A Novel Microgrid Demand-Side Management System for Manufacturing Facilities

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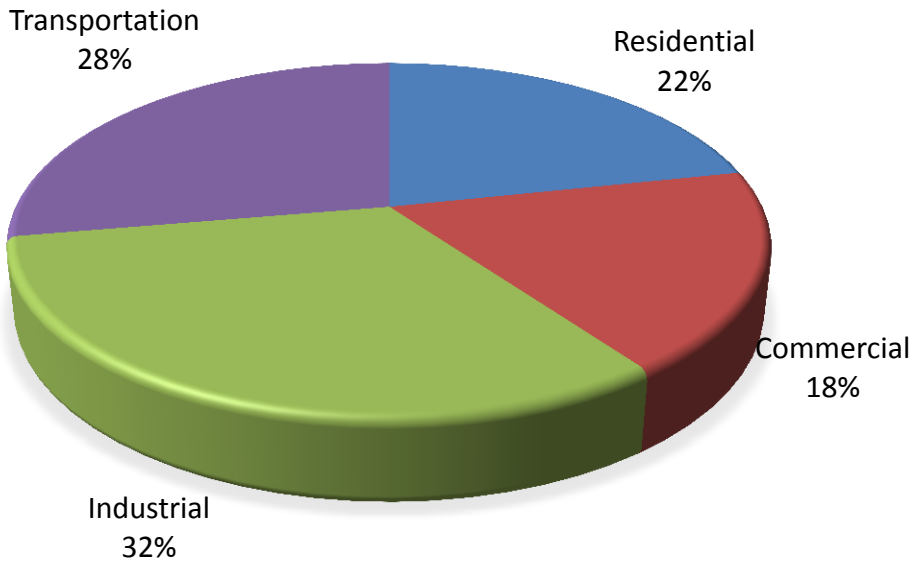
Scope & Significance of Study

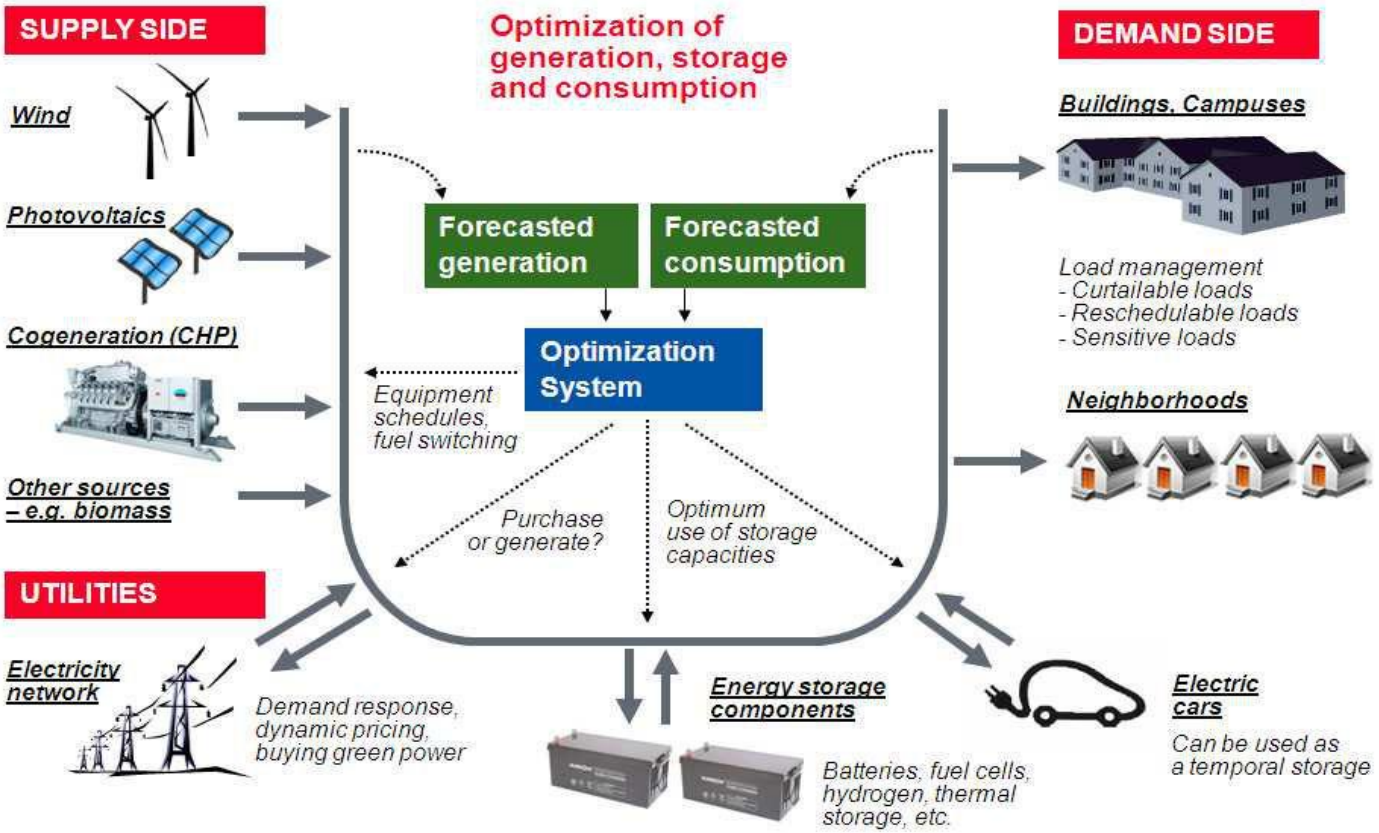
- The manufacturing process is the core of many manufacturing enterprises.
  - In the US alone 31 percent of annual energy consumption is from the industrial sector.
- Peak demand or peak load on national and local utility companies.
  - Utility companies charge manufacturers an extra surcharge based on their highest level of energy usage monthly
- Microgrid technology to improve energy utilization through load management.



