Acknowledgements:

Award #s 1600934 and 1800893

Disclaimer: this work was supported by the US Dept of Energy Solar Energy Technology Office and the National Science Foundation Advanced Technological Education program. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of Energy or the National Science Foundation.
A quick historical snapshot of pioneering clean energy efforts at Madison College..
MATC STUDENT HONORED

The Greater Madison Board of Realtors, Inc. honored Lem Eaton, a MATC student, at the April, 1977 GMBR Board Luncheon. Pictured is President Mike Franzen presenting the $150.00 GMBR Scholarship to Mr. Eaton.

Mr. Eaton, the son of Mr. and Mrs. Nathanial Eaton of Milwaukee, resides in Madison, Wisconsin.

Solar Heat In Portage

The energy of the sun will provide an estimated 42 per cent of the annual heating needs of a new vocational education facility at Portage.

The Area Board of Vocational, Technical and Adult Education District No. 4, reviewed the results of an energy study and instructed architect Kenton Peters to include solar heating in the design of the new building.

Bert Johnson, vice-president of Mechanical Design, Inc., said the cost of the solar heating system would be $62,000.

Johnson recommended electric heat be used to supplement the solar heat and said that arrangement would save about $41,000 over 20 years.

"Most heating will be served electrically 20 years from now," Johnson predicted.

The electric heating system would be capable of carrying the entire heating load, he said, but is expected to be used only as a supplement to the solar system.

The structure will be one of the first educational buildings in the state to employ solar heating.

"I feel strongly we need to go this way even if we consider ourselves experimental," John Mistfeldt, a board member from Fort Atkinson, said.
MATC – Portage Solar Thermal System

2,200 sq.ft. of collector surface area, producing an estimated 5,000 therms of energy annually
2.1 and 1.2 kW
Building Integrated Photovoltaic Bus Shelter – 1.0 kW (2007)
Commercial Ave PV Training Lab. 9 kW total (2010)
Solar Photovoltaic Roadmap

The Madison College Solar Roadmap was created through the College’s participation in the Solar University Network funded by the U.S. Department of Energy SunShot Initiative. Over the course of several months in spring 2018, a team from Madison College participated in a course organized by the Midwest Renewable Energy Association to develop a campus solar roadmap. The course included teams from 14 colleges and universities across the country that worked together to explore and share best practices in solar planning and development. The course included subject matter expert instructors from the education, industry, and financial sectors. Numerous solar informational resources, research analyses, online tools, and case studies provided by government agencies, national laboratories, and other colleges were examined. The Madison College Solar Roadmap is a 60 page document that was produced as an outcome of that process, with the intention that it would be incorporated in the Madison College Facilities Master Plan, to guide solar projects to be completed over the next decade.

The Roadmap was authored by:
Steven Anzorge, Madison College Student Senate President
Tom Helbig, Madison College Electrician and Electrical Instructor
Wes Marquardt, Madison College Facilities Manager
Mark Thomas, Madison College Vice President and CFO
Ken Walz, Madison College STEM Instructor & Director of the CREATE Energy Center

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Section 5: Solar PV Project Financial Modeling
Section 6: Solar PV Contracting - Bid-Ready Solar Projects
Section 7: Solar PV RFPs - Creation and Execution
Section 8: Solar PV Forecast and Future Outlook
Section 9: Solar PV Instruction at Madison College
Section 10: Solar Grant Related Activities at Madison College
Attachments and Figures

Maps Illustrating the Madison College District and MGE Service Territory
Ariel View of the Truax Main Building (taken before new construction)
View of SE corner of 3rd floor roof. Looking East
View of NE corner of roof looking Northeast
View from roof facing south – note 100% open solar window
Decrease in solar costs since 2010
(this allowed the college to increase the system size)

Figure 33. NREL PV system cost benchmark summary (inflation adjusted), 2010–2018
Estimated System Production

2,300,000 kWh average annual PV system production
Energy Impact for MC

- On a good day: offset roughly 75-100% of Truax campus electric load
- Over a year: offset roughly 20-25% of consumption
Let’s Look At the Roof Replacement and Soar Installation Process…
Madison College Alumni were part of the crew!
Ecolibrium ballasted rack
Unirac RMDT

- 8° tilt dual tilt (E-W) design to maximize power density due to existing roof penetrations and skylights
Ecolibrium Eco X Metal – Standing Seam Racking
SolarEdge New Synergy Inverters

