The MSU Solar Carport Project

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MSU

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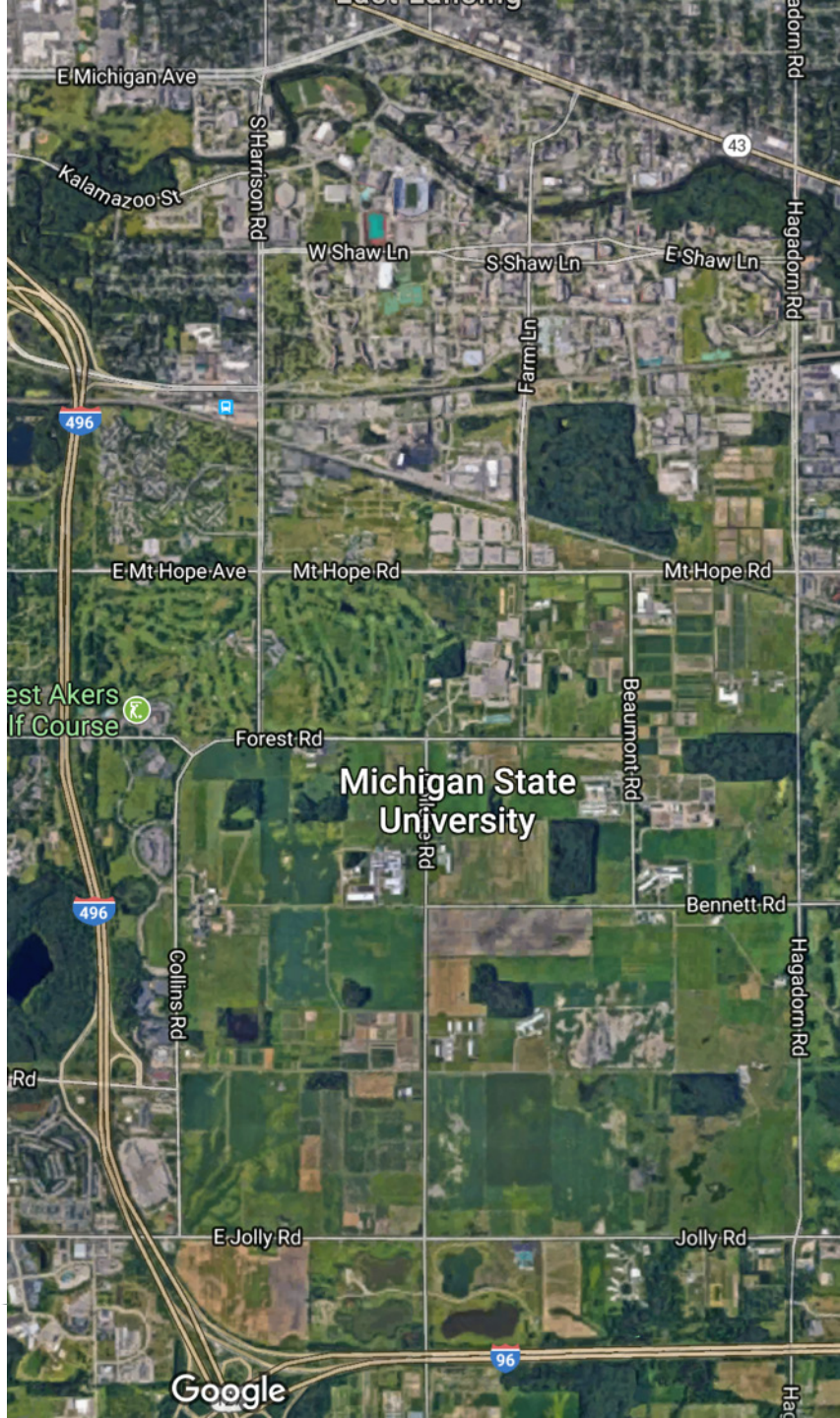
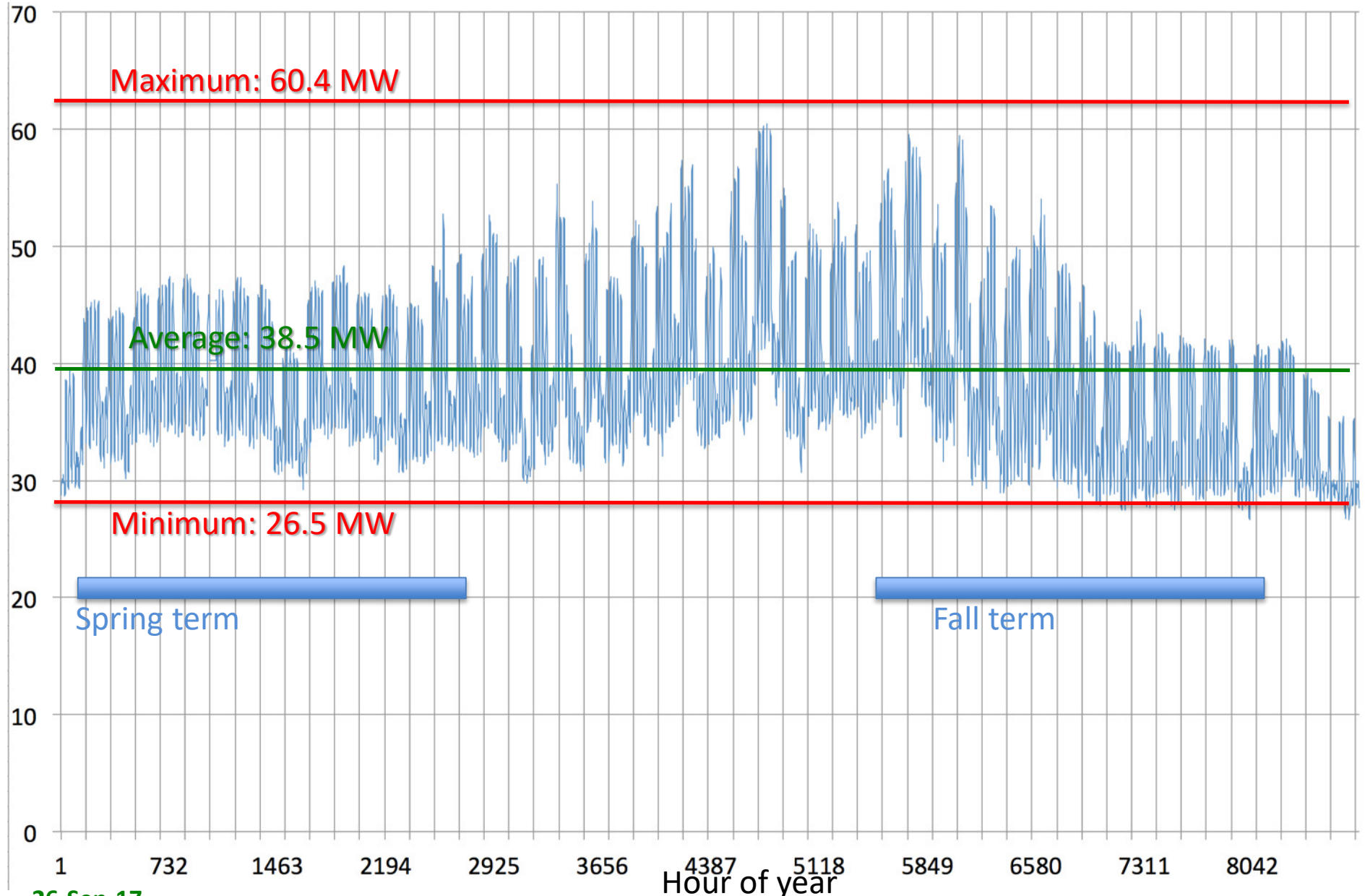
Michigan State University

