MDU Solar Energy Project
Case Study

A Partnership between Ellsworth AFB and MDU Resources Group, Inc.
Based in Bismarck, North Dakota
Celebrated our 85\textsuperscript{th} year in 2009
NYSE - MDU for over 60 years
Over $4B market cap
Fortune 500 Company
Member of the S&P MidCap 400 Index
Over 8,000 employees in 44 states
Business Lines:
- Energy
- Utility Resources
- Construction Materials
- Construction Materials
- Energy
  - Oil and Gas Production
- Utility Resources
  - Natural Gas Pipelines
  - Construction Services
  - Electric / Natural Gas Utilities
Utility Resources

- Montana – Dakota Utilities Co.
- Cascade Natural Gas Co.
- Intermountain Gas Corporation
- Great Plains Natural Gas Co.
- About 950,000 customers
- ND, SD, WY, MT, WA, OR, ID, MN
- Bitter Creek Pipelines, LLC
- Non-Regulated sister company
Ellsworth – Montana Dakota Utilities Co. Service Area

Ellsworth AFB and the MDU Resources Group, Inc. have a well developed partnership having completed numerous projects over the past decade

- Propane Air Mix Plant / Expansion
- Two UESC Task Orders
- Advance Metering Initiative
- New UESC Task Order #3
- Solar Energy Project
Ellsworth Air Force Base
Rapid City Army Air Base
Completed 20 September 1942
Historical Perspective

“If the building is not in compliance and it is the willful disregard of the occupants, the utilities office feeds the information to Shields who deals with it through the chain of command.” (EAFB Newspaper, January 1974)

Brigadier general William L Shields retired in 1981 after a 35 year career.
ELS 3\textsuperscript{rd} QTR 10 Energy Management

**Utility FO Expenditures**

Goal: 2\% Reduction  Actual: 9.0\% Decrease

<table>
<thead>
<tr>
<th></th>
<th>1Q10</th>
<th>2Q10</th>
<th>3Q10</th>
<th>4Q10</th>
</tr>
</thead>
<tbody>
<tr>
<td>K $</td>
<td>$1,000</td>
<td>$2,000</td>
<td>$3,000</td>
<td>$4,000</td>
</tr>
</tbody>
</table>

**Energy Intensity**

Goal: 3\% Reduction  Actual: 2.7\% Decrease

**Water Consumption**

Goal: 2\% Reduction  Actual: 20.3\% Decrease

<table>
<thead>
<tr>
<th></th>
<th>1Q10</th>
<th>2Q10</th>
<th>3Q10</th>
<th>4Q10</th>
</tr>
</thead>
<tbody>
<tr>
<td>GAL / SFT</td>
<td>5</td>
<td>15</td>
<td>25</td>
<td>45</td>
</tr>
</tbody>
</table>

**Renewable Energy**

Goal: 5\% of Total Electricity  Actual: 0.0\% of Total

Legend:

Blue Bar = Previous FY  Yellow Bar = Current FY  Green Bar = Current FY Goal
Advanced Metering Website

