Can Rotational Grazing be an Alternative to Traditional Mechanical Mowing at Solar Sites?

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December 2021

Project Background

- Solar farms regularly use non-native cool season grasses to vegetate the site
- Traditional vegetation maintenance uses mowing and herbicides to control grasses and weeds to prevent shading and avoid loss of energy production
- Traditional maintenance practices are costly and labor intensive
- This study was design to address questions around the cost, stocking densities, and duration of using sheep to manage vegetation at solar farms

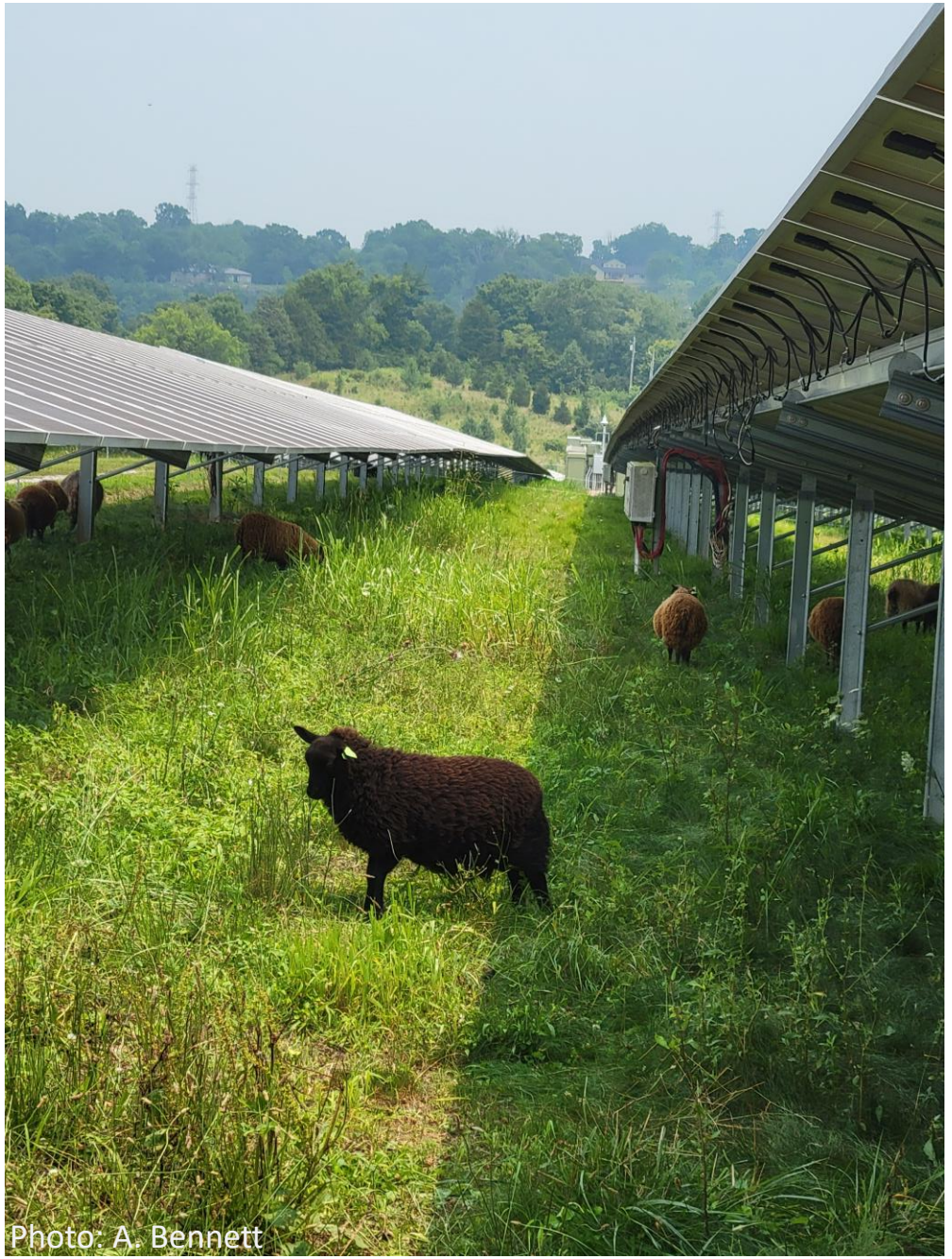


Photo: A. Bennett

Research Questions

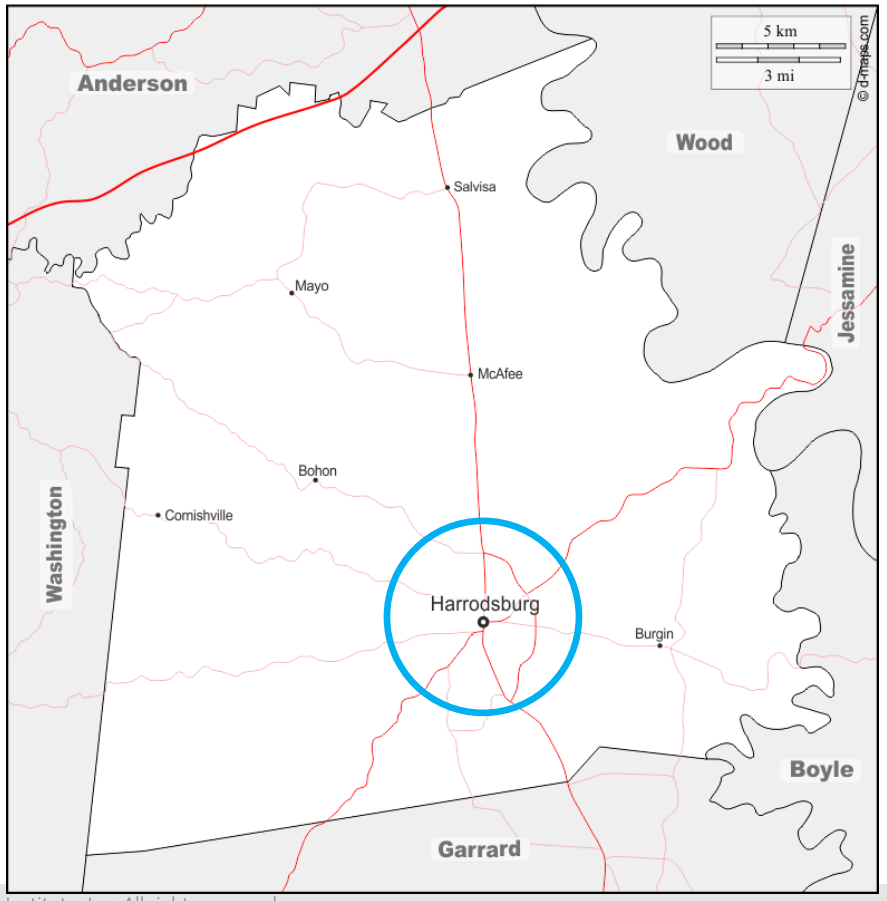
1. Can sheep provide adequate control of vegetation?
    - What is the appropriate stocking density?
    - What is the appropriate stocking duration?
2. Are sheep economically feasible compared to mowing?

Photo: M. Moore

Project Location

- Solar Array – Mercer County, KY
  - Town – Harrodsburg, KY
  - Size of solar array – 50 acres

