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QUEEN'S FUEL CELL TEAM

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HYDROGEN-POWERED SNOWMOBILE

TECHNICAL OVERVIEW

2011 SKANDIC® TUNDRA™ LT

PACKAGE HIGHLIGHTS

- REV-XU™ platform
- SC™-5U articulating rear suspension
- 16 x 154 x 1.5-inch track
- Lynx Telescopic front suspension
- Pilot™ 6.9 skis
- Electric start
- Analog gauge with display
- **NEW** REV-XP™ 2-up seat with strap
- 480-mm / 19-inch windshield
- Mountain strap
- Cargo rack
- HPG™ rear shock
- Hitch

EXTRA HIGHLIGHTS

600 ACE

- **NEW** Rotax® 600 ACE (Advanced Comb with 650W of magneto power
- High windshield
- Engine oil cooler
- Air radiator with fan

ENGINE CHOICE

Engine	Rotax 600 ACE	Rotax 550F

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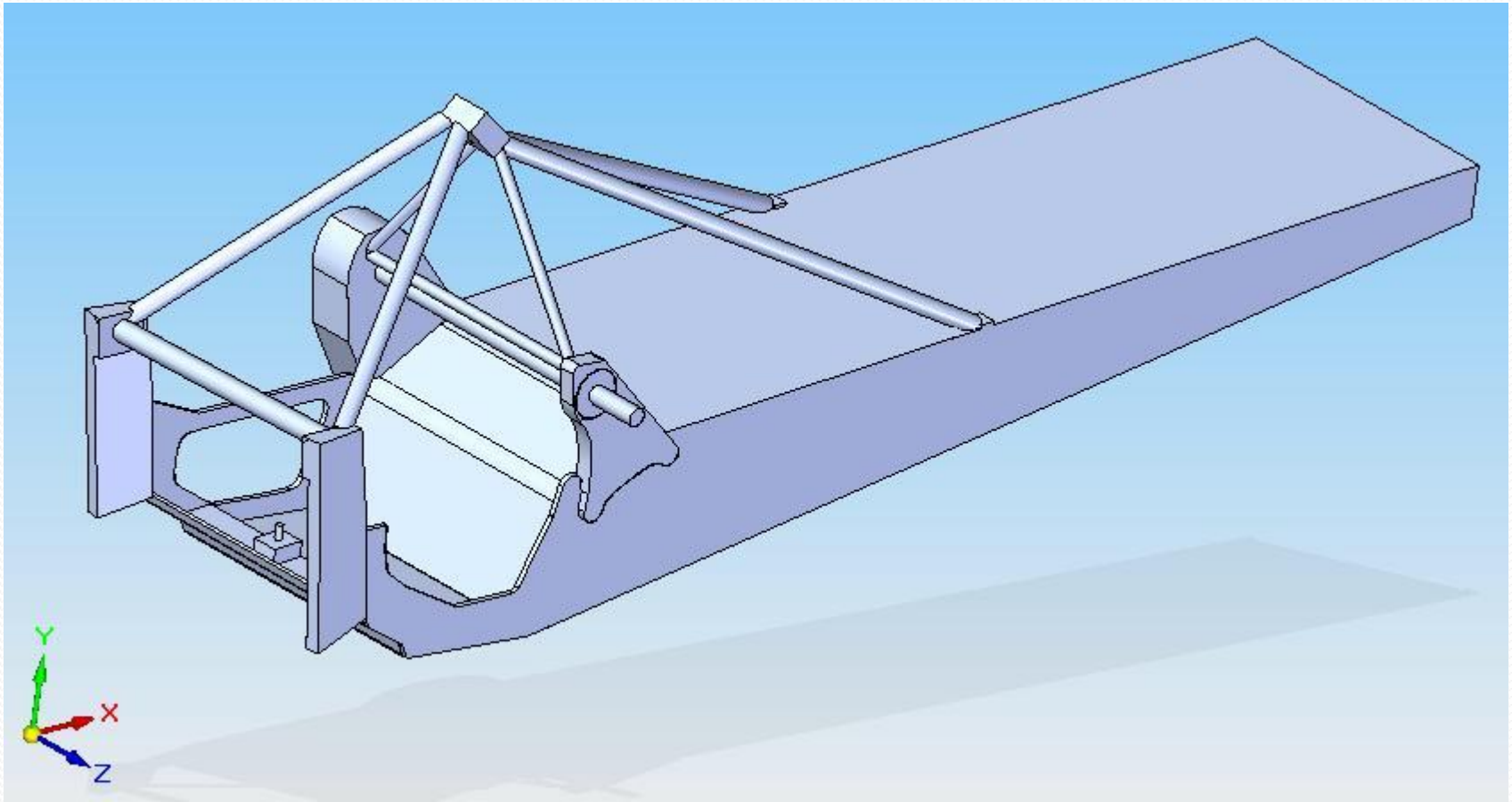
Modelling with CAD



Multi-Faceted Design

- Mechanical Systems
- Stack (Fuel Cell) Systems
- Electrical Systems
- Control Systems

