



Vapor Injection Port Optimization for a Heat Pump Scroll Compressor

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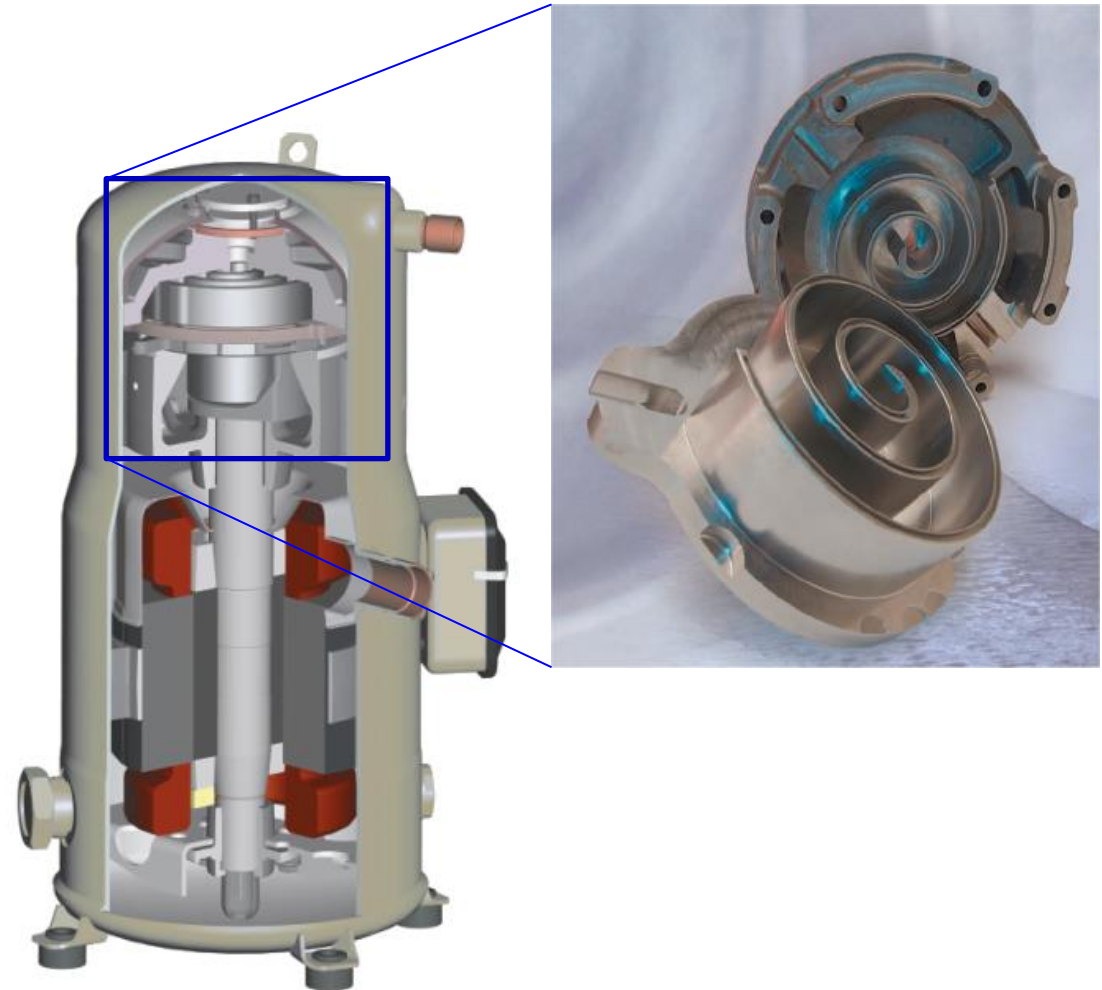
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Agenda

- Scroll Compressor Background & Terminology
- Baseline Design & Performance
- Scaled Auxiliary Port Optimization
- Scaled Optimized Geometry Comparison (Scaled vs. Real)
- Real Auxiliary Port Optimization
- Conclusions