Mercer County, KY



Project Methods

- Grazing Demonstration
  - 10 acres of the solar site
  - 9 ~1-acre paddocks

Demonstration Area

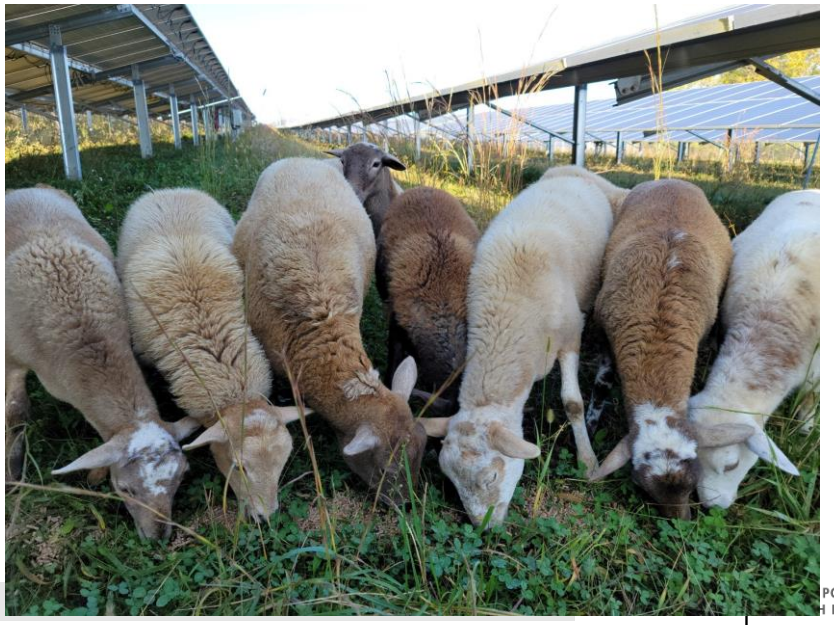
Grazing Paddocks

Project Methods

- Selected Sheep Breeds
  1. Shetland Sheep
     - Small in size
     - Heritage Breed
     - Persists on poor forage
     - Value added - Wool
  2. Katahdin Sheep
     - Small in size
     - Naturally shed hair so low maintenance
     - Value added - Meat
     - Value added - High lambing rate

Shetland Sheep

Katahdin Sheep



Project Methods

- Project Partners
  - Utility – LG&E and KU
  - Grazing Expert – Shaker Village of Pleasant Hill
    - Local non-profit with regenerative grazing expertise
    - Located ~4 miles from the solar site
  - Project Coordinator - EPRI

- Grazing Partnership
  - LG&E and KU provided the land and project materials
  - Shaker Village developed and implemented the grazing plan
  - Shaker Village was responsible for the sheep prior to and after the grazing season
  - Shaker Village would receive any value-add products generated by the sheep

Project Methods

2020 Grazing Plan

- Stocking **Density** = 35 sheep
- Stocking **Duration** = 5 days
- **Recovery** Period = 45 days
  - Sheep foraged in each paddock for 5 days followed by 45 days of recovery
  - After 5 days, sheep were rotated to a new paddock
  - Grazed paddocks rested for 45 days
  - After a 45-day recovery period, sheep were rotated back into the previously grazed paddock


Photo: LG&E KU

Project Methods

Metrics and Observations

- Results consist of observational data only as this is a demonstration project
- Data were recorded on the following metrics:
  - Vegetation response to the grazing plan
  - Documentation of problem weeds
  - Project start-up costs and labor
  - Health of the sheep
  - Safety Incidence

Photos: A. Bennett

2020 Observational Results

Observational Data – Vegetation, cool-season grasses:

- **Spring**
  - Sheep were introduced onto the solar site on April 7th, 2020
  - Sheep successfully controlled vegetation at heights below solar panels during the spring
  - Vegetation was regularly grazed down to 1-2”
  - Higher grazing pressure was observed under panels compared to the rows between panel arrays

2020 Observational Results

- Spring Season – Results of 5-day rotation

Day 1

Photo: M. Moore

Day 5

Photo: M. Moore

2020 Observational Results

Observational Data – Vegetation, cool-season grasses:

- **Summer**
  - Vegetation transitioned from being dominated by cool-season grasses to summer annuals
  - Higher coverage of cool-season grasses was observed under panels compared to areas between panel rows receiving higher levels of sun
  - Height of vegetation after a 5-day grazing period was 3-5”
  - Less forage was removed in the summer due to forage palatability

2020 Observational Results

- Summer Season – Results of 5-day rotation

Day 1

Day 5

Photos: M. Moore

2020 Observational Results

Observational Data – Vegetation, cool-season grasses:

- **Fall**
  - Vegetation returned to being dominated by cool-season grasses
  - Growth rate of forage is reduced due to lower temperatures
  - Grazing goal in the fall is to avoid overgrazing the paddocks
    - Retain vegetation cover to protect and stabilize the soil over winter months
  - Adequate forage was available at the solar site through November
  - Height of vegetation after a 5-day grazing period was 3-5”
    - Unpalatable stems were generally not consumed
  - Late November sheep were returned to Shaker Village

2020 Observational Results

- Fall Season – Results of 5-day rotation

Day 1

Day 5

Photos: M. Moore

2020 Observational Results

Photo: Chris Evans, U of IL, Bugwood.org

<u>Observational Data – Vegetation, weedy species:</u>

- Johnson Grass (*Sorghum halepense)*
  - Johnson Grass is an invasive species in Kentucky
  - This plant was present throughout paddocks
  - Sheep grazed the tender leaves but left stalks
  - Result – Supplemental string trimming was needed to suppress this species, especially along fence lines

- Key Learning
  - Adapt grazing plan to increase control of Johnson Grass
  - Increase stocky density and duration in 2021
  - Introduce sheep early in season before growth of unpalatable stalks

Project Methods

2021 Grazing Plan

- Stocking **Density & Duration** adjusted to match seasonal vegetation growth
  - Higher stocking densities early in the growing season specifically targeted problem weeds such as Johnson grass

	Early Spring	Late Spring / Summer	Fall
Stocking Density	18 sheep	51 sheep	51 sheep
Stocking Duration	7 days	3 days	5 days
Recovery	63 days	27 days	45 days

2021 Observational Results

Observational Data – Vegetation, cool-season grasses:

- **Spring**
  - Sheep were introduced onto the solar site on March 22nd, 2021
  - A lower stocking density, 18 sheep, was used due to slow vegetation growth early in the spring
  - March and April vegetation heights were 3-5” post-grazing
  - To offset faster forage growth rates during May, stocking density was increase to 52 sheep
  - Vegetation was reaching 20-25” in height during May
  - The higher stocking density continued to graze vegetation to heights of 3-5” post-grazing

2021 Observational Results

- Spring Season – Results of 7-day rotation

Day 1

Photo: M. Moore

Day 7

Photo: M. Moore

2021 Observational Results

Observational Data – Vegetation, cool-season grasses:

- **Summer**
  - Higher stocking density improved suppression of weedy species
  - Sheep greatly reduced growth of Johnson grass
  - Patches of Johnson grass did escape grazing along perimeter fencing and required mechanical management
  - Grazing duration was reduced to 3 days and the recovery 27 days
  - Reduced recovery promoted growth and limited plant maturity, increasing the quality and palatability of the forage
  - Summer vegetation heights were 3-5” post-grazing

2021 Observational Results

- Summer Season – Results of 3-day rotation on Johnson grass

Day 1

Day 3

Photos: M. Moore

2021 Observational Results

- Summer Season
  - Results of 3-day rotation

Photos: M. Moore

2021 Observational Results

Observational Data – Vegetation, cool-season grasses:

- **Fall**
  - Still in progress
  - Vegetation has returned to being dominated by cool-season grasses
  - Growth rate of forage is reduced due to lower temperatures
  - Grazing goal in the fall is to avoid overgrazing the paddocks
    - Retain vegetation cover to protect and stabilize the soil over winter months
  - Height of vegetation after a 5-day grazing period is 3-5”
  - Sheep will be returned to Shaker Village late fall

2021 Observational Results

- Fall Season – Results of 5-day rotation

Day 1

Day 5

Photos: M. Moore

Observational Results

Observational Data – Vegetation, Weedy species:

- Higher stocking density and duration reduced Johnson Grass
- String trimming was needed on 3 occasions
- Time spent string trimming in 2020 = 46 h
- Time spent string trimming in 2021 = 6 h
- 87% reduction in labor on weed management

Observational Data – Sheep Health:

- April – June sheep gained weight lost over winter months
- Health checks confirmed sheep remained in good health in 2020 and 2021

Observational Data – Safety Incidence:

- No reportable safely incidences during 2020 or 2021

Observational Results – Cost Estimates

Observational Data – 2020 Start-Up Costs:

Estimated Startup Capital Costs	
Sheep	
Grazing Land (Acres)	10
Grazing Ratio (Sheep Per Acre)	3.5
Number of Sheep Needed	35
Individual Sheep Price	$300.00
Total Initial Sheep Cost	$10,500.00
Infrastructure and Tools	
Fence, Water Tank, Supporting Infrastructure	$5,691.46
Sheep Feed	$205.43
Other	$48.70
Initial Infrastructure and Tool Cost	$5,945.59
Subtotal – Sheep + Infrastructure	**$16,445.59**

Observational Results – Cost Estimates

Observational Data – 2020 Costs:

- Labor = 135 hours
  - Sheep rotations - 40 total
  - Paddock establishment
  - String trimming to suppress weedy species
  - Health checks

Observational Data – 2021 Costs:

- Labor = 63 hours as of October
  - Sheep rotations – 42 to date
  - String trimming required was greatly reduced
    - Higher stocking density improved management of Johnson grass
  - Health checks
  - Total estimated hours for 2021 = 75
    - Includes remaining rotations, sheep movement to Shaker Village for winter

Observational Results – Cost Estimates

Estimated O&M - 2020	
Mileage	
2020 IRS Mileage Reimbursement Rate ($/mile)	0.575
Miles Round Trip (Shaker Village to Solar Farm)	10
Miles Per Week	50
Miles Per Year	2600
Total Annual Mileage Cost ($/yr.)	$1,495.00
Shepherd	
Hours Per Year	135
Shepherd Hourly Rate ($/hr.)	$25.00
Annual Shepherd Cost ($/yr.)	$3,375.00
Paddock Installation and Maintenance	
Hours Per Year	48
Shepherd Hourly Rate	$25.00
Annual Installation Cost ($/yr.)	$1,200.00
Sheep	
Veterinarian and Miscellaneous	$5,500
Total O&M	$11,570

Estimated O&M - 2021	
Mileage	
2020 IRS Mileage Reimbursement Rate ($/mile)	0.575
Miles Round Trip (Shaker Village to Solar Farm)	10
Miles Per Week	50
Miles Per Year	2600
Total Annual Mileage Cost ($/yr.)	$1,495.00
Shepherd	
Hours Per Year - estimated	75
Shepherd Hourly Rate ($/hr.)	$25.00
Annual Shepherd Cost ($/yr.)	$1875.00
Paddock Installation and Maintenance	
Hours Per Year	8
Shepherd Hourly Rate	$25.00
Annual Installation Cost ($/yr.)	$200.00
Sheep	
Veterinarian and Miscellaneous	$5,500
Total O&M	$9,070

Observational Results – Cost Estimates

2020	Contract	Costs
LG&E and KU contractor	Mowing (10 acres)	Estimated $14,000
Shaker Village	Grazing (10 acres)	Estimate total = $28,015.59
Shaker Village - 2020	Grazing (10 acres)	Estimate with capital excluded = $11,570
Shaker Village - 2021	Grazing (10 acres)	Estimated with capital excluded = $9,070

- Estimated grazing costs with capital excluded range from $1,157 to $907 / acre
- The reduction in cost from 2020 to 2021 is the result of lower labor costs
- In 2021, fewer site visits and less maintenance was required
- Shaker Village estimates going forward ~2h / week needed in labor
  - This estimate assumes paddocks are installed and all infrastructure is on site

Summary

- Demonstration results suggest grazing is a viable option at this solar site
- Sheep were able to successfully control vegetation below solar panels in both 2020 and 2021
- Adapting the grazing plan did improve control of weedy species, reducing labor costs
- Initiating a grazing plan can, in the short-term, increase management costs
- Over the long-term, grazing does seem comparable with mowing at this solar site
- Grazing costs decreased from year 1 to year 2 as the grazing plan was adapted, methods improved, and weedy species reduced
- A local grazing partner in close proximity to the site was critical to successfully implementing the grazing plan and keeping project costs low

Next Steps

- Are sheep compatible with pollinator habitat?
- What is the correct stocking densities, duration, and timing for grazing solar pollinator plantings?

