

Efficiency of Refrigerant Circuits

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Comparison of Alternative Refrigerants

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Motivation

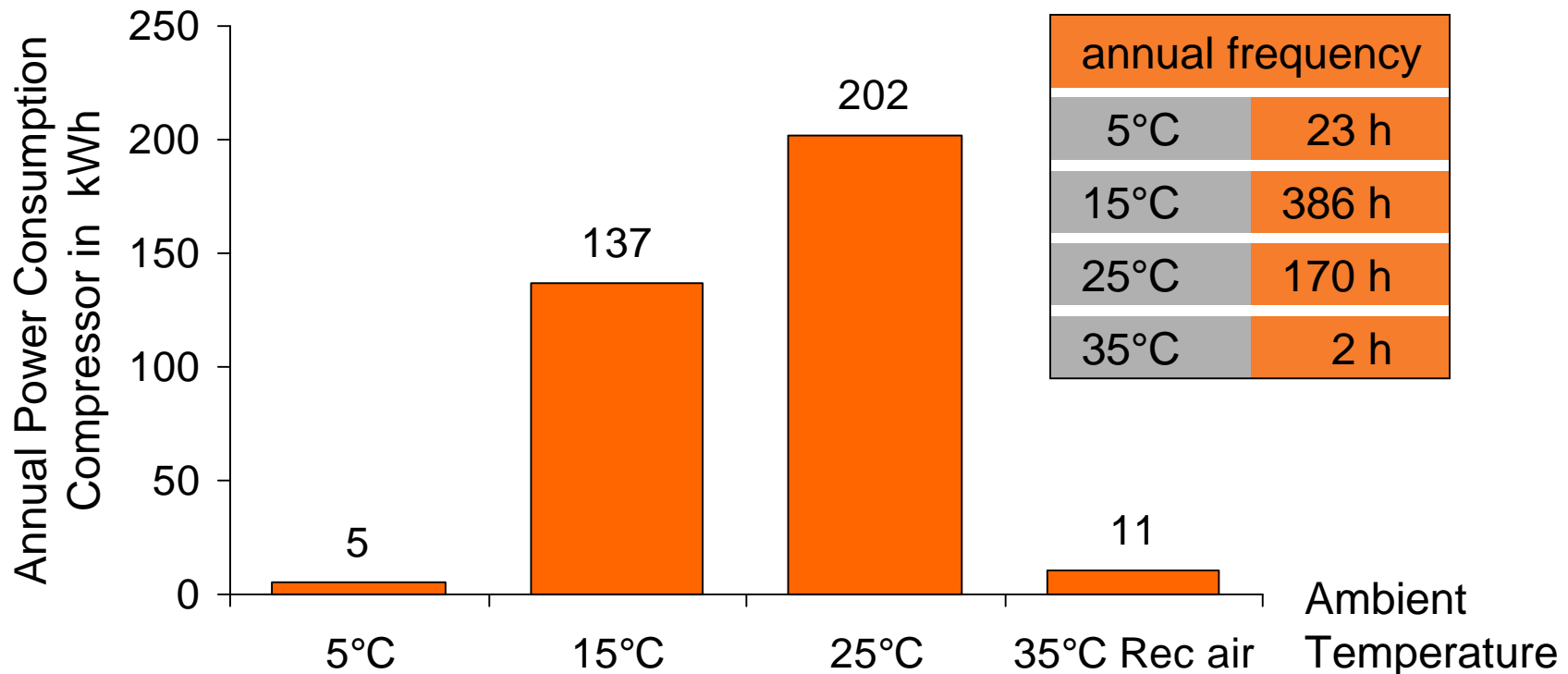
- Comparison of Performance and Efficiency of GAR and R134a
- Potential of Efficiency Improvements

Examined Refrigerant Circuits

	Refrigerant Circuit 1	Refrigerant Circuit 2	Refrigerant Circuit 3
Refrigerant	GAR	GAR	GAR
Circuit	Compact Vehicle	Mid Size Vehicle	Luxury Vehicle
Evaporator	4 dm ² x 40 mm	6 dm ² x 40 mm	8 dm ² x 65 mm
Condenser	20 dm ² x 12 mm	22 dm ² x 16 mm	30 dm ² x 16 mm
Compressor	125 ccm	141 ccm	171 ccm

