CU HVDC Refurbishment

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Why HVDC?

- Less right-of-way than AC
- Flexibility with reliability
- 400 miles +/- break even point
- Losses are less than AC

courtesy of ABB
CU HVDC system key facts

- Voltage: 405 kV
- Capacity: 1,115 MW
- Mileage: 436 miles
- Energized: 1978 (40 yrs)
- Original cost: $250 million
- World class reliability
HVDC systems are unique
Coal Creek Energy Park
HVDC system diagram

230 kV AC

Coal Creek

Valve Hall

Valves

HVDC transmission line

- 405 kV DC Pole 2

+ 405 kV DC Pole 1

345 kV AC

Dickinson

HVDC Transformers
HVDC project path

- Condition assessment
- Option analysis
- Verify option costs
- Approvals

2011 2012 2013 2014 2015
Thyristor failures
Operational risks

1. Capacitors - oil filled/fire risk
2. Thyristor protection
3. Cooling system complexity
4. 1970's components obsolescence
Cooling simplification

#1 – Fan room

#2 – Pressure chamber

#3 – Heat exchanger

#4 – Cooling towers
Identify options

- Minimum Maintenance
  - Reliability
  - Spare Parts

- Refurbishment
  - Transformers/Valves
  - Generation outage timing

- Build new
  - Higher up front cost
  - Outage independent
GRE due diligence

- Plan for 30+ years of operation
  - Opportunity to push reset on the stations
  - Need to think long term needs
  - GRE is an active participant

- Project specification
  - Over 1,500 pages
  - 1 year to complete

- Learn from others
  - Build relationships
  - Administrative burden
Upgrading the HVDC system

New technology
HVDC project budget

- Project Contract
  - 1 year to negotiate
- Payment schedule
  - Removes unknowns
- Contract is key
  - Sets expectations

ABB wins $130 million order to upgrade HVDC power transmission link in the US

Converter station life extension will enhance grid reliability and facilitate efficient power transmission.

Zurich, Switzerland, February 3, 2016 – ABB, the leading power and automation technology group, has received an order worth around $130 million from electric cooperative Great River Energy to upgrade an existing HVDC (high-voltage direct current) connection in the US. The ± 400 kilovolt HVDC transmission system provides a vital link for transferring 1,000-megawatts of electricity between Underwood, North Dakota and Buffalo, Minnesota, a distance of 700 kilometers. The order was booked in the fourth quarter of 2015.
HVDC core team

- Great River Energy team
  - Everyone is unique and has a specific role
  - Every department in GRE is helping
  - 32,000 engineering hours

- Teshmont
  - Owners engineer
Project overview

- **In-scope: 2019 timeframe**
  - Conversion equipment - valves
  - Controls
  - Cooling towers
  - DC yard
  - 7MW efficiency gains
  - 74 day outage

- **Out of scope: transformers**
Project schedule

- **2016**: Engineering
- **2017**: Manufacturing
- **2018**: Construction
- **2019**: In-service
Engineering

- Total documents 1,638
  - Total pages 16,475 and counting
  - Closed documents 90%

- Significant overseas travel
  - 345 person days

- SharePoint helps the administrative burden
Plan ahead

- Put the tools in place for success
  - Action items list
  - Contract deliverables
  - Interface agreement

- Build relationships
  - ABB / GRE / Teshmont / etc.
Safety

- What can be done better
  - Specific health, safety, and environmental plan for each site
  - Station lighting
  - Station communication

- Environmental risks
  - Two independent reports
    - Lead paint
    - Asbestos
Valve – old vs. new
Cooling system overview
Smoothing reactor

- Dry-core Smoothing reactors
  - 5 each site, one is spare
  - 30 ton each
  - 40’ in the air
  - 200mH each coil
New controls
2018 outage plan

- Complete work safely and on time
- Reduce risks related to 2019
- Complete all underground outage dependent work
- Gain lessons learned
Construction begins....

- Have a detailed plan
  - Have a plan for B, C, D
  - Things will not always go to plan
  - Level of preparedness depends on risk
  - Safety, Safety, Safety
Dickinson pipes/foundations
Coal Creek saw cutting
Cooling system overview
Basement wall
2018 Dickinson work
2018 Coal Creek work
2019 outage plan

- 74 day total outage
- Schedule is critical, no stone left unturned
- Build in safety measures
- Weigh risks and plan, plan, plan

- March 7: Pole 1 outage - 39 days
- April 15: Bi-pole outage - 3 days
- April 17: Pole 2 outage - 32 days
- May 19
Questions