

# Manitoba Battery Electric Transit Bus Fleet Development & Demonstration

**Ray Hoemsen, FEC, P. Eng.**

Director, Applied Research & Commercialization  
Red River College | Winnipeg, Manitoba CANADA

**Tohoku University | Sendai JAPAN**

**October 27, 2015**



**Next Generation Automobiles  
in Miyagi**

# Manitoba CANADA

- 49<sup>th</sup> to 60<sup>th</sup> parallel
- 548,000 km<sup>2</sup>
- ~1.3M people
- Ocean access (summer)
  - Net After-Tax Cost of Corporate R&D: 45¢ to 47¢ per \$1 of R&D
- Winnipeg (capital) weather
  - Extreme humid continental climate
  - 306 days with measureable sunshine
  - 521.1 mm precipitation annually
  - 132 days of snow cover – 110.6 cm average snowfall
  - -47.8°C (1879) to 42.2°C (1937) = 90°C difference
  - Windchill (temperature + wind) record = -57.1 (1996)
  - Humidex record (temperature + humidity) = 48 (2007)



# Red River College

- Manitoba's largest institute of applied learning
- Over 200 full- & part-time academic programs
  - Personal Development to Trades to Degrees
- More than 30,000 enrolments across eight campuses
- Annual operating budget ~\$180M
- ***Applied Research & Innovation: Fuelling Manitoba's economic growth & community development***
  - Annual research support ~\$6M
  - Ranked as a TOP 10 Canadian Research College
- Flexible Intellectual Property Policy
  - Institutional ownership (for clarity)
  - Commercial rights routinely assigned to private-sector sponsors
  - Rights retained for future research & education

# Vehicle Technology & Energy “Cluster”

- Focus on Off- and On-Highway Vehicle Technology
- Integrated approach
  - Applied research, education & training
  - Reflective of community needs
  - Partnerships are an essential component
    - Industry, government & academic
    - Ability to leverage cash and in-kind contributions
- Builds on existing College expertise and facilities
  - School of Transportation Aviation and Manufacturing
  - Research Centres, Research Chairs and Research Professionals
  - Technology Access Centre for Aerospace & Manufacturing
- Focused applied research program
  - Vehicle Development & Vehicle Performance

# Vehicle Technology Infrastructure & Projects

## Extreme (cold) & renewable energy focused



# Electric Vehicle Technology & Education Centre

- Mission:
  - Support electric vehicle innovation in/by Manitoba's transportation sector
  - Enhance electric vehicle education at RRC & in the region
  - Increase public awareness of electric vehicle technology
- Provincial financial support (\$645,000) based upon RRC's track record of applied research & demonstrations in advanced transportation & energy
- Leads College engagement in the battery electric transit bus project



# Battery Electric Transit (BET) Bus

- Public-Private Partnership – International Consortia
- 2011 to 2014: \$3 million, three-year project
  - Project development at NFI Winnipeg, Manitoba Hydro & RRC
- Goals
  - Develop a prototype advanced battery electric transit bus
  - Utilize MHI & NFI technologies
  - Demonstrate the bus & associated charging technologies
    - Test operational capabilities under Manitoba's extreme climatic conditions
    - Use demonstration as a showcase for other potential markets in N.A.
- 2012: Expanded scope (with SDTC & consortium partners)
  - \$10M five bus fleet multi-year trial in fare service with Winnipeg Transit



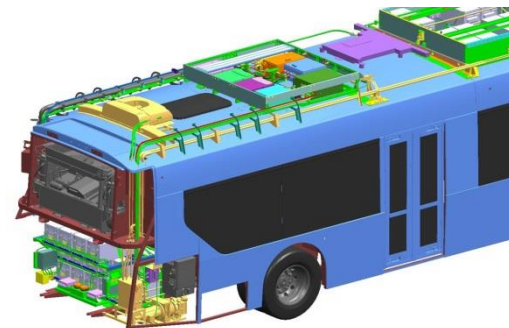
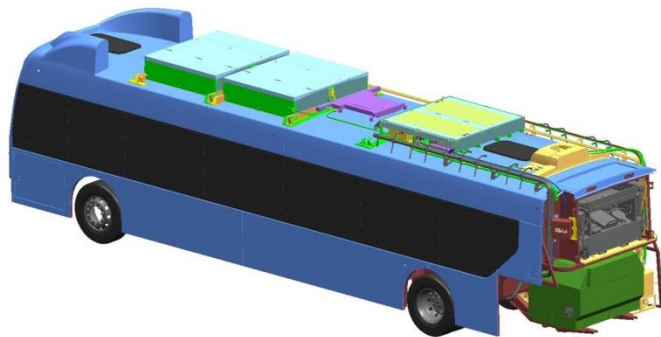
# RRC Role: BET Bus Prototype & SDTC Phases

