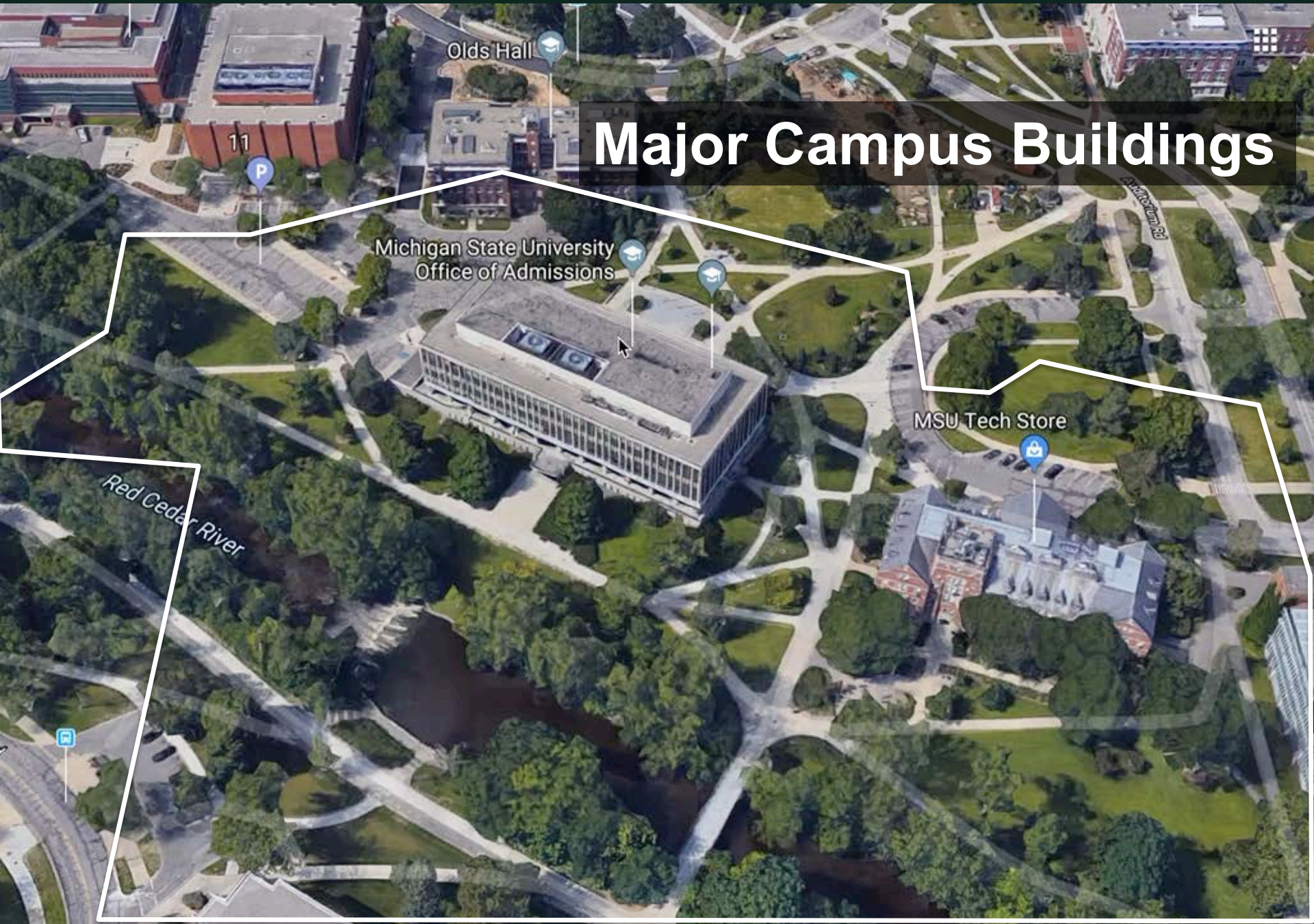


Michigan State University's Solutions to Campus and Smart Cities

Dr. Wolfgang Bauer
University Distinguished Professor
Associate Vice President

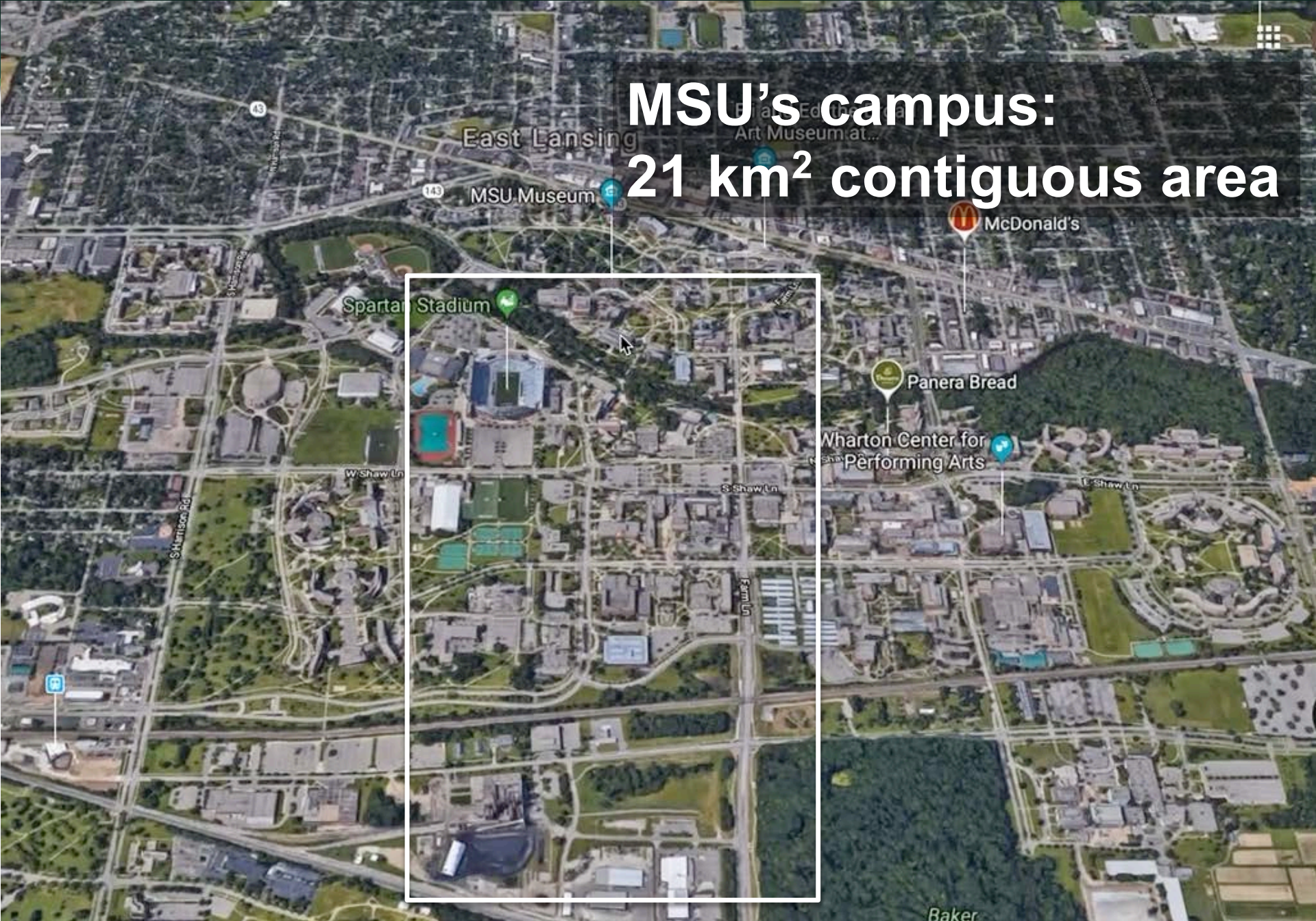


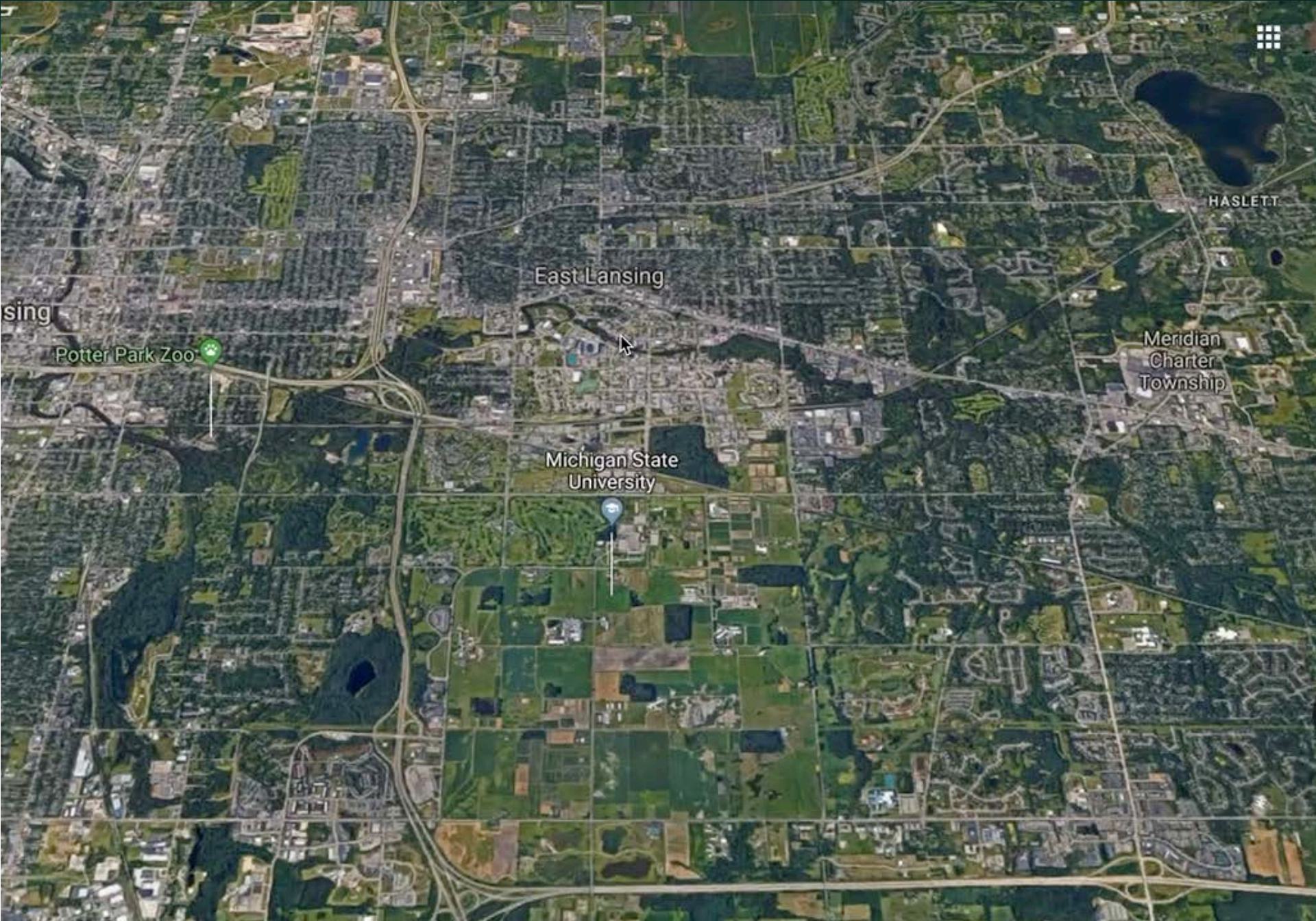
Foto: João Ito



Major Campus Buildings

MSU's campus: 21 km² contiguous area





- 50,000+ students
 - From all 83 Michigan counties, all 50 US states, 141 other countries
- 5,700+ faculty and academic staff
- 7,200+ support staff
- 21 km² campus in East Lansing, Michigan, USA
- 110 major academic buildings
 - 566 total buildings
- Land-grant university founded in 1855
- \$2.8 billion annual budget
