REUTERS EVENTS™

Produced in conjunction with:

WÄRTSILÄ

# Uncovering the Hidden Value of **Reciprocating Engines in Today's Energy Markets**

# Introduction

U.S. electric utilities could be missing out on millions of dollars in value for their customers by using outdated grid modelling techniques, research has found. The finding has profound implications for grid planning in the energy transition, where granularity of data is critical for effective decision making.

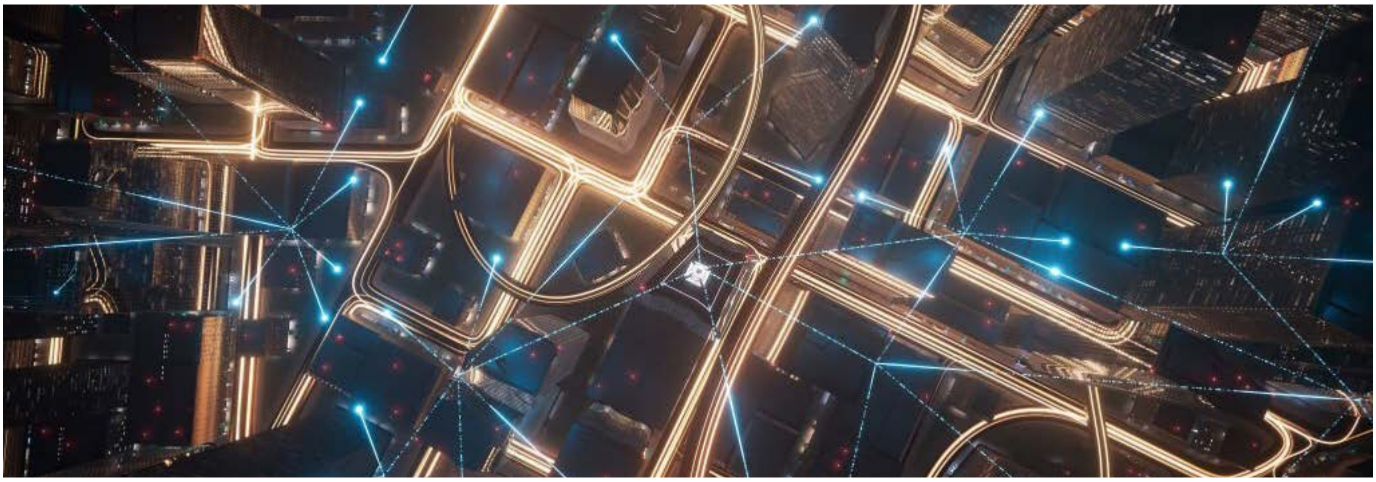
A recent analysis by Ascend Analytics, a leading power market research and analytics firm, shows the use of hourly dispatch modelling vastly underestimates the value of flexible grid resources such as batteries and utility-scale reciprocating internal combustion engines (RICE). This value only becomes apparent if more realistic five-minute modelling is employed. Under a traditional hourly model, RICEs may appear to be the most expensive of three dispatchable gas technologies surveyed. However, when using five-minute modelling, a data intensive approach better suited to grids with a growing proportion of variable renewable energy resources, shows the opposite is true: RICEs deliver greater value than competing technologies.

The implication is that the modelling techniques used by many U.S. electric utilities today contain a major shortcoming when determining the optimum mix of generation assets and result in higher-than-necessary costs and emissions. "This study quantifies and calculates what that value of flexibility is," says David Millar, Principal for Markets, Legislative and Regulatory Policy at RICE manufacturer Wärtsilä, which sponsored the research. "It's hidden because you don't see it when you only rely on hourly models."

# Reciprocating Engines and Their Role in a Decarbonized Electricity Grid

At first glance, RICE technology might seem an odd fit for a future electricity grid with little to no greenhouse gas emissions. However, a deeper look reveals that the technology provides essential services that enable the transition to renewable resources providing most of the grid's energy. Grid operators balance generation and demand down to the millisecond due to the unique physical properties of electricity. They are adapting to renewable energy generation which can at times reach 80, 90, or even 100% of energy demand, or conversely almost nothing, such as during a windless night. Flexible, dispatchable resources such as demand-response, battery storage and reciprocating engines provide grid operators with the tools they need to compensate for the vagaries of renewable output. As more and more renewables are added to the grid, thermal dispatchable generation is required less for generating the energy people use, and more for balancing the grid when renewables are not available. Reciprocating engines can start-up and provide energy at full load in less than 5 minutes and they have no minimum up-time or minimum downtime. RICE can run on natural gas, diesel, or both (dual-fuel) for added reliability and resilience. They are also capable of burning hydrogen, ammonia, or methanol created through the process of electrolysis powered by renewables, for a completely carbon-free combustion cycle. In a grid with high renewables, they may run as little as 10% of the year, but that 10% is critical for keeping the lights on, particularly in extreme hot or cold events where access to electric power is a life-or-death matter.


