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WHY RISK AND RELIABILITY MATTER MORE THAN FUEL DIVERSITY

Devin Hartman

EXECUTIVE SUMMARY

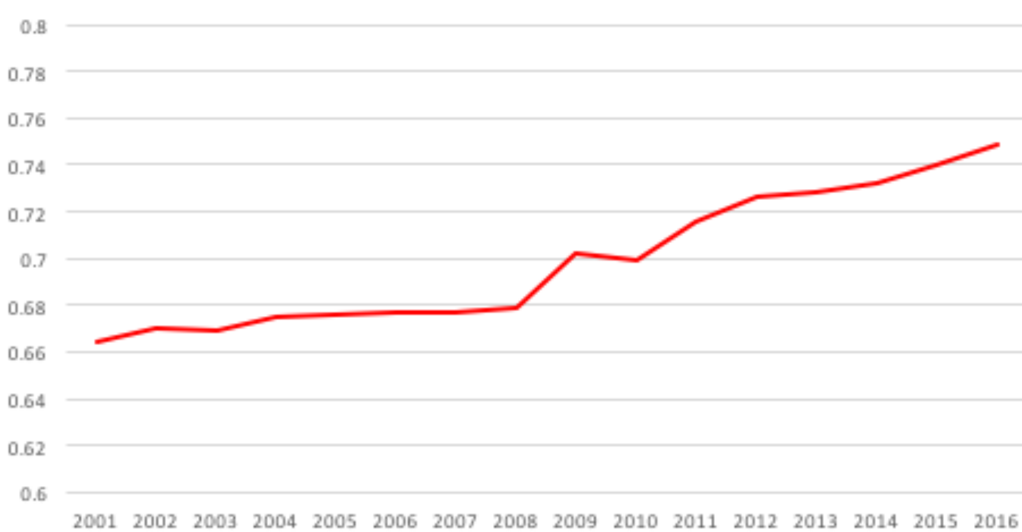
Policymakers often presume that diversity in electricity supply is inherently beneficial, even a necessity. This presumption manifests in industry catchphrases, campaign slogans, government policy objectives and beyond. It frequently surfaces in the stated concerns of those wary of growing reliance on renewables and natural gas, as coal and nuclear decline.

This policy brief examines the conceptual basis for supply diversity as a policy objective; diagnoses ongoing economic and political trends relevant to the subject; and reaches conclusions through the lens of policy analysis. Over the past 15 years, the nationwide trend actually has been toward greater fuel diversity. There is little empirical evidence to support the claimed association between supply diversity and electricity-market performance. The record shows that policy interventions to promote greater diversity typically undermine market performance. If policymakers want to improve electricity market performance, they should instead support targeted reforms that provide proper incentives for risk management and reliability, which commonly are associated with supply diversity.

TRENDS IN FUEL DIVERSITY

Concerns about electricity supply diversity generally emphasize fuel diversity, rather than technology diversity, as many different power-generation technologies use the same types of fuel. One objective measure of fuel diversity is the Fuel Diversity Index (FDI),[1] which is similar to the Herfindahl-Hirschman Index used by the Federal Trade Commission and U.S. Justice Department to measure an industry's market concentration.[2] The minimum possible value for the FDI is zero, where all generation would come from a single fuel. The maximum possible value for a generation fleet of 11 fuel

FIGURE I: U.S. FUEL DIVERSITY INDEX



SOURCE: R Street analysis of U.S. Energy Information Administration data types is 0.91, representing equal shares of generation from each fuel type.[3]

In 2016, the domestic generation mix's FDI stood at 0.75, or just 18 percentage points below the maximum possible value. This indicates a high degree of fuel diversity nationwide. As demonstrated in Figure 1, the trend has increased quite consistently over the past 15 years. Overall, the FDI rose 13 percent—nearly nine percentage points—from 2001 to 2016.

