# Development of a Thermoelectric Device for an Automotive Zonal HVAC System

Todd Barnhart[1], David Thomas[2], Glen Roumayah[3]

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# Project Motivation

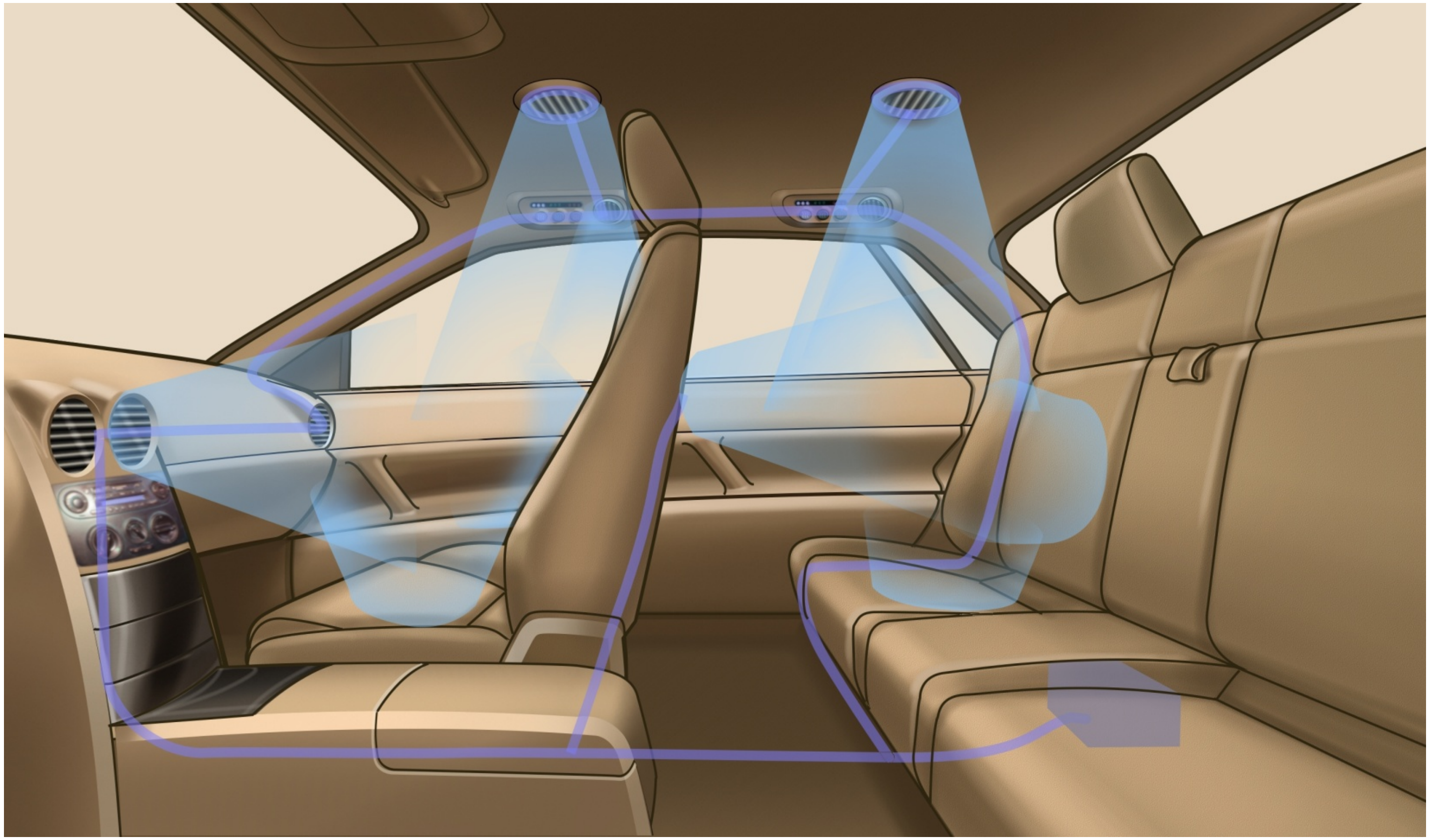
## Reduce Climate Control Energy Consumption!!!!!

GM Vice Chairman…

"The range can vary on any given day depending on temperature, terrain, driving conditions and so forth -- especially temperature," GM Vice Chairman Bob Lutz told reporters this morning at the 2010 Detroit auto show. "Many people don't understand that. The distance you can go in an electric vehicle varies hugely with the outside temperature, including with the Volt."

"If on a standard day you see 40 miles with the Volt, on a cold day where it's right around 32 degrees, you're going to see 28 or 30 miles," Lutz said.

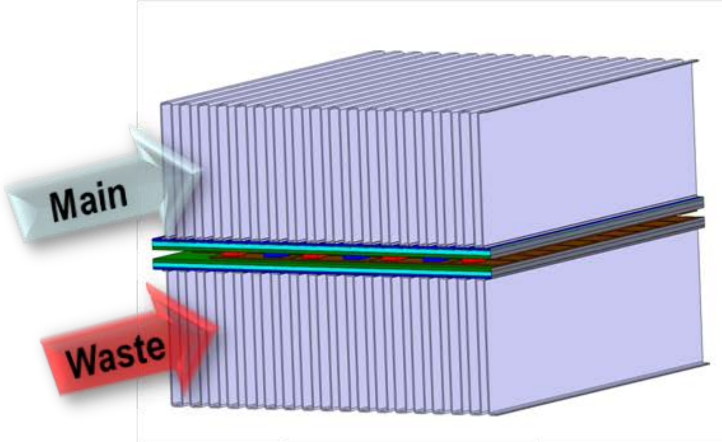
# Zonal Application Description



- Only condition occupied positions

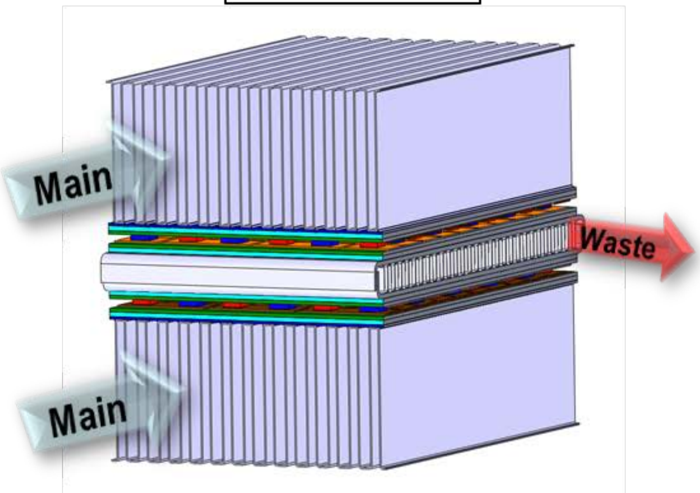
•Downsize/reduce or eliminate the output of the central system