- 1855 Land Grant
- contiguous
  5,200 acres (21 km^2)
- developed
  2,000 acres (8.1 km^2)
- 545 buildings, 103 for instructions
- 39,000 undergrads,
  11,400 graduate students
- 5,300 faculty & academic staff
- 6,800 support staff



Campus Electricity Demand (Year 2013)



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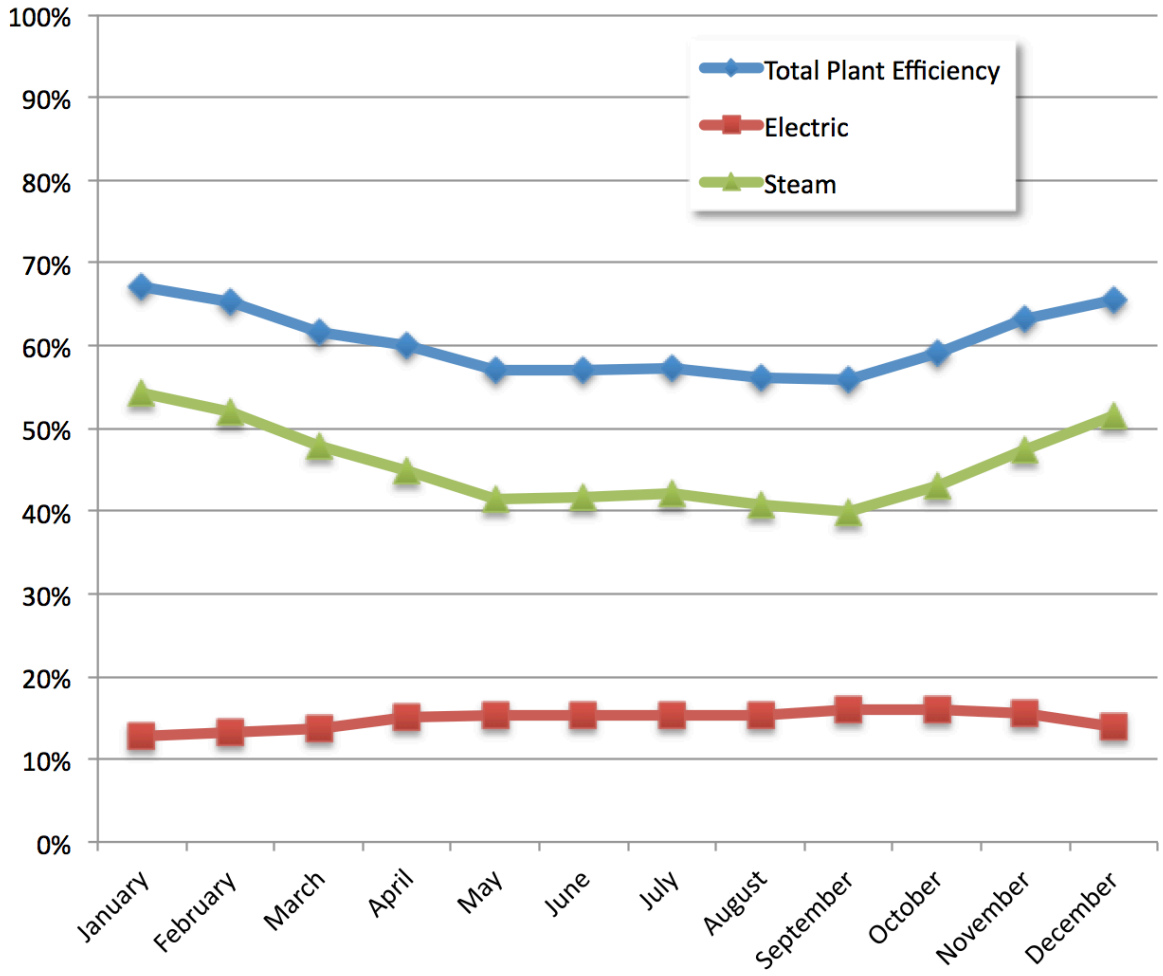
Simon Plant: Electricity & Steam Co-Generation