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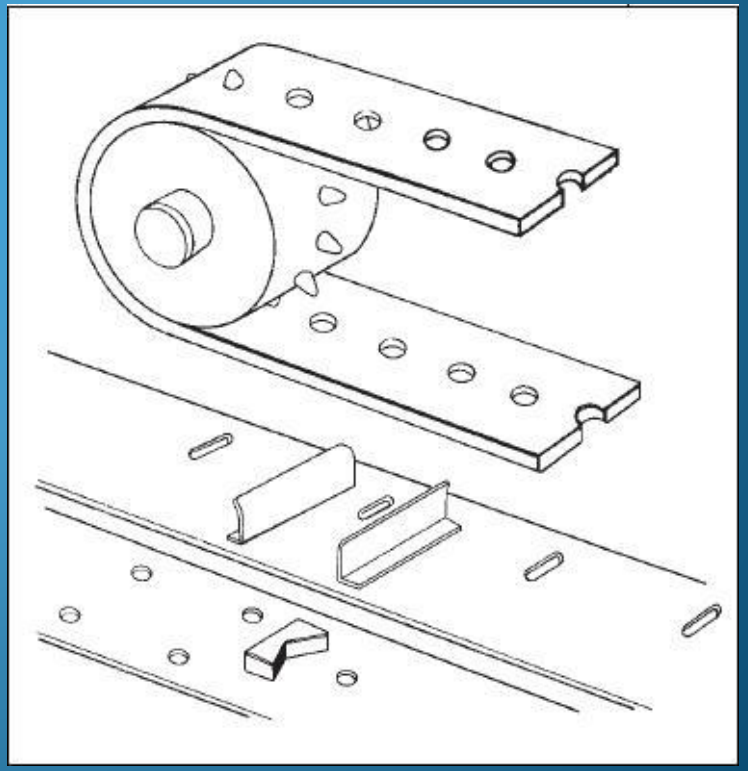
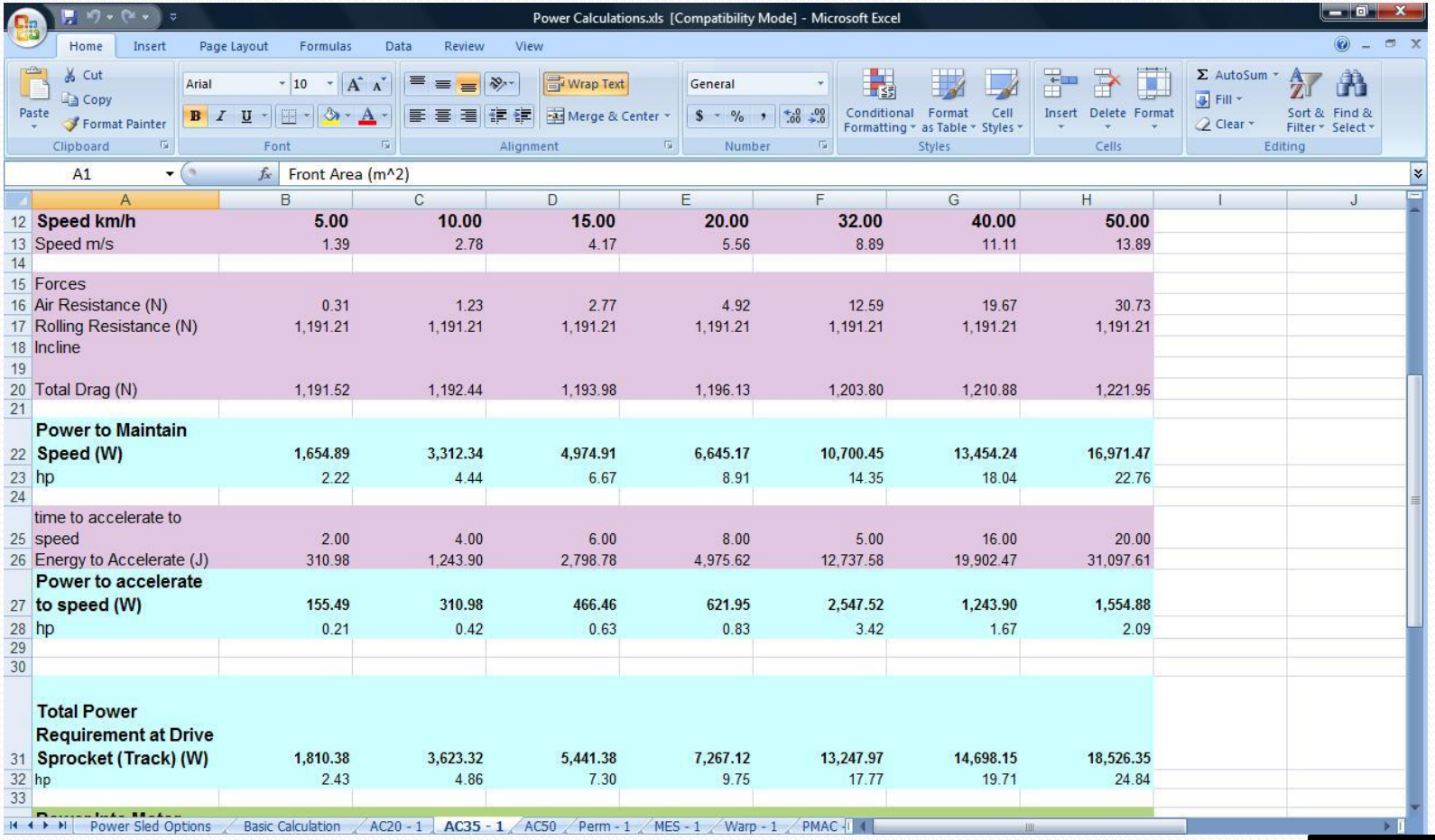
MECHANICAL OVERVIEW

- Motor Selection, Mounting
- Transmission, Belt Drives
- Mounting Components
- Suspension
- Improving Handling
- Space Issues
- FMEA (Failure Analysis)



Comparing Options



	A	B	C	D	E	F	G	H
12	**Speed km/h**	**5.00**	**10.00**	**15.00**	**20.00**	**32.00**	**40.00**	**50.00**
13	Speed m/s	1.39	2.78	4.17	5.56	8.89	11.11	13.89
14								
15	Forces							
16	Air Resistance (N)	0.31	1.23	2.77	4.92	12.59	19.67	30.73
17	Rolling Resistance (N)	1,191.21	1,191.21	1,191.21	1,191.21	1,191.21	1,191.21	1,191.21
18	Incline							
19								
20	Total Drag (N)	1,191.52	1,192.44	1,193.98	1,196.13	1,203.80	1,210.88	1,221.95
21								
22	**Power to Maintain Speed (W)**	**1,654.89**	**3,312.34**	**4,974.91**	**6,645.17**	**10,700.45**	**13,454.24**	**16,971.47**
23	hp	2.22	4.44	6.67	8.91	14.35	18.04	22.76
24								
25	time to accelerate to speed	2.00	4.00	6.00	8.00	5.00	16.00	20.00
26	Energy to Accelerate (J)	310.98	1,243.90	2,798.78	4,975.62	12,737.58	19,902.47	31,097.61
27	**Power to accelerate to speed (W)**	**155.49**	**310.98**	**466.46**	**621.95**	**2,547.52**	**1,243.90**	**1,554.88**
28	hp	0.21	0.42	0.63	0.83	3.42	1.67	2.09
29								
30								
31	**Total Power Requirement at Drive Sprocket (Track) (W)**	**1,810.38**	**3,623.32**	**5,441.38**	**7,267.12**	**13,247.97**	**14,698.15**	**18,526.35**
32	hp	2.43	4.86	7.30	9.75	17.77	19.71	24.84
33								

Power Sled Options | Basic Calculation | AC20 - 1 | AC35 - 1 | AC50 | Perm - 1 | MES - 1 | Warp - 1 | PMAC