# “Waste” Side Working Fluid

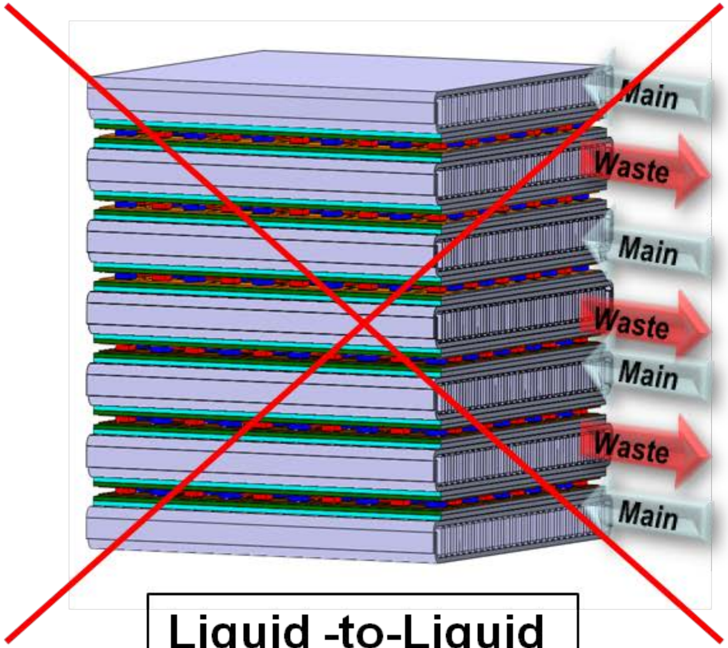



Air-to-Air

Thermoelectric device constructions for use with 2 working fluids.




Liquid -to-Air



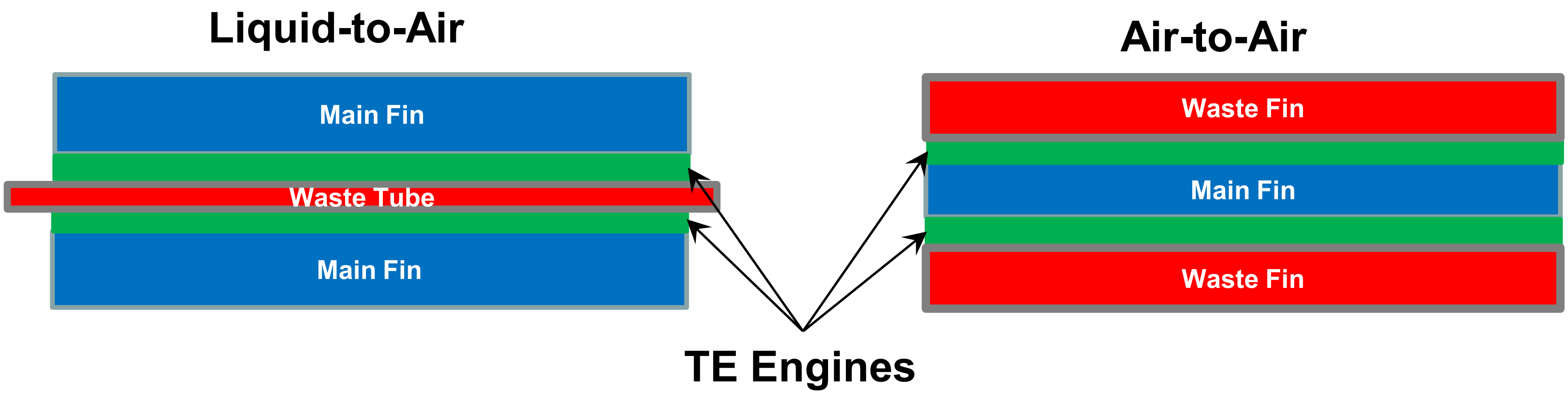

Liquid -to-Liquid

# “Waste” Side Working Fluid

| Air Waste Stream | |
|---|---|
| Pros | Cons |
| Low weight | Poor heat transfer |
| No risk of coolant leaks | Lower power density |
| | Difficult to vent waste heat |
| | Low capacity per gram of Tellurium |
| Minimizes ΔT across TE | Uses and ejects conditioned air |
| | Noise – Higher flow rates |
| | No waste heat scavenging |

| Liquid Waste Stream | |
|---|---|
| Pros | Cons |
| Good heat transfer | Added weight |
| High power density | Routing liquid lines in cabin (leaks) |
| Removes heat from Interior | Requires an additional radiator |
| Capacity per gram of Tellurium | |
| | **Waste side temp tied to ambient** |
| Minimal noise – Lower airflows | |
| Waste heat scavenging | Added coolant controls |

# Air vs. Liquid Performance Comparison



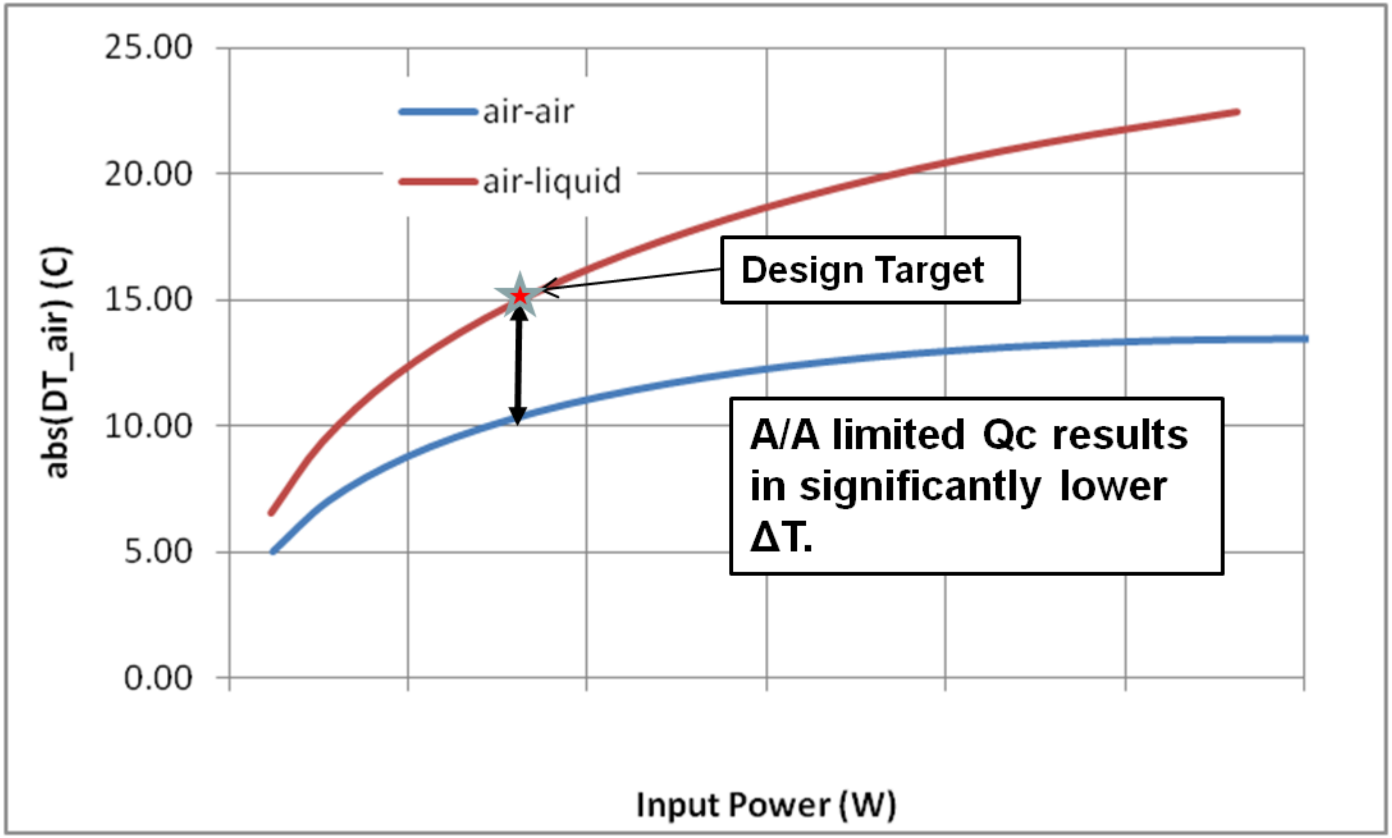

- 2 Devices were modeled, both having the same volume and using the exact same thermoelectric engines.

