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ATC'S MACKINAC BACK-TO-BACK HVDC PROJECT: PLANNING AND OPERATION CONSIDERATIONS FOR MICHIGAN'S EASTERN UPPER AND NORTHERN LOWER PENINSULAS

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CIGRE US NATIONAL COMMITTEE
2013 GRID OF THE FUTURE SYMPOSIUM

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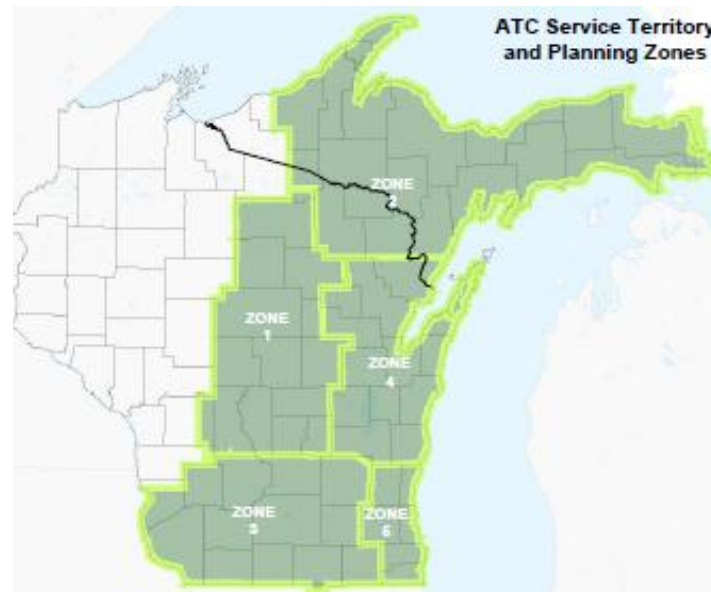
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CO-AUTHORS

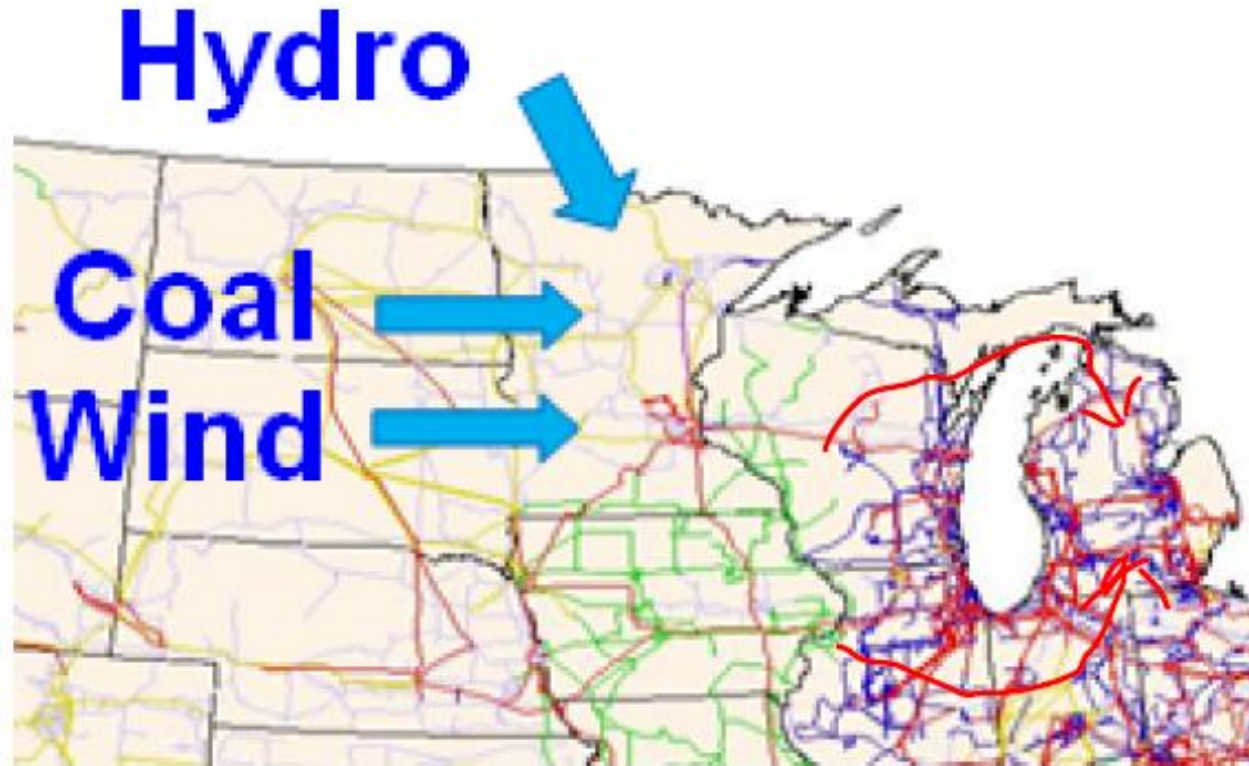
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AMERICAN TRANSMISSION COMPANY (ATC)

