

FEASIBILITY OF CONVERTING HVDC LCC CONVERTER STATION TO VSC STATION

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OUTLINE

- OBJECTIVES
- LCC HVDC SYSTEMS
- VSC HVDC SYSTEMS
- COMMON EQUIPMENT
- DIFFERENT OPTIONS
- ECONOMIC IMPACTS
- CONCLUSIONS

OBJECTIVES

- Investigate Feasibility of Converting or Upgrading Existing LCC to VSC
- Two Scenarios Considered
 - Back to Back LCC HVDC (AEP)
 - Long Distance LCC HVDC (Manitoba Hydro)
- Provide Recommendations based on Converter Equipment Requirements & Economic Impacts

LCC EQUIPMENT

- CONVERTER TRANSFORMERS
- THYRISTOR VALVES
- CONTROL AND PROTECTION
- SMOOTHING REACTORS
- VALVE COOLING SYSTEM
- AC AND DC FILTERS
- MEASURING DEVICES
- AUXILIARY SYSTEMS
- DC SWITCHGEAR



LCC CHARACTERISTICS

- REQUIRES MINIMUM EFFECTIVE SHORT CIRCUIT RATIO (ESCR) OF 2.
- REQUIRES REACTIVE POWER SUPPLY
- LOWER LOSSES COMPARED TO VSC
- CAN EASILY CLEAR DC LINE FAULTS
- VALVE HALL SMALLER THAN VSC
- REQUIRES VOLTAGE REVERSAL TO REVERSE POWER

VSC EQUIPMENT

- CONVERTER TRANSFORMERS
- IGBT VALVES
- CONTROL AND PROTECTION
- SMOOTHING REACTORS
- VALVE COOLING SYSTEM
- AC AND DC FILTERS
- MEASURING DEVICES
- AUXILIARY SYSTEMS
- PHASE REACTORS
- CHARGING RESISTORS



Courtesy Siemens

VSC CHARACTERISTICS

- CAN OPERATE WITH VERY LOW EFFECTIVE SHORT CIRCUIT RATIO (ESCR) (<1).
- CAN SUPPLY OR ABSORB REACTIVE POWER
- HIGHER LOSSES COMPARED TO LCC
- REQUIRES SPECIAL MEASURES TO CLEAR DC LINE FAULTS
- VALVE HALL LARGER THAN LCC
- ABILITY TO BLACK START
- POWER CAN BE REVERSED WITHOUT VOLTAGE REVERSAL

COMMON EQUIPMENT

- CONVERTER TRANSFORMERS
- SMOOTHING REACTORS
- VALVE COOLING SYSTEM
- AC AND DC FILTERS
- MEASURING DEVICES
- AUXILIARY SYSTEMS

CONVERTER TRANSFORMERS

- CAN BE USED HOWEVER THE FOLLOWING MUST BE CONSIDERED
 - TRANSFORMER CONDITION & PERFORMANCE
 - USE OF EXISTING TRANSFORMERS MAY NOT RESULT IN OPTIMUM DC VOLTAGE (NEED WYE-DELTA FOR VSC BUT WYE-WYE MAY BE USED)
 - SPACE FOR PHASE REACTORS
 - INTERFACE WITH THE VALVE HALL (WALL BUSHINGS ETC.)

SMOOTHING REACTORS

- OLDER LCC SYSTEMS TEND TO HAVE MUCH LARGER SMOOTHING REACTORS THAN REQUIRED FOR VSC SYSTEMS
- NEWER LCC SYSTEMS HAVE MUCH SMALLER SMOOTHING REACTORS WHICH MIGHT BE USEABLE FOR VSC SYSTEMS



VALVE HALL

- LCC VALVE HALLS ARE MUCH COMPACT AND HAVE HIGHER HEIGHT
 - **E.G. 500MW (23m X 15m X 17m)**
L x W x H
- VSC VALVE HALLS ARE LONGER AND WIDER BUT LOWER HEIGHT
 - **E.G. 500MW (46m X 35m X 12m)**
L X W X H
- VALVE HALLS CANNOT BE REUSED
(Provided VSC rating is lower than LCC)

CONTROL AND PROTECTION

- THE LCC VALVE CONTROL AND PROTECTION SYSTEMS CANNOT BE REUSED AS FUNCTIONAL REQUIREMENTS ARE COMPLETELY DIFFERENT FOR VSC.
- BUT SIMILAR SPACE REQUIREMENTS FOR LCC & VSC

