Renewable Energy Projects
Lessons Learned

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Dairyland Power

- 25 Member Cooperatives
- 230,000 Class A Meters
- 15 Municipal Systems
- 1,135 MW Generation
- 3,132 Miles of Transmission Lines
- 325 Substations
- 600,000 Consumers
- 600,000 Dairy Cows
- 2,000,000 Pigs
- Millions of Poultry
Dairyland Power System
In the Beginning

- Wisconsin started in 2004 with a requirement of 0.5% renewable ramped up to 2.2% by 2011.
- In 2005 Minnesota went to 1% per year until they reached 10%. Wisconsin, not to be outdone, went to 10% by 2015.
  - These smaller amounts made small renewable projects the reasonable choice.
- In 2010 Minnesota went to 25% by 2025. Wisconsin was going to match that but stayed at 10% state average (the economy was in the tank).
Renewable Energy Requirements

- Wisconsin Renewable Portfolio Standard (RPS)
  - ~6% by 2010 – 4.44% for Dairyland
  - ~10% by 2015 – 8.44% for Dairyland

- Minnesota Renewable Portfolio Standard
  - 12% by 2012
  - 17% by 2016
  - 20% by 2020
  - 25% by 2025

- Iowa
  - Electric utilities must offer alternative energy and allow customers to participate voluntarily.

- Illinois
  - No current requirement for cooperatives.
Renewable Energy Requirements

- Wisconsin Renewable Portfolio Standard (RPS)
  - ~ 130,000 MWh in 2010
  - ~ 260,000 MWh by 2015

- Minnesota Renewable Portfolio Standard
  - ~ 100,000 MWh in 2012
  - ~ 140,000 MWh by 2016
  - ~ 170,000 MWh by 2020
  - ~ 220,000 MWh by 2025

- Iowa
  - ~ 64 MWh for Evergreen program

- Illinois
  - ~ 4 MWh for Evergreen program
2013 DPC M-RETS Generation a Diverse Mix

<table>
<thead>
<tr>
<th>Technology</th>
<th>Number</th>
<th>Capacity MW</th>
<th>Generation MWh</th>
<th>Cap. Fact. %</th>
<th>Percent of Total</th>
<th>Per Project MWh</th>
<th>If Met With</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroelectric</td>
<td>4</td>
<td>22.61</td>
<td>40,997</td>
<td>21%</td>
<td>6.8%</td>
<td>10,249</td>
<td>47</td>
</tr>
<tr>
<td>Wind</td>
<td>13</td>
<td>87.35</td>
<td>207,197</td>
<td>27%</td>
<td>34.6%</td>
<td>15,938</td>
<td>31</td>
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<tr>
<td>Landfill</td>
<td>3</td>
<td>14.13</td>
<td>65,714</td>
<td>53%</td>
<td>11.0%</td>
<td>21,905</td>
<td>22</td>
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<tr>
<td>Digester</td>
<td>8</td>
<td>4.58</td>
<td>10,825</td>
<td>27%</td>
<td>1.8%</td>
<td>1,353</td>
<td>355</td>
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<tr>
<td>Solar</td>
<td>1</td>
<td>0.05</td>
<td>61</td>
<td>15%</td>
<td>0.0%</td>
<td>61</td>
<td>7,870</td>
</tr>
<tr>
<td>Biomass</td>
<td>1</td>
<td>40.00</td>
<td>274,465</td>
<td>78%</td>
<td>45.8%</td>
<td>274,465</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>168.71</td>
<td>599,259</td>
<td>40%</td>
<td>100.0%</td>
<td>19,975</td>
<td></td>
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</tbody>
</table>
DPC Generation Mix

12.2% of DPC sales are from renewable resources.

DPC exceeds the requirements of both Minnesota and Wisconsin for renewable supply.
Projected Renewable Generation and Existing Renewable Requirements
Dairyland Power Cooperative

- Renewable Generation
- Evergreen Program Sales
- Minnesota Requirements
- Wisconsin Requirements
- Renewable Generation

Year


Renewable Generation and Requirements (MWhs)

- 100,000
- 200,000
- 300,000
- 400,000
- 500,000
- 600,000
- 700,000
Cows Productivity

1 cow produces 6-7gal milk/day
~4 million gals/day

1 cow produces ~15 gallons of manure a day
9 million gals/day
Initial Digester Biogas Business Model