Annual Power Consumption Compressor

Climate Profile Los Angeles, Ca 12,500 miles per year, FTP 75

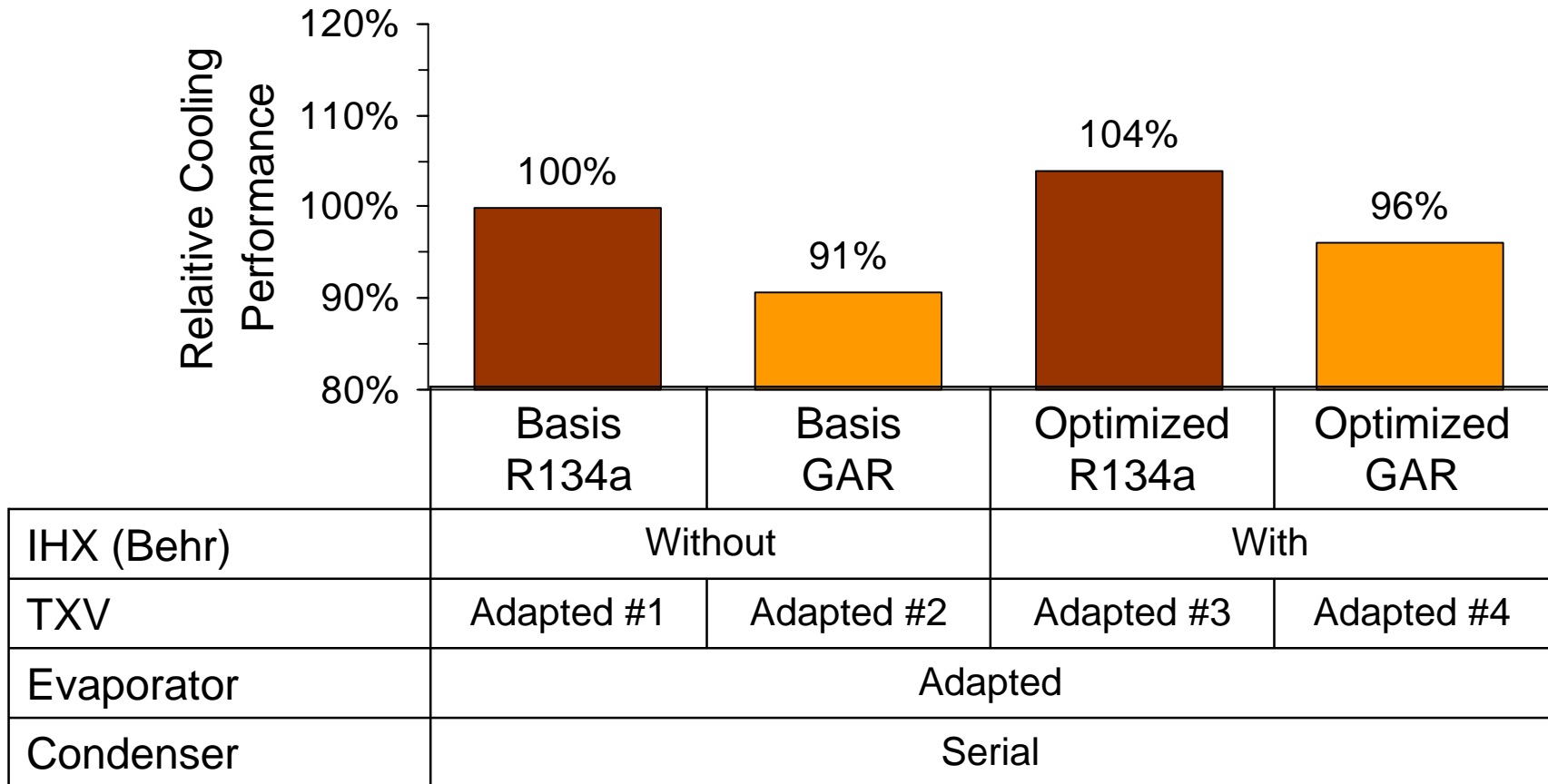


- Evaluation of Efficiency @ 25°C, Performance @ 45°C
- Efficiency with small loads and torques → precise measurement

