APPA Institute for Facilities Management

Energy Systems of Michigan State University

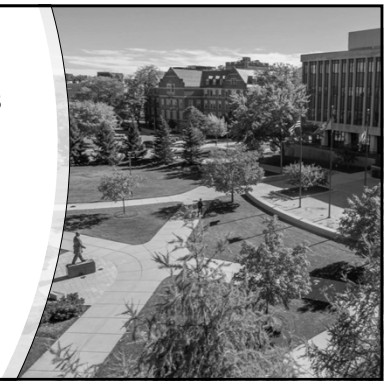
A hybrid energy microgrid / district energy system

Sherri Jett, Director of Utilities

1

Purpose of Today's Presentation

To provide a broad understanding of Michigan State University hybrid energy systems



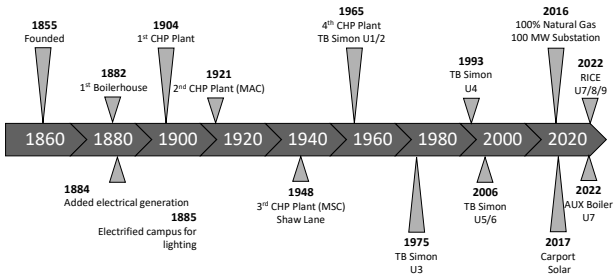
2

University Overview

- Founded in 1855
- Pioneer land-grant institution
- Academic and research
- ~50,000 students
- ~13,000 faculty & staff
- East Lansing, MI campus:
  - 5,300 acres
  - >560 buildings and structures (108 academic)
  - ~25 million GSF building space

3

Microgrid / District Energy History



4

Why central plant heat?

1890 – Botanical Lab before and after fire

1905 – Wells Hall fire

1916 – Shops & Engineering fire

1919 – Williams Hall fire

5

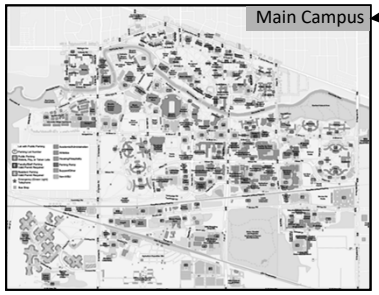
Why central plant electricity?

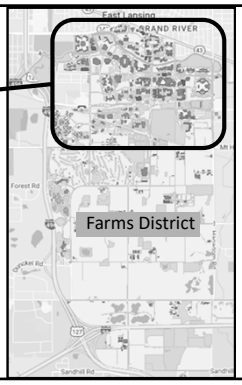
- Resiliency
- Savings
  - Cost
  - Emissions

https://en.wikipedia.org/wiki/Northeast_blackout_of_2003

6

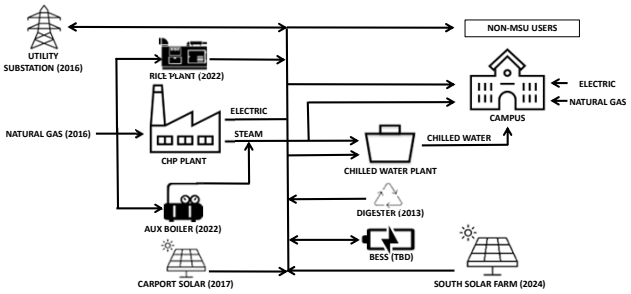
East Lansing Campus Today





7

Campus Energy Diagram



8

Connected Campus Loads

UTILITY	MILLION GSF
Steam	18.2
Electricity	21.6
Potable Water	22
UTILITY	**% TOTAL GSF**
Steam	87.4
Electricity	73.7
Potable Water	89

