

Data Center Energy: The Novel Therm Way

Executive Summary: Novel Therm has a unique solution that allows them to build low-cost HPC data centers that are powered by low temperature geothermal energy. With their innovative technology, they provide 100% green powered data centers with no upfront customer investment and at significantly lower cost than competitors can offer.



Data centers have an insatiable appetite for energy. According to the latest estimates, data centers today are consuming as much as 416 Terawatts of electricity. That accounts for more than 2% of the world's electricity production and is on par with the pollution caused by the entire aviation industry.

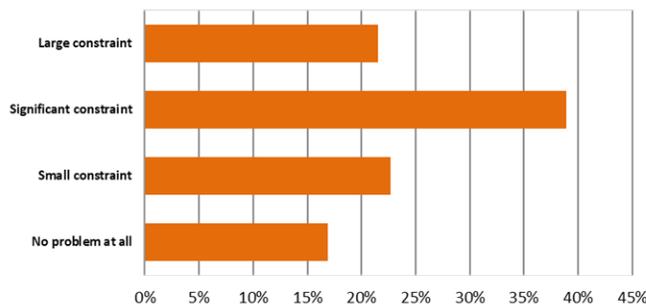
While data centers are becoming more efficient in how they use energy, this isn't enough to counter the growth in overall energy demand from ever expanding usage of computing technology. For example, the number of internet connected devices numbered roughly 26 billion in 2019 and is estimated to skyrocket to more than 75 billion by 2025. All of these devices generate data that needs to be stored, processed and analyzed.

Growth in HPC (High Performance Computing) processing workloads is expected to increase by roughly 20% per year. Organizations using HPC include energy production (oil & gas), financial services, pharma/bioscience, manufacturing, academic/research computing, along with users in a large variety of other industries.

Squeezing the Juice

HPC data centers are experiencing significant electricity-related problems. As systems become larger, their power needs also scale up. With the estimated 20% growth rate in HPC system workload, plenty of organizations are going to find that their local utility will have difficulty supplying increased power to their facilities.

Data Center Constraints: Data center power supply



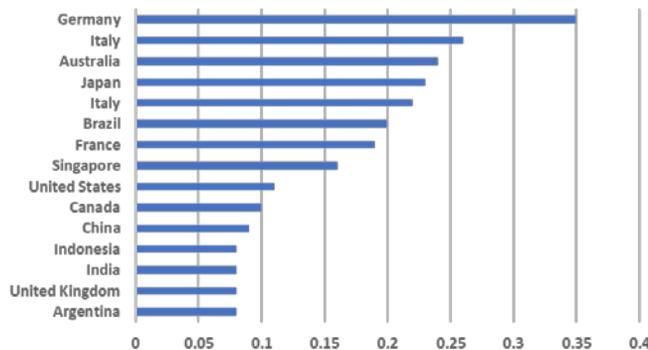
A recent OrionX HPC and large enterprise data center survey confirmed this, showing that 60% of 352 respondents see their data center power supply as a significant or large concern.

As demand grows, we're finding that electrical grids in areas even as developed as the US are fragile. Excess capacity is becoming a thing of the past due to the

changeover from coal and nuclear power generation to natural gas and renewables like solar and wind. Severe weather can stretch aging utility grids to the breaking point, causing brownouts and blackouts which sometimes last for days.

Energy cost is also an increasingly significant consideration for HPC data centers. As systems continue to grow, the cost of powering them also grows.

kWh US \$ Electricity Price



Furthermore, electricity costs in many developed countries are increasing as they move away from fuel sources such as coal and oil towards renewables, which are considerably more expensive in the short to medium term.

The energy price leader, Germany, has instituted a program of mandated renewable energy generation plus carbon taxes. This has resulted in energy

consumers paying as much as 49% more for electricity in 2018 than they did in 2007. As more countries drive towards renewable power generation, we can expect the average cost of electricity (currently about \$0.17 per kWh) to increase and dramatically outpace inflation for the foreseeable future.

