Improvement of Power Saving in R134a Air-Conditioning System

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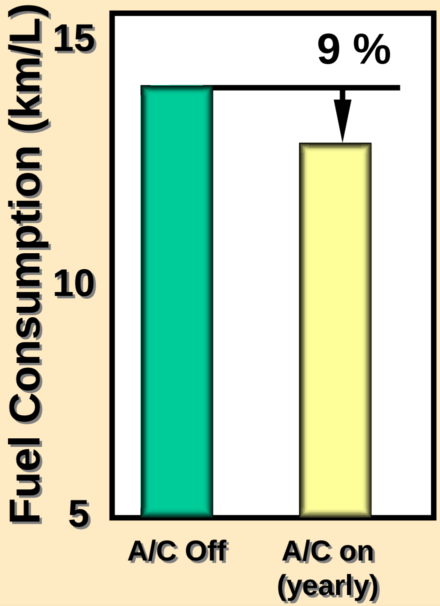
Presentation Outline

- Impact of A/C on Fuel Consumption

- Approaches to A/C Power Saving
  - A/C Cycle & System Efficiency Improvement
  - A/C Control Efficiency Improvement
  - Coordination With Powertrain
  - Vehicle Thermal Management Improvement

Influence of A/C on Fuel Consumption

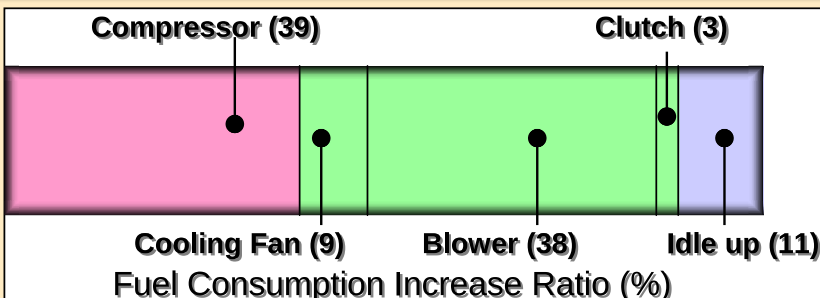


Actual Running Mode:
Compact Car LA4: Stop Ratio 17%

	Yearly
Temperature (^{o}C)	25
Humidity (%)	50
Sun Load (W/m^2)	0
Fresh / Recirculated Air	Fresh
Blower Speed	Low
Evaporator Outlet Air Temperature (^{o}C)	10

Impact on Fuel Consumption

- **Components**
  Compressor, Condenser, etc
- **Influence of Vehicle Thermal Management**
- **Running Condition**
  Constant Speed,
  Acceleration/Deceleration
  Idling,



Yearly
(9%)

Electric load is also a major item.

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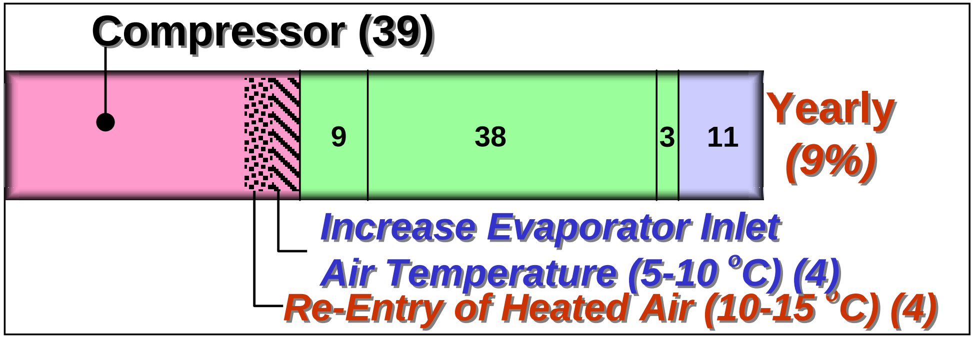
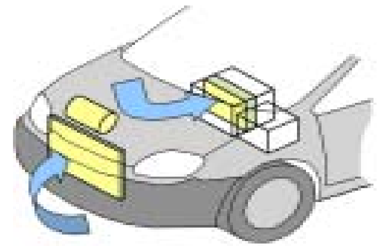
Impact on Fuel Consumption