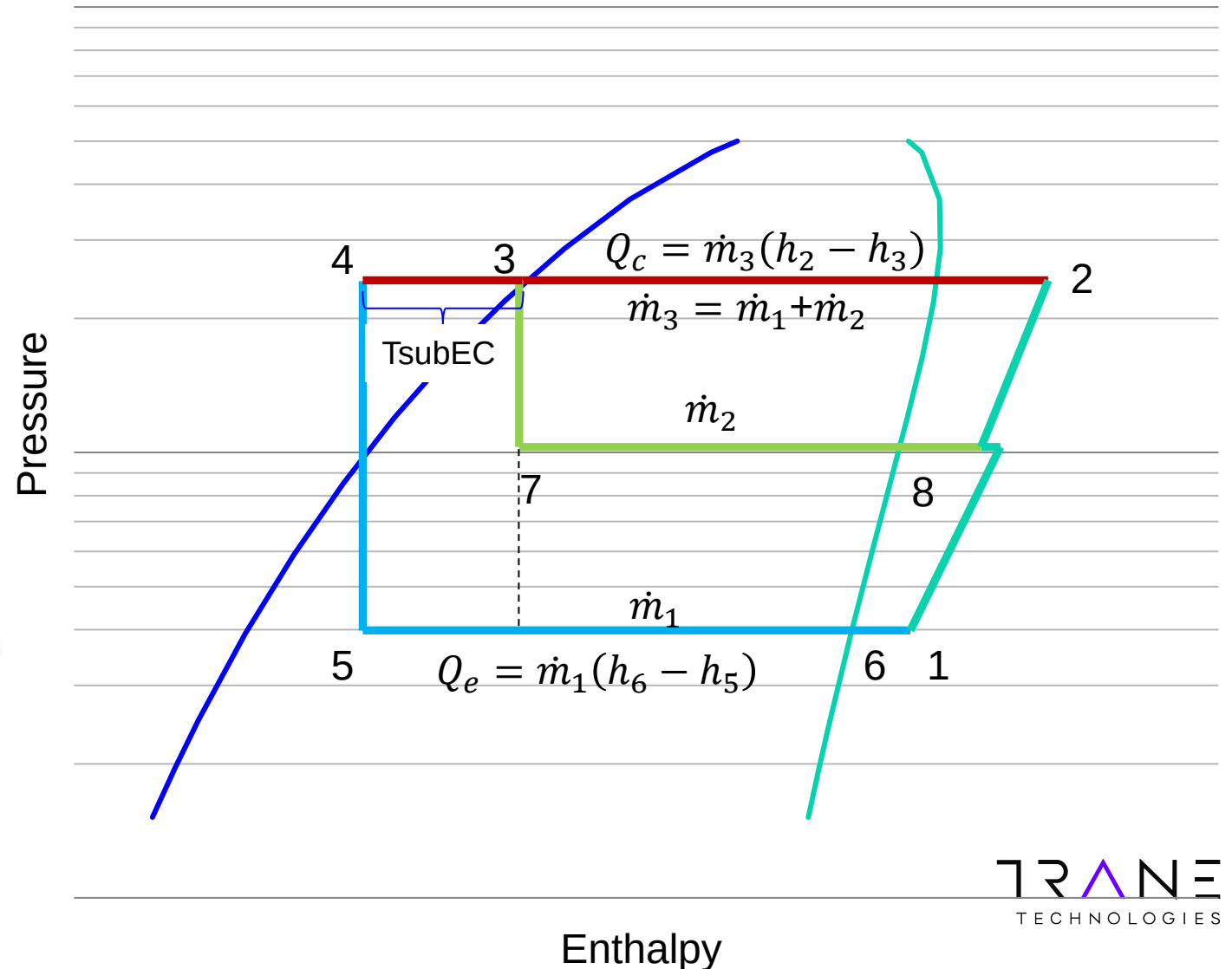
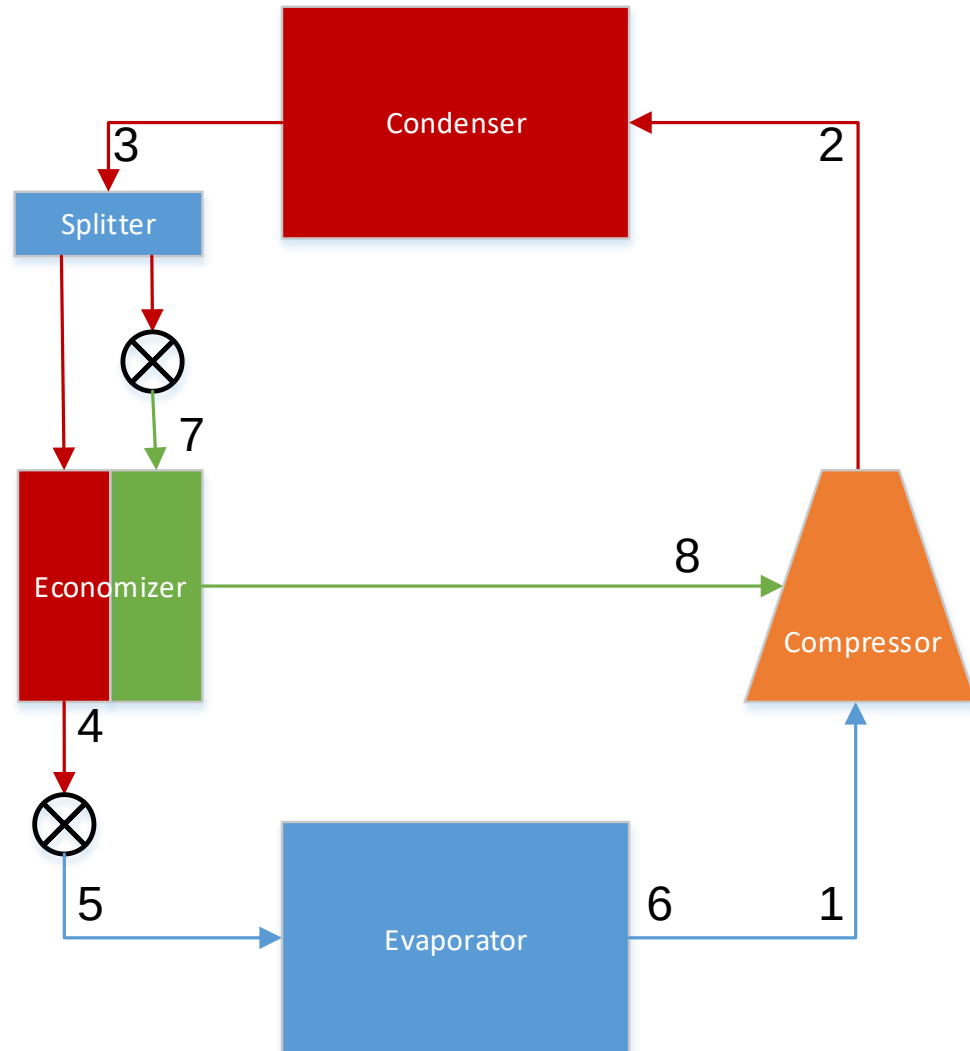
Trane Scroll Compressors

- A **scroll compressor** utilizes two opposing parts, with prismatic, spiral-shaped walls to form and compress a gas, usually air or refrigerant.
- Trane scroll compressors utilize a stationary “fixed” and moving “orbiting” scroll to create the compression mechanism.



