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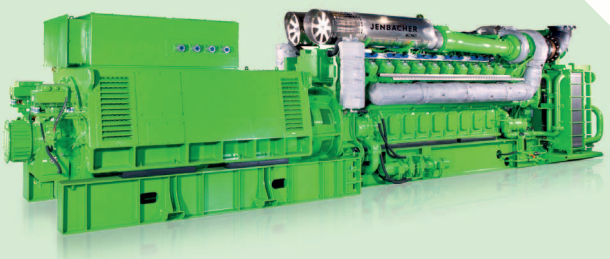
JENBACHER

A RELIABLE, GREENER SOLUTION THAT HELPS MONETIZE YOUR ASSETS

Fast-start, natural gas:
Jenbacher J620



Jenbacher data center solutions
from INNIO

INNIO

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1. EXECUTIVE **SUMMARY**

Data center energy usage has been increasing dramatically, and the trend isn't stopping. Delivering lower emissions and the option of longer run times, fast-start natural gas generators provide electricity when data center operators need it.

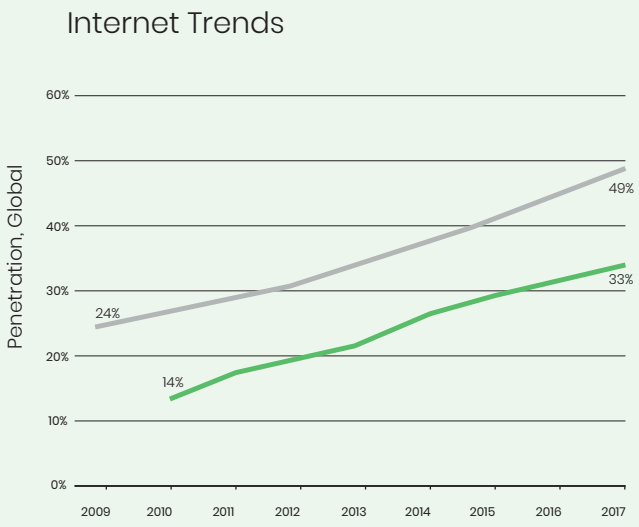
Along with the surge in data center electricity demand has come a push for more renewable energy. As intermittent renewable electricity generation increases, fast-start resources can balance and accommodate the instability of the electric grid. In addition, fast-start, natural gas generators give data center operators the opportunity to monetize assets while providing benefits to the electric grid.

Natural gas generators from INNIO* offer fast-start capability with full load under 45 seconds, along with the additional benefits that come with the ability to run on a variety of operating modes. It's no wonder, then, that natural gas generators are gaining traction with data center and grid operators around the globe.

2. INTRODUCTION

DATA DRIVES DATA CENTER GROWTH

Data generation is driven by e-commerce, payment processing, the Internet, search engines, social networking, software, platform and infrastructure as a service (SaaS, PaaS, IaaS), and infrastructure hosting services.[1] Global data is projected to have impressive growth.



Take a look at the Internet, for instance. Consider that in 2017 only half the world had Internet access, with about one-third using social media:

Internet

Social Media

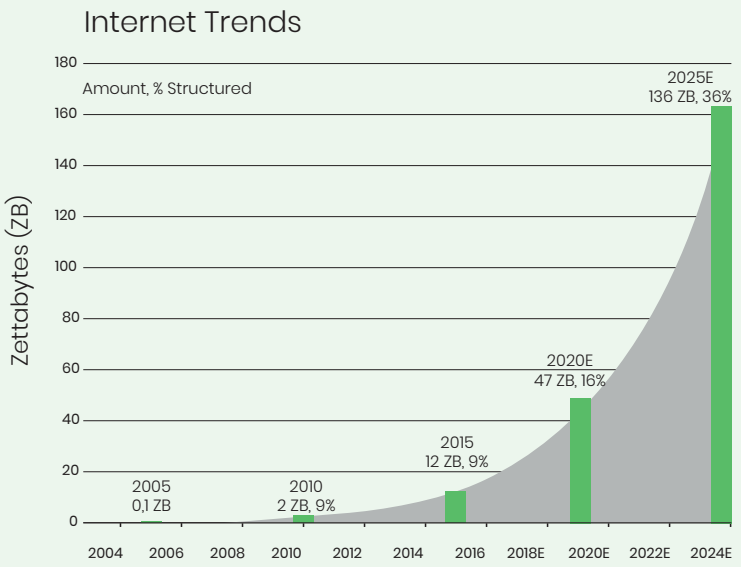
Graphic 1 - Source: Internet Trends 2018, Mary Meeker, Kleiner Perkins

Just two years later, Internet users are growing by an average of more than one million every day[2], and 45% of the people in the world now use social media.[3]

All that means more data, bringing with it tens of billions of dollars in annual revenue to the global economy.[4]