- Top-100 global research university

- MSU operates own micro-grid
 - Since 1894 (!)
 - Co-gen heat and electricity:
T.B. Simon Plant
 - Significant cost savings vs. buying electricity
 - Historic record of reliability
- MSU consumes as much energy as 50,000 Michigan households, ~ 6 peta-Joule (6×10^{15} Joule) per year
- Carbon emissions need to be reduced
 - Man-made global warming is real
 - Fossil fuel burning has adverse health effects
- Funds are tight, and energy expenses need to be reduced



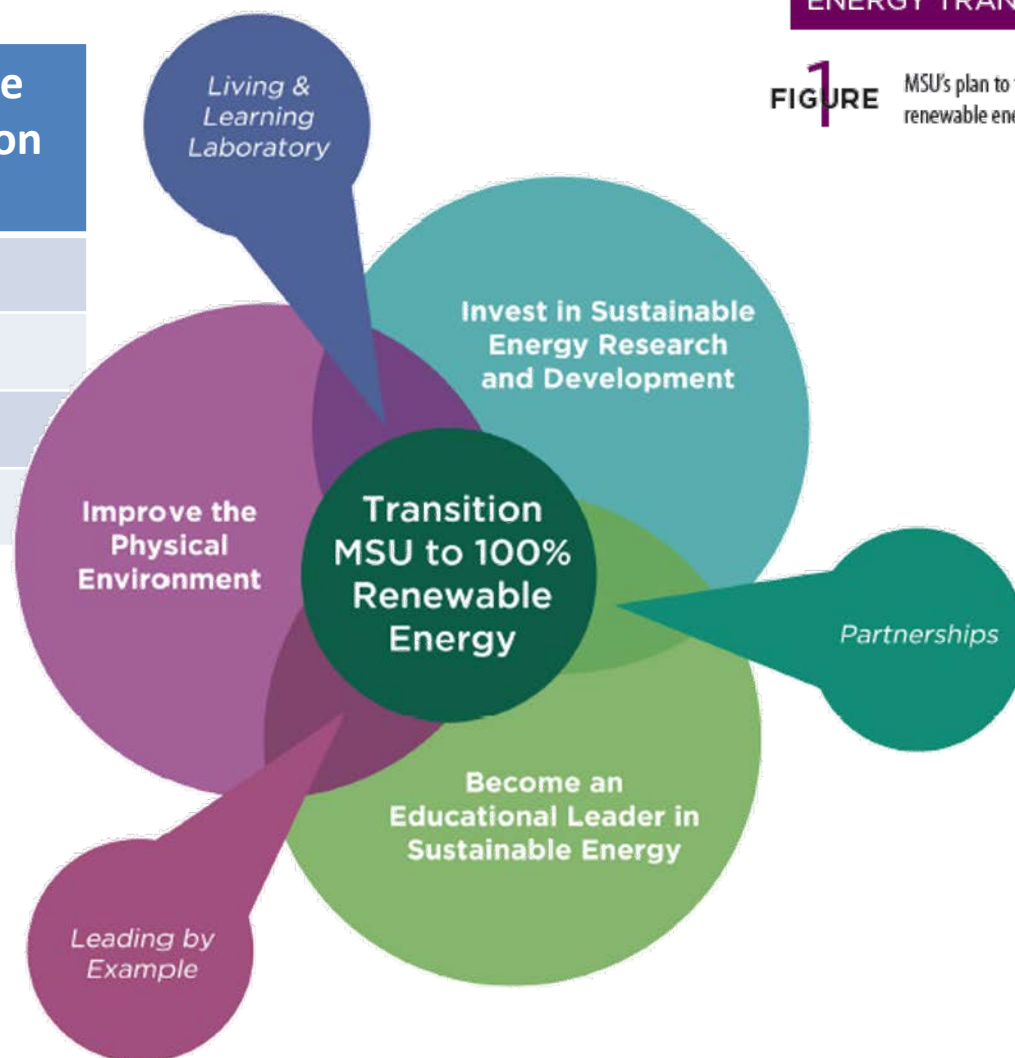
- Timetable

Year	Campus Renewable Energy	Greenhouse Gas Emission Reduction
2015	15%	30%
2020	20%	45%
2025	25%	55%
2030	40%	65%