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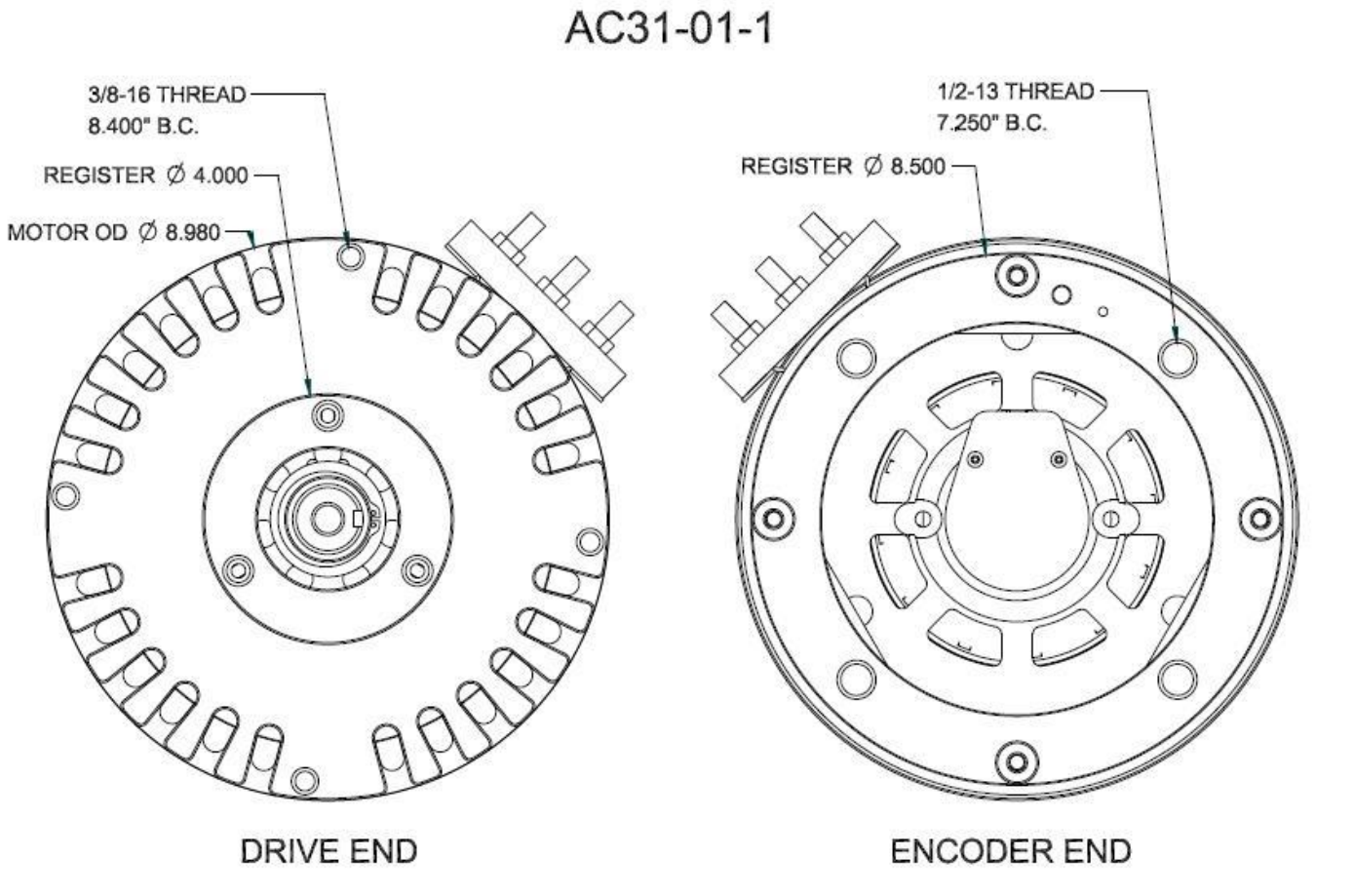
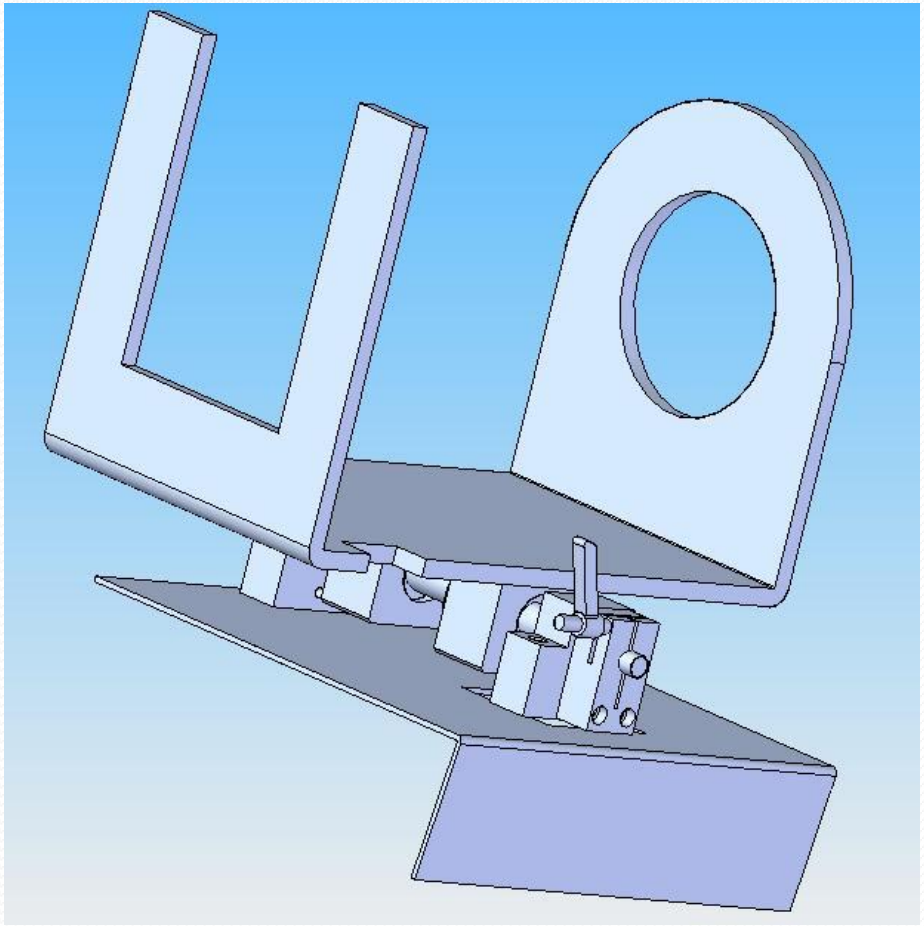
The Electric Motor



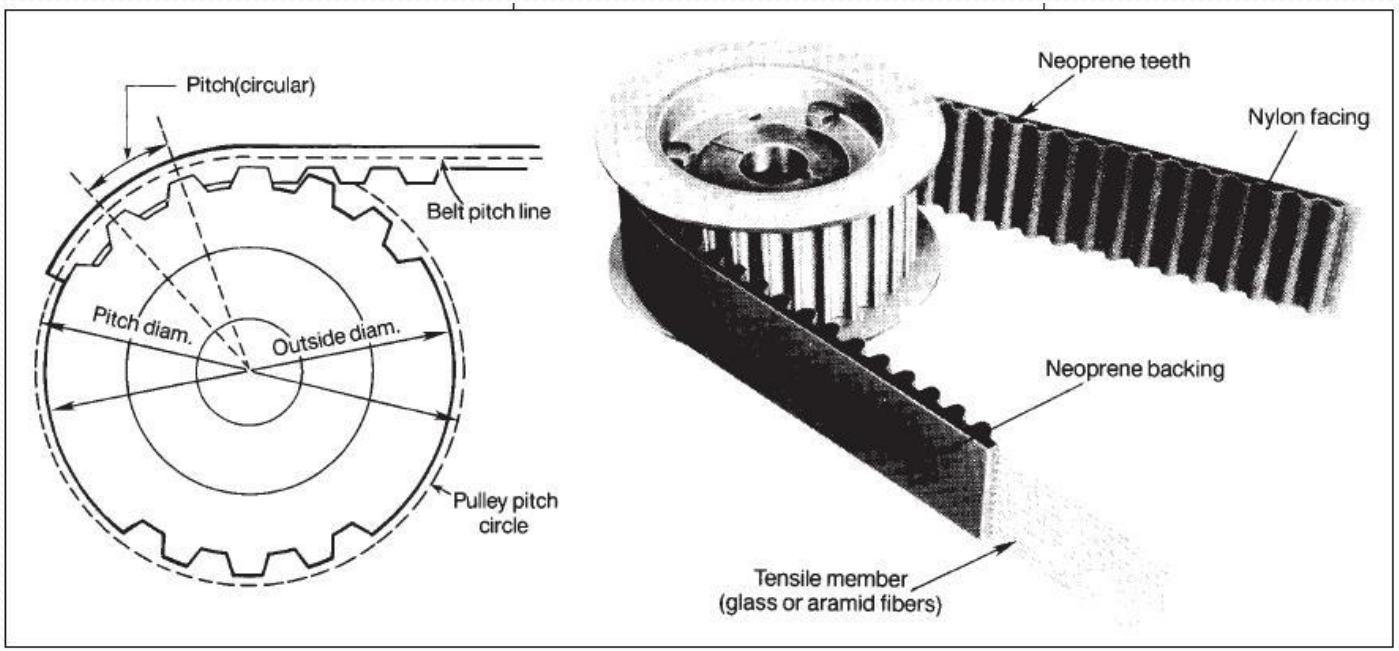
Motor Mount

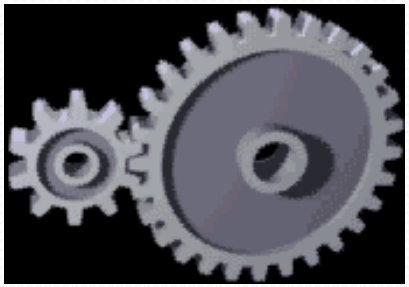


Adjustable?