Bench Test Program

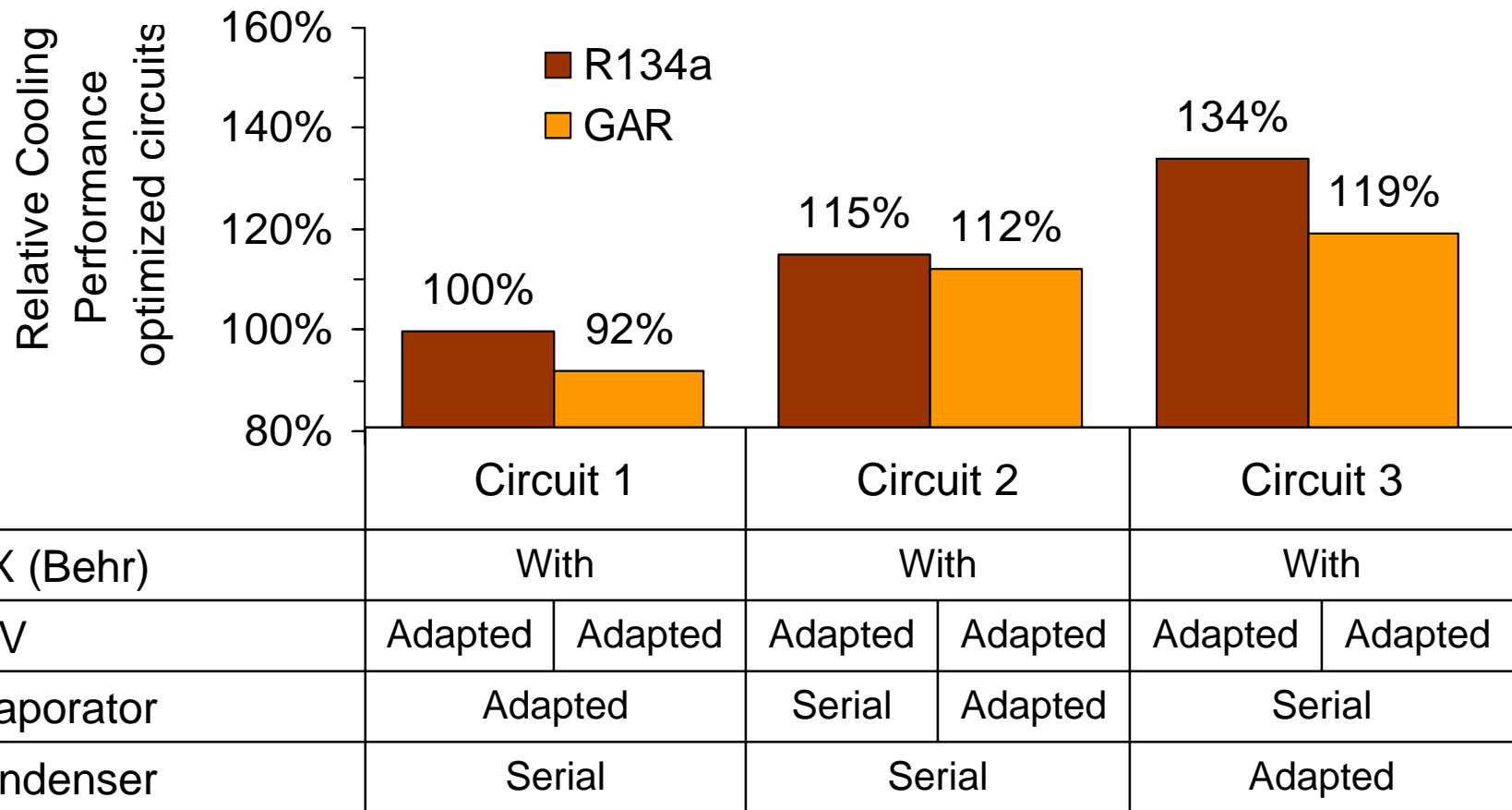
	Performance	Efficiency
Ambient Air	45°C, 25% r.H.	25°C, 50% r.H.
Comparison	SAE, MP #4	SAE, MP #24/#26
Air Evap. out	low	3°C
Air flow evaporator	9 kg/min	6,5 kg/min