- Provides transmission service from the Upper Peninsula of Michigan, throughout the eastern half of Wisconsin and into portions of Illinois.

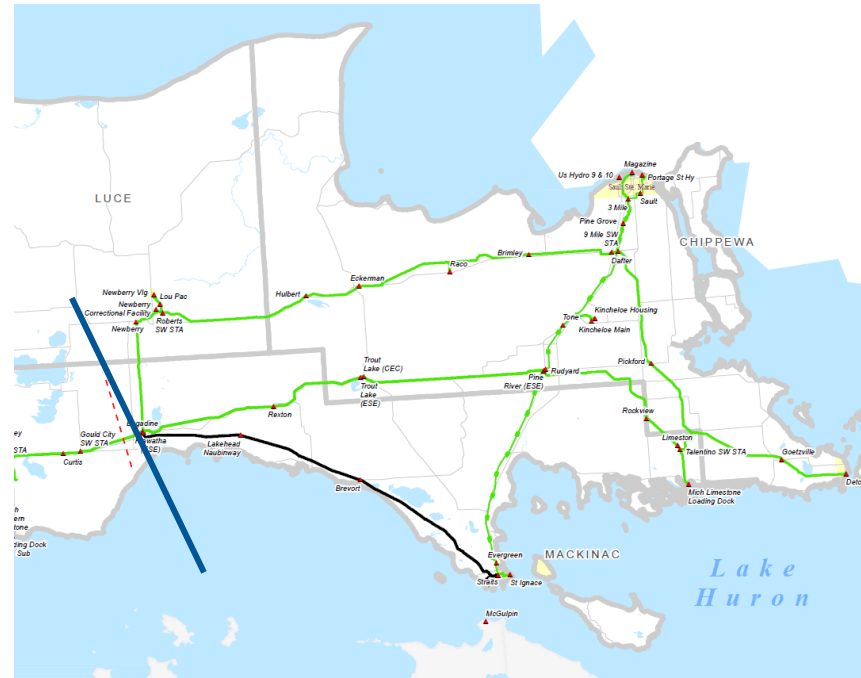


FLOW BIAS THROUGH UPPER PENINSULA (UP)



- Due to heavy loop flows thru UP, lines are over loaded and under voltage issues exist.

EASTERN UP SYSTEM SPLIT



- With the eastern UP split system operation, difficult to get maintenance and construction outages.

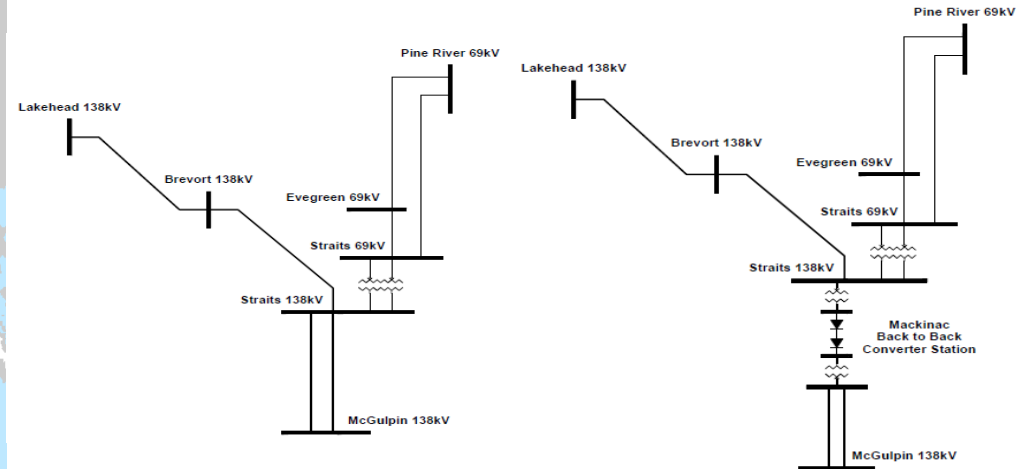
GENERAL SOLUTIONS

- **Re-conductor / Build new transmission lines and install reactive power compensators**
 - Very expensive and long lead times
- **Install flow control device**