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

MSU Energy Transition Plan

- Goals
  1. Improve the physical environment
  2. Invest in sustainable energy research and development
  3. Become an educational leader in sustainable energy
- 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

Achievements since 2012

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

Considerations for Renewables

- Off-site vs. on-site
- Wind / solar / hydro
  - Red Cedar river cannot provide adequate power
  - Wind turbines face strong resistance
  - Solar allows for peak shaving of demand
- Solar
  - Ground- mount vs. car ports
  - Tracking vs. fixed tilt
- Ownership vs. 3rd party ***P***ower ***P***urchase ***A***greement

Constraints on Renewables

- Michigan regulates electric choice (Public Act 286, 2008)
  - "no more than 10 percent of an electric utility's average weather-adjusted retail sales for the preceding calendar year may take service from an alternative electric supplier at any time"
  - Long customer waiting list
  - Off-campus energy purchase not an option

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- On-campus wind faces strong resistance
  - Worries about visual pollution, ice throw, bird killing, "turbulence disturbs pollination patterns", noise pollution, "cows sensitive to vibrations"

Cows Actually Don't Mind

And when there's no wind turbine in sight so you try and make your own.

Jean-Francois Monier / Getty Images

https://www.buzzfeed.com/lanesainty/15-things-all-cows-standing-in-front-of-wind-turbines-will-u

Mind over matter.

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- Ground-mount solar consumes valuable farm land
  - ~60 acres needed

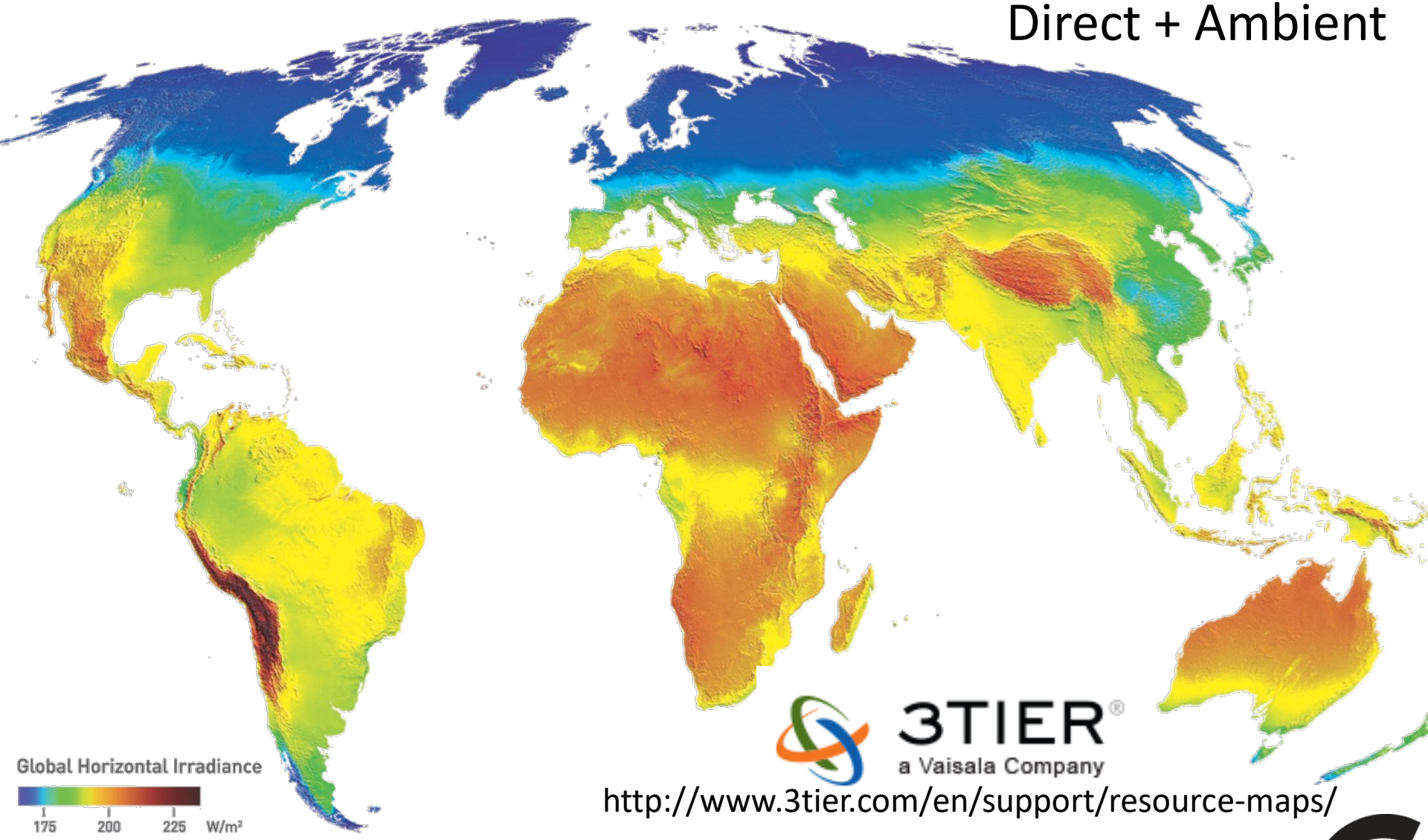
Sweet Spot: Solar Carports!