- DPC digester program started with 1000+ head herds to achieve economies of scale
- Complete mix thermophylic digester with substrates to improve efficiency and gas output to maximize energy production
- Farmer bought digester, had gas sale contract with DPC
- DPC owned engine-generator, gas clean-up and interconnection
- Third party contractor provided O&M for digester and engine and procured substrates
- Achieved biogas flow of 210 CFM (0.75-.8 MW) with 1 part FOG and 9 parts manure
DPC’s Original Plan for Biogas Resources

- Manure Digesters and Landfill Gas
  - Target 5 MW/yr x 5 yrs (1000 head herds) 25MW
  - Was to be a major portion of DPC distributed generation plan
  - CO2 mitigation, will offset coal. Equivalent to not emitting 36,200 tons CO2/yr/1000 head
  - Technically, it will also reduce system losses, offsetting coal generation

- What actually happened?
  - Nine digester projects (4.8 MW) and
  - 3 landfill gas projects (14.13 MW) are up and running,
  - 8 of these 12 projects are PPAs, DPC has ownership in 3 digester and 1 landfill project.

- Distributed generation (behind the meter)
  - 345 projects are solar PV (2.45 MW)
  - 116 projects are small wind (1.79MW)
  - None were on the radar screen 10 years ago
Anaerobic Digesters

- Five Star Dairy Digester - Co-Own
  - 775 kW, Elk Mound, WI - Online June 2005

- Wild Rose Dairy Digester - Co-Own
  - 775 kW, La Farge, WI - Online September 2005

- NorSwiss Dairy Digester - Co-Own
  - 825 kW, Barron, WI - Online March 2006

- Norm-E-Lane Digester PPA
  - 600 kW, Chili, WI – Online October 2008

- Bach Farms Digester PPA
  - 600 kW, Dorchester, WI – Online January 2010

- Central Sands Digester – avoided cost PPA
  - 400 kW, Nekoosa, Wi – Online 2007

- Peter’s Farm - PPA
  - 45 kW Chaseberg, Wi – Online May 2012

- Bush Brothers - PPA
  - 633 kW Augusta, Wi – Online 2012

- Link Energy - PPA (pigs and cows)
  - 600 kW Riceville, IA – Online 2012
Digesters

- Went from big to small, from substrate (FOG) to just manure
  - Substrate quality went bad, cost us $1MM in engine failures (siloxane, struvite, H2S etc.)
  - Instituted a siloxane QA/QC program, got rid of middle man
- Went from ownership position (engine-generators) to PPA for electric output.
  - Made sure farmer had more skin in the game
Initial Business Model Problems

- Contractor had no “skin in the game” other than fuel sales
  - Maximized substrate use to increase gas production with no quality considerations. Siloxane contamination fouled three engines and a boiler (cost DPC $1 million).
  - Gas clean-up was H2S only, increased substrate over topped H2S system.
  - Gas clean-up needed to remove condensable components too, not just H2S.
- Contractor became communications bottleneck between Farmer and DPC.
- DPC now uses PPA with farm if all energy is sold to DPC,
- If farm uses energy, selling excess to DPC, then DPC pays “avoided cost” for excess energy.
Problems Encountered
Short List

- Have fuel/air module failures and ongoing problems.
- Had turbo-charger failures.
- Had lube oil problems, pluggage.
- Had engine/digester control issues resulting in wild output variability.
- Had gas filter/blower bottleneck engine output.
- Siloxanes have abraded pistons and cylinder walls.
- Had catastrophic engine crank shaft failures twice.
- Have changed engine manufacturer.
- Found we don’t need the “SlurryStore”.
- Will bury all future piping and/or place in building.
- Farmer can’t throw boots, etc., in manure, it plugs pumps.
- Are planning to put everything under one roof.
- We can streamline permitting process by using actual data.
Technology Review

- Overall performance of manure to electricity has been poor.
- The anaerobic digestion process works very well.
- Gas chemistry and engine performance have been very problematic.
  - Increased competition for substrates
  - Substrate chemistry variability is a problem
  - Need Quality Control at source
  - Need gas clean-up process
No slurry store, Piping, Gen-set, H2S removal, auxiliary boiler have all been moved into a building.
What We’ve Learned

- Entering streams: Manure 90%, food waste 10%
- Exiting Streams: Digestate 95%, Biogas 5%
- 95% reduction in raw manure BOD.
- 46% reduction in total solids.
- 35% conversion of organic nitrogen to inorganic form.
- Cows like bedding, lay down more and make more milk.
- Solids can be classified as “organic composted cow manure” and sold as such.
- Fertilizer nutrient value largely retained in liquid portion.
Benefits of Digesters

