BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of a Determination of Special Contemporary Resource Planning Issues to be Addressed by KCP&L Greater Missouri Operations Company in its Next Triennial Compliance Filing or Next Annual Update Report	)))))	Case No. EO-2020-0045

PUBLIC COUNSEL'S SUGGESTED SPECIAL CONTEMPORARY ISSUES

COMES NOW the Office of the Public Counsel and, in response to the August 23, 2019, order in the above-captioned case opening it and ordering, "Any party wishing to suggest a special contemporary issue that KCP&L Greater Missouri Operations Company should consider in its next annual update report shall file its written suggestion no later than September 15, 2019," in the attached verified memorandum the Office of the Public Counsel suggests certain special contemporary issues that KCP&L Greater Missouri Operations Company should consider in its next annual update report.

Respectfully,

/s/ Nathan Williams

Nathan Williams
Chief Deputy Public Counsel
Missouri Bar No. 35512

Office of the Public Counsel
Post Office Box 2230
Jefferson City, MO 65102
(573) 526-4975 (Voice)
(573) 751-5562 (FAX)
Nathan.Williams@ded.mo.gov

Certificate of Service

I hereby certify that copies of the foregoing have been mailed, hand-delivered, transmitted by facsimile or electronically mailed to all counsel of record this 16th day of September 2019.

/s/ Nathan Williams

MEMORANDUM

To: Missouri Public Service Commission Official Case File,
Case Nos. EO-2019-0045

From: Geoff Marke, Chief Economist
Missouri Office of the Public Counsel

Subject: Special Contemporary Topics for KCP&L Greater Missouri Operations Company

Date: September 16, 2019

Topic 1: Stacking Concrete Blocks w/ Cranes

The Office of the Public Counsel ("OPC") is resubmitting its request for consideration of concrete block storage technology as a supply-side candidate in a utility's resource planning models. In last year's special contemporary topics, OPC cited "Energy Vault" as a potential energy storage option for consideration. Since that time, Energy Vault has secured over $100 million in Series B funding from investors,[1] was awarded the 2019 World Changing Idea Award from *Fast Company* magazine,[2] and was most recently referenced in *Time* magazine's 2050: The Fight for Earth issue under the "Tech Innovations We Need to Happen If We're Going To Survive Climate Change."[3]

Based on recent conversations with Energy Vault, OPC has learned that the first full scale commercial plant is in manufacturing now and expected to be completed and operational in the fourth quarter of 2019. Additionally, two utilities will begin breaking ground in the first quarter of 2020.

Background:

Intermittent generation produces varying amounts of power based on the vagaries of the weather. There might be violent winds one day, and calm skies the next; broiling sunshine on Monday and 100% cloud cover on Tuesday. Peak energy demand, whether for heating or cooling, can be as much as 20 times the energy consumed on an average day. Moving forward, cost-effective energy storage needs to be considered otherwise the value of intermittent generation is considerably minimized. IOU's should investigate low-cost emerging technologies in response to energy generation exceeding demand. OPC suggests future IRP filings investigate the viability of utilizing concrete blocks and cranes as a cost-effective storage option as recently announced by a Swiss start-up Energy Vault. According to *Quartz*:

---

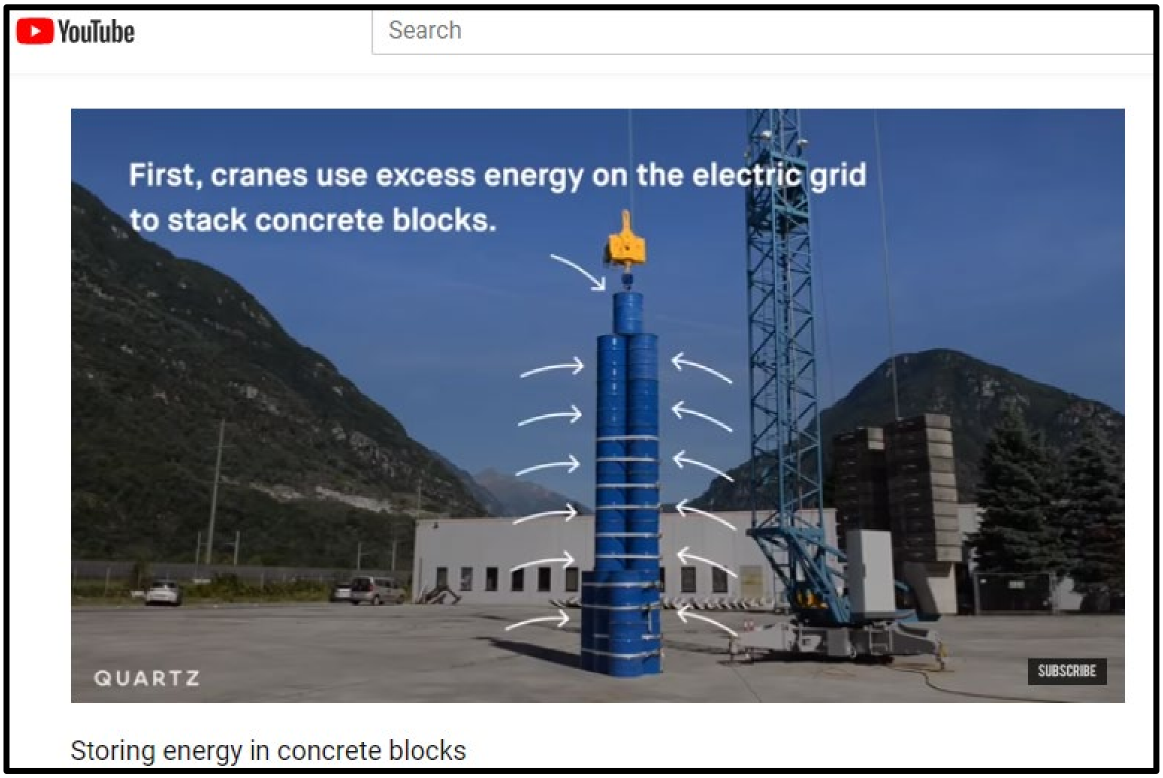
[1] Mai, HJ (2019) Gravity over lithium-ion: SoftBank invests over $110M in Swiss storage company Energy Vault. *UtilityDive*. https://www.utilitydive.com/news/gravity-over-lithium-ion-softbank-invests-110-million-in-swiss-storage-co/561060/

[2] Clendaniel, M. (2019) World Changing Ideas 2019: 17 winning solutions that could save the planet. *Fast Company* https://www.fastcompany.com/90329204/world-changing-ideas-2019-17-winning-solutions-that-could-save-the-planet

[3] Blum, A. (2019) The tech innovations we need to happen if we're going to survive climate change. *Time Magazine*. https://time.com/5669039/technology-fight-climate-change/

> The science underlying Energy Vault's technology is simple. When you lift something against gravity, you store energy in it. When you later let it fall, you can retrieve that energy. Because concrete is a lot denser than water, lifting a block of concrete requires—and can, therefore, store—a lot more energy than an equal-sized tank of water.[4]

Figure 1: Screenshot of Energy Vault demonstration plant on YouTube[5]



The Energy Vault system works as follows:

> A 120-meter (nearly 400-foot) tall, six-armed crane stands in the middle. In the discharged state, concrete cylinder's weighing 35 metric tons each are neatly stacked around the crane far below the crane arms. When there is excess solar or wind power, a computer algorithm directs one or more crane arms to locate a concrete block, with the help of a camera attached to the crane arms' trolley.
>
> Once the crane arm locates and hooks onto a concrete block, a motor starts, powered by the excess electricity on the grid, and lifts the block off the ground. Wind could cause the block to move like a pendulum, but the crane's trolley is programmed to counter the movement. As a result, it can smoothly lift the block, and then place it on top of another stack of blocks—higher up off the ground.