- Air-to-Air Device designed to have the Waste side flow = 2 x Main flow to improve performance. This requires 3x the airflow rate of the L/A device. (This increased airflow has a significant impact on blower power, package & noise.)

- Liquid-to-Air device assumed a conservative flow rate of ~2 L/min

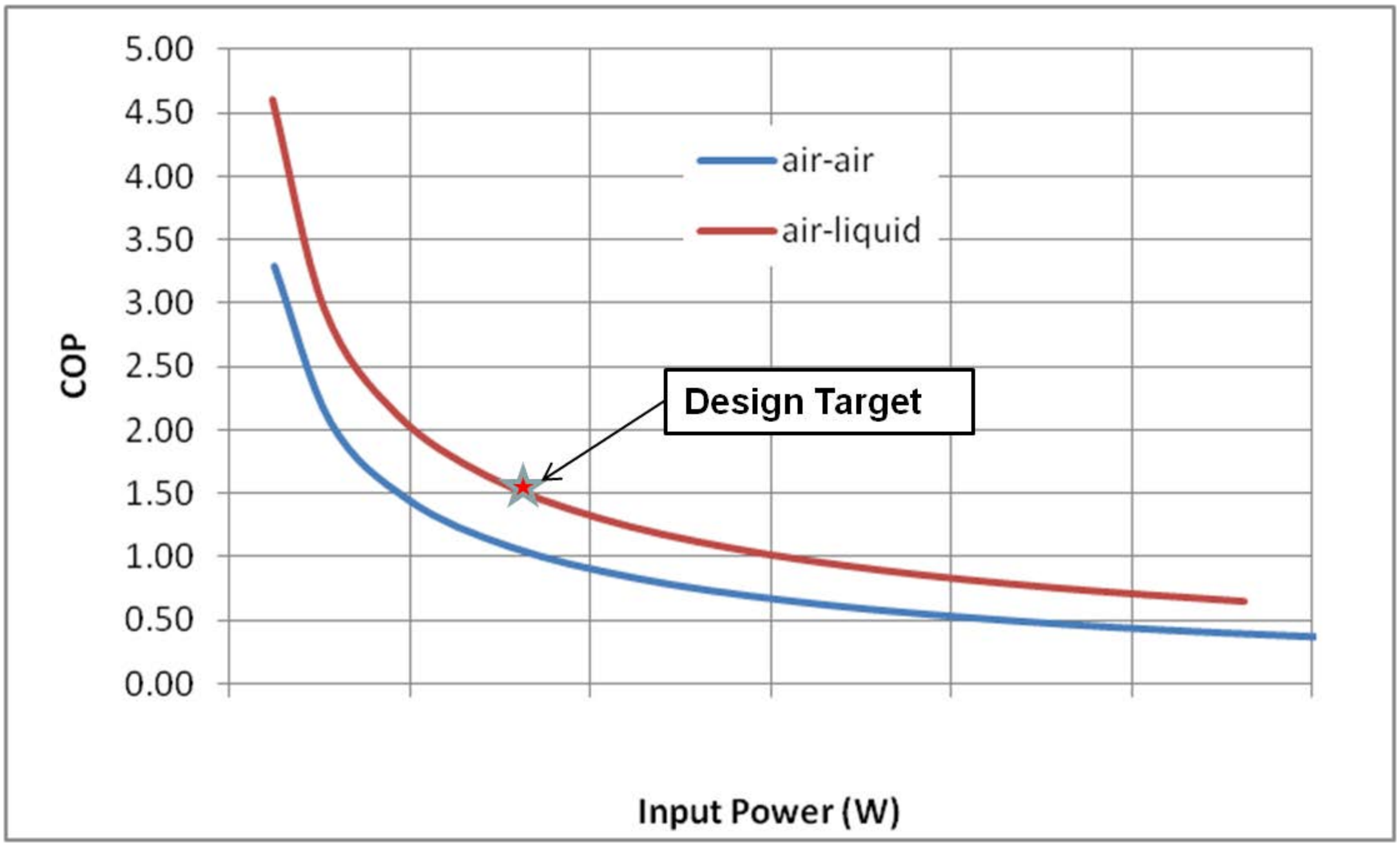
# Air vs. Liquid Performance Comparison

**Main & Waste Inlet Temperatures 30 C**



# Air vs. Liquid Performance Comparison

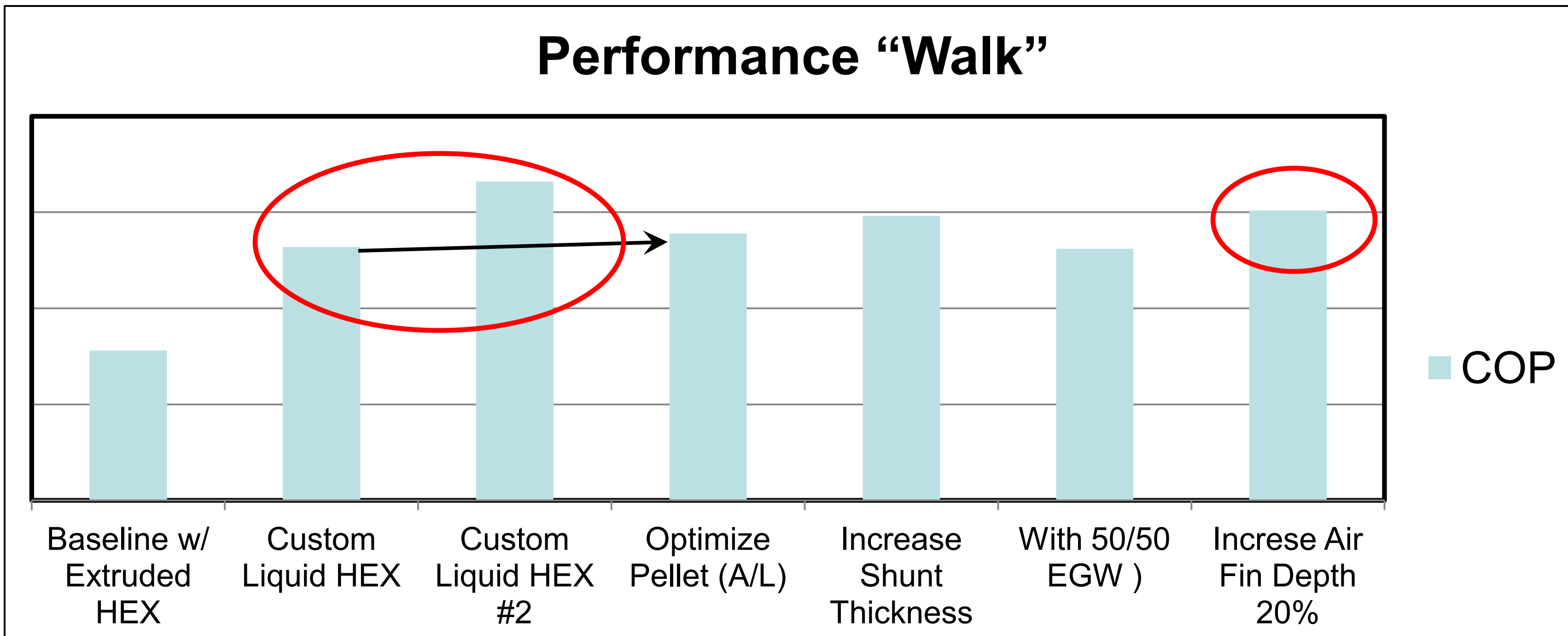
**Main & Waste Inlet Temperatures 30 C**