9

Steam Use on Campus

Heating in the winter

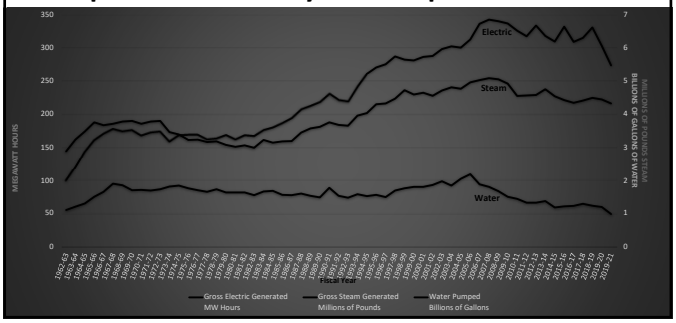
Photo © 2015 Michigan State University Board of Trustees

Cooling in the summer

https://theengineeringmindset.com/absorption-chiller-works/

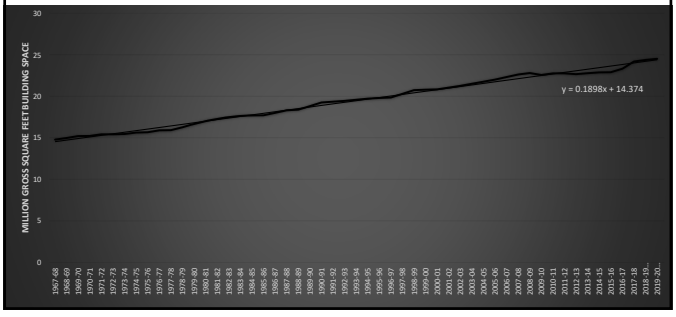
10

Campus Annual Utility Consumption



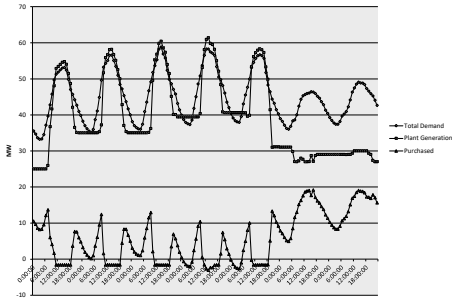
11

Campus Building Space Growth



12

Campus Typical Weekly Electric Use



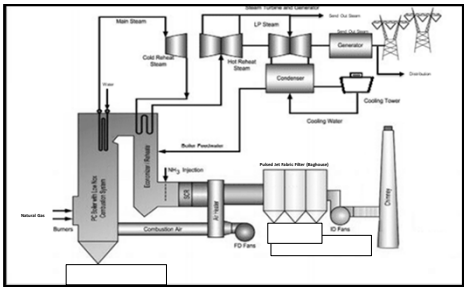
13

Central Plant Infrastructure

GENERATOR	SERVICE DATE	POWER (MW)	STEAM (kpph)
U1: Steam boiler / turbine	1965	12.5	250
U2: Steam boiler / turbine	1965	12.5	250
U3: Steam boiler / turbine	1975	15	345
U4: Steam boiler / turbine	1993	21	150/310
U5/6: Combustion turbine / HRSG / steam turbine	2006	24 + 13.5	110
U7/8/9: RICE Plant (3 x 9.4 MW engines)	2022	27.9	--
U7: Auxiliary Boiler ***NEW***	2022	--	200
TOTAL CAPACITY[3]		**123.9**	**855/1015**
N+1 CAPACITY[3]		**99.9**	**510/765**
FY21 Peak Campus Demand		65	490
FY21 Average Campus Demand		38.6	280.4
Anaerobic Digester	2013	0.45	--
CE Electrical Tie-Line	2016	100	--
Solar Carport	2017	11.5 peak	--
South Solar Farm ***NEW***	2023	20 peak	--

14

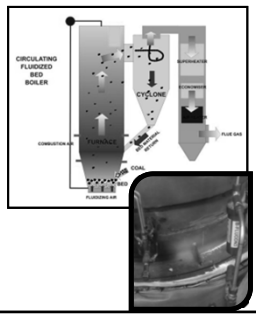
CHP Plant Units 1 – 4 Overview



15

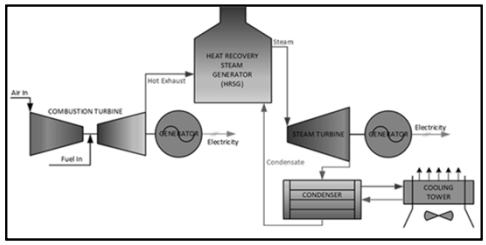
CHP Plant Unit 4 CFB Transition to Natural Gas