---

[4] Rathi, A. (2018) "Stacking concrete blocks is a surprisingly efficient way to store energy." *Quartz*. https://qz.com/1355672/stacking-concrete-blocks-is-a-surprisingly-efficient-way-to-store-energy/

[5] Quartz (2018) Storing energy in concrete blocks. *YouTube*. https://www.youtube.com/watch?time_continue=75&v=mmrwdTGZxGk

The system is "fully charged" when the crane has created a tower of concrete blocks around it. The total energy that can be stored in the tower is 20 megawatt-hours (MWh), enough to power 2,000 Swiss homes for a whole day.

When the grid is running low, the motors spring back into action—except now, instead of consuming electricity, the motor is driven in reverse by the gravitational energy, and thus generates electricity.

Suggested Recommendation

1.) Include concrete block storage as a supply-side resource candidate in resource planning and modeling scenarios.

Topic 2: Additive Manufacturing ("AM" or "3D Printing")

OPC is resubmitting its request to include consideration of additive manufacturing technology as a cost-saving tool for resource planning purposes.

Additive manufacturing (AM) is the process of producing objects from computer-aided design (CAD) model data, usually adding layer upon layer, in contrast to conventional subtractive manufacturing methods that involve the removal of material from a starting work piece. AM is also called 3-D printing, additive fabrication, or free-form fabrication. Once employed purely for prototyping, AM is now increasingly used for spare parts, small series production, and tooling. The continued proliferation of AM can provide utilities (and other industries in general) new design flexibility, reduced energy use, and shorten time to market. The number of materials and complexity that AM can handle is constantly expanding and is already a reality in many industries as seen in Figure 1 from a recent McKinsey Consulting white paper:

Figure 1: Examples of current AM applications[6,7]

Aerospace	Industrial	Healthcare
• Fuel nozzle for flight engines • 5x more durable, 25% lighter	• Repair of burner heads for gas turbines • Reduction of repair time from 44 to 4 weeks	• Hearing aids • Mass production of highly customized parts
• Thrust chamber for aerospace rocket engine. More reliable, robust, and efficient	• Printing of industrial filters with geometrical optimization • 15% pumping energy reduction	• Model to aid tumor surgery • Reduction of surgery time and complications
• Metal brackets designed for additive manufacturing • Resulting in up to 50% less weight and less raw material input	• Increase of machine parts performance through special design • Reduction of production time from days to hours	• Artificial limbs constructed in 2 weeks, replacing lower half of left leg • Perfect physical fit with aesthetic components

[6] Kelly, R. & J. Bromberger (2017) "Additive manufacturing: A long-term game changer for manufacturers." *McKinsey Consulting*. https://www.mckinsey.com/business-functions/operations/our-insights/additive-manufacturing-a-long-term-game-changer-for-manufacturers

[7] See also GM-1 for printout of Siemen's Additive Manufacturing breakdown.

In principle, additive technologies are able to produce almost every part that can be produced by means of traditional procedures. The increase of AM will no doubt have cost and operational implications on an investor-owned utility's cost of service that should begin to be considered as a relevant input in future planning scenarios. Such examples include but are not limited to:

Generation construction of wind turbines (or other production plant parts):

The enormity of wind turbines (blades and tower segments) makes it both difficult and expensive to transport materials on the highway to project sites. 3D printing could enable construction at the project site which should result in increased financial savings. Most recently, a California startup (Reinforced Concrete Additive Manufacturing "RCAM" Technologies) was awarded a grant from the California Energy Commission ("CEC") to develop and test AM printing technology of concrete for turbine towers on-site in the hopes of boosting capacity factors and lowering overall costs.[8]

Lower costs, quicker delivery of spare parts for grid reliability:

Simplification of the supply chain necessary to support grid reliability can be improved by eliminating the need to produce components at different sites or having to store excess distribution and transmission investments in warehouses. With AM, "on-demand" products/parts could be manufactured in proximity to the impacted area following both low-impact, high frequency events (e.g., a power outage from a blown transformer) and high-impact, low frequency events (e.g., severe weather events, earthquake, electromagnetic pulses). In theory, AM could provide a cost-effective alternative to securing long-lead-time transmission and distribution equipment.

