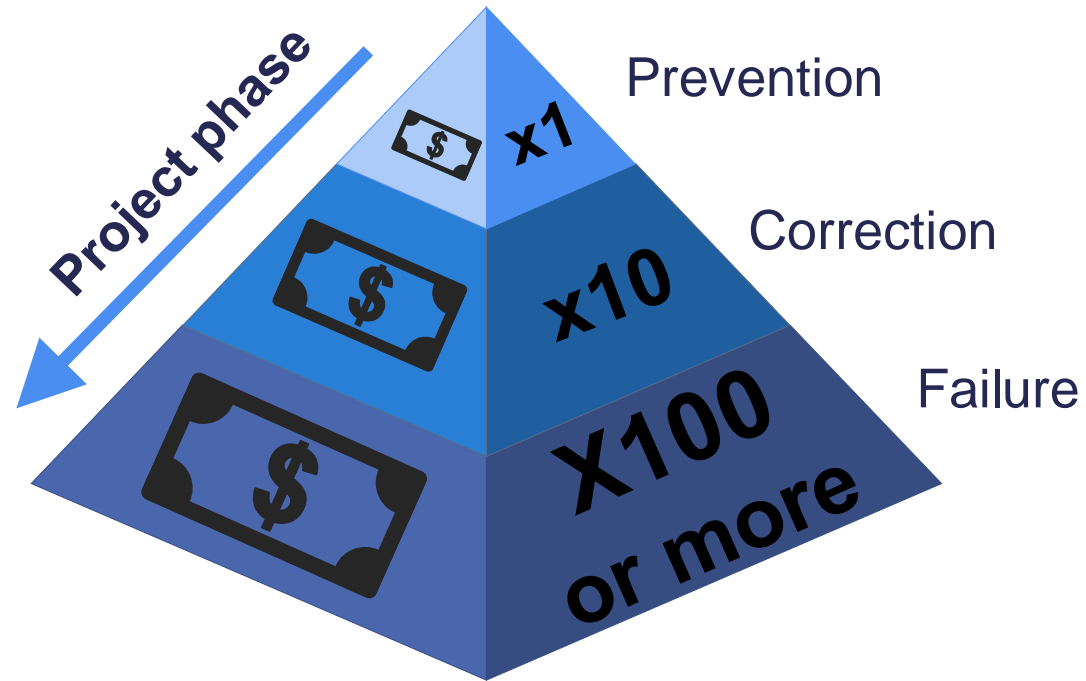


Cost of Change



NASA Space Missions



De-risk Manitoba Hydro Power Grid Transformation

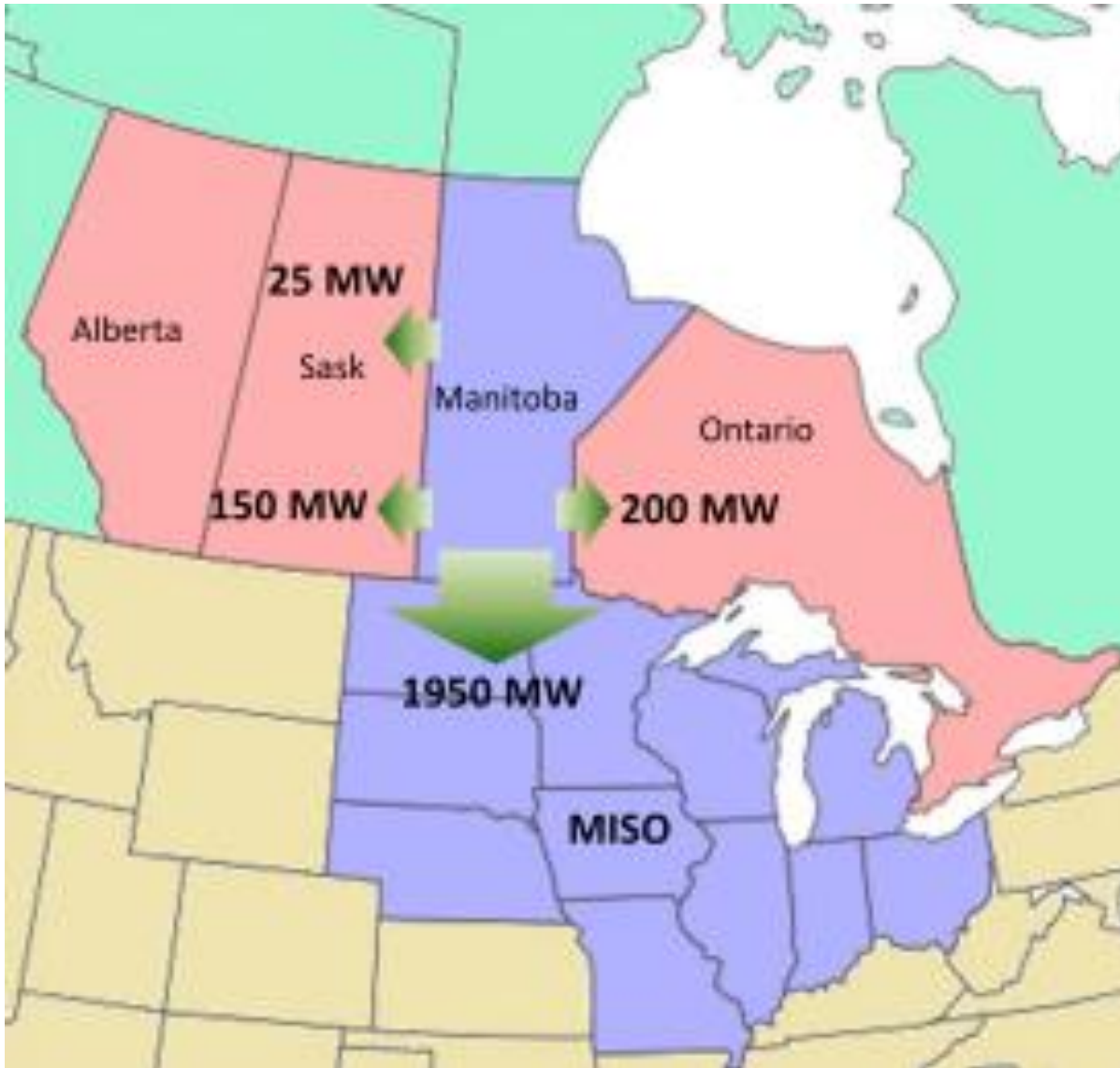
State-of-art Manitoba Hydro Real-time Simulation Centre (MHRSC)

Chun Fang (P.Eng., M.Sc.EE)

