

Kentucky's Clean Energy Successes, Opportunities, and Challenges



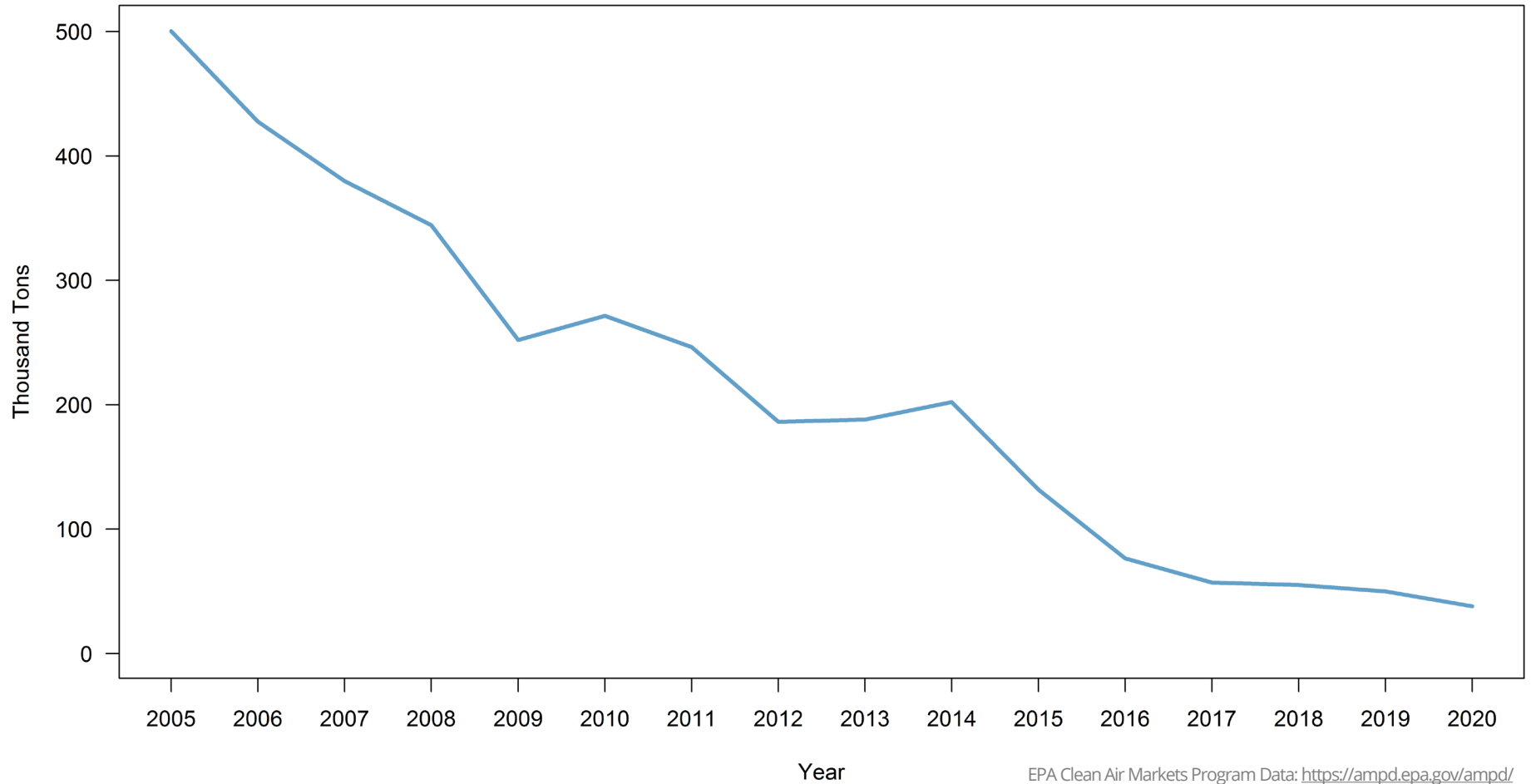
Aron Patrick
Manager, Technology Research and Analysis
<http://lge-ku.com/research>
March 21, 2022 at the University of Kentucky



Kentucky's Clean Energy Successes

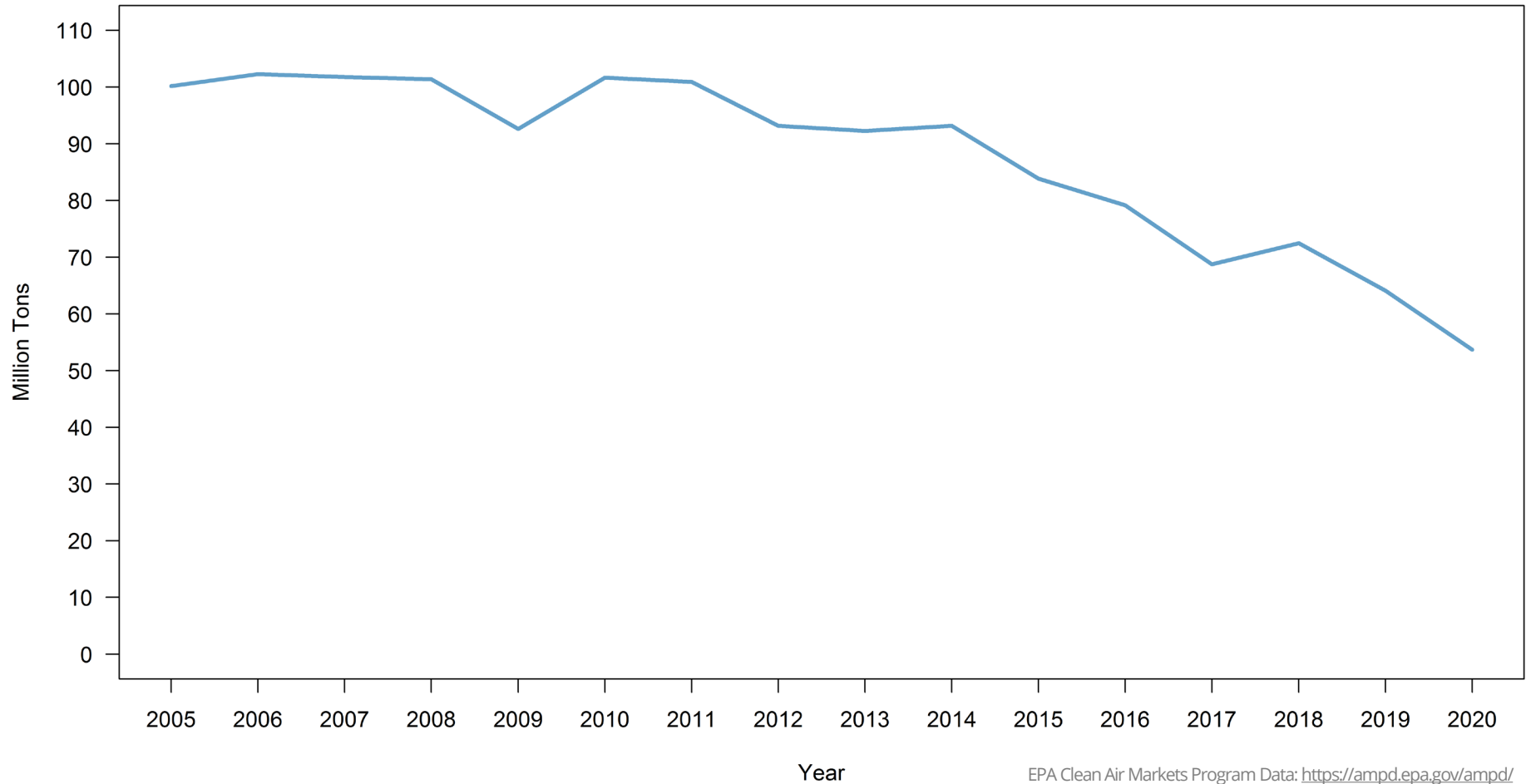
Sulfur dioxide emissions from electricity generation in Kentucky have decreased by 92% since 2005.