Energy Consumption by Sector (www.eia.org))

Commercial Microgrids

- Microgrids, also known as Distributed Energy Resources (DERs), have attracted much attention to provide a reliable, efficient, economic, and sustainable energy supply in Smart Grid initiatives all around the world



Schematic Representation of the Microgrid, (Stluka, Godbole, & Samad, 2011)

Microgrid Prototype

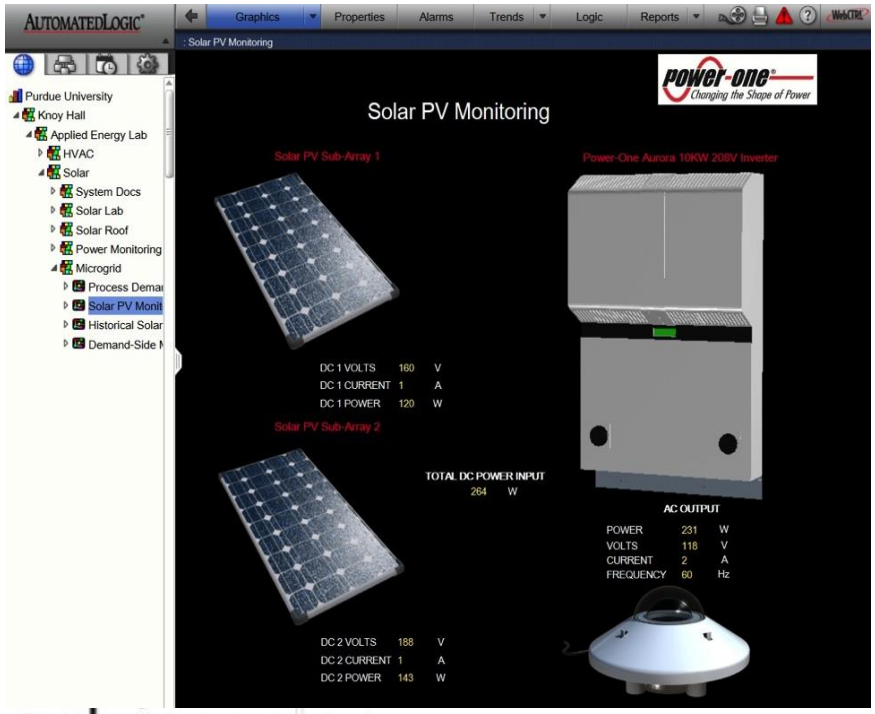
- 3 kW solar PV array mounted at 45°.
  - Electrical infrastructure upgrade to grid-tie the system.
- Process heating and cooling system used to simulate demand-side loads.