- Approved by MSU Board of Trustees, April 2012

ENERGY TRANSITION PLAN

FIGURE 1 MSU's plan to transition to 100% renewable energy

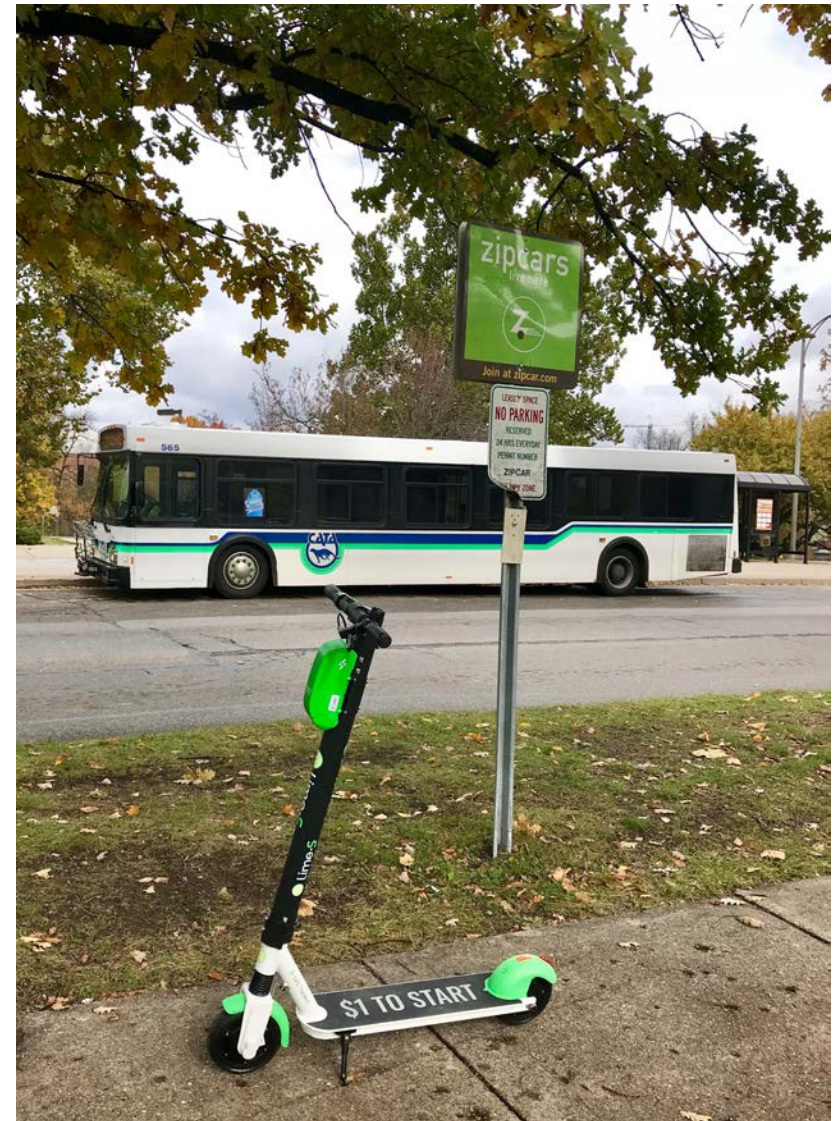


- Recycling center /surplus store
- Organic waste composting facility
- Geo-thermal array
 - Nursing building
- Anaerobic digester
 - Processing of food waste, reduction of artificial fertilizer use, electricity production
- Solar arrays
- Demand reduction
 - M\$5-10/year energy conservation measures
 - Better building challenge
 - Data center challenge
 - Spartan treasure hunts

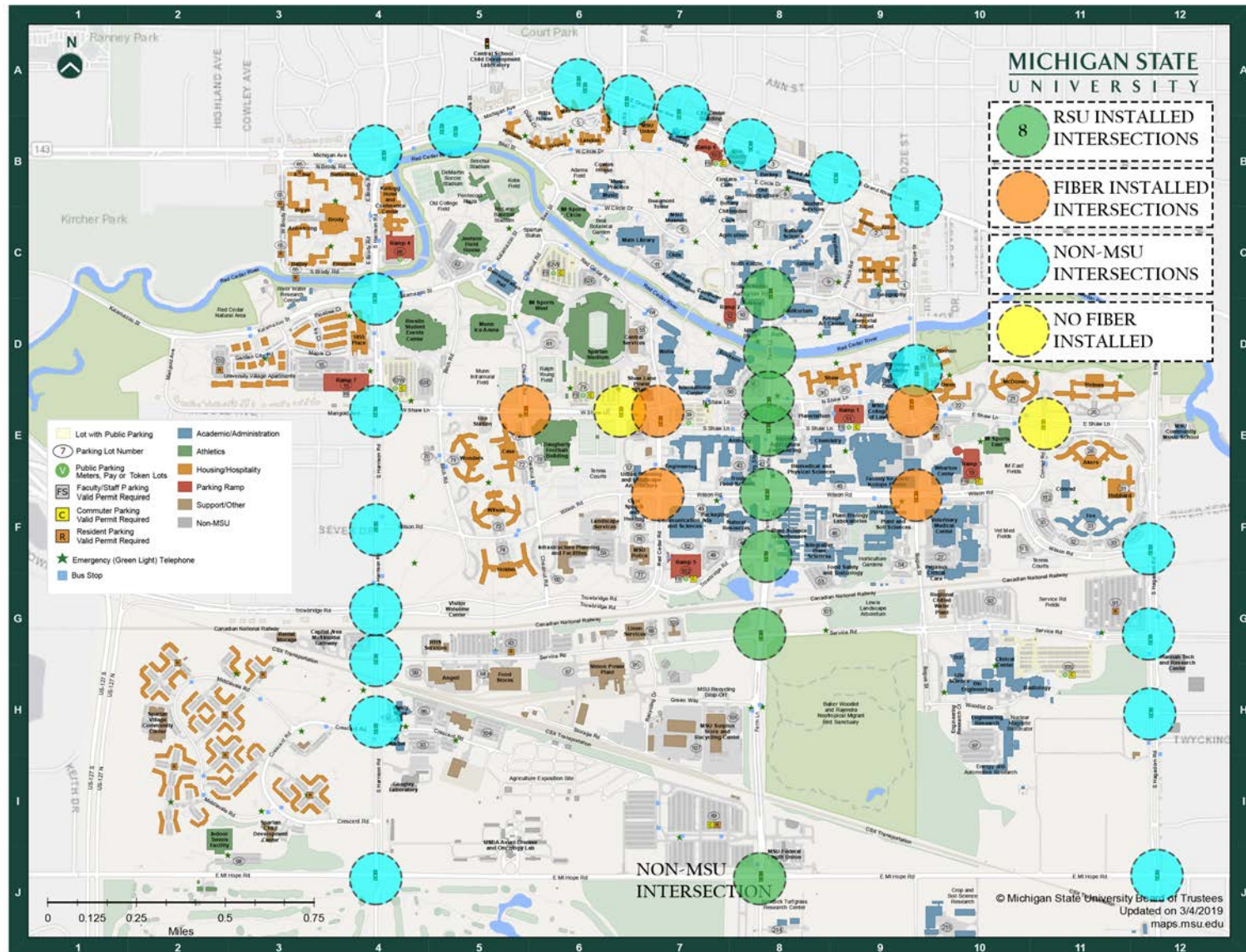


Sustainability: Transportation

- Public transportation
 - Electric bus
 - Autonomous van/bus
- Shared cars
- E-Scooters



Connected Infrastructure



MSU Dormitory Food System







- What happens to the 35,000 trays with plates, cups, food scraps, napkins per day?





- Food preparation





= 10 tons

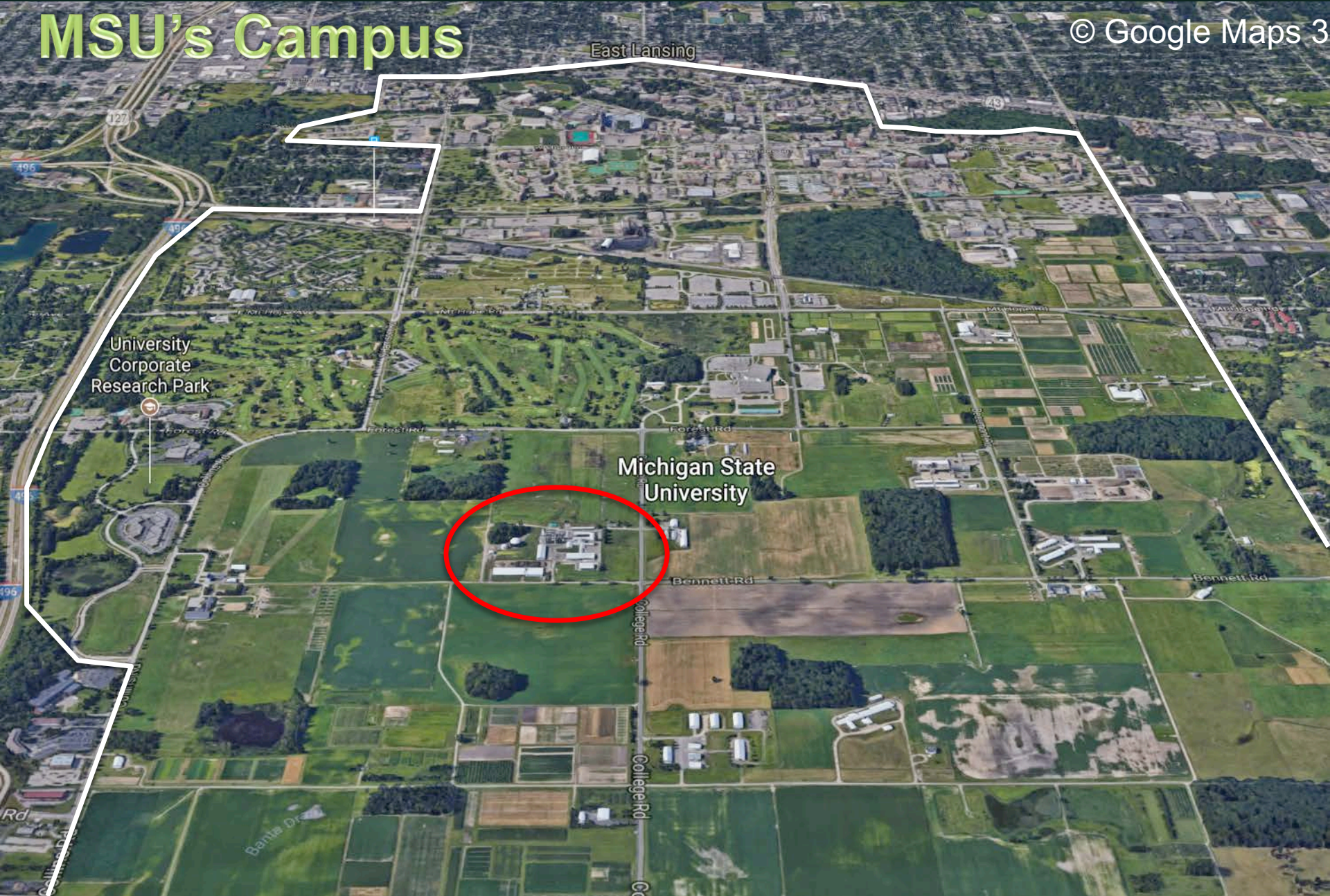


**Food waste
per year**

But what happens to this food waste that we collect?