Kentucky Sulfur Dioxide Emissions from Electricity Generation 2005-2020



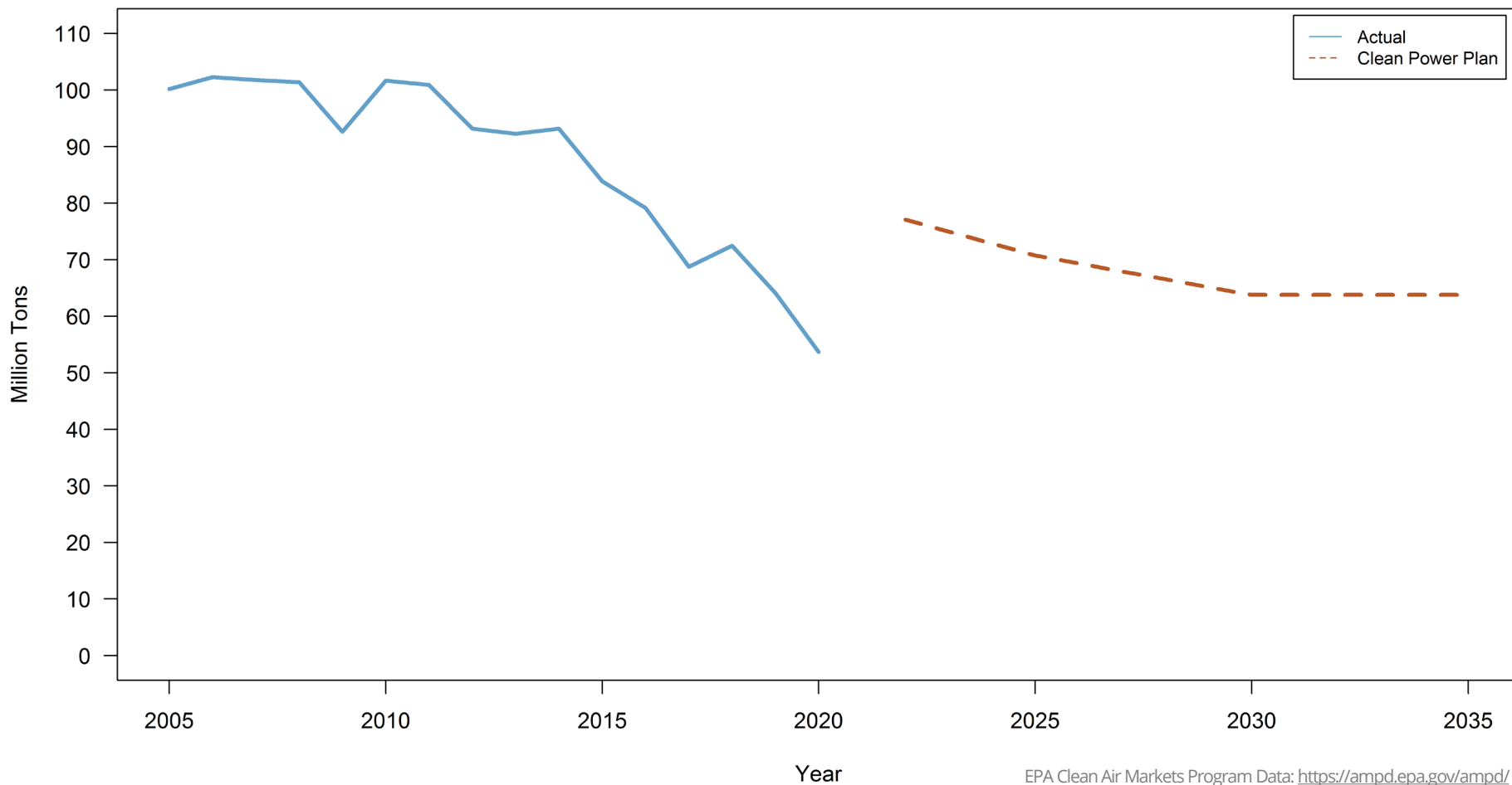
Carbon dioxide emissions in Kentucky have decreased by 46% since 2005.

Kentucky Carbon Dioxide Emissions from Electricity Generation 2005-2020



Kentucky has achieved Clean Power Plan targets more than 10 years ahead of schedule.

Kentucky Carbon Dioxide Emissions from Electricity Generation vs Clean Power Plan 2005-2035



EPA Clean Air Markets Program Data: <https://ampd.epa.gov/ampd/>

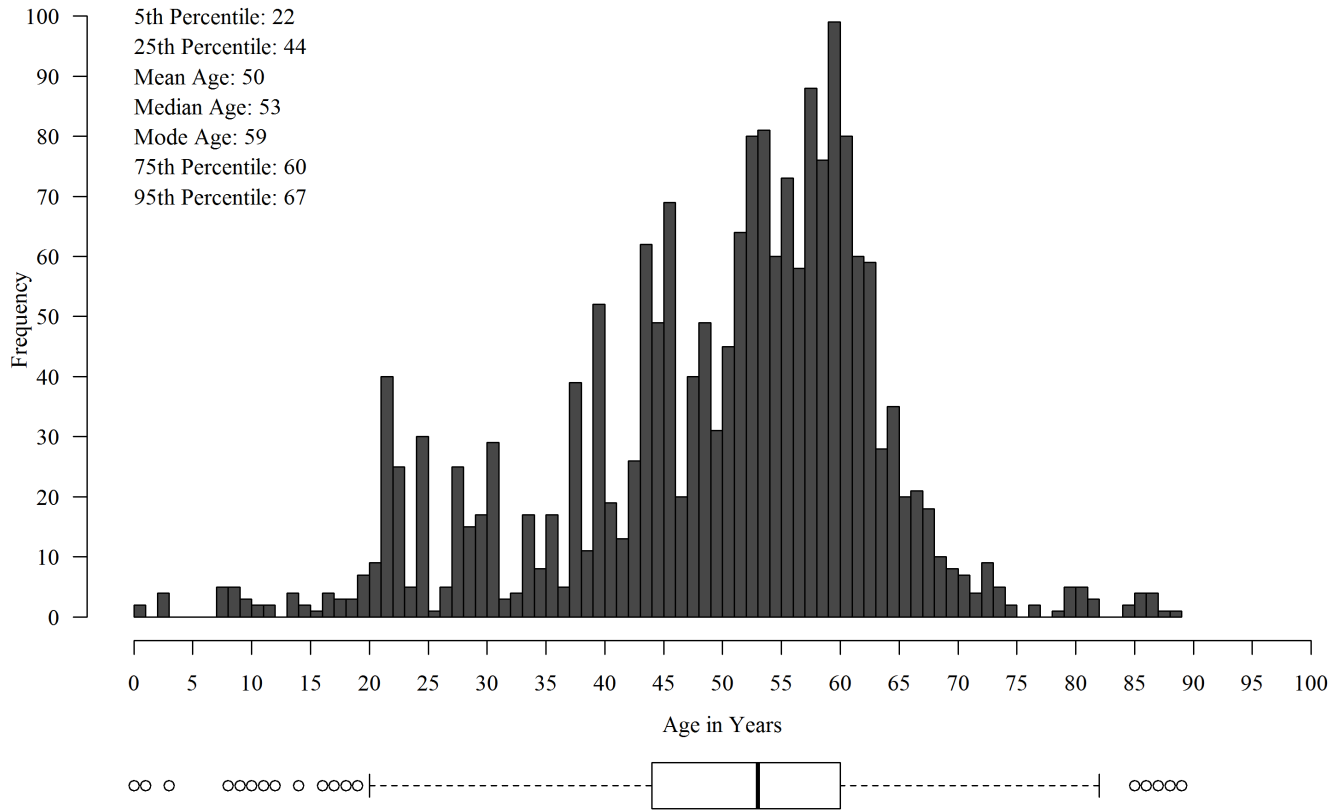
EPA Clean Power Plan Targets for Kentucky:

<https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/kentucky.pdf>

LG&E and KU Technology Research and Analysis

The average age of coal capacity in Kentucky is 47 years old. Coal plants usually last 50 to 60 years. No coal plant built after 2010.

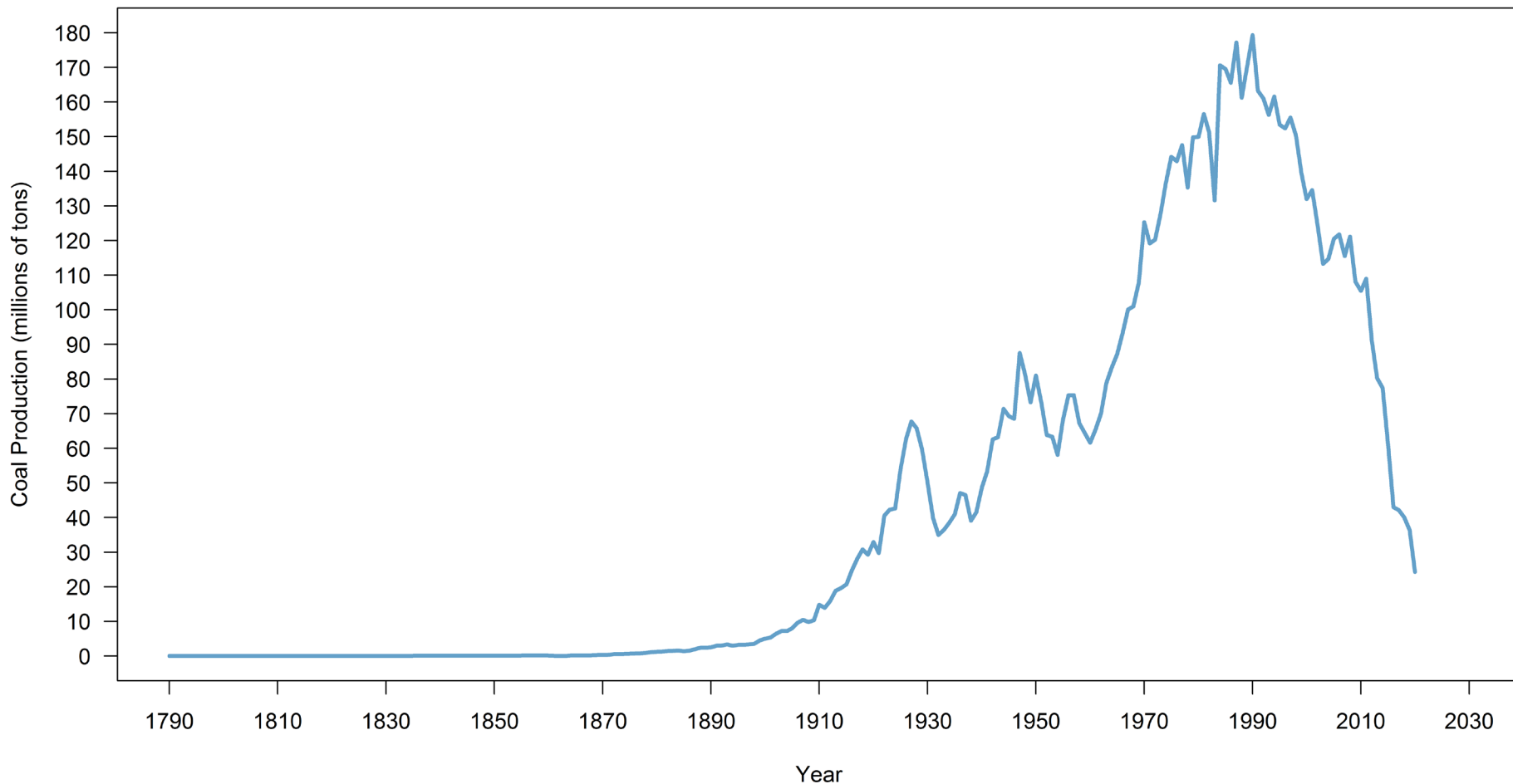
Age of Retired U.S. Coal-Fired Boilers, 1970-2030



LG&E and KU 2018 IRP: https://psc.ky.gov/psc/cf/2018-00348/rick.lovekamp%40ge-ku.com/10192018102925/5-LGE_KU_2018_IRP-Volume_III.pdf#page=71

Kentucky coal production in 2020 has decreased 87% percent since peaking in 1990.