Fuel diversity varies by region. An ideal case study is the PJM Interconnection LLC, the largest domestic electric grid operator, which has experienced extensive turnover in its generating fuel portfolio. From 2010 to 2016, PJM's coal generation fell by 31 percent, in addition to generation declines of 29 percent for waste, 25 percent for oil, 15 percent for hydroelectric and 3 percent for nuclear. Its natural gas generation rose by 125 percent and its wind generation increased by 83 percent.[4] On the surface, this combination of shifts might appear to indicate a decline in fuel diversity. However, PJM's FDI actually has increased since 2010. PJM's fuel diversity increased even as generation from natural gas jumped 19 percent from 2015 to 2016.[5]

The trend toward greater fuel diversity reflects increased deployment of underweighted groups (like renewables) and decreased generation from overweighted groups (like coal). However, these relative weightings will shift if current trends continue, eventually showing up as a decline in fuel diversity. Within a couple of decades, the domestic generation mix may plausibly consist of 61.7 percent natural gas, 27.5 percent wind, 5.5 percent solar and 5.3 percent hydroelectric.[6] Even in this unlikely scenario,[7] the FDI would decline only moderately (19 percent) from the 2001 level.

EVALUATING DIVERSITY

Arguments favoring fuel diversity typically fall into two categories: those that highlight its role in risk management and those that highlight its role in reliability. But the relationships between fuel diversity and each of these goals are tenuous, at best. Depending on particular circumstances, diversity may be positively or negatively correlated, or completely uncorrelated, with improvements in risk and reliability performance. Even when it is positively correlated, there is little evidence to suggest diversity is the cause of improved performance.

Risk management

The value of electricity supply diversity to risk management often is asserted to parallel concepts in financial portfolios. For example, a portfolio with two stocks in the same sector has a greater risk profile than one with 10 stocks diversified across sectors. Translating this to a power-sector example, two wind farms located in close proximity will have more variable output than 10 wind farms dispersed across a wide geographic area. In this case, geographic diversity and a greater number of holdings are associated with reduced risks within the same class of fuel.

But having a diverse portfolio does not always correlate with lower risk. A portfolio weighted more heavily toward lower-risk holdings can have both less diversity and less risk. For example, a portfolio split evenly between bonds and stocks poses greater risks than a less-diversified one with 90 percent bonds and 10 percent stocks. The risk profile of any given portfolio reflects the sum and interplay of the risks posed by each of the individual holdings, not strictly the relative proportion of those holdings.

In the power sector, risk profiles differ substantially across fuel types. Fuel-price volatility historically has been much greater for natural gas and oil than for coal and nuclear.[8] While the cost of wind and solar fuel is zero, uncertainty in the amount and timing of wind and the availability of solar drives supply volatility. Thus, a shift from a coal- and nuclear-heavy portfolio toward natural gas and wind, such as in PJM, can increase both fuel diversity and price volatility. Improvements in natural-gas-generation technology and drastic fuel-price reductions have often made new gas generation a more economical investment than retaining coal and nuclear, but such trends introduce an expanded element of fuel-price risk.

Investment strategies that strike the optimal risk-reward balance will vary based on unique circumstances. This suggests that market participants who bear the full risk of investments will manage them more efficiently than a top-down, one-size-fits-all approach. Electricity suppliers and consumers also vary in their tolerance for risk. This fact further underscores the value of assigning risk to individual market participants, who will make investment decisions consistent with their unique risk profiles.

Merchant power generators, who bear full investment risk in competitive markets, have always used advanced risk-management techniques, such as hedging power sales and natural-gas purchases to stabilize their operating margins.[9] By contrast, monopoly utilities socialize risk across captive ratepayers, using regulation to substitute for the economic discipline provided by competition. In recent years, some state regulators have required monopoly utilities to place greater emphasis on improved risk-management techniques in their resource planning. In either case, risk-management techniques evaluate potential resource portfolios using specific measures of risk (e.g., "value at risk"), not of fuel diversity. A fuel-diversity metric is not a valuable input or criterion for selecting generation portfolios. Rather, diversity is a common condition to result from a low-risk portfolio.[10]

