WÄRTSILÄ

Making money with flexibility

Unlocking revenue streams through operational flexibility in advanced energy markets

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Foreword

The energy transition is unfolding around us and reshaping how we generate, distribute, and consume power. With an increasing share of intermittent renewables, flexibility has emerged as a defining characteristic of resilient and future-ready power systems. Due to the nature of renewables, flexibility is needed to react to supply and demand fluctuations.

But flexibility is not just a technical requirement to balance renewables and ensure power systems stability. It is also a necessity from a commercial point of view.

This report was developed to help explain how utilities and independent power producers can monetise their flexible power generation assets and therefore maximise the return on investment. It brings together insights across markets and technologies, exploring how to take advantage of market designs and mechanisms with flexible power generation assets.

From theory to practice, this report delves into case studies with clear demonstrations of how flexible assets both can and already are delivering value – financially, operationally, and environmentally. They show that with the right market design, technology choices, and commercial mindset, flexibility can be both a stabilising force for the grid and a profitable venture for asset owners.

I hope this report serves as a useful guide and a source for those looking to turn flexibility into profitability.

"Flexibility is not just a technical requirement to balance renewables. It is a necessity from a commercial point of view.

Frederic Carron
Vice President
Middle East & Asia
Wärtsilä Energy

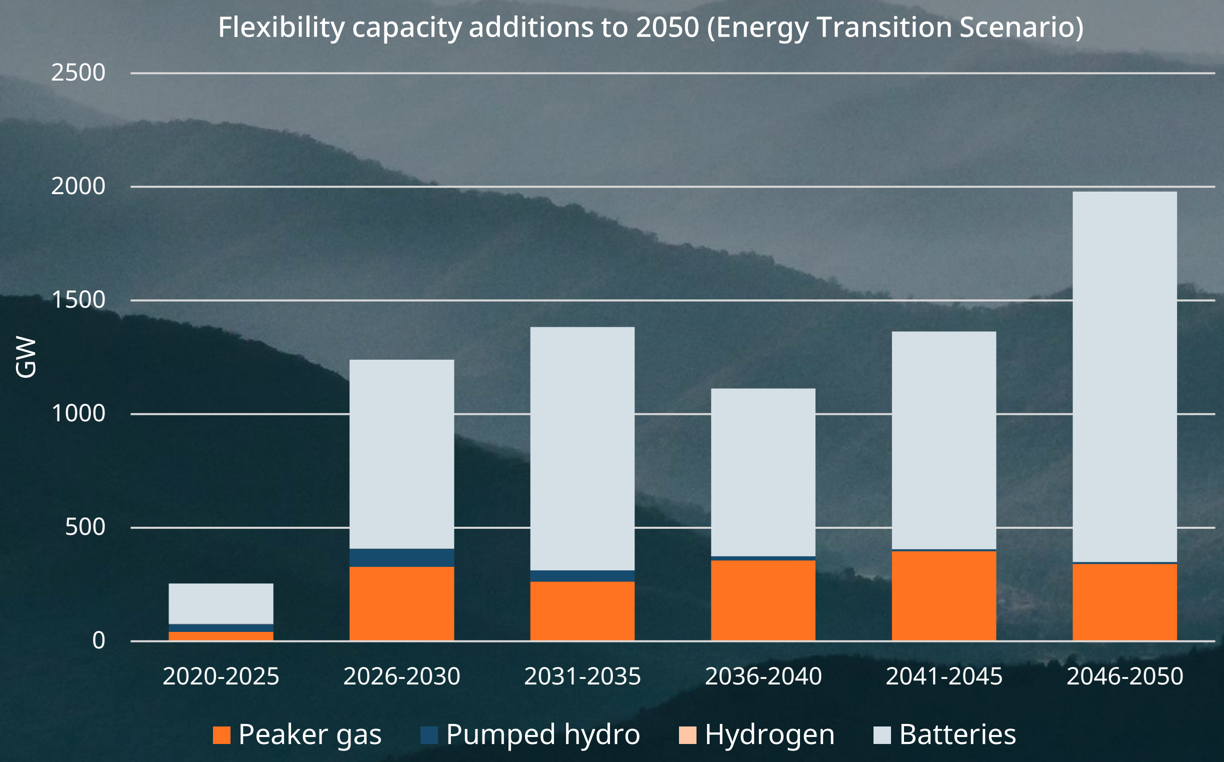
Flexibility in the energy transition

Improving power system stability while maximising value for businesses

In today's rapidly changing energy landscape, flexibility is becoming increasingly crucial for power systems to not only ensure grid stability but also as a strategic opportunity to boost revenue.

The inflexibility of traditional energy systems, combined with the rise of renewables and changing climatic conditions, has led to significant challenges. To accelerate the energy transition and achieve global decarbonisation targets, it is essential to introduce more flexible balancing assets that are capable of rapidly responding to changes and fluctuations that renewables bring to the power system.

According to BloombergNEF, an estimated 6,972 GW of flexible capacity will be added globally by 2050, of which 1,686 GW is peaking gas and 5,286 GW battery storage. Similarly, the International Energy Agency (IEA) predicts that the flexibility requirements will be increased by four times by 2050, compared to 2023, due to higher variability in electricity supply and demand.



Source: BloombergNEF New Energy Outlook 2025

Adding flexibility to power systems offers numerous benefits and adds substantial value. Flexible assets can adjust their output quickly in response to changing system needs. This ability enables integration of an increasing share of renewables by compensating for their variability (e.g. sudden drops in solar or wind output), thus preventing curtailment and allowing more clean energy into the system.

Adding flexibility also leads to increased system efficiency and reduced fuel consumption as flexible assets only need to run when they are needed, avoiding inefficient must-run operations. Lastly, flexibility enhances power system stability and reliability by maintaining real-time balance between supply and demand, controlling frequency and voltage deviations, and providing fast reserves during unexpected events, therefore reducing the risk of blackouts or system failures.

One area which does not get enough spotlight, is that flexibility also brings substantial monetary value to power generation asset owners, such as utilities and independent power producers (IPPs). With renewables on the rise, volatility is increasing in modern, liberalised electricity markets. In these markets, where renewable intermittency already has a visible effect, flexible assets can register better returns than their less dynamic competitors.

Furthermore, flexible assets create additional value by providing grid services or in certain cases reduce the operation costs of their asset owners. For example, a flexible asset can provide protection against high electricity procurement costs during periods of extreme or unpredicted electricity prices, thus reducing its financial risk.