- Moved burners
- 100% silica sand for fluidized bed
- Erodes refractory & loop-seal expansion joints → hot spots
- Increased baghouse bag wear
- Respirable Crystalline Silica (RCS) above Permissible Exposure Limits resulting in mitigation measures for workers in affected confined space



16

CHP Plant Unit 5/6 Overview



17

RICE Plant Units 7/8/9 Overview

Reciprocating Internal Combustion Engines

- 3 x 9.4 MW engines (future 4th)
- 41% efficient (HHV gas)
- Full speed in < 5 minutes
- Operate as peaker units
- Allows the CHP plant to operate more efficiently
- Have reduced total fuel gas consumption 11-12%

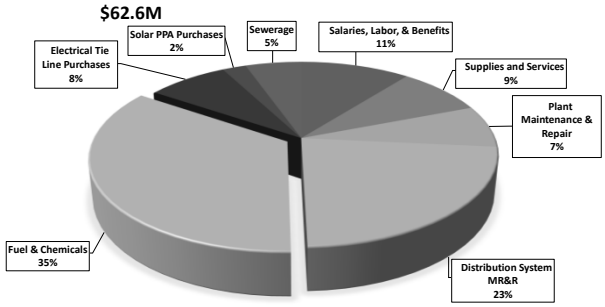
18

Auxiliary Boiler 10 Overview

- 200,000 lb/hr steam @ 90 psi
- Tied directly to campus send-out-steam
- Plan to operate as a peaker unit to meet peak campus steam demands
- Expected to allow us to operate the CHP plant more efficiently, reducing total fuel gas consumption by 10%
- Expected to be in operation by end of 2022

19

UTILITIES COSTS FY21



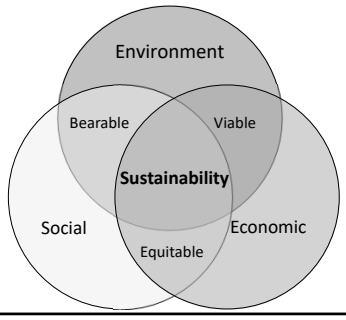
20

Campus Sustainability Goals

- Reduce Scope 1 & 2 GHG emissions 50% from 2010 baseline by 2030
- Achieve platinum STARS ranking by 2030
- Achieve Top 100 THE Global Impact ranking by 2030
- Achieve Climate Neutrality by 2050

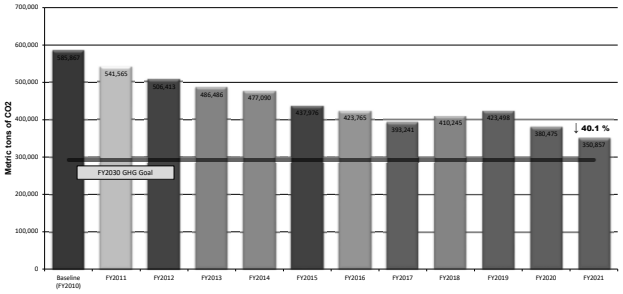
21

Sustainable Development Challenge



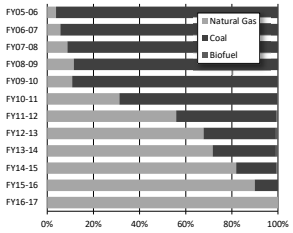
22

Campus Total Scope 1 & 2 GHG Emissions



23

Termination of Coal Firing



Fuel switch from coal to natural gas resulted in CO_2 emission reductions of > 500 million pounds per year!

