APPLICATION OF STATIC SYNCHRONOUS COMPENSATOR (STATCOM) ON THE YUKON INTEGRATED SYSTEM

Ben Korbutiak, Arden Spachynski
ATCO
Nihal Costa
Yukon Energy Corporation
Robert Isbister
Hitachi Energy

2022 CIGRE CANADA CONFERENCE & EXPOSITION

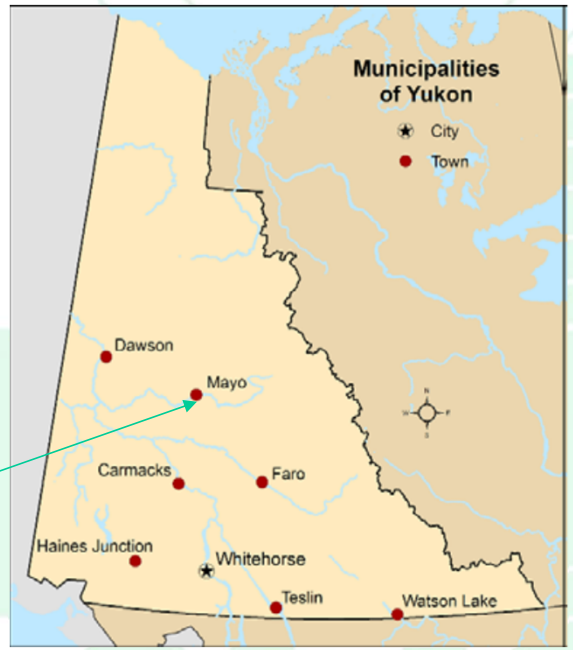
Overview

- Description of Yukon Energy Corporation (YEC) and Eagle Gold Project
- System Evaluation
- Project Execution
- Design Features
- Testing and Commissioning
- Conclusions