- Financial project management & administration
- Assembly & monitoring of lithium ion batteries
- Charging infrastructure involvement (Manitoba Hydro-led)
- Phase 3
  - Operation (drivers), troubleshooting & minor maintenance
  - Service manual input (for EV operation)
  - Monitoring & evaluation of field tests
- Public report drafting (of original consortium project)
- SDTC Phase
  - Redesign, testing & prototyping of MHI battery packs for integration into two NFI Xcelsior XE40 production coaches
  - Monitoring of MHI battery packs
  - Operational support



# BET Bus Prototype Specifications

- NFI Xcelsior platform tested to standard industrial durability & life criteria (6X Altoona Durability Test)
- Energy-efficient electric permanent magnet traction motor
- MHI air-cooled lithium ion battery packs – 120 kWh (8 x 15 kWh)
- Bio-diesel heater for cold climates
- Similar weight to comparable diesel-electric hybrids
- Desired battery life – six to eight years



# BET Charging Infrastructure

- Dual module charger
  - 300 to 500 kW
  - Utility friendly, outdoor enclosure for curb-side installation
  - Enhanced safety & wireless communication
  - Integrated fault & isolation detection
- Overhead rapid charging dock
  - Automated rooftop interface (pantograph) – no operator intervention
  - Easy drive-through ingress/egress for rapid charging
- Now at YWG to enable fare service with Winnipeg Transit
  - Route 20 (**Watt** Street)
- Target of 6 minute charge/hour = no net charge depletion
  - 300 kW charger, 20 kph average speed & 1.45 kWh per km



# RESULTS: BET Bus Prototype (Original – Unit #1)

- MHI 120 kWh Li-on packs integrated in NFI Xcelsior coach
- Prototype completed June 2012, two-year field test/demo
  - Manitoba Hydro suburban-downtown shuttle - 15 kms round trip
  - ~20,981 kms (September 2015)
  - 300 kW charger = 20 minutes to full recharge
- Energy consumption (average of test & industry experience)
  - 2 kWh/mile – no air conditioning
  - 3 kWh/mile – with full air conditioning
  - 4 kWh/mile (estimated) – electric coach heating
    - Bio-diesel or diesel heater recommended
      - Less GHGs & 80-85% thermal efficiency
  - Overall average: 145 kWh /100 km
- [blogs.rrc.ca/ar/2014/05/manitobas-new-electric-bus-and-charging-system-revolutionizing-clean-energy-public-transportation-systems](http://blogs.rrc.ca/ar/2014/05/manitobas-new-electric-bus-and-charging-system-revolutionizing-clean-energy-public-transportation-systems)



# RESULTS: BET Bus Production Units (SDTC)

- SDTC Bus Production Units #2 to #5 (September 2015)
  - SDTC – MHI #1 (180 kWh) – 22,517 kms
  - SDTC – MHI #2 (180 kWh) – 17,599 kms
  - SDTC - XALT Energy #1 (200 kWh) – 9,755 kms
  - SDTC - XALT Energy #2 (200 kWh) – 27,102 kms
- Demonstrations and applications
  - Winnipeg Transit fare (revenue) service – operating reliably
  - Transit Property demonstrations across North America
  - “Altoona Test” per FTA – industry-leading results
- First NFI commercial sales (two) to Chicago Transit Authority
  - 28,852 kms and 27,887 kms (as of 2015 09 08)



# SDTC BET Bus Milestones

- Production units (four) operational in 2014
- Reliability simulation – on route, schedule maintained, shadow service (no passengers)
- Battery duty cycle evaluation (Sept 2014 to March 2015)
  - 1.45 kWh/km (2.3 kWh/mile) energy consumption
  - 57.5 kWh of energy required to recharge (after 40 km route)
  - 29% of battery pack capacity
- Altoona Test very successful, no failures related to:
  - Axles
  - Batteries
  - Electric air compressor
  - Electric drive
  - Electric HVAC
  - Electric steering

# Altoona Test Results (June 2014 to July 2015)

- Federal Transit Administration (FTA) Test Program
  - Testing in Service-Life Category 12 Years/500,000 Miles
- “SDTC” XE40 prototype
  - New Flyer Xcelsior bus platform
  - Siemens ELFA drive motor
  - XALT Energy batteries - 200 kWh
  - 76-person capacity
- Industry-leading results
  - Reliability
  - Fuel efficiency
  - Interior noise
  - Gross Vehicle Weight Rating