1) Source: Cisco Global Cloud Index: Forecast and Methodology, 2016–2021
2) Source: https://wearesocial.com/blog/2019/01/digital-2019-global-internet-use-accelerates
3) Source: https://blog.hootsuite.com/social-media-statistics-for-social-media-managers/
4) Source: Internet Trends 2018, Mary Meeker, Kleiner Perkins

Here's one prediction for the potential global growth in data (where a zettabyte is 1x10 bytes):



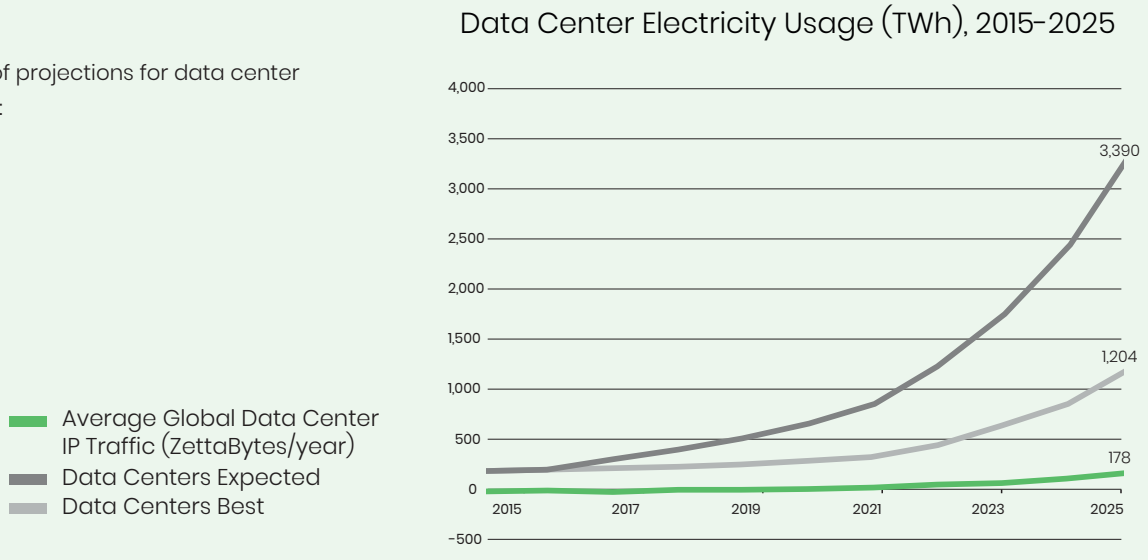
Graphic 2 - Source: Internet Trends 2018, Mary Meeker, Kleiner Perkins

The data driving this economic engine is, in turn, driving data center growth globally. And all this valuable data needs to be housed somewhere, primarily on hard drives ... in servers ... in racks – and in data centers. Other technologies may generate vast amounts of additional data, such as the Internet of Things with mobile/real-time data, machine learning, natural language processing, and artificial intelligence with augmented or virtual reality. Their potential to add to the current ocean of data being produced is just beginning.

DATA CENTER GROWTH AND ELECTRICITY

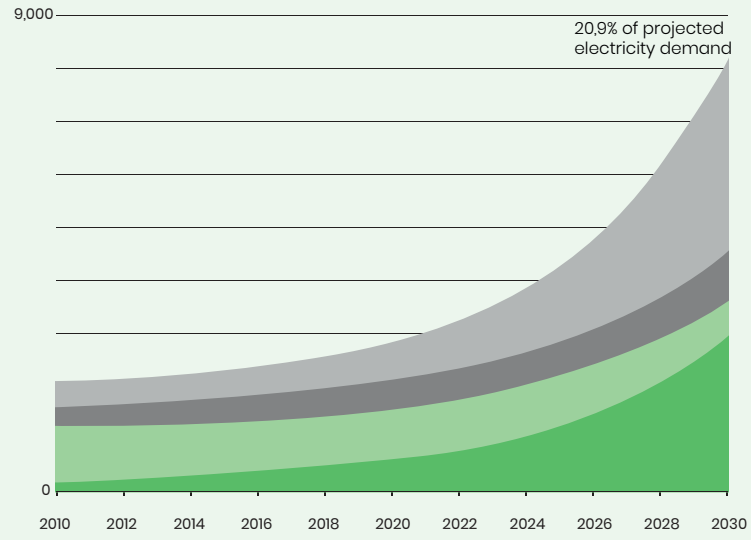
Electricity is the life blood of a data center. Despite efficiency gains over time, with the global expansion of data centers, electricity demand continues to grow. Individual data centers or campuses can require hundreds of megawatts to meet their power supply needs.