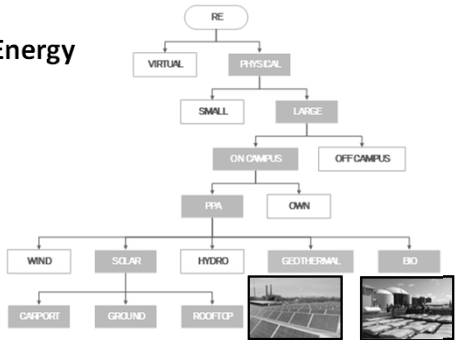
Environmental impact equivalent to planting a half million trees per year!

End of Coal (April 2016)

24

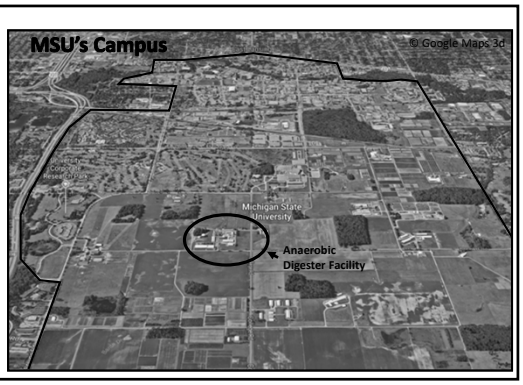
MSU Early Renewable Energy Decisions

Michigan: <10% open retail access



25

Organic Waste Equals Energy



26

MSU's Anaerobic Digester

27

Digester Feedstock

Table 2: MSU South Campus Anaerobic Digester Feedstock

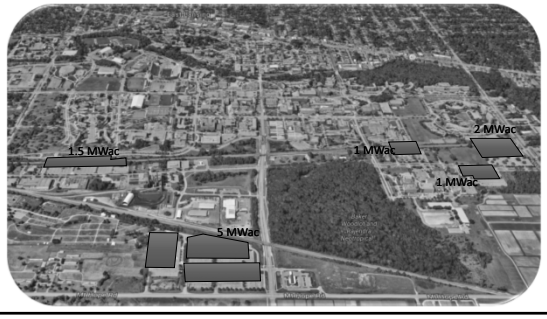
Feedstock	TS	Planned		2014		2015		2016	
	(%)	(tons)	(%)	(tons)	(%)	(tons)	(%)	(tons)	(%)
Dairy manure	12	7,000	43	16,000	67	9,525	43	10,554	52
Fruit & vegetable	11	3,900	24	2,900	12	2,900	13	0	0
Fats, oil & grease	20	5,000	30	4,400	19	3,730	17	4,747	23
Cafeteria food waste	10	750	3	430	2	440	2	513	3
Milk process waste	12					5,475	25	4,444	22
Packing material	90					60	-	34	-
Glycerin	15							88	-
Total		**16,650**		**23,730**		**22,070**		**20,380**	

Annually

- ~2,000 garbage truck loads kept out of landfill
- ~3,000 MWh of electricity generated
- ~20,000 tons of organic fertilizer produced

28

Solar Carport Site Selection

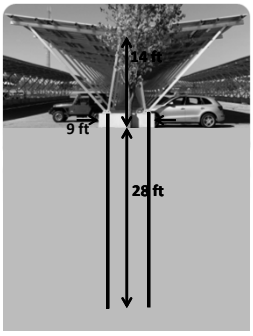


29

Solar Carport Design

- 45 acres
- 5,000 parking spots
- 40,000 solar panels
- 10.5 MW ac peak power
- 15,000 MWh/yr
- Up to 18% campus peak power demand
- 5-7% of annual campus demand

Enough electricity for 1800 Michigan households!