MSU's Campus

© Google Maps 3



© Google Maps 3



- MSU teaching and research centers for beef cattle, beef cow-calf, dairy, horse, poultry, sheep, and swine



Digestate Storage

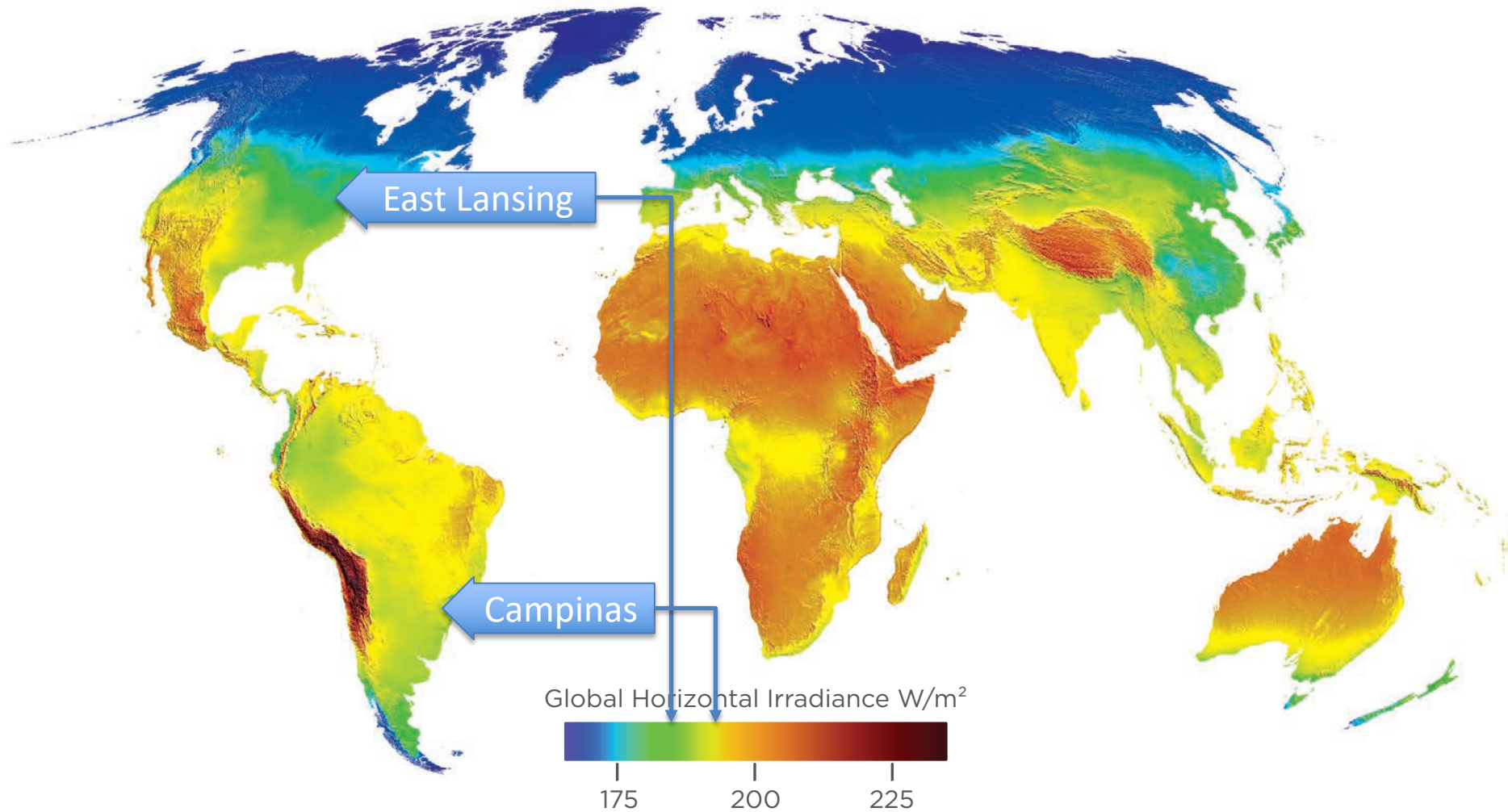
Fermenter

Biogas Engine

Feeder

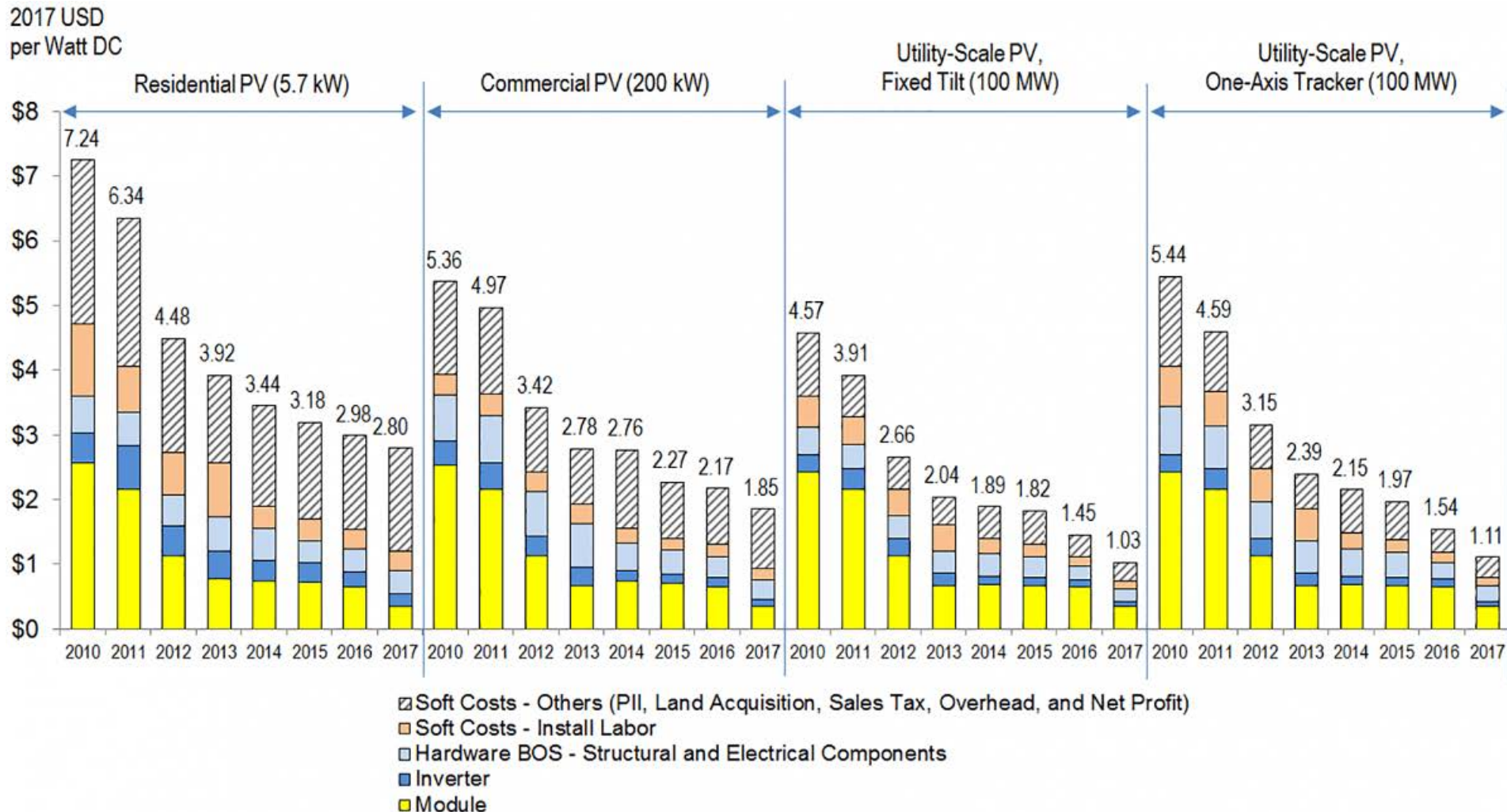
VAISALA

Direct + Ambient



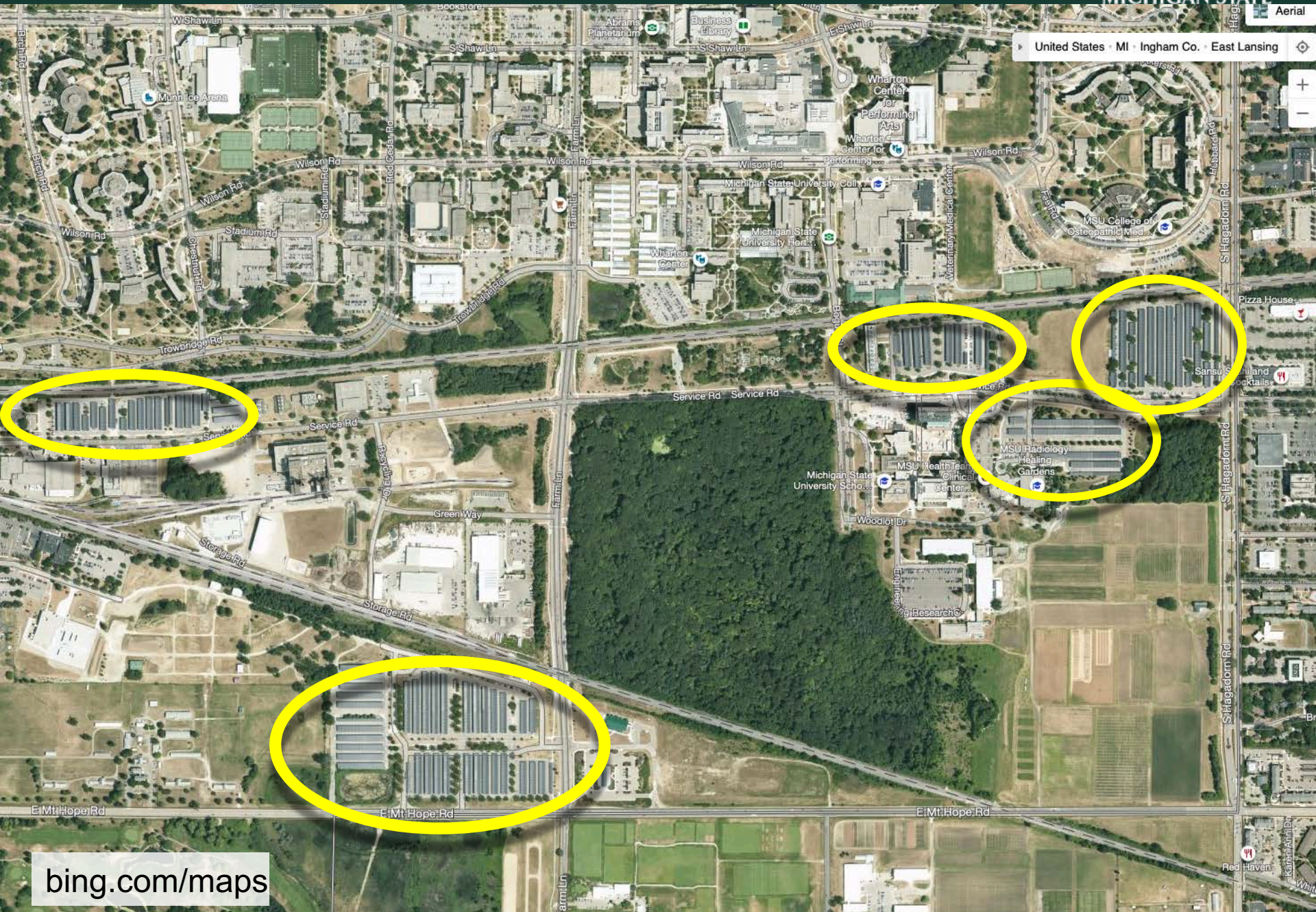
Costs per W_{DC} for Solar Arrays