AC FILTERS

- DEPENDING ON THE DESIGN OF THE VSC CONVERTERS AC FILTERS MAY NOT BE REQUIRED
- FOR SYSTEMS THAT DO REQUIRE AC FILTERS, THE SIZE IS 10-30% OF THE POWER RATING
- THE TUNING FREQUENCIES ARE MUCH HIGHER THAN FOR LCC
- SOME AC FILTERS COULD BE MADE USEABLE FOR VSC – DEPENDS ON CASE BY CASE BASIS
- AC FILTERS COULD PROVIDE ADDITIONAL REACTIVE POWER SUPPORT



OTHER CONVERTER EQUIPMENT

- DC Filters may not be needed for VSC
- DC Switchgear – Some LCC switchgear can be used for VSC
- DC Measuring Equipment – same for LCC and VSC
- Auxiliary Supplies– Batteries & Chargers – same for LCC and VSC

DIFFERENT OPTIONS

- **THREE OPTIONS CONSIDERED**
 - **1. BUILD GREEN FIELD NEW STATION NEAR BY AND TRANSFER OVER**
 - **2. BUILD NEW STATION BUT USE SOME OF THE EXISTING EQUIPMENT**
 - **3. DEMOLISH EXISTING STATION AND BUILD NEW STATION IN SAME LOCATION**

ECONOMIC IMPACTS OPTION 1

- SHORT OUTAGE DURATION (3 TO 6 MONTHS FOR COMMISSIONING)
- EXISTING SYSTEM CONTINUES TO OPERATE DURING CONSTRUCTION
- LOWER LOSS IN REVENUE
 - REVENUE DEPENDS UPON WHOLESALE ELECTRICITY PRICES – RANGES AVERAGE \$20 / MWH TO \$40 / MWH OR HIGHER
- HIGHER EQUIPMENT COSTS
 - CONVERTER STATION COSTS COULD BE IN THE RANGE OF \$110 / kW FOR LCC & \$125 / kW FOR VSC FOR A +/- 500 kV, 3000 MW STATION

ECONOMIC IMPACTS OPTION 2

- OUTAGE OF ADDITIONAL SEVERAL WEEKS WILL BE REQUIRED IN ADDITION TO COMMISSIONING TIME
- IF THE AUXILIARY SYSTEMS ARE TO BE REUSED SYSTEM WOULD HAVE TO SHUT DOWN EVEN EARLIER. THIS OUTAGE IS IN ADDITION TO COMMISSIONING TIME
- COST OF NEW EQUIPMENT VS USING THE EXISTING EQUIPMENT SHOULD BE EVALUATED.
- TOTAL OUTAGE DURATION 6-12 MONTHS
- MEDIUM REVENUE LOSS

ECONOMIC IMPACTS OPTION 3

- SYSTEM WOULD HAVE TO BE SHUT DOWN TO CLEAR THE SITE (6-8 MONTHS)
- ADDITIONAL 28-32 MONTHS WILL BE REQUIRED TO BUILD & COMMISSION THE NEW SYSTEM.
- TOTAL OUTAGE DURATION 34-40 MONTHS
- HIGHER REVENUE LOSS
- MEDIUM TO HIGHER EQUIPMENT COSTS

CONCLUSIONS

- OPTION 1 IS THE ATTRACTIVE OPTION, MOST EXPENSIVE FOR EQUIPMENT BUT WITH LOW REVENUE LOSS DUE TO SHORTER OUTAGE TIME, IF ADDITIONAL SITE IS AVAILABLE NEARBY.
- OPTION 2 SHOULD BE CONSIDERED IF ADDITIONAL STATION SITE IS AVAILABLE & SOME LCC EQUIPMENT CAN BE USED.
- OPTION 3 IS THE ONLY OPTION IF ADDITIONAL SPACE IS NOT AVAILABLE. OPTION 3 WITH NEW EQUIPMENT WILL BE A BETTER CHOICE BECAUSE
 - GREATER RISK OF FORCED OUTAGES WITH OLD EQUIPMENT
 - CHALLENGES OF REMOVAL OF OLD EQUIPMENT AND INSTALLATION OF NEW EQUIPMENT IN THE SAME SPACE..
 - WARRANTY & AVAILABILITY ISSUES WITH MIXED EQUIPMENT (OLD & NEW).
- OVERALL, REVENUE LOSS AND EQUIPMENT COSTS ALSO PLAY A MAJOR ROLE IN THE FINAL DECISION