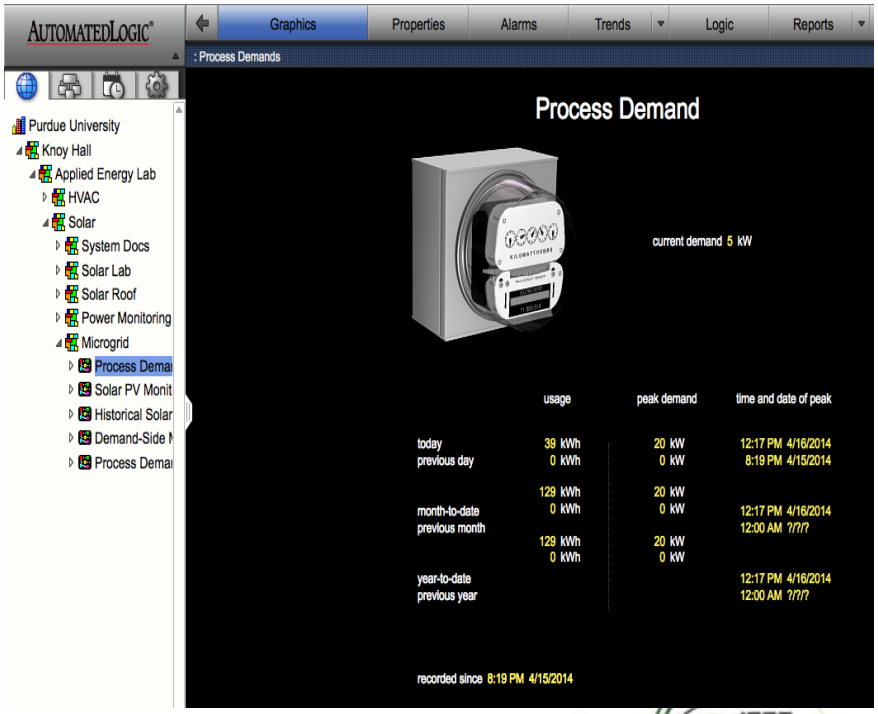
24-Panel Array with Weather Station

AEL Manufacturing Process

Supervisory Control and Data Acquisition (SCADA)

- Supply-Side
  - Inverter read and wrote real-time data
  - Modbus TCP/IP to transfer to third-party SCADA
- Demand-Side
  - Monitored and controlled by building automation software.
  - Sensors monitored electrical energy
- System Integration (WebCTRL)
  - SCADA link for supply and demand.
  - Development of process control strategies.



