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PERSPECTIVES

Energy Transition: Past, Present & Future

Our perspectives feature the viewpoints of our subject matter experts on current topics and emerging trends.

INTRODUCTION

Energy transition—a phrase that is often used as though everyone understands its meaning. In fact, few know what it means, or they have varying opinions as to what it means. As it has been stated elsewhere, "Energy transition is a promising avenue toward sustainability." Sustainability is another word whose definition everyone assumes we all know when there are probably as many different opinions as to the meaning as there are people who use the word. To truly understand what energy transition is, many thought leaders will say, "you need to look at it from the 30,000-foot level," intimating that at that higher level of vision, it becomes so much more clear. Here is what the author says with more than 43 years of experience in business, engineering, decision making, and, most importantly, life: I fly—a lot—and at 30,000 feet, everything is beautiful and serene. However, life also teaches that the actual conditions on the ground are much different; they are not necessarily so beautiful, are generally chaotic, and more importantly, they are where the real work occurs to make things look beautiful at 30,000 feet. To truly understand energy transition, we need to start at ground level.

In this article, we will look at the status of energy transition and attempt to clarify some of today's vernacular as it relates to the current state; we will examine progress (or lack thereof); desired timetables for the transition process and the suitability of that schedule; the real-time opinions of those responsible for implementation; and we will discuss whether the regulatory scheduling requirements and technological capability for this important transformation align.

ENERGY FACTS: GROUND LEVEL

First, energy transition is a fact. Energy, in its many forms, has been transitioning since the beginning of time. We know based on the law of conservation of energy that energy can neither be created nor destroyed; rather, it can only be transformed or transferred from one form to another. That is a law not subject to government fiat. It cannot be overruled or rewritten—it is the first law of thermodynamics.

In an era where artificial intelligence is set to take off and seemingly make our lives better (at least that is what is being reported) most have forgotten this fundamental fact of physics. But not to worry: forgotten or not, the laws of thermodynamics are still present and cannot be abridged or violated. The law will keep us in check.

If it is a fact, if energy has been transitioning for ages, then why the huge discussion and push to accelerate it? In the past, "energy transition" meant "a more efficient form of energy that would enhance society and improve people's lives." Prior to the industrial age, people generally heated and cooked with carbon-based fuel such as wood or coal in their homes. By centralizing the transition of energy from direct burning of fuel to perform a task such as heating the home, energy, in the form of electricity, could be produced and delivered to homes and businesses via transmission and distribution lines thus making the process more efficient and—this statement may create a stir—safer and healthier for everyone.

Here is a contemporary example of what I mean: people in China have suffered from more respiratory disease than the rest of the world combined due primarily to cooking fires in the home, i.e., cooking with wood or coal inside their homes. What does that mean? Well, it is simple. Building coal, oil, or gas fired plants in China is saving lives, at least currently. "Currently," in this case, refers to a time scale like other parts of the world experienced during their initial transition from direct to indirect forms of energy to support the daily lives of their citizens. Energy transition for purposes of this discussion is the process of moving from carbon related energy sources to non-carbon related ones.

ENERGY TRANSITION TIMETABLE: HOW FAST IS FAST ENOUGH?

So, back to the previous question: "Why the need to accelerate the transition process?" It is straightforward. Countries, or rather, governments of countries, have recently (a relative term) coalesced around the position that increased carbon dioxide (CO_2)—an off gas from the burning of carbon in the atmosphere—is leading to a precipitous increase in CO_2 and overall global temperatures that will adversely affect our collective habitat. Simply put, it will no longer be sustainable; hence, sustainability enters the equation. Carbon-based fuels such as coal, oil, and natural gas, just to name a few, produce carbon along with other atmospheric discharges. Another significant contributor is transportation in the form of trains, planes, and automobiles that burn various types of carbon-based fuels. CO2 is the fifth most common gas found in our atmosphere and is a byproduct of cellular respiration, a life process. Since we truly cannot control that source for obvious reasons, the two most common sources that we can control would be power and energy related emissions.

WHY NOT JUST “STOP IT?”

