Agenda

- Corporate overview
- Motivation
- Industrial Facilities Operation
- Energy Footprint Reduction
- Conclusions
M+W Group
At a glance

- Technology-driven global engineering and construction company
- Focus on complex factories & energy generation facilities
- Established in Germany in 1912 with over 100 years of history
- Global data:

  Reach: Offices in 31 countries
  Sales: $3.05B annually
  Employees: 5,700
Key Markets

- Renewable Energy
- Mission Critical
- Electronics
- Next-gen Batteries

- Science & Research
- Life Science, Food, Consumer Products
- Chemicals
- Space & Security
Motivation
Industrial Facilities

- Reduce energy costs, make energy costs more predictable
- Achieve aggressive sustainability goals
- Reduce complexity in decision making (solar, storage, energy efficiency, etc.)
Motivation
Industrial Facilities: Cost Efficiency & Sustainability

Cost Efficiency
- Site Evaluation
- Life Cycle Cost Analysis
- Fab Concept
- Re-Use Recycling
- Modularization
- Fast Track
- Logistics
- Specifications (Benchmarking)
- Contract Approach
- Global Presence and Network
- Automation
- Gigawatt Fab

Sustainability
- Green Building
- Water-Use Effectiveness
- Hook Up
- Process Technology
- Integrated Fab
- Process Supply Systems

Time to Market
- Integrated Fab

Process Integration

Approach
Industrial Facilities: Energy Management Strategy

Step 5
Alternative Energy Systems Optimization

Step 4
Energy Generation System Optimization

Step 3
Thermal Energy Supply System Optimization

Step 2
Facility Systems Efficiency

Step 1
Production Energy Efficiency

- Production Tools
- PCW, CDA, Abatement, Air handlers

Inside-Out Approach to Energy Management during facility design

Heat Recovery

Boilers, Chillers, Co-Gen, Tri-Gen

PV, Storage
# Energy Efficiency
## Industrial Facilities: Case Study

- Energy savings strategy for a fully operational hi-tech manufacturing facility is illustrated
- Efficient design & management of facility systems is a “low” hanging fruit for reducing overall energy footprint, and can have a potential ROI of <3 years
- Implementing energy efficiency measures reduces the degree of electrical power generation from renewable sources (Solar, Storage, etc.)

<table>
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<th>#</th>
<th>System</th>
<th>Changes</th>
<th>Power Saving MWh/a</th>
<th>Power Saving KW (Peak)</th>
<th>Natural Gas Saving MWh/a</th>
<th>Energy Cost Saving $</th>
<th>Payback Years</th>
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Energy Storage
Demand Charge Reduction

Peaker plants support fast ramps to meet demand
- Solar Production: 9 am to 12 pm
- Peak Demand: 3 pm to 9 pm

Independent System Operators (ISO)
- Demand forecasts
- Grid Resiliency

C&I customers pay heavy Electricity Demand Charges
(can account for >50% of the bill)

Contract bids
- Demand
- Time of Use

Peak Demand
- 3-6 X price

Distribution utility A

Distribution utility B

Increasing solar penetration

Over-generation risk

Source: Tariff data from PG&E (2013)
Hi-Tech manufacturing fab: Test case to evaluate potential ROI using storage
- Major loads: Chillers, Cooling Towers, HVAC, other facility loads
- Overall facility demand roughly follows chiller profile
Effect of off-peak hours (evening to night-time) has little effect on load profile.

Seasonal variation in 24-hr load profiles likely related to ambient temperature:
- Summer: 0.76 MW
- Fall: 0.47 MW
- Winter: 0.4 MW

On a typical summer day, magnitude of daily demand shift as high as 4 MW!

The potential for demand peak shaving or shifting opportunity dependent on Utility rate tariffs.
Industrial Facility Demand
Heat map of daily demand

Assumptions
- 25 MW Solar
- 15 MW / 30 MWh Storage
- Data was collected at 60 min-interval for 12 months
- Solar and storage help offset demand from the industrial facility
Economic Analysis
ROI: Solar + Storage on Industrial Facility

- Utility: SCE
- Tariff: TOU-8B
- Utility Bill: $69M
  - Energy: $43M
  - Demand: $26M
- 30% ITC, $1.50/W (installed)
- Capital cost: $37.5M
- **Energy Savings**: $2.8M
- Payback: 4 years
- NPV (20 yr @ 6%): 37.6M
- IRR (20 yr): 21.4%

- Escalators
  - Energy Charge: 3%, Demand Charge: 5.5%, O&M: 2%

- Solar Only
  - (25 MW)
  - 6% Savings
  - $800/KW, $400/KWh
  - Capital cost: $49.5M
  - **Energy Savings**: $5.7M
  - Payback: 3.5 years
  - NPV (20 yr @ 6%): 56M
  - IRR (20 yr): 24.1%

- Solar + Storage
  - (15 MW / 30 MWh)
  - 8% Savings
  - Escalators
Economic Analysis
PV & Storage ROI Analysis: Future Direction

- Key Hurdles:
  - Land acquisition?
  - Technical Feasibility: Storage?
  - Financing vs ownership?

- Sensitivity analysis with multiple scenarios:
  - 15-50 MW solar
  - 15-30 MW / 30-45 MWh Storage
  - Multiple tariff structures
  - Geographies

- Solar & Storage ROI analysis of industrial facilities running at predictable manufacturing capacities (YOY)

- Comparison of ROI with commercial buildings within the same geography
Energy Storage
Value to Stakeholders

- Battery utilization: 5-50% if used only for demand charge reduction
- Regulations prevent unlocking of grid-services today
- Storage Project IRR (commercial)
  - CA ~10% (with SGIP)
  - NY ~10-20% (REV)

Conclusions

- Cost Efficiency and sustainability are the key drivers of innovation in energy supply and management for Industrial Facilities.
- Energy Efficiency measures can be implemented by fab operators with rapid turnarounds.
- Demand Charge Reduction is the key driver for energy storage adoption in the C&I sector today. Storage will provide more value to stakeholders via additional ‘grid-services’.
- Preliminary analysis shows the possibility of a healthy ROI on solar and storage assets at industrial facilities, if certain technical and logistical caveats are addressed.
- Demand-side Efficiency, PV, and Storage are assets Industrial facilities can provide to the grid in a mutually beneficial way.
Thank you for your attention!

Ankush Halbe
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Getting to Zero National Forum
Denver, CO