



Higher Ed: A long-term view on Renewable Energy

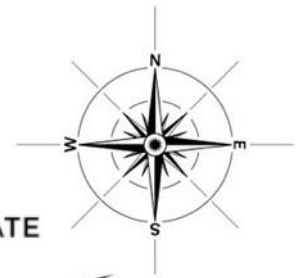
Wolfgang Bauer

Michigan State University

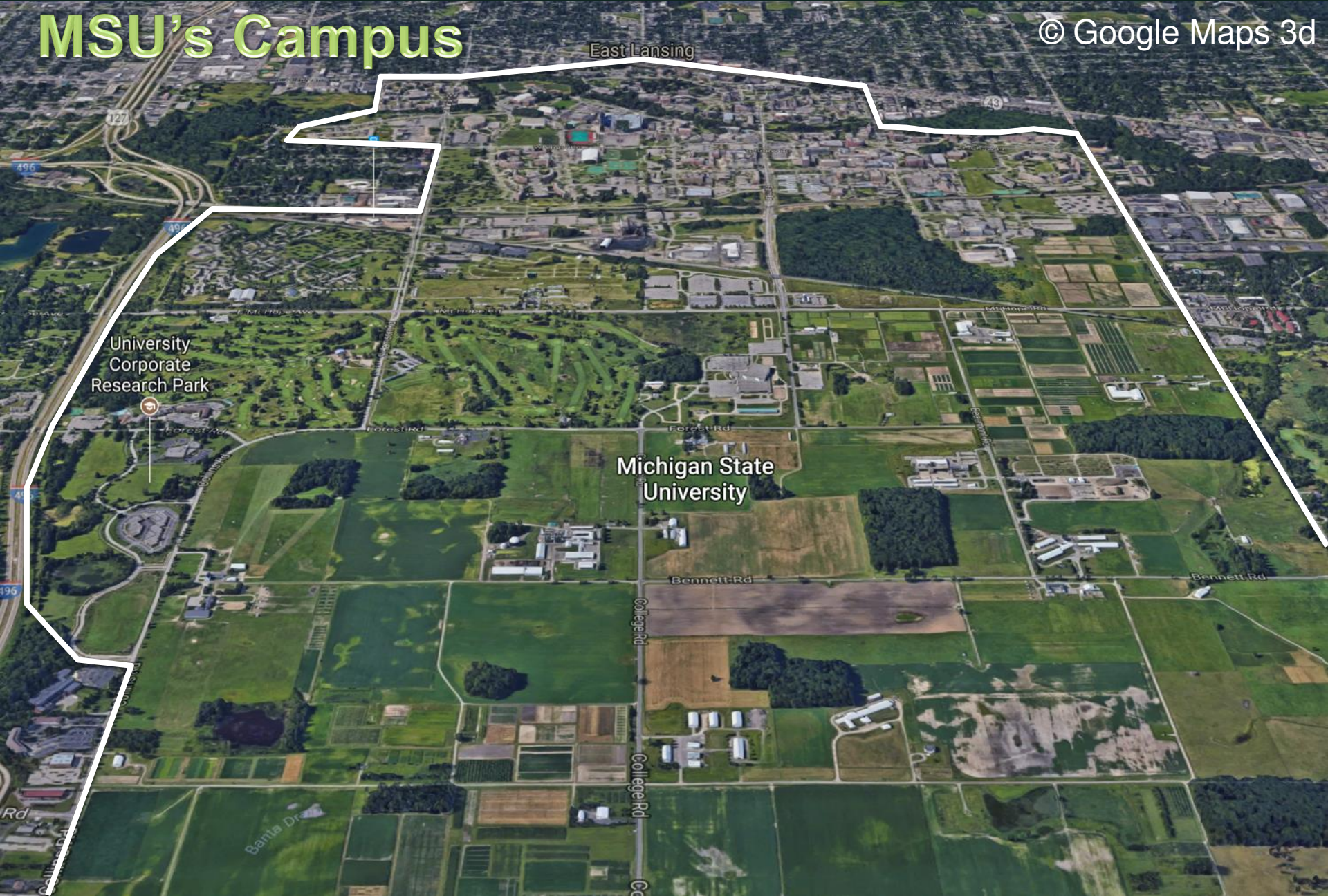


LARGEST UNIVERSITY BY ENROLLMENT IN EACH STATE