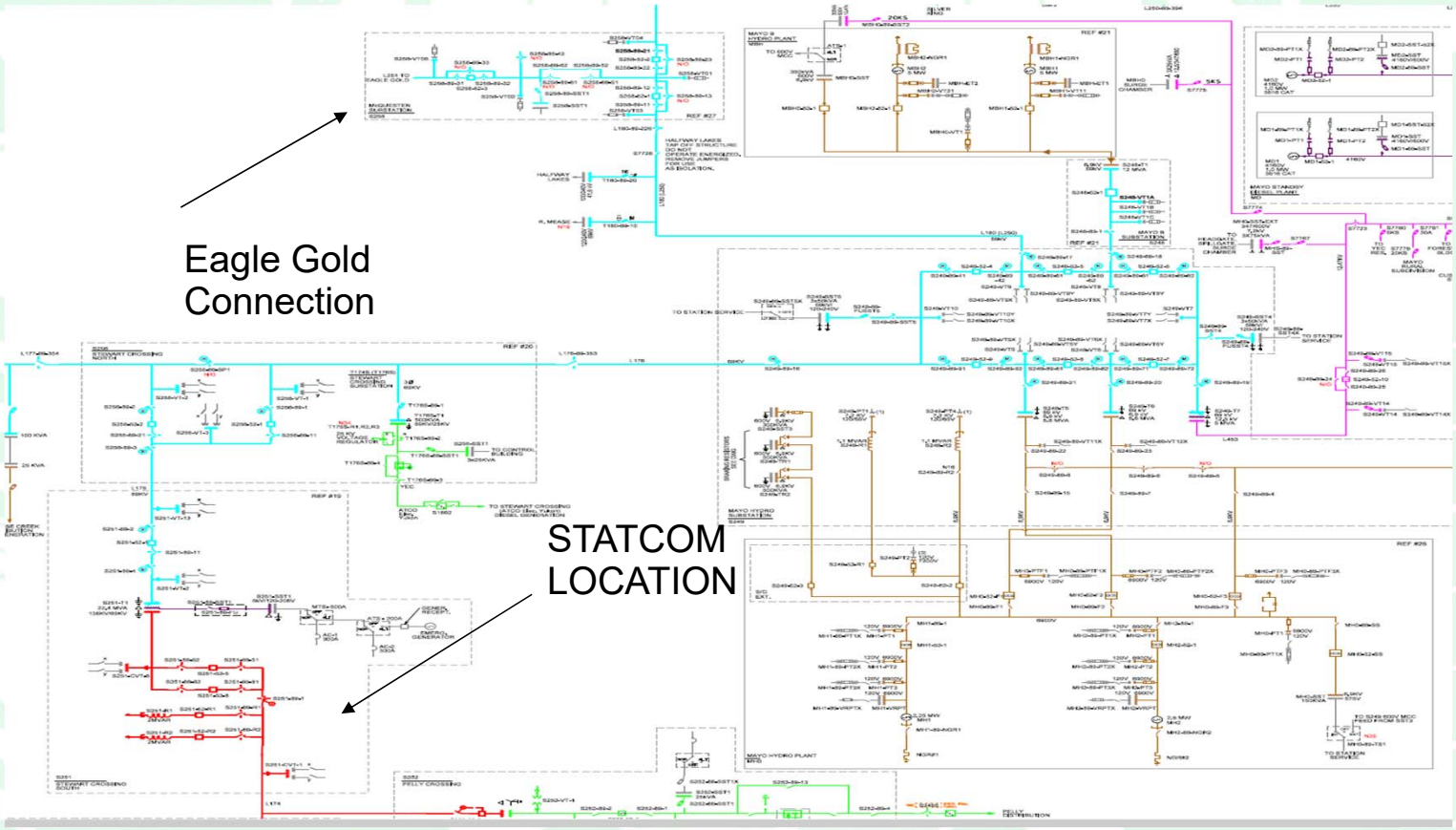
YEC

- Headquartered in Whitehorse, Yukon Territory
- Publicly owned electrical utility that operates as a business at arm's length from the Yukon government
- Main generator and transmitter of electrical energy in the Yukon
- Majority of electricity produced is from renewable sources, primarily from hydro plants located in Whitehorse, Aishihik and Mayo

YEC


Municipalities of Yukon
City
Town
Dawson
Mayo
Carmacks
Faro
Haines Junction
Whitehorse
Teslin
Watson Lake

YEC



EAGLE GOLD MINE

- Situated approximately 85 kilometers northeast of the village of Mayo
- In operation since 2018 utilizing a three-stage crushing plant in its extraction process
- Supplied by 69kV feed out of McQuesten substation, which connects back to Mayo substation at 69kV
- Peak demand expected in 2023

SYSTEM EVALUATION

- Weak system strength at the McQuesten substation
- As mining operation approaches full capacity, voltage fluctuations in the northern section of YEC will become increasingly aggravated
- Options considered for voltage stabilization:
  - Under-frequency load shedding
  - Fixed reactive components
  - Remedial action schemes (RAS)
  - Dynamic reactive support at the 138kV bus at the Stewart Crossing South Substation (Selected option based on system studies)

PROJECT EXECUTION

- ATCO successful bidder on both “The Preparation Of a Detailed STATCOM Specification and Review of Vendors Bids for YEC” and “Owners Engineer for STATCOM for YEC”
  - Preparation of technical specification and Request for Proposal (RFP)
  - Review of vendor’s bids and selection recommendation
  - System studies
  - Witness factory acceptance tests (FAT) and on-site commissioning
  - In service performance analysis

PROJECT EXECUTION

- Additional project involvement by ATCO:
  - Sole sourced by YEC and Eagle Gold in 2018 to modify the McQuesten substation design to a 69kV switching station for connection to Eagle Gold and undertake the construction
  - Owner's Engineer for modifications to the Stewart Crossing South substation to accommodate connection to the STATCOM:
    - Vendor selection
    - Oversight of the design, construction and commissioning of all apparatus additions and interface design related to STATCOM interconnection

PROJECT EXECUTION

Of the submitted responses to the RFP, the most economical and technically feasible proposal was from Hitachi Energy (HE) which was ABB Power Grids at the time.