Integrated Resource Planning Division (IRPD), Manitoba Hydro

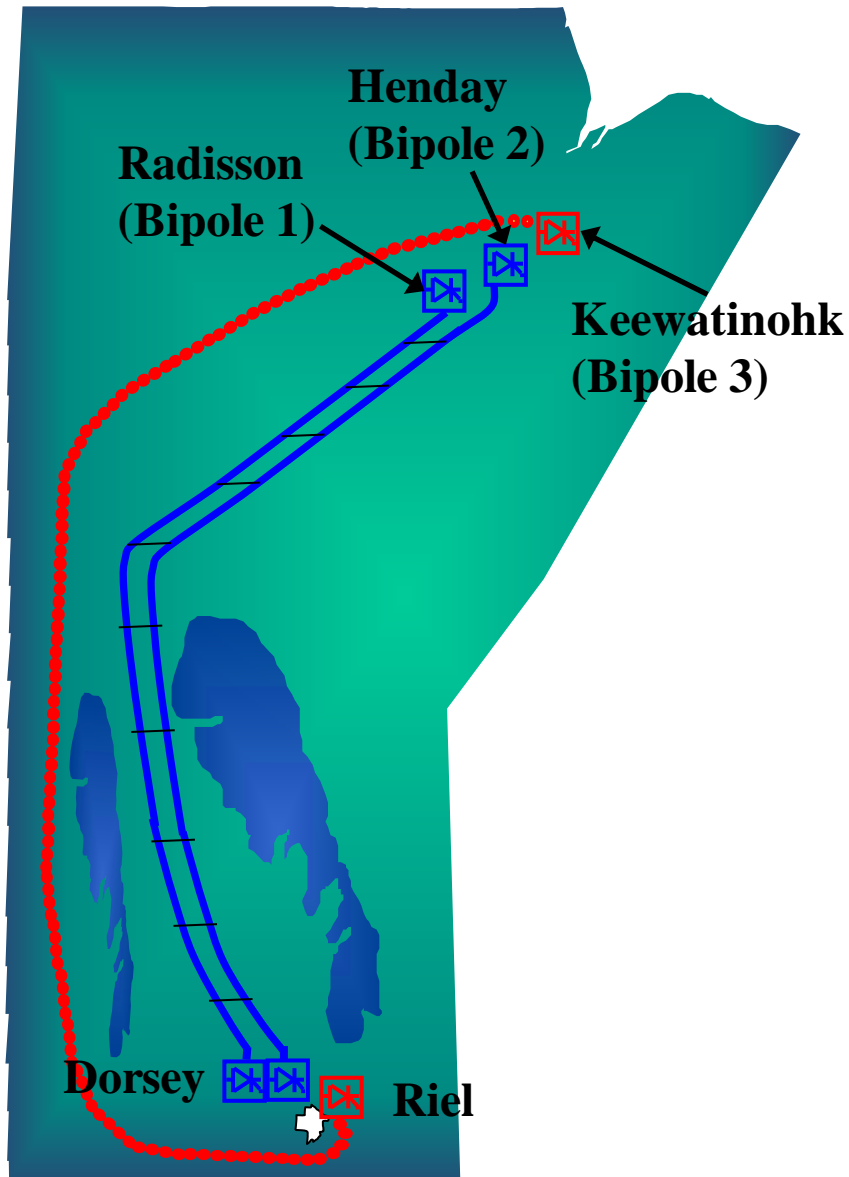
2020 RTDS User Spotlight Series

Manitoba Hydro



- ❑ Crown Corporation owned by Province of Manitoba,, CA headquartered at Winnipeg
- ❑ Fully integrated utility serving over 600,000 electricity and 290,000 gas customers
- ❑ Nearly all 5,700 MW of **clean and renewable** generating capacity by 15 hydroelectric stations;
- ❑ Winter peak 4750 MW
- ❑ 14,000 km Transmission
- ❑ Firm energy sale agreements with neighboring jurisdictions and a participant with the Midcontinent Independent System Operator (MISO)

Manitoba Hydro Bulk Energy System (BES)



❑ Multi-Egress & Multi-Infeed Topology (Classic HVDC)

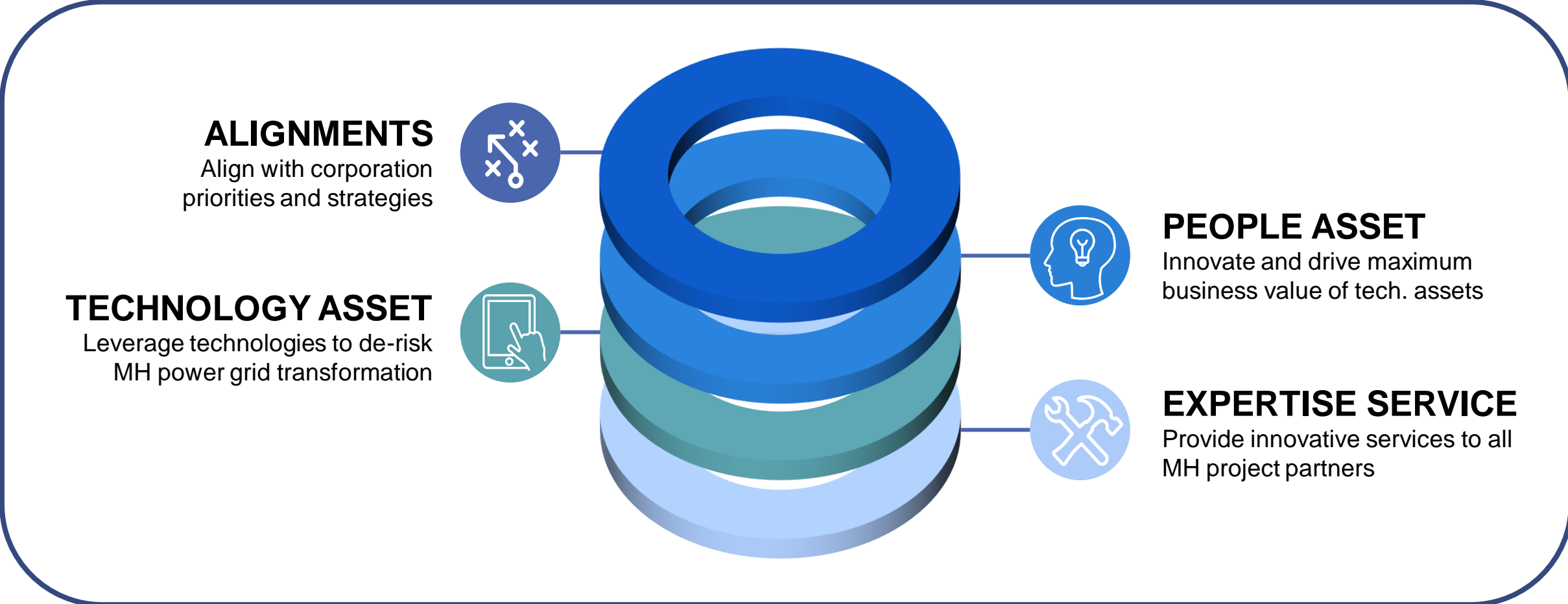
- Multi-egress: three rectifiers in electrical vicinity egressing from northern hydroelectric generating stations
- Multi-infeed: three inverters feeding into an electrically tight-coupled southern ac system relatively low in short circuit capacity and system inertia
- High Multi-Infeed Interaction Factor (MIIF)