Here is a range of projections for data center electricity usage:



Graphic 3 - Source: Total Consumer Power Consumption Forecast, Dr. Anders S.G. Andrae (Huawei), Nordic Digital Business Summit, Helsinki, Finland, October 2017; https://www.nature.com/articles/d41586-018-06610-y

Data centers and networks are the projected drivers in electricity demand forecasts from the information and communications technology (ICT) sector:



Energy Forecast

Widely cited forecasts suggest that the total electricity demand from information and communication technology (ICT) will accelerate in the 2020s, and that data centers will take a larger slice of that demand.

- Networks (wireless and wired)
- Productions of ICT
- Consumer Devices (televisions, computers, mobile phone)
- Data Centers

Graphic 4 - Source: Energy Forecast, https://www.nature.com/articles/d41586-018-06610-y

As demand has grown for global data center net electricity, so has the demand for renewable-based electricity at data centers. In 2017 it was estimated that no more than 20% of global data center electricity was renewable based.[5)]

For the most part, renewable electricity is not supplied on a direct, physical connection basis to the data center. Instead, data center renewable electricity demand has been met mainly by virtual power purchase agreements (VPPAs), renewable energy credits (RECs) and, to a lesser extent, energy providers who change the grid's generation mix.

Wind, hydro and solar are the main sources for renewable energy generation. Wind and solar are intermittent generation resources, meaning the amount of electricity they generate can vary widely and quickly.

Data centers need a stable electricity supply in terms of voltage and frequency. The challenge: Electricity is generated and transported to meet demand at effectively the speed of light, but electricity storage is unable to meet significant grid-level demands for any appreciable duration. Nimble, fast-start resources increasingly are needed – and valued – as a balance to the instability and intermittency of renewable generation.

5) Source: https://www.theguardian.com/environment/2017/dec/11/tsunami-of-data-could-consume-fifth-global-electricity-by-2025

DATA CENTERS AS CRITICAL INFRASTRUCTURE

The combination of data center electricity demand growth, the push for renewable-based electricity by data center operators, and renewable generation intermittency/instability creates an interesting situation. As critical infrastructure, data centers seek to ensure 99.999% operational reliability. This "five 9s" level of reliability means that a data center will be operational all but approximately five and a quarter minutes in a year, and not experience service interruptions and expensive data center restarts.

Electricity outage risk can be addressed with onsite data center backup generation. Many data centers rely on uninterrupted power supplies (UPS) – basically lots of batteries – as a bridge for a short duration until diesel generators can start up for longer term backup electricity generation. The former is expensive, and the latter increasingly are facing emissions and permitting issues, such as Tier 4 emission requirements in areas of air quality concerns and refueling limitations. With limited emergency run times (when certified as standby only), they essentially are a stranded asset for data center operators.

3. NATURAL GAS GENERATOR BENEFITS FOR DATA CENTER OPERATORS

Natural gas generators provide reliability, reduced emissions, and an opportunity to monetize stranded assets. With judicious usage, they can benefit electric grid operations and complement renewable energy integration and growth.

RELIABILITY

Natural gas-powered generators provide cutting edge performance for data centers. Built-in storage with the highly reliable natural gas grid avoids the risks of limited run times and refueling.

The below-ground level natural gas grid is inherently more reliable than the electric grid. This is reflected in reliability indices such as System Average Interruption Duration Index (SAIDI) and System Average Interruption Duration Index (SAIFI) that track the minutes and number of electrical interruptions that a utility customer experiences annually.

Here is an example for a data center citing due diligence. In a five-year period, although there were no natural gas grid outages, a variety of electrical outages occurred due to weather and other factors. In addition, no correlated failures were recorded between the natural gas and electric grid.

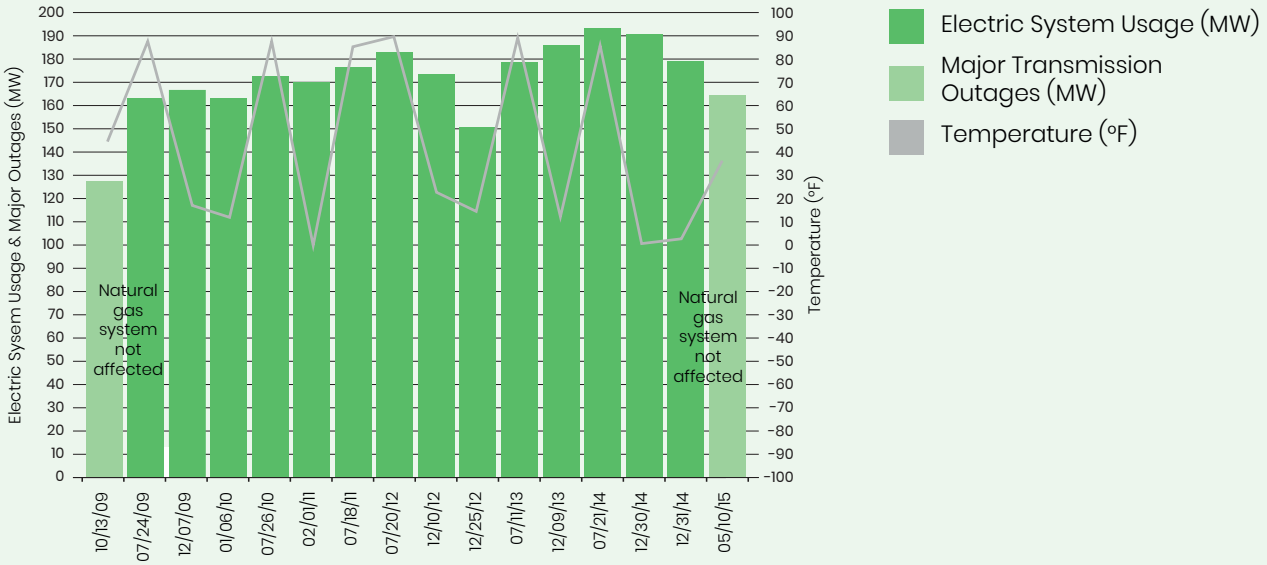
Electric Transmission Outages for the Rocky Mountain Region Group