The proposal was a +/- 14 MVar containerized STATCOM utilizing their PCS 6000 control platform, but several challenges were looming:

Challenges

- Environmental
  - Local average air temperature over a 24-hour period in January is -55° C – impact on container and outdoor heat exchanger to withstand and perform in this temperature extreme
  - Outdoor apparatus, including power transformer, to be rated down to -60° C

- System
  - Maximum short circuit level very weak at point of common coupling (PCC), the 138kV bus at Stewart Crossing South substation and system susceptible to frequency swings and voltage unbalances
  - STATCOM performance requirements to be met for entire range of short circuit levels between maximum and minimum, for frequency variations between 56-66 Hz and operating voltages between 124-163kV

PROJECT EXECUTION

Challenges (cont'd)

- Geographical
  - Remote location, 63°20'34.4" N, 136°40'46.8 W
  - Near the village of Mayo, 4 ½ drive from the city of Whitehorse

- COVID
  - Project commenced in September of 2020, in the midst of the pandemic
  - Travel restrictions impacted ability to hold in person design review meetings and witness factory acceptance testing in person
  - Issues with deployment of construction personnel
  - Equipment delivery issues due to global shipping bottlenecks at the time

PROJECT EXECUTION

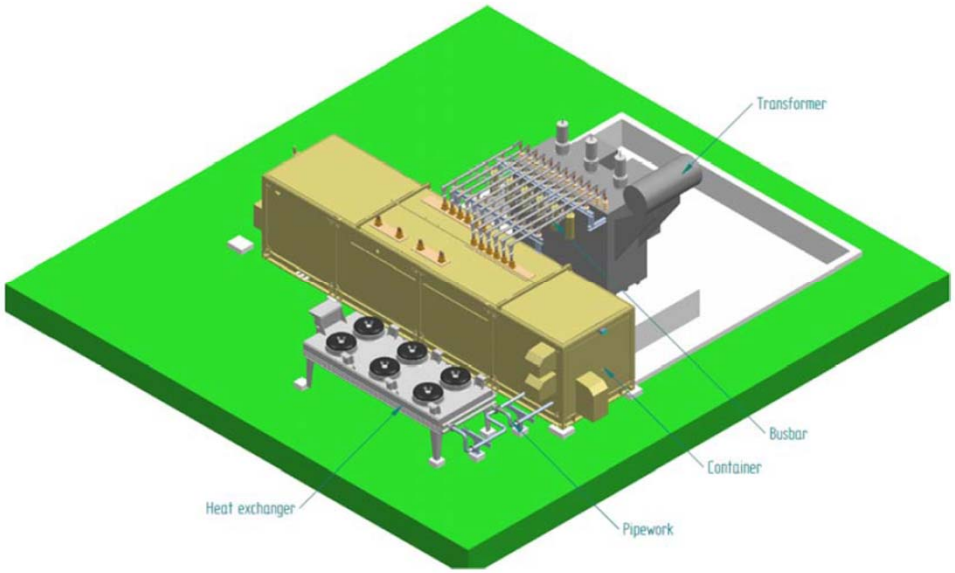
Performance Requirements

The specified performance requirements were very prescriptive and difficult to achieve due to the characteristics of the AC network, in the following categories:

- Step Response
  - Elapsed time to reach 90% of the step magnitude in response to step change in reference voltage
  - Maximum overshoot of instantaneous bus voltage relative to the magnitude of change in reference voltage
  - Settling time, being the elapsed time to reach within 5% of the magnitude of a new reference voltage
- Start-up voltage
  - Voltage reference to default to the existing system voltage at the 138kV bus
- Short Circuit Recovery Overvoltage Limit
  - Following a close in 3 phase fault with successful reclosing, the recovery voltage to be within 6% of pre-fault voltage
- Overvoltage/Undervoltage Operation
  - Defined minimum voltage to which the STATCOM will continue to generate reactive power
  - Defined overvoltage to which the STATCOM will continue safe operation
- Substation Interface
  - Ring bus expansion at Stewart Crossing South substation resulted in STATCOM connection to a two-breaker node, complicating the automatic start-up sequence