- Nearly complete **odor reduction**.
- **Reduced trucking** to spread manure.
- Weed seed and pathogen kill **reduces herbicide needs**.
  - Ideal for organic farms
- Mineralized nutrients (NPK) for **natural fertilizer**. Quicker plant uptake
- Clean, comfortable, economical **cow bedding**.
- **Destruction of methane** before entering atmosphere.
- **Baseload generation**. It can work 24/7.
- Reduction of on-farm fly population
Value Added

- Bedding worth $110 per cow-yr
  - Usually there is excess that can be sold
- Enhanced nutrient value $? per cow-yr
  - Reduces ground and surface water impacts
- Combined Power and Heat
  - Electricity value $70 per cow-yr
  - Heat value (displaces propane)
- Weed seed kill value $35-$55 per acre
- Odor kill for pigs and cows “priceless”
Technology Transition

- Anaerobic up-flow sludge bed technology
  - Short residence time of 5 days vs. 22, therefore smaller, less expensive tank
  - Higher methane content in gas stream
  - 250 head per tank, can address smaller herd/farm
  - Factory construction/modular construction
  - Transportable on flat bed trucks
  - Bank can pick it up and move it
Landfill Gas to Electric

- Started out owning the engine-generator
  - Gas quality (siloxanes) became big problem as their concentrations ramped up over time.
  - Landfill owner gas well O&M became an issue.
  - Landfill leachate management big issue, causes variability in gas volume and quality.
  - With proper gas clean-up can achieve 75-85% cap factors and be a low cost reliable energy supply.
Wind

- Other than conventional hydro-electric, wind is the dominant renewable resource ~70%.
- PPAs only, no ownership.
- Off peak (58.6%) production when it’s not needed or as valuable, competes with coal minimum loads.
  - Sells majority of output into lower priced off peak LMP
  - Small capacity component ~12-13% of name plate
  - Contributes to congestion
  - Lots of it, easy energy to acquire
Wind

- A recent Forbes article said the top 10 wind states electricity costs grew 10x the national average (2008-2013)
- It went on to point out that Minnesota electric costs are 22% above the national average costing the average household $476/year, $1 billion state wide
### Top 10 Wind States According to EIA

<table>
<thead>
<tr>
<th>Percent of State Generation</th>
<th>Cost Above National Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa – 27%</td>
<td>Iowa – 16%</td>
</tr>
<tr>
<td>South Dakota – 26%</td>
<td>South Dakota – 25%</td>
</tr>
<tr>
<td>Kansas – 19%</td>
<td>Kansas – 26%</td>
</tr>
<tr>
<td>Idaho – 16%</td>
<td>Idaho – 34%</td>
</tr>
<tr>
<td>Minnesota – 16%</td>
<td>Minnesota – 22%</td>
</tr>
<tr>
<td>North Dakota – 16%</td>
<td>North Dakota – 23%</td>
</tr>
<tr>
<td>Oklahoma – 15%</td>
<td>Oklahoma – -2%</td>
</tr>
<tr>
<td>Colorado – 14%</td>
<td>Colorado – 14%</td>
</tr>
<tr>
<td>Oregon – 12%</td>
<td>Oregon – 16%</td>
</tr>
<tr>
<td>Wyoming – 8%</td>
<td>Wyoming – 33%</td>
</tr>
</tbody>
</table>

*(10 times higher than National Avg of 2.8% and 20% of cost remains hidden as the PTC, a tax payer cost)*
Biomass

- PPA only, no ownership.
  - Fuel quality and availability issues
  - Odor and dust control issues
  - Spontaneous combustion, smoldering, odor etc.
  - Neighbor issues
  - Expensive $85-$120/MWh
  - It is dispatchable
  - Solid fuel can be stockpiled (energy storage)
  - Has low CO2 emission component
Solar

- On peak only, a good thing.
- 1,358 MWhs per year per MW 15% cap factor.
- Not a big energy play but good peak demand reduction for both generation and transmission.
- Needs lots of space, 75 sq ft per kW.
- Expensive, for now it needs subsidies.
  - Competes with residential rates at $4/Watt and less
  - Costs are dropping, multi band gap technology will double/triple current efficiency
  - Utility scale costs are around $2/Watt, 9 cents/kWh
    - 5 years ago it was at $7/Watt
  - Some cost reductions are due to China selling below production cost
Renewables Lessons

Questions?