NREL PV system cost benchmark summary (inflation adjusted), 2010–2017



Time Line

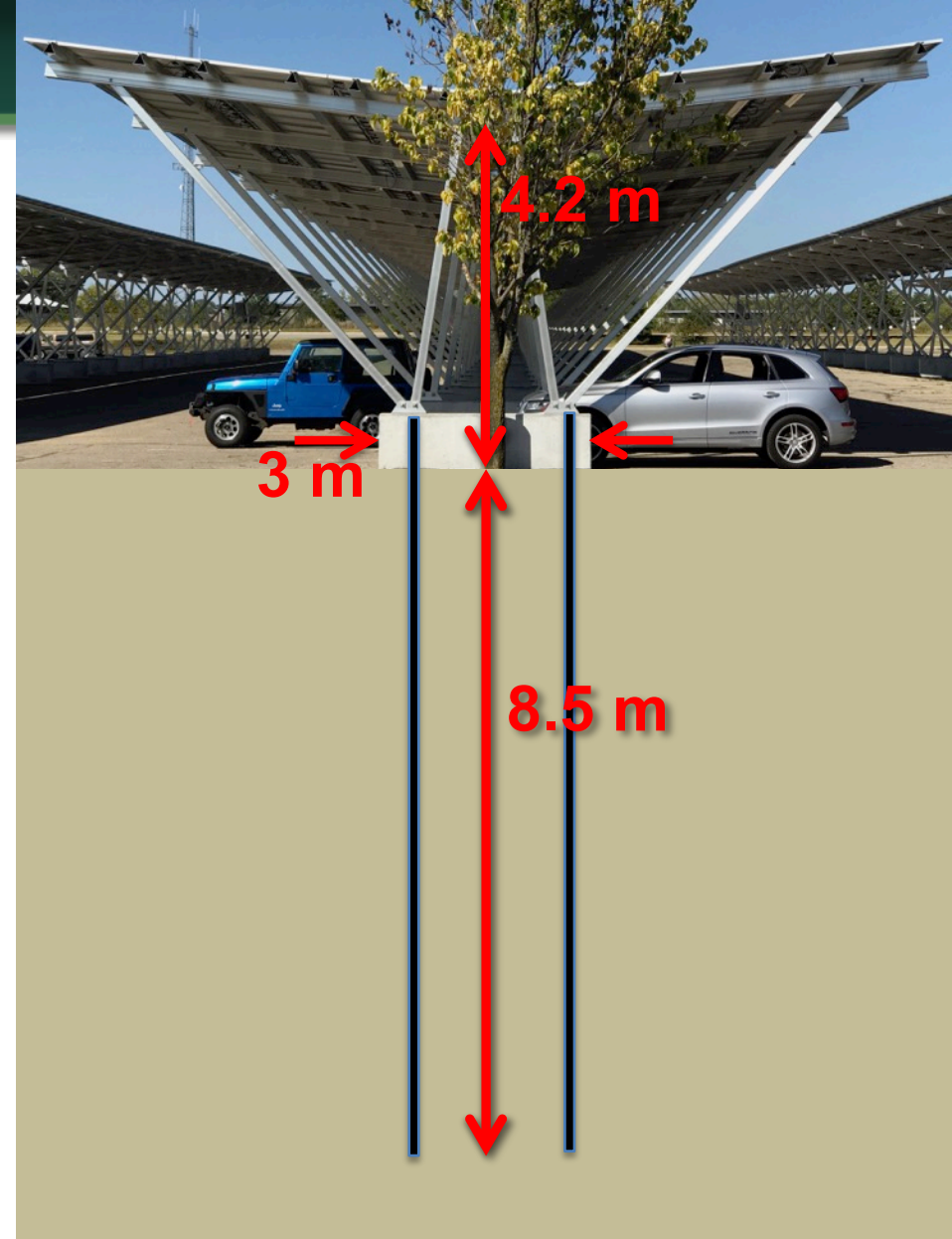




bing.com/maps

Dimensions

- 5,000 parking spots
- 180,000 m²
- 40,000 solar panels
- 13.4 MW dc peak power
- 10.5 MW ac peak power
- 15,000 MWh/year of solar energy
 - Enough electricity for 1,800 US households



Finished Product (2017)