If the issue of too much CO2 is in fact existential in terms of impact, why not just stop manufacturing and make the change? That is where the term “energy transition” was repurposed and applied to the contemporary process of going from a carbon-based energy state to a non-carbon one. The challenge? How long should that take, or, maybe more importantly, how long must it take to do it with the least harm? How do we measure “least harm?” One analogy would be an airliner at 35,000 feet facing a mechanical malfunction which requires an emergency diversion from its original destination to the closest airport where it can safely land. Ideally, the plane could just immediately get back on the ground—the shortest distance possible. Unfortunately, that may not be the safest or most prudent. The direction it should go is not straight downward, as that is a foregone conclusion, but rather at a slope at which the plane minimizes impact to those on board and ensures a successful and safe landing.

Similarly, it is not the direction that energy transition is taking but rather the slope of the glide path ensuring that we maintain operational reliability for each of the sectors that currently relies heavily on carbon-based fuels as we transition to sources of energy that rely less on those fuels. The ongoing debate is much easier to have as long as the current energy delivery systems are still maintaining reliability of service at levels we are accustomed to, but that is changing.

The fact remains that energy generation and, more specifically, grid-scale electrical energy that drives our industries, businesses, and our daily lives has not changed much since the time it was first developed. Yes, there have been significant improvements to technology in the final delivery, but the actual generation process still requires a source of fuel with prime movers collectively and completely synchronized. The assumption is that one form of electrical energy in the form of kilowatt-hours is the same as another. That is not a correct assumption. There are significant differences, and current technology is challenged to ensure that we can maintain the correct balance.

For example, synchronization is an important part of maintaining reliability. A simple analogy is a car in motion. For a car to go in a straight line, all four wheels need to be turning at the same speed. Simply put, they must be synchronized with each other. If one of the wheels is not in sync with the other wheels, it will be difficult to keep the car going in a straight line. If that difference in synchronization gets large enough, it will not be possible to keep it on the road. So it is with generators that are connected on our power grids.

Another important reliability requirement is concerned with how much energy is available and when it is available. Sources of generation that depend on atmospheric elements are only available when those elements are available. There is significant debate over technology being able to overcome the intermittent nature of inverter-based resources (IBRs) such as solar and wind. It is true, there have been significant and exciting advances as to the state of the art for those generation resources. However, those improvements are insufficient to completely satisfy the entire replacement of our current carbon-based generation assets. Advances in technology will continue, and other forms of non-carbon generation sources such as hydrogen will continue to advance as well as improvements to nuclear byproduct safety, but until then, we need to understand the “glide path” we can safely, effectively, and economically achieve. Otherwise, we will be left with the unintended consequences of reduced reliability that affects us all. This is not just a concern, it is already happening and has been experienced primarily at the margins for extreme weather. Cold weather such as Winter Storm Uri in 2021 in Texas confirmed this, and in California during periods of high ambient temperatures, we have seen significant generation capacity shortages. There are also other states in the U.S. that are either currently experiencing or projecting shortfalls entering the summer season. This will be a regular challenge for many years to come.

WHAT ARE OTHER EXPERTS SAYING ABOUT ENERGY TRANSITION?

Energy transition as we described earlier is the process of moving from carbon related energy sources to non-carbon related ones. Significant discussion and action regularly occur at the strategic level, both from a regulatory and legislative perspective, regarding this important and fundamental change, but it is also imperative to hear from those who must manage and operate the Bulk Power System (BPS) in real-time. Strategic directives need to be sufficiently demanding to drive change, but it cannot outpace technology to the point that reliability of the system is markedly impacted. These are recent inputs from those in charge of the overall reliability of the BPS:

- The North American Electric Reliability Corporation (NERC) has authority via the Federal Power Act (FPA) over transmission and generation facilities needed to maintain transmission system reliability in the U.S.[1] James B. Robb, President and CEO of the NERC, testified before the Committee on Energy and Natural Resources for the United States Senate on June 1, 2023. In that testimony, Mr. Robb stated that, "The bulk power system (BPS) is at an inflection point. The electric transmission grid is highly reliable and resilient and has grown more so under the current reliability regime. Yet the risk profile to customers is steadily deteriorating."[2]

- NERC's 2021 ERO Reliability Risk Priorities Report finds that the rapid interconnection of BPS-connected Inverter Based Resources (IBRs) and how they interact with the high voltage power grid and other resources is the most significant driver of grid transformation and poses a high risk to BPS reliability.[3]

- According to recent data reported by PJM, the nation's largest grid operator, PJM is warning that, "it may face a major coming shortfall in electric generating capacity as utilities retire more and more traditional fossil fuel power plants."[4] In the report, PJM projected 40 GW (40,000 MW) of retirements due to economic and policy factors, including regulations issued by the U.S. Environmental Protection Agency, state climate laws or regulations, as well as private sector environmental, social, and governance (ESG) commitments.

