GRANDES MENTES PENSAM ELETRICAMENTE
LAS MENTES BRILLANTES TIENEN IDEAS ELÉCTRICAS
EVS26
GREAT MINDS THINK ELECTRIC
LES GRANDS ESPRITS S'ILLUMINENT
AGAR BUDDHIMAN HO BIJLI YAAD KARO
GROTE GEESTEN ZIJN VERLICHT KLUGE KÖPFE DENKEN ELETRISCH
26th International Electric Vehicle Symposium

The Impact of Driving Cycle & Temperature on Electrical Consumption & Range of Electric Passenger Vehicles

ecoTECHNOLOGY for Vehicles Program - Transport Canada

ORGANIZED BY THE WORLD ELECTRIC VEHICLE ASSOCIATION, WEVA
HOSTED BY ELECTRIC DRIVE TRANSPORTATION ASSOCIATION, EDTA
IN COLLABORATION WITH
World Electric Vehicle Association
Electric Drive Transportation Association
AVERE
Electric Vehicle Association of Asia Pacific

Transport Canada's ecoTECHNOLOGY for Vehicles Program (eTV)

- Transport Canada's ecoTECHNOLOGY for Vehicles Program (eTV) tests, evaluates and provides expert technical information on advanced light-duty vehicle (LDV) and heavy-duty vehicle (HDV) technologies that are anticipated to enter the Canadian market over the next 10-15 years.

- Key activities include:
  - conducting in-depth integrated safety, performance and environmental testing of LDV and HDV technologies – in laboratories, on test tracks, and in real world conditions as required;
  - sharing or publishing technical reports, recommendations and guidance documents to inform the development of safety and greenhouse gas (GHG) emissions regulations; and
  - input of technical information to support the development and alignment of non-regulatory (industry-based) codes and standards.

Battery Electric Vehicle Testing Rationale

- Throughout 2011-12, Transport Canada's eTV program expanded on its preliminary battery electric vehicle (EV) testing

- The following data presented here is derived from laboratory dynamometer testing, with an emphasis on cold testing.

- Test results are helping to:
  - inform the development of international procedures, e.g.:
    - SAE J1634: Electric Vehicle Energy Consumption and Range Test Procedures.
  - study the performance of EVs in unique Canadian Conditions, e.g. cold weather:
    - 5- Cycle Testing + additional cold testing (-7 °C & -20°C).

Examples of Current Test Vehicles

Testing Approaches

Three OEM EV vehicles were tested

Energy Consumption and Range (Laboratory) Testing

- Environment Canada's Emissions Research & Measurement Section (ERMS) laboratory (Ottawa, ON)
- National Research Council Canada's Institute for Fuel Cell Innovation (NRC-IFCI) environmental test chamber (Vancouver, BC)

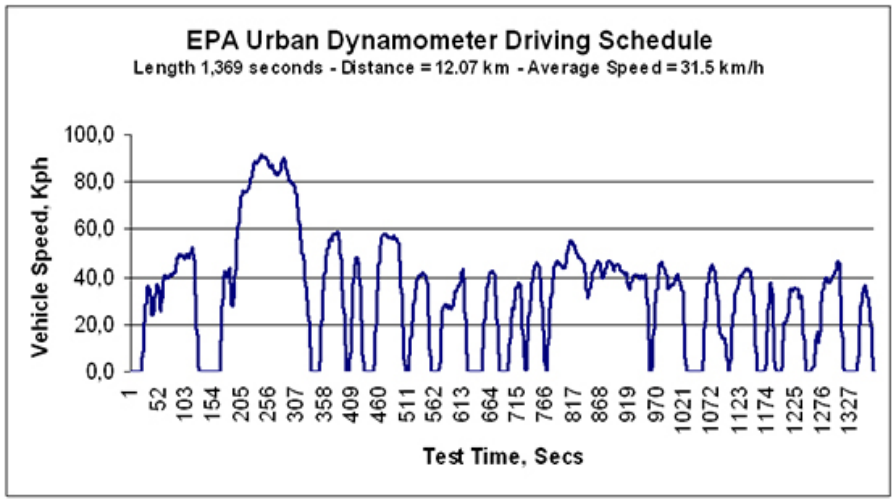
Laboratory Test Schedules (Cycles)