Flexibility supply by technology

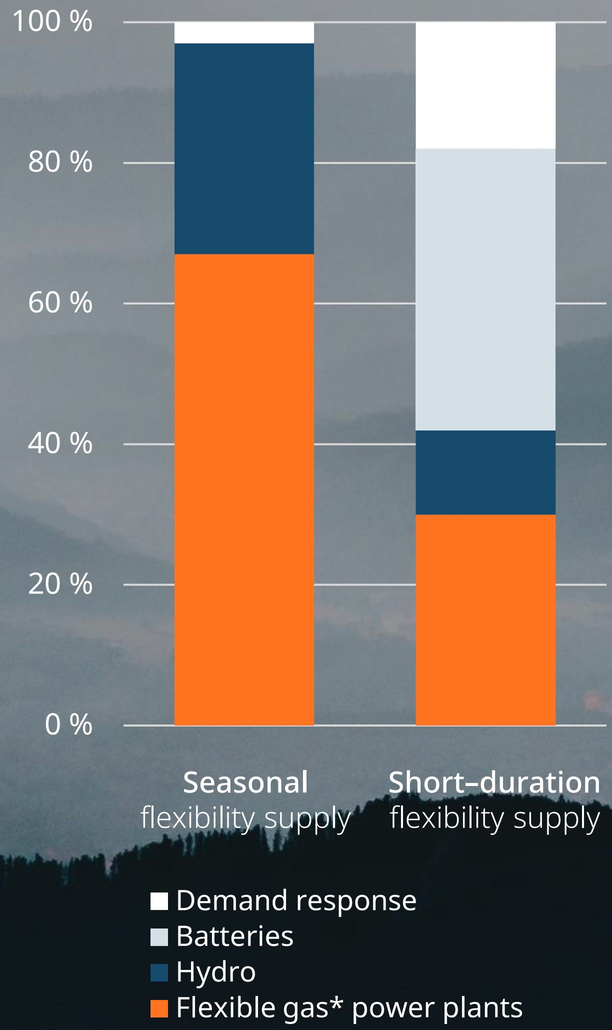


Chart source: International Energy Agency.
*Able to run on hydrogen or other sustainable fuel in the future.

Understanding flexibility of different technologies

As the energy transition progresses, flexibility is becoming a critical factor for utilities and IPPs to ensure business continuity and profitability. The International Energy Agency (IEA) defines flexibility as "the ability of a power system to reliably and cost effectively manage the variability and uncertainty of supply and demand across all relevant timescales".

As the share of intermittent renewable energy increases, the ability for power plants and energy storage systems to respond to changes in supply and demand across various timeframes is becoming increasingly important. Understanding the main differences between technologies and the extent to which they are flexible enough to provide services across different timeframes is key for IPPs and utilities to optimally monetise their assets in the electricity market. Defining the intended use case helps to narrow down technology choices.

Examples of how different dispatchable technologies vary in terms of flexibility:

Battery energy storage systems
Energy can be stored or discharged to handle millisecond and minute-level fluctuations and providing support during peak times. Thus, battery energy storage systems are ideal for providing ancillary services, and energy up to 2-4 hours in duration if they are in charged state.

Flexible thermal generation
Flexible reciprocating internal combustion engine power plants and aeroderivative gas turbine power plants can be dispatched on demand, to fill gaps in renewable energy across minute-level, daily, seasonal and inter-annual variations.

Pumped hydro
Where geographically possible, pumped hydro can provide balancing across multiple timeframes, but its availability is dependent on seasonal water cycles, which can vary considerably year by year.

Inflexible thermal generation
Traditional power plant technologies such as coal, nuclear and combined cycle gas turbines are designed to operate at high utilisation rates with minimal starts and stops. Dynamic utilisation is typically technically limited and incurs increased operating costs.

In order to monetise flexibility, it is essential to have a more nuanced understanding of technical parameters of different technologies within the intended use case. This is especially important as flexibility related value capturing opportunities can be unpredictable and vary in duration. Even technologies within the same category provide trade-offs in their features.

As an example, thermal generation is sometimes mistakenly viewed as having similar technical flexibility parameters. In this category, the key properties used to measure flexibility include:

Start-up time to full load: Shorter start-up times enable rapid response to sudden gaps in renewables or supply-demand changes. Measured in minutes or hours.

Ramp rate: The ability to ramp up and down quickly is essential for providing balancing and firming capacity. Measured as %/minute or MW/minute.

Minimum uptime and downtime: Minimum uptime refers to the minimum operational time after start-up before safe shutdown. Minimum downtime refers to the minimum time after shutdown before safe restart. Measured in minutes or hours.

Plant net efficiency: High efficiency at different load levels helps minimise fuel costs and emissions, maximising operational flexibility as thermal power plants shift from pure baseload to balancing renewables. Measured in percentages or heat rate.

Minimum stable load: The lowest power output at which a power generating unit can operate continuously and in a stable fashion, without time limitations. Measured as % of nameplate capacity.

Understanding flexibility is key to making the most revenue with flexible assets in the evolving energy landscape. Flexibility in power generation is not only a requirement to ensure stability in the grid, but also something businesses can utilise strategically to increase their revenues. By having the right technology to match with available market opportunities, utilities and IPPs can manage their risks and ensure positive returns for their businesses.

	Engines	Aero-GTs	OCGTs	CCGTs	Coal
Start-up time	2 min	8 min	5 – 10 min	30 min – 4 h	75 min – 10 h
Average ramp rate [% Pnom/min]	>100%	50%	8 – 15%	2 – 11%	1 – 6%
Minimum uptime	0 min	10 min	10 – 30 min	4 h	8 – 48 h
Minimum downtime	0 min	30 min	30 – 60 min	2 h	8 – 48 h
Plant minimum load [% Pnom]	10%	20 – 40%	20 – 50%	20 – 50%	10 – 60%
Efficiency (at 100% load)	45 – 48%	36 – 40%	35 – 39%	52 – 57%	40%
Efficiency (at 50% load)	45 – 48%	28 – 33%	27 – 32%	47 – 51%	35%

Sources: IRENA (2019) and Wärtsilä (2024)

Why do IPPs and utilities need to care about flexibility?

Without flexibility, utilities and IPPs face challenges that can significantly impact their operations and profitability. By incorporating flexible assets, they can better manage the risks associated with renewable energy integration and hedge their own exposure to extreme market prices.

Flexibility is crucial for IPPs and utilities for several reasons:

1 Protect against price spikes and situations of tight supply

High electricity prices typically occur when there is an imbalance between demand and supply. This can happen during peak times, such as morning and evening, or seasonally when renewable generation is low. Utilities and IPPs face increased electricity procurement costs if they are not generating sufficient power or lack contractual protections. If a utility has assets that can be called into dispatch with short notice – and can generate electricity for shorter or longer periods in an efficient fashion – the company is much more resilient to high-price events. A flexible asset can enable the owner to "cherry-pick" between price points, and switch back-and-forth between sourcing from the grid and its own generation.