❑ Complex Operating Environment

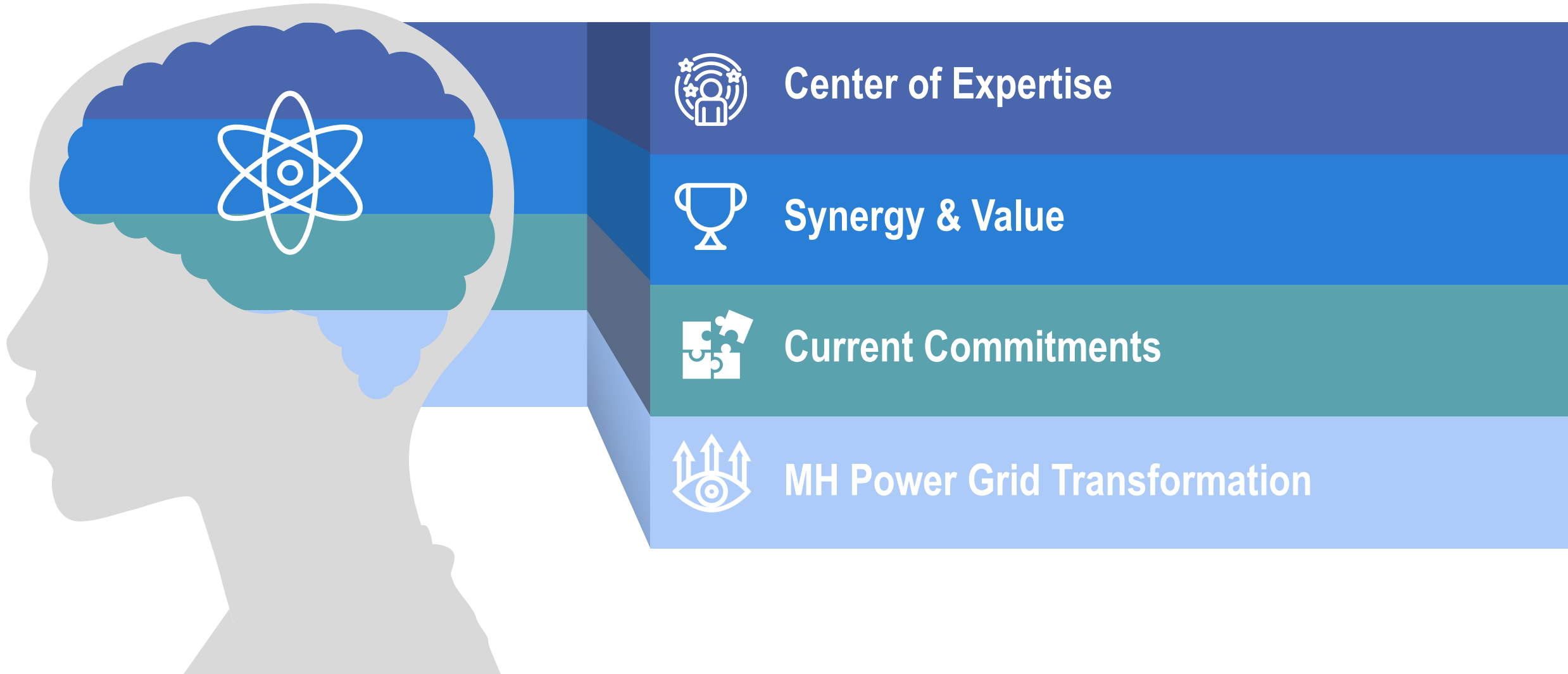
- Judicious coordination of HVDC recovery strategy vital to de-risk potential adverse interactions among three Bipole classic HVDC
- Uncoordinated or ill-conceived rapid simultaneous HVDC power resumption detrimental to overall system recovery and prone to provoke commutation failures

Manitoba Hydro Real-time Simulation Centre (MHRSC)