- **Pros:**
  - No farm land used
  - Keeps sun, rain & snow off parked cars
  - Extends life of asphalt
  - Advertises ‘green’ efforts
- **Cons:**
  - $20-$30 / MWh initial cost premium due to car port structure
  - Need for phased construction

Site Selection

Usable Solar Radiation

Direct + Ambient

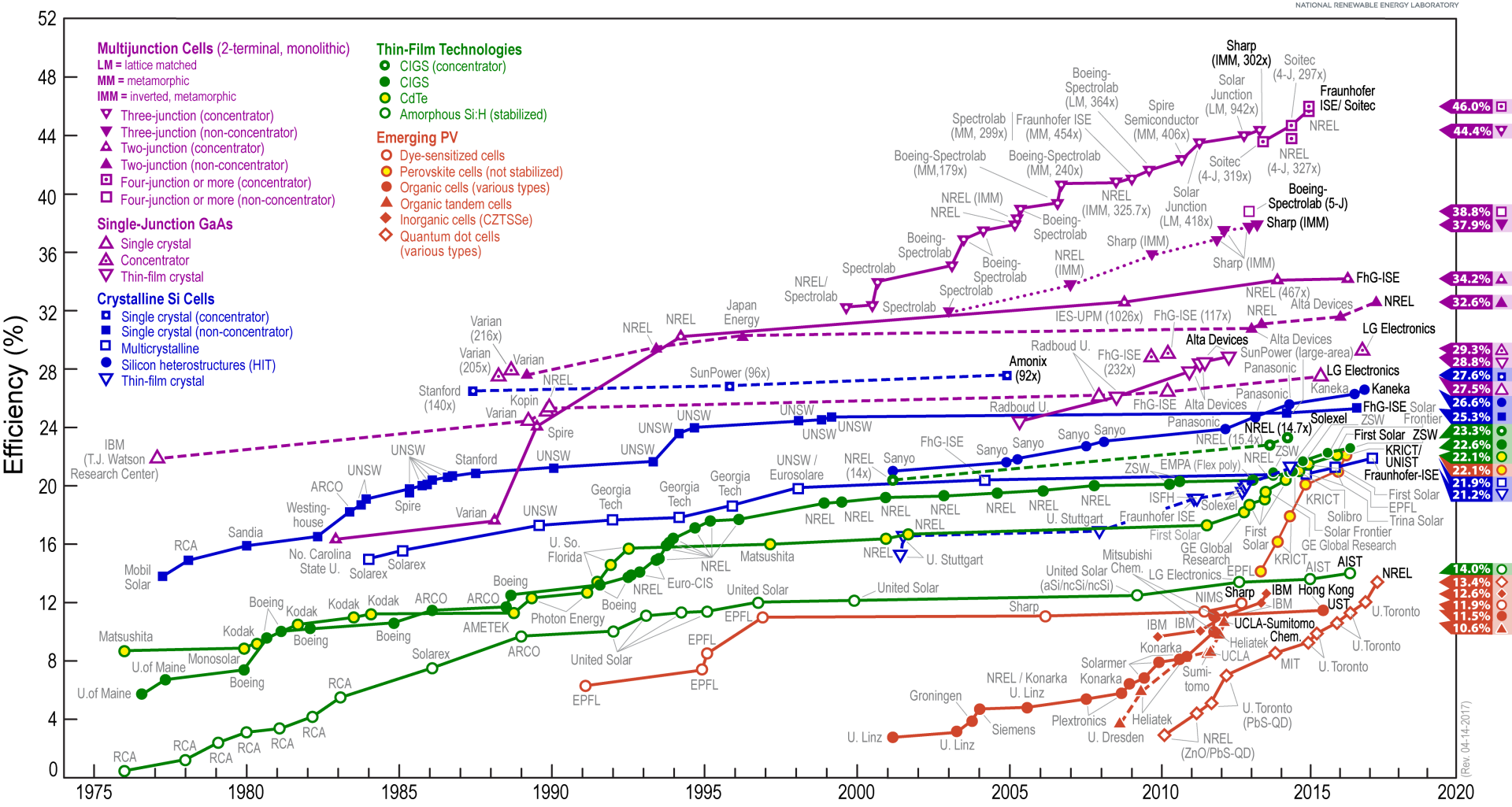