18% of MSU peak power demand, 5% of MSU total annual energy

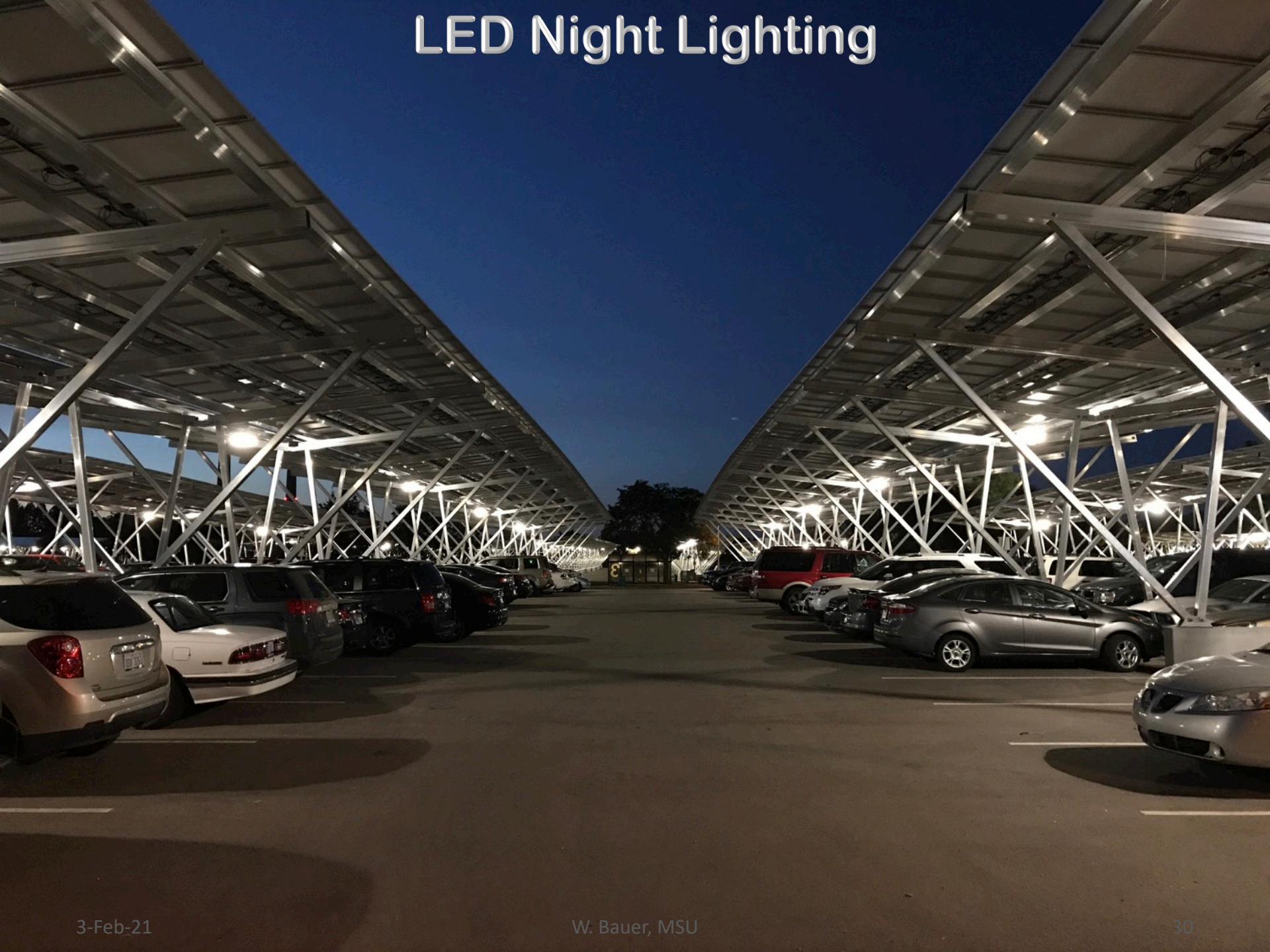


Finished Product (2017)