*Figure 1: Wartsila's RICE technology is a large internal combustion engine that can be deployed modularly to fit the needs of any high-renewables power system.*



# Grid Modelling in the United States

The statistician George Box famously stated that all models are wrong—but some are useful. In U.S. power system planning, models can be highly complex because energy demand and production vary on a second-by-second basis. Historically, though, it has not been necessary to model the system with such precision.

In a world predominantly comprised of traditional baseload generation from hydro, coal, and nuclear power plants, supplemented by peaking capacity from natural gas and oil units, it was sufficient to estimate roughly what demand would look like at different times of day, and have enough capacity in hand. If there was enough generation on standby to cope with peak demand in any given hour, grid planners and regulators could be reasonably sure of system resource adequacy.

Most grid resource planning in the United States is carried out using representations of future loads and power resources in what are known as "production cost models." Most utility planners still use older modelling technology that, at best, provide a single hourly simulation over twenty years (8,760 hours per year times 20 years = 175,200 data points). These legacy modelling platforms can run on a laptop of modest computing power because the mathematical algorithms are highly simplified.[i] Unfortunately these simplifications yield "optimal" resource mixes that are systematically biased towards more inflexible "cheaper" legacy resource technologies. The problem stems primarily from 1) the use of normalized weather inputs that fail to capture real-life grids conditions with significant levels of variable renewable energy and 2) failing to drill down to the 5-minute level where much of that variability occurs. Both of these issues lead to a systematic undervaluation of flexible, dispatchable resources like battery storage and reciprocating engines.[ii] Put differently, solving real-time power system models at an hourly level is like trying to measure a car's zero-to-sixty time using an egg-timer: Whether you're timing a sports car or a semi-truck, the timer will read "one-minute" for either. A power system with growing complexity demands equivalently precise tools to achieve accurate solutions.

Experts say regulators are generally unaware of this problem and utilities have little incentive to move to more granular modelling, since sub-hourly models can only be resolved using costly computational resources. "It's very time consuming, it's very complicated and there's no strong reason for utilities to undertake that type of analysis when they are regulated monopolies and regulators are not requiring them to," says Brandon Mauch, director of resource planning analytics at Ascend.

# Model-Limited Choice in Low-Carbon Grids

Mauch and Millar believe there is increasing danger of these legacy models mischaracterizing the behaviour of modern grids that are, to a growing extent, dominated by variable renewable generation. Variable renewable energy generation leads to increasing volatility in electricity prices. Because wind and solar have no marginal costs, they can drive pricing to zero in times of oversupply. But if wind or solar conditions cause renewable output to drop, other assets must come online to balance demand. Traditionally, inflexible technologies, such as coal- and gas-fired turbines, have filled these needs. These technologies incur added costs when starting up, and once turned on, they may need to run for multiple hours. If inflexible generation cannot be turned off once renewable output ramps back up, the renewable energy must be curtailed if supply exceeds demand, which increases costs and emissions.

As variable generation sources increasingly dominate U.S. grids, flexible assets such as batteries and RICE units are better-suited to compensate for the gaps in renewable output because they can operate only when necessary. However, since these flexible assets act on sub-hourly timeframes the value they provide to the grid is not captured in traditional daily or hourly models.

# Comparing Technologies on an Hourly Basis

To investigate the shortcomings of hourly models, the Ascend study used an hourly model to value three common thermal generation technologies and then compared the findings to those obtained using an additional five-minute dispatch analysis. The technologies chosen for the analysis were as follows:

| Parameter | RICE | Aeroderivative GT | Heavy Duty GT |
|---|---|---|---|
| Model | Wärtsilä 18V50SG | GE LM6000 | GE 7FA |
| Unit Size | 18.8 MW | 53 MW | 225 MW |
| Number of Units | 12 | 1 | 4 |
| Total Plant Size | 226 MW | 212 MW | 225 MW |
| Capital Cost | $1,000/kW | $900/kW | $750/kW |
| Start-up Cost | $0 | $500 | $8,250 |
| Start Up Time | 5 minutes | 60 minutes | 120 minutes |
| Ramp Rate | 90 MW/min | 50 MW/min | 37.5 MW/min |
| Minimum Up Time | 0 | 1 hour | 2 hours |
| Minimum Down Time | 0 | 1 hour | 2 hours |

Based on pricing drawn from a grid node close to the Denver metropolitan area, the hourly model showed the RICE units as having the highest cost to ratepayers. The technology appeared to cost $30 million more than the LM6000 plant because the model overlooked sub-hourly attributes such as not having a minimum uptime or start-up costs.

In a thermal generation-heavy grid, such attributes would have little value because assets would tend to start up and continue running for medium to long periods of time. But in a renewables-heavy grid where flexible capacity must kick in regularly and for short periods, the value grows.