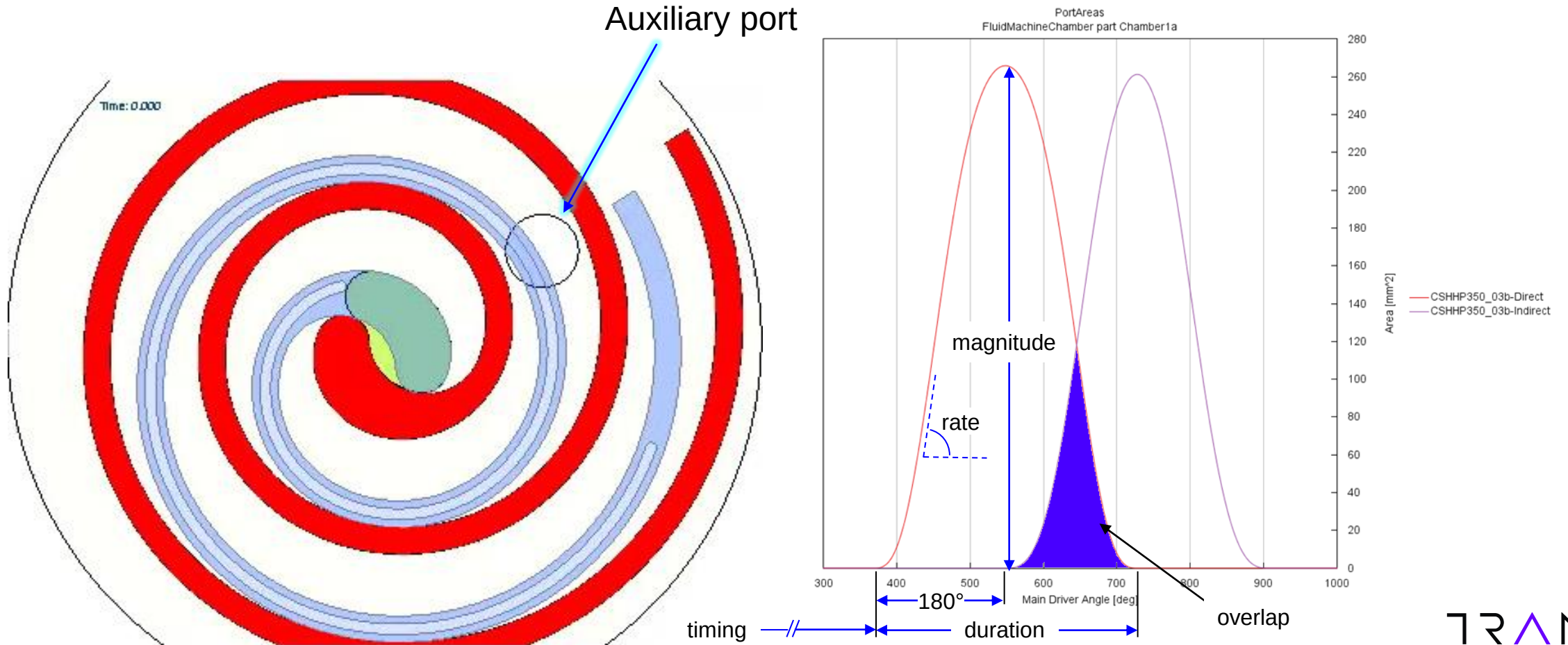
Heat Pump with Economizer Cycle

- Heating effect enhancement with economizer heat exchanger causes greater evaporator heat absorption (subcooling) and greater condenser mass flow to boost heating capacity.



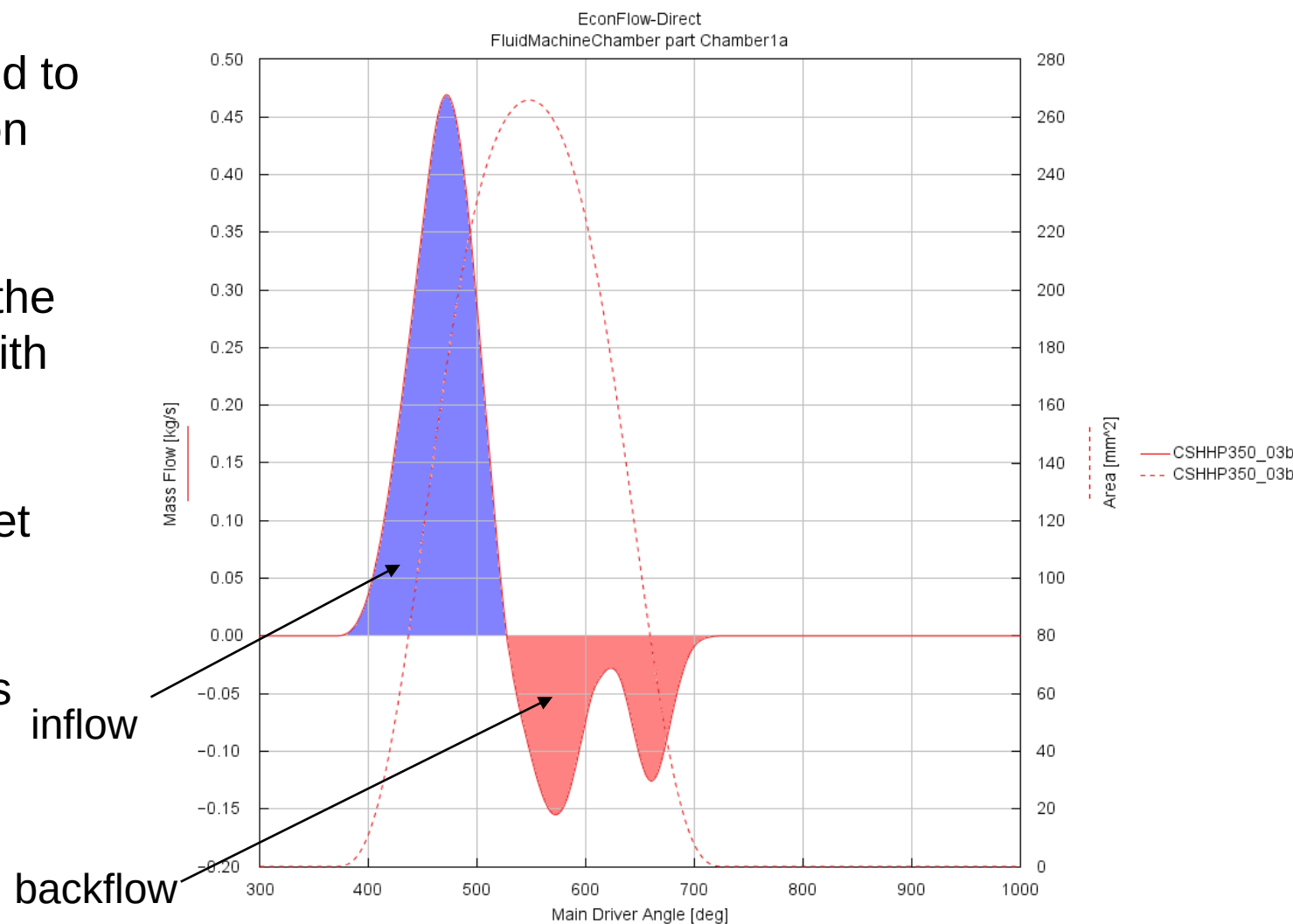
Vapor Injection

- Auxiliary (economizer) port located in compression to inject refrigerant vapor
- This auxiliary port is shared between the direct and indirect pockets.
- The size and position affect timing, magnitude, duration, rate, and overlap.