Power: The Novel Therm Way

Novel Therm has a unique geothermal approach to solving the HPC data center energy 'crisis'. Geothermal power is a well-known technology that has been used commercially for decades. Typical geothermal power plants require very high temperature steam or fluids in order to operate. To get access to these high temperatures, they must drill between 3 and 4,000 meters into the earth. The deeper the well the higher the cost. Geothermal hot spots like these are typically found in relatively remote areas, which means that building the facilities and the infrastructure to tie them into the grid can be costly. All in, building geothermal power plants is a very expensive proposition. Until Novel Therm, that is.





Full-scale Stirling Engine

The Novel Therm engine is 100% green and provides a highly stable source of large amounts of energy 24x7. It can operate completely independent of the traditional electrical grid as well.



Scale Model of Novel Therm Stirling Engine

While there are other heat engines, such as the organic Rankine cycle machines from ORMAT and Pratt & Whitney, the efficiency of these engines drops off considerably when the input water temperature drops. At 200°F or less, their efficiency plummets to 10% or less while the Novel Therm engine operates at 20% efficiency at these temperatures – producing over twice as much energy.

In today's environment it is far less expensive to move data to and from a highly efficient data center than to purchase power from the grid, particularly a grid that in many areas is aging and

Novel Therm has a proprietary right to use a modified Stirling Engine, which is an engine operated by cyclic compression and expansion of a supercritical fluid so that the heat energy is converted into mechanical work. Stirling Engines are a closed loop, not needing any fuel source other than hot liquid or gas.

The profound difference in the Novel Therm engine is that it can convert low temperature water, 160°F and above, into useful energy in the multiple megawatt range.

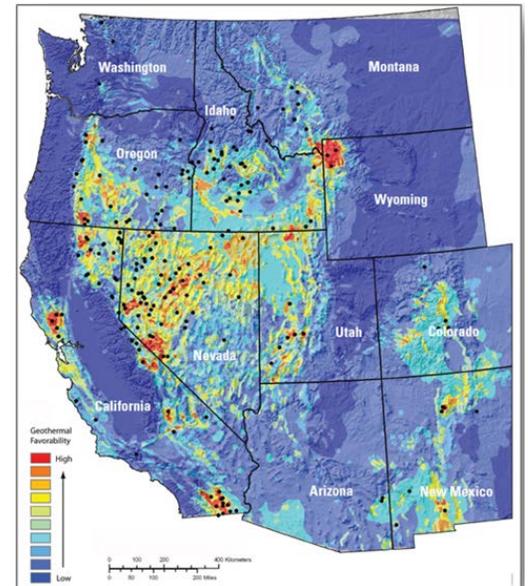
By design, the engine is quiet and odorless, with no need for connection to outside power. The hot geothermal water that feeds the engine first runs through the engine heat exchangers and then is recycled by being fed back down a nearby injection well. This means that the aquifer which feeds the engine will not be depleted.

The power plant is low maintenance and has fewer moving parts than other geothermal heat engines. Plus, with pistons that move at only 1 -2 cycles per minute, our engine parts are moving much slower than other mechanisms. This lowers the wear and tear on the parts and increases useful life giving the Novel Therm machine an estimated lifespan of more than 40 years.

overburdened.

Low Temperature Geothermal Sites

Two of the greatest benefits from being able to use low-temperature geothermal water is that it is plentiful and untapped.



These maps of the western US and Europe are highlighted to show shallow geothermal heat sources at various temperatures. Many, if not all, of the highlighted areas would be appropriate for Novel Therm's heat engine and data center facilities. Essentially, any place with mountains or hot springs are potential sources of low-temperature geothermal water with sufficient flow to provide megawatts of electricity with Novel Therm technology.

HPC Data Centers: The Novel Therm Way

The Novel Therm business model is designed to make it easy for organizations to take advantage of Novel Therm's unique technology and approach. The highlights are simple:

- Build HPC data centers near geothermal source with redundant grid power backup and high speed fiber connectivity.
- Populate the data center to customer specifications to include servers, storage, accelerators, etc. from the vendor of the customer's choice.
- The systems will be configured for immersive liquid cooling to maximize performance, availability and energy efficiency. Novel Therm explicitly takes responsibility for all immersive cooling subsystems and server configuration for liquid cooling.
- No upfront investment from the customer. The customer simply commits to a minimum five year rental term. This agreement can be a simple rental agreement or modified to take into account a three or five year refresh cycle.
- Novel Therm provides break/fix maintenance and over-provisions servers in order to guarantee that the customer always has at least 100% of the capacity contracted for.

