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 Kansas City Power & Light Company in its Next Triennial Compliance Filing or Next Annual Update Report	)	Case No. EO-2019-0063
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-2019-0064
In the Matter of a Determination of Special Contemporary Resource Planning Issues to be Addressed by Union Electric Company d/b/a Ameren Missouri in its Next Triennial Compliance Filing or Next Annual Update Report	)	Case No. EO-2019-0065
In the Matter of a Determination of Special Contemporary Resource Planning Issues to be Addressed by The Empire District Electric Company in its Next Triennial Compliance Filing or Next Annual Update Report	)	Case No. EO-2019-0066

PUBLIC COUNSEL'S SUGGESTED SPECIAL CONTEMPORARY RESOURCE PLANNING ISSUES

COMES NOW the Office of the Public Counsel ("OPC") and, in response to the *Order Opening a File Regarding Special Contemporary Resource Planning Issues and Offering an Opportunity to File Suggestions* filed by the Commission in each of the above styled cases, offers the following *Suggested Special Contemporary Resource Planning Issues* and attached memorandum. In support thereof, OPC states as follows:

1. The *Order Opening a File Regarding Special Contemporary Resource Planning Issues and Offering an Opportunity to File Suggestions* filed by the Commission on September 17, 2018 for each of the four referenced cases stated that "[a]ny party wishing to suggest a special contemporary issue" to be considered by the respective public utility "shall file its written suggestion no later than September 15, 2018."
2. Pursuant to the Commission's order, the OPC offers the attached memorandum laying out the OPC's written suggestions regarding what special contemporary issues should be addressed by the relevant public utilities.
3. The OPC requests that the first two topics set forth in the attached memorandum be addressed by each of the four utilities (Kansas City Power & Light Company, KCP&L Greater Missouri Operations Company, Union Electric Company d/b/a Ameren Missouri, and The Empire District Electric Company) while the remaining third topic be addressed solely by KCP&L Greater Missouri Operations Company.

WHEREFORE, the Office of the Public Counsel respectfully submits its attached memorandum regarding special contemporary resource planning issues and asks the Commission to order Kansas City Power & Light Company, KCP&L Greater Missouri Operations Company, Union Electric Company d/b/a Ameren Missouri, and The Empire District Electric Company to address these issues in their next triennial compliance filing or annual update report.

Respectfully submitted,
OFFICE OF THE PUBLIC COUNSEL

By: /s/ John Clizer
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CERTIFICATE OF SERVICE

I hereby certify that copies of the forgoing have been mailed, emailed, or hand-delivered to all counsel of record this fourteenth day of September, 2018.

/s/ John Clizer

MEMORANDUM

To: Missouri Public Service Commission Official Case File,
Case Nos. EO-2019-0063, EO-2019-0064, EO-2019-0065 and EO-2019-0066

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

Subject: Special Contemporary Topics

Date: September 14, 2018

Topic 1: Additive Manufacturing ("AM" or "3D Printing")

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[1]

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

[1] 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

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 utilities 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.[2]

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,[3] cars,[4] and homes + cars.[5] 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

[2] 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

[3] Cowan, M. (2018) The world's first family to live in a 3D-printed home. BBC. https://www.bbc.com/news/technology-44709534

[4] 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/

[5] 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."[6] 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:[7]

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

Key: ● Very High ◉ High ○ Medium ○ Low

IRP requests regarding topic #1:

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.