Photos: A. Bennett

Thank You!

Photo: A. Bennett

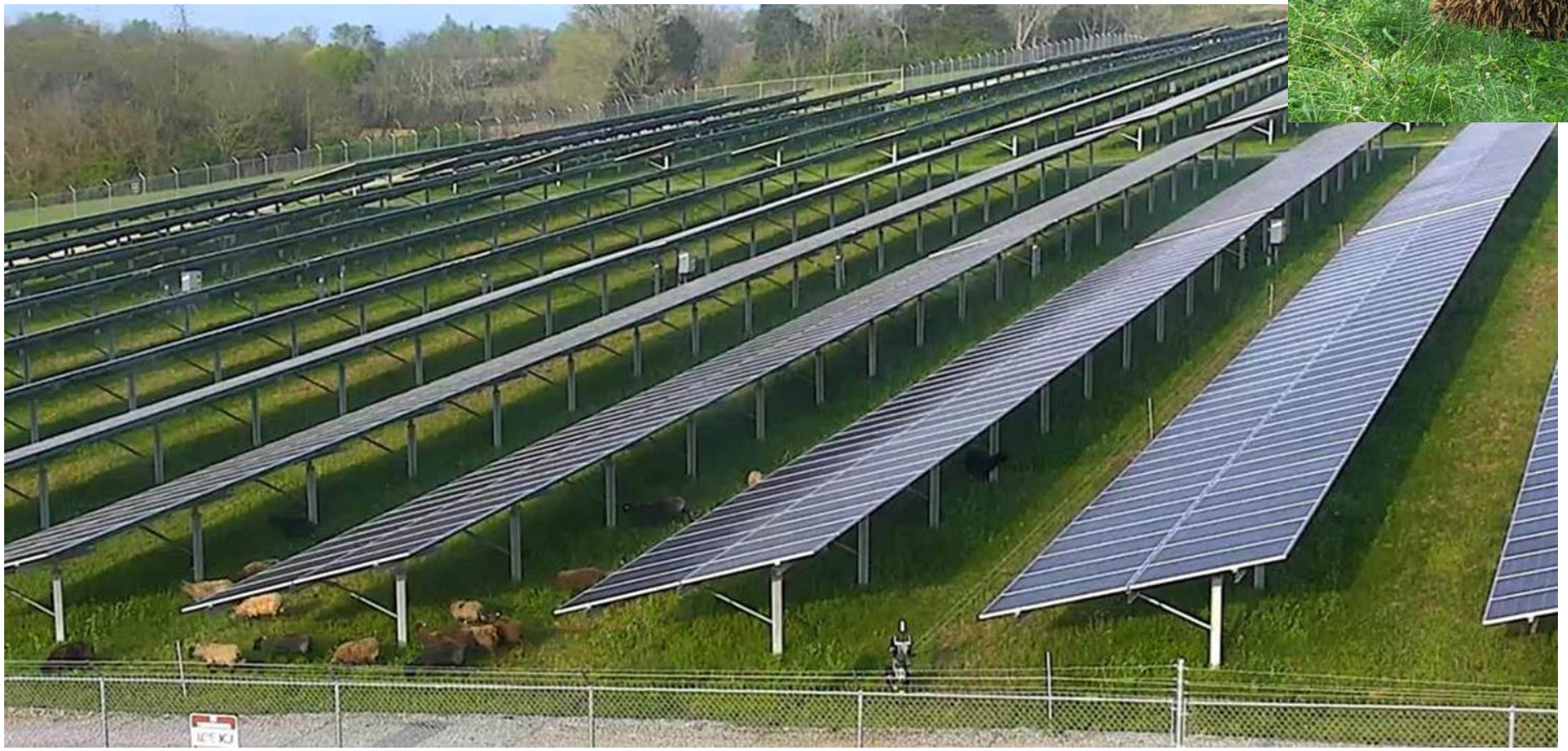


Photo: LG&E KU