AFAMMS
Air Force Advanced Meter Monitoring System

Top Meters at Ellsworth Air Force Base for the selected date range

<table>
<thead>
<tr>
<th>Electric</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Meter</td>
<td>Building</td>
<td>Usage (kWh)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2399173S</td>
<td>7540 - 2BMXS CC/SHP AVIONICS/SUPPLY WAREHOUSE 12A/SUP ADMIN</td>
<td>3,005.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23868100</td>
<td>3920 - COMMISSARY</td>
<td>2,934.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23604693</td>
<td>6000 - MEDICAL CLINIC</td>
<td>2,589.00</td>
<td></td>
<td></td>
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<tr>
<td>23991684</td>
<td>2500 - RUSHMORE CENTER</td>
<td>2,136.75</td>
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<tr>
<td>23991405</td>
<td>7540 - 2BMXS CC/SHP AVIONICS/SUPPLY WAREHOUSE 12A/SUP ADMIN</td>
<td>1,919.22</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Gas</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Meter</td>
<td>Building</td>
<td>Usage (Dth)</td>
<td></td>
</tr>
<tr>
<td>54493457</td>
<td>7709 - SWIMMING POOL &amp; GYMNASIUM</td>
<td>29.15</td>
<td></td>
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<tr>
<td>54488992</td>
<td>8210 - BASE ENGINEERING MAINTENANCE SHOPS COMPLEX</td>
<td>18.69</td>
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<tr>
<td>54493669</td>
<td>7244 - DOCK 80 AMXS SUPPORT SECTION/TOOL ISSUE FOR 37TH</td>
<td>17.67</td>
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<tr>
<td>54493472</td>
<td>7260 - DOCK 61 SHIP AGE/STOR FACILITY NO OFFICES</td>
<td>17.35</td>
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<tr>
<td>51935663</td>
<td>7504 - PRIDE HANGAR/RUNNING TRACK, SIDE OFFICES VACANT</td>
<td>15.79</td>
<td></td>
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<table>
<thead>
<tr>
<th>Water</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Meter</td>
<td>Building</td>
<td>Usage (Gal)</td>
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</tr>
<tr>
<td>16244753</td>
<td>7709 - SWIMMING POOL &amp; GYMNASIUM</td>
<td>18,100.00</td>
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<tr>
<td>57938515</td>
<td>4207 - JEFFERSON CHAMBERS NORTH OF 4304 COMM</td>
<td>9,000.00</td>
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<tr>
<td>57938516</td>
<td>5806 - ROOSEVELT INN EAST OF BUILDING 4304 COMM SQ</td>
<td>8,000.00</td>
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<tr>
<td>57938524</td>
<td>3705 - WASHINGTON HALL</td>
<td>7,000.00</td>
<td></td>
</tr>
<tr>
<td>57938540</td>
<td>3603 - LINCOLN HALL</td>
<td>7,000.00</td>
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</table>
# Top 10 Gas Meters – Annual

DOD Agency USAF Utility Rate - $8.56943/Dth

<table>
<thead>
<tr>
<th>Building</th>
<th>Consumption</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 7504 Pride Hangar</td>
<td>13,396.23 Dth.</td>
<td>$114,798</td>
</tr>
<tr>
<td>B 7709 Pool &amp; Gymnasium</td>
<td>13,382.33 Dth.</td>
<td>$114,678</td>
</tr>
<tr>
<td>B 7262 Dock 60 AGE Service</td>
<td>11,927.25 Dth.</td>
<td>$102,209</td>
</tr>
<tr>
<td>B 7260 Dock 61 SHP AGE Storage</td>
<td>10,299.01 Dth.</td>
<td>$ 88,256</td>
</tr>
<tr>
<td>B 7244 Dock 80 AMXS Support</td>
<td>8,209.00 Dth.</td>
<td>$ 70,346</td>
</tr>
<tr>
<td>B 7239 Dock 83</td>
<td>8,031.50 Dth.</td>
<td>$ 68,825</td>
</tr>
<tr>
<td>B 8210 Base Engineering Shops</td>
<td>7,605.33 Dth.</td>
<td>$ 65,173</td>
</tr>
<tr>
<td>B 7240 Dock 82 MUN AGE</td>
<td>7,128.97 Dth.</td>
<td>$ 61,091</td>
</tr>
<tr>
<td>B 2500 Rushmore Center</td>
<td>6,962.00 Dth.</td>
<td>$ 59,660</td>
</tr>
<tr>
<td>B 7618 Dock 31 28AMMXS</td>
<td>6,921.51 Dth.</td>
<td>$ 59,313</td>
</tr>
</tbody>
</table>
Air Force Energy Vision

• Reduce demand through conservation
• Increase alternative energy sources
• Consider energy impact in everything we do
• Achieve goals and mandates
• Advance energy independence
• Leverage technology
• Foster Energy Development
• Match system reliability with asset security
• Enhance mission capability
A New Energy Technology Partner*