2 Mitigate financial losses from negative market prices

Negative prices occur when the power system faces overcapacity at certain times. Some inflexible power generators must choose to stay online during these periods because shutting down and restarting can be more costly. This situation forces utilities and IPPs to pay consumers to use electricity, leading to financial losses. This phenomenon is an emerging trend in regions with high renewable energy penetration, such as Germany and Australia.

3 Reduce risks and strengthen portfolio

Utilities and IPPs need to ensure their portfolios have stable returns under all possible market and weather scenarios. Renewable-only portfolios carry higher risk of lower returns in years with poor renewable energy output. Adding flexible capacity helps maintain returns by ensuring reliable supply. Insufficient operational flexibility of thermal assets, such as relying on large single units that cannot efficiently operate at multiple load points, can also lower returns and increase unplanned maintenance risks. In contrast, using multiple smaller units improves reliability and utilisation.

4 Enhance market opportunities and additional revenue streams

Flexibility allows asset owners to participate in ancillary service markets, providing services such as primary or secondary regulation. Participation in these segments have strict activation time requirements, hence not all dispatchable assets can offer it. The ones with higher degree of flexibility have a better chance to be selected to provide ancillary services.

Navigating the changing energy landscape with flexibility is vital to remain competitive and ensure business continuity under all market circumstances.

How can utilities and IPPs monetise their flexible assets?

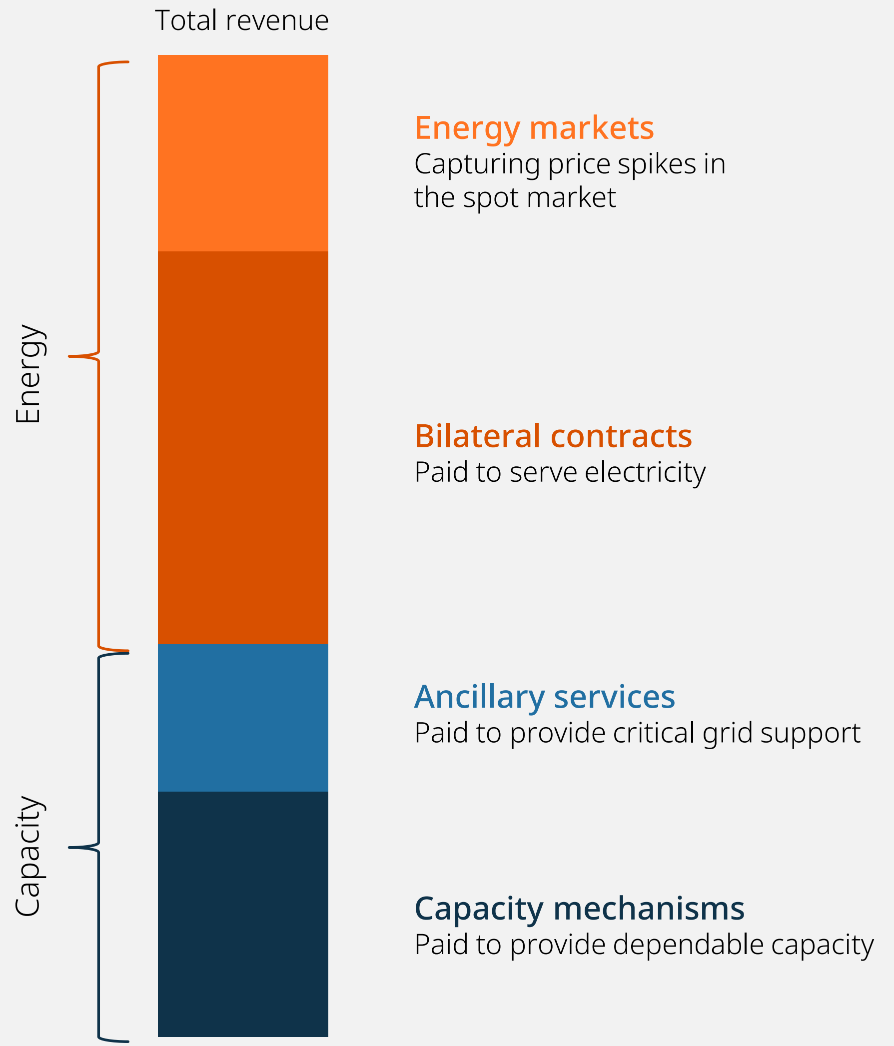
Traditionally, integrated utilities have used flexible assets to lower costs by activating peaking units during high demand or risk events. This remains a viable strategy as imbalance and activation costs rise with renewable energy led systems. However, the increased volatility also creates new market opportunities for utilities and IPPs to adopt a more active approach.

In short, flexible assets do not derive revenues by only selling energy to electricity markets, but can combine multiple revenue streams, which can range from providing multiple services to the power system and its participants. The business model for each actor is unique, depends on their risk-reward profile and the technology choices they have available. Most liberalised power markets enable asset owners to tap into multiple revenue streams, such as:

- **Bilateral contracts**
- **Energy markets**
- **Capacity mechanisms**
- **Ancillary services**
- **Financial markets**

Combining multiple revenue streams, also known as revenue stacking, is key to making flexible assets financially viable. Relying solely on energy sales may not offer sufficient returns so flexible asset owners are optimising returns by offering multiple services simultaneously and/or switching between revenue streams as market opportunities shift throughout the day. Therefore, it is important to understand and capture all available revenues. The next sections will explain the commonly available revenue streams for flexible assets.

Illustrative example of revenue stacking from various streams



Note: Actual revenue from each stream will depend on multiple factors, such as market design, contract terms, asset performance, and regulatory framework, among others.

Bilateral contracts

Power plant owners often earn revenue through bilateral contracts, such as a power purchase agreements (PPAs). These agreements involve two parties agreeing to buy and sell electricity at predetermined prices and volumes for a specified time period.

Flexible asset owners can for example package a renewable energy portfolio and a firming asset into a PPA that provides a fixed price to a buyer at a premium. Alternatively, owners of a flexible asset can offer time-of-day contracts to meet specific demand periods only.

Integrating bilateral contracts together with market participation allows owners of flexible assets to improve bankability of the project and to secure a stable and predictable revenue stream for multiple years, while leveraging market opportunities for lowering costs and tapping into additional revenue streams.

Energy markets

Power plants can sell electricity in the day-ahead, intraday, and real-time markets. In some APAC markets, like Australia's National Electricity Market (NEM) and the Philippines' Wholesale Electricity Spot Market (WESM), operators can submit bids just 5 to 7 minutes before delivery. This is also the case in various markets in the US, such as Electric Reliability Council of Texas (ERCOT), Midcontinent Independent System Operator (MISO) and Southwest Power Pool (SPP). This gives them the chance to adjust output based on the latest prices and forecasts.