Kentucky Coal Production 1790-2020



LG&E and KU Technol

Kentucky Coal Facts: <https://eec.ky.gov/Energy/News-Publications/Pages/Coal-Facts.aspx>

Kentucky's Largest Solar Farm

<https://lge-ku.com/live-solar-generation>

Kentucky's Largest Solar Farm Built in 2016



- Proposed by LG&E and KU in 2013
- State approved in 2014
- Construction Finished in 2016
- Kentucky's first utility-scale solar site
- Kentucky's largest solar site to date
- 50 acres at the LG&E-KU E.W. Brown
- 44,500 315 W DC fixed-tilt solar panels
- Combined DC output of 14 MW DC
- 10 DC to AC Inverters
- Total combined output of 10.24 MW AC

Kentucky's Largest Solar Farm Built in 2016



Kentucky's Largest Solar Farm Built in 2016



Kentucky's Largest Battery

<https://lge-ku.com/research>

Kentucky's Largest Battery Built in 2016



- 1 Megawatt
- 2 Megawatt-hours
- Three testing bays
- Modular construction
- 1.2 MVA resistive, inductive, capacitive (RLC) load bank
- Grid-connected or islanded (micro-grid).
- High accuracy metering and data logging

Open Rack of Battery Modules inside Container

1

4,760 Cells

14 Cells per Module

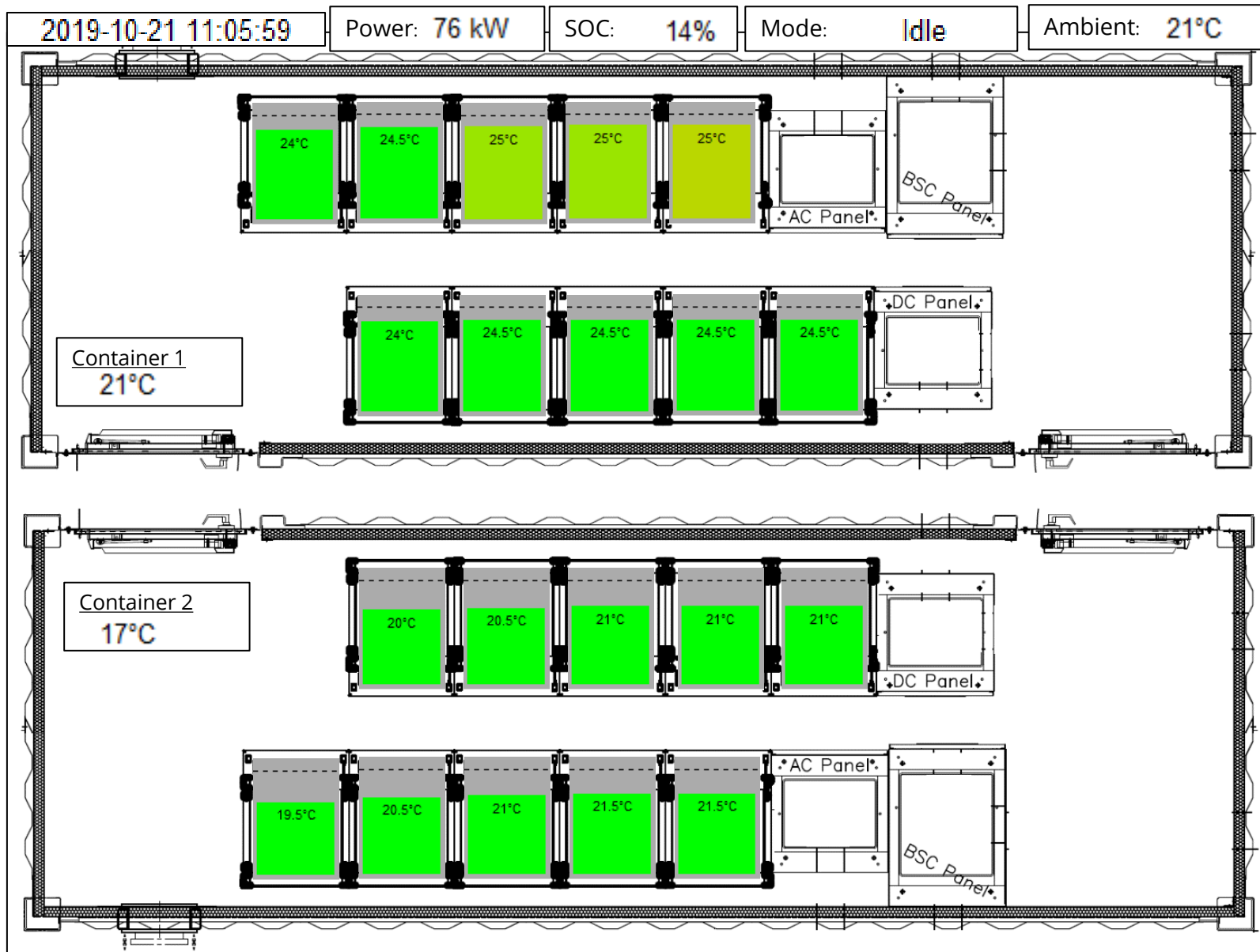
17 Modules per Rack

10 Racks per Container

2 Containers

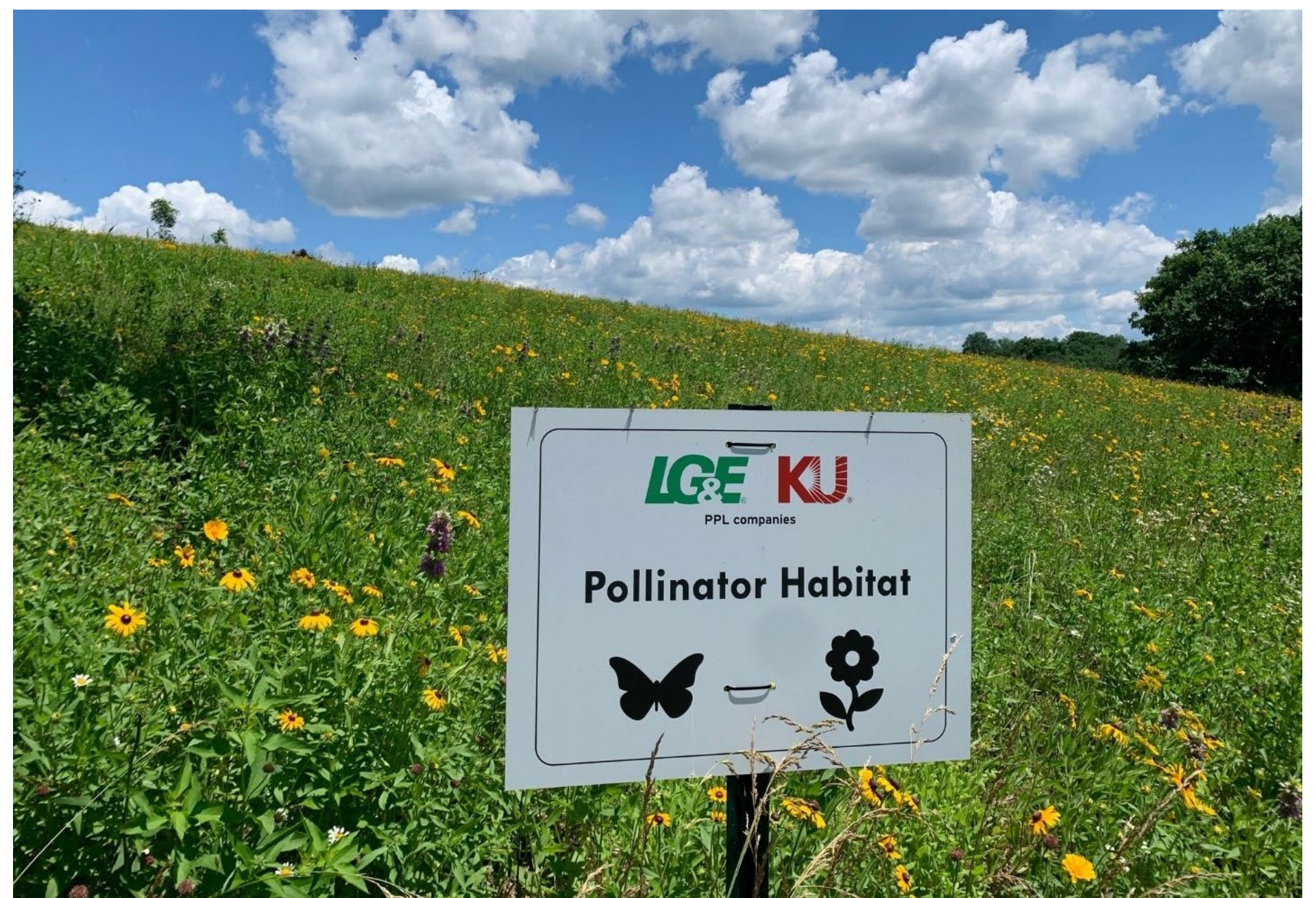


Battery Module Temperature



Solar Pollinator Habitats

<http://lge-ku.com/research>



LGE & KU

PPL companies

Pollinator Habitat



Pollinator Habit Work Began in 2019 with RoundStone









Solar Sheep

<https://lge-ku.com/sheep>



We "hired" 35 sheep to graze our largest solar farm in 2020.



