# ACS AMA: I'm Kyle Bradbury, Managing Director of the Energy Data Analytics Lab at the Duke University Energy Initiative. Ask me anything about energy storage systems and energy data analytics.

AmerChemSocietyAMA [1] and r/Science AMAs[1]

[1]Affiliation not available

April 17, 2023

*the*
WINNOWER

REDDIT

# ACS AMA: I'm Kyle Bradbury, Managing Director of the Energy Data Analytics Lab at the Duke University Energy Initiative. Ask me anything about energy storage systems and energy data analytics.

AMERCHEMSOCIETYAMA R/SCIENCE

[removed]



CORRESPONDENCE:

DATE RECEIVED:
October 12, 2016

DOI:
10.15200/winn.147619.90287

ARCHIVED:
October 11, 2016

CITATION:
AmerChemSocietyAMA , r/Science , ACS AMA: I'm Kyle Bradbury, Managing Director of the Energy Data Analytics Lab at the Duke University Energy Initiative. Ask me anything about energy storage systems and energy data analytics., *The Winnower* 3:e147619.90287 , 2016 , DOI: 10.15200/winn.147619.90287



How long do you think it will be until we see an affordable battery, both for commercial and residential use? Before the price comes down, it seems like the tech has quite a ways to go. How swift do you think adoption will be?

Finally, energy markets fascinate me but also confuse me. Is there a book or resource that would give me a start in understanding them?

ordinaryplus

The prices of energy storage have been dropping rapidly for a number of energy storage technologies, driven in no small part by the demands of electric vehicles, wind, and solar. Most notably, lithium-ion battery prices are projected to fall 50-60% in the next 5 years (Australian Renewable Energy Agency report). Initially, I believe these trends will enable utility-scale storage, since utilities can use those systems in conjunction with existing wholesale electricity markets, and I think we'll see slower adoption for the residential space since it will take some time to make the case for the benefits to the end user. In particular, that case will be stronger once time of use pricing, enabled by smart meters, is further deployed to give individuals with or without solar arrays a tangible financial benefit through price arbitrage and other applications (see RMI's report). For commercial entities, demand charge reduction will likely be an important consideration as well (charges for the the largest rate of power consumption over a month rather than just the total amount of energy consumed).

Energy markets can be confusing, especially as each region of the country has slightly different rules, but fortunately, there are a number of commonalities that apply across these markets. My suggestion for a good resource on electric power markets would be this book: Kirschen, Daniel S., and Goran Strbac. Fundamentals of power system economics. John Wiley & Sons, 2004. For a higher level description and a discussion of other energy markets beyond electricity, FERC's Energy Primer can be useful.

Which is more cost effective? Large solar farms or solar panels on roofs?

beanstalkandthejack

The short answer is large, utility-scale solar farms (see Brattle group report). However, this is focusing on dollars per unit energy ($/kWh). This doesn't tell the whole story, though. Distributed/rooftop solar may have many additional benefits for the building owner such as time of use price arbitrage, demand charge reduction, and backup power, the benefits of which would not be captured in a $/kWh metric. I think there are compelling cases for both large-scale and small-scale solar.

One of the contributing factors of the stability of the electrical grid is the so called "inertia" of the grid. As more people move towards "at home generated/stored" electricity at what point will the impact be felt by major industrial customers who may have trouble bringing larger motors online without said "inertia" to support the frequency?

Sublimical

This is an interesting question that gets at the heart of an interesting tradeoff: grid inertia vs grid resilience. The concept of inertia in a power system stems from the fact that for the most part, we have giant steam generators being spun by multi-ton turbines. If a plant is coal-fired and we suddenly stopped burning coal, the turbine (and therefore the generator) would not instantly stop spinning, because the intertia in that system would continue spinning it for a time. This allows the system to be able to ride through some short-lived grid issues. Solar power has minimal physical intertia, however, and wind turbines have less inertia than traditional fossil plants. With distributed generation, we're typically talking about solar power, and so this question of grid resilience arises. However, distributed storage is a way of adding resilience to the system since storage could start injecting energy into the grid as needed. Distributed storage also has the ability to increase resilience of power grids in that if any one storage unit fails, there would likely be many, many others to "pick up the slack". It's possible that the loss of physical inertia from large steam generators is compensated for by a significant build out of distributed energy storage. This could usher in a very different operational paradigm for the power grid in terms of ensuring system stability.