Load forecasting implications:

If AM technology were to be adopted and utilized on a macro-scale it could have profound implications on the entire economy. AM has already created homes,[9] cars,[10] and homes + cars.[11] Verhoef, et al (2018) estimate that AM could lead to a 5-27% reduction in global energy use by 2050 primarily from "material savings, transportation savings, production savings, savings in the

[8] Gerdes, J. (2017) Is 3-D printing the solution for ultra-tall wind turbine towers? GTM. https://www.greentechmedia.com/articles/read/is-3d-printing-the-solution-for-ultra-tall-wind-turbine-towers#gs.uTRrnsU
[9] Cowan, M. (2018) The world's first family to live in a 3D-printed home. BBC. https://www.bbc.com/news/technology-44709534
[10] Hanley, S. (2018) LSEV 3D-printed electric car costs just $7,500. How is that possible? *Clean Technica* https://cleantechnica.com/2018/03/19/lsev-3d-printed-electric-car-costs-just-7500-possible/
[11] Oak Ridge National Laboratory (2018) ORNL integrated energy demo connects 3D-printed building, vehicle. https://www.ornl.gov/news/ornl-integrated-energy-demo-connects-3d-printed-building-vehicle see video at: https://www.youtube.com/watch?v=RCkQBlFJRN4&feature=youtu.be

use phase and in operation and maintenance."[12] Table 1 provides a U.S. Department of Energy assessment of AM impact attributes on both product offerings and supply chain structures.

Table 1 Impact of AM on product offerings and supply chain:[13]

AM Attributes compared to traditional manufacturing	Impact on product offerings	Impact on supply chains
Manufacturing of complex-design products	Very High	High
New products that break existing design and manufacturing limitations	Very High	High
Customization to customer requirements	Very High	High
Ease and flexibility of design iteration	High	Medium
Part simplification/sub-parts reduction	Medium	Medium
Reduced time to market	Medium	Medium
Waste Minimization	Medium	Medium
Weight reduction	Medium	Low
Production near/at point of use	Medium	Very High
On-demand manufacturing	Low	Very High

Key: Very High, High, Medium, Low

Suggested Recommendations

1.) Analyze and document the feasibility and cost saving implications (if any) in adopting AM technology to maintain present-day and future supply-side investments.
2.) Analyze and document the feasibility and cost saving implications (if any) in adopting AM technology to maintain present-day and future transmission system investments.
3.) Analyze and document the feasibility and cost saving implications (if any) in adopting AM technology to maintain present-day and future distribution system investments.

OPC does not presently recommend modeling a high-AM adoption scenario in the IOU's load forecasts but would not be opposed to such modeling considerations either.

[12] Verhoef, L.A., et al (2018) The effect of additive manufacturing on global energy demand: An assessment using a bottom-up approach. *Energy Policy* 112. p. 349-360. https://www.sciencedirect.com/science/article/pii/S0301421517306997

[13] US Department of Energy. (2015) Quadrennial Technology Review 2015 Chapter 6: Innovation Clean Energy Technologies in Advanced Manufacturing. https://www.energy.gov/sites/prod/files/2015/11/f27/QTR2015-6A-Additive%20Manufacturing.pdf

Topic 3: Virtual Power Plant

Background:

A virtual power plant ("VPP") is a cloud-based distribution power plant that aggregates the capacities of heterogeneous distributed energy resources ("DERs") (e.g., many rooftop solar units) for the purposes of enhancing power generation, as well as trading or selling power on the market. Examples of virtual power plant partnerships include Hawaiian Electric Company ("HECO"), Open Access Technology International, and Sunrun[14] as well as demonstration projects in Sunverge and Consolidated Edison ("Con Ed") and Sunverge and Puget Sound Energy.[15]

Suggested Recommendation

1.) Include a virtual power plant option as a supply-side resource candidate in resource planning and modeling scenarios.