# Uncovering Hidden Value Every Five Minutes

This is apparent when the analysis is repeated using Ascend Analytics' PowerSIMM Planner software. This simulation shows how flexible resources can capture short-duration spikes in real-time market (5-minute) prices, returning additional value to ratepayers. Over twenty years, the heavy-duty gas turbine can deliver an extra $23 million and the aeroderivative turbines can secure $57 million. On the other hand, the flexible operations of the RICE units, returned $93 million of value based on the five-minute model. This would make them the most cost-effective resource in real world conditions—exactly the opposite of what the hourly dispatch model suggests.

Ascend's research from 2021[iii] published by the National Regulatory Research Institute (NRRI) confirms the importance of this new class of "high-definition" production cost modelling in the selection of assets for grids with high levels of variable renewable energy.

# Implications for Regulatory Authorities

It is clear from this research that the hourly production models being used for grid planning in the United States will not provide rate payers the lowest cost solutions in a world of growing renewable generation and pricing volatility. Not only do they fail to capture the true value of generation assets, but in many cases offer results that are the opposite of what a more granular analysis would reveal.

It is vital for regulators to understand the importance of this issue as the proportion of wind and solar generation grows. Due to the variable nature of renewable resources, sub-hourly pricing volatility is set to increase dramatically across U.S. electric grids. Improved modelling in regulatory filings to account for this sub-hourly pricing volatility is needed to ensure electricity rates remain just and reasonable.

"The higher your penetration of renewables, the more price volatility we see, and the greater the benefit ratepayers will get from adding flexible resources" says Karl Meeusen, Director of Markets, Legislative and Regulatory Policy at Wärtsilä North America. "These benefits are not captured using hourly models and ratepayers bare those unnecessary costs of inflexible generation."

Such grids could see electricity prices soaring up to thousands of dollars per megawatt-hour when supply fails to meet demand. In 2019, for example, ERCOT—which has limited interconnection capacity to handle imbalances—reached a price cap of $9,000 per megawatt-hour.[iv] "Flexible generation that can be dispatched in real-time would provide utilities with a hedge against these high prices," says Meeusen.

# Choosing the Right Technologies to Enable a Highly Renewable Grid

Experts hope a move to more granular production models will assist regulators and network planners in selecting technologies that are best suited to increasingly volatile pricing conditions. RICE units are a case in point. "These assets are frequently overlooked in utility procurement because current modelling does not reveal their true value and there is a lingering misconception regarding their costs and the scale at which they operate," says Bhawramaett Punruckwong Broehm, an energy market analyst at Wärtsilä.

"There is this perception of them being for backup power in your home or small business," he says. "But these are resources that are utility grade and utility scale."

RICE units can fulfil many of the functions of battery plants, but with the added advantage of being able to run for longer than the three to four-hour maximum discharge time of most lithium-ion energy storage systems. "If you have, say, a weather system where it's cloudy and not windy for a week, a battery might not solve your problems," notes Brent Nelson, director of market intelligence at Ascend Analytics.

In the long run, he adds, grids will have to deploy long-duration storage technologies, such as thermal resources burning low or zero carbon fuels for prolonged periods of low wind and solar generation. But in the meantime, "you want to have something that can solve a one-week problem," he says.

# Conclusion

The research outlined here demonstrates the need to update resource planning models to account for real-time, 5-minute variability in high renewable systems. It shows that commonly used methodologies for grid planning in the United States may result in sub-optimal outcomes for ratepayers.

Following the 2022 Inflation Reduction Act, the country is about to unleash new levels of variable renewable energy generation. Consequently, there is an urgent need for regulators to be made aware of the shortcomings of traditional hourly and weather-normalized modelling in forecasting current energy system dynamics. Without regulatory pressure to use more granular models, there will be little incentive for U.S. electric utilities to embrace sub-hourly models. This will lead to increasingly sub-optimal results and rising costs for ratepayers, who will have to endure price spikes and grid instability while electric companies invest millions in assets that are poorly equipped to operate in a low-carbon energy world.

"Although traditional planning processes are steeped in regulatory precedents, they are increasingly at risk of failing to meet the prudence standard by not exploring what is known and knowable," say the authors of the 2021 study.[v] "In particular, the economic construct of power planning needs to capture the fundamental physical dynamics of high renewable systems and their impact on market prices and costs."

Given the forecasted rate of increase in renewables on the grid, the shift to capture these fundamental dynamics is one that cannot wait.

# References

[i] *David Millar, Ascend Analytics, April 22, 2022: Uncovering the hidden value of RICE Units.*

[ii] *Ibid.*

[iii] *Ibid.*

[iv] *Matt DaPrato, Greentech Media, August 19, 2019: Texas' Power Price Spike and Designing Markets for a Carbon-Free Grid. Available at https://www.greentechmedia.com/articles/read/texas-power-price-spike-and-designing-markets-for-a-carbon-free-grid.*

[v] *Dorris and Millar, 2021.*