Managing Bakken Oil Field Load Growth From a Transmission Perspective

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Basin Electric – Manager of Transmission Services

November 10 2015
• Generation = 5000MW (700MW Wind)
• 2.8 Million Consumers
• 134 Member Cooperatives
• 2000 Miles of Transmission
Basin Electric’s Resource Portfolio (above) consists of generation in megawatts (winter ratings) from owned facilities and purchased power contracts longer than 3 years. The renewables percentage includes wind, recovered energy generation, and flaregas totals.
Where is the “Bakken”??
What Happened?

• Horizontal Drilling
• Hydraulic Fracking
• Lease Fulfillment Rush
  • This Seems To Have Passed
  • Now Adding New Wells To Existing Pads
• Explosion of Activity ~2010
Depth ~ 2 miles
Horizontal Distance ~1-2 miles

ND Dept of Oil and Gas Data
Multiple Layers, Bakken, Three Forks, Others?

Bakken Development Plan

- Original dual-zone development plan
  - 8 wells per 1,280 acres – 4 MB, 4TF
  - 603,000 Boe EUR per well (avg. 24.5 stages/completion)
  - ECO-Pad® design: 2 wells south, 2 wells north

- Additional Three Forks potential

1st ECO-Pad well pair
Upper Bakken Shale
Lower Bakken Shale
Nisku

Charlotte 2-22H: 1,140 Boepd IP
Performing hydraulic fracture stimulation south of Tioga
- all Bakken wells must be hydraulically fractured to produce
- > 2 million gallons of water
- > 3 million pounds of sand
- cost > $3 million
Multiple Wells Per Pad

Phase 3 “Harvest” 6 – 28 or more wells per spacing unit

Vern Whitten Photography 6 wells producing - drilling 7-12 - and 13-18 coming soon

ND Dept of Oil and Gas Data
Typical 2012 Bakken well
- 45-year well life
- 615,000 barrels of oil
- $9 million to drill and complete
- $20 million net profit
- $4 million in taxes
- $7 million in royalties
- $2 million in wages
- $2 million in operating expenses

ND Dept of Oil and Gas Data
Linear Development of Pads
Every Well Produces Oil
Horizontal Wells
Multiple Wells Will Fill In From Each Pad

ND Dept of Oil and Gas Data
Flaring

- ~30% of gas is flared
- Captured gas needs to be processed
- Difficult to add gathering system pipelines
North Dakota Monthly Gas Flared

ND Dept of Oil and Gas Data
Gas Processing Facility Required
Major Electrical Load ~10MW to 30MW Each
Exporting Oil Out of Bakken
• Rail 2/3
• Pipeline 1/3
Williston Substation Area - 2009
Slow Down?

$40$/barrel Oil
North Dakota Average Monthly Rig Count

In 2009/2010 each rig drilled 8-10 wells per year.

In 2015/2016 each rig can drill 20-24 wells per year.
October 2014 Active Drill Rigs ~ 190

ND Dept of Oil and Gas Data
November 2015 Active Drill Rigs ~ 65

ND Dept of Oil and Gas Data
North Dakota Daily Oil Produced and Price

BOPD

ND Sweet $/BO

0 100,000 200,000 300,000 400,000 500,000 600,000 700,000 800,000 900,000 1,000,000 1,100,000 1,200,000 1,300,000


$0 $15 $30 $45 $60 $75 $90 $105 $120 $135 $150 $165 $180 $195

ND Dept of Oil and Gas Data
Total BEPC Williston Basin Load Growth

2015 Forecast Update
2015 Forecast Alternate

1,850 MW
1,384 MW

MT
ND
SD

MW

0
500
1,000
1,500
2,000
2,500
3,000
3,500

2010 2015 2020 2025 2030 2035
Mountrail-Williams Coop
MWEC
10 years of impact
Coop Footprint in North Dakota
Mountrail-Williams and McKenzie Electric = Ground Zero
MWEC System Growth 2006 to April 2014

Legend:
- Cities
- County Lines
- Township Lines
- Existing Substations (Pre-2006)
- New Substations
- Existing Distribution (Pre-2006)
- New Distribution
- New Transmission
- Owner
  - BEPIC
  - MWEC
  - New Wells

2006 January

Prepared: 3/31/2014
Operating Revenue ($Millions)

- 2004: $12.4
- 2005: $12.4
- 2006: $14.8
- 2007: $16.5
- 2008: $21.1
- 2009: $30.5
- 2010: $40.6
- 2011: $54.1
- 2012: $82.3
- 2013: $131.5
Basin Electric (BEPC)

- Generation and Transmission Provider Impact
History Of Load Forecasts

Williston Load Pocket Winter Peak Forecasts
50-50 Weather Normalized

345kV Line Development Time


- Williston Pocket Total 2014 Forecast
- Williston Pocket Total 2013 Forecast
- Williston Pocket Total 2012 Forecast
Exceptionally High Load Factor
Transmission Strategy

- Load Forecast Is Not Providing Time To Develop Transmission
  - Also not desirable to overbuild
  - Need To Follow Planning Authority FERC 890 and 1000 Process
  - NERC Compliance - TPL Standards
  - SPP ITP as of October 2015