Bitter Creek Energy Services
Ellsworth Air Force Base

*South Dakota School of Mines and Technology
The People

• Mr. Chuck Miller, Bitter Creek Energy Services
  – Energy Manager
  – UESC Contractor EAFB and Minot AFB
  – Part of MDU Resource Group
• Mr. Dell Petersen, Civ USAF ACC 28 CES/CEAOU
  – Energy Manager
• Ms. Lisa Teeslink, Tetra Tech, REM, EAFB
• Engineering Student Interns from SDSMT
• Mr. Dale “Butch” Skillman, PE
  – SDSMT Research Engr., Dir. Office of Tech Transfer
The Projects

- SDSM&T Senior Design Project Sponsorship
  - Bitter Creek Energy Services $25K
  - Four Types of Flat Plate Solar Collectors
    - Photovoltaic
    - Straight Thermal
    - Hybrids I and II
- BAA – AFRL (Proposed - $400K)
  - Full sized Building Integrated (BI) Collectors
  - BOS to include Organic Power Cycle & Heat Pump
    - (BOS = Balance of System)
Four Functional Solar Arrays, SDSMT
Sr. ME Design Project 2009-2010
Nellis AFB PV Array

- Designed to provide 25 million kWh annually
- Direct use, no storage
Solar Thermal

• Where’s the Heat?
EAFB knows where the heat goes!

- Which building/system/process uses the most thermal energy at your facility? (Metering)
- Which demands may be met through a direct use of solar thermal? (System Inventory to Characterize Thermal Loads)
- What type of solar thermal best meets your needs? (Application Design)
- What energy performance/design algorithm best models your system? (Does it model the Thermal System you would like to specify?)
- How do you verify your energy savings once the Solar Thermal System is on and operating? (Monitor)
Types of Solar Thermal Collectors

• Transpired Collectors (with or without glazing)
  – Low Temperature rise
  – Ventilation Air Preheating
  – Relatively High Efficiency – 70+%  
• Flat Plate Collectors (with Glazing)
  – Medium Temp Rise
  – Space Heating
  – Reasonable Efficiency – 60%

• Note: Solar Thermal raises the temp of a fluid.
Transpired Solar Collector

- Pre-heating of Make-up Air
Transpired SolarWall – Fort Drum
In The Beginning – circa 1977
Building Integrated Solar

- Suitable for New and retrofit construction
- Solar Collector integrated into the building envelope.
- Typically a Lower First Cost
- Aesthetic Appeal
- Job-Site Fabrication
The MR-24 Metal Panel

Early Solar Design and Modeling

• NREL was SERI with Denis Hayes as its first Director
• Amory Lovins was on “Soft Energy Paths”
• Mid-America Solar Energy Complex - Operational
• John A. Duffie, William Beckman, S.A. Klien
  – These are the true fathers solar thermal design and modeling. TRNSYS and FChart in the Mid-70’s.
  – PV modeling w/TRNSYS not until mid 1980’s
• Currently hundreds of Solar Algorithms – very few address solar thermal, fewer address Hybrid PVT
Current Thinking PVT– circa 2010
Hybrid Solar - PVT

- Very Widely used in Europe
- Collectors have Both Electric and Thermal Outputs
- Cooling the PV Array increases the PV Efficiency
- Hybrid Solar Collector Efficiency 65%+
PVT Demo at EAFB

• Free Standing Solar Structure near EAFB PAMP
• 1000-1200 Square Feet of BIPVT
  – Standing Seam Metal Roof Platform
  – Half of roof Area = Liquid Type Flat Plate
  – Half of roof Area = Air Type Flat Plate
  – 1/3 glazed with Poly Crystalline Module (Hybrid)
  – 2/3 Glazed with Low Iron double glass glazing
• Designed utilizing TRNSYS
• Instrumented for performance assessment.
Insuring Energy Project Successes

- Characterize loads thru metering
- Use Solar Thermal whenever you can
- Select applications with the most potential
- Design utilizing predictive dynamic models
- Monitor performance thru metering
MDU RESOURCES
GROUP, INC.

Questions