Current Canadian Cycles
- UDDS LA4 (City)
- US HWFET (Highway)

Additional Cycles
- US 06 (Aggressive)
- US SC03 (High Load)
- NYCC (Urban Traffic Simulation)
- Steady State 55 mph (Constant Speed)

Data captured or calculated:

- range & abbreviated range
- energy consumption rates
  - DC energy consumption (from main battery)
  - AC energy consumption (from wall socket)



**tests are used to measure vehicle energy consumption in controlled lab conditions.*

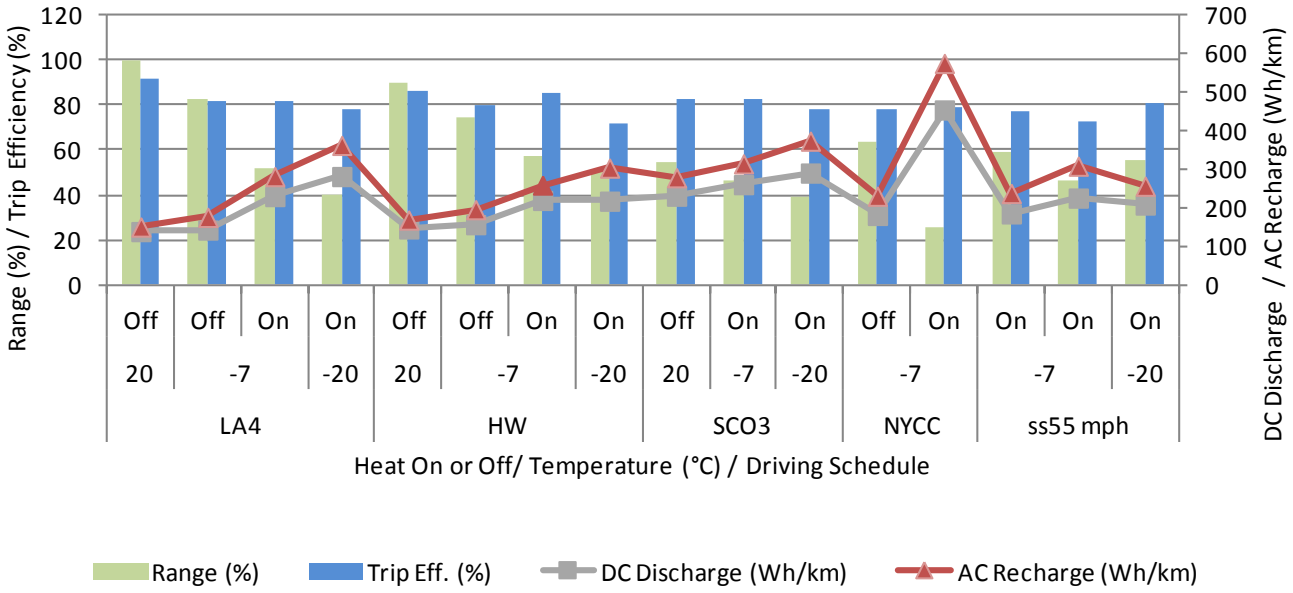
Round Trip Efficiency

- The round trip efficiency is a full depletion efficiency measurement that relates the useable battery energy to the total recharge energy:
  - (RTE) (Round trip efficiency - %).
  - (UBE) (full depletion DC discharge energy).
  - (TRE) (full depletion AC recharge energy).

$$RTE = \left[\frac{E_{dc\,total}}{E_{ac}}\right] = \frac{UBE}{TRE}\left(\frac{DC \cdot W \cdot hr}{AC \cdot W \cdot hr}\right)$$