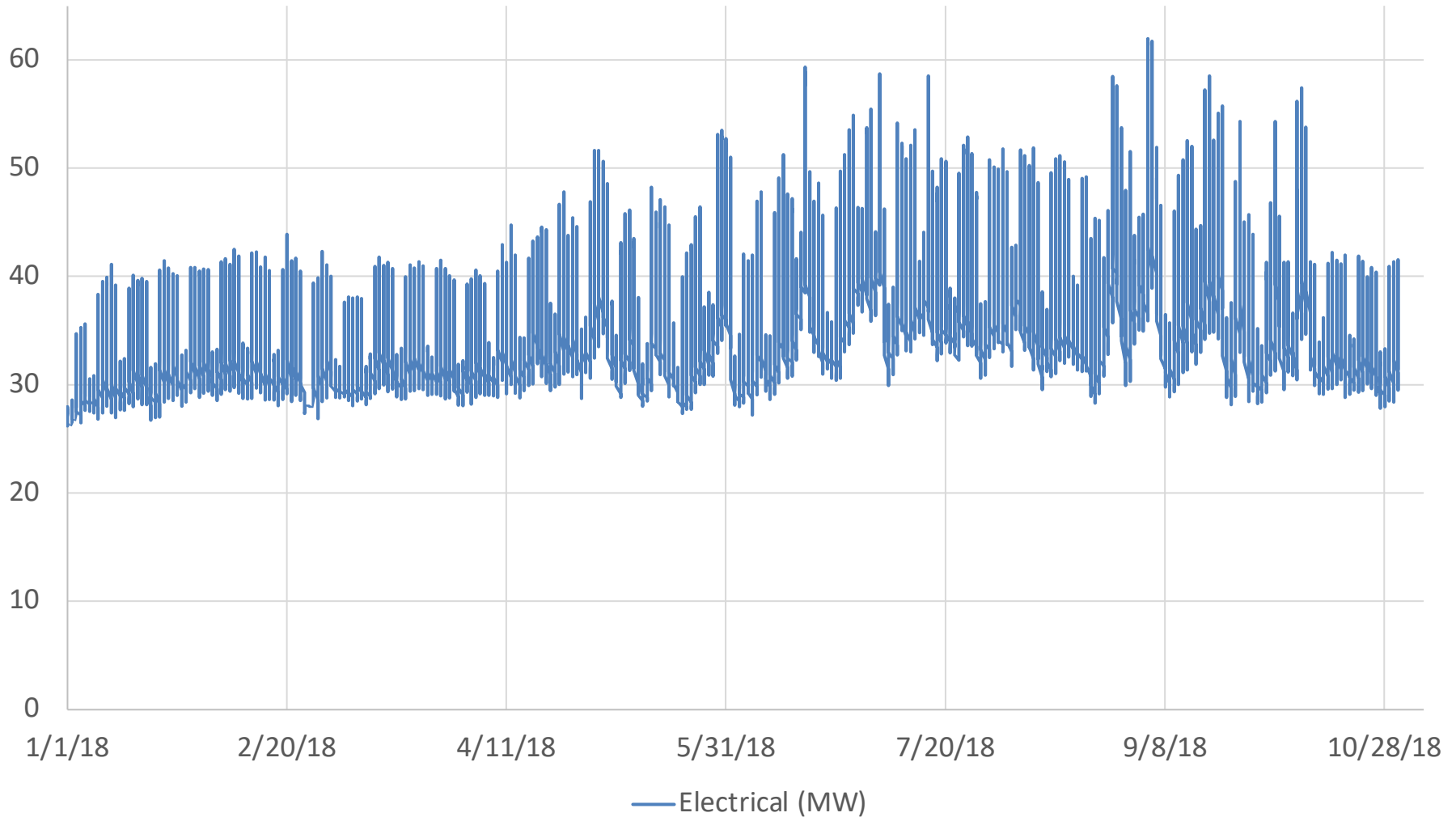
Largest solar carport array in the USA



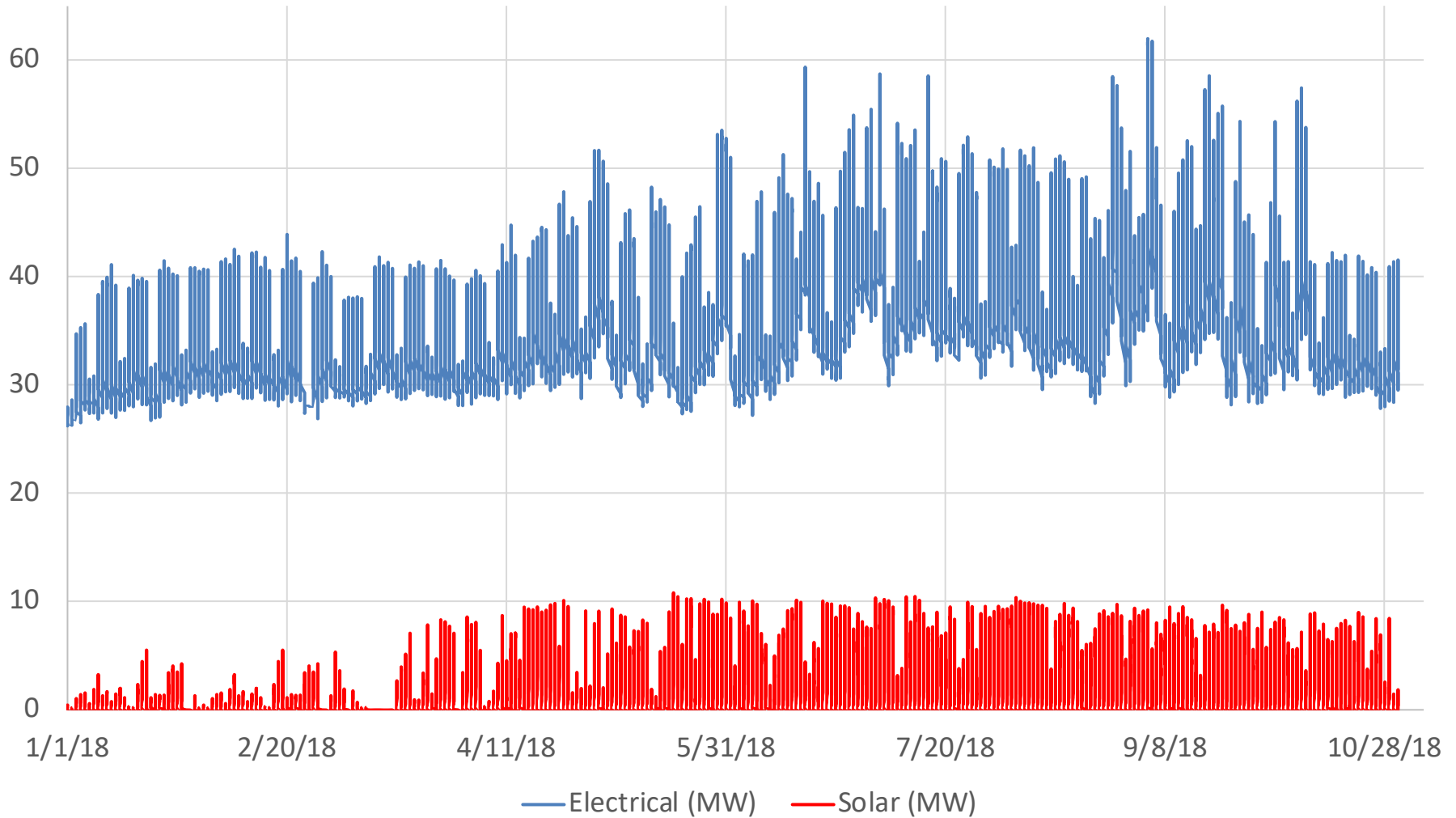
LED Night Lighting



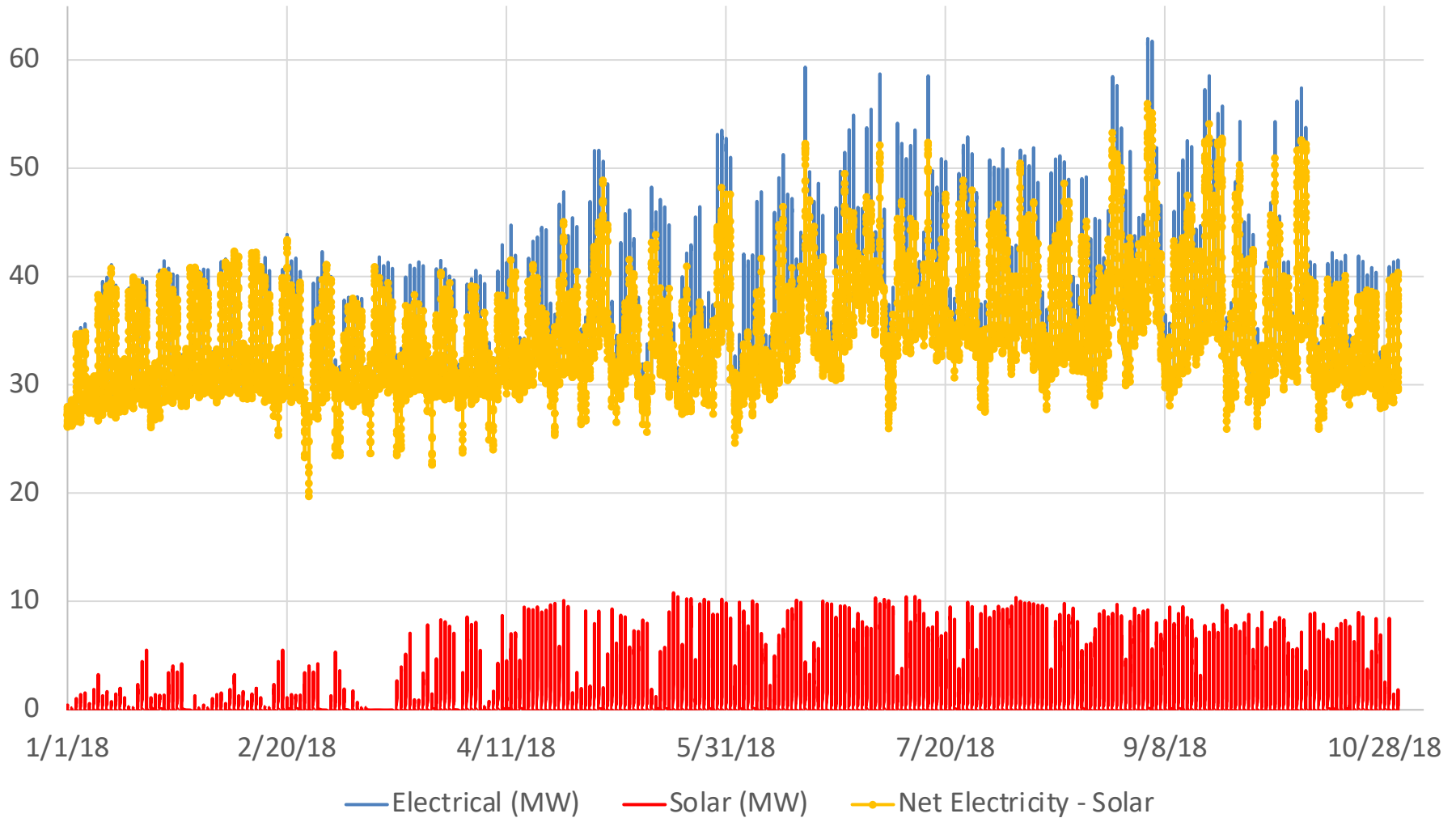
2018 Campus Electricity (MW)



2018 Campus Electricity (MW)



2018 Campus Electricity (MW)



Proposed 20 MW Array

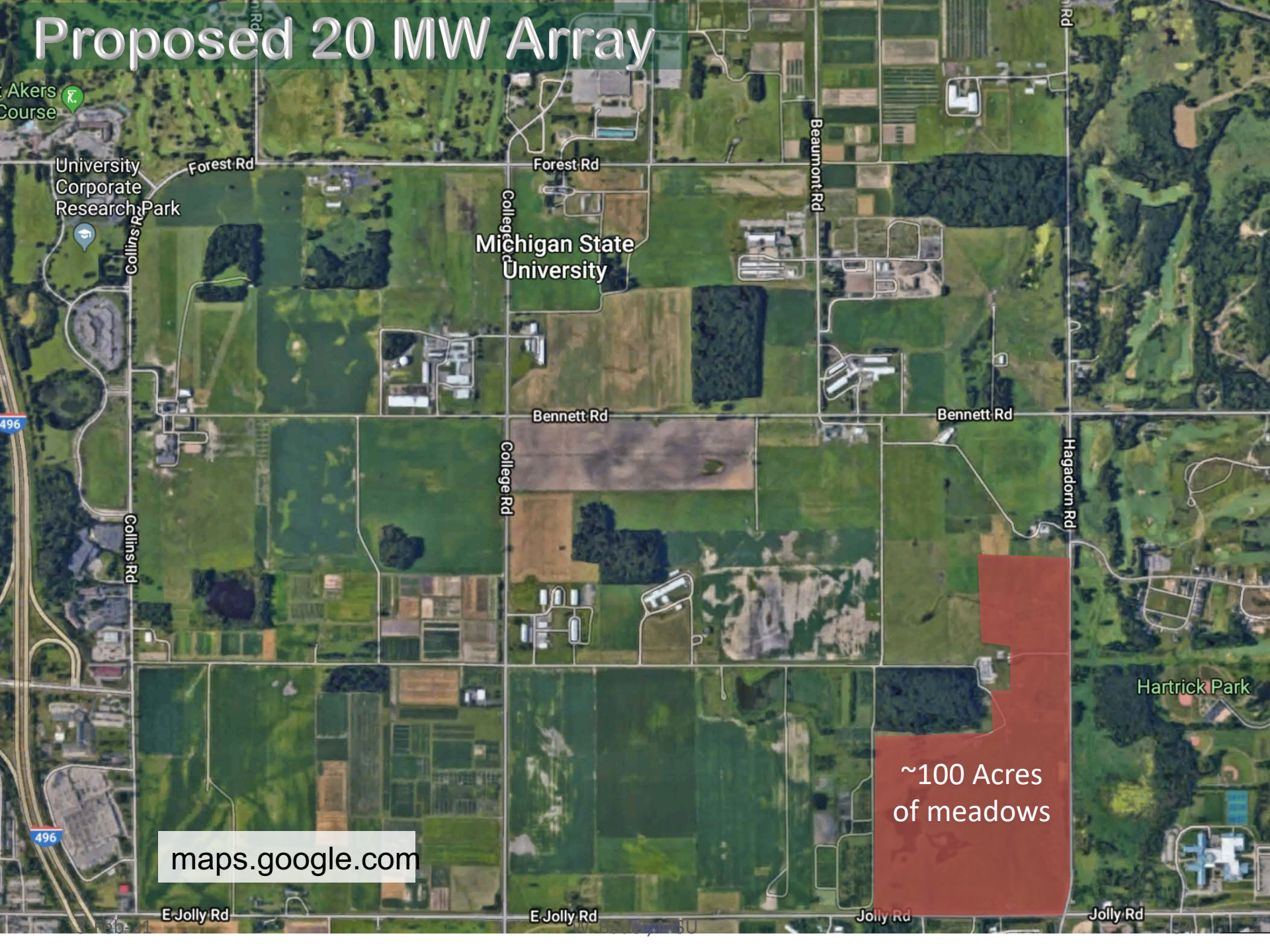
Akers
Course

University
Corporate
Research Park

Michigan State
University

~100 Acres
of meadows

maps.google.com





<https://www.princeton.edu/news/2018/06/28/sheep-shear-maintenance-princetons-solar-field>