Fixed?

Transmission Redesign





Suspension

(SAE regulations)

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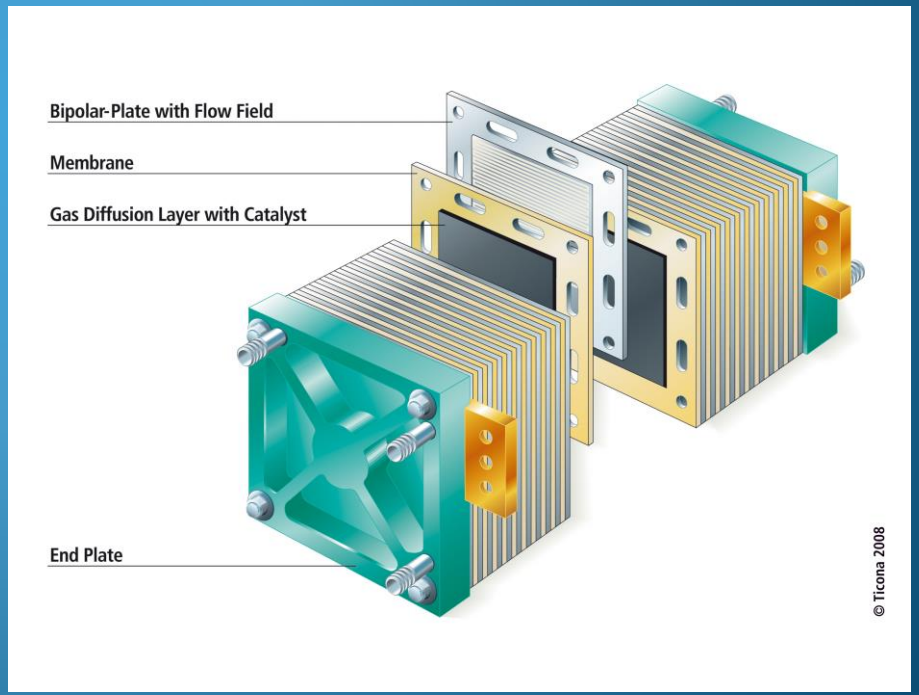
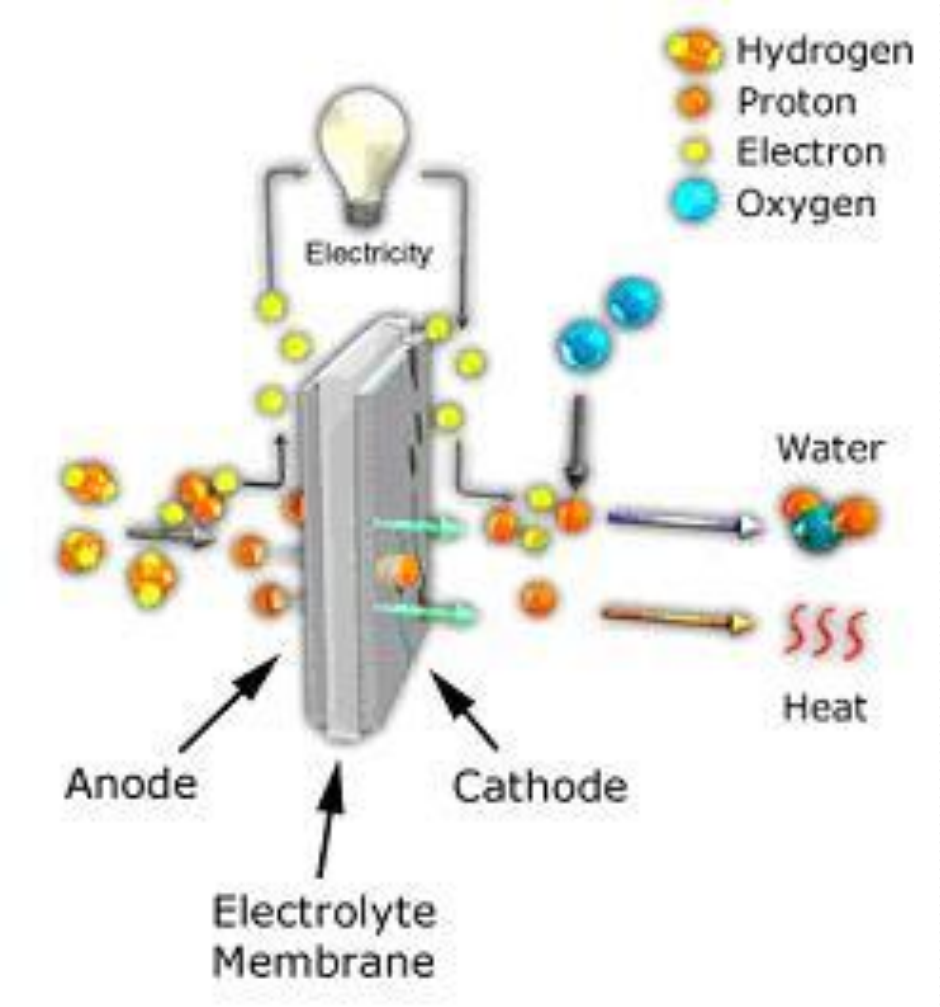
Stack (Fuel Cell) Overview

- Selection
- Auxiliary Systems
- Hydrogen Tanks
- Thermal Regulation



Operational Principle



In Practice

- Simple concept that requires a lot of support!