Sheep at Kentucky's Largest Solar Farm



Watch Our Sheep Live at: <https://lge-ku.com/sheep>

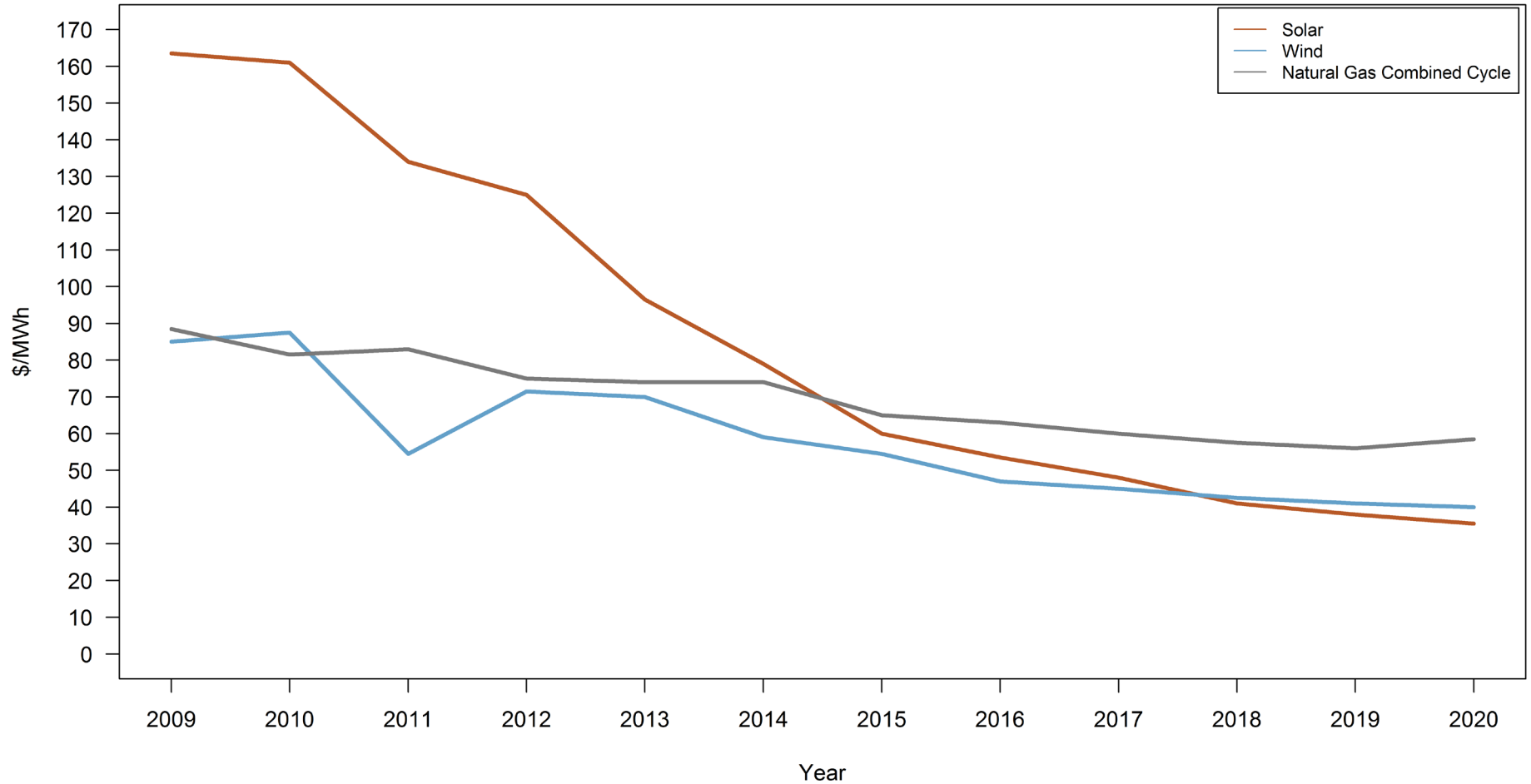
Video Overview



Kentucky's Clean Energy Opportunities

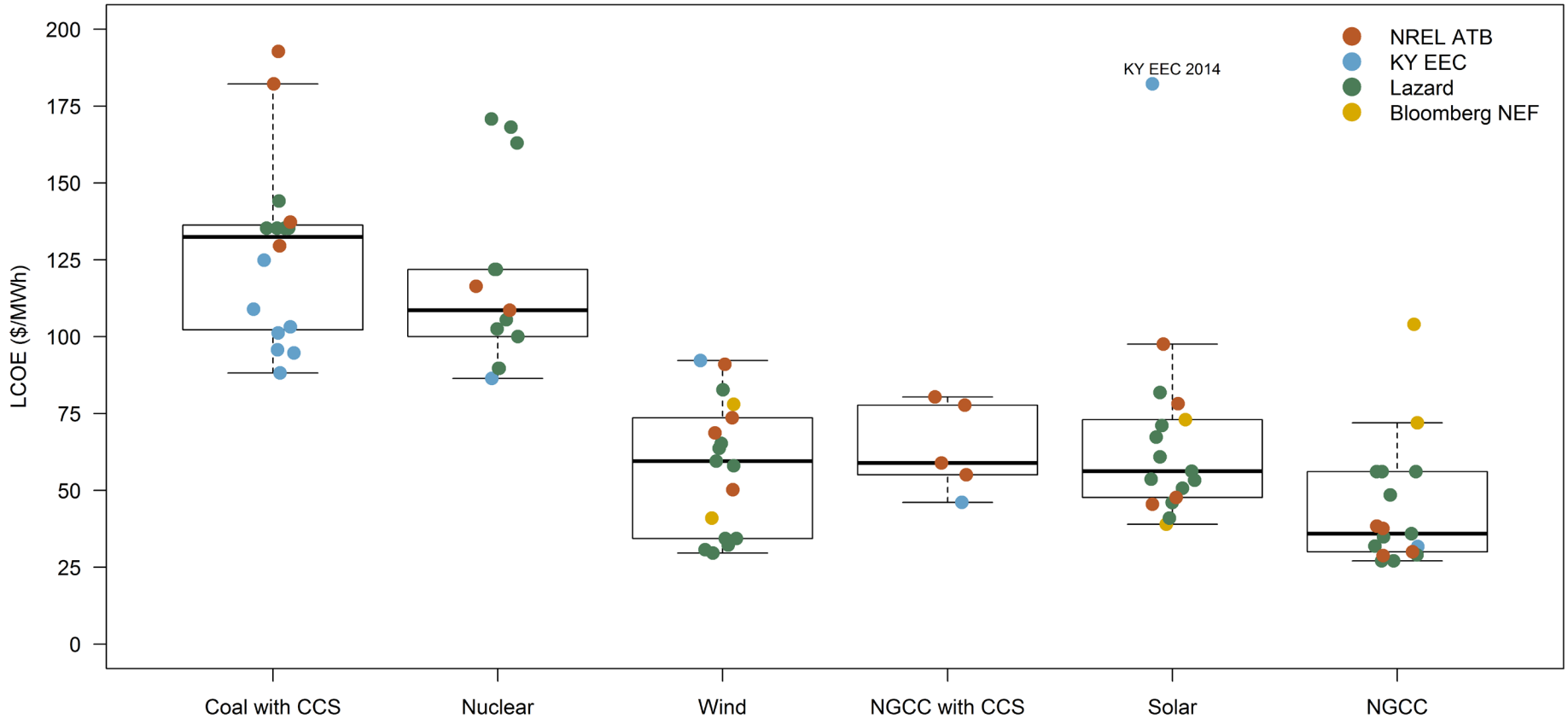
Average levelized cost of wind and solar have decreased since 2009.

Average Levelized Cost of Energy by Technology 2009-2020



Natural gas, wind, and solar are cost competitive. Carbon capture and other technologies are not.

