A REVIEW OF MICHIGAN'S UNDERGROUND HYDROCARBON STORAGE

SPE MWGS SPRING WORKSHOP 4 MARCH 2015

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PRESENTATION OVERVIEW

- Why does Michigan need underground storage?
- Where are the storage facilities?
- What is stored and how much?
- How is it stored?
- What are the formations that are used?
- How is the working gas distributed by formation?
- What is the percentage of base gas to total storage?
- How many wells are involved?
- How does the base gas requirement differ between zones?
- How much area do the fields require/BCF?
- How old are the facilities?

NOTE: ALL INFORMATION IN THIS PRESENTATION HAS BEEN OBTAINED FROM PUBLIC SOURCES – USEIA, MDEQ AND MPSC
MICHIGAN NATURAL GAS CONSUMPTION AND PRODUCTION, 2001-2013*

* Per USEIA
MICHIGAN STRATIGRAPHIC COLUMN SHOWING STORAGE FORMATIONS*

- Stray Sandstone
- Reed City
- Salina Salts, Carbonates, Niagaran and Reef
- Trenton

* Michigan DEQ Office of Oil, Gas and Minerals
WHAT IS STORED UNDERGROUND IN MICHIGAN?

• Natural Gas
• Natural Gas Liquids
  • Propane
  • i-Butane
  • n-Butane
  • Mixed Butanes
  • Mixed NGL’s
HOW MUCH IS STORED?

• Natural Gas*
  • Working Gas: 688 BCF
  • Base Gas: 447 BCF
  • Total Storage Gas: 1,135 BCF

• NGL**
  • Total Cavern Capacity: 537 MMGAL
  • Number of Facilities: 5
  • Number of Caverns: 40

* Per Michigan Public Service Commission
** Per Michigan DEQ Office of Oil, Gas and Minerals, not necessarily storage volume
HOW IS IT STORED?

• Natural gas
  • Depleted reservoirs – former producing reservoirs that have been converted to storage
  • Salt caverns – former solution mining operations for salt production and dedicated caverns constructed for gas storage

• NGL’s
  • Salt Caverns – former solution mining operations for salt production and dedicated caverns constructed for NGL storage
WHAT FORMATIONS ARE USED?

- **Natural Gas**
  - Michigan Stray Sandstone (Mississippian), 14 Fields, 11 Active
  - Reed City Dolomite (Devonian), 1 Active Field
  - Salina Salts (Silurian), 2 Active Facilities, 9 Cavens
  - Salina Carbonates (Silurian), 2 Active Fields
  - Regional Niagaran (Silurian), 2 Fields, 1 Active
  - Niagaran Reefs (Silurian), 39 Fields, 38 Active
  - Trenton (Ordovician), 1 Inactive Field

- **NGL’s**
  - Salina Salts (Silurian), 5 Active Facilities, 40 Active Cavens
**NATURAL GAS STORAGE WORKING GAS BY FORMATION, BCF**

* Per Michigan Public Service Commission
NUMBER OF WELLS INVOLVED*

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<th>Active I/W</th>
<th>Plugged I/W</th>
<th>Active OBS</th>
<th>Plugged OBS</th>
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<td>Gas Storage</td>
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<td>708</td>
<td>465</td>
<td>152</td>
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<td>NGL Storage</td>
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<td>18</td>
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* Per Michigan DEQ Office of Oil, Gas and Minerals
BASE GAS % OF TOTAL GAS STORAGE CAPACITY*

* Per Michigan Public Service Commission
GAS STORAGE
ACRES/BCF WORKING GAS*

* Per Michigan Public Service Commission
STORAGE RESERVOIRS
AVERAGE AGE, YEARS

Average Age in Years

- A1 Carbonate
- B Salt
- Michigan Stray - Active
- Michigan Stray - Abdh
- Niagara Reef
- Niagara Reef - Prop
- Reed City
- Regional Niagara
- Regional Niagara - Abdh
- Trenton - Abdh
- NGL Storage

* Per Michigan Public Service Commission
FUTURE DEVELOPMENT

• Most likely additional natural gas storage will occur in depleted Niagaran Reefs
  • High deliverability
  • Lower base gas requirement
  • Less areal extent required
  • Large number of potential targets
• Most likely additional NGL storage will occur in and around existing facilities, due to infrastructure.
QUESTIONS?

• Thank you for the opportunity to share this information today.

• Brock Engineering, LLC is a professional engineering consulting company. Our mission is to provide top quality engineering solutions to our clients’ needs in a timely and in a cost effective manner.