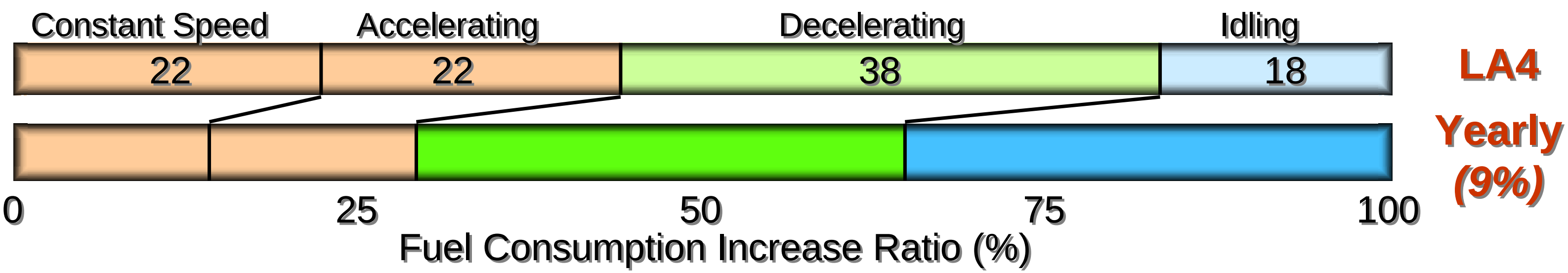




Assumption by Thermal Data at Idling and 40 km/h Running

Thermal Management Improvement:

- **Evaporator Air Inlet Temperature Reduction**
- **Preventing Hot Air Recirculation**



Large Effect When Idling and Decelerating (Accelerating In Summer)