<http://i.imgur.com/NvjViUc.jpg>



MSU's Campus

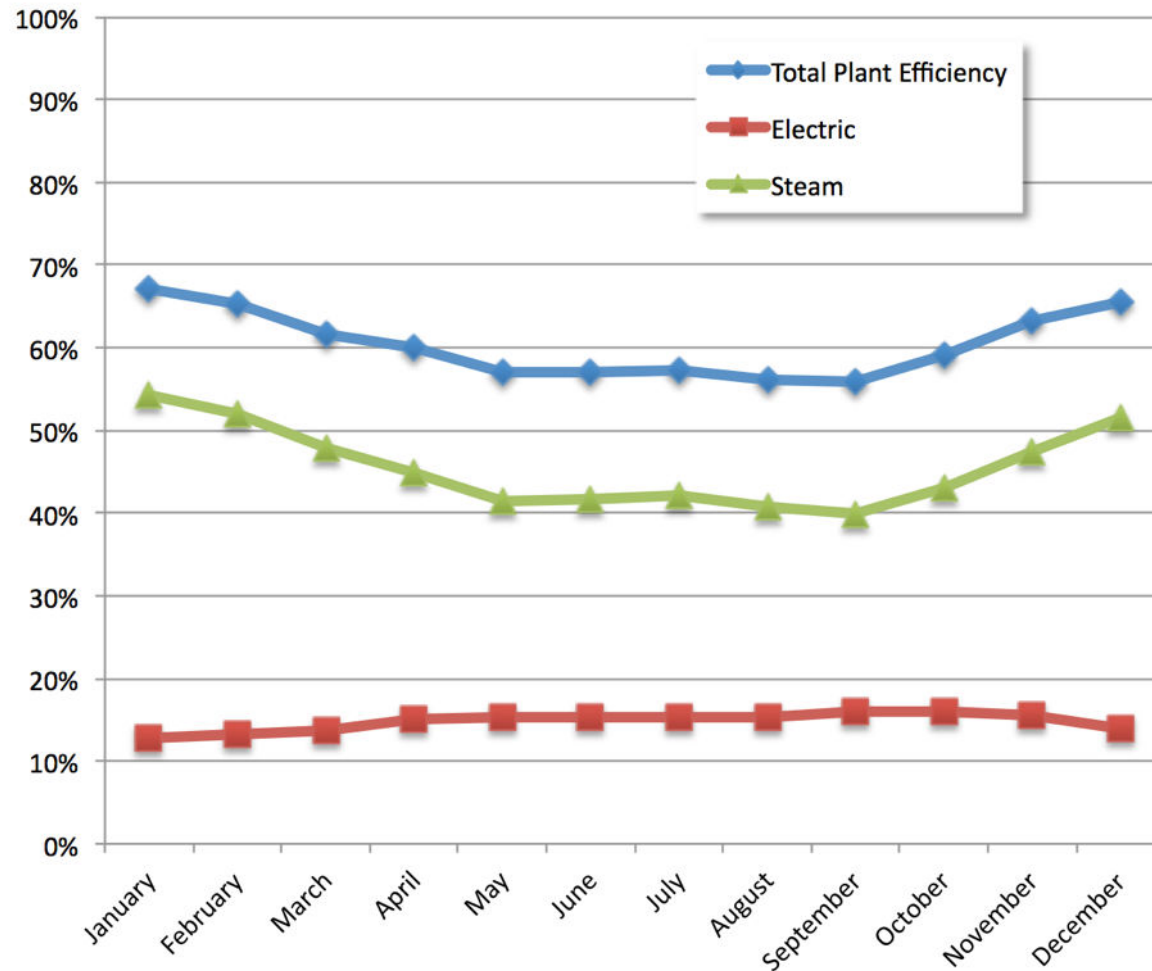




Major universities tend to have very long life expectancies

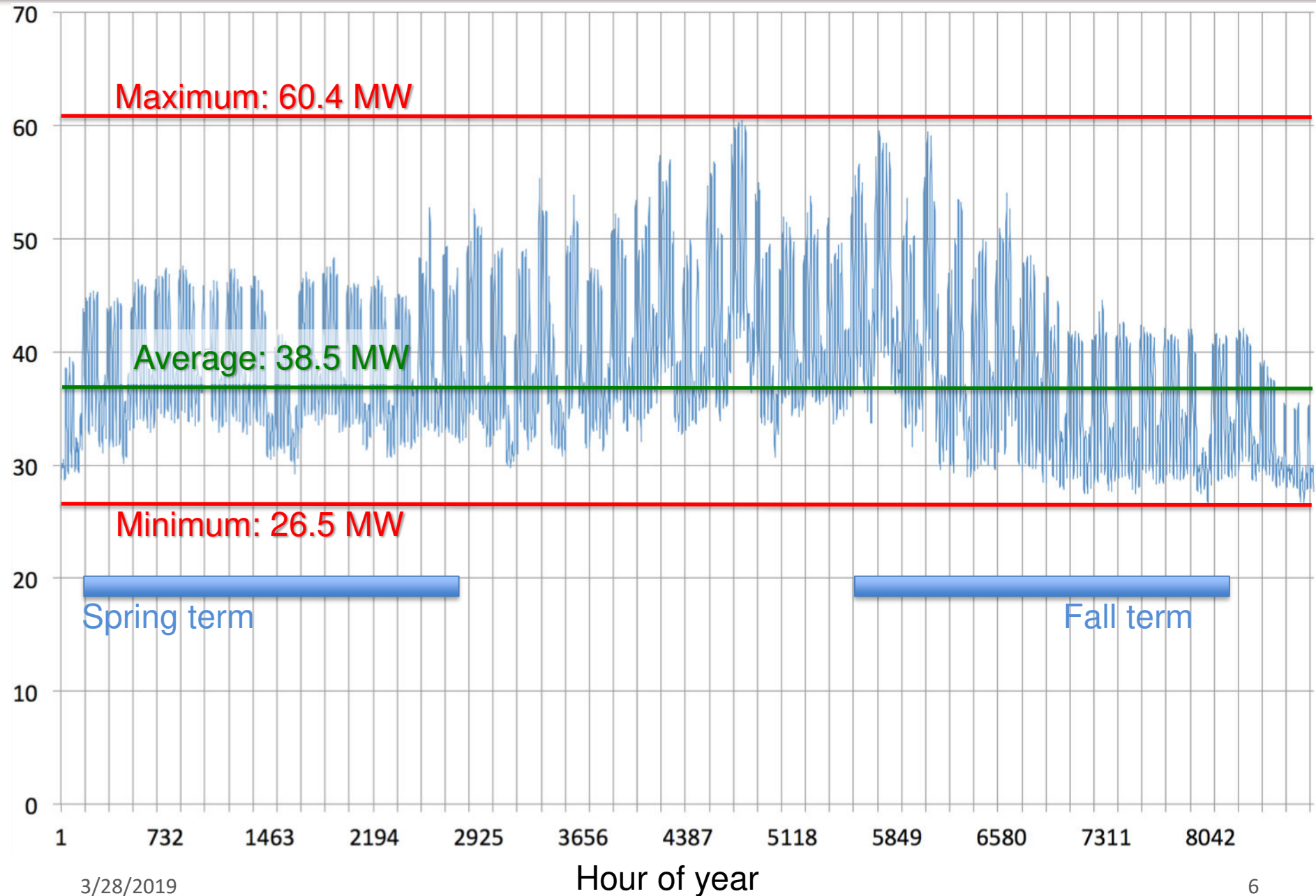
- Unlike (some) tech companies ...

