The SAE Clean Snowmobile Challenge

Electric Drivetrains for Zero Emissions Over-Snow Transportation
What is the Clean Snowmobile Challenge?

• The newest competition in the SAE International collegiate design series. Others include Formula SAE, Baja and others.
• Challenges engineering students to improve on existing snowmobiles to reduce emissions and noise and improve public perception.
• Events include: emissions bench test, in-service emissions, noise, handling, static display, cold start, endurance run, range, draw bar pull, acceleration.
• Hosted by Michigan Technological University, Keweenaw Research Center, Houghton, MI past eleven years.
• Zero Emissions category funded by NSF Arctic Program for past six years.
• I serve as a technical inspector, judge, event coordinator, sit on the rules committee and evaluate papers and presentations.
Clean & Quiet Does Not Mean Slow

The faster IC sleds in the 2013 competition hit >60mph in the ¼ mile acceleration event.
Benefits

- Teaches students real-world engineering skills
- Innovations transfer to snowmobile industry
  - Direct injected 2-stroke engines
  - Better overall fuel economy and lower noise levels
- NSF gets to use zero emissions sleds at Summit Station, Greenland
- Rapid advances in electric drive snowmobiles has resulted
IC Emissions Testing

Static (dyno) and in-service emissions tests are performed.
SUNY Buffalo shoehorned a 3-cylinder diesel engine into their machine and won the emissions event!
Zero Emissions Category

• Added to CSC in 2006 in response to NSF need for motorized access to atmospheric sampling sites in Greenland

• Fastest growing category in the competition

• Meets a real need and may ultimately result in another transfer to snowmobile industry

• Truly ZE: All the energy used for charging ZE sled batteries over the week is more than offset by a 2kW PV array over the course of the year.
Electric Drive Trends

• Lithium ion batteries in universal application
• Different flavors result in different energy densities and performance characteristics
• LiFePO4 seems to be favored due to inherent stability
• Some require a BMS to prevent any unwanted “Thermal Events”, but all benefit from cell balancing
• AC induction motors seem favored due to greater efficiency – but DC is less expensive
• Direct belt drive to jack-shaft common due to power characteristics of electric motors
• Higher voltages = smaller wires
Safety First!
Raising The Bar

• Lots of energy on board – up to 8kWh
• New rules to better match other SAE competitions
• New electrical safety form
• Significant attrition in 1st year of tougher rules:
  - Seven ZE teams registered
  - Five made it to the competition
  - Two made it through technical inspection to compete
Technical Inspections
ZE Events

Acceleration With Load

• Representative of utility type application of electric drive snowmobiles, yet still competitive and fun
• Note PV array in middle left – truly a ZE event
Cold Start Event

Not much drama for the ZE machines, which just quietly power up and pull away.
Objective Handling
UAF won the draw bar event with >500lbs pulling force.
Current record is ~21 miles on a charge
Electric Drive Snowmobile for Summit Station, Greenland

• Built for NSF by Cross Chasm Technologies
• Still expensive, but 2.5X less than quote from three years ago.
• Built to specifications:
  - 10 mile range
  - 800 lb towing capacity
  - Reliability/servicability paramount
Acceptance testing in Montreal in February
Hybrid design snowmobile for Canadian Armed Forces
Conclusions:

• Electric drive snowmobiles are a viable zero emissions transportation alternative
• Suitable for supporting scientific research and other niche applications
• Barring a major energy storage breakthrough, they will remain very range limited
• Wheeled vehicles are potentially more efficient if ground pressure can be optimized
• Even more than most electric vehicles, the overall efficiency is very good at Summit due to generator waste heat recovery and use of renewable energy
Questions?