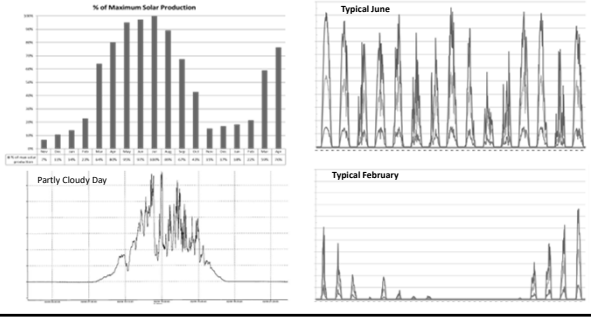
30

Solar Carport PPA

- Purchase net produced power at a fixed $/kWh price over 25 years
- Only investment by MSU is the cost of interconnect
- Developer is responsible for O&M
- Projected total net savings of about $10M over the 25-year PPA period based on projected energy cost inflation of 2.3%/year

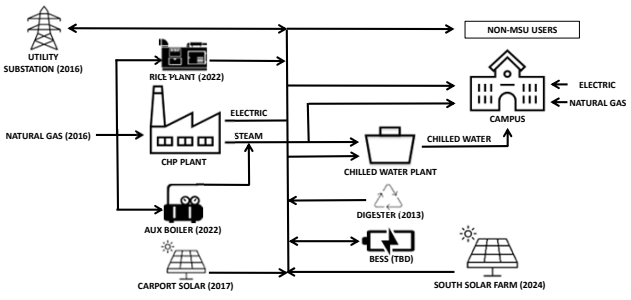
31

Solar Carport Performance



32

Firming Solar Production

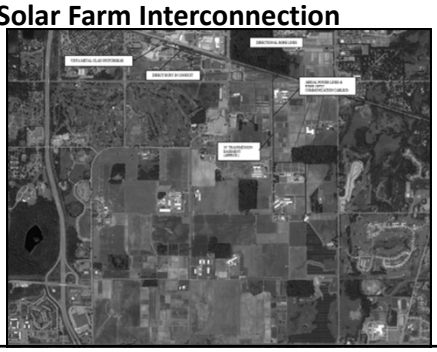


33

South Solar Farm Location

34

South Solar Farm Interconnection



35

South Solar Farm Project

- Purchase net produced power at a fixed $/kWh price over 35 years
- MSU receives Renewable Energy Credits (REC)
- Only investment by MSU is the cost of interconnect equipment
- Developer is responsible for O&M
- Projected NPV of $15-17M over the 35-year PPA period based on projected energy cost inflation of 2.3%/year and 4% discount rate

36

Energy Conservation Measures

- The #1 thing anyone can do to reduce cost and emissions
- If the power or steam is not needed, we don't have to produce it

37

Energy Conservation Measures

- In 2010, initiated a steam trap management program reducing average failure rate from 21% to 3%
- In 2011, MSU committed to reduce building energy use 20% by 2020 as part of the Better Building Challenge, we surpassed this goal 2 years ahead of schedule through:
  - Building retro-commissioning
  - Conversion of HVAC to Variable Air Volume and Variable Frequency Drives
  - HVAC control system upgrades
- Replacing fluorescent-light fixtures with TLED tubes which reduced lighting electrical consumption by about 50% and require less maintenance labor of their lifespan

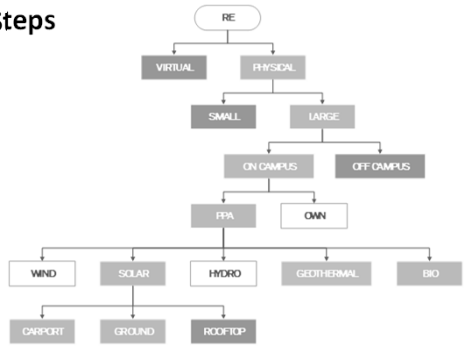
38

Current Status

INTEGRATED
UTILITY MASTER PLAN

39

Next Steps



40

Key Takeaways

- **Complex hybrid-energy microgrid supporting our East Lansing Campus**
- **Expect to reduce Scope 1 & 2 GHG emissions reduction by 50% from 2010 baseline well before 2030 goal**
- **Undergoing an Integrated Utility Master Planning effort including an assessment of:**
  - Utility generation and distribution equipment condition assessment
  - Campus energy model and forecast demand development
  - Options evaluation to cost effectively move towards carbon neutrality
- **Energy conservation is essential to any plan**

41

Questions / Comments

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Sign-in Sheet / Evaluation Form

Sherri Jett
jettsher@msu.edu

42