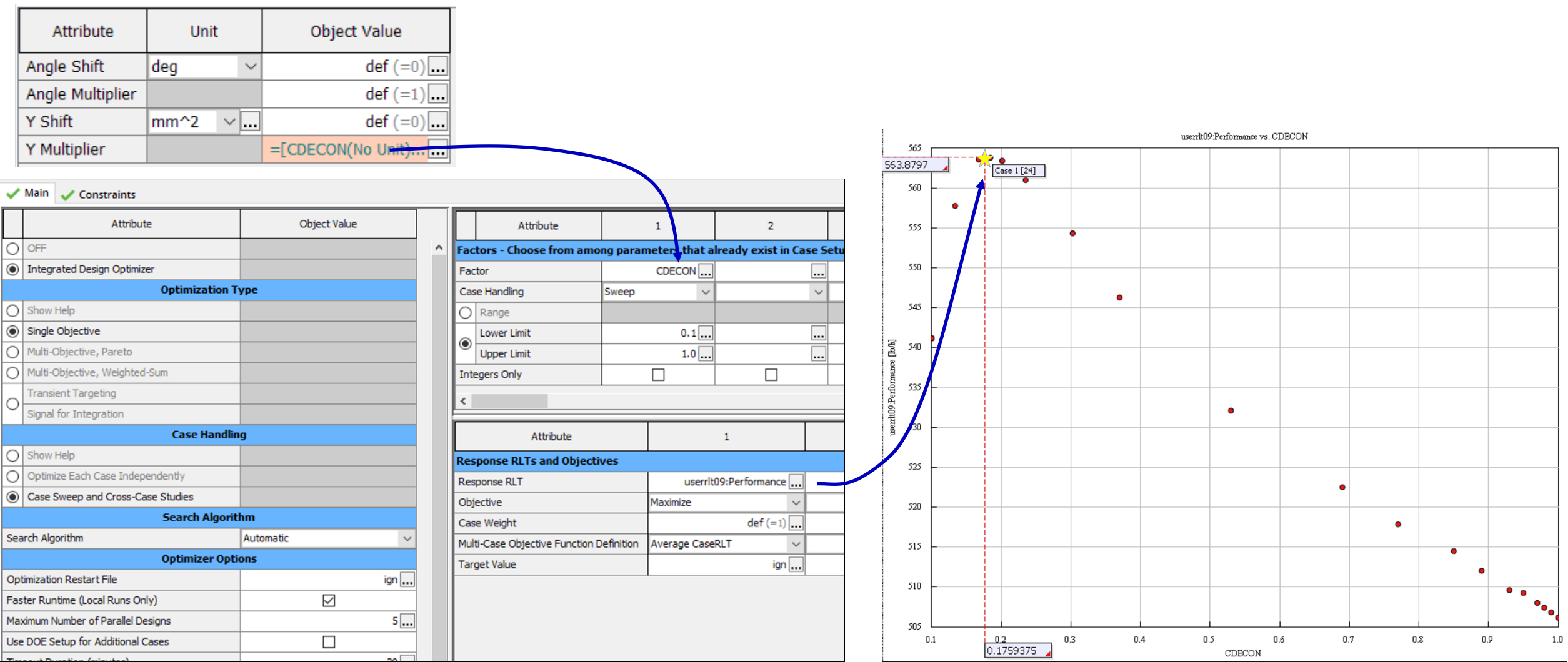
Non-Optimized Performance

- Auxiliary mass flow rate is directly related to heating capacity for a vapor-compression heat pump
- These results show mass flow rate into the direct pocket through an auxiliary port with maximized circular area
- Significant backflow (red) reduces the net mass flow rate
- If the goal is to maximize capacity (mass flow), how can the net mass flow be increased?
- Can this optimization be done all from within GT-SUITE?



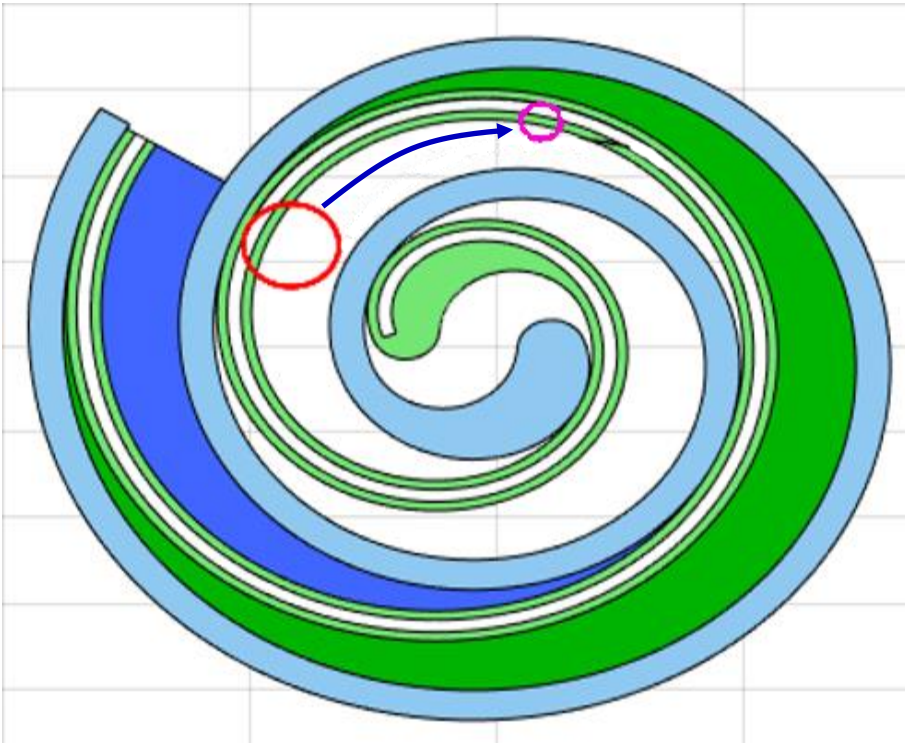
Scaled Port Optimization

- A scaled auxiliary port area profile can be used to represent a resized port all within GT-SUITE