- Extract Maximum Capacity From Existing Facilities
  - Perform LIDAR On Critical Transmission Lines
  - LIDAR = Look ID Decreased Another Rating
  - Reconductor, Change CT’s, Relays

- 345kV Plan Is In Progress
  - 4th Quarter 2015 In Service

- Basin Electric Needs Peaking Generation
  - Place In Bakken Area To Support System
  - Use Synchronous Condenser Option

- Basin Electric Acquired Seven 15MVAR 115kV Mobile Capacitors
Transmission Strategy

• Optimize Operating Guides
  • Curtail Exports, DC Ties and Canada
  • Run Local Generation

• Install Under Voltage Load Shedding

• Coordinate Outages Very Carefully
  • New Construction Often Requires Long Outages
  • Degrades Transmission Capacity

• Voltage Regulation Struggles
  • Hard To Coordinate Caps and LTC’s
TYPICAL SYSTEM INTACT VOLTAGE PROFILE
VOLTAGE STABILITY SUPPORT

1. Capacitor Bank
   Pro’s
   Cheap, Fast Installation
   Con’s
   E^2/X, Voltage Step Change

2. More Transmission
   Pro’s
   Improve Surge Impedance Loading Effect
   Con’s
   Expensive, Long Lead Time

3. More Generation
   Pro’s
   MW & MVAR’s Support System
   Con’s
   Typically Transmission Can’t Direct Generation Location

4. Dynamic VAR’s – SVC, Statcom, DVAR, Etc....
   Pro’s
   Active VAR’s, Fast, “Smooth” Response
   Con’s
   O&M, Eventually Obsolete

5. Under Voltage Load Shed “UVLS”
   Pro’s
   Cheap, Fast
   Con’s
   Tripping Load

6. Synchronous Condenser
   Pro’s
   Active VAR’s, “Smooth” Response, Incrementally Cheap
   Con’s
   Need Generation Project, Otherwise Expensive

   Active VAR’s combined with capacitors work well
## Voltage Support Additions

### 2013-2014 Cap Banks

<table>
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<tr>
<th>Location</th>
<th>Entity</th>
<th>Cost</th>
<th>In Service</th>
<th>Total Size</th>
<th>Notes:</th>
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<tr>
<td>Dickinson 115</td>
<td>MDU</td>
<td>~$2M</td>
<td>2012</td>
<td>30 MVAR</td>
<td>2 x 15 MVAR</td>
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<tr>
<td>Logan 115</td>
<td>Basin Electric</td>
<td>~$2M</td>
<td>2012</td>
<td>30 MVAR</td>
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<tr>
<td>Blaisdel 115</td>
<td>Basin Electric</td>
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<td>2012</td>
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<td>Dunning 115</td>
<td>Central Power</td>
<td>~$1.7M</td>
<td>2013</td>
<td>20 MVAR</td>
<td>2 x 10 MVAR</td>
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<td>Kenaston 115</td>
<td>Burke Divide</td>
<td>~$1.5M</td>
<td>2012</td>
<td>12 MVAR</td>
<td>2 x 6 MVAR</td>
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<td>Watford City 115</td>
<td>WAPA</td>
<td>~$2M</td>
<td>2013</td>
<td>30 MVAR</td>
<td>2 x 15 MVAR</td>
</tr>
<tr>
<td>Grenora 115</td>
<td>MWEC</td>
<td>~$1.5M</td>
<td>2012</td>
<td>15 MVAR</td>
<td>1 x 15 MVAR</td>
</tr>
<tr>
<td>SW Minot 115</td>
<td>Central Power</td>
<td>~$1.2M</td>
<td>2013</td>
<td>10 MVAR</td>
<td>1 x 10 MVAR</td>
</tr>
</tbody>
</table>

- 2 LM6000’s Have Sync Condenser Capability
- Acquired 7 x 15 MVAR Mobile Caps
- 1 UVLS Location
Sync Condenser Mode

Overexcited
Produce 60MVAR

Underexcited
Absorb 20MVAR
2009 Transmission System

Map showing the transmission system with lines marked for 345kV, 230kV, and 115kV.
2010 Transmission System

2010 Culbertson 95MW LMS100

345kV Line
230kV Line
115kV Line
2011 Transmission System

![Map of 2011 Transmission System](image_url)

- 345kV Line
- 230kV Line
- 115kV Line
2012 Transmission System
2013 Transmission System

- 345kV Line
- 230kV Line
- 115kV Line

- 2013
- 45MW LM6000
- 45MW LM6000
- 2013
- Minot
- Williston
- Tioga
- Stanley
- Watford City
- New Town
- Watford City
- Hazen
- L.OLDS
2015 Transmission System

Map showing transmission system with various lines and nodes.
Total Project Costs:

Transmission:
AVS-Neset 345KV = $300M
Patent Gate-Round Up 345KV = $100M
Belfield-Rhame 230KV = $40M
Williston-Tioga 230KV = $40M
Wheelock and Blaisdel 230KV Substations = $50M
Blaisdell-Berthold 115KV = $10M
TOTAL ~ $540M

Generation:
Culbertson = $100M
Lonesome Creek Station = $250M
Pioneer Station = $250M
TOTAL ~ $600M

Grand Total ~ $1.14B
Questions?