Electrification Challenges and Opportunities in the Cooling and HVAC systems

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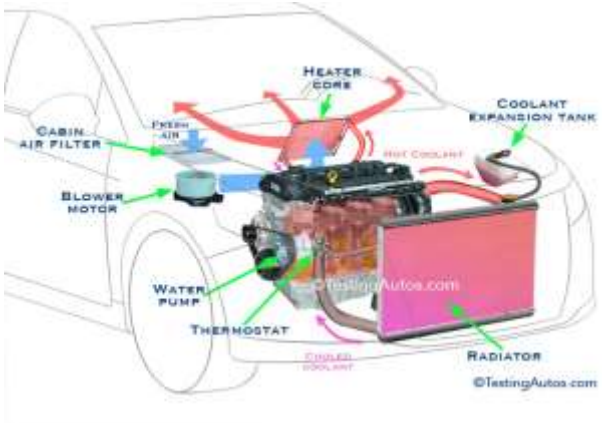
A Conventional Automotive HVAC System

- **Purpose:**
  - To keep the Engine (and other powertrain components) at the correct temperature – cooling.
  - To keep the cabin at a comfortable temperature – heating and cooling.
  - Cabin ventilation.

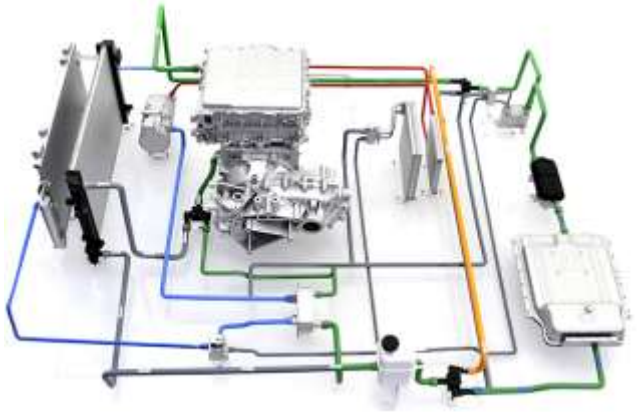
- **How does it work:**
  - Engine and powertrain cooling through radiator(s), using air-flow to cool circulated fluid.
  - Cabin heating using **waste** heat from engine.
    - ICE < 40% efficient.
  - Cabin cooling using engine driven air-con compressor or mixing with outside air.
  - Cabin ventilation by mixing outside air with cabin air.



HVAC System for an Electric Car

- **Purpose:**
  - To keep the battery at the correct temperature – heating and cooling ~20DegC.
    - *Can be during operation, charging and preconditioning.*
  - To keep the electric motor and power electronics from overheating – cooling ~60-70DegC.
  - To keep the cabin at a comfortable temperature – heating and cooling.
  - Cabin ventilation.

- **Observations:**
  - More **complicated** cooling system – multiple cooling circuits at different temperatures.
  - No waste heat from engine for heating, motor/power electronics > 90% efficient, so how do we heat?
  - Energy used for HVAC will reduce range.



Source: Hyundai

Typical HVAC Parts for Electric Car – MORE PARTS

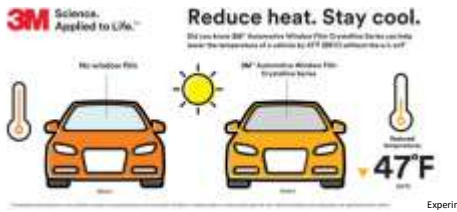
- **Cabin Comfort:**
  1. PTC heater to provide cabin heat.
  2. High Voltage A/C Compressor
  3. A/C Condenser
  4. Electric Pump, Pipes/Hoses.
  5. A/C Control Module.
  6. Cabin blowers, vents.
  7. Temperature sensors.
- **Battery Cooling and Heating:**
  - Small PTC heater
  - Electric pump for coolant.
  - Header tank
  - Radiator (+ Fan) / heat exchanger
  - Pipes.
  - Chiller / link to A/C system.
- **Motor and Power Electronics Cooling:**
  - Radiator / Electric fan.
  - Pipes/Hoses.
  - Electric Pump
  - Temp sensors.
  - Header tank.

If you supply parts for a conventional car HVAC system, then you can supply parts for EVs and there are more parts!

Electric HVAC Issues and Potential Solutions

- **The problem:**
  - The energy to power the HVAC system comes from the battery, reducing range.

- **Potential Solutions:**
  - **Increase efficiency of HVAC system:**
    - Maintain temp:
      - Cabin insulation,
      - IR reflective glass.
      - Reduce mixing of air in cabin.
    - Improved control algorithms.
    - Use available waste heat from motor cooling.
    - Alternative heating/cooling technology:
      - Phase change materials.
      - Heat pumps.
  - **Precondition Cabin:**
    - Using mains power to get cabin to temperature.
  - **Wear a coat (*only joking*).**



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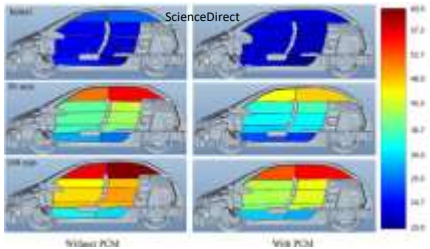
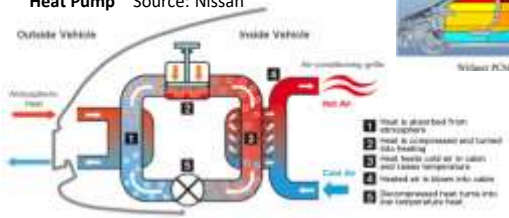
Experimental Analysis of car incorporating phase change material, Oro et al



Heat Pump Source: Nissan



Cost of increasing the battery size to compensate means that manufacturers have business case to spend on alternative solutions.
A real business opportunity.

Thank-you