And for the second half of your question, this same trade off also applies to powering large motors. With motors, however, there's also the additional need for reactive power at startup and throughout its use. Providing reactive power from energy storage systems is possible from pumped hydro and compressed air energy storage, since they have large rotating generators, but may require some additional power electronics for other energy storage technologies including chemical systems.

One of the main problems with renewable energy such as solar is that they can only generate electricity at certain times (only when its sunny/windy/ etc). How far are storage solutions coming to making renewables more appealing?

galacticdick

You've hit on an important point there - renewable energy such as wind and solar is intermittent and can greatly benefit from using energy storage to "smooth" the power output from those systems so that it's more constant. Energy storage solutions, if we factor out costs for the moment, are at a place where they can overcome two of the major challenges of renewables integration: short term and long term energy imbalances. For short term imbalances between supply and demand, we have systems like flywheels and ultracapacitors, which may not be able to store huge amounts of energy, but are fully capable of meeting short term needs on the order of a few seconds to a few minutes, while longer term energy storage systems like pumped hydroelectric and compressed air energy storage can address energy imbalances on the order of hours. Of course costs can't actually be ignored, but in a few years, we may not have to worry as much about that as prices of energy storage fall. As those prices fall, it may become possible to construct a "baseload" (constant power output) wind farm or solar farm, which is not feasible today. Of course the production scale of energy storage will have to increase, but we're already seeing trends in that direction today, especially with lithium-ion batteries.

What is your opinion of using energy from the grid off of peak load times to generate ice for ice storage? The cold water from the thawing ice is then used in the building cold water loop.

I'm seeing this more and more in HVAC design. It seems to me to strictly be a money saving tool rather than an energy saving one. Is there a greater benefit from evening out those peaks in the grid load?

p.s. currently writing this from right next to the DBAP. Woo Durham!

maxman1313

Ice can be a highly useful medium for energy storage when coupled with HVAC systems. Energy storage doesn't directly save energy, but enables innovations in the energy system, such as peak shifting. HVAC systems are typically the number one consumer of energy in a building, so it's an important appliance to focus on for peak shifting. Companies are currently deploying these systems for residential and commercial use (e.g. Ice Energy).

There are huge benefits to peak shifting. As it stands, when peak demand hours occur, fast-ramping, expensive generators are dispatched to meet the demand. This increases the overall price of electricity, so by "flattening" the peaks, electricity is produced more efficiently and typically at lower cost to everyone.

Additionally, fewer peaks in the daily demand profile means that system operators for the grid are able to keep the generators dispatched at a more constant level - this can increase system reliability since there are fewer fluctuations in the system.

Thanks for doing this AMA!

I have a physics background but in about 3 weeks I'll be starting a job in Data Analytics. Do you have any advice for someone with very limited knowledge just getting started?

Edit: spelling

Fenzik

Absolutely - first off, congratulations on the new job. I think what's most important in starting in data analytics is to jump into trying new ideas as soon as possible. Find a coding language that you like (Python, R, Matlab) and stick with it, developing a working knowledge of how to load and manipulate data. Simultaneously, read up on regression and classification techniques so you can answer serious questions in the field in statistically meaningful ways (An Introduction to Statistical Learning is the book I recommend to my students. Don't be afraid to try new techniques, and explore and visualize that data sets your working on. If you can visualize it, you'll be able to develop more insight into the data. Best of luck!

What are some applications of machine learning in the energy sector that you think have so much potential?

sighhhxif

Great question - for electricity, a significant machine learning application will be grid monitoring and power flow optimization, especially given the growth of phasor measurement unit (PMU) data for monitoring the system. Additionally, from these data it's possible to predict and detection faults in the system and automate the response to increase system reliability.

For the electricity consumer, with the deployment of electric utility smart meters, those data can be used to disaggregate the building-level data into device-level information to help building owners identify opportunities for increasing energy efficiency, minimizing costs when faced with time of use pricing, and engaging in demand response programs. Additionally, machine learning coupled with building energy data can enable home automation and novel internet-of-things applications.