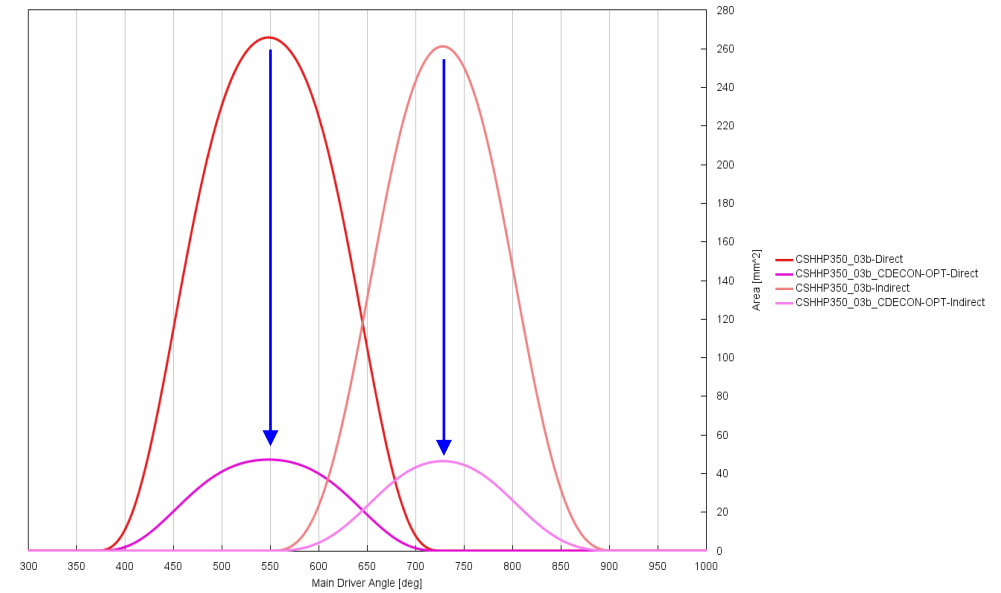


Scaled Optimized Design

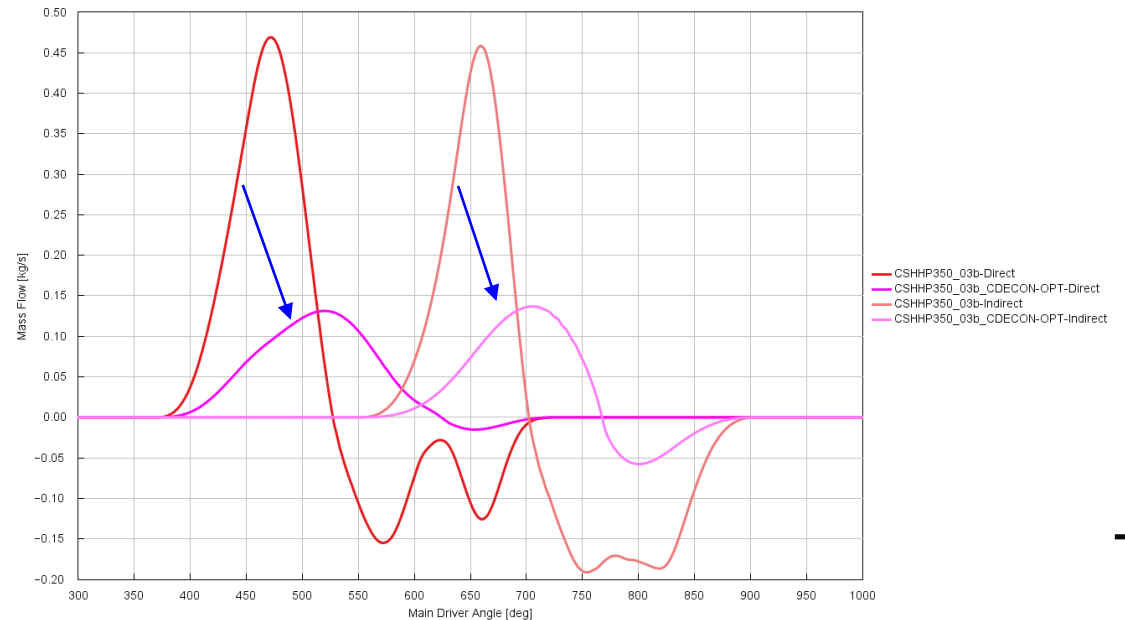
- Optimal design candidate area ↓ 82%
produced ↑ 11% massflow