Reliability

A portfolio with low fuel diversity may perform far more reliably than one with high diversity. In theory, the bulk electricity system is capable of reliably operating with just one or two fuel sources. A 2017 analysis by PJM found that fuel diversity alone is not an indication of reliability,[11] thus validating the PJM market monitor's earlier conclusion that "diversity is not a synonym for reliability."[12]

Proponents of fuel diversity often conflate it with, and use it as a proxy for, particular attributes that affect reliability directly. Such attributes include dependability and specific capabilities like frequency response and operational flexibility (e.g., "ramp," or the ability to adjust generation output) that sometimes are associated with particular fuel types. Monopoly utilities and competitive markets must procure reliability attributes in the correct proportion. This does not necessarily mean employing a fuel-type ratio, even if specific fuel types are associated with the specific needed attributes.[13] Prudent utility planning and well-designed markets can achieve reliability without assigning an explicit value to fuel diversity.

Fuel diversity is distinct from fuel security (or fuel assurance), where the reliability of a fuel supply is a function of that fuel being available. Increased reliance on resources with fuel limitations pose valid concerns about fuel security. For example, weather conditions dictate the availability for wind and solar generation. As deployment of these generation sources expands, portfolios become more sensitive to weather conditions. Integrating these variable resources at high levels will require electricity systems to procure specific reliability attributes that have not been the traditional focus of electric-resource planning. These reliability services include frequency response, voltage support and ramping capability.[14]

There could be legitimate reliability concerns if the pace of wind and solar deployments proceeds more rapidly than utility planning and market design can change to accommodate them. Such modifications to electricity-system planning and operations have been underway by monopoly utilities and competitive markets for years. Going forward, the most economical way to achieve reliability—especially those attributes that would be needed to integrate wind and solar—would to define a product for these attributes and procure sufficient amounts through competitive-market mechanisms.

Increased reliance on natural gas has also raised the specter of fuel security. Generators operating on natural gas historically have strong reliability performance, but there have been fuel limitations when pipelines become congested or face operational disruptions. Where this has happened, it's been due to very specific circumstances unrelated to the degree to which the entire system depends on natural gas. For example, a system with 25 percent gas dependency concentrated heavily in one congested pipeline may have worse fuel security than a system with 50 percent gas dependency and a robust pipeline network that has excess capacity. For this reason, measuring fuel diversity would not reflect the very specific circumstances that determine fuel security.

There are a variety of remedies to shortages of natural gas deliveries, but they are very situation-specific. For example, a natural-gas generator may elect a more expensive "firm" contract with the pipeline owner to guarantee access; use oil as backup when pipeline service is unavailable; purchase physical call options from gas-pipeline marketers; or, in some areas, invest in natural-gas storage behind a chronic pipeline constraint (e.g., underground or liquefied natural gas storage). The costs of each are specific to location and the individual generator, highlighting the advantage of using technology-neutral market incentives to encourage reliable behavior.

The value of mitigating fuel shortages depends on whether they cause an electricity system to have insufficient resources to meet reliability needs. Typically, pipeline constraints occur in winter, when power-system needs are lower than in summer. For example, a system requiring 50 gigawatts of power in the summer and 30 gigawatts in the winter can manage to have 20 gigawatts of summer resources not perform reliably in the winter. This demonstrates the value of having utility planning and market design procure enough reliable generation to meet fluctuating reliability needs, rather than set a pre-determined year-round target.

POLICY IMPLICATIONS

Policymakers and regulators should recognize that fuel diversity is a poor proxy for valid policy objectives like risk management and reliability. Specifically, a high level of fuel diversity does not mean an electricity system necessarily manages risk efficiently or meets reliability needs. Conversely, policies or market-design changes intended to increase fuel diversity will not necessarily improve risk management or reliability.

Policymakers and regulators can improve incentives for efficient risk management and reliability-enhancing behavior. Fundamentally, the most efficient approach is to commit to competitive electricity markets and consumer choice, which provide the base set of incentives for market participants to manage risk efficiently. Well-functioning electricity markets require market design to correct for market failures associated with reliability, such as resource adequacy.[15] The most efficient market designs signal reliable behavior when and where it meets system requirements by placing an explicit value on discrete reliability services. Current market designs do not fully account for all reliability attributes. They will need to be refined as the fuel mix evolves.