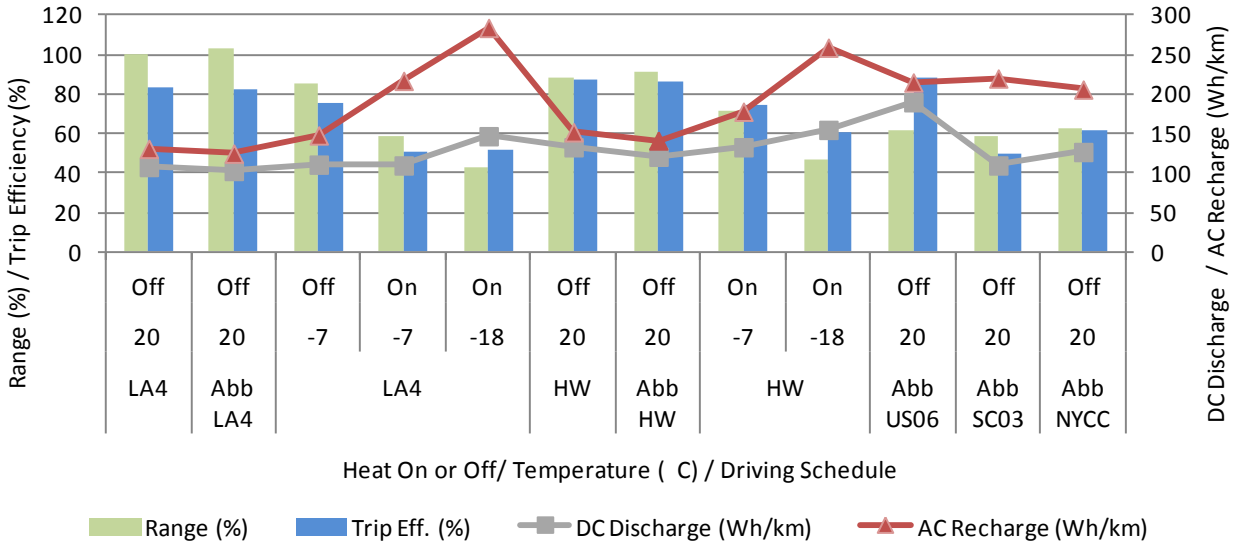
** source: SAE J1634 Draft Jan 2012*

EV 1 Test Results



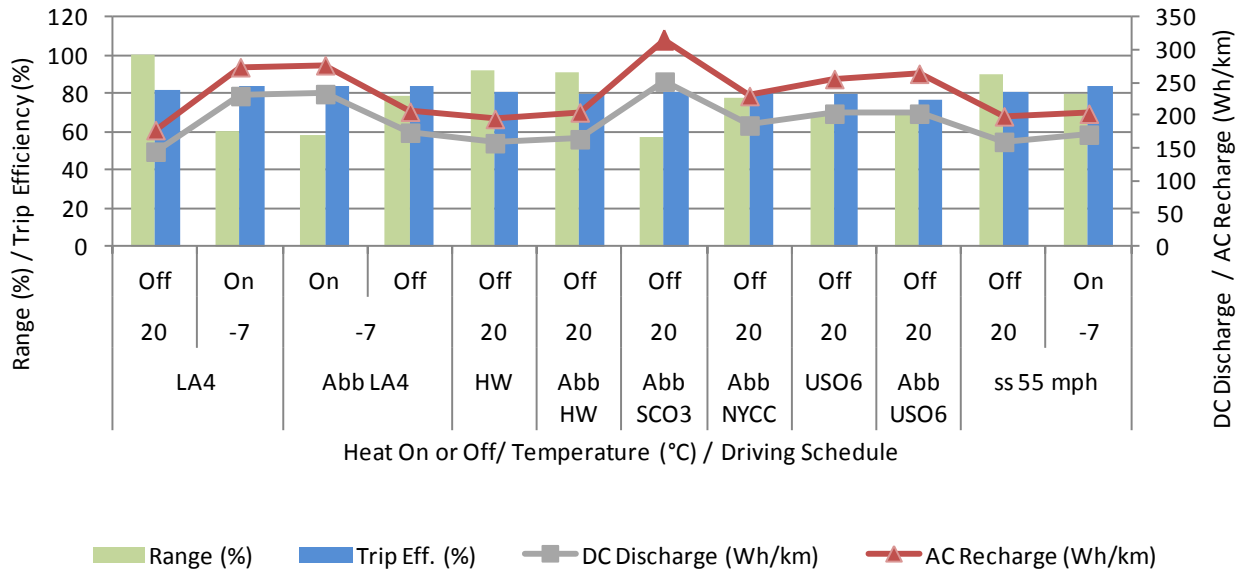
- cabin heating was set to 22 C (72 F)
- range on the LA4 (City) was reduced by 17.5% at -7 C (20 F) with no heat compared to 20 C (70 F)
- range on the LA4 (City) was reduced by 48.4% at -7 C (20 F) with heat compared to 20 C (70 F)

