* occurs when limiting definitions from the early days of a new industry are adjusted to enable innovation and value expansion, introducing a Value-Added Energy marketplace open to innovation.

I. Technology-based Energy Comes of Age

As we move into a world filled with commoditizing renewable energy in multiple forms, how long will we keep talking about single-technology systems or referring to customers and markets based on a single technology? And for that matter, how long will metered kWh prices and $/gal drive our conversations about the value of energy (e.g, Levelized Cost of Energy or LCOE)?

These two issues are connected, after all: technology advances enable value-based services that displace commodities, leading businesses that sell commodities by cost (e.g., utilities) to transform into businesses selling services by value. Consider, for instance, that "all-you-can-eat" service plans in telecom made tracking long distance minutes and cell phone budget restrictions distant memories, and led to the internet and the smart phone revolutions.

Today we talk with excitement about growth in emerging energy markets: PV owners, EV drivers, *PowerWall* purchasers, LED customers, and *NEST* buyers. But what happens when these individuals and businesses start buying not one product, but all five, putting them to use in new ways to gain energy independence? Each of these energy pioneers has entered the same room from a different door, converging on a common hallway forward. This *Personal Energy* consumer gains the option to become a *prosumer*, leveraging new tools to gain energy independence by producing energy onsite. And prosumers are remarkably different than ratepayers.

Personal Energy represents a new marketing field whose purpose is to understand and serve the consumer on the path to becoming a prosumer – the *rising prosumer*. The potential of the microgrid – DERs organized into a system - has teased us for years by replicating the stability of a large utility grid on a single campus. Whether for *power access* where the grid does not reach, for *power continuity* in regions prone to extended power outages, for *economic stability* against potential rate increases, or as a source of clean energy to support *climate change mitigation*, microgrids have remained more about potential than ready value, more an alluring research project always one or two years from commercialization.

The complexity and price of microgrids has so far mostly limited them to demonstration trials and research projects. But now that combinations of energy and information technologies may be considered for synergy value, moving up an escalating chain of value, as demonstrated in Figure 1 *Innovative microgrids* in a variety of formats will soon start to appeal to specific market segments, but also to look like the most appealing form of *dispatchable DER* to grid operators.

Microgrids (and community-scale DER deployments like *solar gardens*) represent a more digestible form of DER for distribution utilities and regional grid operators than the alternative - massive numbers of small, individual PV systems and EV chargers popping up throughout a service territory like mushrooms in a forest after a rainy night.

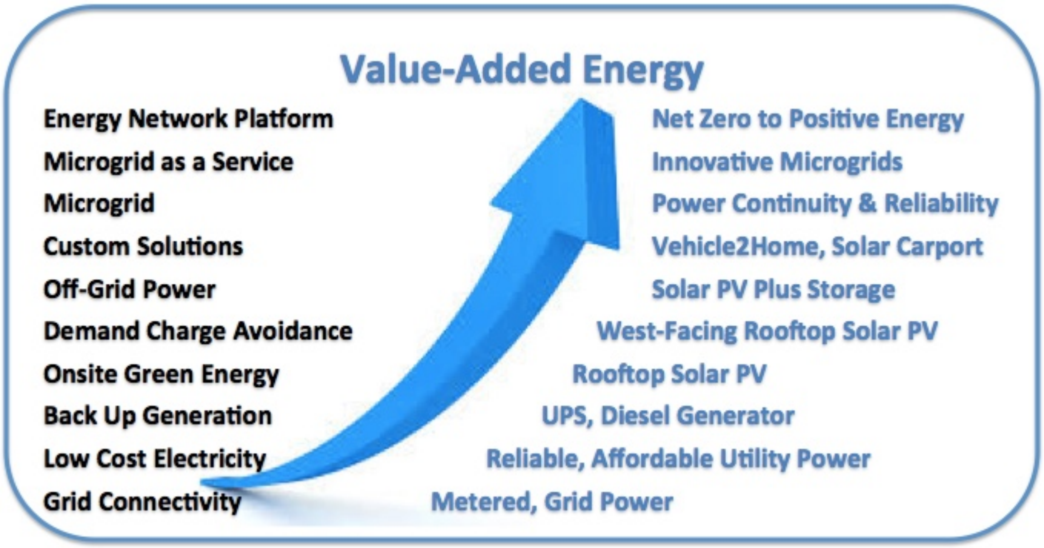

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Figure 1. Value-Added Energy, Source: MaaS Energy