States that retain the regulated monopoly model can bolster use of risk and uncertainty analyses in utility resource planning. Regulators must remain cognizant that the increased complexities of portfolio evaluation exacerbate the information asymmetry that utilities may leverage to their advantage. Third-party evaluators may help identify specious risk applications that play to utilities' capital-expansion incentives. Regulated states may also find benefit in performance-based regulation. Traditional output price regulation distorts utilities' fuel purchase behavior away from minimizing costs.[16]

Cautionary tales of monopoly regulation without rigorous risk accounting go back to the late 2000s, when utilities convinced regulators to approve advanced coal and nuclear plants, in part by appealing to the value of fuel diversity to mitigate the risk of price volatility in natural gas. Paradoxically, this introduced new risk in the form of immense construction cost overruns that have far outweighed any apparent risk associated with natural-gas prices. Monopoly utilities also convinced regulators to add capital-intensive pollution-control retrofits to coal plants in the early 2010s, in part to hedge against natural-gas prices, whereas merchants elected to retire the same kinds of coal plants, because the going-forward costs of alternative sources of generation were lower.

Fuel neutrality is essential for both monopoly-utility resource planning and competitive markets to manage risk and achieve reliability efficiently. Interventions to promote specific fuel types—such as bailouts for coal and nuclear or mandates and subsidies for renewables—skew investment risk and can undermine incentives for reliability-enhancing behavior (e.g., a public intervention to finance pipeline expansion removes incentives for the private sector to invest in fuel security). Fuel-specific subsidies and mandates replace individual choice with collective choice. This one-size-fits-all approach to risk mitigation ignores variances in individuals' risk tolerances,[17] results in high-cost risk mitigation and creates perverse incentives for market participants by transferring risk and costs from the private to the public sector.

A policy intervention that enhances fuel diversity would have to increase the weighting of an underweighted technology or fuel, and vice versa for an overweighted technology or fuel. This would require verification through a fuel-diversity metric, such as the FDI, applied to sensitivity analyses of potential future fuel portfolios. To date, we have not seen this sort of technical approach to the topic. Typically, bailouts for coal and nuclear reflect political responses to rent-seeking behavior, while the quantified benefits associated with diversity seldom factor into decisions to alter state renewable portfolio standards.[18]

For regulators, attempts to achieve fuel diversity in market designs explicitly would likely result in inefficient and potentially discriminatory practices that are inconsistent with the Federal Power Act. The reliable performance of power generators varies across and within fuel types and changes with fluctuating conditions. This renders any attempt to value fuel diversity very complex. It would require extensive administrative judgment, expanding the potential for government failure. Ultimately, the central aim of market design should remain to procure specific reliability attributes at the least cost.

CONCLUSION

Fuel diversity is not an economically valid concern or policy objective. As wholesale electricity market design evolves to ensure reliability at least-cost, it should not explicitly value fuel diversity. Fuel diversity is, at best, a proxy for benefits that already are remunerated in well-functioning markets.

Legitimizing fuel diversity as a policy objective risks cooption by special interests who seek policies that promote a preferred fuel type (or vice versa), thus degrading market performance. There already have been many economically inefficient policy interventions taken under the banner of fuel diversity. However, some of these interventions aim to improve risk management and reliability, which are laudable policy objectives.

Policymakers and regulators can improve the performance of electricity systems by focusing on incentives for efficient risk management and reliability-enhancing behavior. Market mechanisms are ideal tools to signal behavioral improvements. That begins by ensuring regulatory and market structures assign risk to those making investment decisions, not socializing it across ratepayers or other market participants.

Ensuring reliability requires well-crafted market products that meet reliability needs as the technology and fuel mix evolves. This means policymakers and regulators should remain cognizant of changes in the generation mix, while keeping market design and policies neutral with respect to both technology and fuel type. Market signals, not political interventions, will guide investment decisions that achieve reliability at least-cost and provide the right incentives for the private sector to manage risk.