# Device Optimization

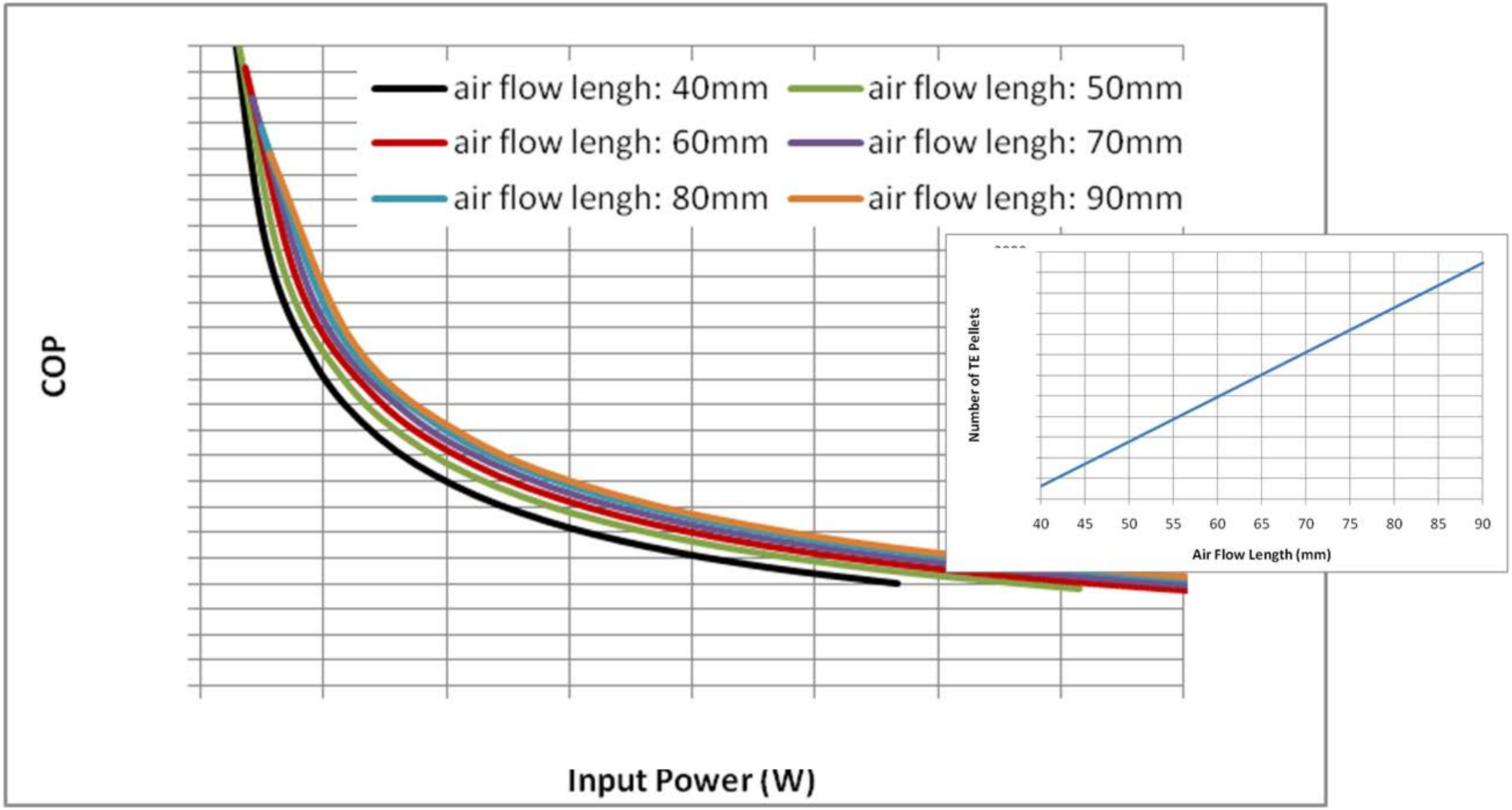
## Design Methodology:

- Optimize at the device and component level
- Major components are:
    - Liquid HEX, Air Fin, Dielectric Systems and Thermoelectric Engine