EV 2 Test Results



- cabin heating was set to maximum for repeatability
- abbreviated testing is a reasonable proxy compared to full range testing
- DC discharge measured for propulsion motor only.
- range on the LA4 (City) was reduced by 15 % at -7 C (20 F) with heat off and 41 % with heat on compared to 20 C (70 F)

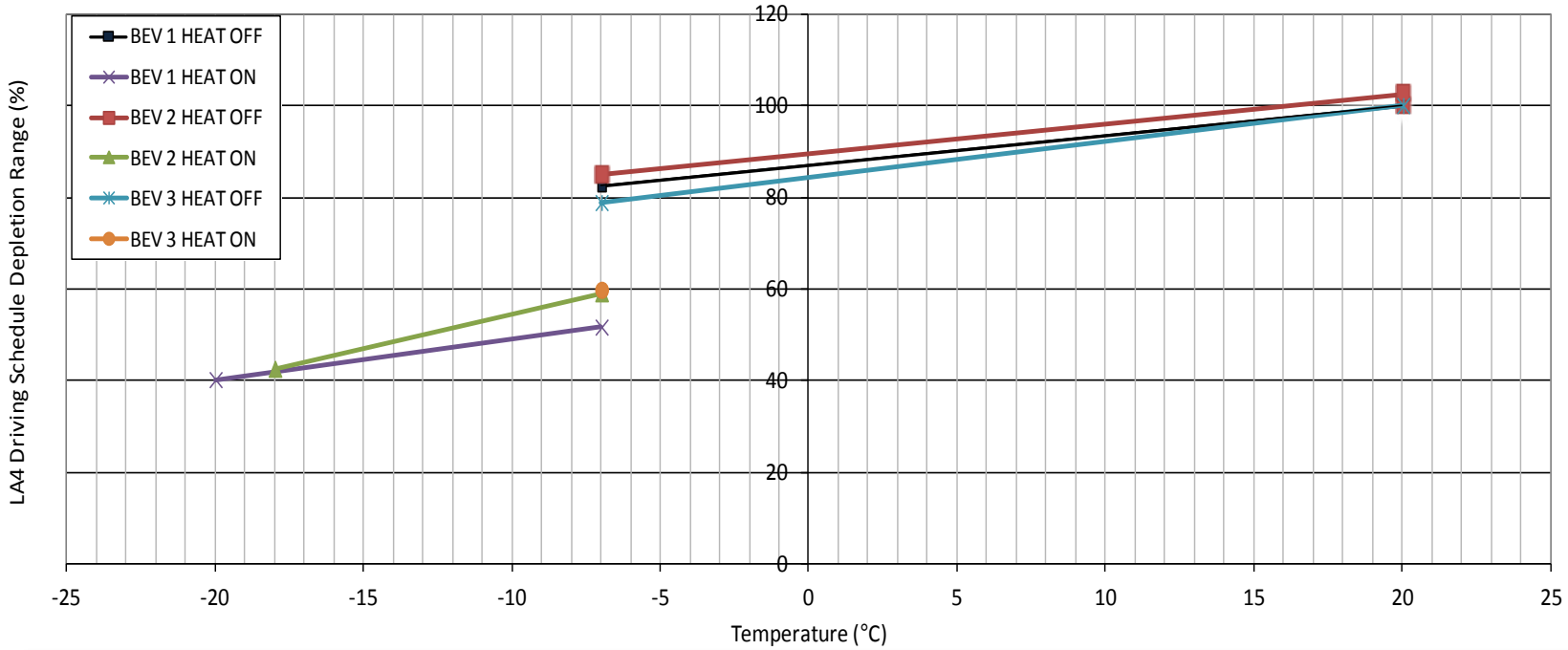
EV 3 Test Results



- cabin heating was set to maximum for repeatability
- "top-off" charging was performed prior to testing
- abbreviated test results are similar to full range test results
- range on the LA4 (City) was reduced by 21 % at -7 C (20 F) with no heat and 40% with heat on compared to 20 C (70 F)