- SE10KUS, SE66.6K, & SE100KUS inverters with integrated monitoring, 10 year warranty
- P730 DC power optimizers – two modules per optimizer
  - Max Power Point Tracking
  - Monitoring to the optimizer level using powerline communication
  - NEC 2017 rapid shutdown compliant
- Israeli company founded in 2006; 2,500 MW shipped in 2017
Madison College 1.85 MW Solar System

5700 panels
119,300 sq ft
Roughly two football fields worth of panels

ADA Accessible Student Lab
Overview

Current Power: 94.1 kW
Energy today: 1.65 MWh
Energy this month: 119.97 MWh
Lifetime energy: 621.14 MWh

Power and Energy

Day: 05/31/2019

System Production: 11 MWh

Weather

Cloudy
65 °F
Feels like 65 °F
Wind: 3 MPH
Humidity: 68%
Sunrise: 05:17
Sunset: 20:39

Monday: 73 - 59 °F
Partly Cloudy

Tuesday: 75 - 61 °F
Partly Cloudy

Wednesday: 68 - 55 °F
Cloudy

Environmental Benefits

CO2 Emission Saved: 961,815.5 lb
Equivalent Trees Planted: 24,224.62
Madison College Truax PV System
Commissioned 2019

• 1.85 MW_{DC} - (5,700) Yingli YL325P-35b modules
• 1.65 MW_{AC} - SolarEdge 33kW kW Inverters
• 277/480 VAC output for three phase interconnection
• Fully UL listed, NEC 2017 Rapid shutdown compliant
• 730 W DC optimizer per pair of modules

• Conception, Mar 2017 – Completion, June 2019
How can Madison College’s Experience help other schools?
10 Steps to a Solar Roadmap for Educational Institutions

Honors student: Steven Ansorge
Honors Mentor: Ken Walz

Download available at: www.CreateEnergy.org
Why Solar Roadmaps?

Smart of Allocation of Resources

- Schools have many places to invest $, solar is just one of them
- Spend $ where it has the greatest benefit
Step 1: Assemble Roadmap Team

- Steven Ansorge, Student Senate President
- Tom Helbig, Electrician and Electrical Instructor
- Wes Marquardt, Facilities Manager
- Mark Thomas, Vice President and CFO
- Kenneth Walz, Renewable Energy Instructor
### Step 2: Motivating Objectives

<table>
<thead>
<tr>
<th>Reason for &quot;go solar&quot;</th>
<th>Rank</th>
<th>Rank</th>
<th>Rank</th>
<th>Rank</th>
<th>Rank</th>
<th>Average Rank</th>
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<tbody>
<tr>
<td>Cost savings</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>2.4</td>
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<tr>
<td>Learning opportunities for students</td>
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<td>4</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2.8</td>
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<tr>
<td>Energy budget certainty (cost hedging)</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>3.2</td>
</tr>
<tr>
<td>Social and environmental goals</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>3.6</td>
</tr>
<tr>
<td>Energy resilience for critical electrical loads</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>&quot;Green&quot; visibility</td>
<td>5</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>5.2</td>
</tr>
<tr>
<td>Off balance sheet treatment (e.g., capital or operating leases)</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td>5.8</td>
</tr>
</tbody>
</table>
## Step 3: Identify Stakeholders

### Phases of Development

<table>
<thead>
<tr>
<th>Development of Solar Roadmap</th>
<th>Prioritization of Solar Sites</th>
<th>Exploration of Funding Vehicles</th>
<th>Proposal and Approval of Projects</th>
<th>Legal/Contractual</th>
<th>Project Design</th>
<th>Project Execution</th>
<th>Operations and Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV Roadmap Team</td>
<td>PV RoadMap Team</td>
<td>PV RoadMap Team</td>
<td>Facilities Team</td>
<td>Facilities Team</td>
<td>Facilities Team</td>
<td>Facilities Team</td>
<td>Facilities Team</td>
</tr>
<tr>
<td>Internal Stakeholders</td>
<td>Campus Managers</td>
<td>Financial Team</td>
<td>Presidents Office</td>
<td>Legal Office</td>
<td>Program Faculty</td>
<td>Faculty?</td>
<td>Faculty?</td>
</tr>
<tr>
<td>PV Students?</td>
<td>MATC Foundation</td>
<td>College Board</td>
<td>Procurement Office</td>
<td>Students?</td>
<td>Students?</td>
<td>Students?</td>
<td>Students?</td>
</tr>
<tr>
<td></td>
<td>Grants Office</td>
<td>Grants Office</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roofing Contractors</td>
<td>NSF, DOE, etc.</td>
<td>Electric Providers</td>
<td>Electric Providers</td>
<td>Electric Providers</td>
<td>RE Industry Adv Board</td>
<td>Solar Contractors</td>
<td>Electric Providers</td>
</tr>
<tr>
<td>Focus on Energy</td>
<td>City Permitting</td>
<td>Electric Providers</td>
<td></td>
<td>Electric Providers</td>
<td>Electric Providers</td>
<td>Electric Providers</td>
<td>Electric Providers</td>
</tr>
<tr>
<td>PV Developers</td>
<td>FAA Permitting</td>
<td>NREL</td>
<td></td>
<td>Permitting Bodies</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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START <-----------------------------Phases of Development ------------------------------> FINISH
Step 4: Energy Usage and Costs