# TE Engine & Air Fin

- **Select number of elements and airflow depth**



# TE Engine & Air Fin

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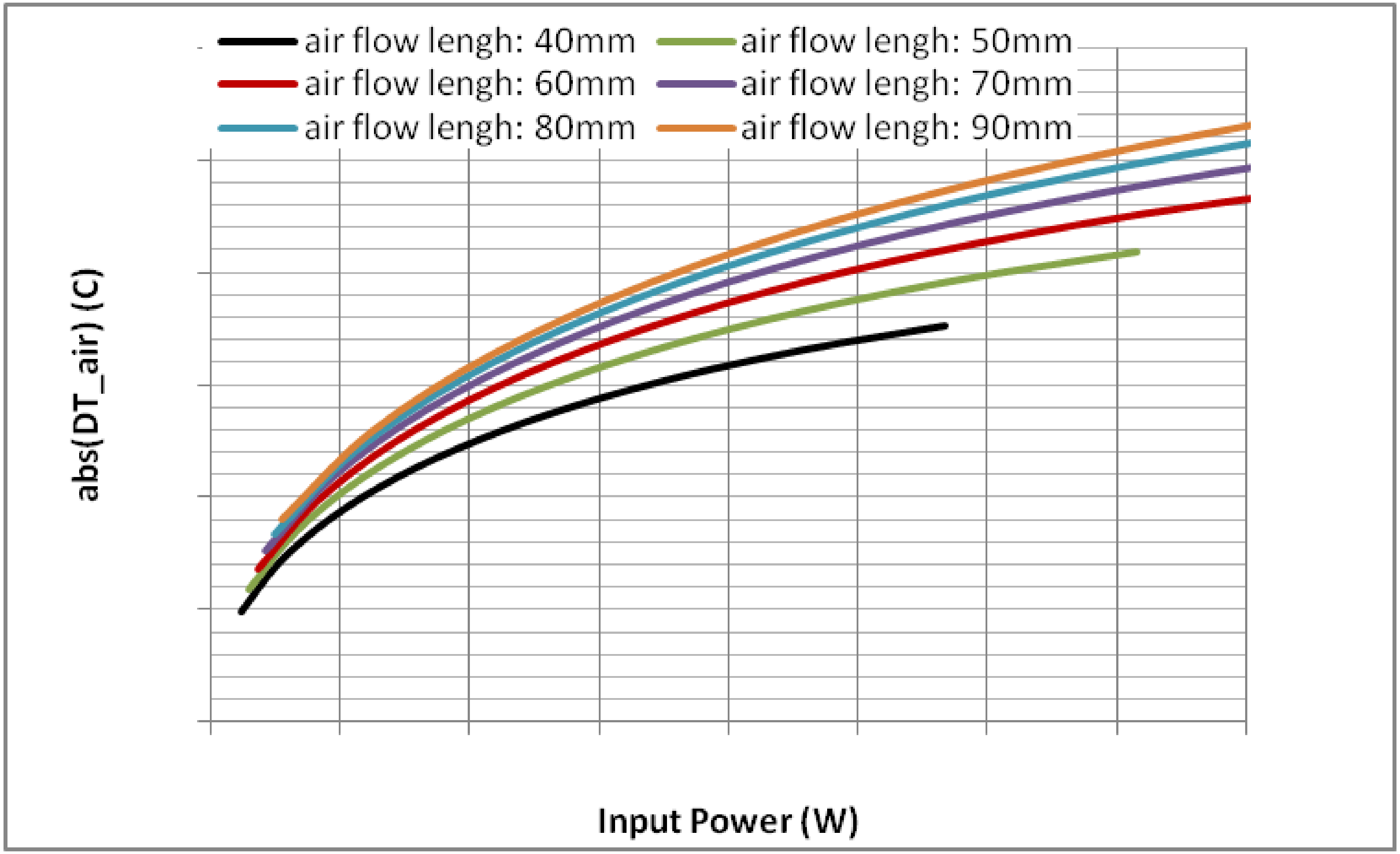
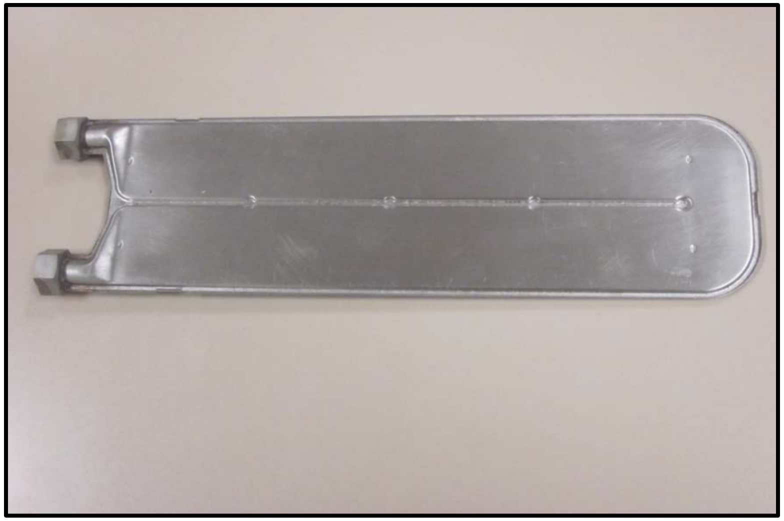


# Liquid Heat Exchanger

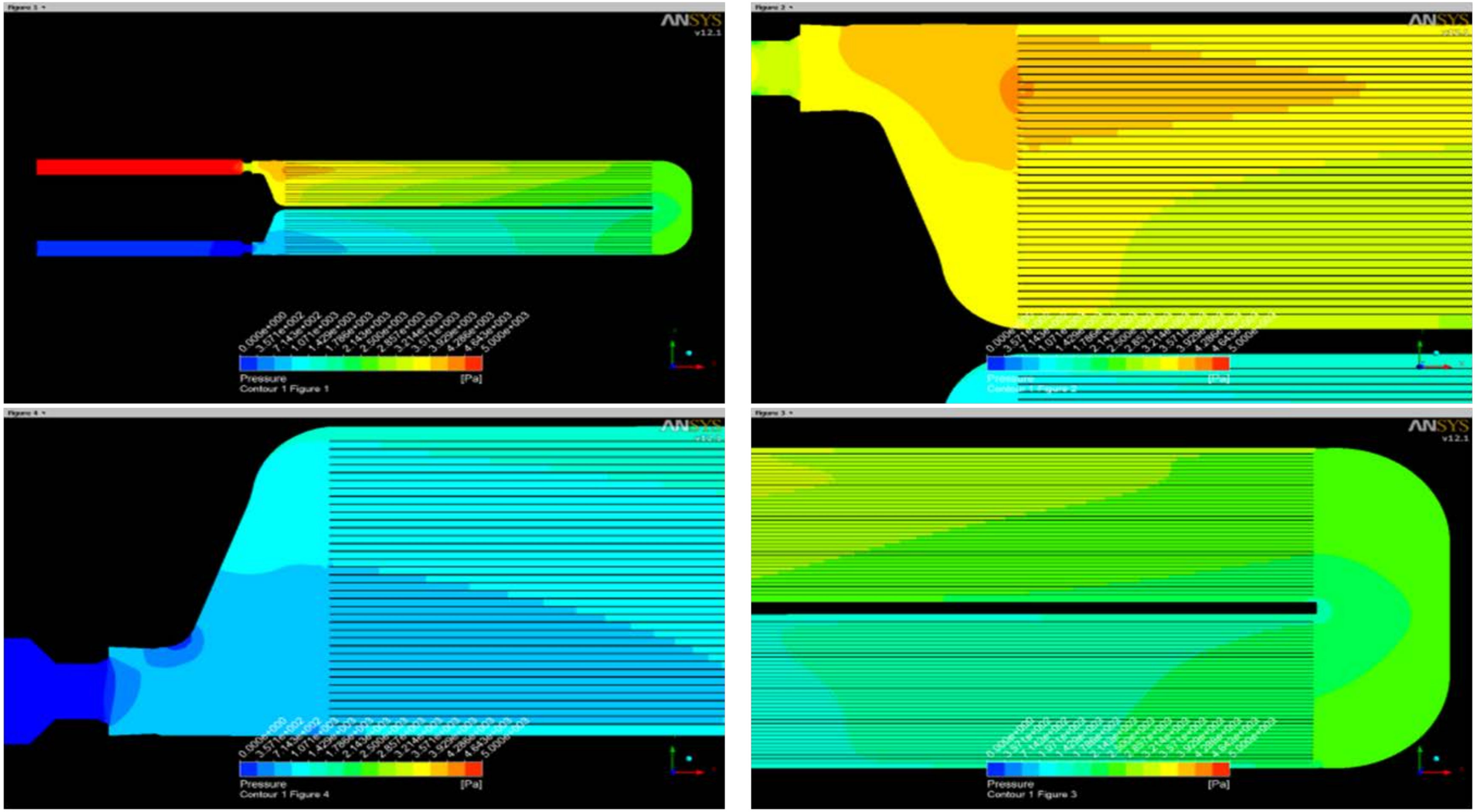


**Goals:**

- **Maximize heat transfer efficiency**
- **Minimize coolant pressure drop**
- **Control flatness**
- **Manufacturing feasibility – utilize current production processes**