Area Profile

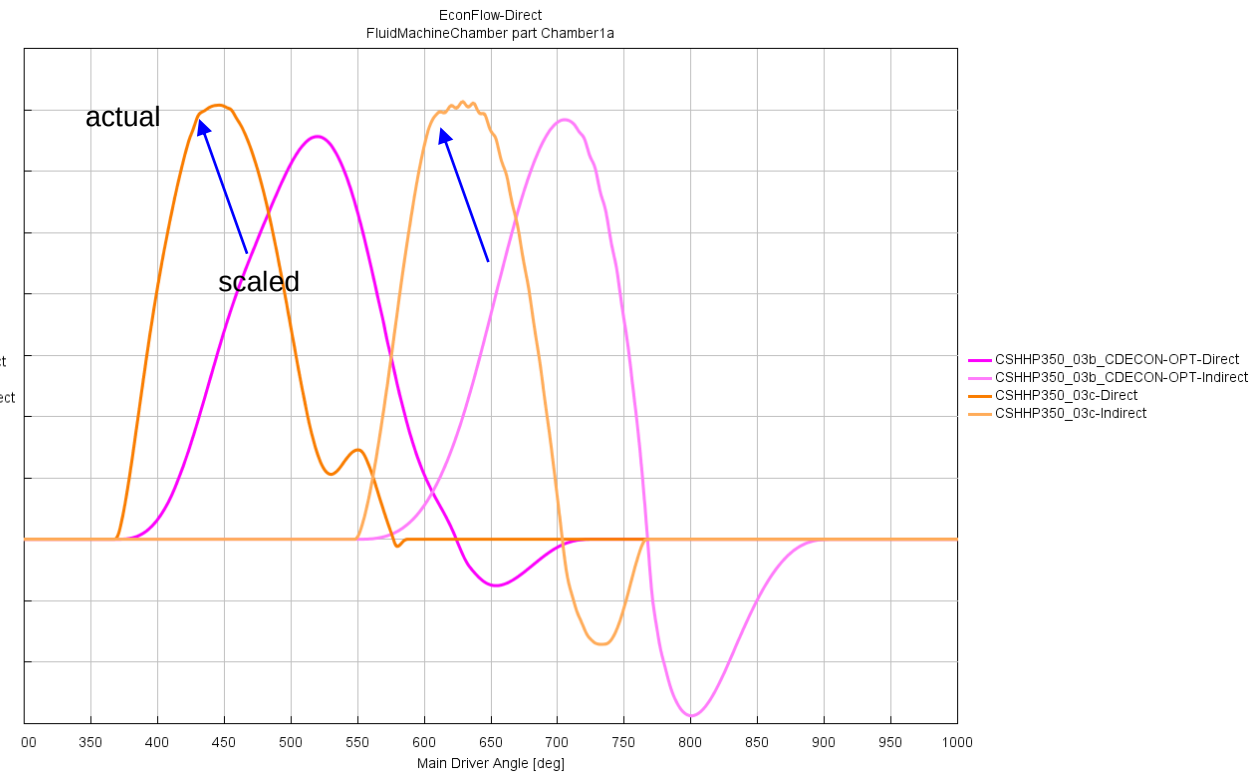
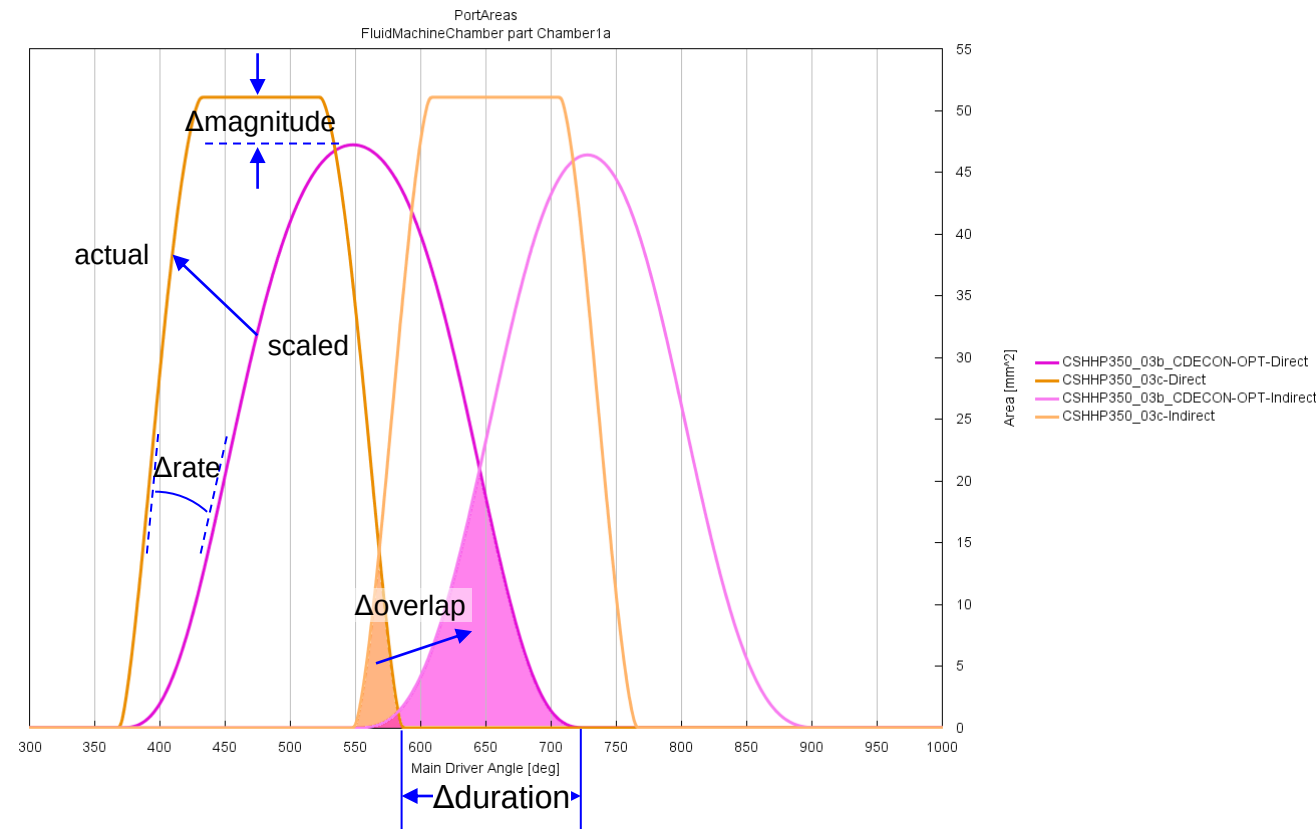