Drive Cycle Range (City)

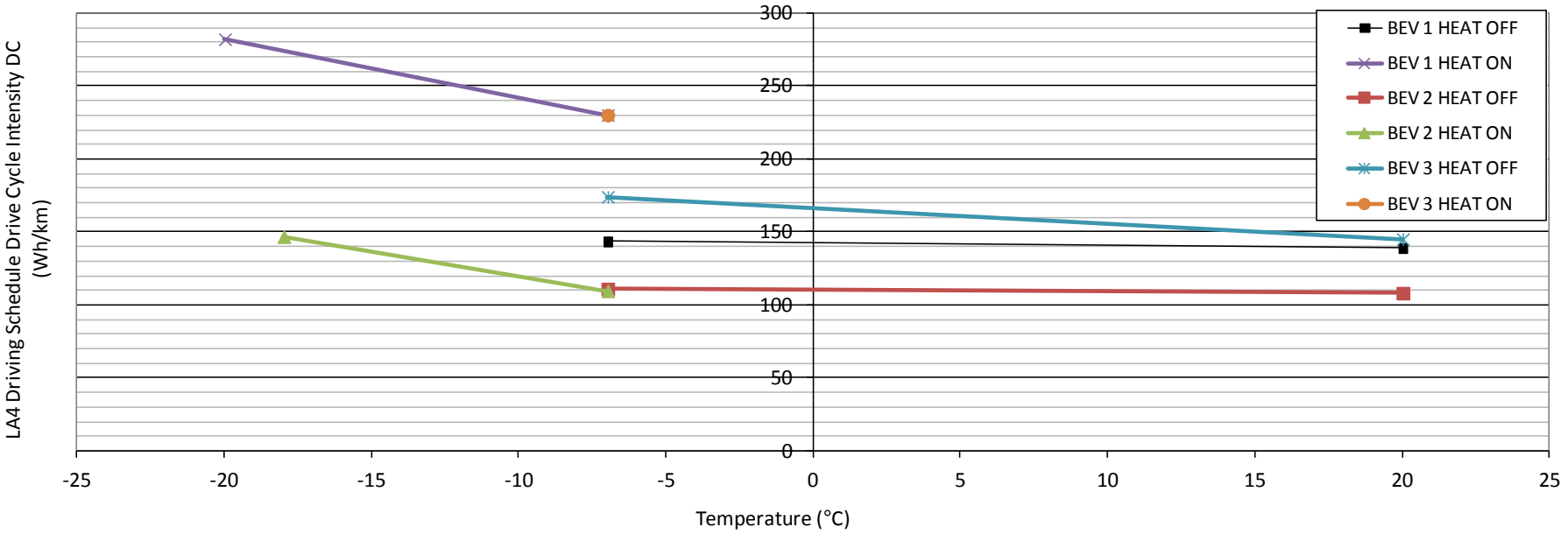
Comparison EV 1,2 &3
LA4 Driving Schedule vs. Temperature



- lower trip efficiency combined with smaller battery capacity account for the decrease in range
- EVs demonstrated a 15 to 21% reduction in range at -7 C (20 F) without the use of cabin heating
- at -7 C (20 F) cabin heating further decreases range by 26% to 31% (compared to range at -7 C (20 F) without heat)
- at -18/-20 C (0/-4 F) with cabin heating reduces range approximately 57% to 59% (compared to range at 20 C (70 F) without heat)

Drive Cycle Intensity (City)