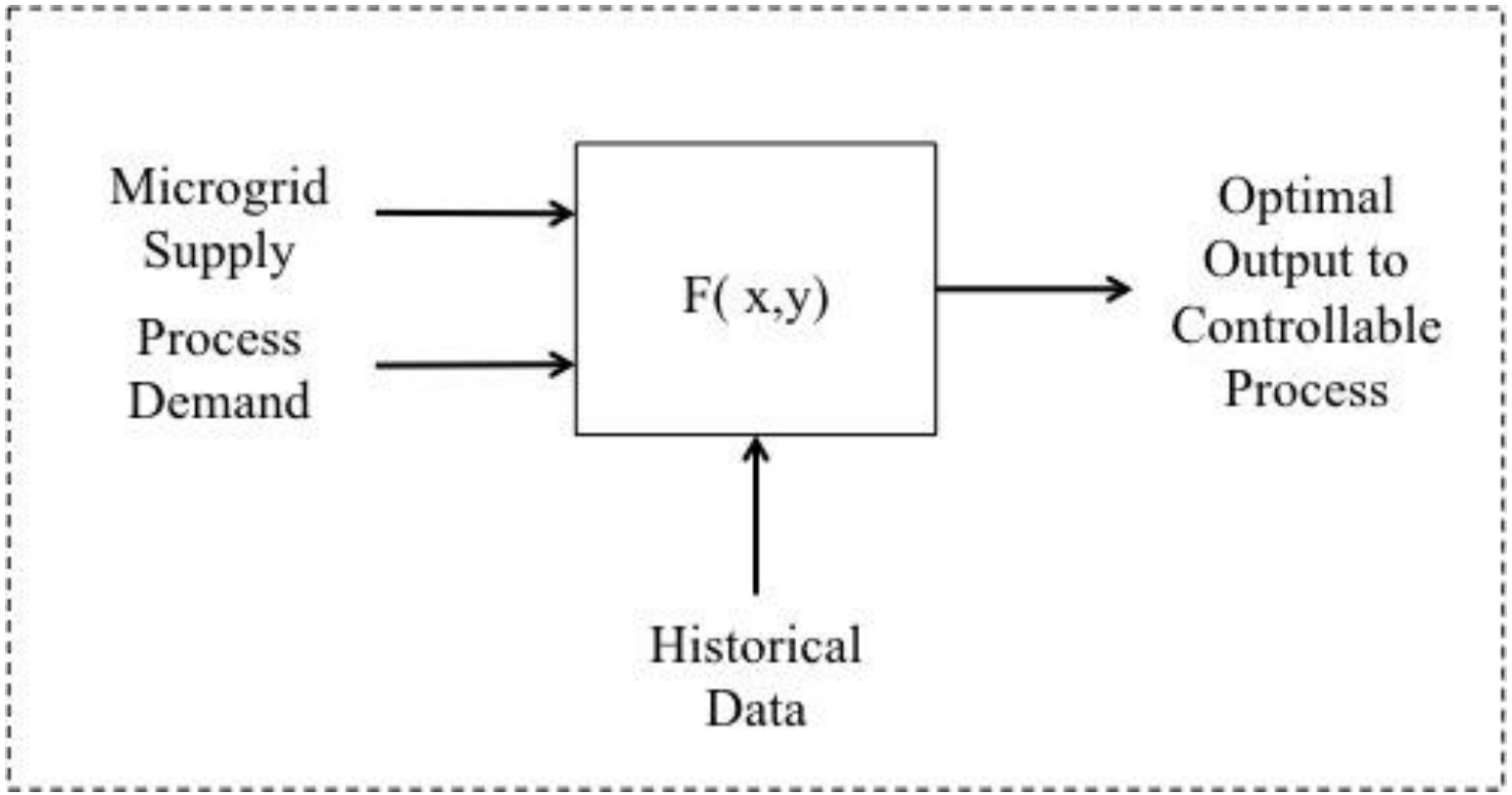


Hypothesis

- This research should determine if microgrid technologies have the potential to reduce peak demand and electrical consumption for manufacturing facilities by using DSM programs based from microgrid generation and process demand.

Performance Objective	Metric	Data Requirements	Success Criteria
1. Manufacturing Process Output	Instantaneous Demand vs. Power Generated	Power Sensors(s)	Maintain 70% of full capacity
2. Peak Demand Reduction	Peak Demand (kW)	Power Sensor(s)	Reduce peak demand 5%
3. Electrical Consumption Reduction	Electrical Consumption (kWh)	Power Sensor(s)	Supply 15% capacity