Mass Flow Rate



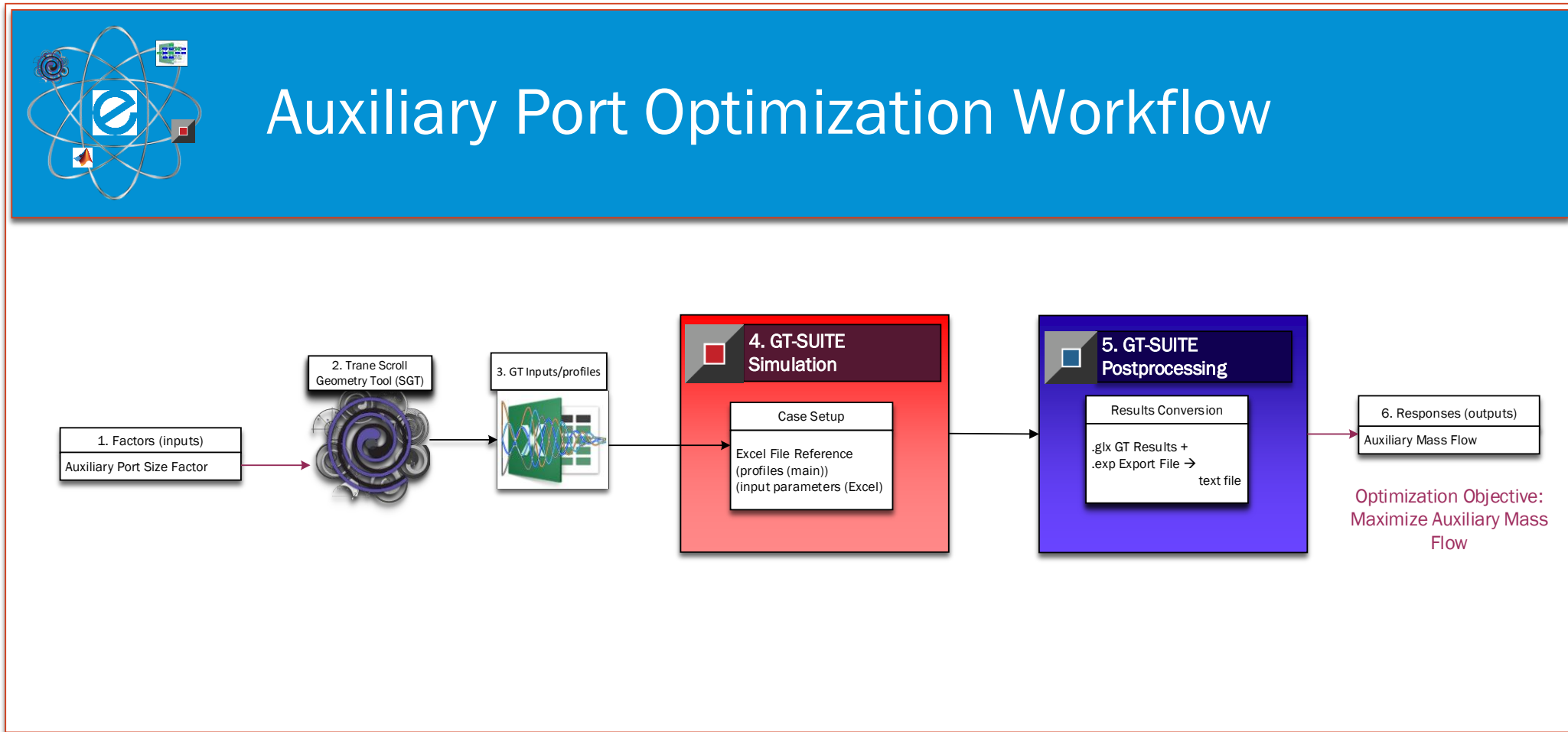
Optimized Geometry Comparison (Scaled vs. Actual)

- Actual geometry produces different profiles from a simple scaling. What is the effect?
- Observed differences in rate, magnitude, duration, and overlap
- Actual mass flow benefit +22% from baseline (+11% with the scaled profile)