Given the falling prices and increasing capabilities of new energy technologies, electric distribution utilities are likely to sidestep the disruption that comes from being stuck in reactive mode as ever more small systems come on line. Instead, look for these utilities in growing numbers to proactively plan networks of dispatchable DER and microgrids that more tightly fit into their current grid paradigm. And regional grid operators will follow suit at the ISO level.

Accelerated DER penetration and the potential of advanced energy networks like the *Internet of Things* and the *Energy Internet (eNet)* will make *network platforms* necessary to provide data access and advanced operational capabilities. Such platforms will usher in this new world of microgrids, providing the necessary transparency and value creation to enable co-optimization for both building owners and grid operators.

II. Redefining the Microgrid

A common understanding of the microgrid has emerged over the past decade or so, by definition:

> *"A group of interconnected loads and distributed energy resources (DER) with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid [and can] connect and disconnect from the grid to enable it to operate in both grid connected or island mode."*

Two key challenges, noted in the underlined sections above, have shaped the development of this new industry. First, with few exceptions, the regulated utility distribution monopoly has remained the only legal entity allowed to distribute power from one property to another, which has bounded the physical dimensions of a microgrid to a campus or larger facility on a single piece of real estate. That definition has also bounded our imagination when it comes to possibilities. A second challenge has been the need to *island* (connect and disconnect) the system, which increases the complexity of control systems and adds considerably to costs. These challenges have so far limited deployed microgrids to large, complicated and expensive systems, even as technology has improved and component costs have dropped. Islanding introduces complexity and cost that in most cases are unnecessary.

If we were to modify this definition, focused on those two key limiting provisions, a market for simpler, easier *innovative microgrids* could expand dramatically. Consider this new definition.

> "*A system of interconnected distributed energy resources (DER), load(s), and energy storage, equipped with energy management and control, designed to meet or exceed unique site requirements, and islanded only during outages when backup power is required.*

Such simpler, smaller, more affordable microgrids would introduce the potential for innovation as well, as demand shifted from single DER power systems to DER bundles then on to Innovative Microgrids, in the pursuit of escalating value.

III. From DER Bundles to Innovative Microgrids

The recent approval for Tesla to merge with Solar City in November 2016 sparked the imagination of the DER world. Bringing three DER technologies (PV, EV and Energy Storage) under the same corporate umbrella raises expectations for dramatic new sales and value opportunities (e.g., shared sales processes, retail stores, etc.) and more innovation to come.

Looking past sales potential, there is a value shift from combining technologies like *solar PV* and *energy storage*, creating a system that can both shift output to be used during peak periods and that can operate when the grid goes down.

Another binary bundle with tremendous value is *solar PV* and *LED lighting*, two technologies that have experienced relatively recent, dramatic price drops. Will it make sense much longer to deploy rooftop solar on a building that's not yet optimized with LED lighting? Arguably, *PV plus LED* is on the way to joining *PV plus Storage* as the "peanut butter and jelly combos of DER."

Now combine a resource (PV), load (LED) and *energy storage* and you're well on your way to what might be called a *simple microgrid*.

> "*A single resource, a single load and energy storage, with energy management and control functions operating as an integrated system.*"

Perhaps more than the sales advantages discussed in press coverage of the Tesla merger, the value of integrating *solar PV, energy storage and electric vehicles* is expansively more valuable when sold as a system – an *innovative microgrid* - offering to eliminate gasoline and related automobile expenses, shift load to avoid peak expenses (DR), enable ancillary services to the grid and the ISO, and with oversized PV, even enable long-term PPA sales, leading to *transactive energy* among peers in a novel energy market.

Now imagine specializing these innovative microgrid solutions to match the facilities and business models of unique consumers. Consider a *Warehouse Microgrid* for example.