Energy market revenues are generally stackable with other revenue streams, except for certain reserve services that require exclusivity during activation windows.

Price volatility is increasing due to renewable generation swings and changing demand patterns. This creates opportunities for flexible assets to stay offline when prices are low (e.g. during high solar output) and ramp up when prices spike (e.g. during supply shortage).

Different countries have different settlement intervals, but the trend is moving toward shorter periods. Shorter intervals better reflect system variability and reward fast response. For example, Australia, the Philippines and ERCOT, MISO, and SPP in the US all operate 5-minute settlement markets. By the end of 2025 the European Union is transitioning its power market to 15-minute intervals. Shorter intervals allow flexible assets to capture sharp price spikes that would otherwise be averaged out in longer settlement periods.

To make the most of price swings, operators need to monitor the market prices and develop a trading strategy based on:

- Long-term price levels
- Sub-hourly price patterns
- Short-term volatility (caused by weather, load changes, or renewables)

Capacity mechanisms

Capacity mechanisms address the “missing money problem”* in energy-only markets by paying for available capacity rather than energy delivered to secure capacity adequacy of the system. These programs are becoming more common as share of renewables grow and older thermal plants retire. Such programs can be seen across the globe in Asia, Europe and America, for instance in Japan, Oman, Italy, and the US.

In countries with capacity markets, payments are often set through competitive auctions. Winning bidders receive a fixed amount (e.g., $/kW per year) in return for committing to deliver power during extreme shortages of electricity. Failing to deliver when called can lead to serious penalties.

Capacity payments are typically stackable with other revenues, since they reward readiness rather than actual dispatch. It is a reliable and steady revenue stream, thus considered low risk. However, the income potential depends on factors like asset type and derating factors, which reduce payments for assets that can’t supply power for long durations, such as short-duration batteries.

In some countries, like in the US, capacity accreditation is utilised. It determines how much dispatchable capacity a technology can contribute to meeting peak electricity demand. For utilities and IPPs, a high accreditation value translates into greater eligibility for capacity payments and strengthens business cases in resource adequacy markets, making these assets more attractive for both grid reliability and long-term revenue stability.

Ancillary services

Ancillary services help maintain frequency, voltage, and system reliability in real time. System operators procure them through contracts or dedicated markets. Ancillary services are generally measured based on three key attributes:

- Speed of response
- Duration of response
- Accuracy in following dispatch signals

The characteristics of ancillary services vary by country, and country specific types of mechanisms exist.

In some countries ancillary services are procured under monthly or annual contracts. In Australia, UK, Finland and the Philippines, some ancillary services are auctioned in 5-minute intervals, favouring fast and flexible resources. The short contract period provides more flexibility for asset owners to dynamically adjust their capacity allocation among different market segments.

Payment for ancillary services providers is based on availability fees (in $ per hour in each availability period) and/or utilisation fees (in $/MW per hour paid in respect of actual energy delivered). Some revenue is protected through the availability payment, but the total revenue derived may vary significantly depending on whether the asset is dispatched.

Some services can be stacked with energy sales, while others require exclusivity during activation, meaning careful scheduling is needed to avoid penalties.

*

The "**missing money problem**" occurs when market prices don’t generate enough revenue for power plants to stay financially viable. This is particularly challenging for plants that run infrequently but are essential for reliability during peak demand, making it hard to justify new investment or ongoing operation. As a result, markets may underinvest in needed capacity.

Financial contracts

Financial markets for electricity, also called electricity derivatives markets, are a marketplace for financial instruments that are settled based on realised electricity market prices. Such derivatives markets are operating in several countries in the Asia-Pacific region with centralised exchanges including Australia, Japan, China, Singapore, India, and New Zealand. In Europe, the most liquid electricity derivatives markets are the EEX (European Energy Exchange) based in Germany, the ICE Endex in the Netherlands and the Nasdaq Commodities in the Nordics.

In the US, power derivatives products can be found for the PJM Interconnection, ERCOT, New York Independent System Operator (NYISO), California Independent System Operator (CAISO) areas, provided by various market operators, such as Chicago Mercantile Exchange (CME) or Intercontinental Exchange (ICE)*.

Larger exchanges provide a bigger and regulated marketplace, support with pricing of financial instruments and protect against counter-party risk. Utilities and IPPs frequently use electricity derivatives markets for additional risk management. These markets allow asset owners to hedge against price fluctuations but can also be used to secure an additional revenue stream for flexible assets.

For example, in the Australia Securities Exchange (ASX) owners of flexible power plants in the National Electricity Market (NEM) can originate A$300 cap contracts and sell them to buyers that want to protect themselves against high electricity prices.

When the electricity market price is below the strike price, the contract is profitable for the seller. When the electricity price is above the strike price, asset owners can run their flexible asset to reduce the price difference.

Types of financial instruments available and their demand varies in each country. The most liquid financial contracts tend to be shorter in nature than bilateral contracts between electricity market participants but can offer an additional revenue boost for flexible assets on annual level.

*EEX, ICE, and CME are major global exchanges where commodities (like electricity, natural gas, oil, and others) — including derivatives such as futures and options — are traded.

Key considerations for revenue stacking

Timing is everything. Understanding when markets are procured and how services interact is critical for stacking to succeed.

For instance, some services, like capacity auctions, are locked in years ahead, while energy and balancing services are traded much closer to real-time. Shorter settlement intervals (like 5-minute intervals) help maximise flexibility value and enable better demand forecasts and price signals. Some contracts prevent assets from participating in other markets at the same time, so asset owners must understand exclusivity rules and penalties.

Other factors that influence revenue stacking potential:

- **Regulatory changes:** For example, Japan's long-term decarbonisation auction reforms, the Philippines' reserve market launch, the EU electricity market reform, and Singapore's evolving price caps are reshaping incentives.
- **Local context:** Market design, carbon prices, and the supply-demand mix vary across countries.
- **Technology-specific rules:** Some technologies are more suitable for different needs. For example, different ancillary service products have different technical requirements, so each technology earns differently based on its capabilities.

Operators who understand market rules and optimise across different services will be well-positioned to earn strong returns with a viable business model. At the same time, this approach supports the development of a more reliable power system that's ready for higher shares of renewables.