3TIER®
a Vaisala Company

http://www.3tier.com/en/support/resource-maps/

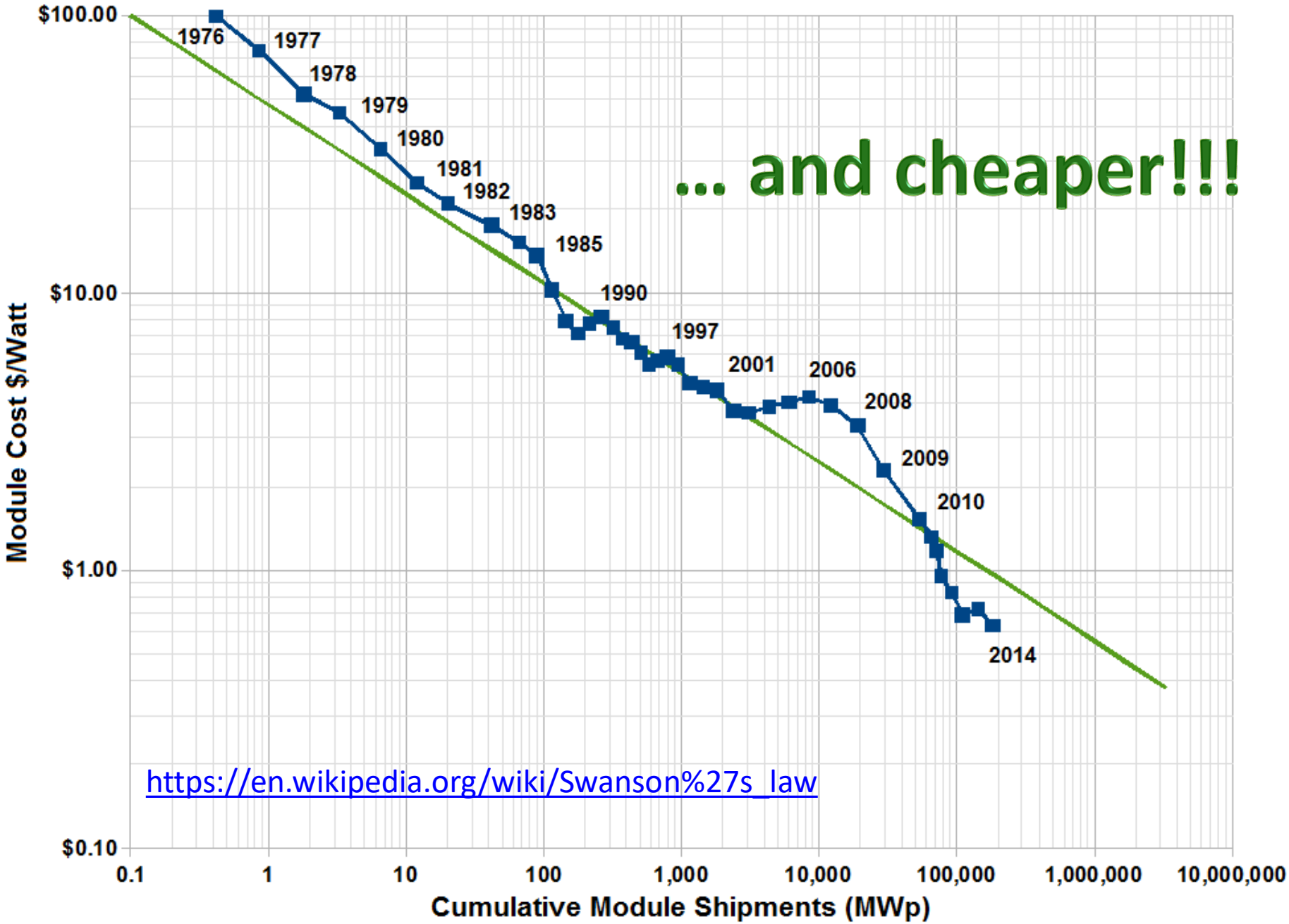
PV Cells are Getting More Efficient

Best Research-Cell Efficiencies



https://www.nrel.gov/pv/assets/images/efficiency-chart.png

Swanson's Law

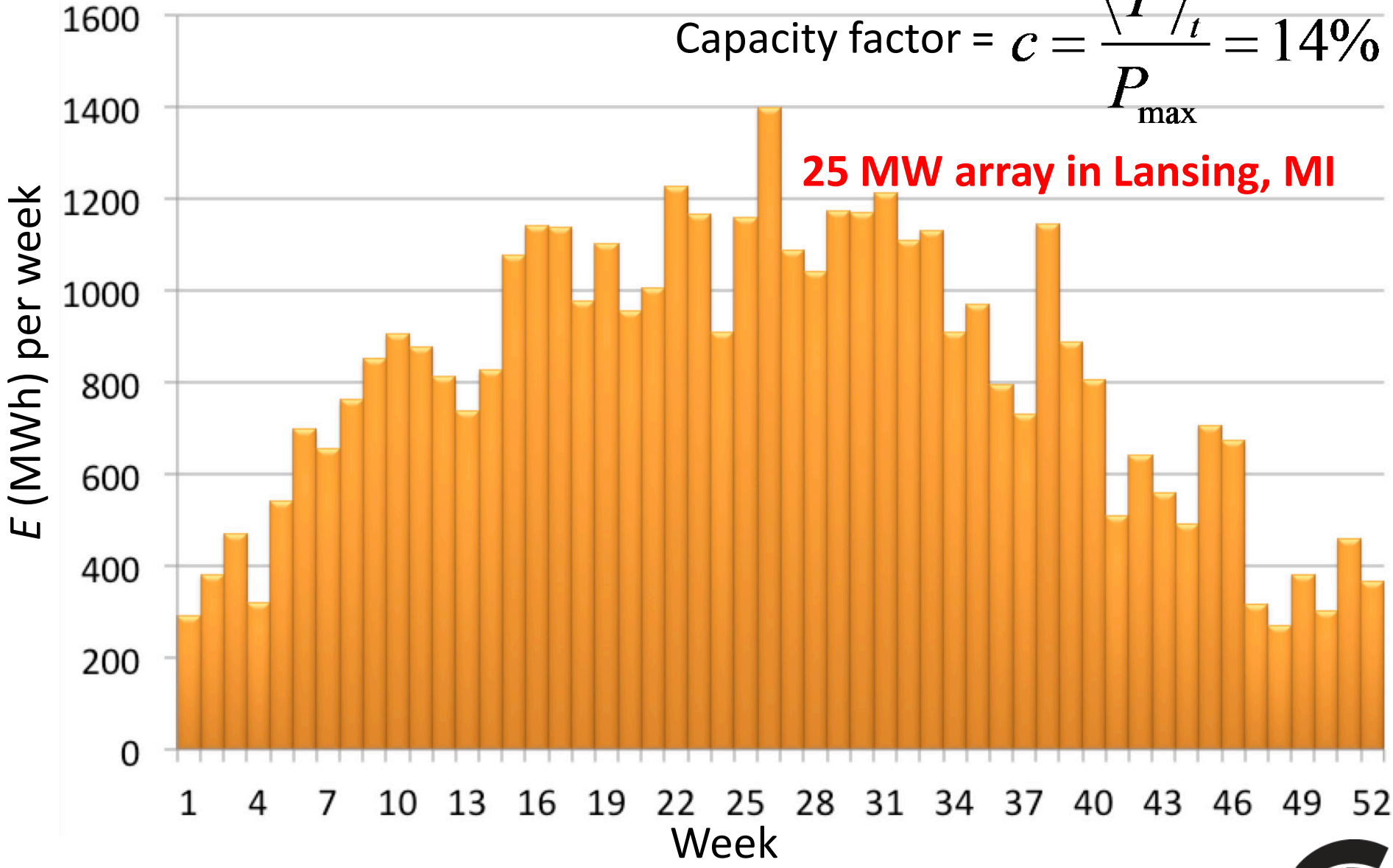


... and cheaper!!!