Efficiency for each month



- Totally self-contained micro-grid
- Co-generates all heat and electricity for campus
- ~ 6 TBTU primary fuel consumption

Campus Electricity Demand (Year 2013)

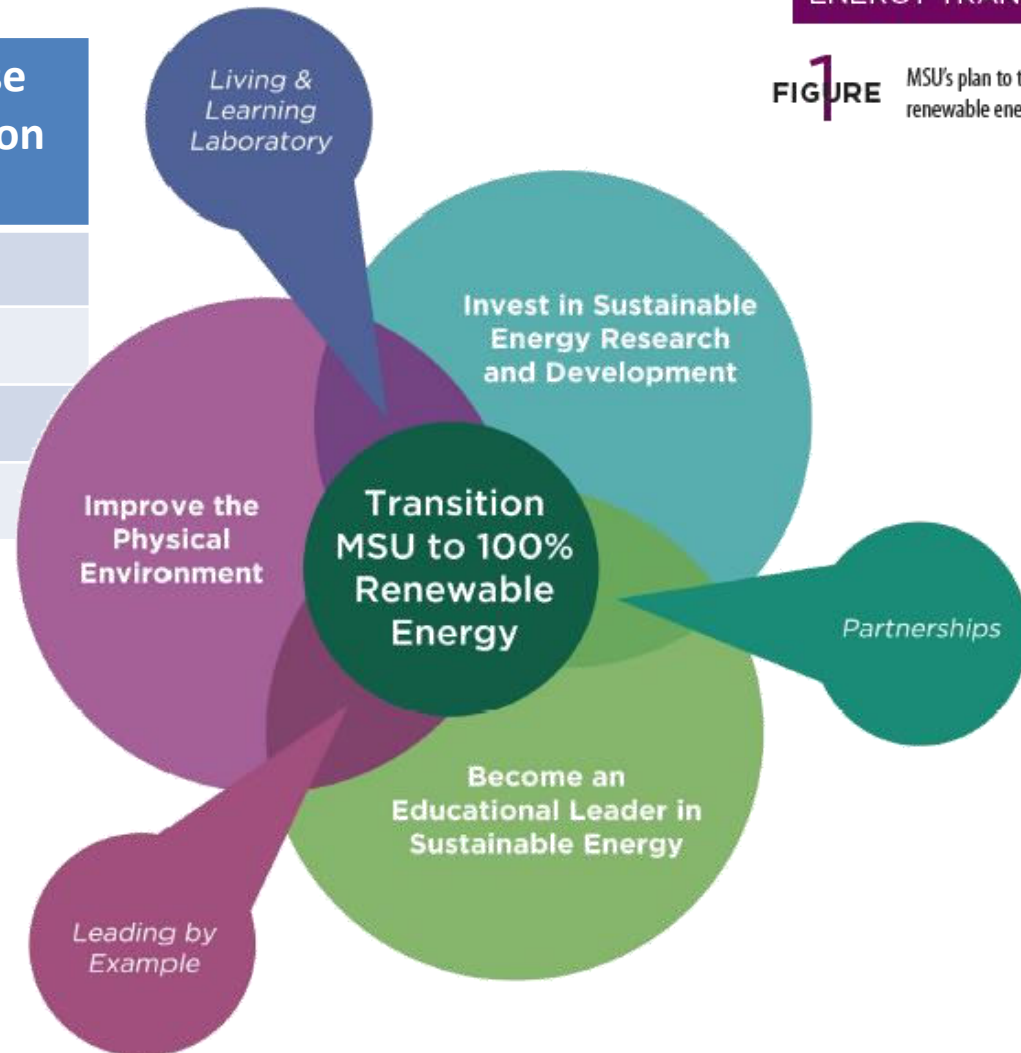


- Timetable

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

ENERGY TRANSITION PLAN

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



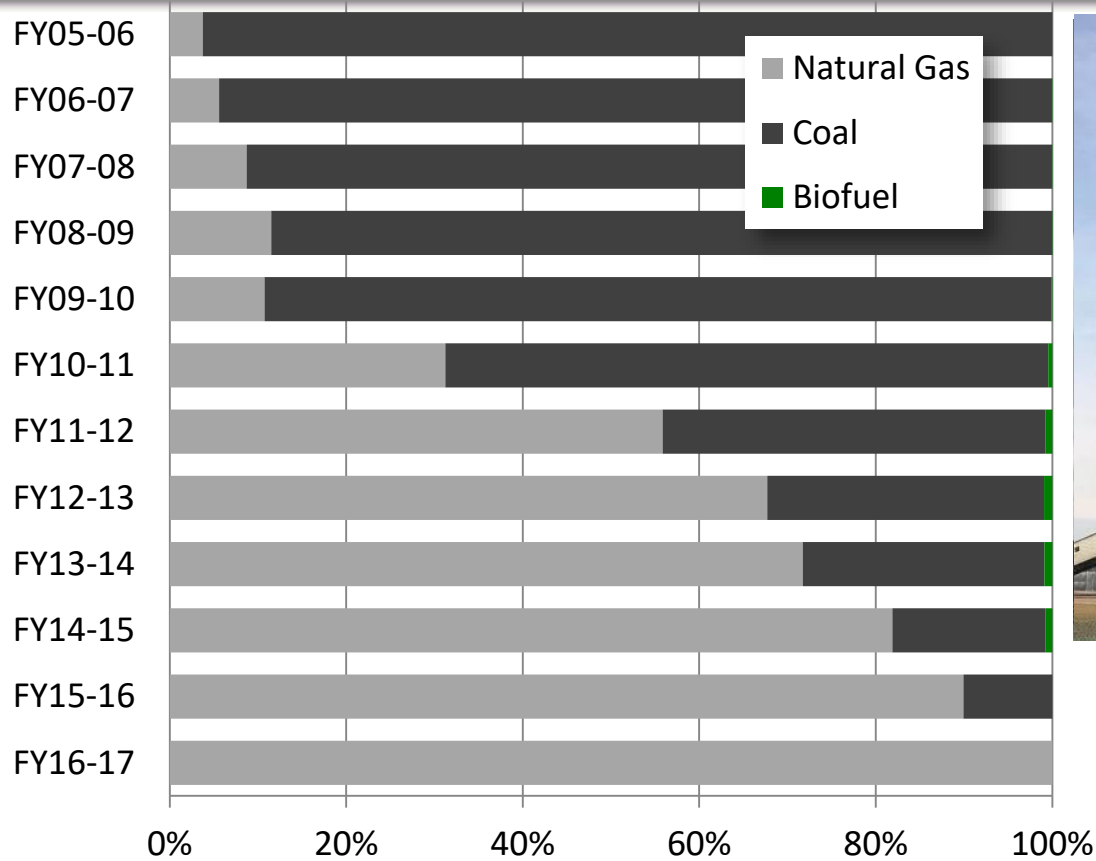
- Approved by MSU Board of Trustees, April 2012

E = **\$**

GO GREEN GO WHITE

- **GREEN** means environmental sustainability
- **GREEN** also means financial sustainability
 - Only way to make lasting changes in energy portfolio

Termination of Coal Firing



Fuel switch from coal to gas resulted in CO₂ emission reductions of > 500 million pounds per year!

Environmental impact equivalent to planting a half million trees per year!

GE-Spartan-(Toyota) Treasure Hunts

- The greenest energy is the energy we do not consume
- 25 buildings

- 4.6 M sqft
- Participation from Facilities Staff, Students, and Faculty



- Recurring investment
 - \$5 - \$10 million per year
 - ROI time of 5 years or less
- Sample projects:
 - LED lighting for dorms/offices/streets
 - Steam traps
 - Variable speed fans
 - Occupancy sensors
 - Double-paned windows



Advancing Energy Efficiency at MSU

Showcase projects: **Anthony Hall & Erickson Hall**

The goal of the Better Buildings Challenge is to improve the efficiency of American commercial, institutional and industrial buildings by 20% or more by 2020.

Organizations committing to the Better Buildings Challenge agree to:

- **Conduct** an energy efficiency assessment of their building portfolio and pledge an organization-wide energy savings goal.
- **Take action** by showcasing an energy efficiency project and implementing a plan to achieve lasting energy savings.
- **Report** results by sharing cost-effective approaches for saving energy and performance data that demonstrates the success.