Levelized Cost of Energy by Technology

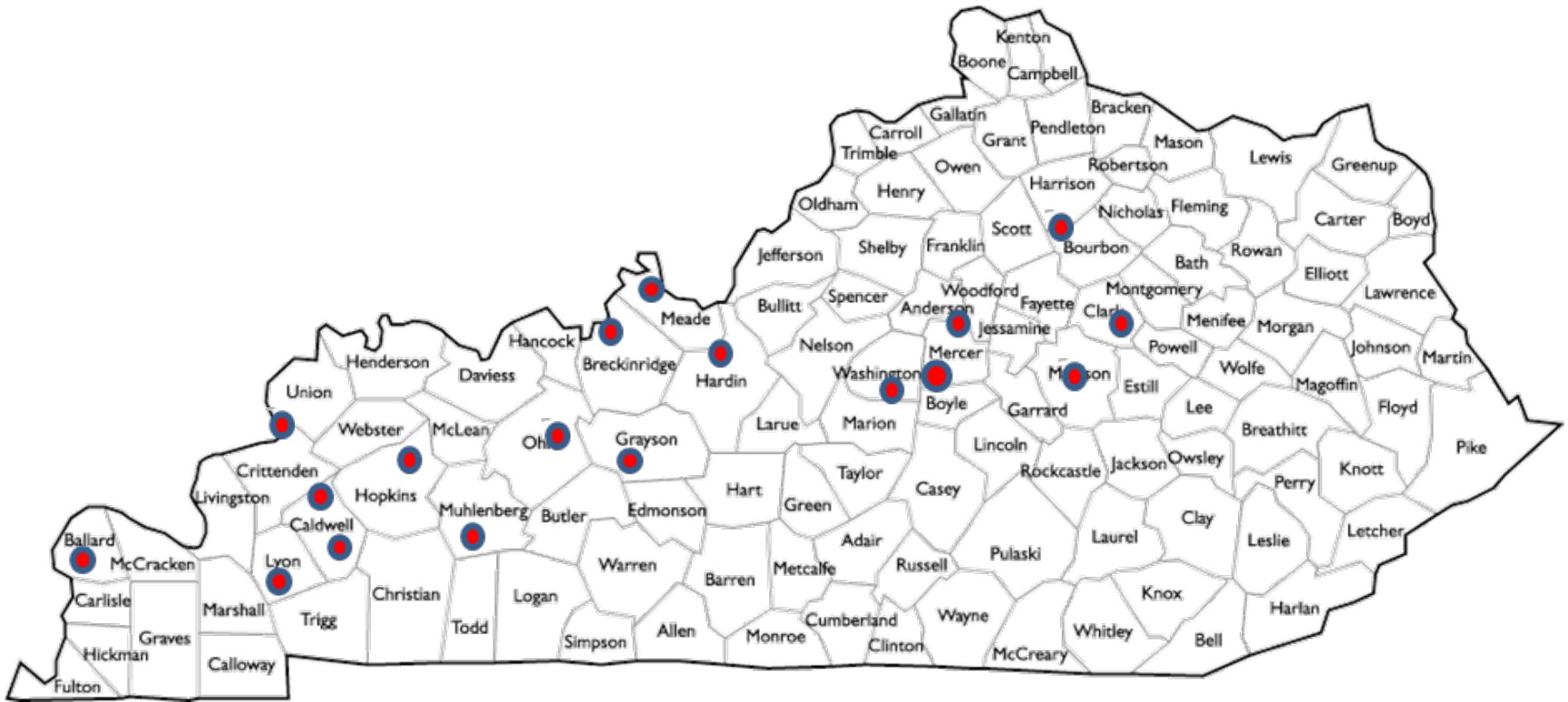


Assumes fuel cost is \$2/MMBtu for coal and natural gas and a discount rate of 9.6%

LG&E-KU Technology Research and Analysis

2020-09-28

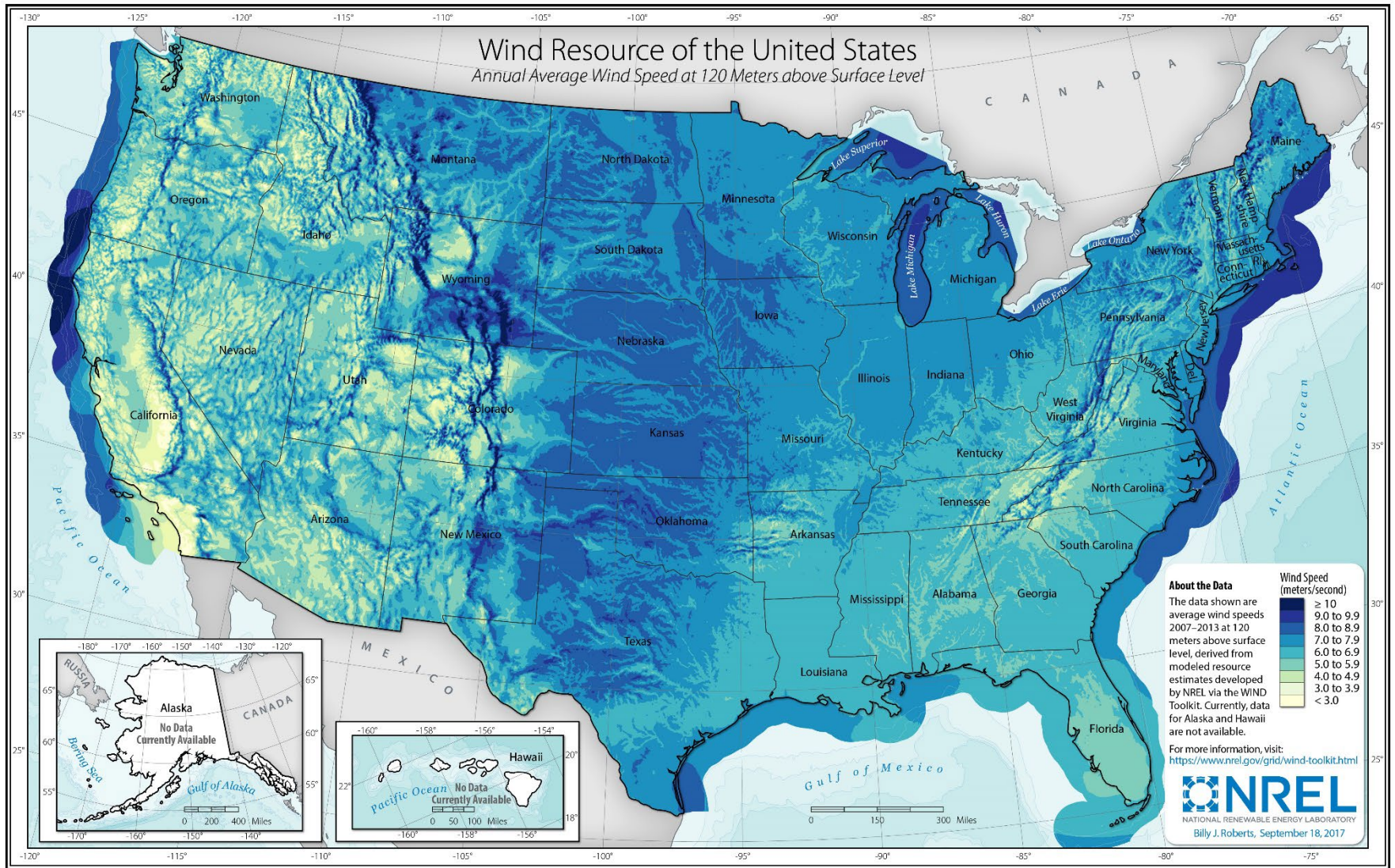
20 Future Solar Projects Proposed Across Kentucky



- Total of 20 proposed solar projects totaling 2 gigawatts of capacity
- Average project size is 100 megawatts
- Project sizes range from 9 to 200 megawatts.
- Projects are proposed in 16 counties

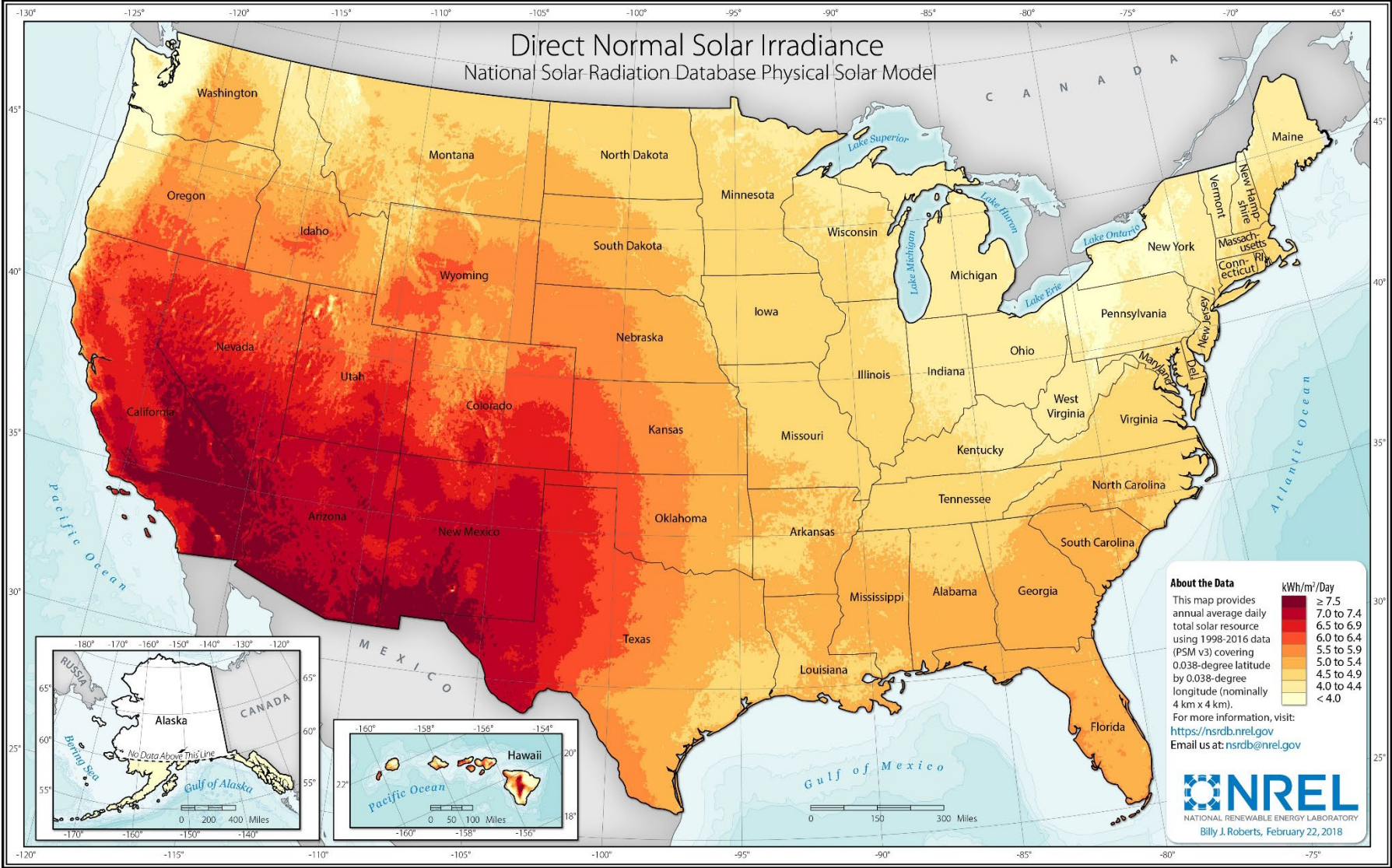
Public Interconnection Queue:
https://www.oasis.oati.com/woa/docs/LGEE/LGEEdocs/LGE_and_KU_GI_Queue_Posting_March_18_2021.pdf

