



APPLIED RESEARCH &
COMMERCIALIZATION
Applying Knowledge, Delivering Results™

Vehicle Technology & Energy Centre

Canadian Applied Research Experience at Red River College

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Winnipeg, Manitoba CANADA

Local/Global Innovations for Next Generation Automobiles

Tohoku University

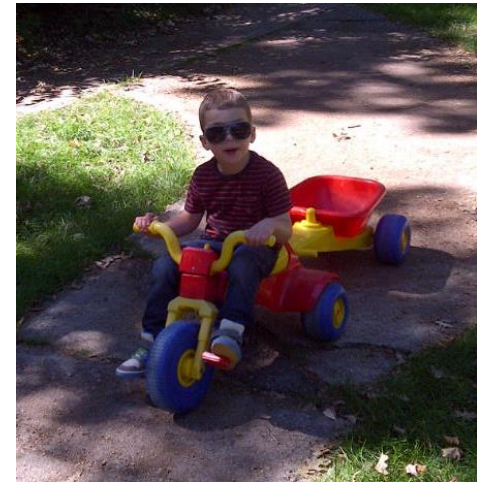
Sendai JAPAN

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Scope

- Overview
 - Manitoba
 - Red River College
 - College-based Applied Research
- Capabilities & Cases
- Projects Results & Learnings



Manitoba CANADA

- 49th to 60th parallel
- 548,000 km²
- Ocean access
- Exports = \$11.1B
 - Japan = \$581M
- Imports = \$19.1B
 - Japan = \$202M
- ~1.3M people



Winnipeg Weather (& Extremes)

- 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
- Minimum daily temperature $< -20^{\circ}\text{C}$ for 49 days, December through February
- Windchill (temperature + wind) record = -57.1 (1996)
- $30^{\circ}\text{C}+$ 14 times per year
- Humidex record (temperature + humidity) = 48 (2007)