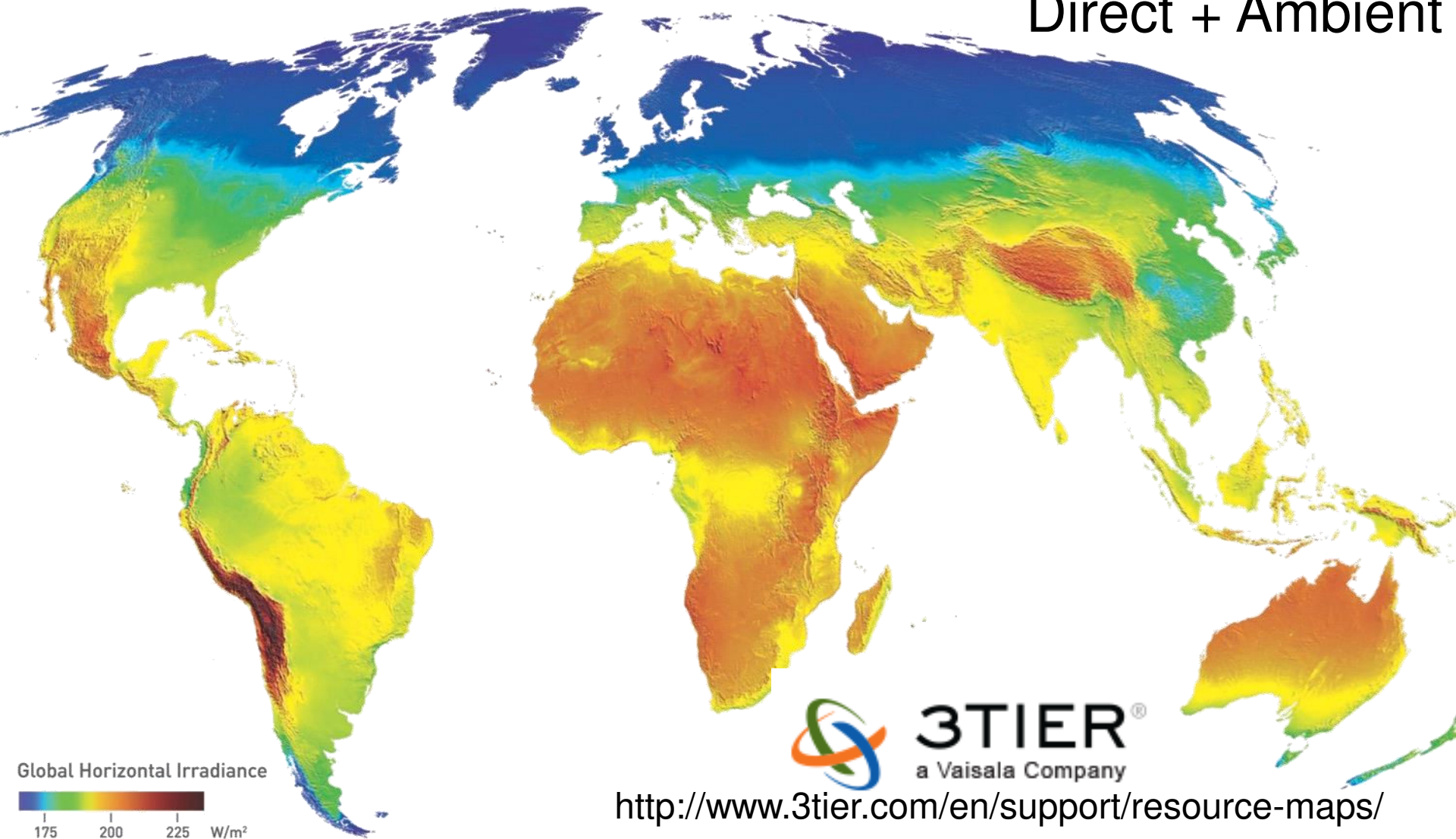


- Power Utilization Efficiency (PUE) improvement
 - $PUE = \text{Total power to data center} / \text{power to computers}$
 - 70+ data centers on campus with average PUE ~ 2
 - New data center has PUE < 1.3
 - 2 MW compute load $\Rightarrow \sim 12,000$ MWh energy savings / year
- Cyber security, ...

Completed Nov. 2017



Direct + Ambient



Free Money from the Sun

- **180 W/m²** solar radiation reach the ground *on average*
- **15%** can get converted into electricity
- **¢ 10 / kWh**



- **MSU's campus area: 5,200 acres = 21 km²**
- **On average, MSU receives \$50,000 in solar radiation EACH HOUR 24/7/365**
Let's get some; GO GREEN