Quick overview of key considerations

Understanding the timing

Contractual limitations

Regulatory changes

Local context

Technology-specific rules

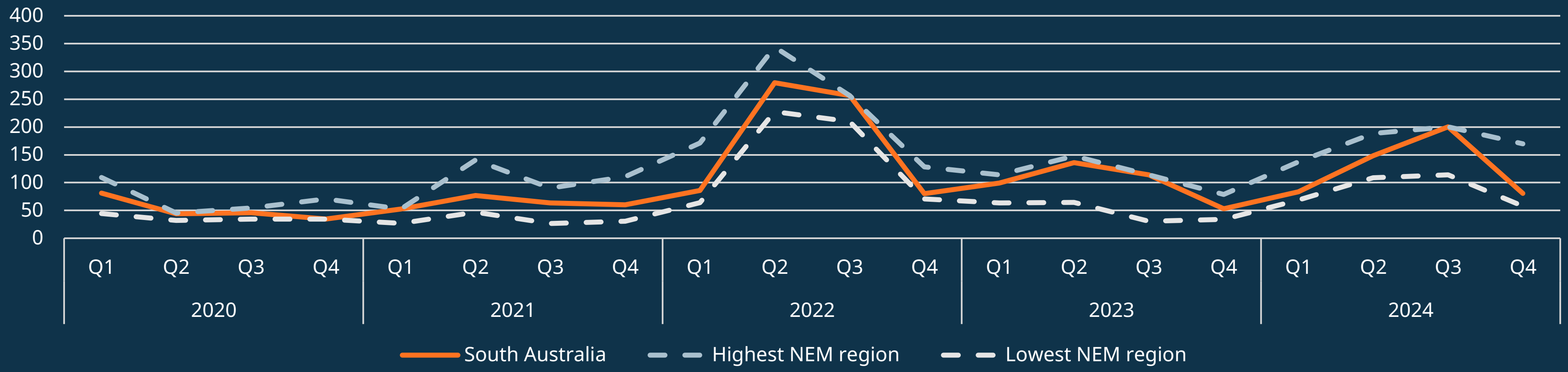
Creating financial value with operational flexibility in South Australia

Case study

South Australia has one of the highest renewable energy penetrations in the world with 72% of electricity coming from solar and wind in 2024. During times when renewable output is high, the state produces more electricity than it needs, so the surplus is exported to neighbouring states. On the contrary, when there is too little renewable energy, gas firming power plants and interconnection capacity form the backbone of the region's power system.

South Australia is connected to the National Electricity Market (NEM), which is one of the longest electricity transmission systems in the world. The NEM is also a real-time wholesale market that is settled on 5-minute intervals to provide more accurate pricing signals, as the share of renewable energy keeps increasing. Given the high share of renewable energy in the South Australia NEM, energy prices vary considerably between lowest and highest of NEM regions.

Average quarterly prices in South Australia and the NEM



The 211 MW Barker Inlet Power Station
in South Australia

Barker Inlet Power Station is a 211 MW engine power plant that has operated in the South Australia NEM since 2020. The plant features twelve Wärtsilä 50DF engines that have better operational flexibility and efficiency compared to other gas firming assets in the state. Based on an analysis of NEM data by the Australian Energy Market Operator (AEMO), the engine power plant, compared to other gas firming power stations in the region, has:

- **450 starts per engine**: runs more frequently outside morning and evening peaks
- **2,500 running hours**: 2-5 times more running hours than open cycle gas turbines (OCGTs)
- **20% higher operating profit** based on dispatch revenues

As the energy transition in South Australia continues with the state aiming for 100% net renewable target by 2027, the trend towards more flexible and resilient power system is expected to continue. Given that authorities are considering to introduce a capacity mechanism, the business case for flexible assets continues to improve.

450

Starts per engine
Rruns more frequently outside morning and evening peaks

2,500

Running hours
2-5 times more than open cycle gas turbines

>20%

More operating profit
than OCGTs based on dispatch revenues

Flexible engine power plants in Japan provides reliable profits and supports grid
Case study

As Japan works toward a major shift in its power mix, aiming for 40-50% renewable energy by 2040, the need for flexible generation to compensate for the fluctuations from sources like wind and solar is increasing. Engine power plants deliver the flexibility needed for this balancing role.

The 100 MW Sodegaura engine power plant

An example of a gas engine power plant integrated into Japan's market is the 100 MW Sodegaura power plant. Located in Sodegaura city in the Chiba Prefecture, this plant operates with ten Wärtsilä 34SG engines. The plant was built by Tokyo Gas Engineering Solutions (TGES) and is owned and operated by its parent company, Tokyo Gas. It is used as a balancer, responding to fluctuations in renewable energy supply and electricity demand.

The Sodegaura plant plays a key role in supporting Tokyo Gas's participation in and earning revenues from both the Japanese balancing market and the newly launched capacity market.

In Japan, engine power plants can make money through stacking multiple revenue streams if a power plant participates in, for instance:

1. JEPX day-ahead and intraday markets
In these spot energy markets engine power plants can respond to prices. They can serve retail demand and sell excess electricity. The revenue stream comes from dispatch payments (yen/kWh).

2. Balancing markets
The balancing market is designed to bridge the gap between energy demand and supply caused by fluctuating renewable energy. Engine power plants can participate in all the five categories of the balancing market i.e. I, II-1,II-2, III-1 and III-2. Revenue streams include availability payments (yen/kW) and directional dispatch payments (yen/kWh).

3. Capacity auctions
These markets secure firm capacity years in advance.

A. **The OCCTO annual capacity auctions** secure capacity about four years before commissioning. Awarded payments from OCCTO auctions can be volatile. Revenue comes from annual capacity payments (yen/kW).
B. **The long-term decarbonisation power source auctions** (LTDA) secure capacity about two years before commissioning. The LTDA offers fixed payments for 20 years to low carbon power sources.

To understand the business potential of a 100 MW engine power plant in Japan, a simulation was done using real JEPX price data from 2022 to 2024. The study found that a 100 MW engine power plant in Japan would generate average returns but can achieve modest profits during supply shortages.

For instance, during a six-month period between April 2022 and January 2023, the operating profits of the engine power plant would have earned a third of the project's total investment cost.

The expected internal rate of returns (IRRs) for the simulated 100 MW engine power plant in Japan are:

- ~8.2% when participating in OCCTO capacity auctions, and
- ~5.9% under the LTDA, which is structured to ensure a minimum 5% internal rate of return over 20 years if awarded.