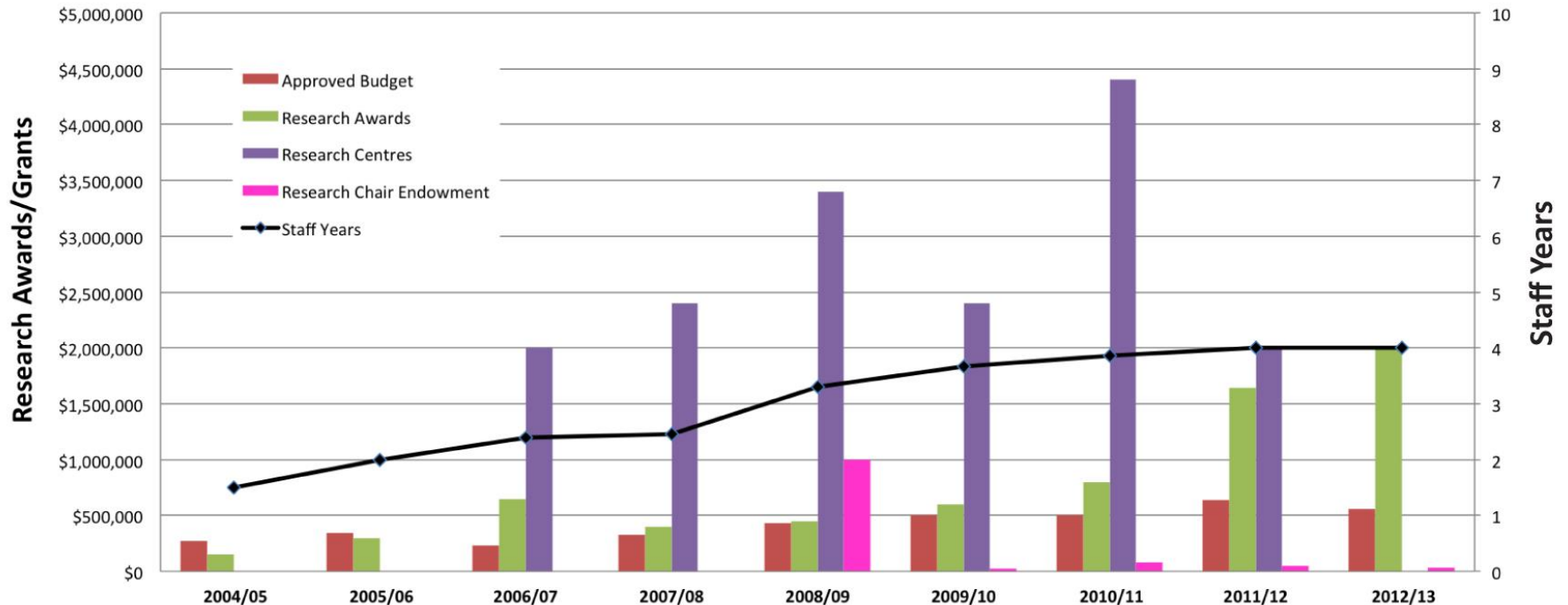
Red River College

- 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
- Annual operating budget ~\$160M
- Annual research operating support ~\$2M
 - 50+ private- & public-sector research partners since 2004
- Ranked a Top 10 Research College (Canada)
- ***Applied Research & Innovation: Fuelling Manitoba's economic growth & community development***

College-based (Applied) Research is.....

- Application of Knowledge
 - Problem solving
 - Focus on the "HOW" not the "WHY"
 - Technology diffusion (vs. commercialization)
 - Adoption & adaption of technology
 - Knowledge translation
 - Putting the research results (often from others) into practise
- Flexible Intellectual Property Policy
 - Institutional ownership (for clarity)
 - Commercial rights routinely assigned to private-sector sponsors
 - Rights retained for future research & education

Applied Research Enterprise Growth



- 2009: Manitoba Roundtable on Sustainability Award of Excellence
- 2010: Winnipeg Chamber of Commerce Spirit of Winnipeg Award
- 2011: ACCC National Gold Leadership Award

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
 - ATEC, CARSI, CATT, CNDI & EVTEC
 - Technology Access Centre within TAM
 - Research Chairs & Professionals
- Focussed applied research program (NSERC proposal)
 - Vehicle Performance, Improving Fuel Efficiency & Reducing Emissions

Transportation Aviation & Manufacturing

- **Certificate, diploma, advanced diploma & (proposed) degrees**
 - Trades, technology & apprenticeship education & training
 - ~100 faculty
 - 18 regular programs & 16 apprenticeships
 - ~575 enrolments
 - ~875 apprenticeships
 - ~ 200 contract trainees
- **Applied Research, Specialized Technical Services & Training**
 - Heavy Equipment Transportation Centre
 - 350+ students & ~30 instructors & staff
 - Model Factories for metals & composites
 - Industrial Campuses for aerospace materials & NDI
 - Research Chair & Research Professionals (3)
 - Technology Access Centre
 - Applied research, technical services & technology diffusion/training

Vehicle Technology Infrastructure (selected)

Extreme (cold) & renewable energy focus

➤ **Advanced Transportation & Energy Centre**

- Focus on product development & improving fuel efficiency, especially with renewable fuels
 - Licensed bio-diesel refinery, CNG, electricity, hybrid, hydrogen technologies
 - Portable vehicle emissions testing (NO_x, SO_x, particulate matter)
 - 1,000 HP chassis & 1,000 HP engine dynamometers (to-be-installed)
- Specialized curriculum development & training

➤ **Centre for Aerospace Technology & Training**

- Process development for materials & bonding

➤ **Centre for Non-Destructive Inspection**

- Distributed network of technologies, facilities & expertise in non-destructive inspection of components (traditional & composite materials) and assemblies
- Defect visualization including ultrasonic imaging, laser inspection, x-ray tomography etc.

➤ **Centre for Applied Research in Sustainable Infrastructure**

- Environmental chambers (side-by-side) able to accommodate a small electric vehicle
 - -40° C to + 40° C, independently controlled, additive humidity
- Structural dynamic test system with "strong" floor
- Prototype "skunk works" development

Vehicle Technology Infrastructure (selected)

Extreme (cold) and renewable energy focussed



Ground Transportation Experience (selected)