Time Line

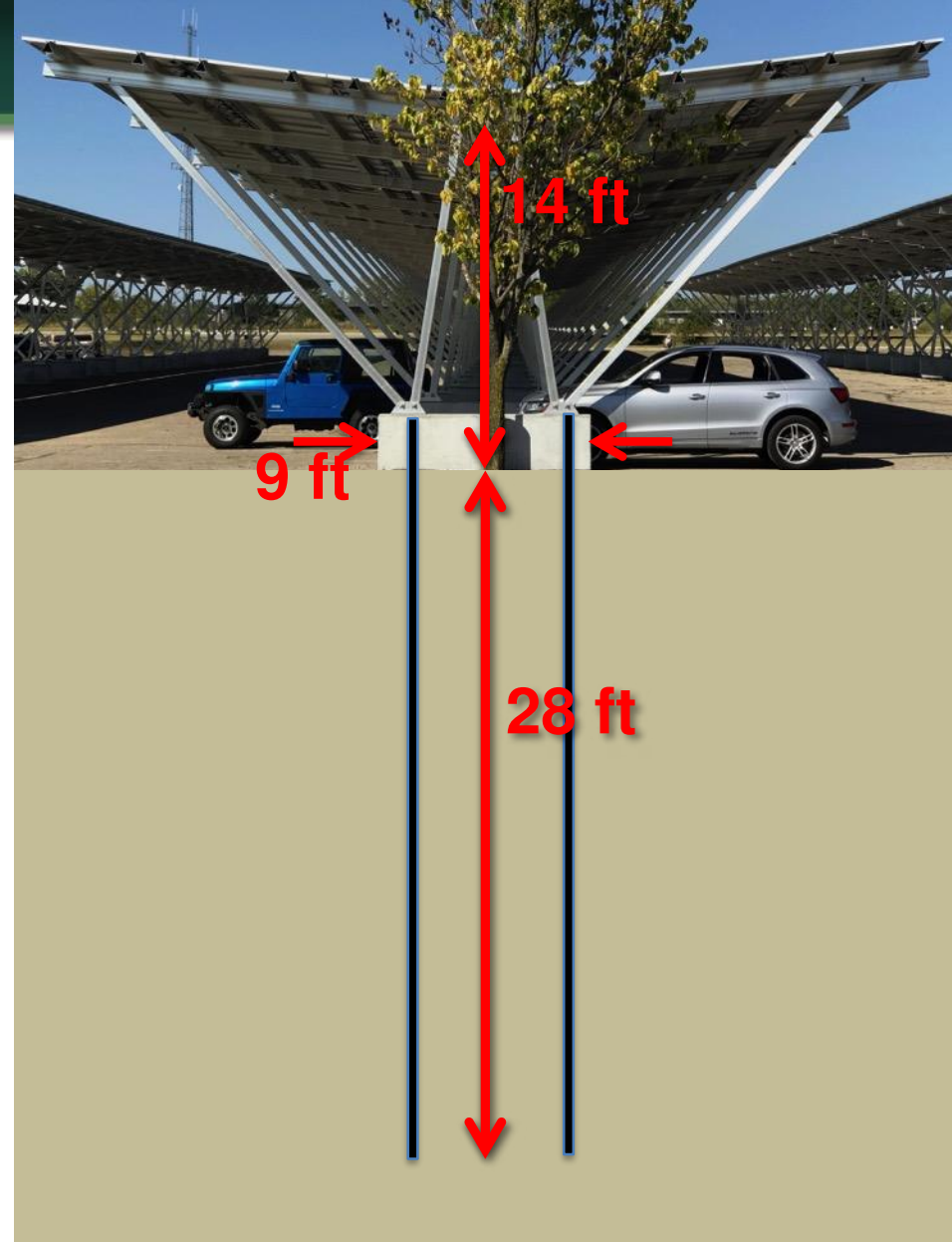


Solar Arrays: Site Selection



Dimensions

- 5,000 parking spots
- 45 acres
- 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 Michigan households



Finished Product (2017)