Calendar Year	2010	2011	2012	2013	2014	5 Year Average
Foreign Interference	5	15	0	0	8	6
System Condition	5	8	10	7	9	8
Human Caused	17	21	14	23	18	19
Equipment Failure	17	20	30	24	15	21
Other	61	50	10	15	39	35
Unknown	38	51	22	44	26	36
Weather & Environment	46	35	24	54	37	39

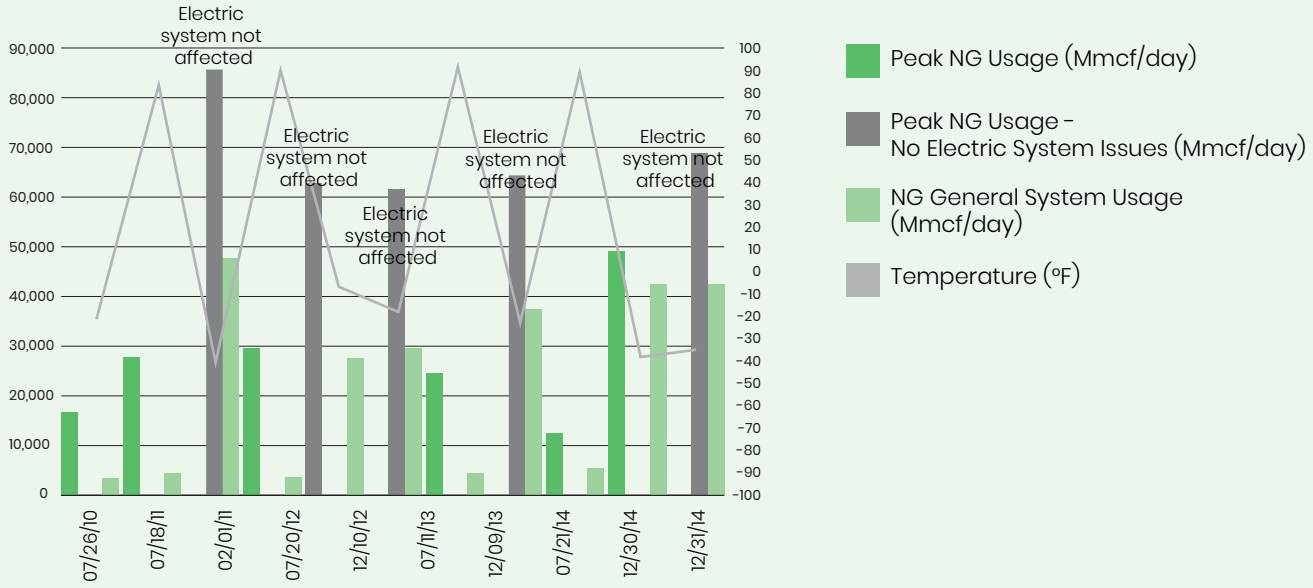
Natural Gas Transmission Outages

Equipment Failure	0	0	0	0	0	0
Foreign Interference	0	0	0	0	0	0
Human Caused	0	0	0	0	0	0
Other	0	0	0	0	0	0
System Condition	0	0	0	0	0	0
Unknown	0	0	0	0	0	0
Weather & Environment	0	0	0	0	0	0