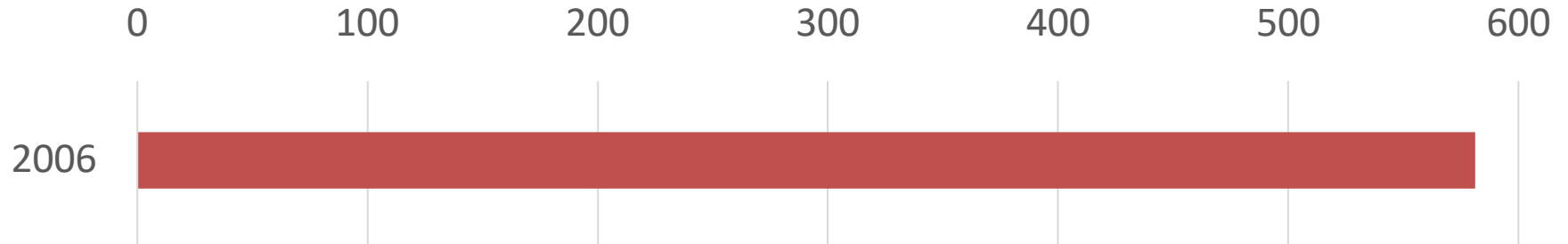
Sheep Grazing Meadow



<https://denison.edu/news-events/featured/131013>

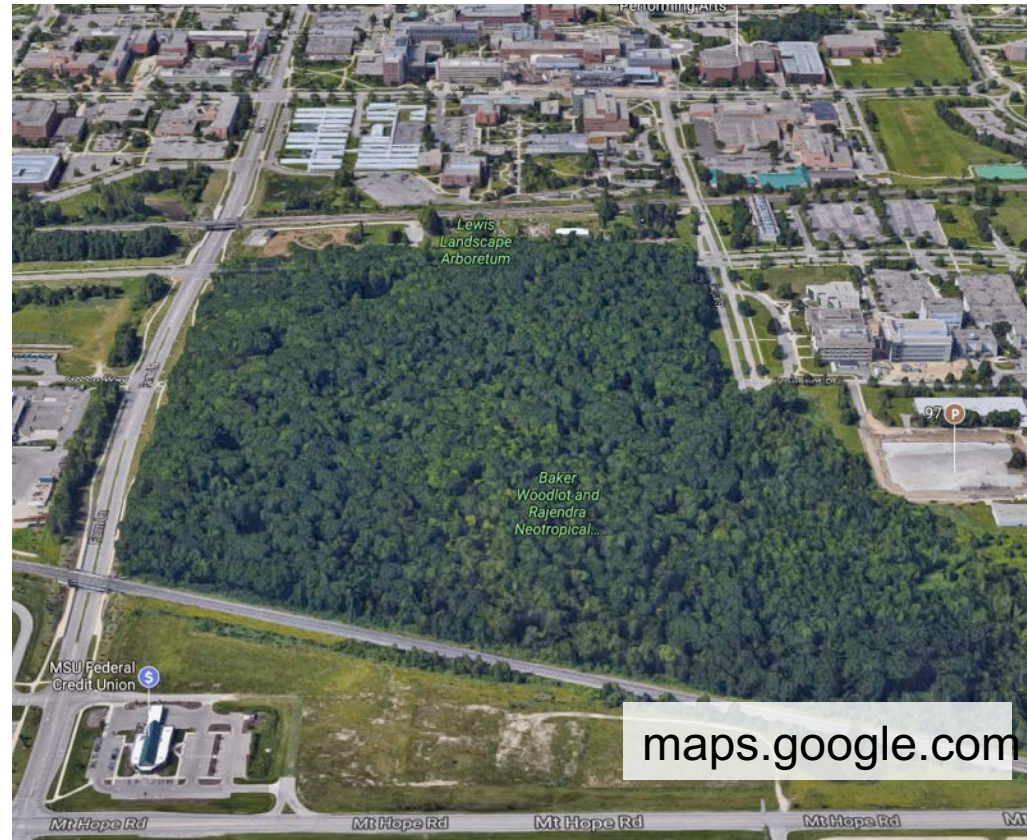
Wildflower/Pollinator Habitat

MSU Emissions: kiloTons of Carbon Dioxide / year



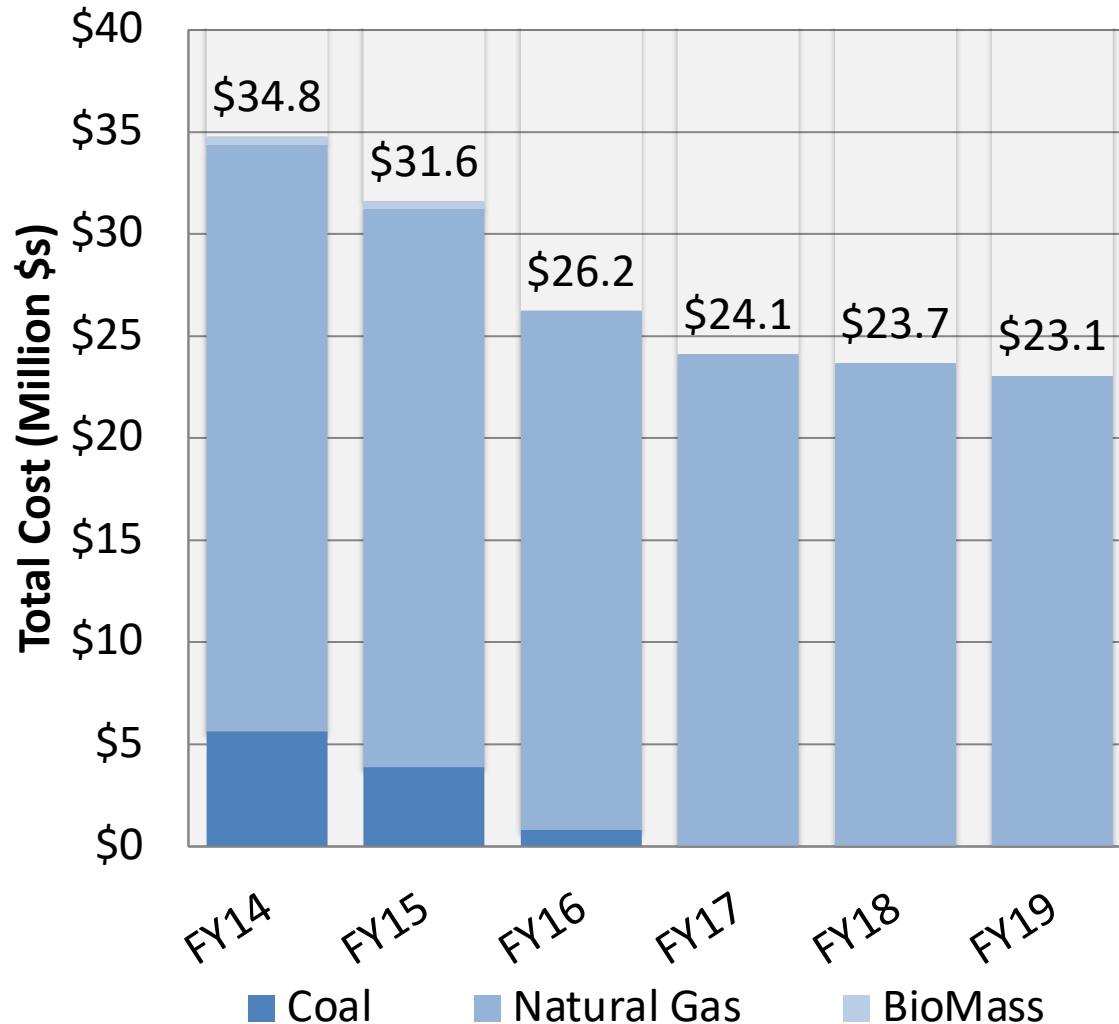
How many trees?

- 700 trees/acre
- 1000 pounds of CO₂ sequestered during life of a tree
- Total CO₂ emission reduction equivalent to planting 14 Baker Woodlots of trees (> 800,000 trees) *each year.*



Baker Woodlot, MSU:
78 acres (~ 320,000 m²)
~55,000 trees

Purchased Coal, Natural Gas and Biomass Costs



**34% cost reduction
since FY14!**

**New Solar Array will
save \$57 Million
during next 25 years**

**True
Sustainability:
Saving Money
while Saving
the Planet**



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