United States Wind Resource Map



NREL Map: <https://www.nrel.gov/gis/assets/images/wtk-120m-2017-01.jpg>

United States Solar Resource Map

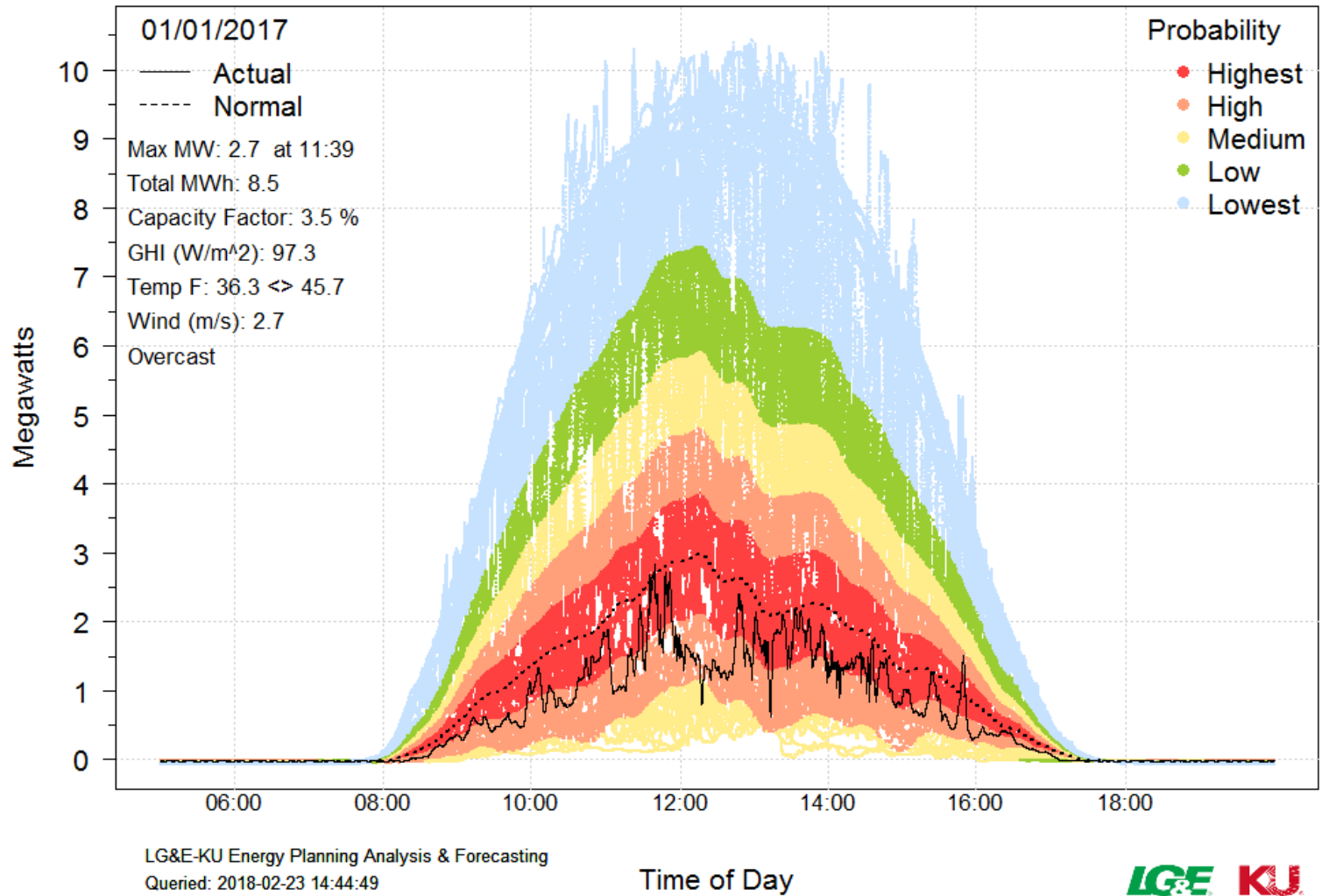


NREL Map: <https://www.nrel.gov/gis/assets/images/solar-annual-dni-2018-01.jpg>

Kentucky's Clean Energy Challenges

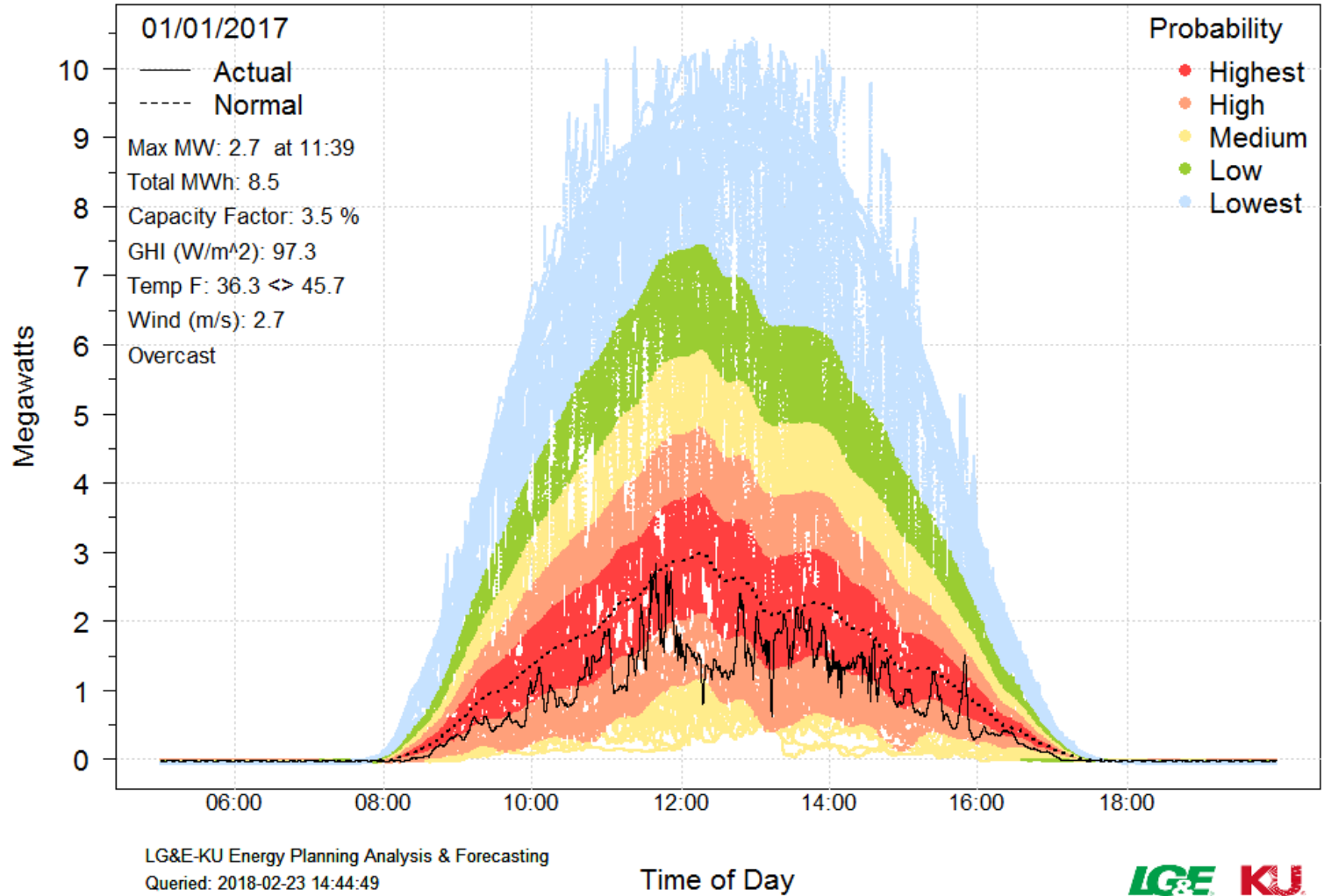