DESIGN FEATURES

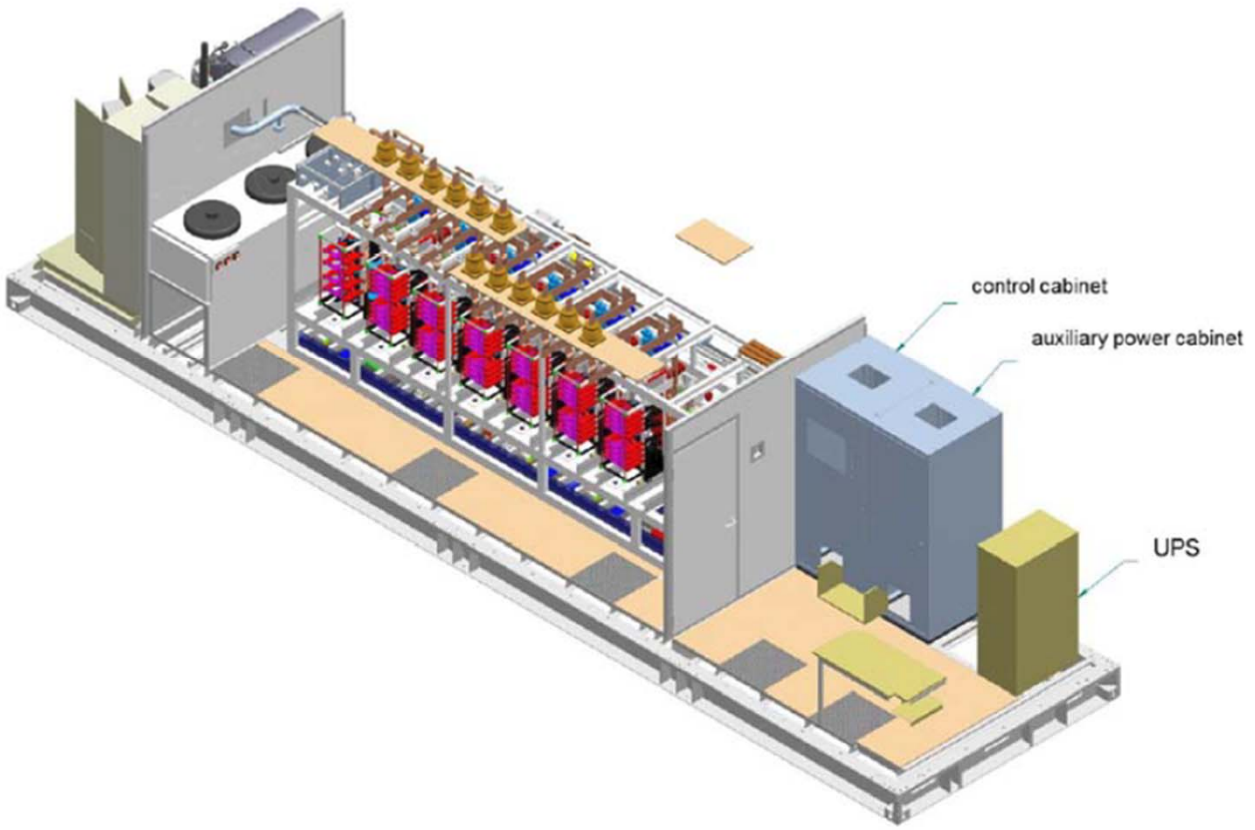
Layout
Overall:



DESIGN FEATURES

Layout

Container:



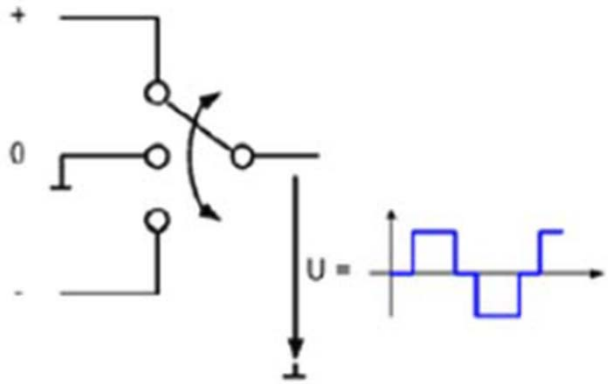
DESIGN FEATURES

DESIGN FEATURES

DESIGN FEATURES

Converter

- Integrated Gate Commutated Thyristor (IGCT) technology
- Power Electronic Building Block (PEBB) configuration
  - Three-level phase modules to produce an AC voltage from a DC source
  - Essentially a switch with a three-position output: positive (+) , zero (0) or negative (-) potential of the DC source