MHRSC: a critical planning & delivery framework established in 2013



MHRSC People as Core Asset

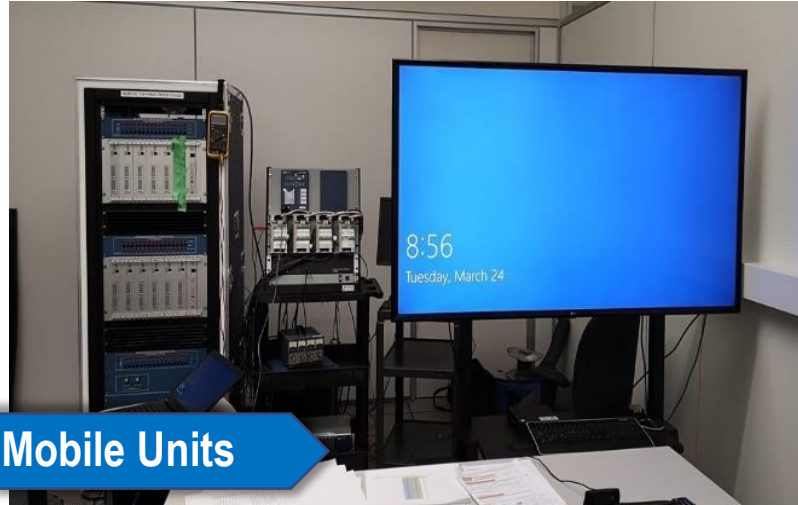


MHRSC RTDS and Replica Asset

RTDS Fleet (2 Fully Licensed NovaCor & 14 PB5 Racks)