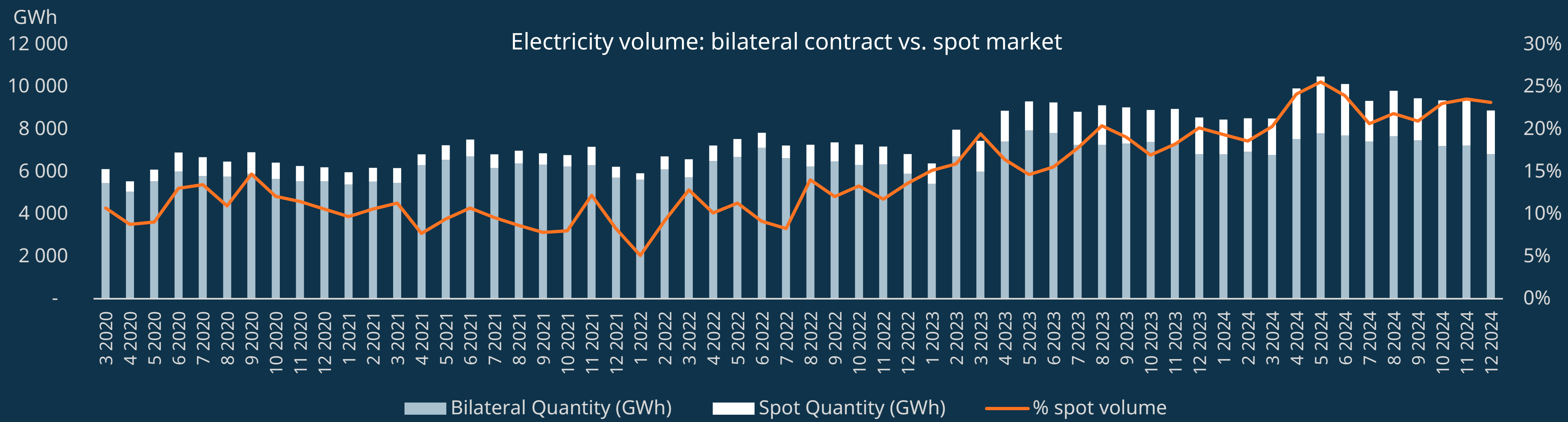
Japanese expression	English	Required response time (from command)	Duration
Balancing Category III-2	Replacement Reserve for FIT	45 min	30 min
Balancing Category III-1	Replacement Reserve	15 min	3 hrs
Balancing Category II-2	Frequency Restoration Reserve	5 min	30 min+
Balancing Category II-1	Synchronized Frequency Restoration Reserve	5 min	30 min+
Balancing Category I	Frequency Containment Reserve (FCR)	10 sec	5 min+

Advantages of engines as balancers in the Philippine 5-minute WESM and reserve market

Case study

The Philippines operates one of Southeast Asia's most advanced electricity markets. Following sector deregulation in 2001, the launch of the Wholesale Electricity Spot Market (WESM) in 2006, and retail competition in 2013, the country introduced a major structural reform in 2021 by transitioning to 5-minute dispatch and settlement intervals. This move, matched only by Australia in the region, significantly increased price granularity and volatility, creating new opportunities for flexible technologies to respond to short-term price spikes.

Over time, the role of the spot market has expanded. Spot transactions now account for around 20% of total market volume, which is double the share observed just a few years ago. Alongside this, the frequency and magnitude of price volatility have also grown, offering strong arbitrage opportunities for technologies capable of rapid response. In early 2024, the Philippines launched a co-optimised reserve market, which became fully operational by August of 2024. This development enabled real-time trading of ancillary services on the same 5-minute interval basis as the energy market, further increasing the value of flexibility.



To assess the business potential, a simulation was conducted using actual WESM price data from 2023 for a 100 MW engine power plant operating purely as a merchant balancer. The results were compelling:

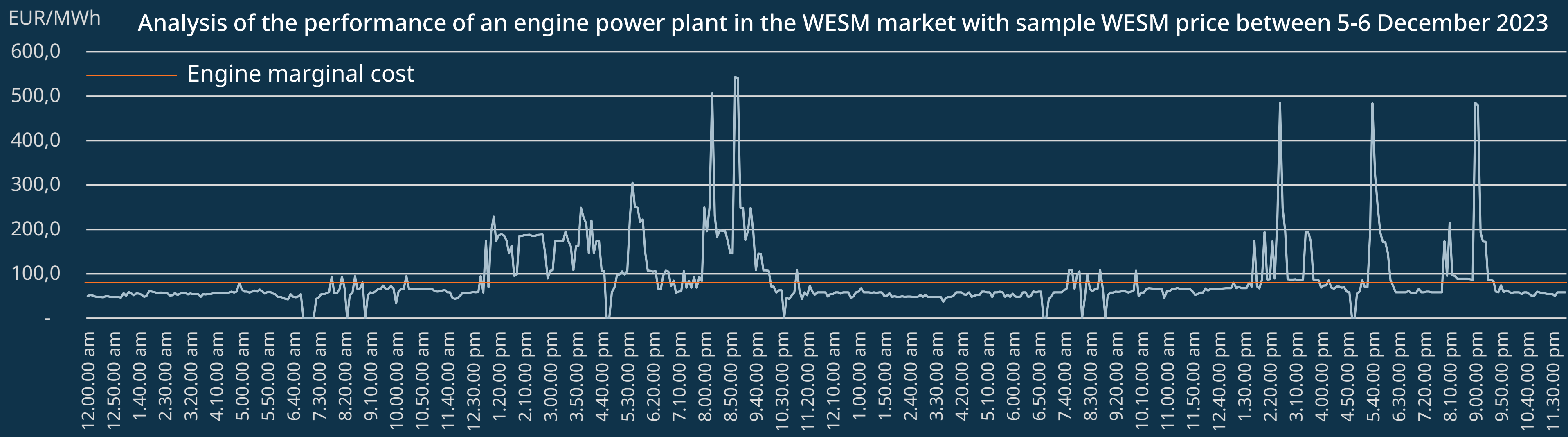
- **Annual running hours:** 3,400 hours (39% capacity factor)
- **Gross profit:** 20 MEUR
- **Equity IRR:** 25%
- **Payback period:** 5 years

This performance was driven by the engine's ability to start and stop quickly, ramp throughout the day, and shut down entirely during periods of low or negative pricing – without incurring start-up penalties or excess maintenance costs.

Compared to other thermal technologies, engine power plants demonstrated a clear advantage. Aeroderivative gas turbines, due to their lower efficiency and slower response times, failed to capture most price spikes. Combined cycle gas turbines (CCGTs), while more efficient, are constrained by longer minimum run times and are often forced to operate during low-price hours, reducing profitability. Engine power plants, by contrast, operate only when profitable and benefit from the modular design and fast responsiveness, enabling them to effectively monetise market volatility.