- Identify the local sites with the greatest potential from both the user and supplier perspectives using a distribution utility service territory audit for locational optimization and an energy efficiency data evaluation to identify the warehouses with the greatest optimization potential
- Design a standardized system that optimizes for *warehouse* building and business type
- Address internal energy efficiency with LED and HVAC retrofits – key focus will be LED, as lighting expenses are predominate in warehouse load
- Deploy rooftop PV - the ample roof space on warehouses enables an oversized solar PV system (providing new sources of revenue for added value)
- Integrate smart energy storage to tie the system together into a microgrid, lower or eliminate demand charges and enable grid ancillary services
- Monetize the investment with a *Resource PPA* (power to REP or vertical utility)
- Accelerate system value with a *Grid Services PPA* (services to distribution utility and ISO) to make the system cost competitive even with historically low kWh rates
- Network the system, adding data analytics to optimize system ops, improve value, and aggregate multiple sites to create a Virtual Power Plant (see next section)

A. Data/Ops Networking Platforms

Just as desktop PCs accelerated in value, first with LANs and Ethernet, then with the Internet and TCP/IP, individual innovative microgrids will gain still more value when considered as a part of a broader value-added energy network. The last stage to turn this new Microgrid Paradigm into a truly compelling prosumer value proposition is to interconnect the system with a *data/ops networking platform*. Beyond transparency and remote system control, a platform that enables multiple microgrids to interact within a broader system introduces previously unattainable benefits at minimal cost.

In sufficient numbers, such *nested microgrid* networks introduce a compelling value proposition that has not been available before. At scale, they will create a Virtual Power Plant, which will enable additional clean and affordable renewable wind and solar farms to be built. These energy networks will enable aging dirty coal plants to be retired ahead of schedule. They will enable greater grid resiliency as well, ensuring that critical facilities stay on line, even during extended power outages.

B. Personal Microgrid

Innovative microgrids as described herein can be found already, especially in areas of energy poverty like rural Kenya, as shown below. This simple microgrid integrates a single Resource, some energy Storage and two Loads to create a compelling Personal Energy solution at its most basic. Expanded options enable still more functionality, including a digital TV. The value potential for this population from energy innovation is huge, with relatively little investment when viewed from developed world standards.

> *SunTransfer Kenya was established in 2009 to provide full power access to off-grid areas. "Our main target is to install power for families in rural off-grid areas," Wanjiru said. The lifespan of the SunTransfer solar is around 20 years, enabling the families to significantly reduce their lighting expenses. The solar systems come in different packages — ST20 comes with four light bulbs, a 20-watt solar panel, 12-volt battery, and phone charging kit. The ST50 comes with five light bulb, a 50-watt solar panel, and 38-volt battery system. ST100 has six light bulbs, a 100-watt solar panel, 24-inch digital TV, phone charging kit, and DC/AC inverter."*
> Pay-As-You-Go Solar Model Brings Security to Small Kenyan Communities *Renewable Energy World*, December 12, 2016

IV. The Microgrid Paradigm Shift

When progress in technology enables a shift in imagination as described herein, new possibilities emerge.

- **Microgrid-as-a-Service.** Rethinking a microgrid as a service offer - *microgrid-as-a-Service* (*MaaS*) – that is tailored to a variety of critical businesses and organizations, even individual residential customers, expands the promise of microgrids exponentially.
- **DER as System Components.** As DER technologies become ever more affordable and capable, they can be repurposed as components of higher value systems.
- **Innovative Business Models.** When innovation is applied to new business models for these systems, the value is accelerated still further.
- **Network Platform.** Finally, when these individual systems are interconnected over network platforms with remote management and control, aligning with the needs of incumbent power systems, their value expands even more.

Nested microgrids large and small, designed and deployed to meet the needs of various organizational and individual business models, then networked with distribution and regional grids, represent the foundation of a Microgrid Paradigm Shift beyond the campus vision defined several years ago by the DOE and others.

When microgrids of all sizes and shapes are widely deployed and interconnected with legacy grids using network platforms, we will have shifted to Value-Added Energy, which will unlock tremendous economic and environmental benefits.

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