75-kW Fuel Cell System for prototype Mercedes Benz, Ballard Power Systems

Peripheral Systems

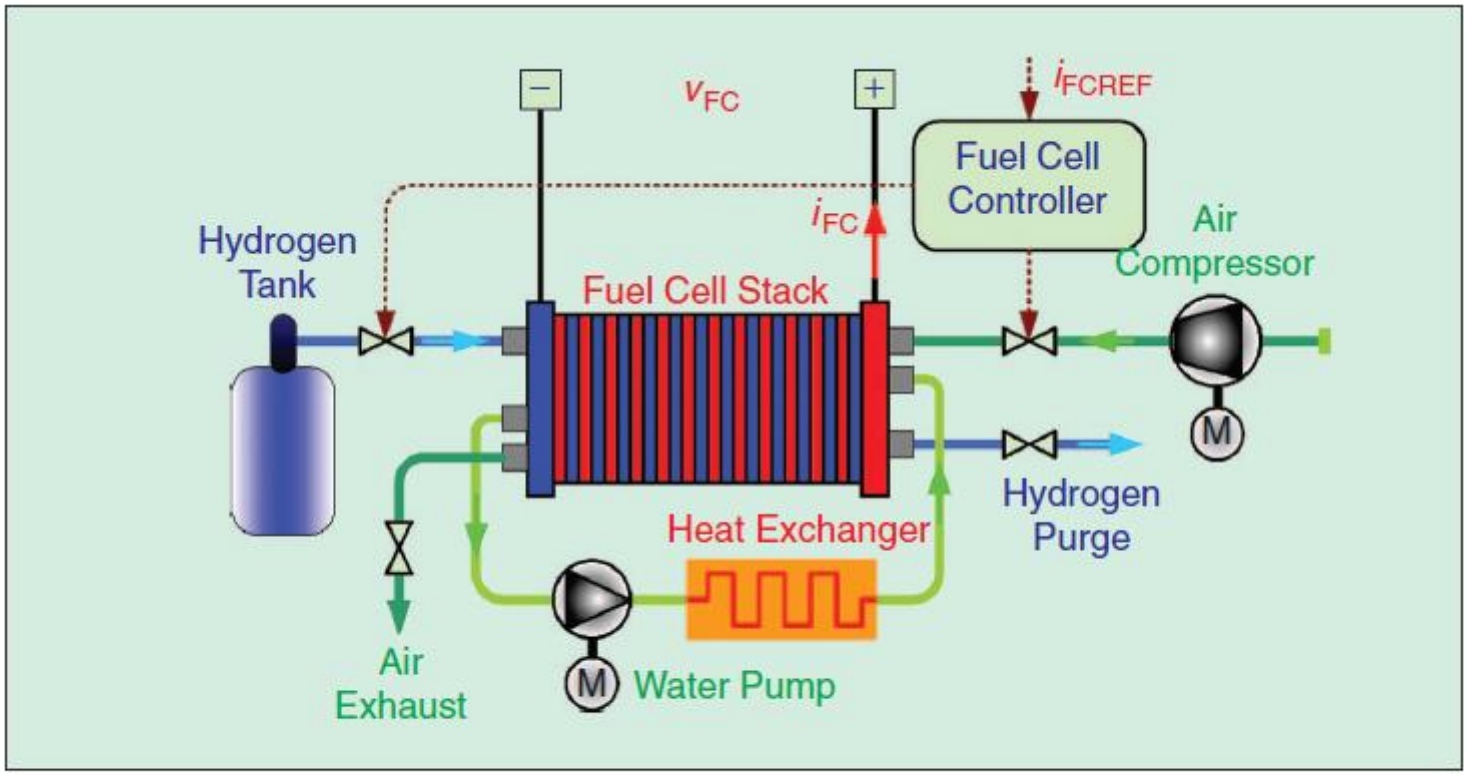
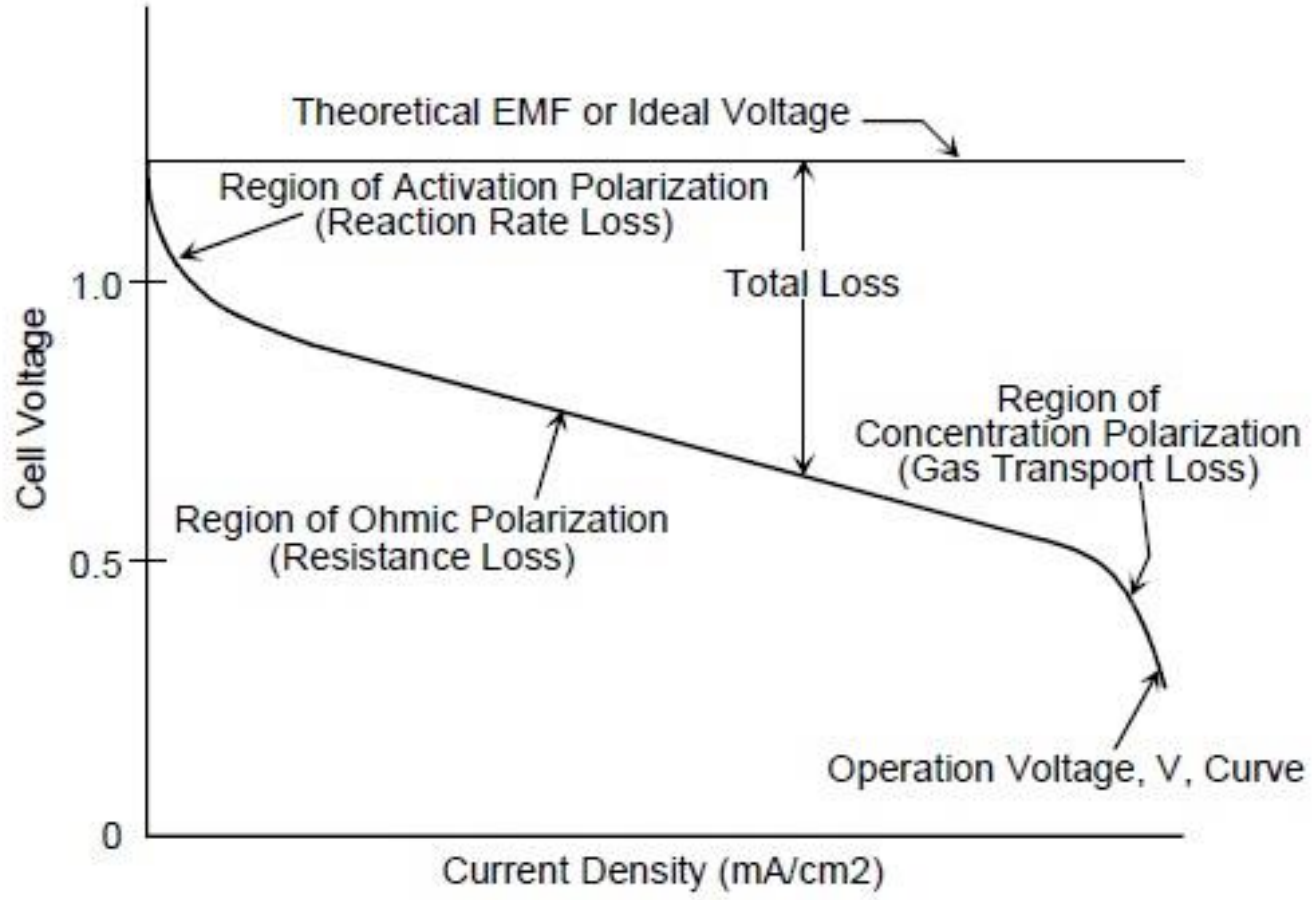


FIGURE 3 – Simplified diagram of the PEMFC system. v_{FC}, i_{FC}, and i_{FCREF} are the FC voltage, current, and current demand, respectively.