Electric bills represent an ongoing operational cost for colleges and universities.

**Madison Gas and Electric Rates per kWh**

<table>
<thead>
<tr>
<th></th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-Peak (nights and weekends)</td>
<td>$0.049</td>
<td>$0.037</td>
</tr>
<tr>
<td>On-Peak (days)</td>
<td>$0.099</td>
<td>$0.086</td>
</tr>
</tbody>
</table>

- HVAC upgrades
- LED and natural daylighting
- Occupancy (motion) sensors
- Insulation and weatherization
- Sleep mode for computers/printers
- Solar and Wind energy installations

**WI Tech College System Statewide Average Building Energy Use**
83,000 BTU/sq ft

- **2020 Target = 25% less than WTCS Ave goal met in 2013**
- **2030 Target = 50% less than WTCS Ave goal met in 2018**
Step 6: Assess Sites for Solar

Health Education Building

1705 Hoffman St., Madison, WI 53704

Electric Provider = MGE, CG-2 Rate
Energy Use Index (Btu/ft²) = 33,178
Peak Electric Load = 545 kW

Age of Roof = 3 years
Rooftop solar system size estimate = 250 kWdc
Step 7: Economic Modeling

The year by year benefit of the system taking into account all revenues and expenses

- **Inputs**
  - System Size (W): 1,350,000 W
  - System Term (years): 30 years
  - Electricity Rate ($/kWh): $0.099
  - Electricity Rate Escalator (%): 2.00%

- **Economics**
  - Initial Capital Cost ($): $(2,197,500)
  - Avoided Electricity Cost ($): $6,487,887
  - Operating Expenses ($): $(136,917)
  - Incentives ($) : $500,000
  - Total Lifetime Benefit ($) : $4,653,470

- **Returns**
  - Internal Rate of Return: 10.5%
  - Net Present Value: $2,170,000
  - Levelized Cost of Electricity: $0.038/kWh

**Online Calculator:** SolarProjectBuilder.org
### Step 8: Prioritize Projects

<table>
<thead>
<tr>
<th>System and Status</th>
<th>Target Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.85 MW Truax Rooftop solar system</td>
<td>Dec 2018</td>
</tr>
<tr>
<td>New Madison South Campus</td>
<td>Summer 2019</td>
</tr>
<tr>
<td>Highest Priority Future System for Energy Generation</td>
<td>Dec 2019</td>
</tr>
<tr>
<td>Health Science and Protective Services</td>
<td>(to take adv of 30% ITC tax credits)</td>
</tr>
<tr>
<td>Highest Priority Future System for Instructional Use</td>
<td>2020</td>
</tr>
<tr>
<td>Commercial Avenue PV Training lab redesign to incorporate energy storage and electric vehicle charging</td>
<td></td>
</tr>
<tr>
<td>Lower Priority Systems</td>
<td>Dec 2021</td>
</tr>
<tr>
<td>Regional Campuses</td>
<td>(to take adv of 22% ITC tax credits)</td>
</tr>
<tr>
<td>Energy Storage (lithium-ion battery) system for Truax</td>
<td>?</td>
</tr>
<tr>
<td>Feasibility Study to be completed in 2018-2019</td>
<td></td>
</tr>
</tbody>
</table>
Step 9: Disseminate the Plan

Facilities Plan
Academic Plan
Grants Office
Community
Step 10: Implement Projects
Questions?

kwalz@madisoncollege.edu