- Industry, Government and/or Academic Partner Projects
 - CNG heavy vehicle cold weather assessment
 - Lithium ion battery assembly & battery pack modification/integration
 - Battery electric transit bus prototype & demonstration
 - Electric Vehicle apprenticeship module development
 - Electric Vehicle Technology & Education Centre
 - Bio-diesel refinery design, fabrication & operation (licensed facility)
 - Highway coach prototypes for US EPA 2007 & 2010 emission requirements
 - Prius PHEV conversions (A123 Hymotion) & multi-year fleet demonstration
 - Hydrogen Fuel Cell Bus Prototype Demonstration (pre-2010 Olympics)
 - Hybrid Hydrogen Internal Combustion Engine Bus Demonstration
 - Studies, business/market intelligence, policy consultation & technology roadmaps
- Student Projects
 - Solar & electric motorcycle design & fabrication
 - Red River Raycer (solar car)

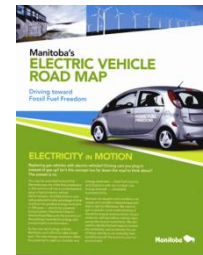


Ground Transportation Experience (selected)



CASE: Community Engagement

- Association of Manitoba Municipalities Working Group on Next Generation (Non-Conforming) Green Vehicles
- City of Winnipeg Mayor's Environmental Advisory Committee
- Electric Mobility Canada
- Environmental Testing Research & Education Centre
- Manitoba Centre for Renewable Energy
- Manitoba Vehicle Technology Centre
- National Research Council of Canada (IRAP)
- Natural Sciences and Engineering Research Council (CARD-2)
- Post-secondary institutions
- Province of Manitoba
- Research & commercialization partners - business & industry



Canada

Manitoba



Winnipeg

A123
SYSTEMS



Kraus
GLOBAL

Manitoba
Hydro



PERSENTECH

CASE: EVTEC

Electric Vehicle Technology & Education Centre

- Demonstration & public education site for all-electric & plug-in hybrid-electric vehicles & recharging equipment
- Provincial support based on RRC's track record of applied research & demonstration projects in advanced transportation
- 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



CASE: Motor Coach Industries



- Evolved from NSERC LAMP pilot project
- Engine/transmission system design/integration for US EPA 2007
- Five students, three instructors: three students since hired by MCI
- Six months from idea to prototype (including US legal approval)
- Met/exceeded all test requirements of all prototypes
- ***"The nature of the outcome is a new model that sells."***
Interview with Jim MacDonald, Director of Engineering by Marcel D. Mongeon, Mongeon Consulting Inc.
- Results incorporated in ~20% product sold (~400 units p.a.)
- Referenced in 2007 Federal Budget <http://www.budget.gc.ca/2007/bp/bpc5de.html#innovation>
- Four subsequent projects, including US EPA 2010 prototype
- Subject of positive column about RRC-MCI relationship/mutual benefits by Martin Cash, Business Columnist, Winnipeg Free Press
<http://www.winnipegfreepress.com/business/rrcs-savvy-fuels-green-buses-110901159.html>

CASE: PHEV Prius/A123 Fleet Demonstration

➤ GOAL: Understand benefits & limitations



LEARNINGS: Passenger Vehicles in Cold Weather

- Significantly more electricity (up to five times) required to heat the vehicle than to charge for motive operation
- Preheating of the cabin (with electric in-car warmer and/or use of winter front) is essential to defog/defrost the windshield and improve cabin warmth, especially when ambient temperature is below -20°C
- Charging can take longer
- May be able to increase oil change intervals
- Expected PHEV battery life ~ 8 years
- Fuel consumption (gas for ICE) increases in winter months
- Significant reduction in range (up to 40%)

CASE: Battery Electric Transit (BET) Bus

- Public-Private Partnership – International Consortia
- \$3-million, three-year project - 2011
 - Project development at RRC (EVTEC) & NFI Winnipeg
- 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 NA
- Expanded scope (with SDTC & consortium partners) - 2012
- \$10M five bus fleet multi-year trial in fare service with Winnipeg Transit



SDTC BET Bus Fleet Expansion

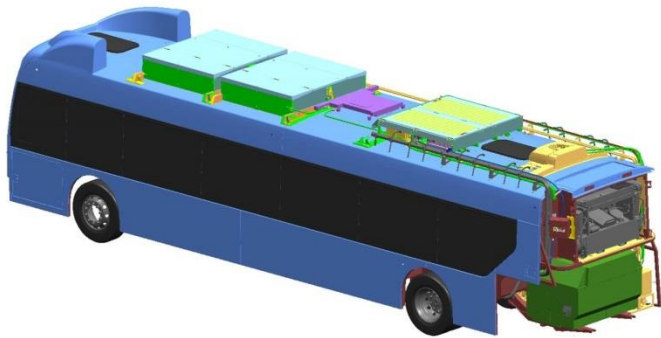
- Demonstrate feasibility of electric transit buses in cold weather climates
- Further validate business case for electric transportation
 - Four additional battery electric buses to be built in 2014
 - Winnipeg Transit a new partner
 - Fleet (five, including original prototype) will operate in fare service on a dedicated route
 - Four year demonstration period
- Sustainable Development Technology Canada awarded NFI \$3.4M, leveraging initial \$3M consortia investment & additional partner contributions = \$10M value