https://en.wikipedia.org/wiki/Swanson%27s_law

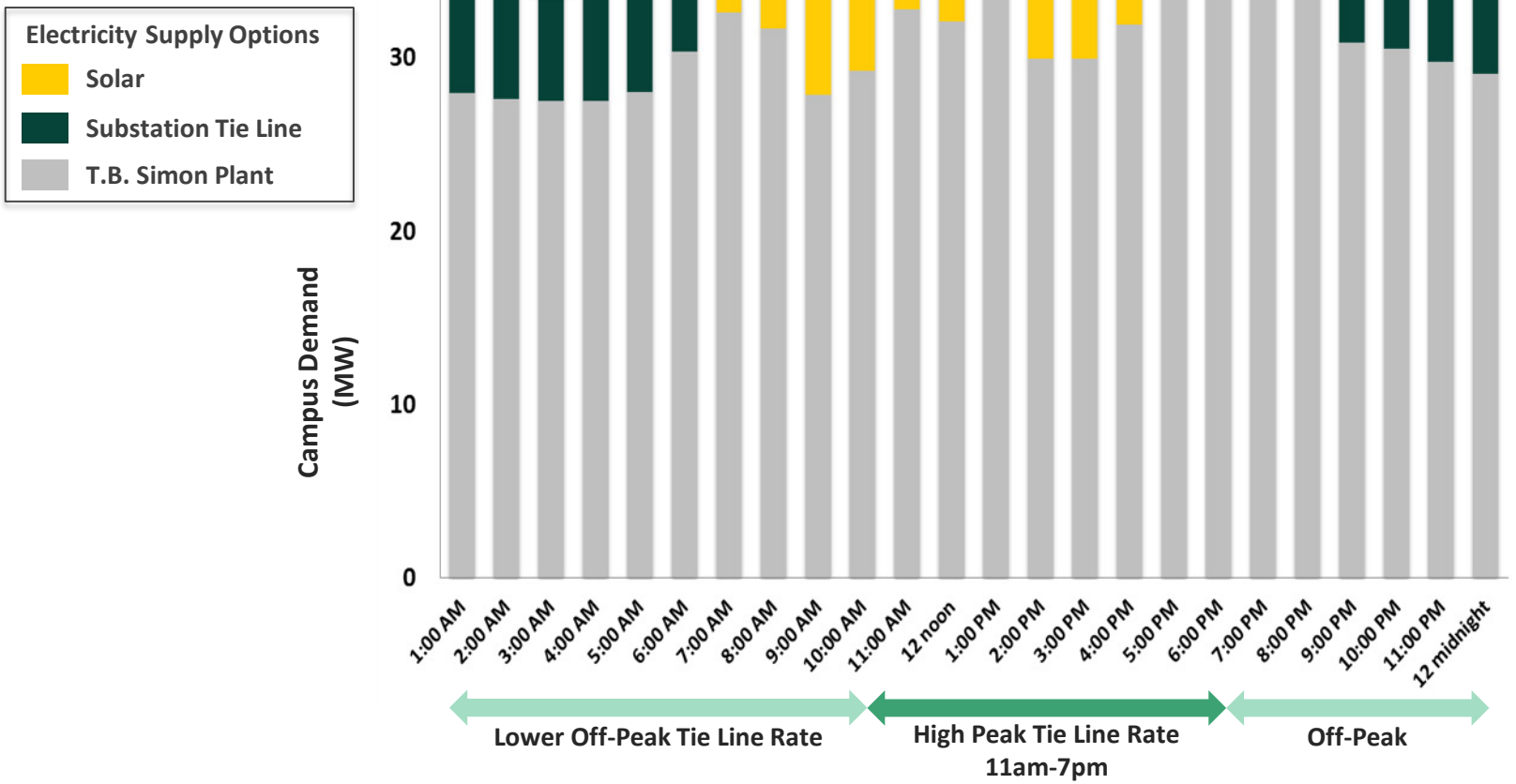
Seasonal Variation

Capacity factor = $c = \frac{\langle P \rangle_t}{P_{\max}} = 14\%$

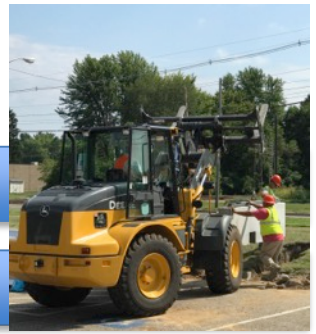


Micro-Grid Integration and Optimization

Illustrative Example- One day of **Campus Demand**



Time Line



2017 — Array Completion

2017 — Start Array Construction (March 3, 2017)

2016 — (Jul. 26, 2016) Alterra Power Corp

2015 — (Jul. 8, 2015) Inovateus Solar

2015 — RFQ: Renewable Energy Projects (Jan. 29, 2015)

2014 — (Sep. 11, 2014) Customer First Renewables

2014 — RFQ: Renewable Energy Integrator (July 17, 2014)

2013 — Anaerobic Digester Completed

2012 — Energy Transition Plan Completed (Jan.) & BOT adopted (April)

2011

2010 — Kick-off: Energy Transition Plan — Black & Veatch

Solar Panel

TP672M
72 CELL SERIES

TALESUN

- 72 cells on each panel
  - Size: 6”x6”
  - Monocrystalline silicon
- Panel Size: 3’x6’
- Maximum power output: 335 W
- Power degradation < 0.7%/year
  - Year 25: no less than 80% of initial power