FLOW CONTROL DEVICE OPTIONS

- **Series Reactors**
 - Limited flow control, voltage regulation issues and higher losses
- **Phase Shifting Transformers (PST)**
 - More than one PST in series is required, less flexible, higher maintenance, inability to power runback under emergency conditions
- **Variable Frequency Transformers (VFT)**
 - Requires additional dynamic reactive power compensators, very few projects in service
- **HVDC Tie**
 - Technically most suitable option

FLOW CONTROLLER LOCATION



- Upper Peninsula of Michigan is connected with Lower Peninsula via 2 x 200 MVA submarine cables across the Straits of Mackinac.
- The most logical location for the flow control device location is at Mackinac.
- The required rating for the device is 200 MW.
- The minimum Short Circuit Ratio (SCR) at Mackinac is about 0.6.

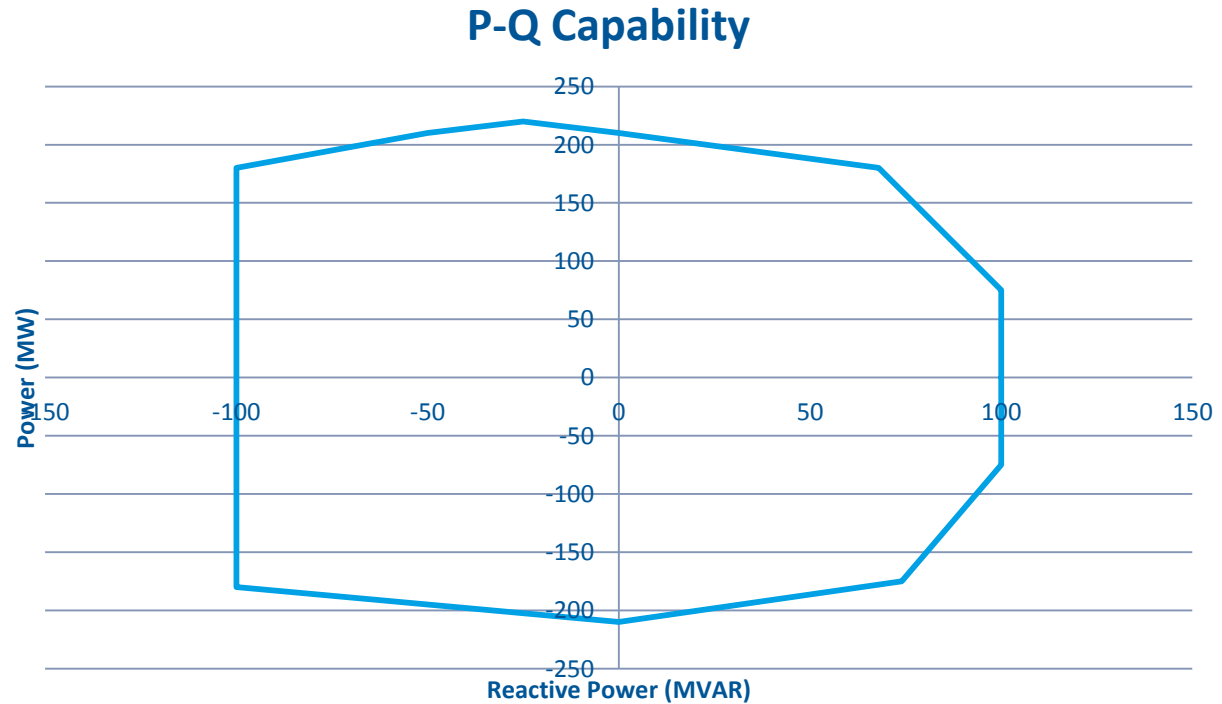
HVDC OPTIONS

- **Line Commutated Converters (LCC)**
 - SCR is too low and would require additional synchronous condensers
- **Capacitor Commutated Converters (CCC)**
 - Would require additional dynamic reactive power compensators
- **Voltage Source Converters (VSC)**
 - Provides both power flow control and reactive power support
 - VSC Back-to-Back converters were chosen as the flow control device.