Solar Generation is Intermittent

E.W. Brown Solar Generation

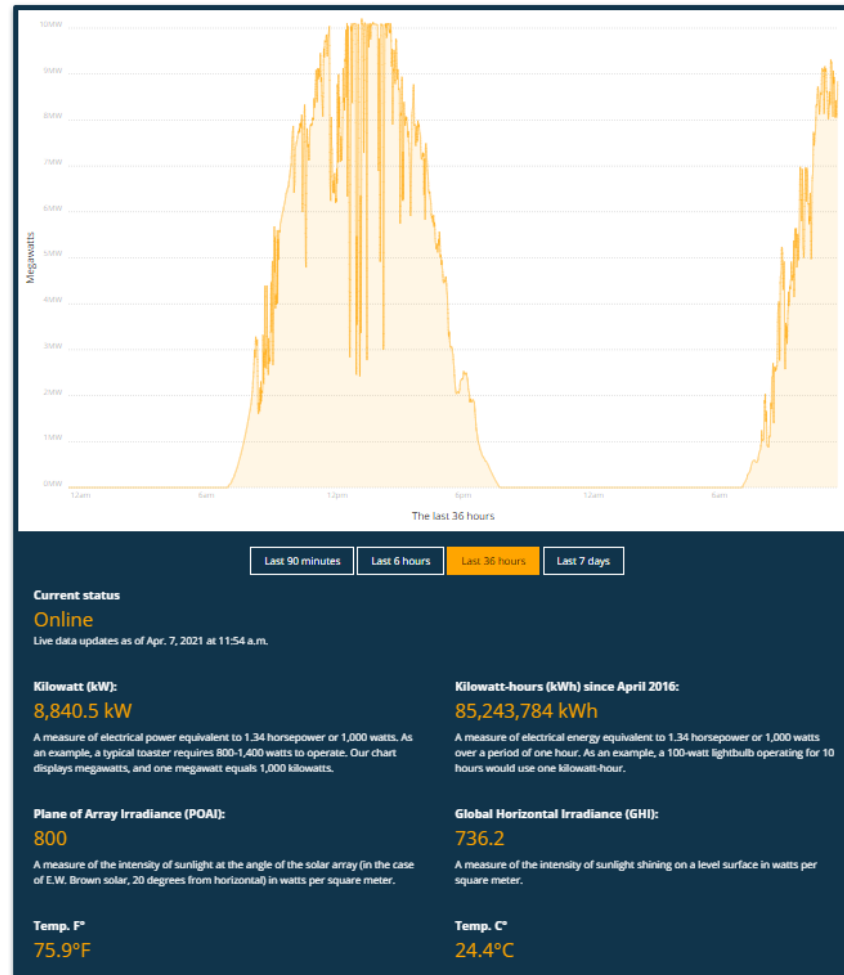


Solar Generation is Intermittent

E.W. Brown Solar Generation



Solar Generation is Intermittent



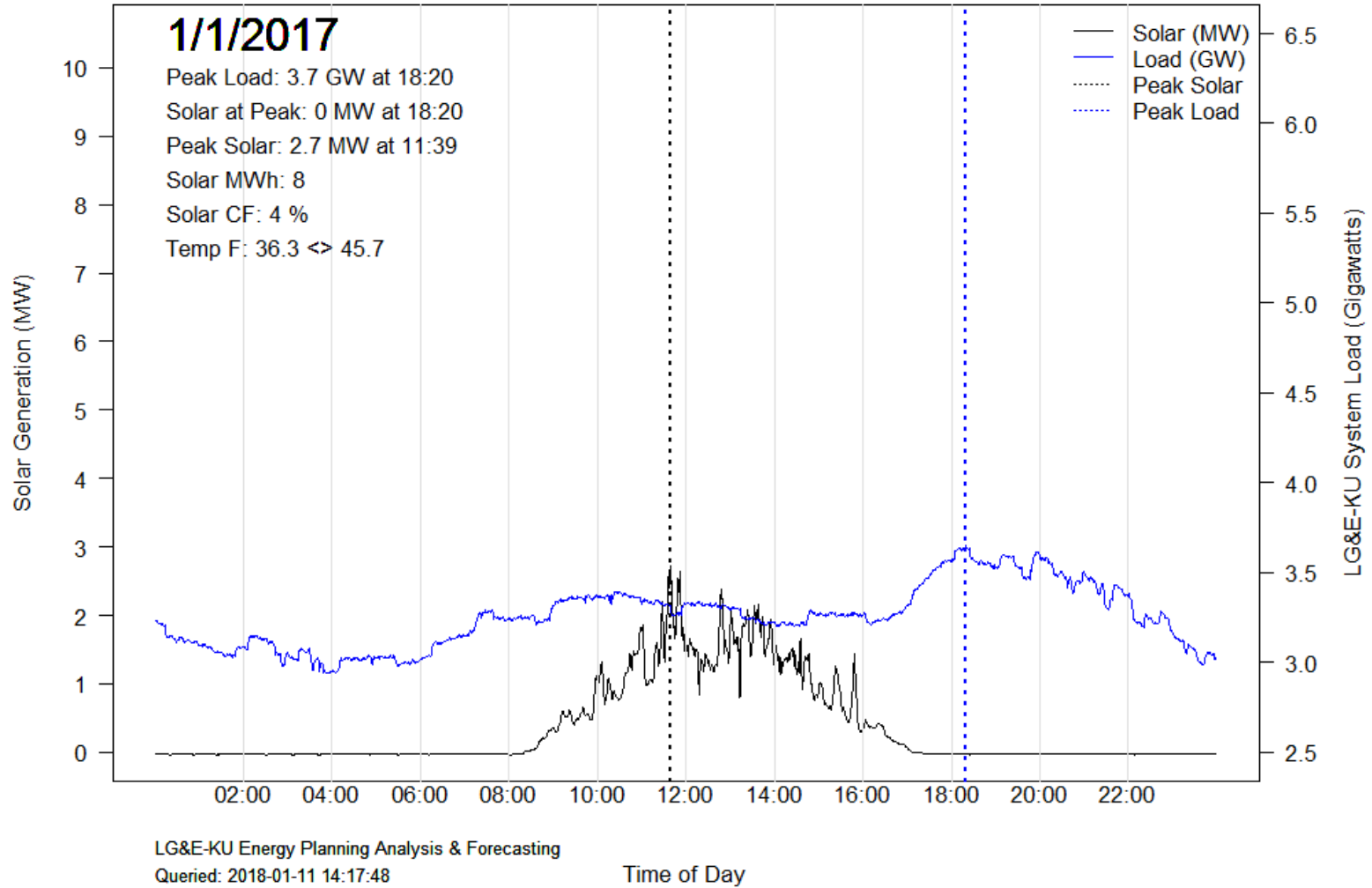
View live public solar dashboard:
<https://lge-ku.com/live-solar-generation>