MHRSC Home Base

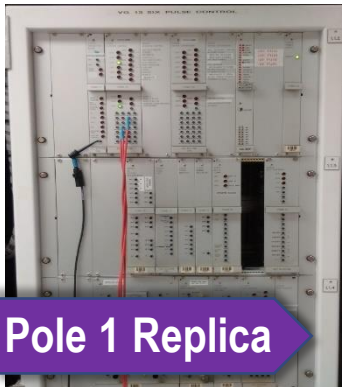


Mobile Units



Project Support

HVDC Control & Protection (C&P) & Auxiliary Equipment Replicas



Pole 1 Replica



Pole 2 Replica



Bipole 2 Replica

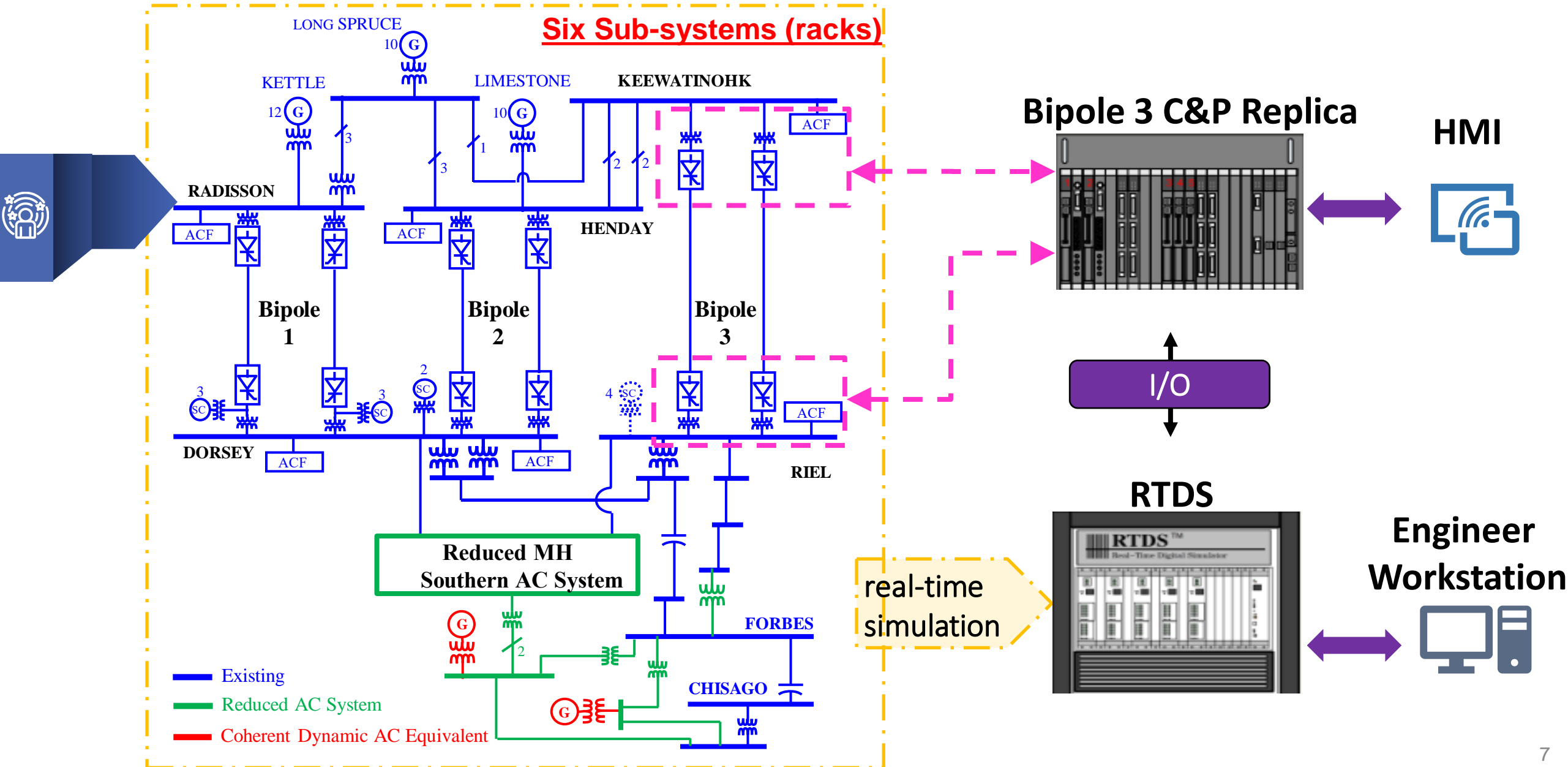


Bipole 3 C & P Replica