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

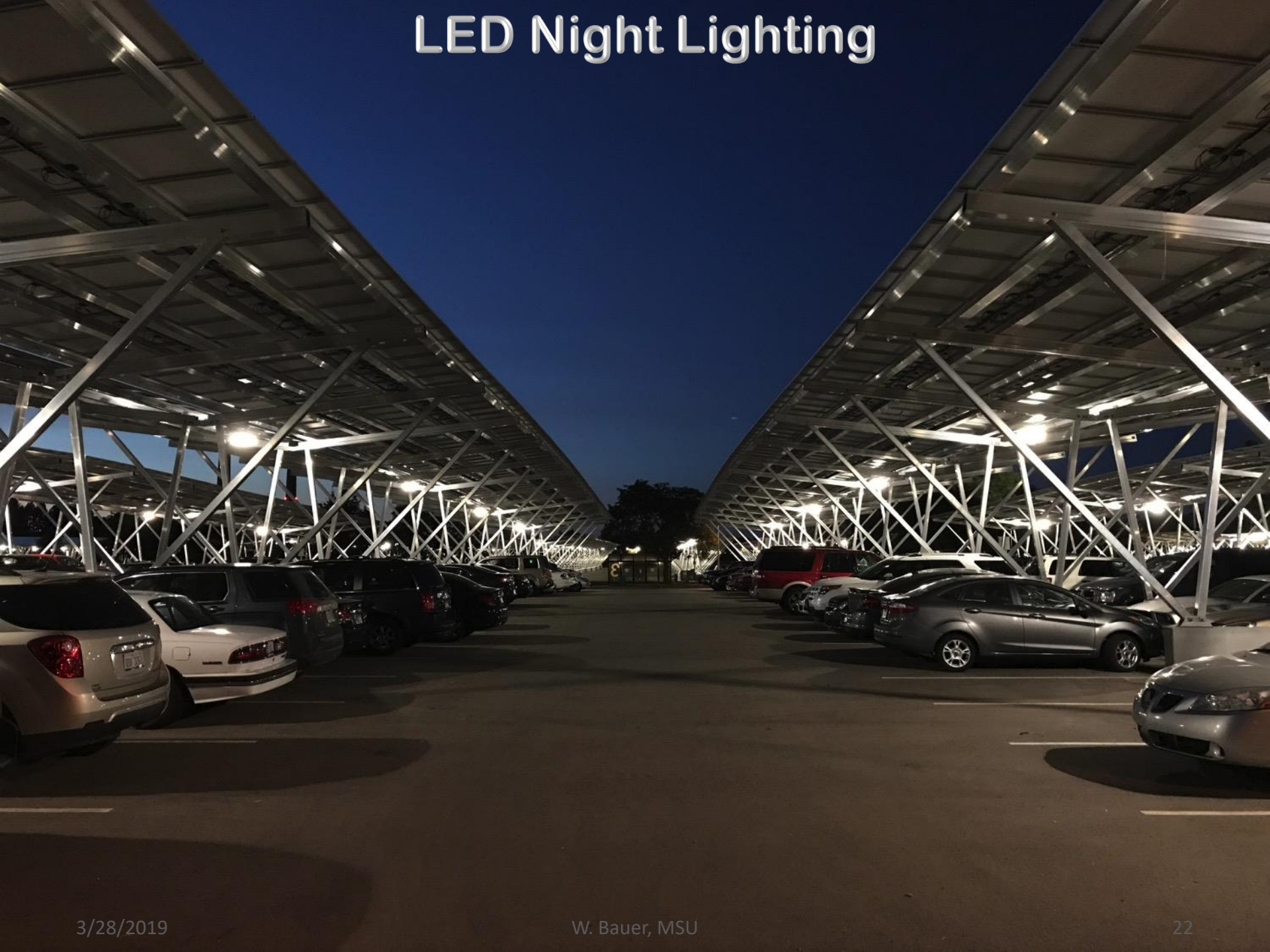


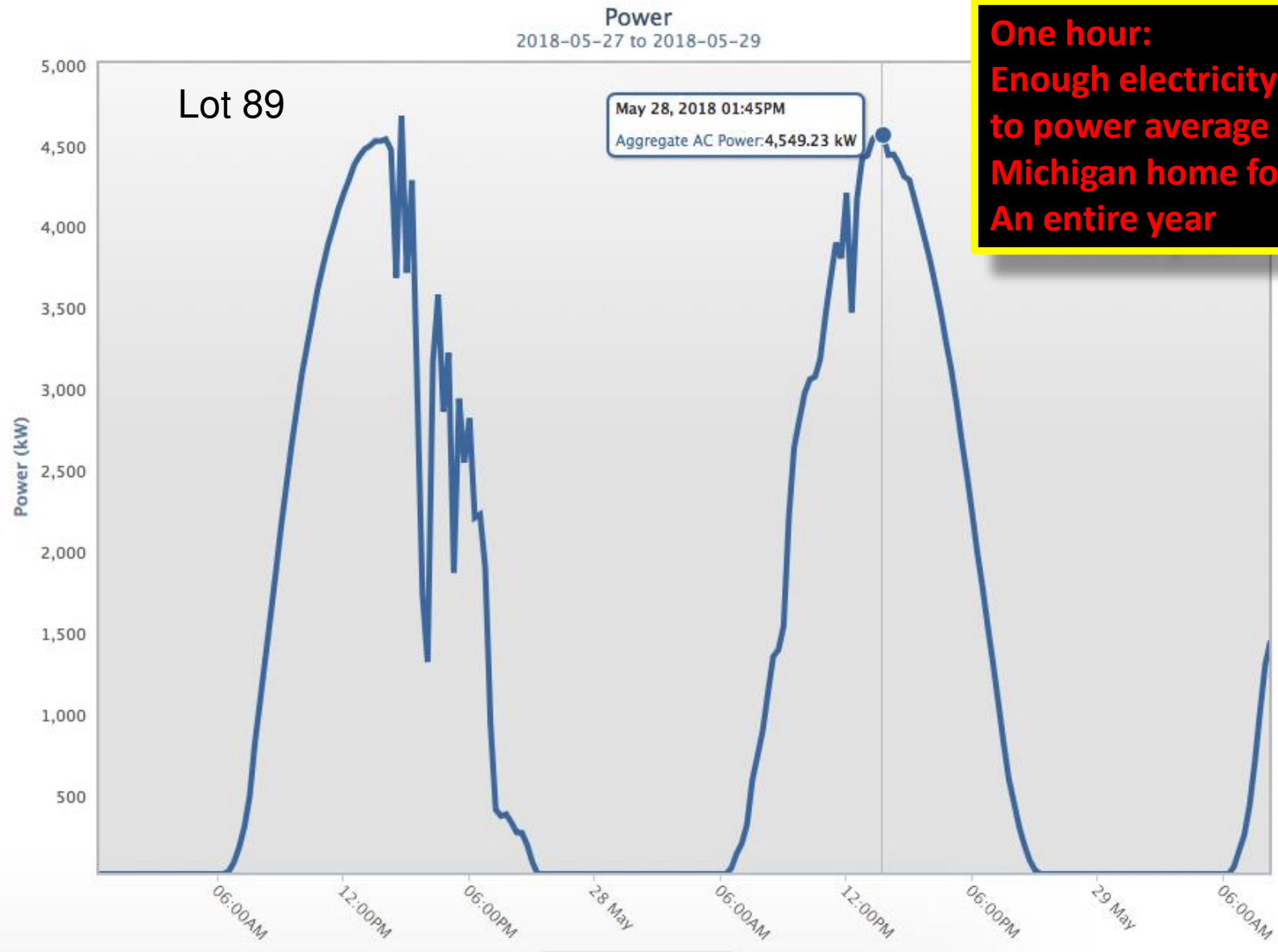
Finished Product (2017)