- For the past several summers, the California Independent System Operator (CAISO) implemented rolling outages to balance its lack of dispatchable generation with increasing demand for electricity. According to an Electric Power Research Institute (EPRI) study conducted in 2020, "[t]he CAISO supply deficiency was largely due to a resource adequacy issue."[5]

- In a recent study conducted by the Midcontinent ISO, the grid operator highlighted the pervasive risk of capacity shortfalls across its system by noting it had a "1.2-gigawatt (GW) capacity shortage in the planning resource auction […]"[6] Additionally, the Southwest Power Pool (SPP) could potentially face energy shortfalls. According to the NERC, in SPP, "outages and reduced output from thermal and hydro generation could lead to energy shortfalls at peak demand."[7]

THE FUTURE OF ENERGY TRANSITION

There are many significant drivers pushing the energy transition timing including how quickly we move through the timeline and by how much. "How much" refers to whether a completely carbon free energy system is fully achievable and still maintains adequate reliability and life-required services. Compelling local, state, or federal regulations are forcing the transition to occur on schedules that may or may not align

[1] Testimony of James B. Robb, President and Chief Executive Officer, North American Electric Reliability Corporation, Before the Committee on Energy and Natural Resources, United States Senate, June 1, 2023.
[2] Ibid.
[3] NERC, *2021 ERO Reliability Risk Priorities Report* (July 2021), https://www.nerc.com/comm/RISC/Documents/RISC%20ERO%20Priorities%20Report_Final_RISC_Approved_July_8_2021_Board_Submitted_Copy.pdf.
[4] Blackout risk: Nation's largest grid operator warns of capacity shortfalls | Washington Examiner https://www.washingtonexaminer.com/policy/energy-environment/pjm-warns-of-capacity-shortfall
[5] Electric Power Research Institute, "Resource Adequacy Challenges: Issues Identified Through Recent Experience in California," October, 2020.
[6] S&P Global, "US Midcontinent ISO study says 200GW new capacity additions needed by 2041 to meet utility climate goals," August 25, 2022.
[7] North American Electric Reliability Corporation, 2022 Summer Reliability Assessment

with technological advancements. The current timing is being driven by timeframes that are the legislative negotiations and consensus. Given the general disconnect in timing between regulatory mandates and technological advances, there are several opportunities for potential negative impacts on system reliability. Reduced reliability and system resilience results in increased risks. No matter the consumer, business, or entity that manages those risks, the reliability of future energy delivery will be impacted and at a higher cost. The actual and eventual impact in reliability and cost will be driven by how steep or gradual the "glide path" is to reach the necessary CO2 levels defined by statute.

CONCLUSION

The transition from a primarily carbon-based electrical generation system to one that is either less carbon dependent or entirely free of carbon is ongoing and will continue for years to come. The technology necessary to ensure that occurs in a way that maintains appropriate and reliable access to that energy at current levels is the real and significant challenge. Regulatory mandates are increasing the constraints on more traditional forms of power generation that are leading to early retirement of those assets. At the same time, governmental incentives through production and investment tax credits in addition to selective partiality of financial capital through metrics such as ESG are promoting IBRs that are affecting current reliability standards. States aggressively transitioning their electrical grids such as California are having to incorporate rolling blackouts into their planning to be able to adequately balance available generation with demand during certain operating scenarios.[8] As another example, Texas has more than 120,000 MWs of capacity—significantly greater than any other state in the U.S.; but it has recently struggled with meeting its electrical load during extremes of cold or hot weather. There are several factors related to those challenges but conversion of approximately one third of its generation to IBRs is certainly playing a part.

The fact that large and complex electrical grids such as Texas's and California's can have trouble meeting load is not unheard of, but the frequency and extent of those operational shortages are increasing, and it is not restricted to just a few jurisdictions. Increased interruptions are occurring throughout the U.S.

Increased system interruption means increased operational and financial risks for businesses and those that insure, underwrite, or finance them. It also can have broad, negative implications for the overall economy. The key to meeting the challenge is in the timing. It is not the direction that energy transition is taking but rather the slope of the glide path ensuring that we maintain operational reliability as we transition from carbon-based fuels to sources of energy that rely less on those fuels.

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[8] Penn, Ivan (2020-08-16). "Rolling Blackouts in California Have Power Experts Stumped". The New York Times.