Electric System Usage, Major Outages & Temperature

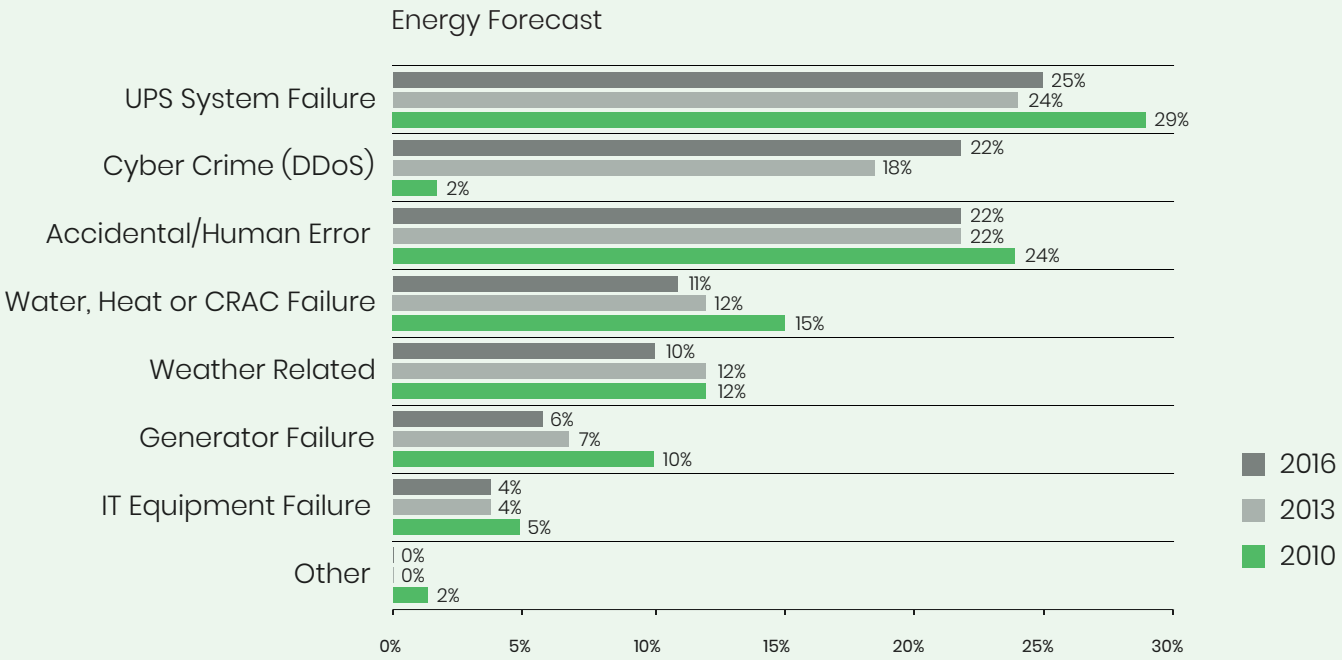


Natural Gas Systems Usage



Correlated failure between the natural gas grid and the electric grid has an estimated likelihood of 1.5% for outages over 36 hours. In comparison, diesel resupply failure is 14% at 36 hours, increasing to 28% at 72 hours. For critical reliability, natural gas generators are less likely than diesel generators to fail during a power outage.[6)]

Data also shows that UPS/battery system failures are the primary cause of unplanned data center outages (25%), whereas gas generators have a more reliable track record (6%):



Graphic 5 - Source: Energy Forecast, https://www.vertiv.com/globalassets/documents/reports/2016-cost-of-data-center-outages-11-11_51190_1.pdf

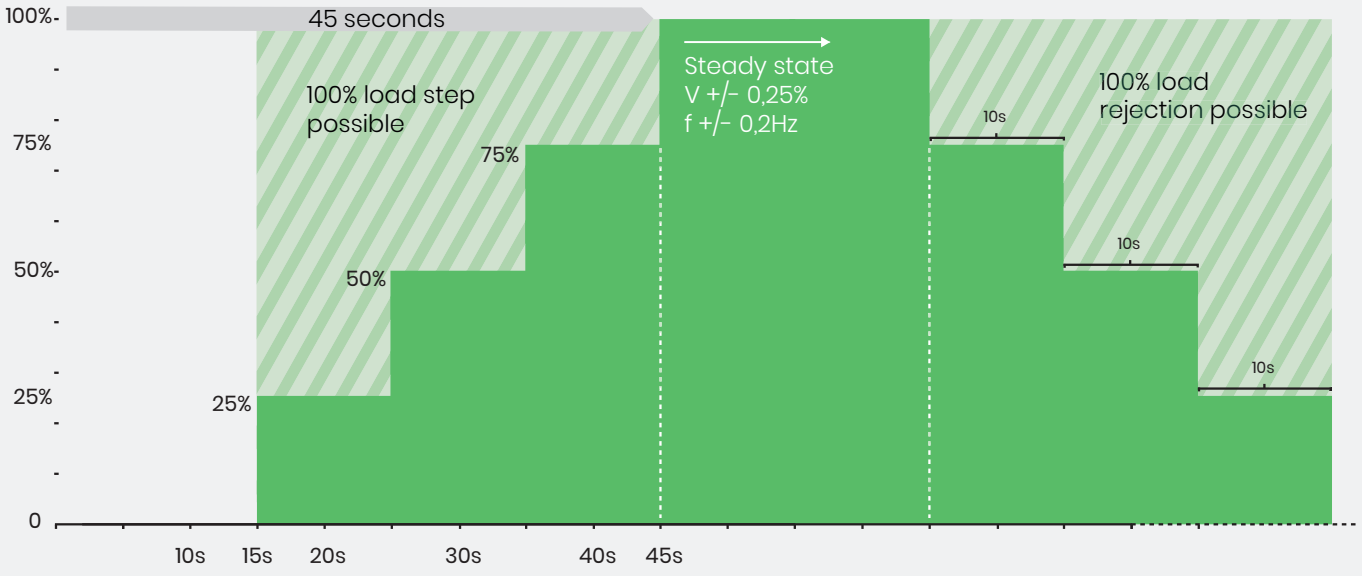
6) Source: Ericson, Sean and Dan Olis, 2019. A Comparison of Fuel Choice for Backup Generators. Golden, Co: National Renewable Energy Laboratory. NREL/TP-6A50-72509