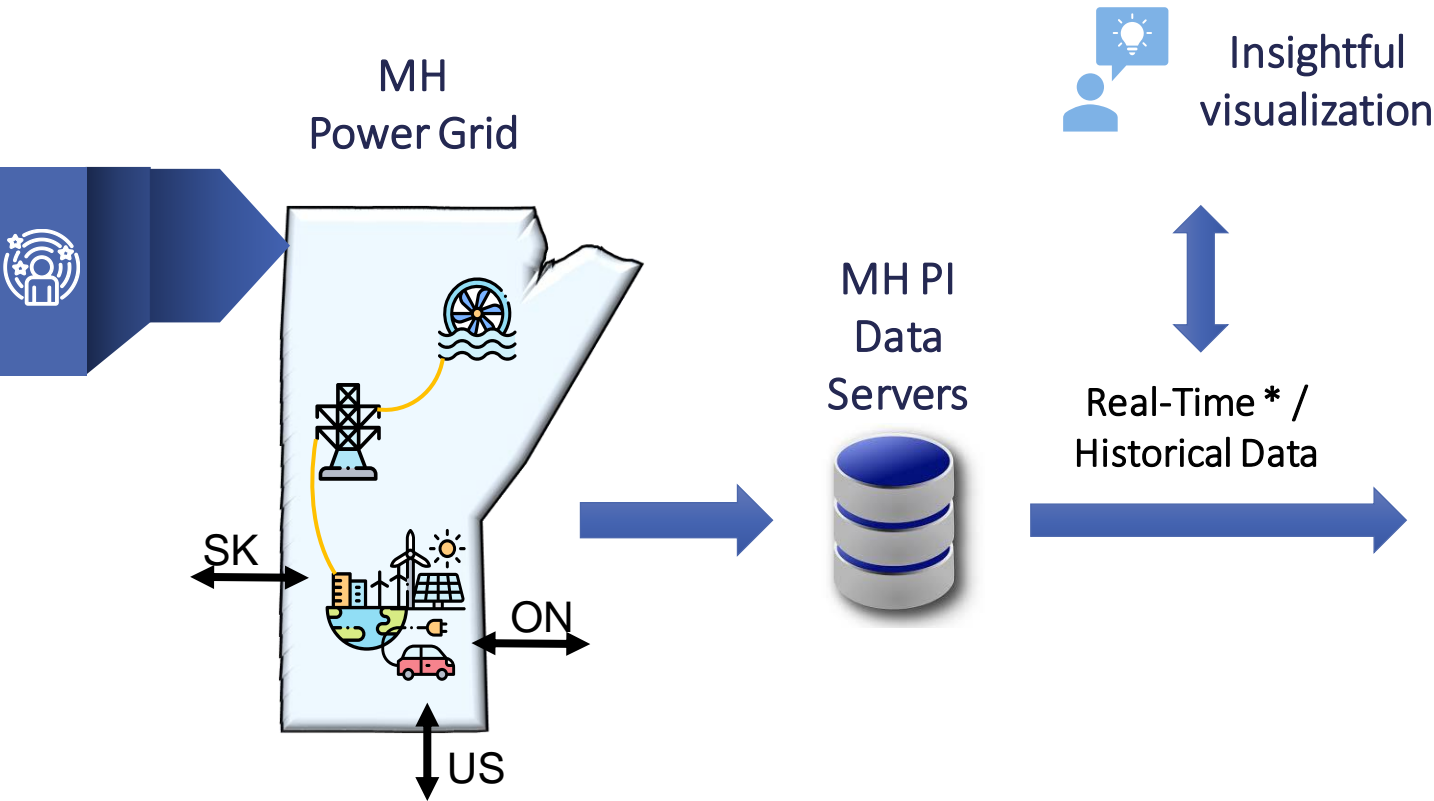


Exciter Ctrl Replica

MHRSC Large-Scale Multi-Infed HVDC HIL Simulation

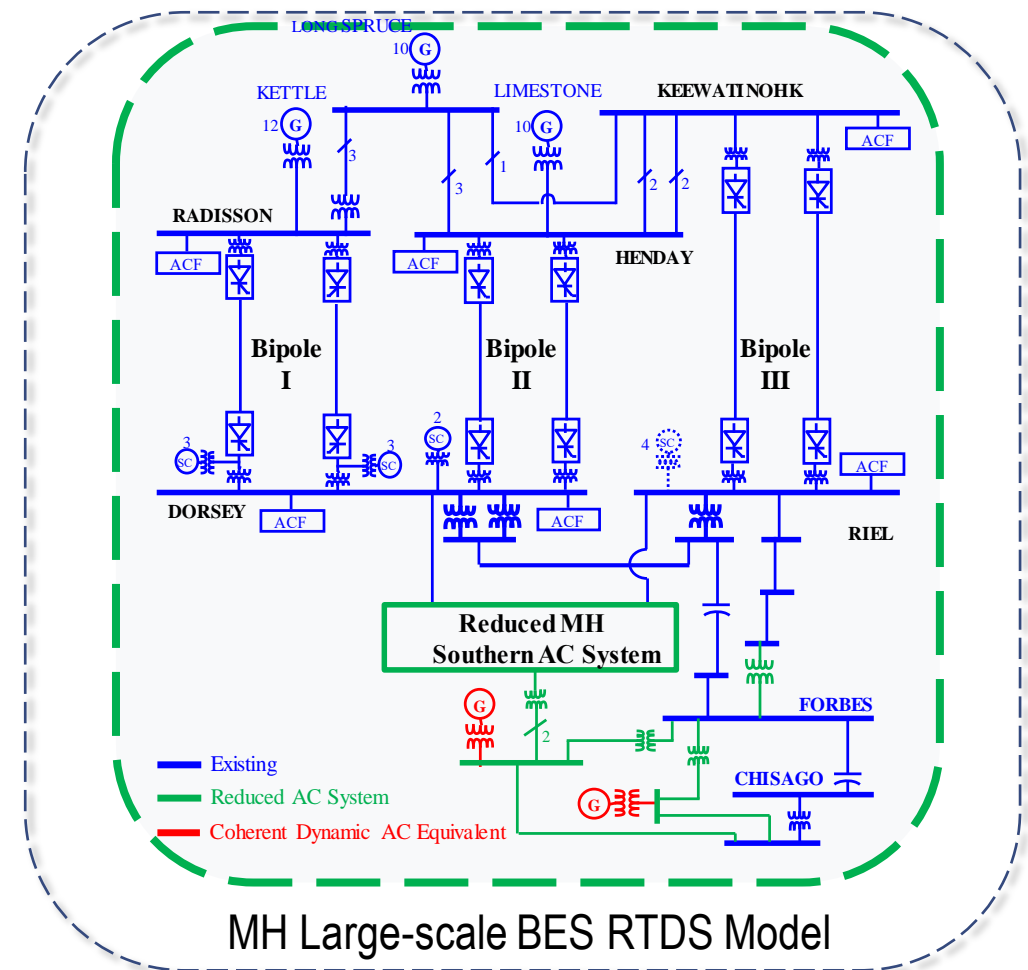


MHRSC Data-Driven Simulation Powerflow Posturing

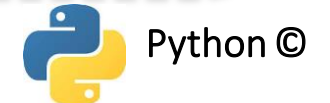


- Model component recognition & attributes assignment;
- Powerflow solution preparation, posturing & auto-initialization;
- Network topology, equipment status & export transfers;
- Machine, transformer OLTC, AC filters, HVDC transfers, load profile, etc
- Acceptable error (~ 5% to 8%);