Largest solar carport array in the USA



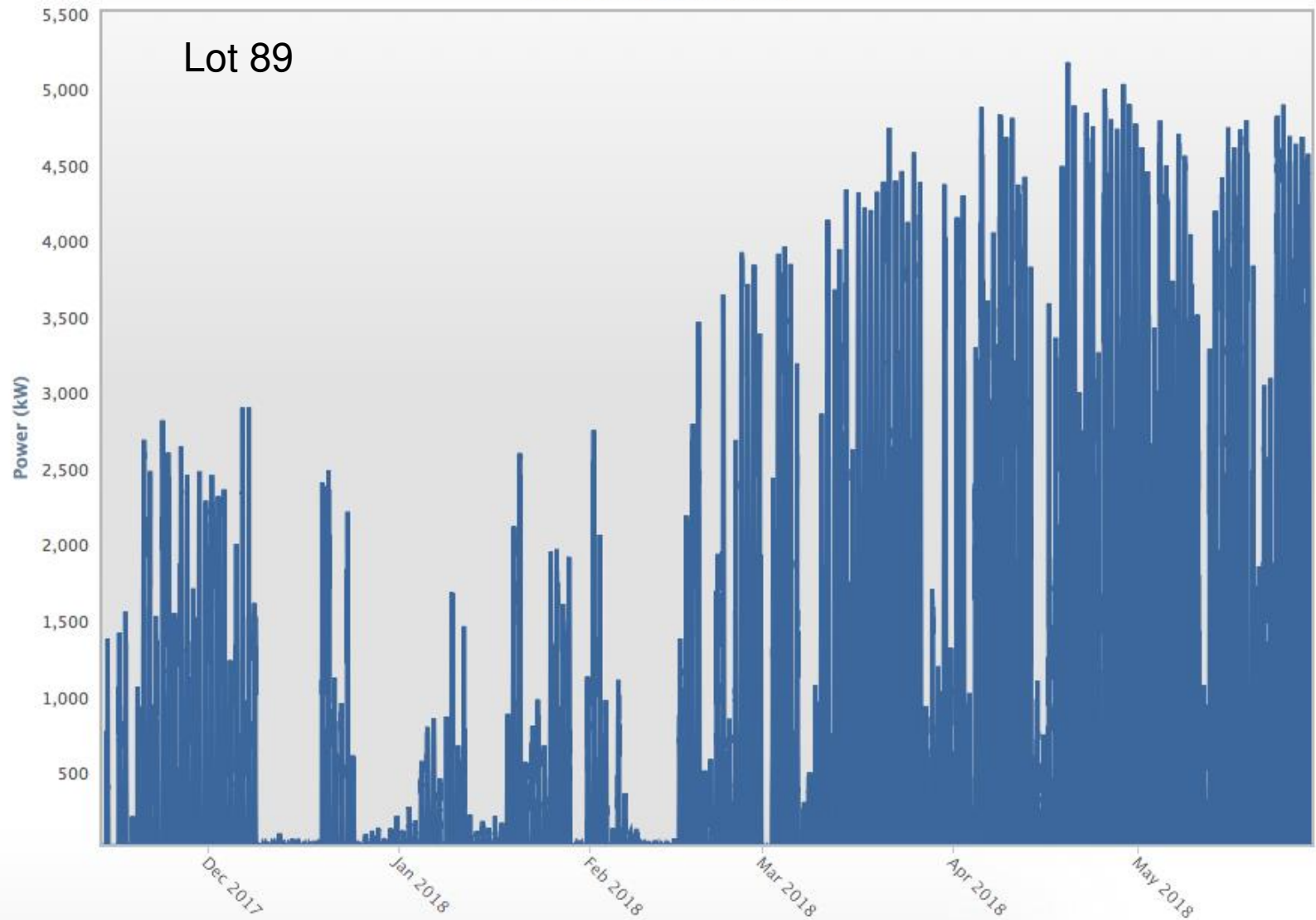
LED Night Lighting





**One hour:
Enough electricity
to power average
Michigan home for
An entire year**

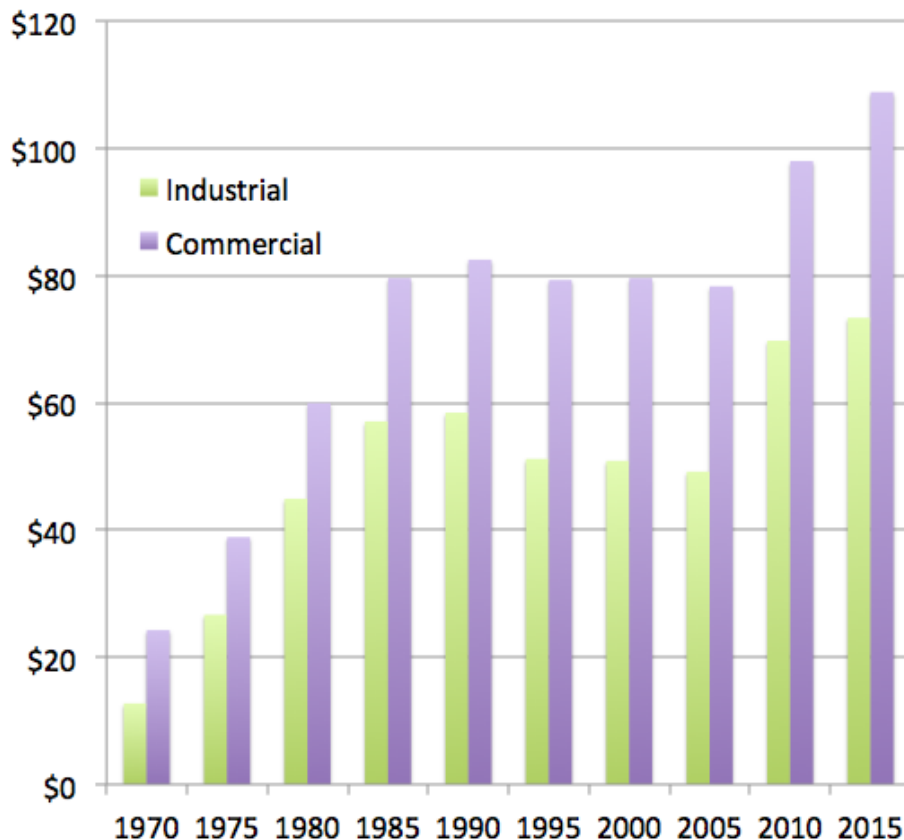
Power
2017-11-01 to 2018-05-29



Financial Benefits: GO GREEN!

- PPA allows MSU to purchase power at a fixed price over the next 25 years
- 2015 public service commission utility rate **\$91/MWh**, but will increase. (DOE-EIA projection: 2.3%/year; last decade: 3.35%/year)

Michigan Electricity Price per MWh



Projected total net savings
~\$10M for MSU over the
25 year PPA period

Green power is now
cheaper than **brown**
power!

- Only possible because MSU micro-grid can firm the fluctuating production of solar electricity

End of Coal (Mar'16)



Energy Conservation



Waste Reduction



Renewable Power



Bottom Line (end of 2016)

- 10.4 % increase in renewable energy
- 27.7 % reduction in greenhouse gas emissions
- 7 % savings on energy budget, \$\$ returned to general fund

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