Performance Potential (45°C)



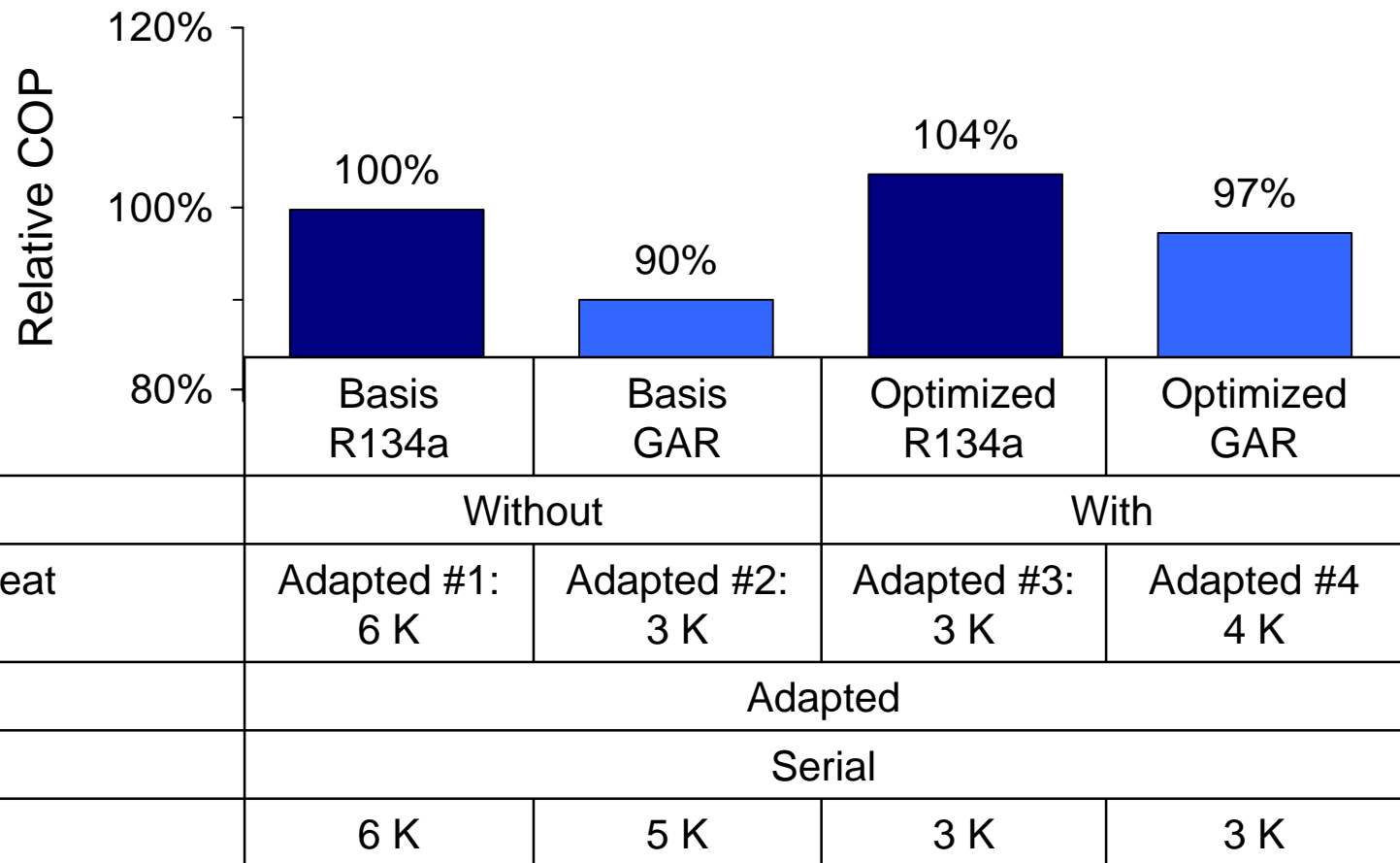
- Cooling Performance of GAR is less than R134a
- GAR Performance can be improved, comparable to serial (R134a today)