Power Characteristics



Hydrogen Storage

- Consider capacity, dimensions, weight, placement

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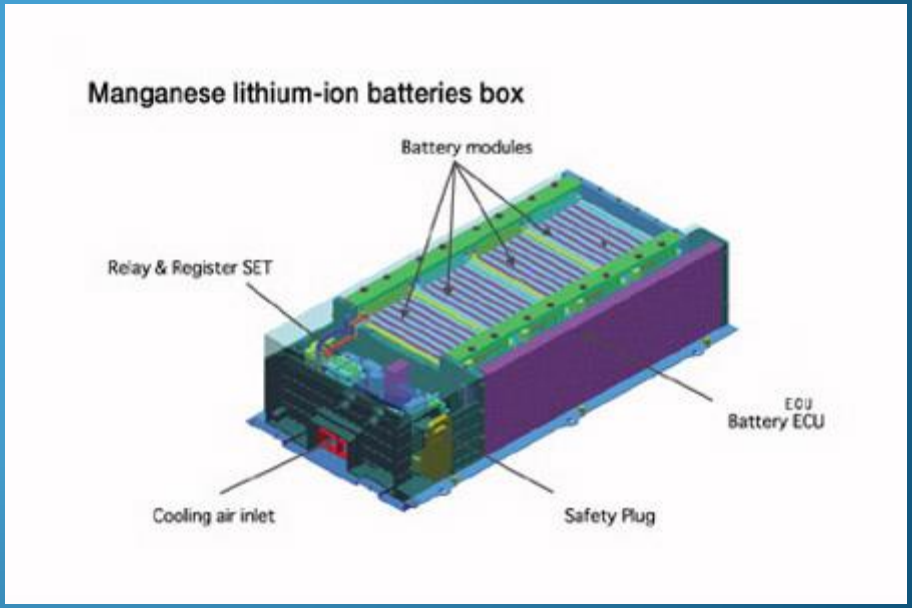
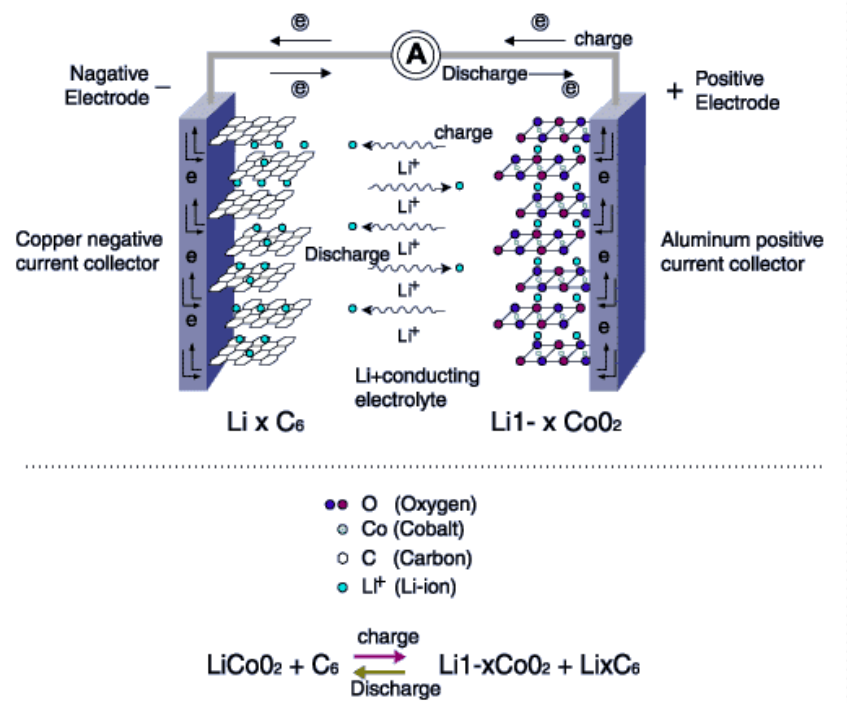
ELECTRICAL OVERVIEW

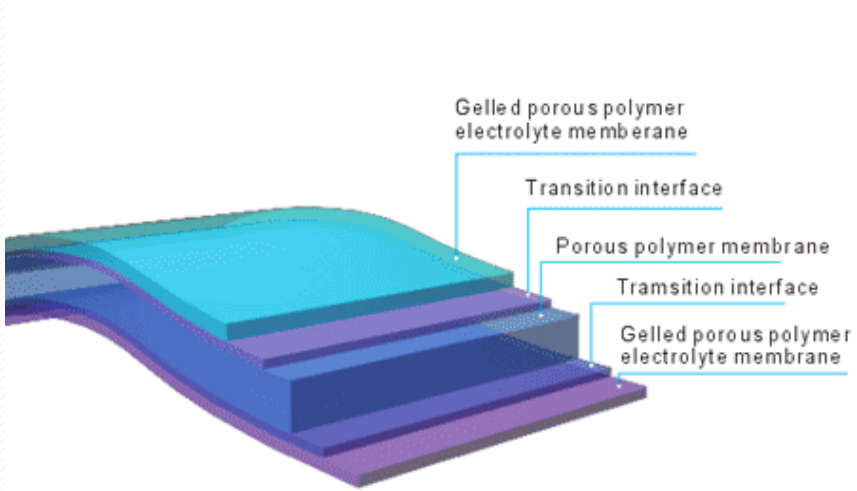
- Energy Storage
- Battery Management
- Accessories and Readout
- Robust Wiring
- Battery Housing



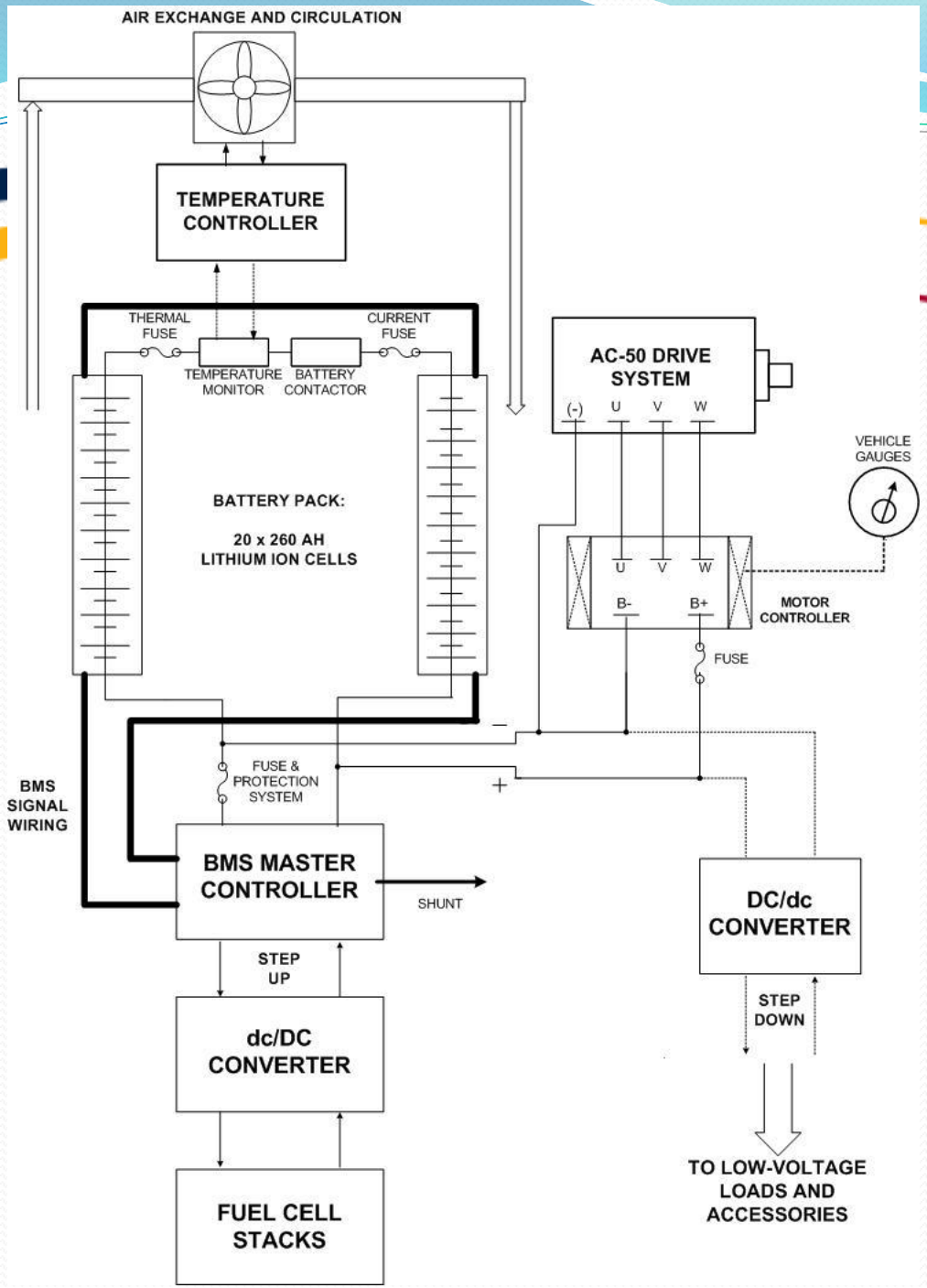
Why Batteries?