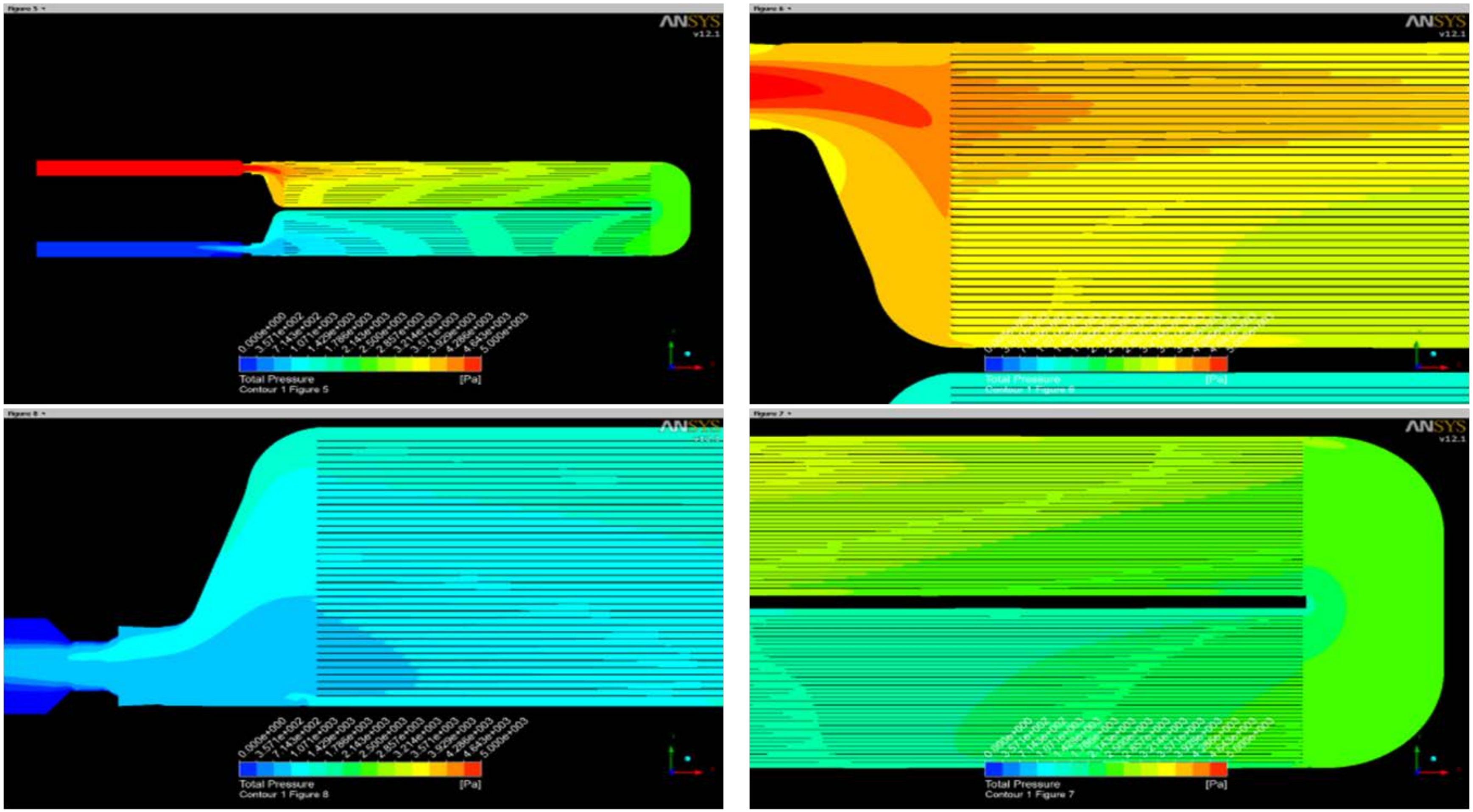
# Liquid Heat Exchanger

**Static Pressure Profile-**



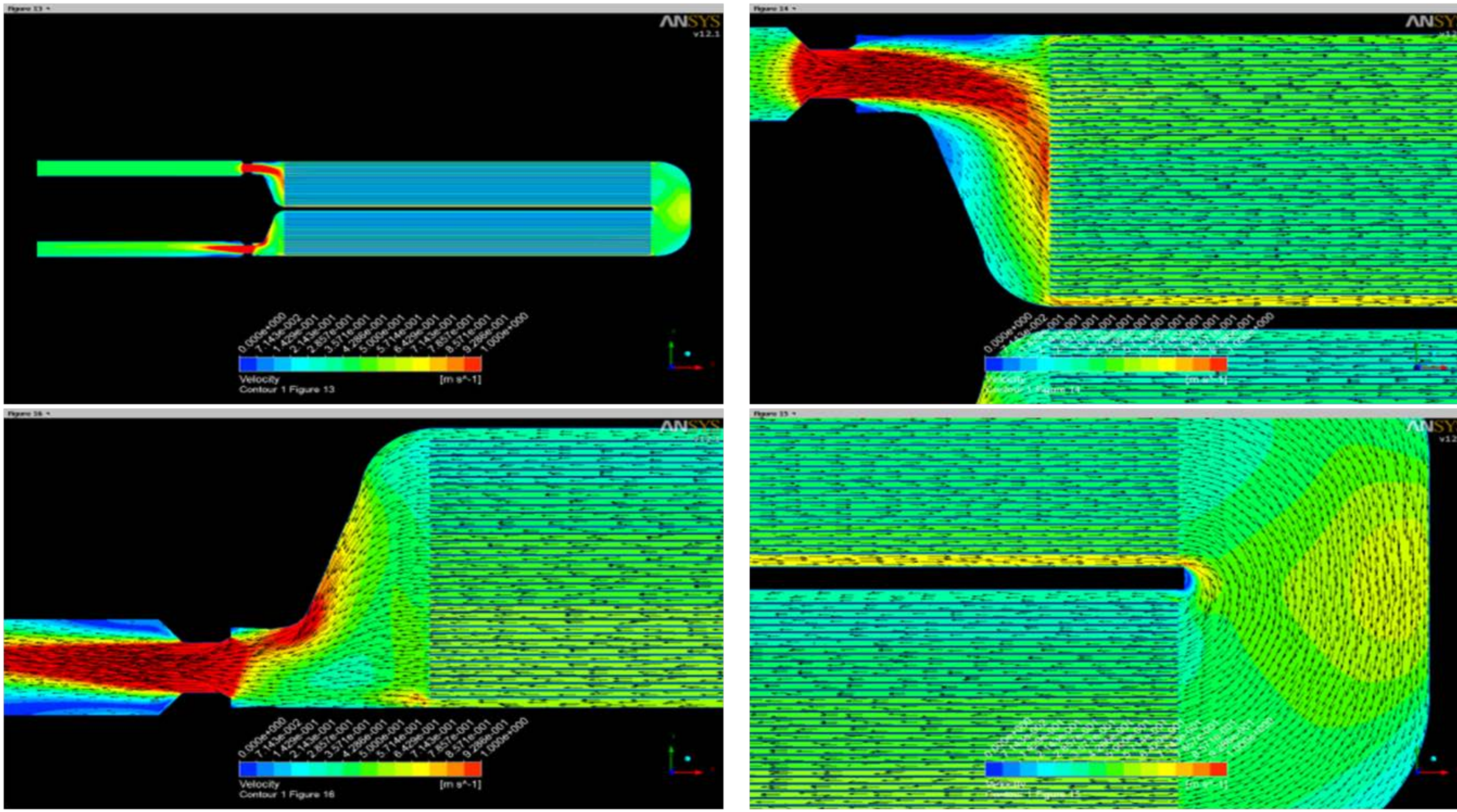
# Liquid Heat Exchanger

**Total Pressure Profile-**



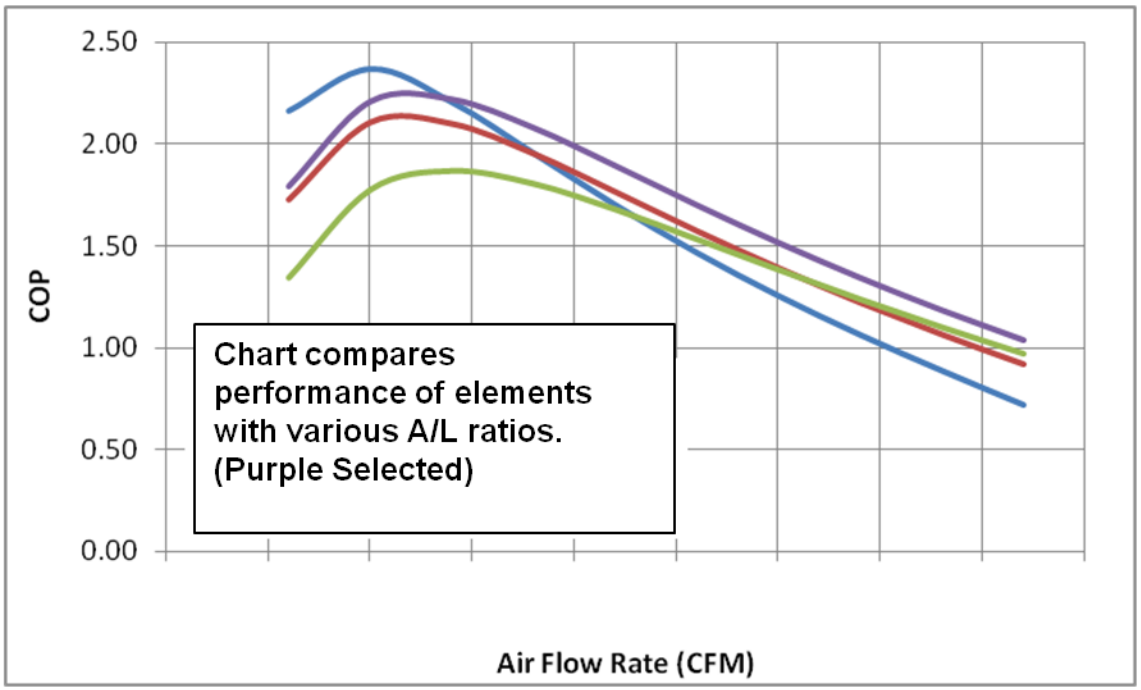