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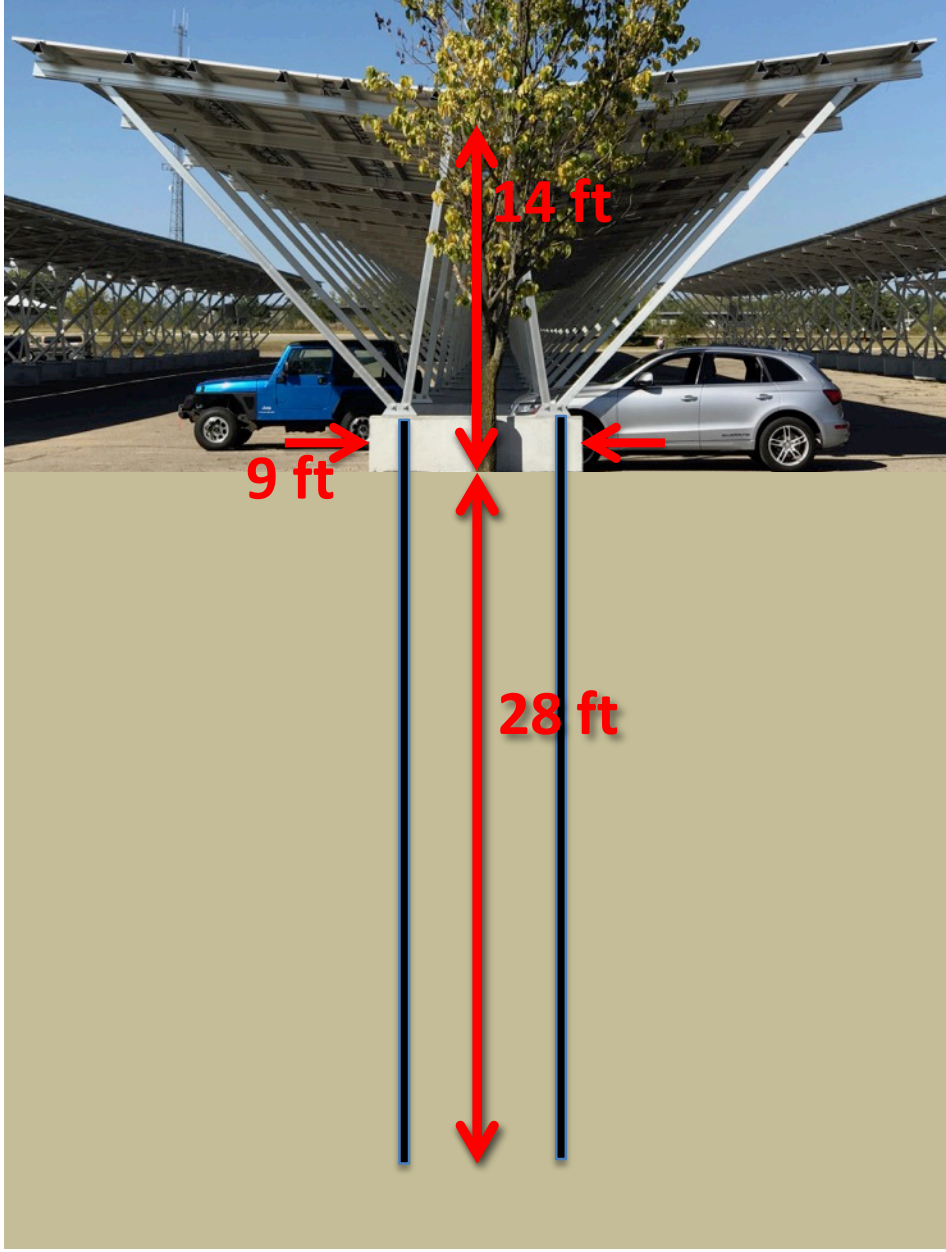
Dimensions

- 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



Finished Product

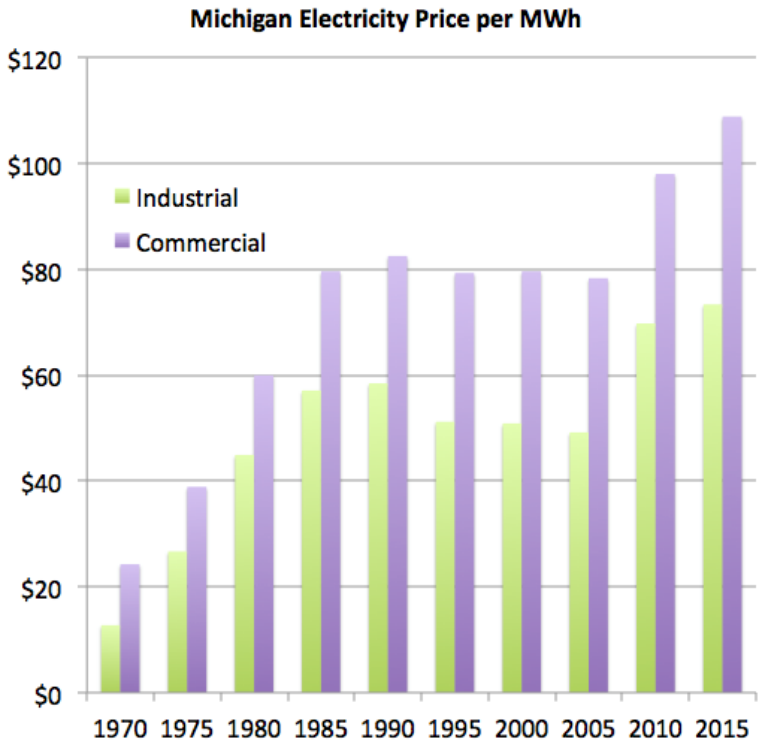
Finished Product

Largest solar carport array in the USA

LED Night Lighting

Financial Benefits

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)



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

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

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Thank you

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