Topic 4: Aggressive Customer-Side Renewable Scenarios

To date, IRP modeling has centered primarily on utility-owned and procured renewable resources to: meet statutory mandates (RES compliance, see Ameren Missouri, et al.), for resource adequacy (see KCPL-GMO), or for speculative merchant generation investments (see Empire).

However, the increased cost of service (e.g., Empire's failure to secure contracts with long-term wholesale customers) and the subsequent decrease cost of customer-side renewable generation (e.g., rooftop solar) has the potential to exacerbate fixed cost recovery and impact future resource planning needs.

To date, there has not been significant modeling conducted to examine the impact of aggressive customer-side renewable adoption on customer rates and future resource acquisition.

Suggested Recommendations

1.) Model a low (e.g., 3%), medium (e.g., 6%) and high (e.g., 12%) customer-side renewable adoption scenario in the Company's load forecast;
2.) Describe and document future resource acquisition strategy selection in light of a low, medium and high customer-side renewable adoption load forecast scenario;
3.) Describe and document annual average rates under a low, medium and high customer-side renewable adoption load forecast scenario for non-renewable customers.

[14] Gheorghiu, J. (2019) Sunrun partnership enhances HECO's ability to tap into DER systems when power demand spikes. *UtilityDive*. https://www.utilitydive.com/news/sunrun-partnership-enhances-hecos-ability-to-tap-into-der-systems-when-pow/562733/

[15] See GM-2.

Topic 5: Historical review of energy forecasts

GMO has recently added renewable resources based not on need, but "economics" (i.e. these generation facilities will generate revenues greater than the costs). Historically, market forecasts have been used to justify these power purchase contracts. At this point, GMO has enough historical forecasts to consider the accuracy and potential margin of error in these forecasts. Moving forward, it is essential that GMO review its forecasts used in the past and make changes going forward, based in part, on the accuracy of those historical forecasts.

Suggested Recommendation

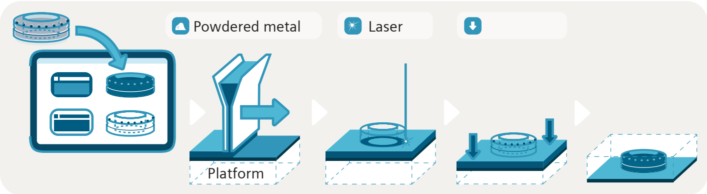
1.) GMO should include a review and a narrative explanation of their findings in regards to the accuracy of their market price forecasts in their collective IRP filings to date.

Additive Manufacturing

SIEMENS
Ingenuity for life

Additive Manufacturing (AM) refers to a production process in which components are created layer by layer on the basis of digital 3D design data.[1)]

How Additive Manufacturing works



Drivers to leverage Additive Manufacturing

Lead time reduction & life cycle improvement for complex parts

- Lead time reduction
- Reduced number of process steps
- Saving of material
- Eliminated tools
- On-demand

Improved efficiency thanks to almost unlimited possibilities to design internal passages and structures

- Better heat transfer
- Improved cooling duct design
- Improved mixing of fuel and air
- Processing of new alloys

Improved efficiency thanks to:

- Bionic structures e.g. load optimized structures
- Integrated design
- Weight reduction

Challenges for Additive Manufacturing technologies in power generation

- High temperatures
- High centri-fugal forces
- High velocities

Technological challenges for gas turbines

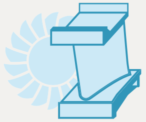
- Thermal loading is close to the melting point of the used metals. For example in the case of iron 1636°C
- The centrifugal force affecting the blades is 10,000 times the net weight force
- The blade tips reach almost sonic velocity

Technological challenges for steam turbines

- Components require a long operational lifetime under high mechanical and thermal load

Areas of application

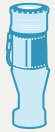
Rapid Prototyping



75% development time reduction

Prototypes produced with AM are increasingly used for production development to test certain properties before series production begins. As production with AM is much faster than conventional manufacturing, testing and development time of components are accordingly reduced. Early validation of new designs is possible.