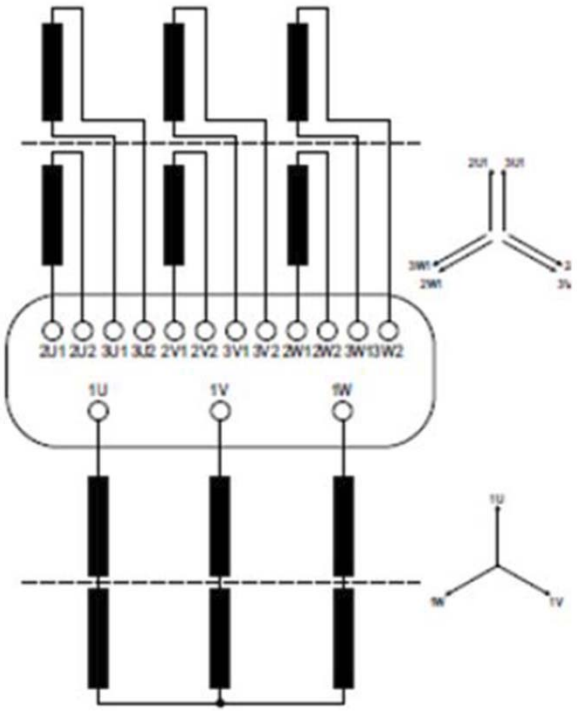
DESIGN FEATURES

PEBB

DESIGN FEATURES

Transformer

- Special connection to accommodate converter
- Rated power – 14 / 2x7.02 MVA
- Rated voltage – HV - 138kV, LV1&LV2 - 2589V



DESIGN FEATURES

DESIGN FEATURES

- Control Parameters:
  - Voltage control mode – Vref range 0.95….1.1 p.u. with 0.0025 resolution
  - Reactive power control mode – Q range -14….+14 Mvar
- Cold Start Procedure:
  - Measures for operation at temperatures below -30ºC and a cold start procedure developed for specific ranges of low ambient temperatures
- Additional cold weather design features:
  - Bypass valve to allow coolant circulation only inside container at low temp
  - Heat exchanger fans equipped with ring heaters and added insulation for external pipes
  - Transformer features:
    - Nynas 10XN oil – low viscosity
    - Oil pipes equipped with electrical pipe heating
    - Heaters on top and bottom of radiators – turn on at -35ºC

DESIGN FEATURES

Cold Weather Operation

- In ambient temperature range -30….+40ºC normal operation
- In ambient temperature range -45….-30ºC outdoor fans will not operate, bypass valve will operate, additional heaters will turn on to keep room temperatures inside container above 5ºC
- Alarm is raised if transformer bottom oil temperature drops below -35ºC, at which point manual Q mode may be invoked to increase transformer loading
- For cold start at ambient temperature range -60….-45ºC pre-loading at 30% of transformer rated power is required to bring bottom oil temperature to above -35ºC provided bottom oil temperature is above -45ºC to begin with. At below -45ºC no load operation is required

IN SERVICE

- Initial 30-day trial period commenced in early Novembe, 2021 following successful completion of online performance commissioning tests
- Performed correctly for system events that occurred during the period with some tuning require for negative sequence override
- Extreme temperatures late in the month and into early December caused cooling system related outage due to pressure drops resulting from inflow of large amount of cold coolant during switch bypass valve switch off. Temporary modifications made to modulate bypass valve to control volume of inflow
- Trial period resumed on December 23rd and final acceptance issued 30 days later
- Permanent modifications to bypass valve operation completed in May of 2022
- To date, the performance of the STATCOM has met all dynamic performance requirements

CONCLUSION

Project successfully executed, numerous constraints and factors notwithstanding:

- Remote site location
- Extreme climatic conditions
- Interconnecting to weak AC network
- Design, construction and commissioning during the midst of COVID pandemic