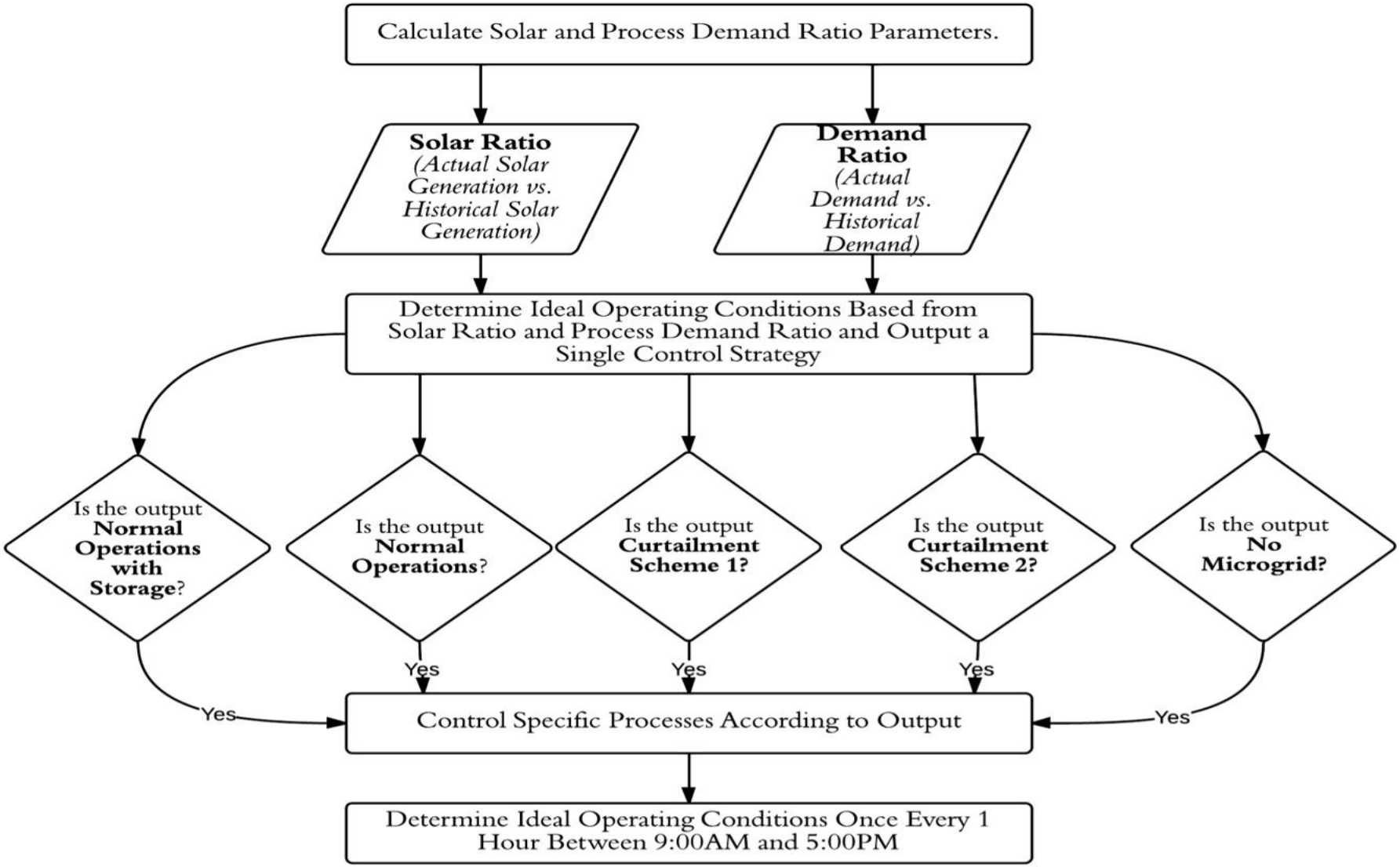
Demand-Side Management Model



Coordination with Facility Engineer

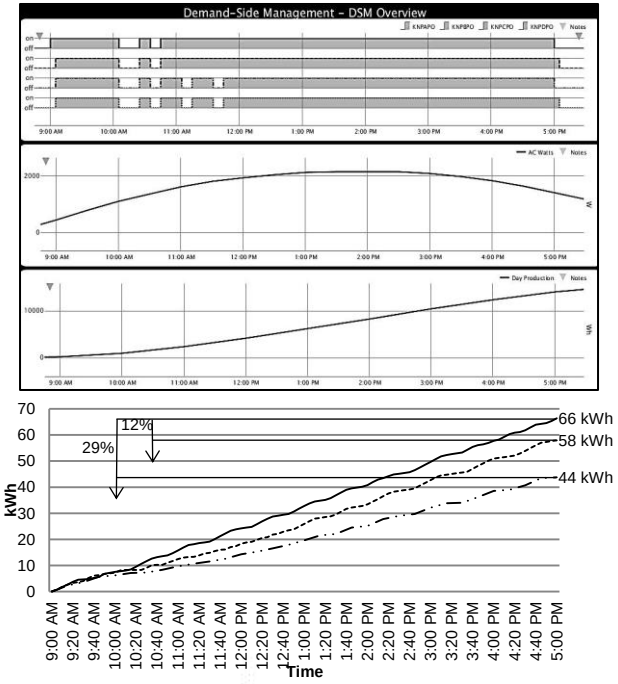
- This algorithm is customized for a manufacturing facility based on its geographic location and load profile.
- A Facility Engineer would work closely with the Microgrid system integrator to determine:
  - Solar (or other renewable) resource availability
  - Load use patterns
  - Curtailable loads

