Manitoba Battery Electric Transit Bus Fleet Development & Demonstration

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Manitoba CANADA

- 49th to 60th parallel
- 548,000 km²
- ~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 measurable 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
  o Applied research, education & training
  o Reflective of community needs
  o Partnerships are an essential component
    ➢ Industry, government & academic
    ➢ Ability to leverage cash and in-kind contributions
• Builds on existing College expertise and facilities
  o School of Transportation Aviation and Manufacturing
  o Research Centres, Research Chairs and Research Professionals
  o Technology Access Centre for Aerospace & Manufacturing
• Focused applied research program
  o Vehicle Development & Vehicle Performance
Vehicle Technology Infrastructure & Projects
Extreme (cold) & renewable energy focused
Electric Vehicle Technology & Education Centre

• Mission:
  o Support electric vehicle innovation in/by Manitoba’s transportation sector
  o Enhance electric vehicle education at RRC & in the region
  o 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
  o 300 to 500 kW
  o Utility friendly, outdoor enclosure for curb-side installation
  o Enhanced safety & wireless communication
  o Integrated fault & isolation detection

• Overhead rapid charging dock
  o Automated rooftop interface (pantograph) – no operator intervention
  o Easy drive-through ingress/egress for rapid charging

• Now at YWG to enable fare service with Winnipeg Transit
  o Route 20 (Watt Street)

• Target of 6 minute charge/hour = no net charge depletion
  o 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
RESULTS: BET Bus Production Units (SDTC)

• SDTC Bus Production Units #2 to #5 (September 2015)
  o SDTC – MHI #1 (180 kWh) – 22,517 kms
  o SDTC – MHI #2 (180 kWh) – 17,599 kms
  o SDTC - XALT Energy #1 (200 kWh) – 9,755 kms
  o SDTC - XALT Energy #2 (200 kWh) – 27,102 kms

• Demonstrations and applications
  o Winnipeg Transit fare (revenue) service – operating reliably
  o Transit Property demonstrations across North America
  o “Altoona Test” per FTA – industry-leading results

• First NFI commercial sales (two) to Chicago Transit Authority
  o 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)
  o 1.45 kWh/km (2.3 kWh/mile) energy consumption
  o 57.5 kWh of energy required to recharge (after 40 km route)
  o 29% of battery pack capacity
• Altoona Test very successful, no failures related to:
  o Axles
  o Batteries
  o Electric air compressor
  o Electric drive
  o Electric HVAC
  o Electric steering
Altoona Test Results (June 2014 to July 2015)

• Federal Transit Administration (FTA) Test Program
  o Testing in Service-Life Category 12 Years/500,000 Miles

• “SDTC” XE40 prototype
  o New Flyer Xcelsior bus platform
  o Siemens ELFA drive motor
  o XALT Energy batteries - 200 kWh
  o 76-person capacity

• Industry-leading results
  o Reliability
  o Fuel efficiency
  o Interior noise
  o 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
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


• Paul Cantin, New Flyer Industries and Dale Friesen, Manitoba Hydro. January 29, 2013. CEATI SOIG-STWG.

References


Questions?


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AR&C Team: January 2014