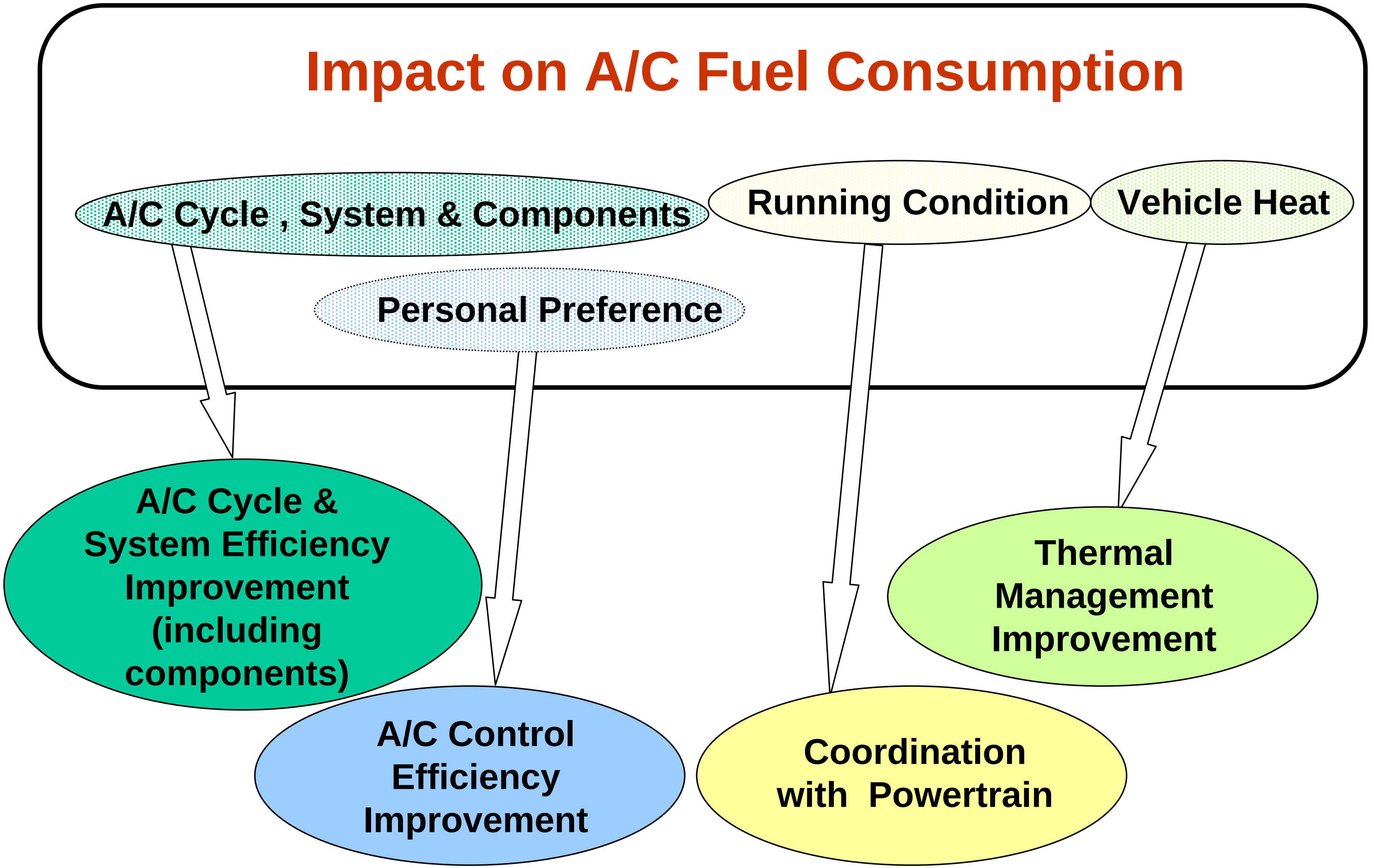
⇩

A/C Control Considering Running Condition

⇩

Coordination Control with Powertrain

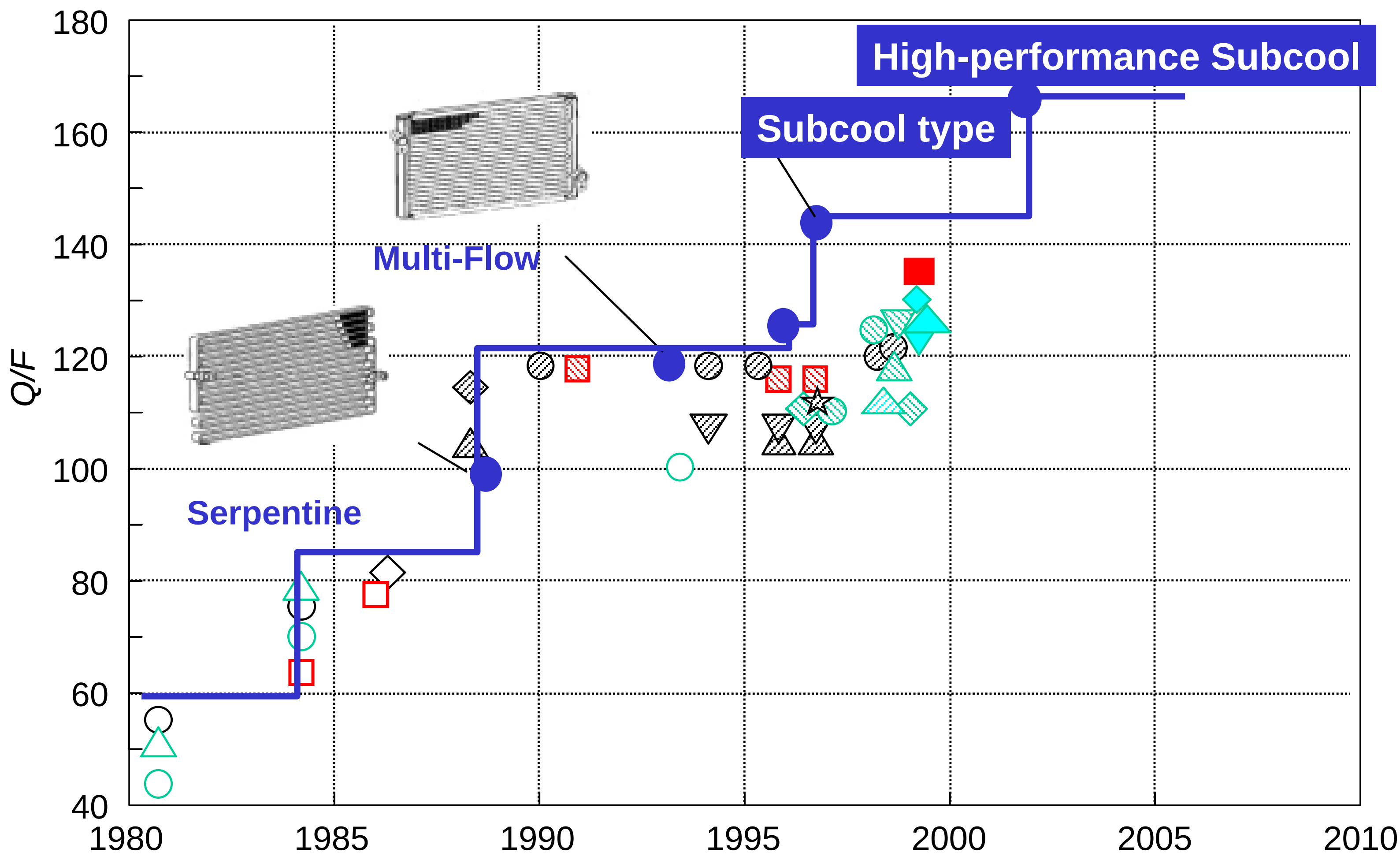
Approach to A/C Power Saving



- A/C Cycle & System Efficiency Improvement
  - ➢ Subcool Cycle & Improvement of Subcool condenser
  - ➢ Improvement of Compressor’s Efficiency & Variable Displacement Compressor System
- A/C Control improvement
- Coordination with Powertrain
- Vehicle Thermal Management Improvement