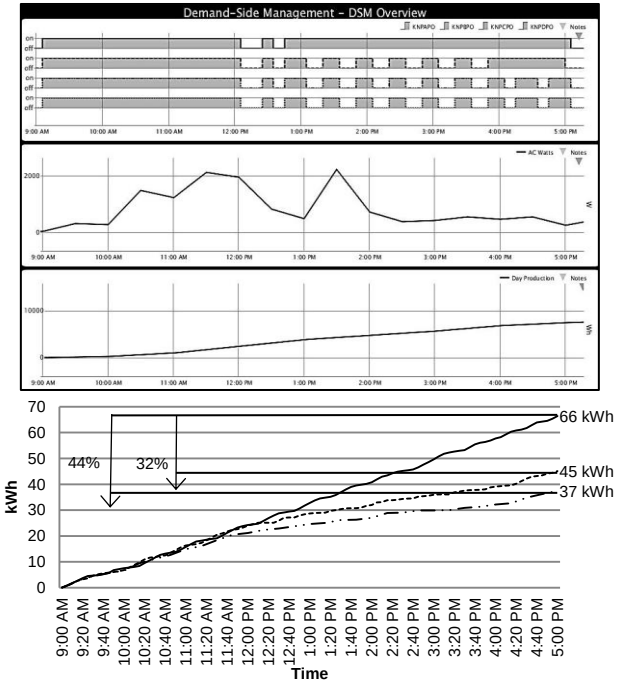
Methodology: DSM Control Algorithm

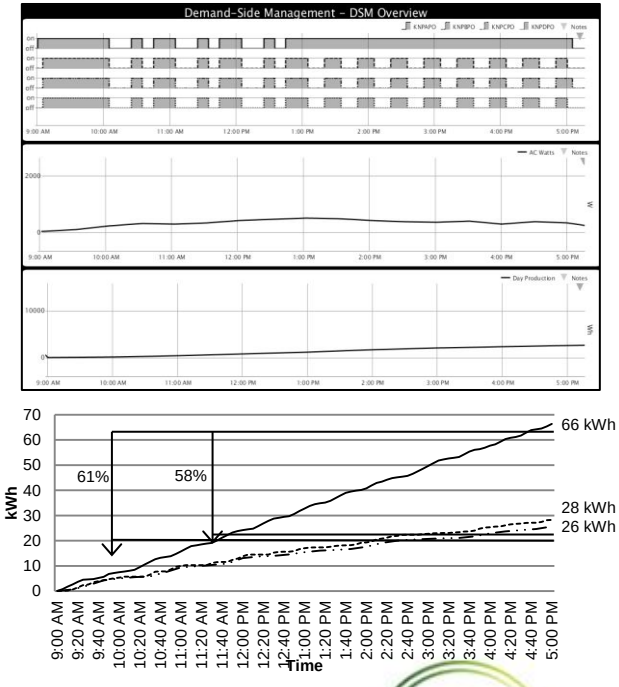


Electrical Consumption Reduction

- Ideal Supply Generation
  - DSM: 12% Reduction
  - Microgrid : 29% Reduction
  - Generation: 14 kWh
  - Total Reduction : 22 kWh
- Optimal Supply Generation
  - DSM: 32% Reduction
  - Microgrid : 44% Reduction
  - Generation: 8 kWh
  - Total Reduction : 29 kWh
- Less than Optimal Supply Generation
  - DSM: 58% Reduction
  - Microgrid : 61% Reduction
  - Generation: 2 kWh
  - Total Reduction : 41 kWh