# Liquid Heat Exchanger

**Velocity Profile-**



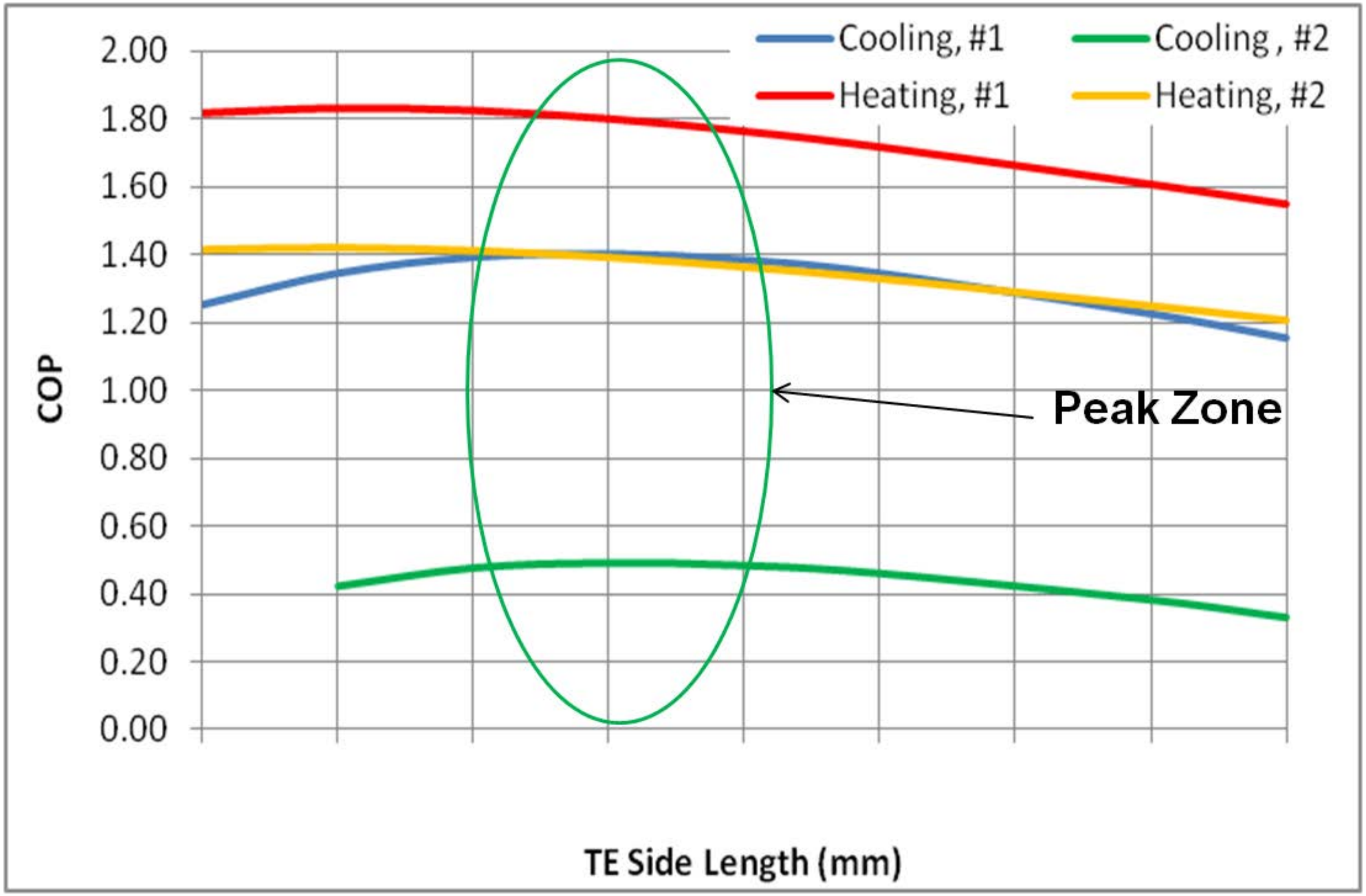
# Thermoelectric Engine

- Select pellet side length
  - Optimize for performance
  - Material usage
  - Thermal stress management