Lithium Ion



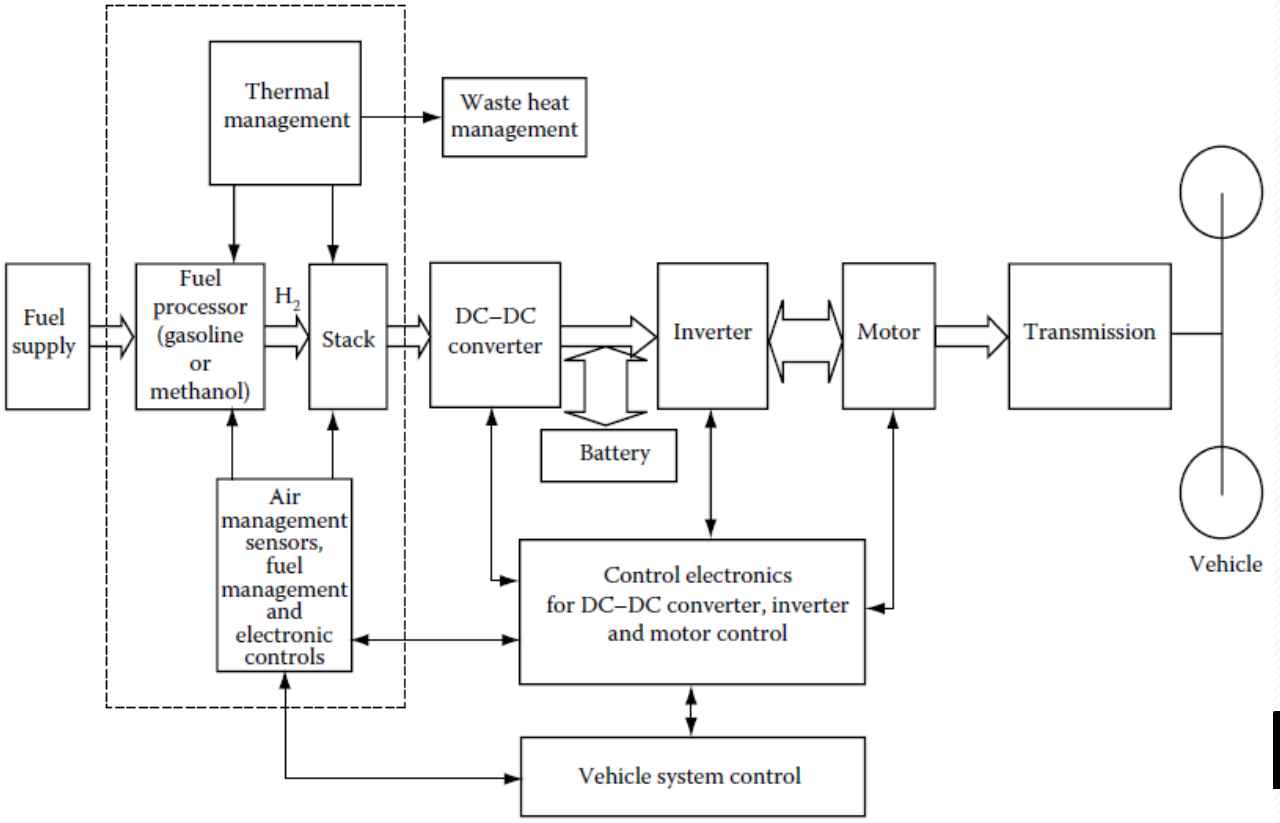
Lithium Polymer



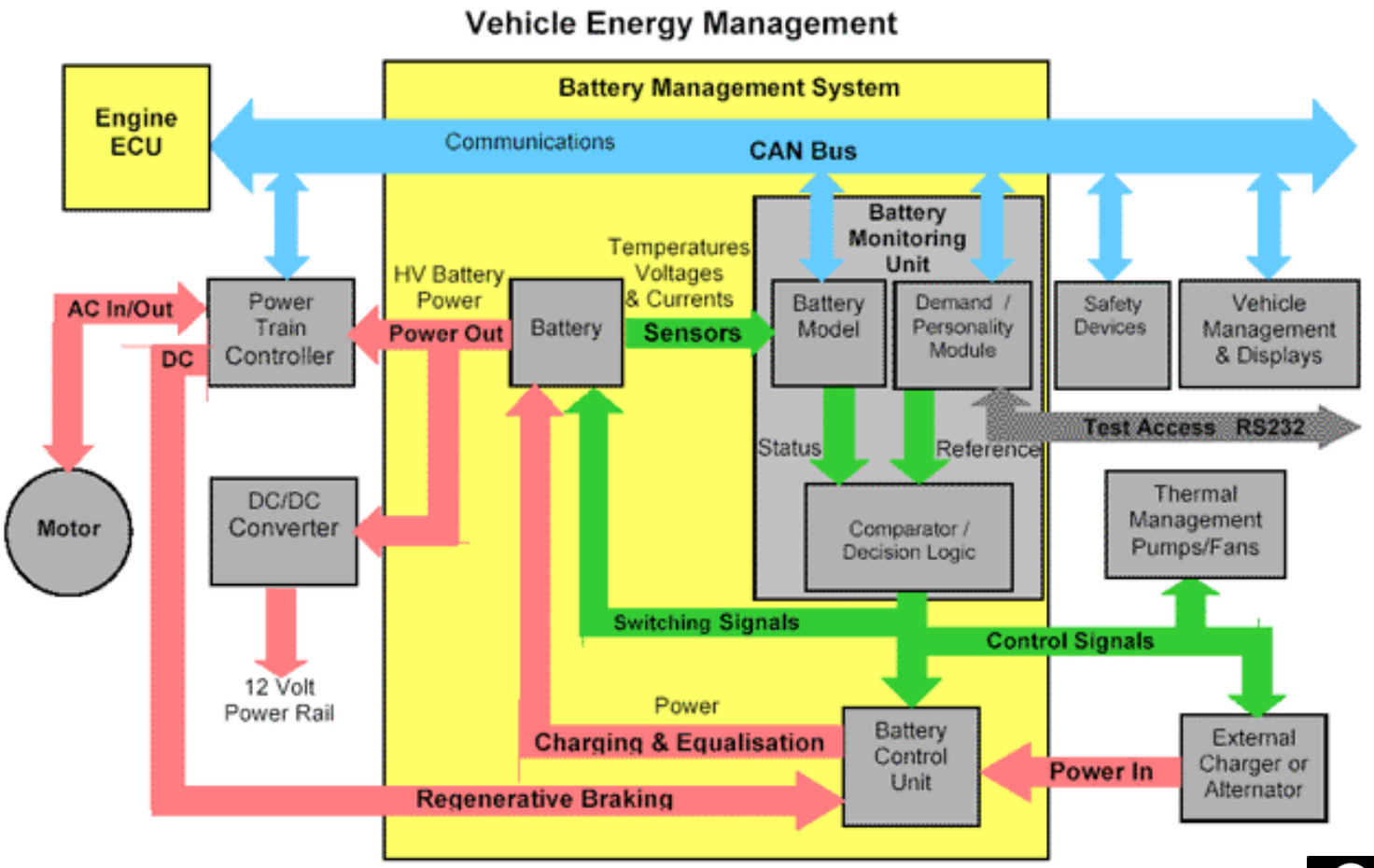
Original Design

Modified Configuration

- Due to advances in Fuel Cell Capabilities
- Still being revised…

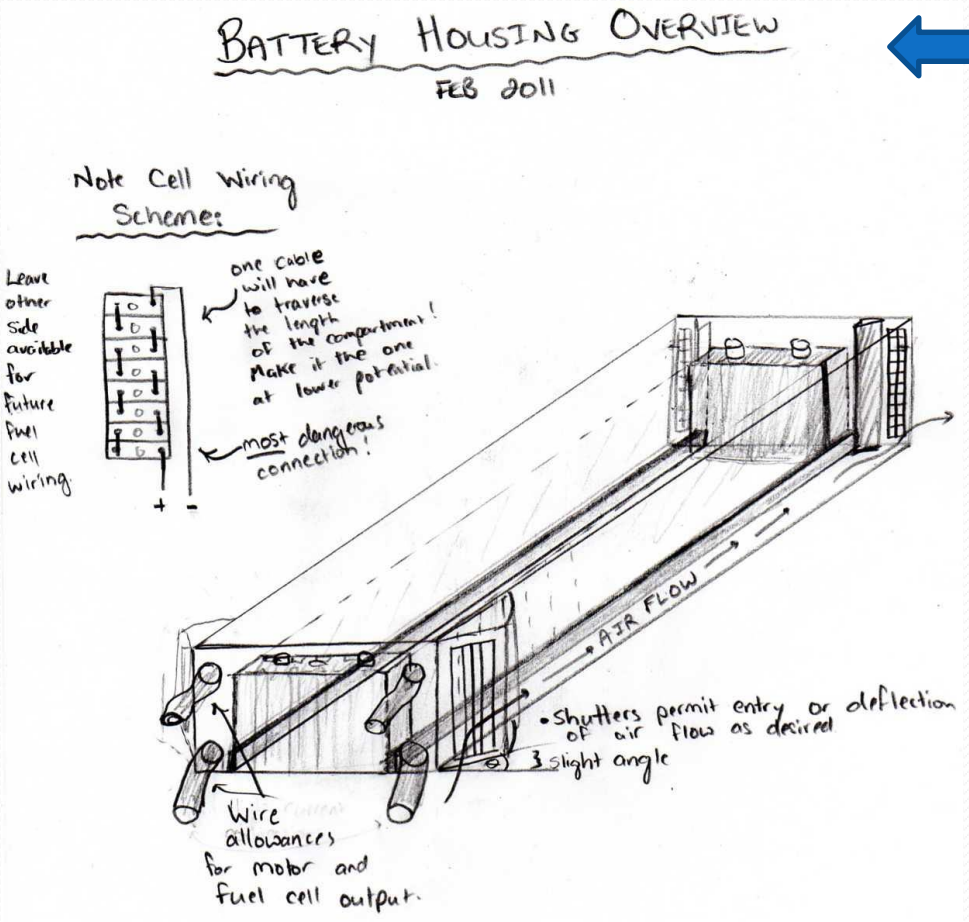


Battery Management



Generic diagram – not specific to our vehicle

Battery Containment



Early Ideas

- Dimensions await battery selection.

Must Consider:

- Insulation
- Thermal Regulation
- **SAFETY**

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Control Systems Overview

- Battery Management (Already Discussed)
- Motor Controller
- User interface and readout