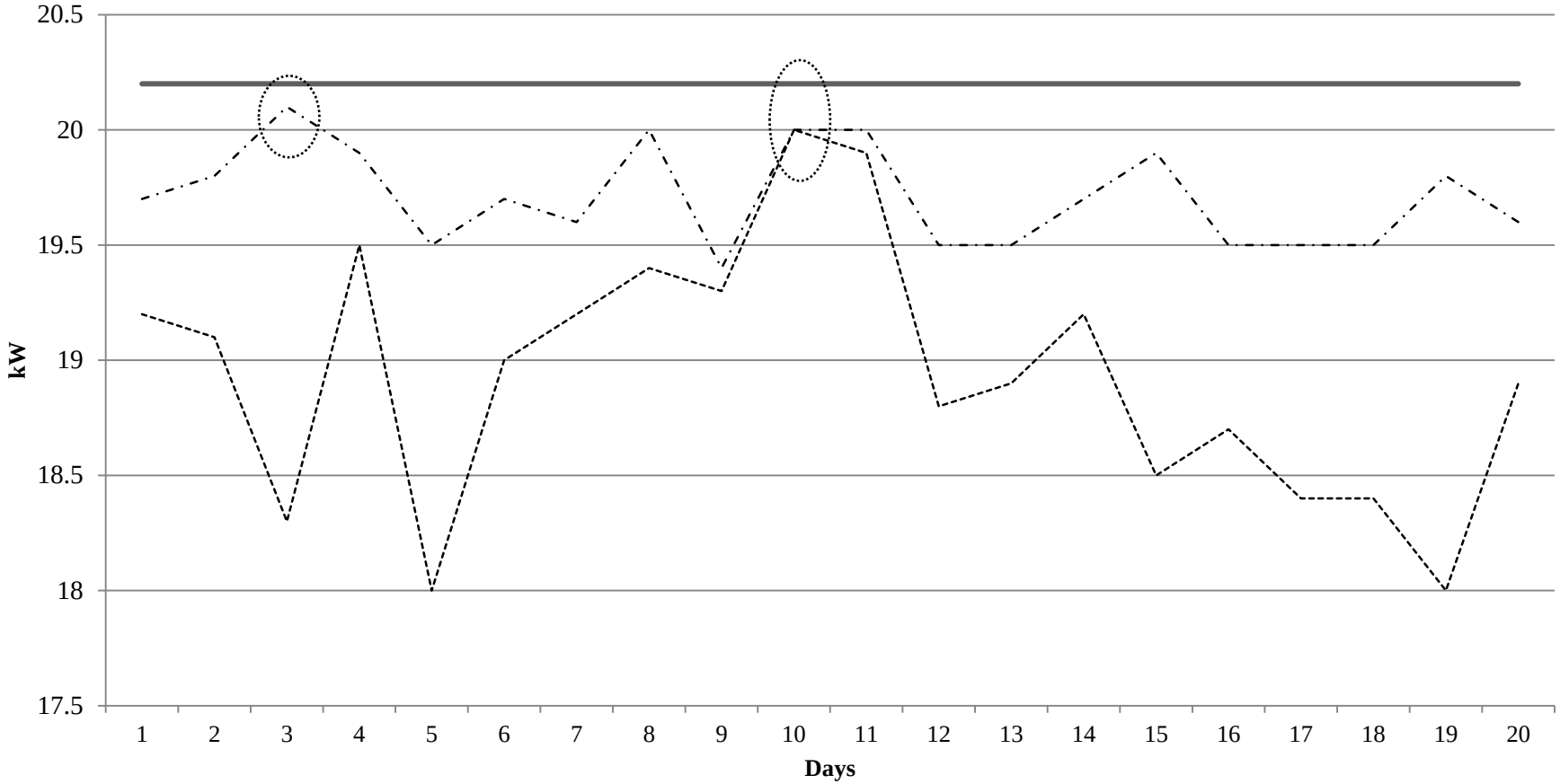




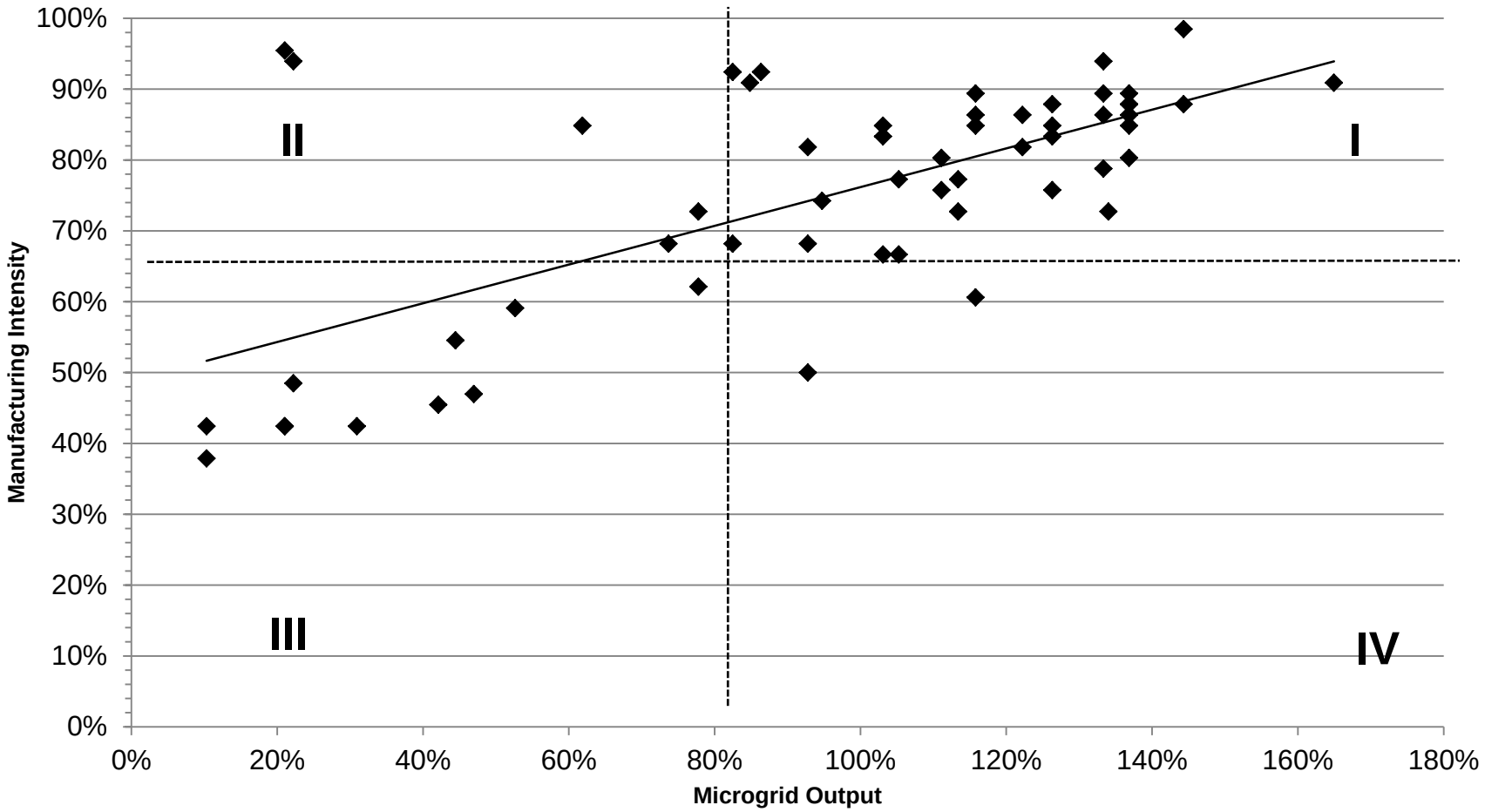


Peak Demand Reduction

- DSM Reduction: .5%
- DSM/Microgrid Reduction: 1%



Impact of DSM/Microgrid on Manufacturing Process



Manufacturing Scale-Up

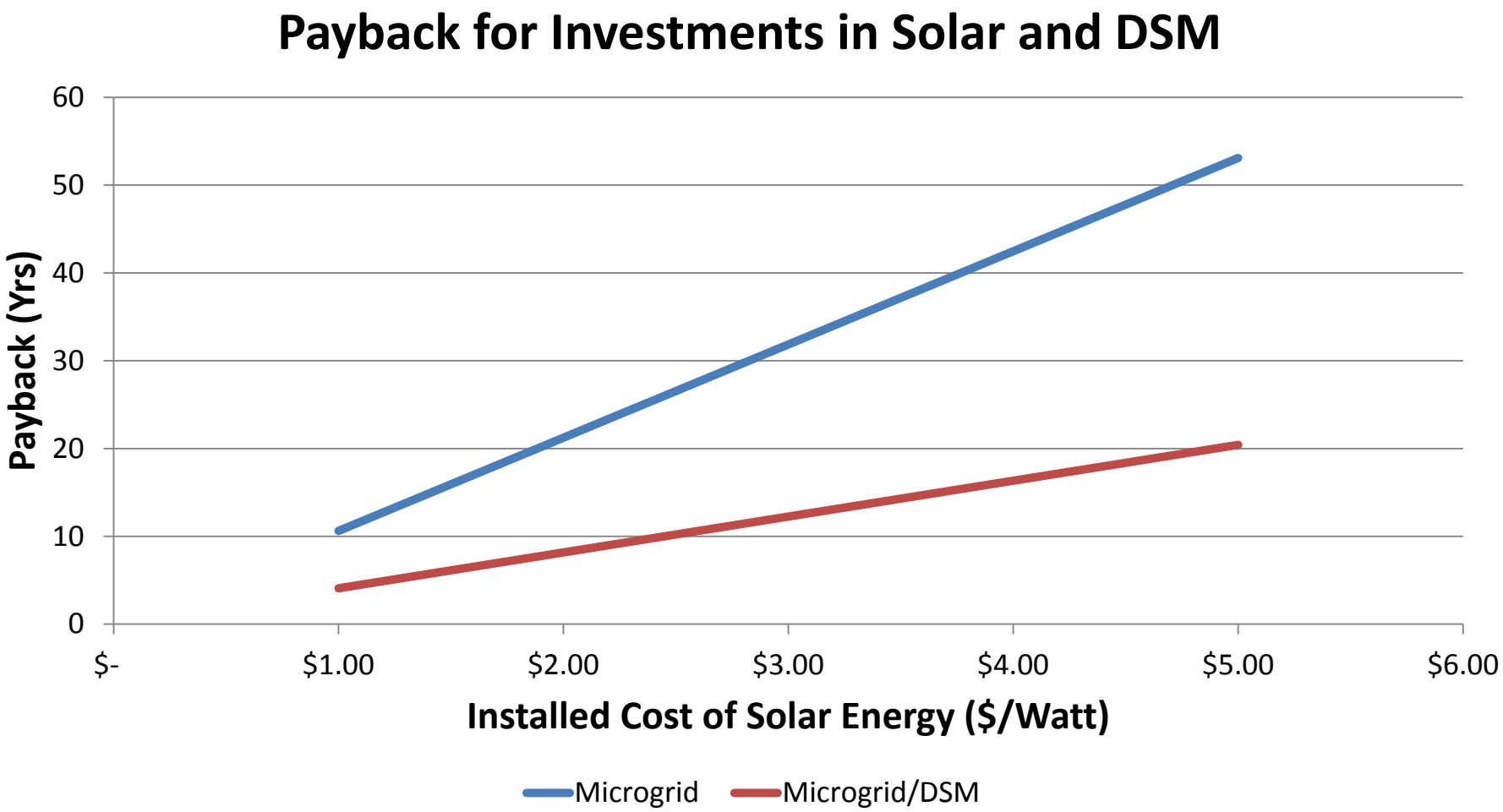
Prototype		Full-Scale projection	
System Size (kW)	Annual Electric Generation (kWh)	System Size (MW)	Annual Electrical Generation (MWh)
3	3,100	8	9,500

	Prototype		Full-Scale projection	
	Electric Consumption (kWh)	Annual Electric Consumption (kWh)	Reduction (%)	Annual Electric Consumption (MWh)
Baseline	66.0	24,100	0%	75,000
DSM	50.1	18,300	24%	57,000
Microgrid	41.5	15,100	37%	47,300
Total Reduction	24.5	8,950	-37%	27,800

Manufacturing Scale-Up

	Prototype		Full-Scale projection	
	Peak Demand (kW)	Annual Peak Demand (kW)	Reduction (%)	Annual Peak Demand (MW)
Baseline	20.2	20.2	0%	12.0
DSM	20.1	20.1	0.5%	11.9
Microgrid	20.0	20.0	1%	11.8
Total Reduction	0.2	0.2	-1%	0.1

Present Value Analysis



Conclusions, Future Opportunities

- A methodology for using renewable energy and DSM to save energy at a manufacturing facility was developed
  - Close collaboration with facility engineers at a specific manufacturing facility is needed
- The microgrid prototype showed the potential for energy savings of up to 37% percent using combinations of renewable energy and DSM
- There is significant potential for additional savings by reducing peak demand but that cannot be fully realized without some form of energy storage
- Working on a collaborative proposal to the U.S. Department of Energy's "Solar Market Pathways" solicitation that will investigate the feasibility of university investments in utility-scale solar energy