PRE-SPECIFICATION STUDIES

- Due to the very weak system conditions at Mackinac, extensive system studies, including PSCAD studies were performed.
- Under certain critical contingencies, HVDC tie is required to transition to islanded mode operation.
- Depending on the contingencies, DC power order is required to be ramped down / reversed in order to maintain system stability.
- Requires complex communication signals, such as line flows and breaker statuses, from various remote substations to compute the new power order.
- Alternatively, bidders were encouraged to develop “AC Line Emulation” using locally measured signals in order to compute the new power orders.

CONVERTER SPECIFICATION



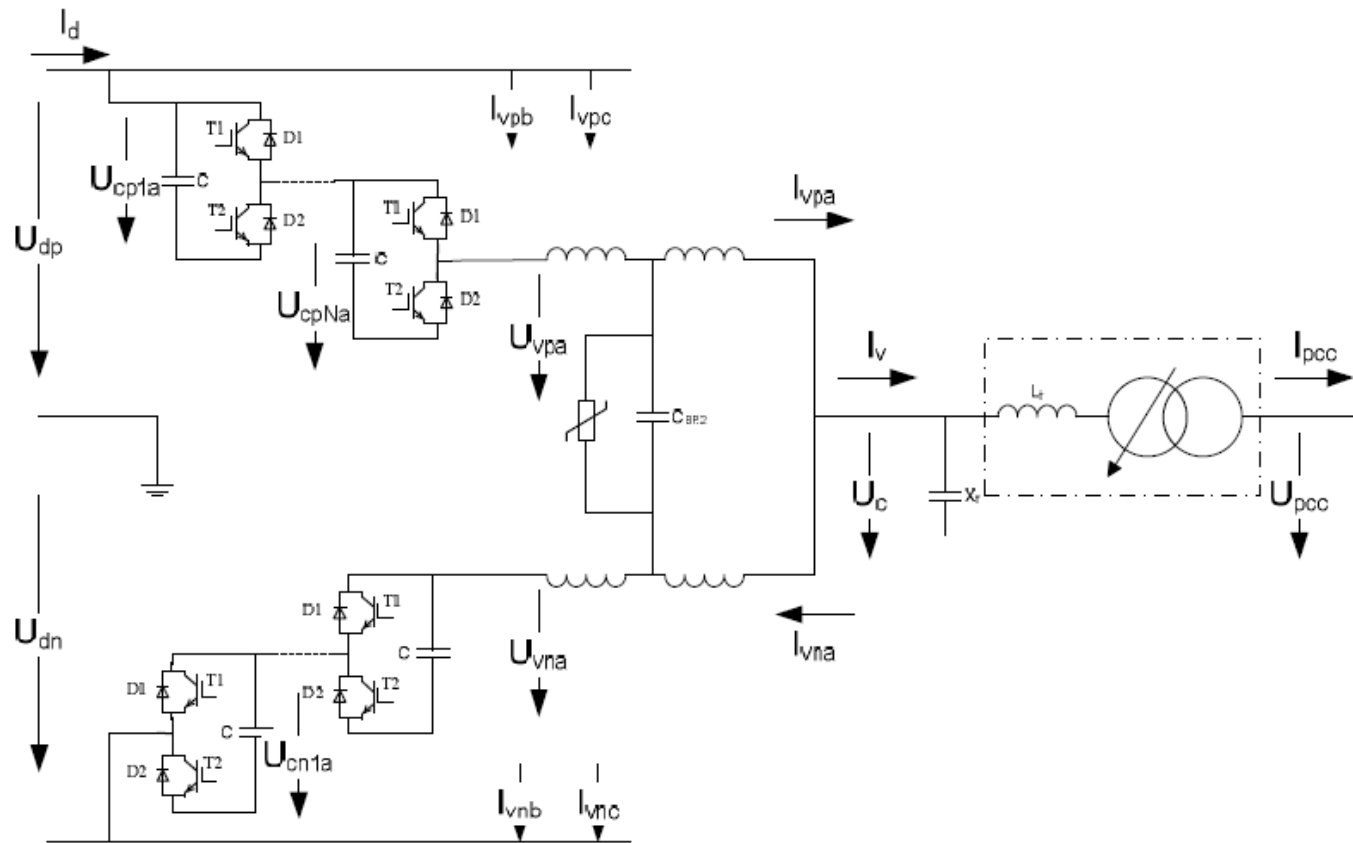
CONVERTER STATION SPECIFICATION

- Able to operate as two independent STATCOMs when not transferring power
- Operate as one STATCOM while one of the converters is out of service
- Islanded mode operation with fixed frequency and voltage droop settings
- Black start capability