RELIABILITY - JENBACHER* J620:
FAST-START, NATURAL GAS GENERATOR SOLUTION FOR DATA CENTERS

The Jenbacher J620 natural gas generator for data centers can reliably take on full electric load in under 45 seconds with fast transient response. It also can perform this on a 25% step load basis.

Startup steps	Fast startup with the Jenbacher J620 engine for data centers
Conditions	*Pre-heated and pre-lubricated*
Start command, delay and pre-lubrication	5 sec
Firing to nominal speed	10 sec
Nominal speed to full load	30 sec
Start to full power	**45 sec**

FAST-START, BLACK START PROFILE[1]



1. Example profile for pre-heated/-lubricated; Without synchronization; 480 V configuration; Power quality within +/- 10% voltage, +/- 5% frequency

Fifteen seconds after receiving the start command the generator reached stable rated speed and is ready to take the first 25% load step, keeping the requested limits on power quality.

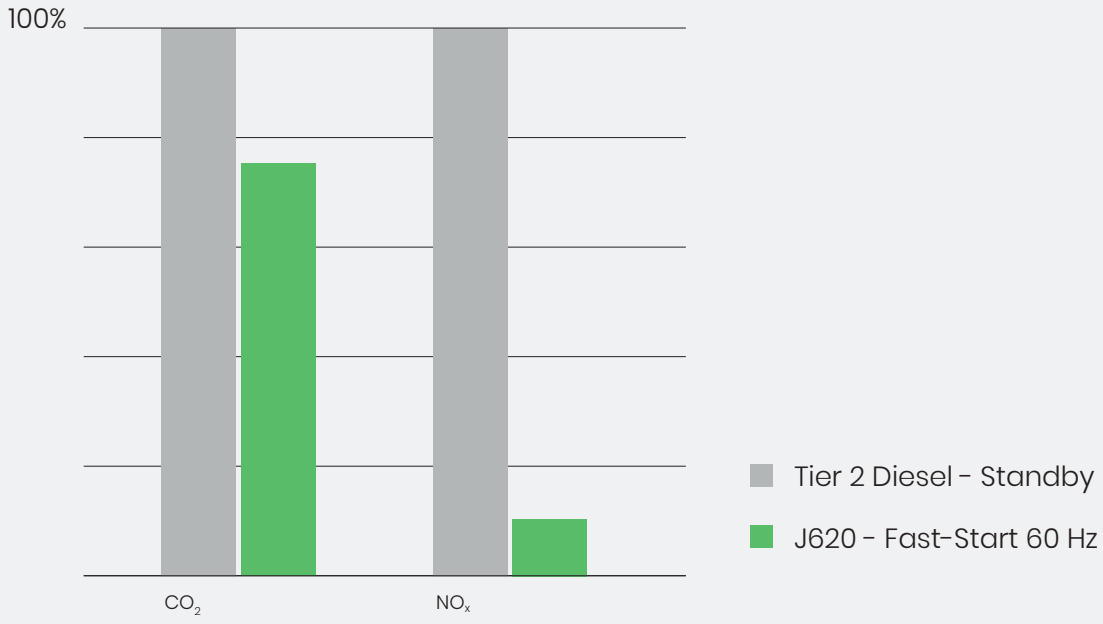
In addition, 100% load step and shed in under 45 seconds is possible with this generator with frequency and voltage fluctuations outside of the recovery band until the generator is running in steady state again.

EMISSIONS

Simply put, natural gas generators can lower a data center's emissions. Reductions of 80% to 90% for NO_x, and up to 25% for carbon dioxide (CO_2), and negligible SO_2 and particulates can be expected without after-treatment, compared to diesel-fueled generators.