Performance Comparison (45°C) optimized



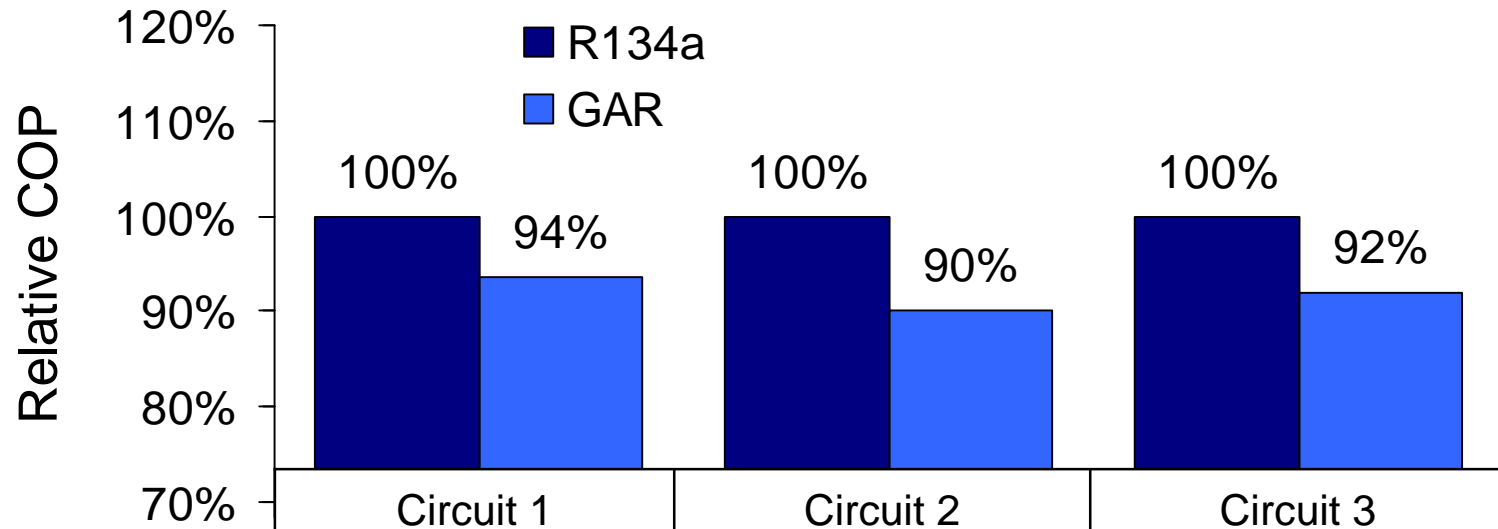
● Performance gap of GAR to R134a (optimized circuits)

Efficiency Potential (25°C)



- R134a and GAR have efficiency potential
- Optimized GAR efficiency comparable to serial (R134a today)

Efficiency Comparison (25°C) optimized



	Circuit 1		Circuit 2		Circuit 3	
IHX	With		With		With	
TXV / superheat	Adapted 3 K	Adapted 4 K	Adapted 2 K	Adapted 2 K	Adapted 6 K	Adapted 2 K
Evaporator	Adapted	Adapted	Serial	Adapted	Serial	Serial
Condenser	Serial		Serial		Adapted	
Sub cooling	3 K	3 K	6 K	5 K	1 K	1 K

● Efficiency gap of GAR to R134a (optimized circuits)

Conclusion

- Improved GAR circuits have performance and efficiency like today's R134a circuits
- GAR with performance and efficiency gap to comparable R134a circuits
- Efficiency improvements of today's R134a circuits possible