In-house Powerflow Posturing with MH Operation Data



MH Large-scale BES RTDS Model



MHRSC Journey of Synergy & Value



2013



Riel-Forbes 500kV FSC Inter-tie

- De-risked crucial 500kV SPTR on FSC inter-tie
- Enabled 34 years after built due to complexity
- Fast, reliable, secure & safe restoration of market access



Bipole 3 LCC HVDC In Multi-infeed HVDC

- De-risked Bipole 3 on-site commissioning
- Significant schedule reduction (about 3 months) & outage cost saving
- Fast & secure integration
- Data-driven innovation

2020
> \$7M Saving
 200% Return on Capital (ROC) of MHRSC

World 1st HVDC Controlled Switching

- De-risked HVDC converter transformer emerging & smart technology
- Substantial assets life-cycle cost reduction & benefits
- Over \$ 5 Millions saving
- Prestigious CEA Centre of Excellence Award for Innovation



New Manitoba-Minnesota 500kV Inter-tie Protection

- De-risked complex protection schemes otherwise T-Line cannot safely energize
- Secured key “buy-ins” from MP & strengthened MH reputation
- Co-created engineering solutions with project partners
- Fast, reliable, secure & safe restoration of market access from 1st day of operation



2030
> \$17M Saving
 or 400% ROC

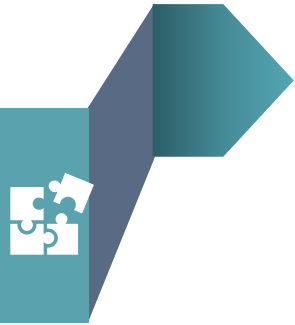
MHRSC Current Commitments

- Glenboro Phase-Shift Transformer Power Flow Control Remedial Action Scheme (RAS)**
 - RAS designed automatically regulate phase of two phase-shift transformers to prevent overloading of a 230kV interconnection to US following selected contingencies
 - MH in-house design and implementation RAS

- HVDC Reduction Control Remedial Action Scheme (RAS) Pre-deployment Testing**
 - RAS to prevent MH - US 230kV interconnections overloading tripping following any 500kV interconnection related loss
 - Internal design to quickly allocate power reduction on multi-infeed HVDC system based on 500kV pre-contingency power transfers

- Bipole 3 HVDC Control & Protection Conceptual Model**
 - In-house development of detailed Bipole 3 Control & Protection (C&P) model
 - Conceptual representation of Bipole 3 C&P philosophy and digital control implementation
 - Development and validation completed in PSCAD/EMTDC and RTDS counterpart ongoing

- MH Large-Scale Multi-Infeed Simulation Model Enhancements**
 - Continuous model enhancements to fully represent MH power system 115 kV and above
 - Coherency based AC equivalency for jurisdictions external to MH power system
 - PSCAD/EMTDC and PSS/E co-simulation



MHRSC Long-Term Strategies

MH Power Grid Transformation



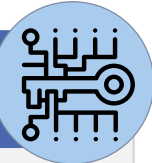
- Ready MH for future grid
- De-risk technological frontiers

Decarbonization Decentralization



- Microgrid Autonomous
- Renewables / DERs
- Decentralized Automation
- Energy Storage Integration
- PV Inverter

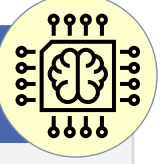
Digitalization



- Digital Substations
- Cyber Security
- Emerging Digital Tech.
- Travelling wave relay
- Data-Driven Models

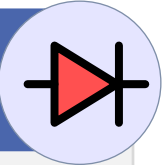


Smart Grid



- Smart Control & Protection (C & P)
- Wide Area C & P
- PMU Strategies

Power Grid Electronics



- HVDC (Mid-V & LV) & FACTS
- Energy Conversion
- Converter Drives

Operation & Maintenance



- C & P Asset Sustainment
- Black start & restoration
- C & P Optimization
- Control Interactions



The background features a complex geometric pattern of overlapping triangles in various shades of gray. Overlaid on this is a network diagram consisting of white lines connecting several circular nodes. Some nodes are white with black outlines, while others are solid black. The overall aesthetic is modern and technical.

Thank you!