If SCR emissions technologies are added, the NO_x, that frequently is the limiting factor for permitting at large-scale data centers can see additional reductions. As the net global growth in data center electricity continues, these significant reductions in emissions will have increasing value for data center operators.

EMISSIONS - JENBACHER J620:
FAST-START, NATURAL GAS GENERATOR SOLUTION FOR DATA CENTERS



The Jenbacher J620 fast-start, natural gas generator without after treatment technologies can provide an emission reduction of up to 23% CO_2 and up to 90% NO_x compared to Diesel Tier 2 standby generators.

MONETIZATION

Lower emissions can provide longer run times, so natural gas generators can become an asset to data centers. As the electric grid decarbonizes with an increasing use of renewables, the need will be greater for fast-start resources to provide balancing and ancillary service solutions.

In the last 10 years, entire regions in Europe or North America, particularly in states like Kansas, Texas, California, Colorado and Minnesota, have become increasingly dependent on fluctuating renewables, creating the necessity for reliable fast starting power systems to ensure grid stability, even when not in an emergency situation[8].

Natural gas generators can engage in demand response, curtailable tariffs and/or emergency standby participation – all while avoiding coincident peak charges. Add in lower, stable natural gas fuel costs, particularly in North America, and it is easy to see how significant money can be made by data center operators working in collaboration with energy providers in the electricity markets.

MONETIZATION – JENBACHER J620:
FAST-START, NATURAL GAS GENERATOR SOLUTION FOR DATA CENTERS

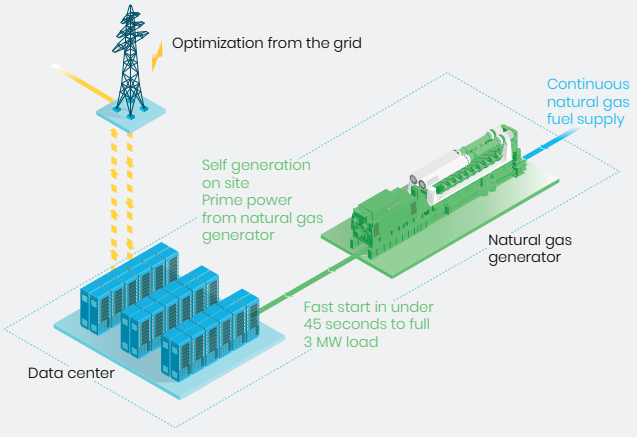
The Jenbacher J620 fast-start, natural gas generator can provide more than just backup power to data centers. It can give data center operators an opportunity to monetize stranded assets while providing additional benefits to the electricity grid:

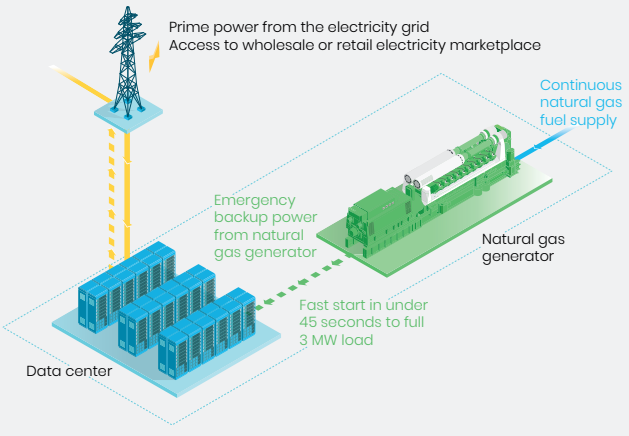
Advantages when running in island mode, away from the electricity grid (self generation on site):

- ✓ Cost savings due to lower grid connecting power
- ✓ Avoidance of coincident peak charges for electricity or demand charges
- ✓ Easily expandable due to grid independence
- ✓ Participation in curtailable tariffs and/or as emergency standby

Advantages when running in parallel to the electricity grid:

- ✓ Fast-start resource – providing balancing and ancillary service to the grid
- ✓ Grid value – accommodating intermittent renewable generation
- ✓ Demand response – when needed
- ✓ Peak shaving – with the ability to sell electricity when retail or wholesale prices are high





8) Source: Ray, Suparna, Feb. 2019, Natural gas-fired reciprocating engines are being deployed more to balance renewables, U. S. Energy Information Administration

4. CONCLUSION

A reliable, continuously run platform since 1989, the 3 MW Jenbacher J620 generator has been upgraded to a fast-start solution for data center operators. It provides full electric power in under 45 seconds and fast transient response capabilities.

In some ways, the J620 performs like a diesel engine – with its fast-starting capabilities and transient performance when ramping up and down or applying loads. However, the J620 provides all the advantages of lean burn technology, such as high power density and low emissions. This greener generator can be used for emergency backup power, island mode operations, and for operations in parallel to the grid, including participation in the electricity marketplace. Thus, the J620 offers additional monetization opportunities.