- Thermal regulation (batteries and stack)
- Safety cut-offs, contactors, warning systems

Example of a Controller

Encoder/ Resolver

CAN BUS 2.0 B option

Battery management system

Instrumentation panel

Auxiliary battery

Pedals

PC

Water Cooling

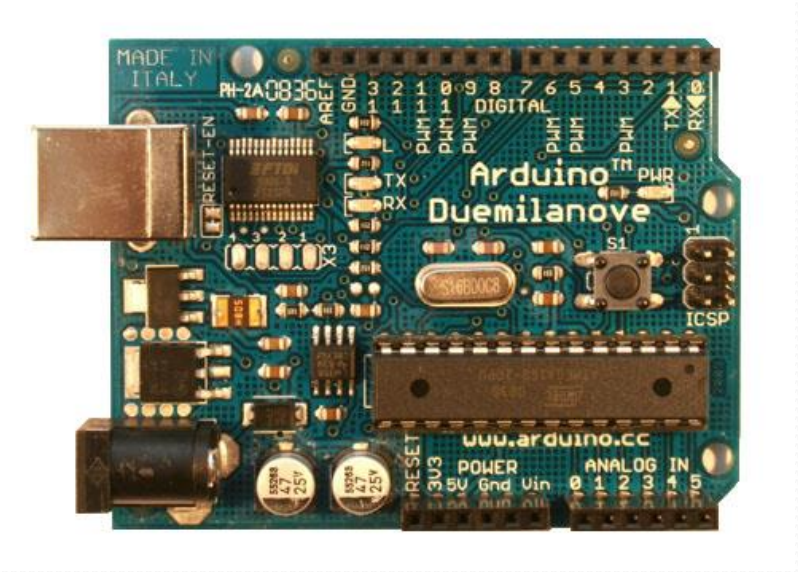
Battery pack

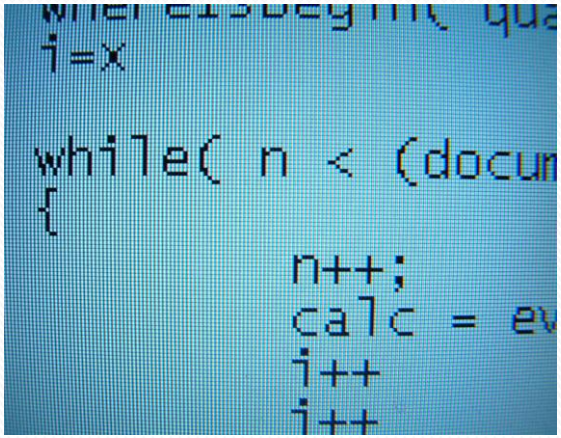
AC motor

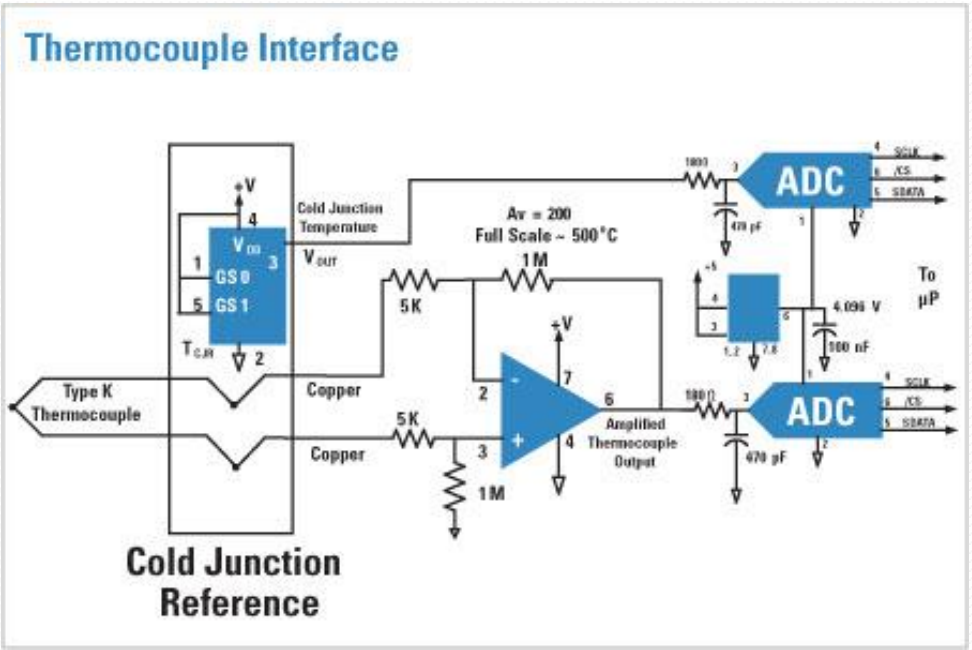
Interface & Safety

- Display panel
- Emergency Shutoffs
- Temperature Warnings
- Current Warnings
- Lock on Battery Cabinet
- Adjustable vents/fans for thermal regulation

Microcontrollers, Sensors







QUESTIONS?