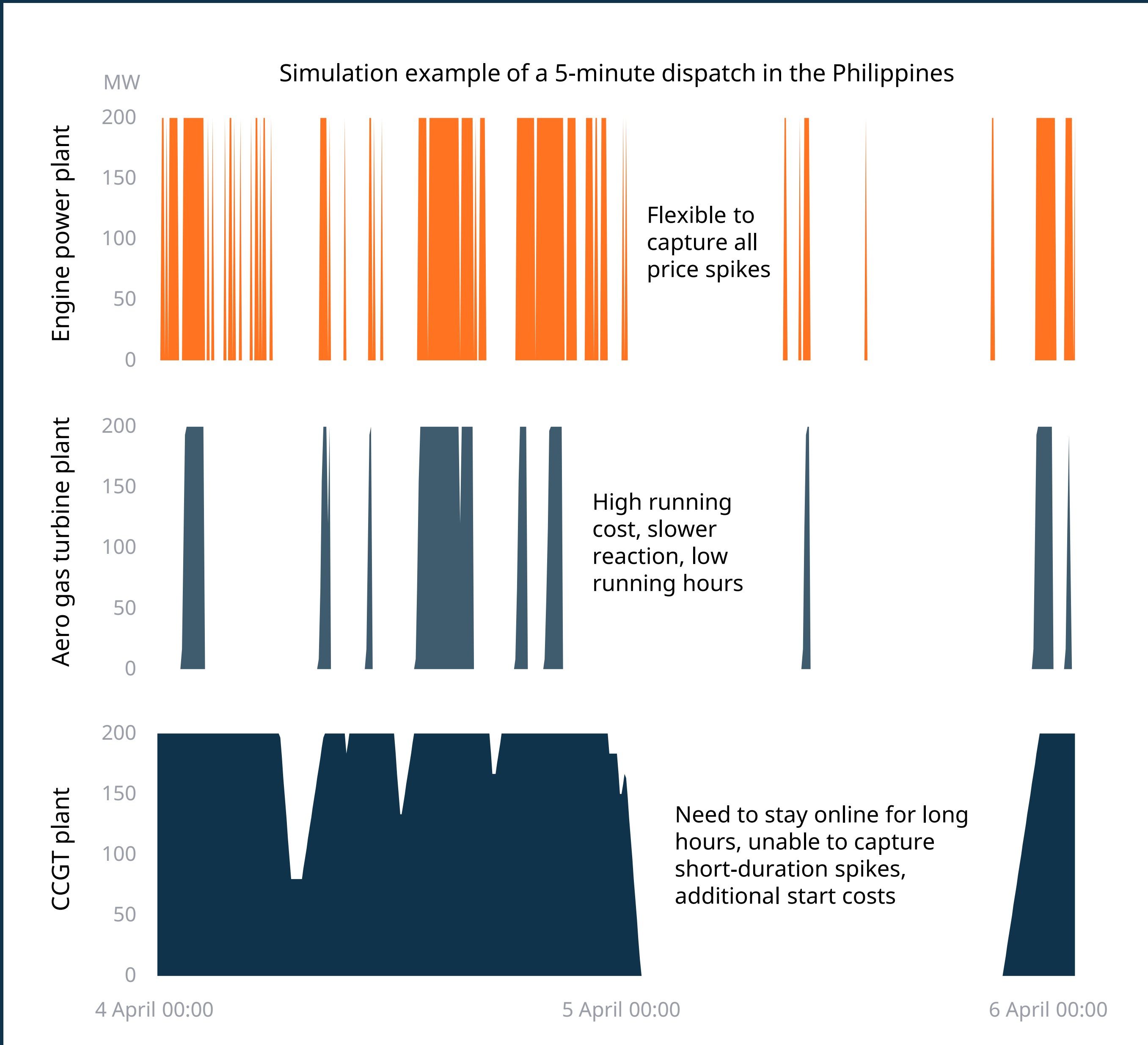
The modular design of engine power plants allows them to run in smaller, flexible blocks, unlike large gas turbines that must commit bigger capacities. This means that engine power plants can better match output to demand, reduce part-load inefficiencies, and avoid committing unnecessary capacity during low-demand periods.

Analysis of the performance of an engine power plant in the WESM market with sample WESM price between 5-6 December 2023



The introduction of the reserve market further strengthens the business case for engine technology. These plants are well-suited to participate across all reserve products, offering system operators a single asset class capable of delivering both energy and reliability services. This revenue stacking potential improves asset utilisation and derisks merchant exposure.

In conclusion, the Philippines' 5-minute co-optimised market creates strong incentives for fast and flexible power generation. As the country moves toward its targets of 35% renewable energy by 2030 and 50% by 2040, the influx of variable renewables will require balancing solutions. Engines, with their rapid dispatch capability, modular scalability, and diversified revenue potential, are well positioned to meet these needs. They represent a versatile and financially attractive solution for ensuring system reliability in a renewable-intensive grid.

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Considerations for utilities and IPPs

What to evaluate in power markets before building a flexibility monetisation business case

The possibilities to monetise flexibility are increasing as the need for renewable balancing is globally rising. Some early movers have already made significant returns by making flexibility a key pillar of their commercial strategy, proving the viability of the concept. However, the conditions and business case for flexibility monetisation are not identical across all electricity markets.

Market evolution

First, a certain degree of market openness is essential. In such liberalised markets, the price of electricity is constantly changing, reflecting the system's real-time needs (demand) and available options (supply). When demand is high and supply is limited, prices soar. In a dynamically changing pricing environment, the supplier able to react the fastest to a favourable price signal has an advantage over others. Modern electricity markets with such principles already operate in many countries, like Australia, Japan, Singapore, Germany, UK, US and in the Philippines to name a few.

Market design

The other challenge lays in the actual design of the spot market. In this respect Europe, Australia or the US can serve as a compass for many countries in designing well-functioning electricity markets.

In Europe, the spot electricity market has a few subsegments, such as day-ahead or intra-day market. The intra-day market is often referred as the balancing market, as it is designed to handle the short-term imbalances between the scheduled and delivered electricity. In these platforms, market players can settle their imbalances among each other, so they can avoid penalties from the grid operator for deviating for their indicated generation plan.

Market incentives

The more the market players are incentivised to manage their imbalances among each other, the better the business case is for flexibility. This means entering the spot market should be allowed to a wide range of players and the registration process should be lean and simple. Regulatory interventions, such as price caps and floors, should be minimised as they can discourage market players to develop power projects that are anchored to operate in the balancing markets.

The national energy regulators can incentivise the use of spot markets, which helps the transition towards a more market-based power procurement, and the accurate and transparent price formation of electricity. In certain countries utilities must procure some part of their retail demand directly from the spot market, which manually drives traffic to the spot market. In other instances, national regulators are trying to boost the use of spot markets by not offering fixed-price feed-in-tariffs for new renewable energy projects but forcing them to sell their generation on the spot market. Utilities and market players can engage with regulators and policy makers to provide feedback and ensure future market designs take these points into consideration.