ABOUT THE AUTHOR

Devin Hartman is electricity policy manager and senior fellow with the R Street Institute, where he researches and promotes competitive electricity markets, efficient energy innovation and environmental policies, and sensible electric rate designs.

Devin joined R Street in January 2016, having previously conducted economic analysis of wholesale electricity markets at the Federal Energy Regulatory Commission (FERC). His areas of focus included renewables integration, environmental regulation, coordination of natural gas and electric industries, and using markets to procure resources to meet reliability needs.

ENDNOTES

1. FDI recently was developed by Monitoring Analytics, the independent market monitor of the PJM Interconnection LLC. This is the first known attempt to apply it nationally.

2. The FDI formula is 1 minus the sum of the squared market shares of each fuel type.

3. The 11 fuel types represent those reported by the U.S. Energy Information Administration: coal, petroleum, natural gas, other gases, nuclear, hydroelectric, wind, solar, biomass, geothermal and other.

4. R Street derived these figures from PJM State of the Markets Reports for 2016 and 2010.

5. Monitoring Analytics LLC, "State of the Market Report for PJM," March 2017. http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2016/2016-som-pjm-volume2.pdf

6. IHS Energy, "The Value of US Power Supply Diversity," July 2014. http://www.energyxxi.org/sites/default/files/USPowerSupplyDiversityStudy.pdf

7. The likelihood of zero contribution from coal, nuclear and oil generation within the next couple of decades is low.

8. Jason Brown and Andres Kodaka, "U.S. Electricity Prices in the Wake of Growing Natural Gas Production," Federal Reserve Bank of Kansas City, 2014. https://www.kansascityfed.org/publicat/mse/MSE_0214.pdf

9. Frank Graves and Steven Levine, "Managing Natural Gas Price Volatility: Principles and Practices across the Industry," The Brattle Group, November 2010. http://www.brattle.com/system/publications/pdfs/000/004/848/original/Managing_NG_Price_Volatility_Graves_Levine_Nov_2010.pdf?1378772134

10. Both merchant and monopoly utility evaluations reveal that the most fuel-diverse prospective portfolios seldom have the least risk, but that risk reduction is often associated with some degree of diversification.

11. PJM Interconnection, "PJM's Evolving Resource Mix and System Reliability," March 2017. http://www.pjm.com/~/media/library/reports-notices/special-reports/20170330-pjms-evolving-resource-mix-and-system-reliability.ashx

12. Monitoring Analytics LLC, "Post-hearing reply brief of the independent market monitor for PJM," Feb. 26, 2016. http://www.monitoringanalytics.com/reports/Reports/2016/IMM_Post_Hearing_Reply_Brief_Case_No_14-1297-EL-SSO_20160226.pdf

13. PJM Interconnection, "Resource Investment in Competitive Markets," May 2016. http://www.pjm.com/~/media/documents/reports/20160505-resource-investmentin-competitive-markets-paper.ashx

14. North American Electric Reliability Corporation, "2016 Long-Term Reliability Assessment," December 2016. http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/2016%20Long-Term%20Reliability%20Assessment.pdf

15. Devin Hartman, "Wholesale Electricity Markets in the Technological Age," R Street Institute, August 2016. http://www.rstreet.org/wp-content/uploads/2016/08/67.pdf

16. E.g., see Akshaya Jha, "Regulatory Induced Risk Aversion: Coal Procurement at U.S. Power Plants," January 2017.

17. Retail customers in restructured states can choose electric-supply contracts that provide greater rate stability. Market participants are best equipped to undertake hedges consistent with their individual risk profiles, which vary substantially.

18. Few states conducted benefit-costs analyses of renewable-portfolio-standard policies, according to J. Heeter, et al., "A survey of state-level cost and benefit estimates of renewable portfolio standards," National Renewable Energy Laboratory and Lawrence Berkley National Laboratory, May 2014. http://www.nrel.gov/docs/fy14osti/61042.pdf