Rapid Manufacturing



85% faster manufacturing of complete burner set

AM technology industrialization enables new opportunities for spare part and supply chain enhancement such as the manufacturing of spare parts on demand and even close to site. Currently, Siemens uses AM for rapid manufacturing of Siemens gas turbine components.

Rapid Repair

60% faster repairs of SGT-700 and SGT-800 burners tips

Replacement of conventional repair processes with Additive Manufacturing technologies provides not only a significant reduction in repair time, but also an opportunity to modify repaired components to the latest design.

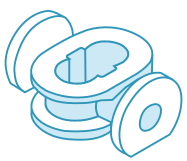
Spare parts on demand

40% lead time reduction

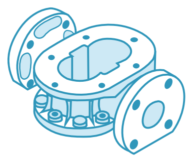
Printed spare parts on demand mean reduced lead time, higher engine availability and fast technology validation for the customer. In June 2016, Siemens has put into commercial operation the first printed spare part on demand for large gas turbines.

Design for additive manufacturing

Design evolution from Casting to Additive Manufacturing



Casting



Additive Manufacturing

Design for Additive Manufacturing focusses the development and implementation of design philosophies into the product development and engineering processes. Each 3D-printing technology has its own set of demands and possibilities, and it is our task to transform parts from their conventional manufacturing history into the AM design accordingly. Typically, geometric features like cavities, drilled holes, thick walls and overhanging edges get remodeled and enhanced, while weight reduction, added functions and integrated design become a reality.

The value of Additive Manufacturing in facts and figures

- **65%** less resources in production process
- **75%** reduction of development time
- **∞** flexibility for design of parts
- **60%** faster repairs
- **50%** reduction of lead time
- H_2 **60%** hydrogen in the fuel mix

Status of Additive Manufacturing in the power generation at Siemens

- First industrial Siemens facility for power generation components
- Gas turbine components incommercial production
- Innovation frontrunner on steam turbine additive
- Development of specific steam turbine alloys for AM
- In preparation for commercialization of steam turbine components

Sources
1) International Committee F42 for Additive Manufacturing Technologies (ASTM)
2) http://www.rolandberger.com/media/pdf/Roland_berger_Additive_Manufacturing_2013119.pdf

US utilities eyeing virtual power plants as emerging assets

Wednesday, August 14, 2019 10:01 AM CT

By Garrett Hering
Market Intelligence

Sunverge Energy Inc. is one of numerous companies offering software to aggregate distributed energy systems, such as this rooftop solar array being installed in Hawaii, into virtual power plants.
Source: Associated Press

Disrupted in recent years by an uncoordinated rollout of distributed energy resources across their service territories, U.S. electric utilities are increasingly exploring how to benefit from rooftop solar arrays, batteries and other small-scale resources by combining them into virtual power plants.

If unsuccessful, utilities and their regulators "will continue to plan on traditional fossil fuel-based generation," said Martin Milani, CEO of Sunverge Energy Inc., a developer of cloud-based energy management systems that control distributed renewable energy resources and tie them into grid operations, enabling their broad participation in wholesale power markets.

"We have the ability to actually respond in real time, in nanoseconds," Milani said in an interview.

To facilitate its supply of virtual power plant software, the California-based company raised $11 million in an investment led by venture capital fund the Ecosystem Integrity Fund, with participation from venture capital affiliates of Midwestern U.S. utility Evergy Inc. and Norwegian energy giant Equinor ASA, Sunverge disclosed Aug. 7. Founded in 2010,

GM-2
1/3

Sunverge has raised roughly $65 million, including from investment arms of Siemens AG and TOTAL SA, according to S&P Global Market Intelligence data.

The latest capital injection will help Sunverge enhance its offering and expand its business with utilities, who "are looking at [virtual power plants] as something they want to control for grid services beyond peak shaving," Milani said. Sunverge's utility and grid services platform also offers demand response, frequency regulation, voltage management, operating reserves and time-shifting of variable solar resources.