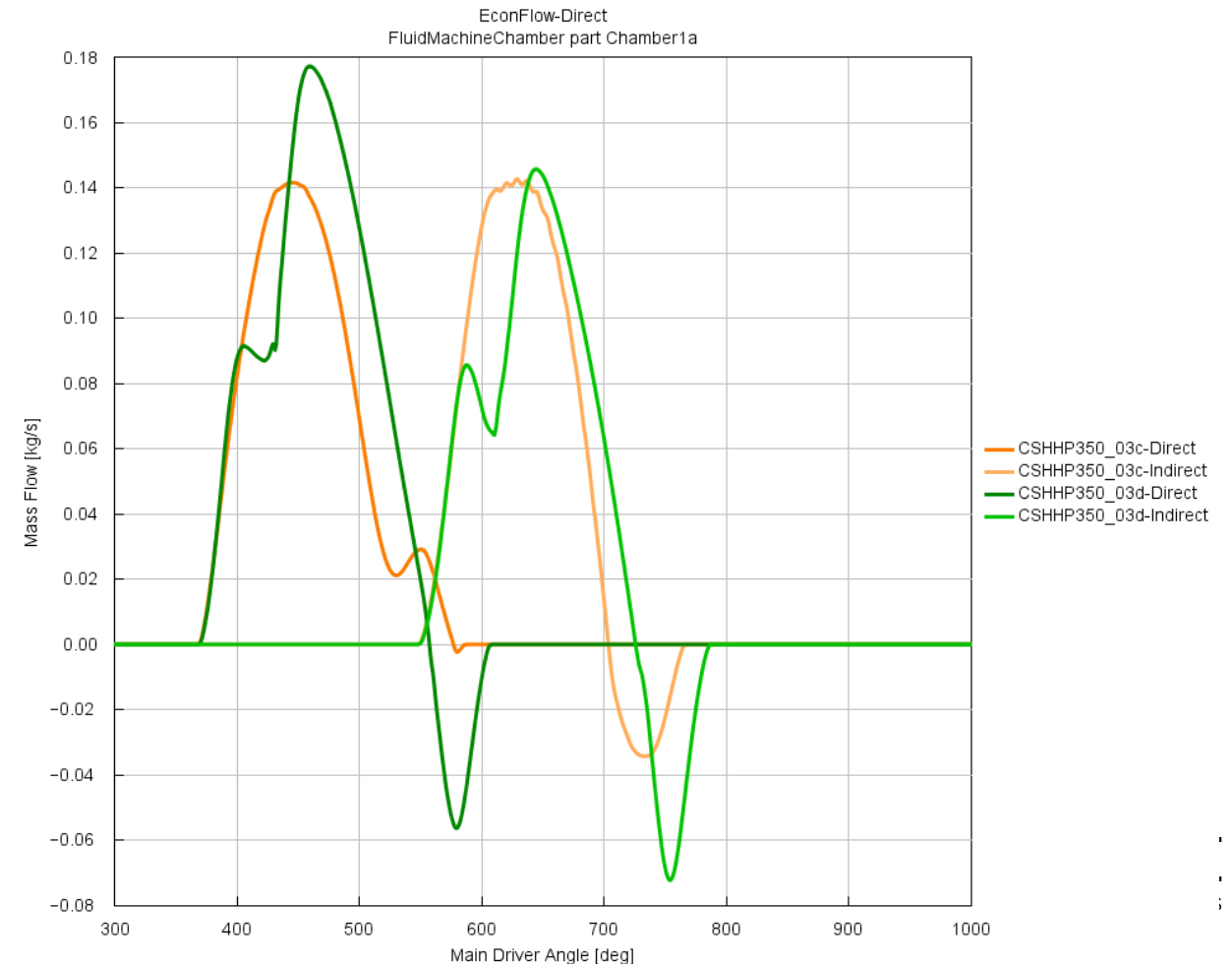
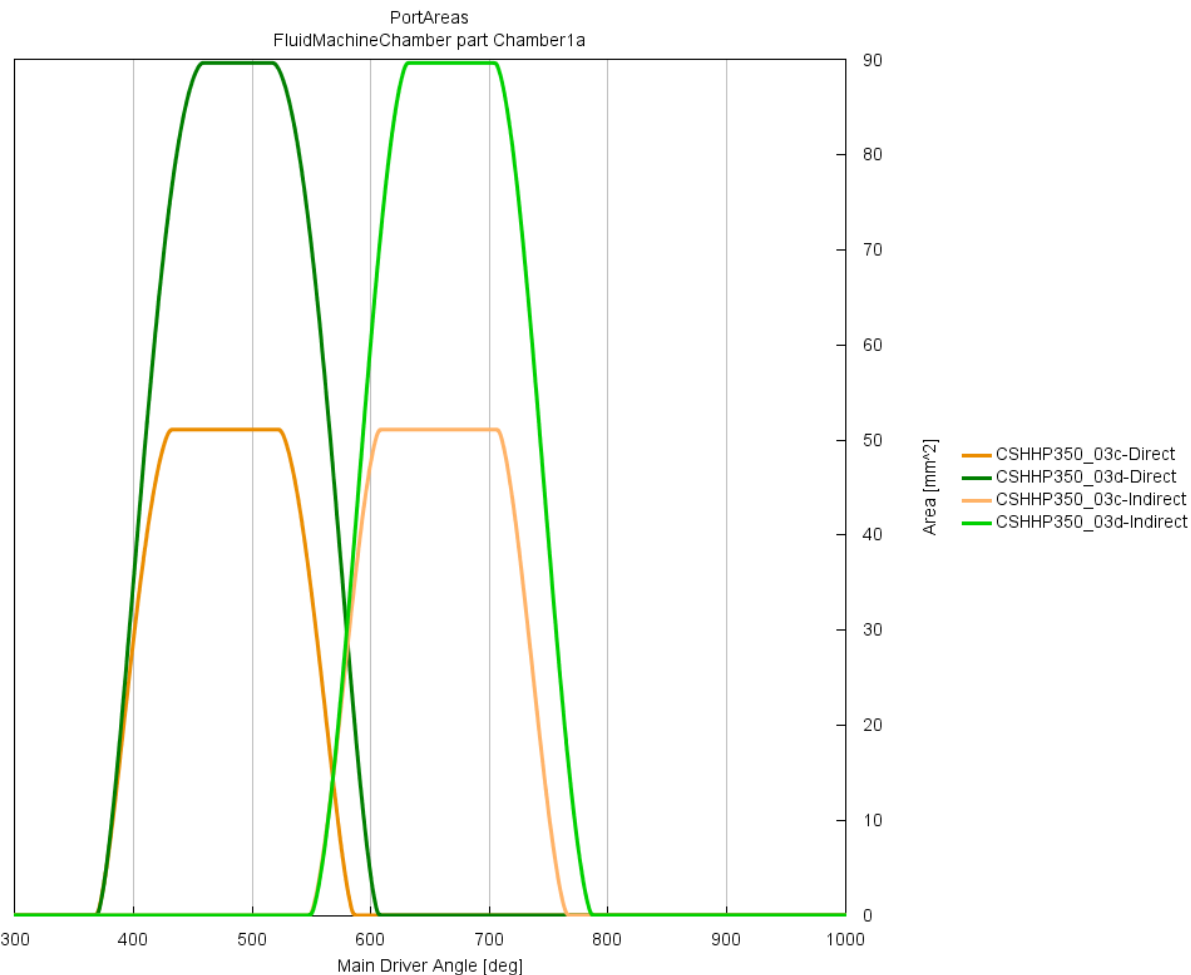
Real Port Optimization

- Because the underlying geometry needed to vary, it was necessary to use a specialized geometry tool to generate the actual auxiliary port profiles.



Real Port Optimization

- Direct auxiliary port size optimization with actual profile variation.
 - Includes the effects on magnitude, duration, rate, and overlap.
- Incremental mass flow rate performance improvement to +25% from baseline (+22% with scaled optimized)



Conclusions

- A scaled-auxiliary port optimization captures some of the area profile characteristics, but not all, with a simple Y-scaling
- Real geometry produces a more complex and accurate effect on the profile, showing a greater improvement in mass flow.
- A geometric optimization captures all profile characteristics and results in additional performance gains, but only a marginal improvement from the scaled optimization.
- The expeditious approach, involving a simple scaling all contained within GT-SUITE, appears to produce near-optimal results.
- The savings from avoiding costly design-test iterations, due to optimization, could be conservatively estimated ~\$10k per iteration.

Questions?