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
- SDTC Phase
 - Redesign, testing & prototyping of MHI battery packs for integration into two Xcelsior 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 (8x15 kWh)
- Bio-diesel heater for cold climates
- Similar weight to comparable diesel-electric hybrids
- Desired battery life – six to eight years



Charging Infrastructure

- Dual module charger
 - 300 to 500 kWh
 - 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
- Target is full charge in < 30 minutes
- 7.5 minutes charging per hour = no net charge depletion
 - 300 kW charger, 20 kph average speed & 1.9 kWh per km consumption



RESULTS: BET Bus Prototype

- MHI 120 kWh Li-ion packs integrated in NFI Xcelsior coach
- Prototype completed June 2012, two-year field test begun
 - Manitoba Hydro suburban-downtown shuttle - 15 kms round trip
 - ~8,000 kms to date
 - 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
 - 5 kWh (estimated) – with electric coach heating
 - Bio-diesel or diesel heater recommended
 - Less GHGs & 80-85% thermal efficiency
- Energy consumption, overall average: 133 kWh /100 km

RESULTS: <http://vimeo.com/61570502> (batterybus)



N SERC Vehicle Technology & Energy Centre

- Natural Sciences and Engineering Research Council of Canada CCI “Innovation Enhancement” competition, decision in March 2014
 - Builds on existing experience & capabilities
 - \$2.3M over five years for research program (\$3.25M proposal)
- Heavy vehicles account for \$1B (of \$7B) of Manitoba’s manufacturing exports & 10% of manufacturing workforce
- Focus on off- & on-highway vehicle technology, especially in cold
 - Use of renewable & alternate fuels
 - Improving fuel efficiency (especially in fleets), while reducing emissions
 - Related vehicle development & testing
- Will enable
 - Greater support for innovation in vehicle manufacturing & transportation
 - Introduction of new vehicle technologies
 - Training the next generation of skilled workers

Heavy Vehicle Centre of Excellence

- Currently in discussion with off- & on-highway vehicle industry sector
 - Potential to include aerospace sector
- Industry-wide need for local access, on a timely basis, to specialized facilities to meet technological & innovation needs of heavy vehicle (agricultural machinery, bus & specialized equipment) manufacturers
- Shared use facility located within HETC at Red River College
 - ~\$6M capital investment
- Three-axle 1,000 HP chassis dynamometer integrated into a drive-in environmental chamber, complementing existing HETC capabilities
 - 50' (l) x 25' (w) x 16' (h), can be partitioned
 - -40°C to +50°C operating range, with chassis dynamometer operating
 - 2°C to 5°C temperature control, ability to upgrade to increase precision
 - Operating environment sized for maximum vehicle output of 650 HP
 - 15 minute maximum run time for chassis dynamometer
 - Fans capable of generating 70 mph winds can be integrated

Research Partnership Opportunities

- Focus Areas
 - Advanced Design & Manufacturing
 - Clean Technology
 - Digital Technology
 - Social Sciences (business & market intelligence & analysis)
- Company-specific applied research projects
- Technology demonstrations & evaluations
 - Especially for technologies which may need to operate in different climatic extremes/conditions from where they were developed
- Knowledge exchange, through workshops & seminars
- Staff & Faculty exchanges
- Student participation and/or exchange

References

- ▶ Province of Manitoba (Manitoba EV Road Map & all reports)
<http://www.manitoba.ca/iem/energy/transportation/index.html>
- ▶ Gregor, C. and Parsons, R. V. 2011. Cold-weather modifications of plug-in hybrid electric vehicles for Manitoba operation. IEEE Electrical Power and Energy Conference.
- ▶ 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. 2nd Annual Electric Vehicle Infrastructure Summit.
- ▶ 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.

Thank You

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