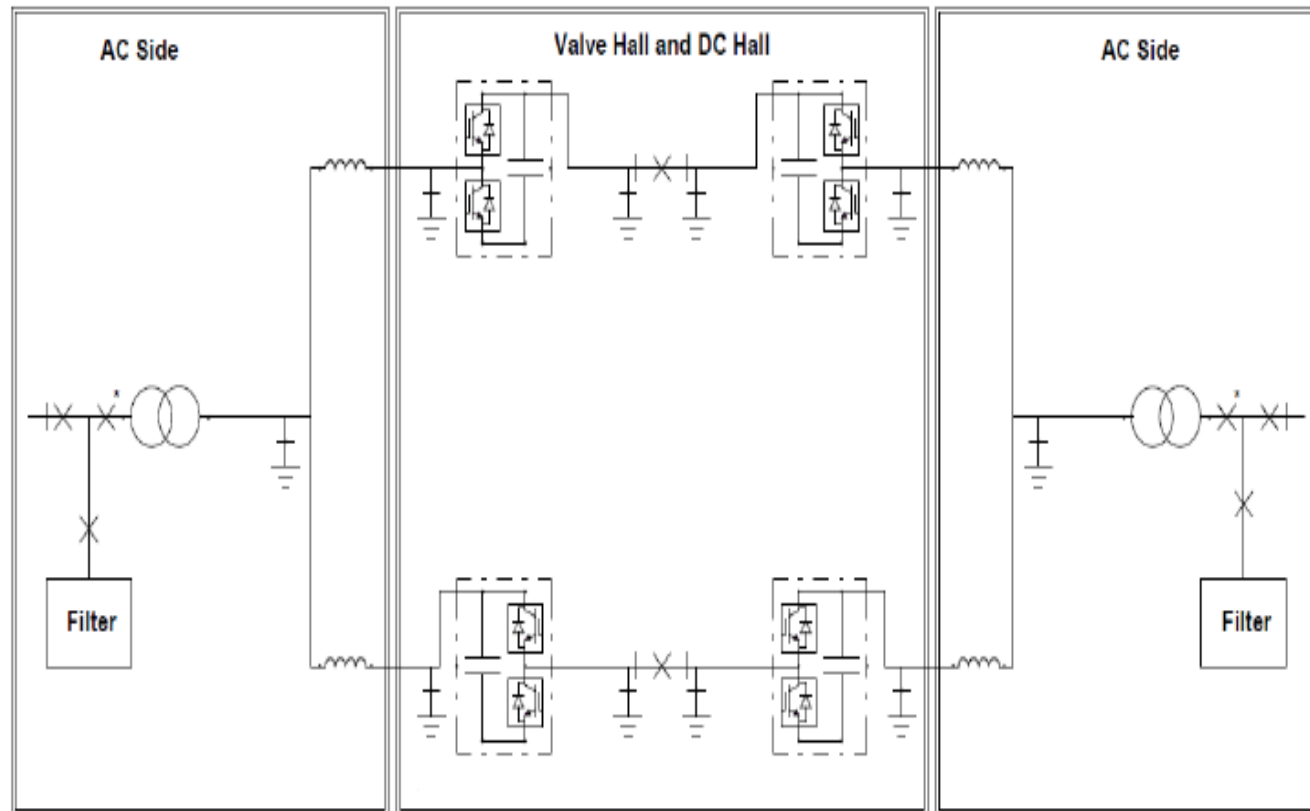
TURN-KEY CONTRACT

- ABB was awarded a turn-key contract in early 2012.
- Expected commercial operation in July 2014.
- Converters are of cascaded 2-level with PWM
- Have HP harmonic filters
- Symmetrical monopole configuration
- DC voltage is +/- 71 kV

CASCADED 2-LEVEL CONFIGURATION



SIMPLIFIED ONE LINE DIAGRAM



SUMMARY

- **Voltage Source Converter (VSC) Back-to-Back converters were selected as the Flow Control Device due to its technical advantages.**
- **There were some challenges with regards to control strategies.**
- **The new control concepts are under testing now and will be discussed in the future publications.**

QUESTIONS?