As the needs of data centers continue to evolve, so do natural gas generators. At INNIO*, we constantly are working to reduce our product emissions, increase their performance, and achieve even faster startup capabilities to meet customer requirements.

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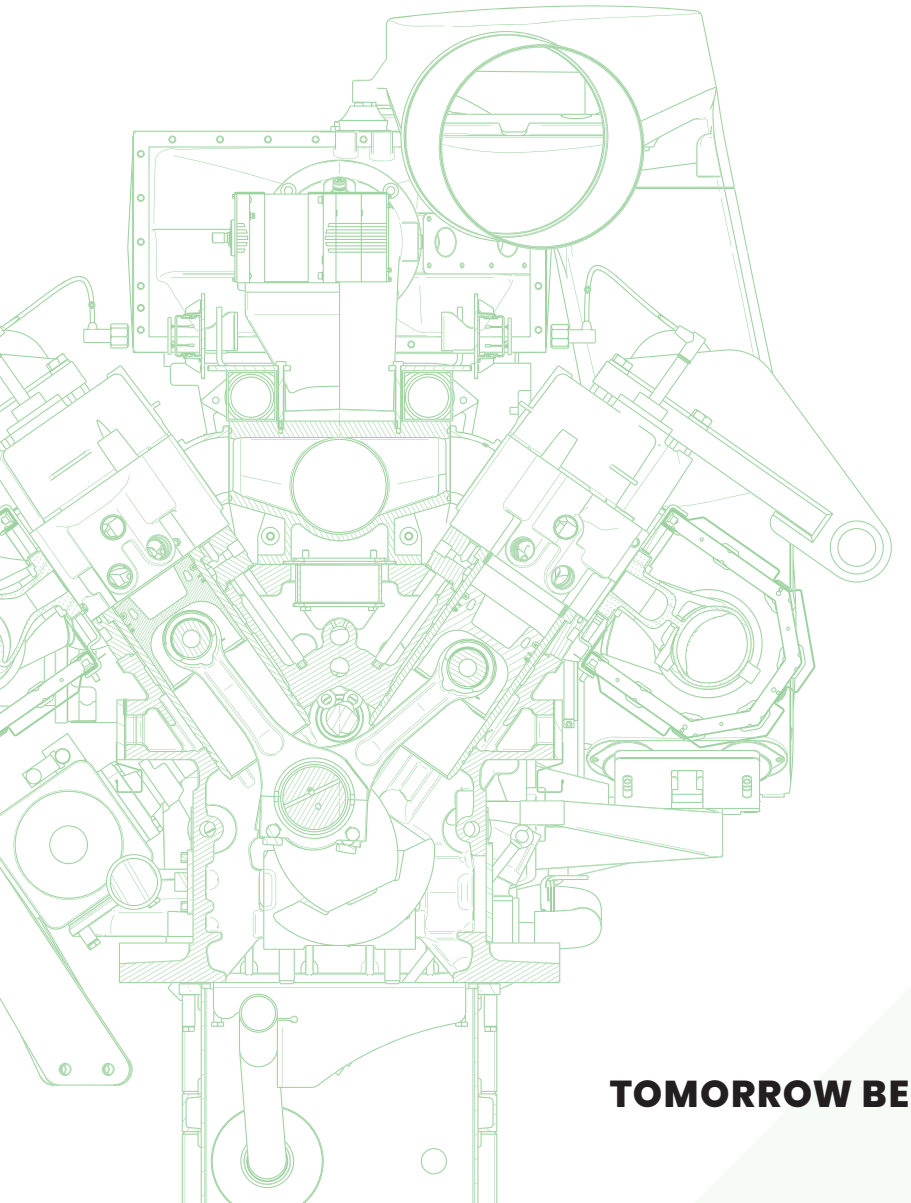
INNIO* is a leading solutions provider of gas engines, power equipment, a digital platform and related services for power generation and gas compression at or near the point of use. With our Jenbacher* and Waukesha* product brands, INNIO pushes beyond the possible and looks boldly toward tomorrow. Our diverse portfolio of reliable, economical and sustainable industrial gas engines generates 200 kW to 10 MW of power for numerous industries globally. We can provide life cycle support to the more than 50,000 delivered gas engines worldwide. And, backed by our service network in more than 100 countries, INNIO connects with you locally for rapid response to your service needs. Headquartered in Jenbach, Austria, the business also has primary operations in Welland, Ontario, Canada, and Waukesha, Wisconsin, US.

Want to find out more about the Jenbacher J620 fast-start, natural gas solution for the data center industry?
For more information, visit: innio.com/datacenter

*Indicates a trademark



TOMORROW BELONGS TO THE BOLD.