For transportation, along with the advent of self-driving cars, machine learning can be used to optimize driving for maximizing fuel efficiency.

In traditional oil and gas, machine learning can be used to analyze seismic and other data sources to detect oil and gas, and estimate the production capacity.

For renewables, machine learning can be used for citing wind and solar, and for identifying building for which it would be most advantageous to install solar arrays.

The team at Duke that I work with has been exploring methods for analyzing aerial and satellite imagery to create better estimates of distributed solar arrays around the country and to generate high-resolution spatial estimates of energy consumption using machine learning and image processing techniques.

We're at the beginning of a period of growth of exploring the potential of new sources of energy data. Machine learning will help us to make those data actionable.

A few days ago Reddit hosted an AMA by a Sandia scientist working on hydrogen fuel. I thought that technology had more or less been surpassed by other options, but the author disagreed. Having worked in the weeds on a new technology I know how valuable it is to have people like yourself working to understand the broader context. Do you have am assessment of hydrogen's prospects as a storage medium today? Thank you.

AlkalineHume

Great question - hydrogen is a very interesting storage medium, that has faced one primary challenge: low efficiency. Today's systems are around 50% efficient. For lithium-ion batteries, the efficiency is around 90%. Until the efficiency can be improved, I doubt hydrogen energy storage will gain much traction.

How much of a shakeup will the power grid need to successfully incorporate renewables at a large scale? Are microgrids the future, or will the current infrastructure stick around for the next century or two?

ccesare

The power grid, although it's changing and will likely change significantly over the next century, I don't anticipate loosing it's overaching bulk energy transmission backbone anytime soon. There will continue to be needs for large scale generation and to maintain grid reliability, especially in times of emergencies. However, microgrids may very much start changing how we interact with the energy we generate and consume and lead to more peer-to-peer energy transactions that were not possible before. Additionally, microgrids may take some of the burden off the distribution and transmission lines if they won't be needed for carrying as much power from a central power station to a community miles away. This would challenge the traditional model and will require a rethinking of grid operations. Renewables have already started this process of operational changes, but so far, those changes have been well-handled centrally by the regional system operators.

A lot of the future utility of renewables rests upon the development of more efficient energy storage technologies. If we can back one and only one, which of these technologies would be the best investment for society today?

Taper13

Interesting question - I think we have to be forward thinking about what technologies will be both most efficient, and for which we can reasonably continue pushing down the cost going forward. Chemical storage systems that rely on rare materials that may face greater price uncertainty may be less desirable than those built with abundant materials (including lithium), however, lithium-ion batteries appear to be the most promising for the immediate future given falling costs and their large-scale deployment. Site-limited technologies like pumped hydroelectric may be more challenging to develop going forward, but are efficient and can store huge quantities of energy. Compressed air is also extremely compelling in terms of the quantity of energy stored, but requires some amount of natural gas combustion for its generation phase. There's currently no silver bullet, but I'm most hopeful to see new innovations in advanced, innovative chemistries in the next few years.

Have you ever struggled to "sell" the idea of using machine learning because the techniques weren't transparent? Will this cause any road blocks in solving energy problems with data science?

SwedishFishSyndrome

Transparency is an important issue in machine learning. Decision tree classifiers are much easier to understand (and visualize) than neural networks and even though the performance of the latter may be superior in some cases, if the application is something critical (like the stability of the power grid), it's understandable that decision makers might take pause at the idea of allow a "black box" technology to automate a critical process. I think the best way to push forward for innovation is through extensive testing and rigorous performance evaluation that is able to reduce doubt in the efficacy of data science-based solutions.

What mode of energy production do you think will be the eventual go-to? And what do you feel are the benefits of a decentralized power grid?

cmc22377

Personally, I don't think there's one silver bullet in the energy space, and I think we'll need a mix of energy sources for the foreseeable future. However, I see significant potential for growth in solar energy - if costs of solar arrays and energy storage both get low enough, it has the potential to be quite transformative.

For thoughts on benefits of a decentralize power grid, see the second have ofthis discussion.