# Altoona Test Results (June 2014 to July 2015)

- Failures = 21
  - Competitors: "A" @ 33 | "B" @ 49
- Unscheduled Repairs = 74.0 hours
  - Competitors: "A" @ 258.5 hours | "B" @ 278.5 hours
- Energy consumption overall average = 1.84 kWh/mi
  - Diesel equivalent fuel economy = 20.50 mpg
- Vehicle range average = 87.01 miles
- 0 to 35 mph interior noise average = 68.6 dBA
  - Competitors: "A" @ 70.4 dBA | "B" @ 75.2 dBA
- Highest passenger-carrying capacity of any electric bus in N.A.
- Federal Zero-Emission Bus Voucher Incentive Program registered, including California
- [altoonabustest.psu.edu/buses/458](http://altoonabustest.psu.edu/buses/458)

# Takeaways

- “Clean Tech” offers socially rewarding & technically interesting opportunities for innovation
- Personal & corporate relationships are the foundation for project success
- Clear roles are necessary, especially in consortia
- Many partners & enablers have contributed over the last decade to project success - partnerships work
- Battery electric transit buses perform reliably & efficiently in Manitoba’s extreme climate, especially cold
- Altoona Test shows that “Made-in-Manitoba” electric vehicle technology is an industry leader



# Enablers & Partners

- **Enablers – since 2003**

- Canada Foundation for Innovation
- Department of Foreign Affairs and International Trade
- Knowledge Infrastructure Program
- Manitoba Vehicle Technology Centre
- National Research Council Industrial Research Assistance Program
- Natural Sciences & Engineering Research Council (CCIP, IE, ARTI, TAC & ARD-2)
- Province of Manitoba (COPSE, ETT & IEM)
- Sustainable Development Technology Canada
- Western Economic Diversification

- **Partners – since 2011**

- New Flyer Industries
- Manitoba Hydro
- Mitsubishi Heavy Industries (Japan)
- Province of Manitoba (Energy Division)
- Red River College
- Winnipeg Transit

# References

- Province of Manitoba (Manitoba EV Road Map & all reports) [manitoba.ca/iem/energy/transportation/index.html](http://manitoba.ca/iem/energy/transportation/index.html)
- Robert V. Parsons, Manitoba Innovation Energy and Mines and Ray Hoemsen Red River College. 2012. Advancing Electric Vehicle Adoption: Insights from Manitoba Experience. EV2012VÉ.
- Thomas Small, New Flyer Industries. 2012. Electric Transit Buses: The Bus, The System, The Road to a Cleaner Future. EV2012VÉ.
- Paul Cantin, New Flyer Industries and Dale Friesen, Manitoba Hydro. January 29, 2013. CEATI SOIG-STWG.
- Dale Friesen, Manitoba Hydro and Ray Hoemsen, Red River College. February 6, 2013. Moving Forward with a Green Economy Through the Development & Integration of Electric Vehicles. 2<sup>nd</sup> Annual Electric Vehicle Infrastructure Summit.

# References

- Robert V. Parsons, Energy Division, Province of Manitoba and Ray Hoemsen, Red River College. 2013. Advancement of Electric Vehicles: Update of Manitoba. EV2013VÉ.
- Ray Hoemsen. Red River College. 2013. Electric Vehicle Technology & Energy Centre. Electric Vehicle Symposium 27.
- Martin Cash, Winnipeg Free Press. November 28, 2014. Battery-powered bus to hit city streets. [winnipegfreepress.com/business/its-electrifying-284125961.html](http://winnipegfreepress.com/business/its-electrifying-284125961.html)
- Pennsylvania Transportation Institute. 2015. Federal Transit Bus Test. Report Number: LT-BT-R14005.
- New Flyer News Release. September 1, 2015. New Flyer Battery-Electric Xcelsior® Bus Delivers Industry Leading Results in Reliability, Fuel Efficiency, Interior Noise and GVWR at Altoona Test Facility.

# Questions?

**Ray Hoemsen, M.Sc., FEC, P. Eng.**

Director, Applied Research & Commercialization  
Red River College

Winnipeg, MB

Voice: 204.632.2523 or 204.799.6987 (mobile)  
Fax: 204.633.3079

E-mail: [Rhoemsen@rrc.ca](mailto:Rhoemsen@rrc.ca)

Web: [rrc.ca/appliedresearch](http://rrc.ca/appliedresearch)  
Blog: [blogs.rrc.ca/ar](http://blogs.rrc.ca/ar)  
Twitter: @RRCResearch



*AR&C Team: January 2014*