Fuel supply agreements

Another area where asset owners should be mindful of is the conditions of their fuel supply agreements. Having flexible fuel offtake agreements can enable them to operate in a more flexible fashion, hence better react to market signals. On the contrary, rigid fuel supply obligations – such as high take-or-pay obligations, limited offtake flexibility – may force power plant owners to run their assets even if they cannot make a profit.

Revenues from the spot market only is often not sufficient or certain enough to cover the investment cost and deliver the expected returns of investors. Some plant owners prefer to split their generation capacity and allocate a portion of the capacity for fixed contracts, where there is a high degree of payment certainty, and reserve a portion to dispatch on the spot market, which has a bit bigger speculative element. It is up to the lenders and asset owners' risk appetite in what ratios they allocate their capacity for various segments.

Flexiblity monetisation check list:

- ✓ Existence of a spot market where price of electricity constantly changes, and is determined by the momentary demand and supply conditions.
- ✓ High share of renewables that introduce high level of price volatility.
- ✓ Short trading periods i.e., 15- or even 5-minute that reflect the fine changes in the system.
- ✓ Shorter gate-closure times allowing market participants to adjust positions closer to real-time, improving forecast accuracy and system responsiveness.
- ✓ Established well-functioning ancillary services markets to support evolving flexibility needs and monetise system flexibility.
- ✓ Low entry barriers so a high number of generators and consumers can participate.
- ✓ Asset owners are penalised if their delivered energy deviates from the scheduled amount.
- ✓ Flexible fuel offtake agreements that allow generating assets to operate in a flexible fashion.

Summary

As explored throughout this report, flexibility is becoming an essential component of modern power systems. It is no longer simply a technical necessary feature but a strategic asset that can unlock additional revenue streams in modern energy markets. For utilities and independent power producers, the focus has shifted from questioning whether to invest in flexible assets to understanding how to do so effectively and profitably.

Among the various technologies available, reciprocating internal combustion engine power plants stand out for their unique ability to monetise flexibility across multiple market and stacking revenue streams. Their modularity, rapid ramping, and short start-up times make them exceptionally well-suited to today's volatile electricity markets. Unlike traditional baseload plants, engine power plants can respond in minutes, allowing operators to capture price spikes, avoid negative pricing events, and participate in ancillary and capacity markets with precision.

Case studies from Japan, the Philippines, and South Australia have shown that engines consistently outperform other thermal technologies in real-time markets. Their ability to start, stop, and rapidly change output without incurring excessive wear or penalties gives them a commercial edge. Especially in markets with five-minute settlement intervals, this agility translates directly into higher returns and shorter payback periods.

Of course, monetising flexibility isn't just about technology. Market design also plays an essential role. Shorter trading intervals, open access, and well-structured capacity and reserve markets are all critical enablers. But even in less mature markets, engine power plants offer a hedge against uncertainty, providing both operational resilience and financial upside.

In short, flexible assets are not just filling gaps in renewable output – they're filling gaps in business models. For asset owners looking to future-proof their portfolios, engine power plants offer a compelling blend of flexibility, reliability, and return on investment.

The energy transition demands agility. With the right strategy and the right assets, flexibility can be more than a system requirement – it can be a competitive advantage.

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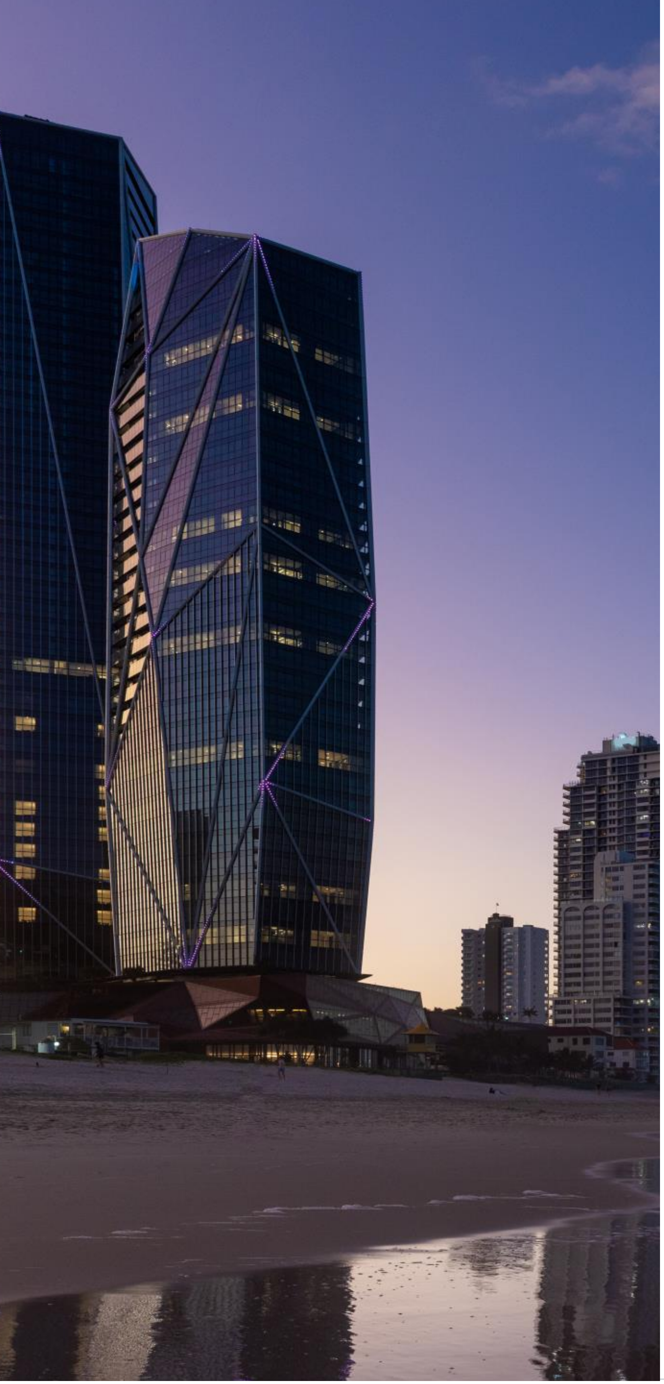

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Wärtsilä Energy in brief

Wärtsilä Energy is at the forefront of the transition towards a 100% renewable energy future. We help our customers and the power sector to accelerate their decarbonisation journeys through our market-leading technologies and power system expertise. Our solutions include flexible engine power plants, energy storage and optimisation technology, and services for the whole lifecycle of our installations. Our engines are future-proof and can run on sustainable fuels. Our track record comprises 79 GW of power plant capacity and over 130 energy storage systems in 180 countries around the world. Over 30% of our operating installed base is under service agreements.