[6] 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

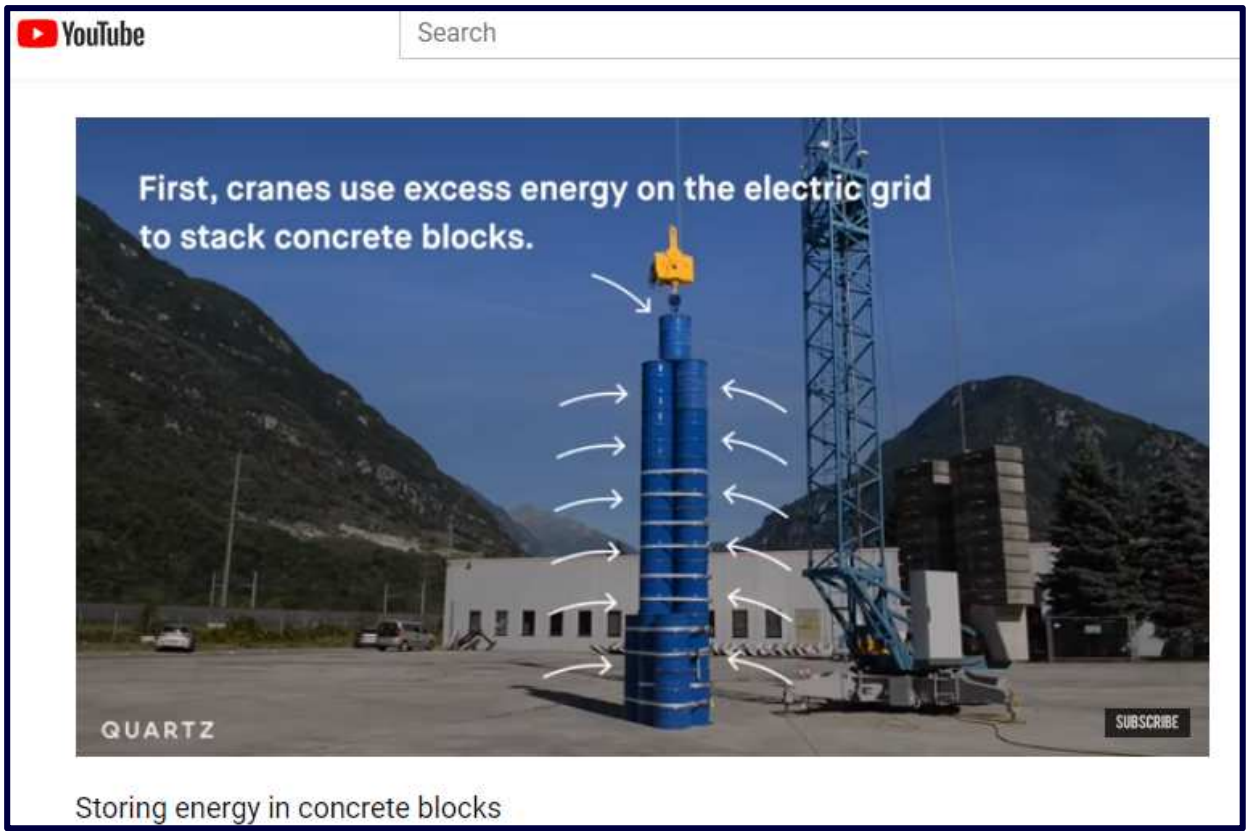
[7] US Department of Energy. (2015) Quadrennial Technology Review 2015 Chapter 6: Innovation Clean Energy Technologies in Advanced Manufacturing. https://www.energy.gov/sites/prod/files/2015/11/f27/QTR2015-6A-Additive%20Manufacturing.pdf

Topic 2: Stacking Concrete Blocks w/ Cranes

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*:

> 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.[8]

Figure 1: Screenshot of Energy Vault demonstration plant on YouTube[9]



[8] 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/

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

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 cylinders 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 arm's 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.
>
> 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.

IRP requests regarding topic #2:

1.) Analyze and document the feasibility and cost saving implications (if any) in utilizing concrete blocks and cranes as a battery storage option for resource needs.
    a. Given the specific nature of this topic, OPC would not be opposed to a singular response/investigation on this topic from all of the IOUs as opposed to four separate responses.

Topic 3 (KCP&L Greater Missouri Operations Company-specific): Crossroads

IRP requests regarding topic #3:

1.) Model a scenario that does not include Crossroads ownership in 2029.

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 *SPECIAL CONTEMPORARY 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 14th day September 2018.

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.