Essentially this is an Infrastructure as a Service (IaaS) opportunity with Novel Therm providing the data center configured to customer specifications and then renting it to the customer.

Cost Advantages

There are several options for organizations considering either cloud services or remote hosting for their HPC workloads. The most popular service today is Amazon's AWS. Amazon has been a pioneer in the IaaS arena and has built a multi-billion dollar business over the past decade.

While Amazon is undeniably the market leader, there are some drawbacks to their offerings.

- Amazon has a wide range of instances, but there are still some gaps. For example, customers can't get ultra high-speed interconnects/networking with smaller instances and they can't get 10-GPU instances.
- Customers can't configure their own instances to suit their applications; they're stuck with what Amazon offers.
- AWS can be very expensive, particularly when it comes to high performance servers configured with accelerators.

Given Amazon's dominating presence in the IaaS market and published prices, they make the best comparison for Novel Therm TCO and cost-efficiency.

The following tables outline three different AWS configurations vs. what Novel Therm can construct using current price quotes from name brand vendors.

CPU-only Configuration	Total Cores Per Server	Memory Per Server	Network Speed	Monthly Cost (3 yr. contract)	% Cost Difference
AWS CPU-only configuration	16 @ 2.3 GHz	244 GB	10 Gb/s	\$659.52	
Novel Therm Name Brand system w/4x NVIDIA V100	44 @ 2.2 GHz	256 GB	100 Gb/s	\$558.69	-15%

In the above real-world example, Novel Therm has a 15% cost advantage vs. AWS when it comes to simple CPU-only server instances. But it's important to note that the Novel Therm servers pack much more performance than what customers will receive from AWS. With Novel Therm, customers will receive 44 physical cores (rather than 16 cores), slightly more memory, and a network that is 10x faster.

When it comes to intense number crunching, AI and Deep Learning model training, or a heavy simulation workload, GPUs (Graphics Processing Units) have become required equipment.



However, they're expensive to purchase, power hungry to operate and generate a lot of heat – tailor made for Novel Therm's low cost power and immersive cooling approach.

4 GPU Configuration	Total Cores Per Server	Memory Per Server	Network Speed	Monthly Cost (3 yr. contract)	% Cost Difference
AWS p3.8 x large w/4x NVIDIA V100	16	244 GB	7 Gb/s	\$3,260.88	
Novel Therm Name Brand system w/4x NVIDIA V100	32	384 GB	100 Gb/s	\$2,858.81	-12%

In the above instance, Novel Therm provides **double** the number of compute cores, significantly more memory and more than **10x** the network speed than the competitive AWS system instance – while costing 12% less.

8 & 10 GPU Configurations	Total Cores Per Server	Memory Per Server	Network Speed	Monthly Cost (3 yr. contract)	% Cost Difference
AWS p3.16 x large w/8x NVIDIA V100	48	768 GB	100 Gb/s	\$7,499.52	
Novel Therm Name Brand system w/10x NVIDIA V100	48	768 GB	100 Gb/s	\$4,833.74	-36%

The comparison above really shows the Novel Therm difference. Customers will see a whopping **36%** cost savings with Novel Therm vs. AWS. And the kicker is that the Novel Therm configurations include **ten** NVIDIA V100 32GB GPUs rather than the eight GPUs included with the AWS instance.



Summary

Organizations that have outgrown their existing HPC data centers or who are looking to add more data center capacity without having to build their own facility should take a close look at what Novel Therm can provide.

We can give you use of a 100% green custom data center built to your standards with no upfront investment – with total costs significantly below what the leading competitor can offer. That's a hard deal to beat. Contact us for more details and to get a quote.