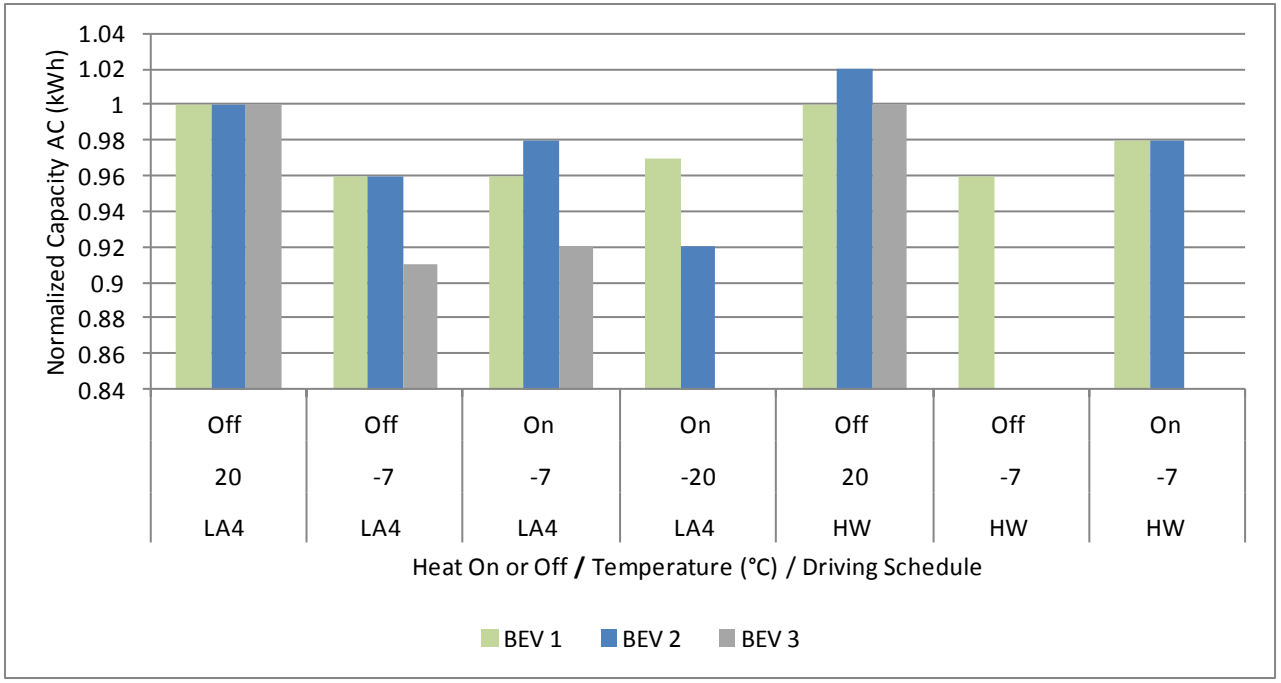
Comparison EV 1,2 & 3
LA4 Cycle Intensity vs. Temperature



- EV 2 only reports DC discharge to the propulsion motor, not to be directly compared to EV 1 & 3
- EV 1 DC energy consumption is approximately the same at -7 C (20 F) compared to 20 C (70 F)
- as temperature decreased, DC energy consumption increased

Battery Capacity Results

AC Battery Capacity for LA4 and HW Duty Cycles



- AC battery capacity was reduced for all EVs as temperature decreased
- capacity was reduced by approximately 4% to 8% at -7 C (20 F)

Summary

- Cold temperature and cabin heating have a significant impact on overall EV range.
- At -7°C, the use of cabin heating reduced the driving range by ~25%.
- At -20°C, with the use of maximum cabin heating, the vehicle range is reduced by more than 50%.
- Abbreviated test procedures may offer a reasonable proxy for full range testing.
- EV range in cold temperatures could possibly be calculated using abbreviated cold LA4 energy consumption and cold steady-state 55 mph battery capacity procedures.

Summary

- The repeatability of cold tests appears to be similar to the repeatability of 20°C temperature tests. However, the repeatability of abbreviated tests can be affected by the intermittent intervention of the battery management systems.
- Variations in battery management, charging procedures and driving modes across manufacturers may present regulatory challenges to measuring and publishing EV range.
- Additional testing may be required with climate control and/or heated seats instead of “maximum heat” scenario tests.
- Investigate impacts of a pre-conditioned battery (garage scenario) vs. cold weather performance.

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ELECTRIC VEHICLE SYMPOSIUM

Thank You!

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