'The right investment'

Sunverge is collaborating in demonstration projects in New York with Consolidated Edison Inc. and Washington with Puget Sound Energy Inc., the company announced in early 2019. Other utilities on its client roster include Arizona Public Service Co., the Sacramento Municipal Utility District and the Glasgow Electric Plant Board in Kentucky.

"All the programs we are doing will expand over the next 18 months," Milani said.

While Sunverge first developed software to manage its energy storage system hardware, its future growth will center on software for utilities, the CEO said. The company's new investors appear sold on that strategy.

"We believe the Sunverge platform can play a critical role in transitioning our existing power system from fossil fuel to reliable and clean distributed generation," Geoff Eisenberg, partner at the Ecosystem Integrity Fund, said in a news release.

The platform "proves the value of the baseload power generated by [distributed energy resources] and will ultimately help utilities convince both public utilities commissions and consumers that assets like solar and energy storage are the right investment for the future of our energy markets," added Gareth Burns, managing director at Equinor Energy Ventures.

Several other California companies are also ramping up efforts to squeeze more value out of distributed resources through virtual power plants.

Sunrun Inc. is setting up residential virtual power plants in Northern California and New England, while Advanced Microgrid Solutions is supplying a network of battery-backed commercial buildings in Southern California. Stem Inc. has also developed a software platform for solar-plus-storage arrays and virtual power plants.

Looking abroad

In addition to expanding its business with U.S. utilities, Sunverge is looking to demand for virtual power plants abroad, especially in Europe and Japan, according to Milani. The company already has a foothold in Japan, supplying its software in a pilot project with Kyushu Electric Power Co. Inc. Project participant Mitsui & Co. Ltd. is also an investor in Sunverge.

With its dense population, limited domestic energy resources and ongoing questions related to its reliance on nuclear power, Japan may become "a major hotbed of [virtual power plant] innovation," according to a recent Navigant Research white paper commissioned by Vancouver, British Columbia-based virtual power plant technology supplier Enbala Power Networks Inc.

Another software developer, AutoGrid Systems Inc., in June announced it was working with ENERES Co. Ltd. on a sprawling virtual power plant project in Japan, involving the addition of more than 10,000 distributed energy assets between 2020 and 2021, including behind-the-meter solar, energy storage and combined heat and power resources, and electric vehicles.

Australia is emerging as another early hotbed. Tesla Inc. is building a virtual power plant consisting of up to 250 MW of solar power and 650 MWh of energy storage on 50,000 homes in South Australia. Enbala is supplying its cloud-based platform for a project in South Australia with AGL Energy Ltd.

Virtual power plants in the Asia-Pacific region as could grow to roughly 12,637 MW by 2029, up from about 1,045 MW in

2019, making it the world's fastest-growing market for the technology, according to Navigant.

This article was published by S&P Global Market Intelligence and not by S&P Global Ratings, which is a separately managed division of S&P Global.

BEFORE THE PUBLIC SERVICE COMMISSION OF THE STATE OF MISSOURI

AFFIDAVIT OF GEOFF MARKE

STATE OF MISSOURI	)	
	)	SS.
COUNTY OF COLE	)	

COMES NOW GEOFF MARKE and on his oath declares that he is of sound mind and lawful age; that he contributed to the foregoing *PUBLIC COUNSEL'S SUGGESTED SPECIAL CONTEMPORARY RESOURCE PLANNING ISSUES* and that the same is true and correct according to his best knowledge and belief.

Further the Affiant sayeth not.

Geoff Marke
Chief Economist

JURAT

Subscribed and sworn before me, a duly constituted and authorized Notary Public, in and for the County of Cole, State of Missouri, at my office in Jefferson City, on this 16th day of September, 2019.

NOTARY PUBLIC NOTARY SEAL STATE OF MISSOURI

JERENE A. BUCKMAN
My Commission Expires
August 23, 2021
Cole County
Commission #13754037

Jerene A. Buckman
Notary Public

My Commission expires August 23, 2021.