Intermittent Renewable Integration

<https://www.mdpi.com/945692>

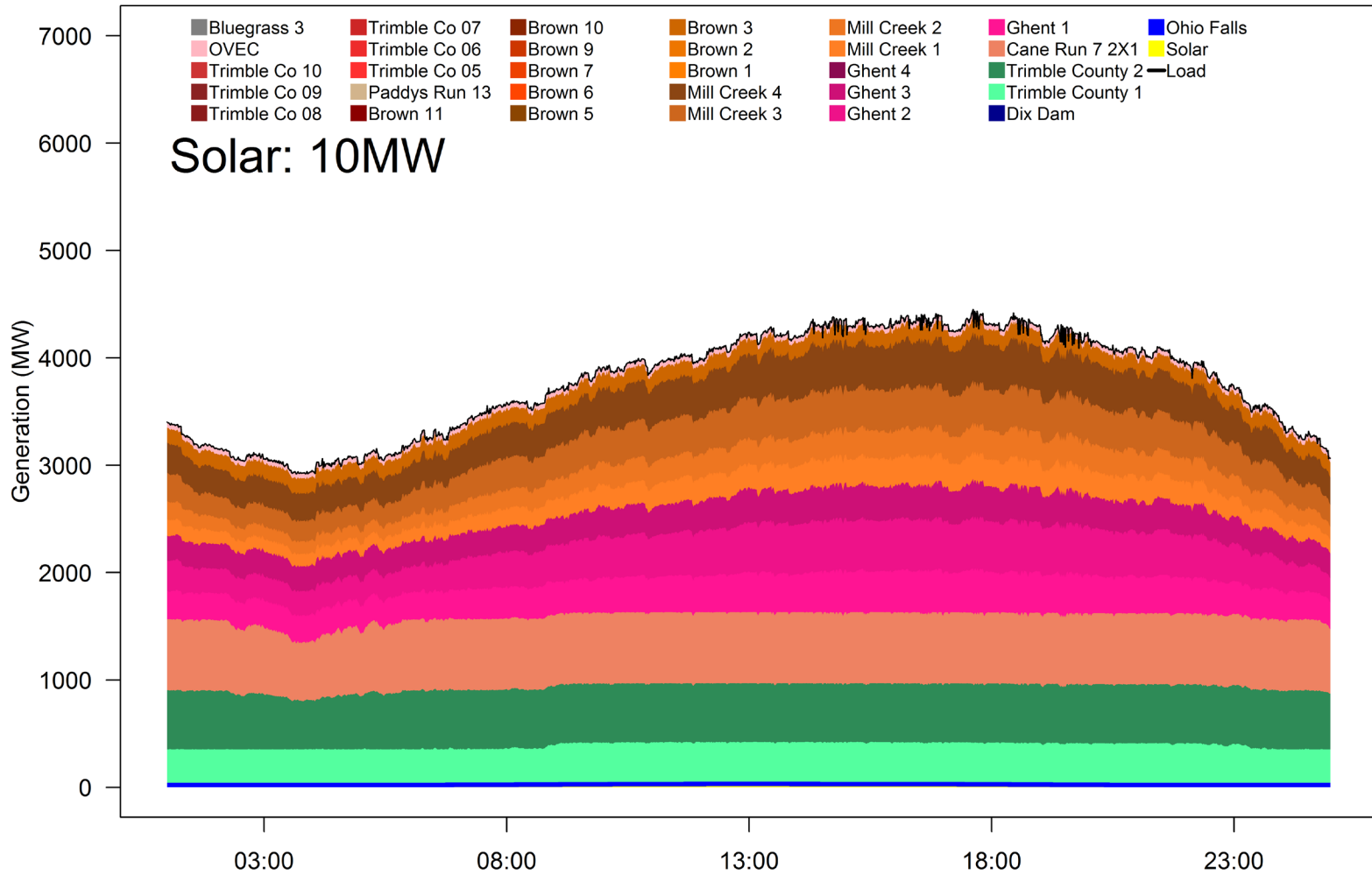
Solar Generation is Intermittent

Brown Solar Generation vs. LG&E-KU Load



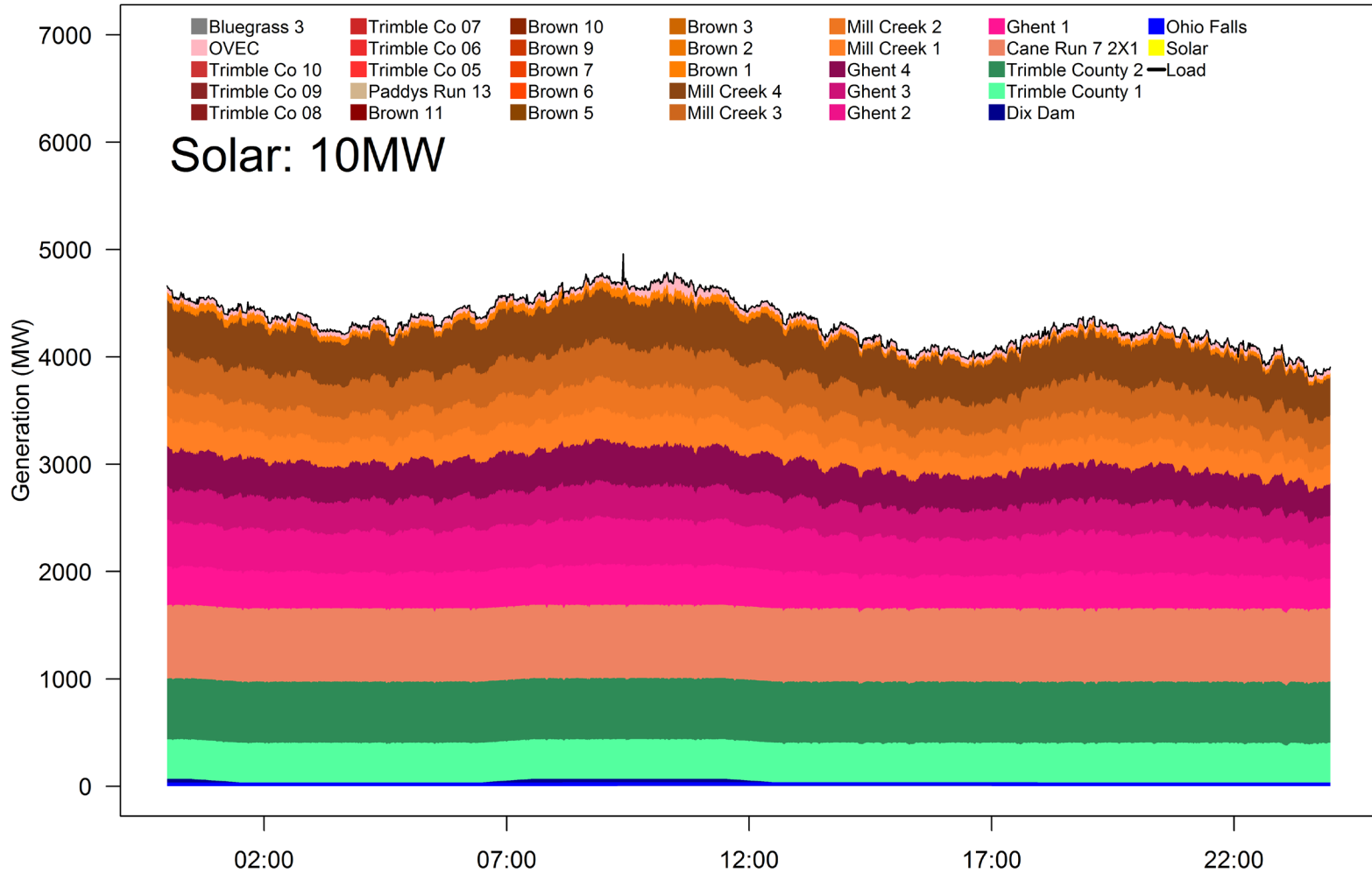
Example Solar Impact by Unit – June

LG&E-KU Electricity Generation, 2019/6/20



Example Solar Impact by Unit – January

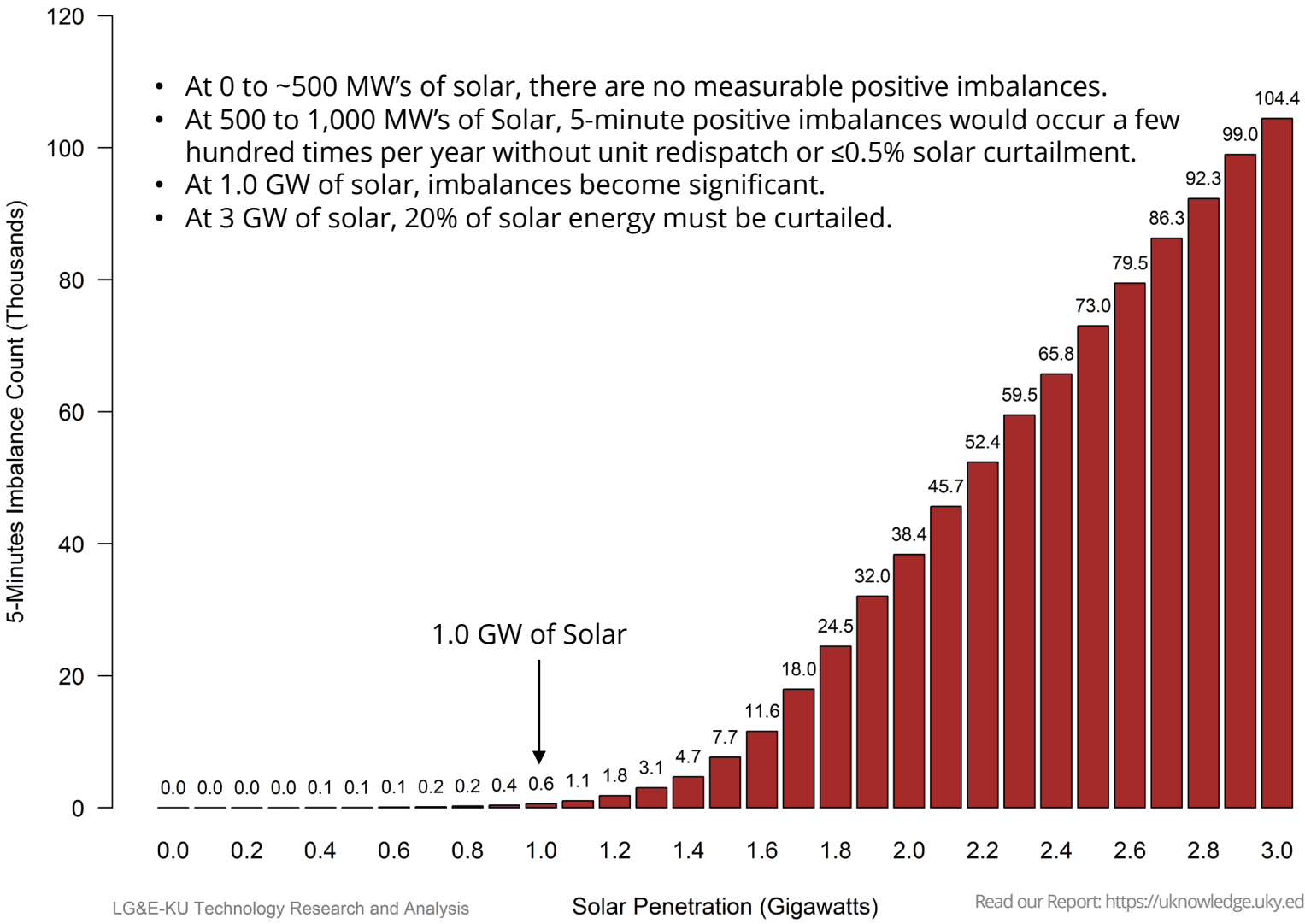
LG&E-KU Electricity Generation, 2019/1/26



Annual 5-Minute Imbalances by Solar Penetration

Annual LG&E and KU Generation Positive Imbalance: 2019

- At 0 to ~500 MW's of solar, there are no measurable positive imbalances.
- At 500 to 1,000 MW's of Solar, 5-minute positive imbalances would occur a few hundred times per year without unit redispatch or $\leq 0.5\%$ solar curtailment.
- At 1.0 GW of solar, imbalances become significant.
- At 3 GW of solar, 20% of solar energy must be curtailed.



LG&E-KU Technology Research and Analysis

Read our Report: https://uknowledge.uky.edu/ece_facpub/40/

Thank You to Our Research Partners