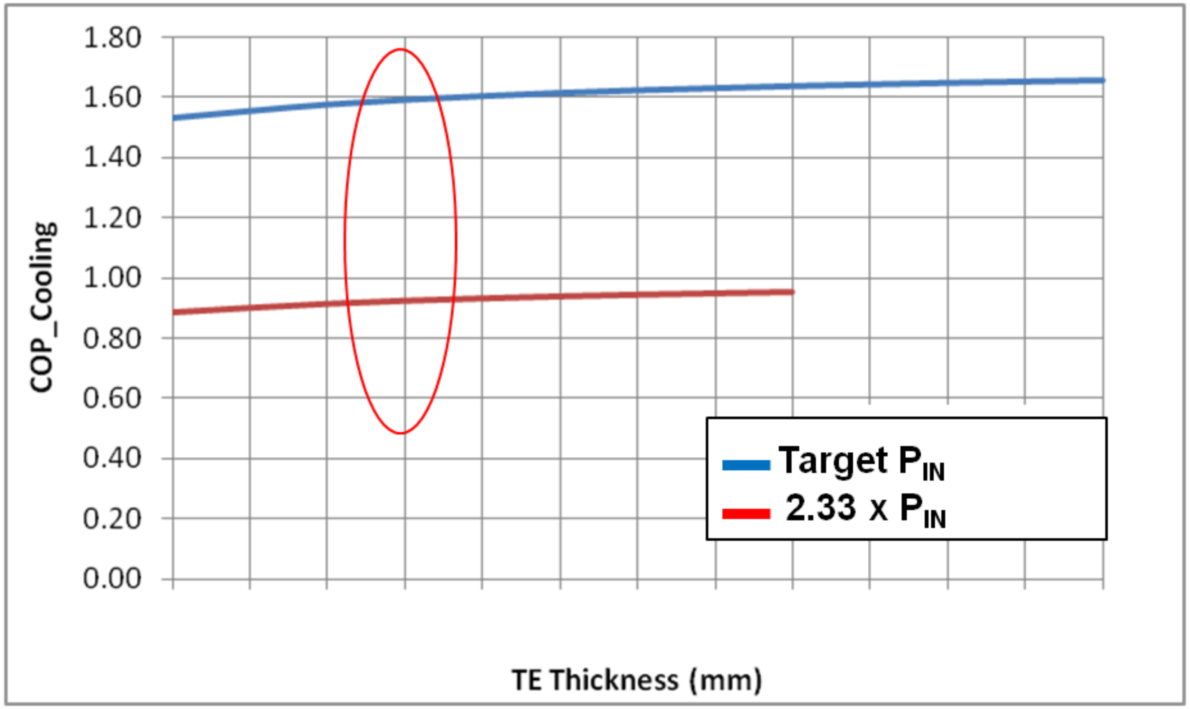
# Thermoelectric Engine

- **Select pellet side length**

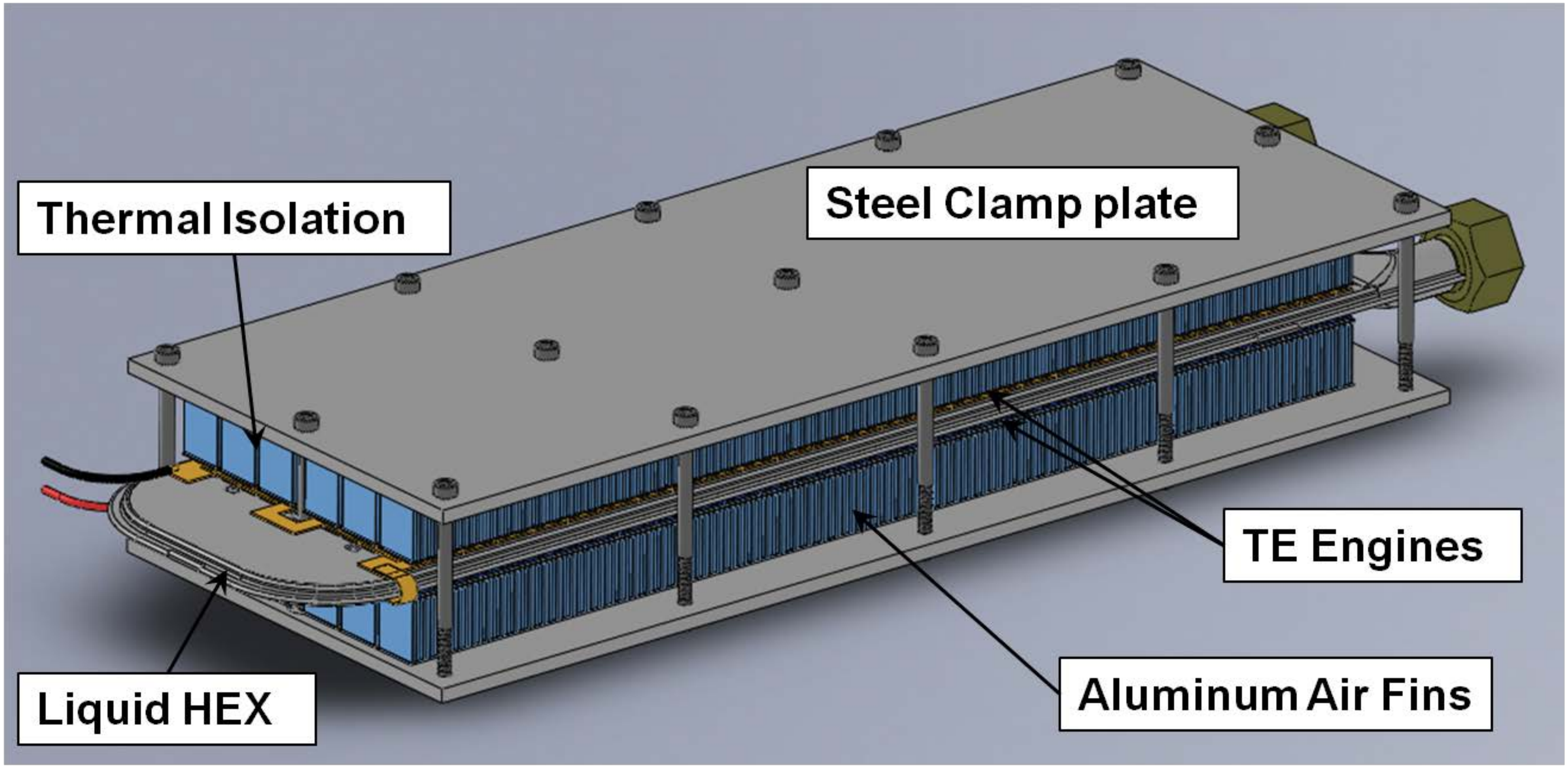


# Thermoelectric Engine

- **Select pellet thickness**
  - Optimize for performance
  - Manufacturing process capability
  - Material usage
  - Thermal stress management



# Phase 2 Device



# Status

**<u>Where Are We?</u>**

- **Testing Phase 2 Devices**
  - ➢ **Evaluating various air fin derivatives**
- **Start durability testing of Phase 2 device.**
- **Preparing Phase 3 device refinements for the design and manufacturing process. Scheduled for delivery 3rd Qtr 2012.**
- **Prepare a detailed cost analysis of the devices and system components. 4th Qtr 2012.**

# Summary

**Conclusions:**

- Phase 2 Device has been tested at a wide range of Input Powers from 100 to 700 W.
- Design is scalable to customer requirements
- Heavy focus on production feasibility.
- Durability – Phase 1 part survived  150,000 cycles
- Available for alternative applications:
  - Battery thermal management
  - Electronics cooling

# Acknowledgements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