Condenser Efficiency Improvement

Q/F = Performance/(core width x core height)



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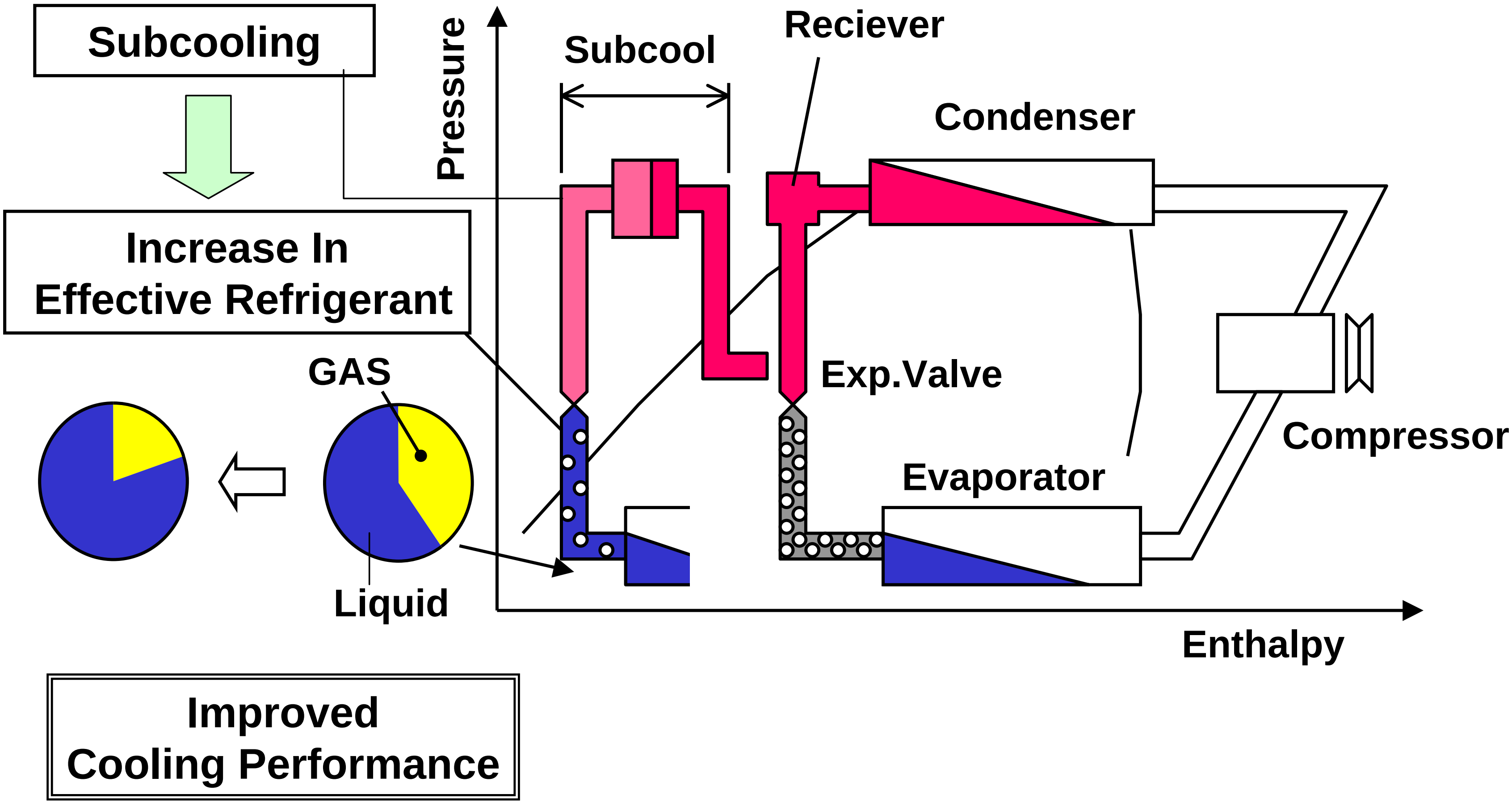
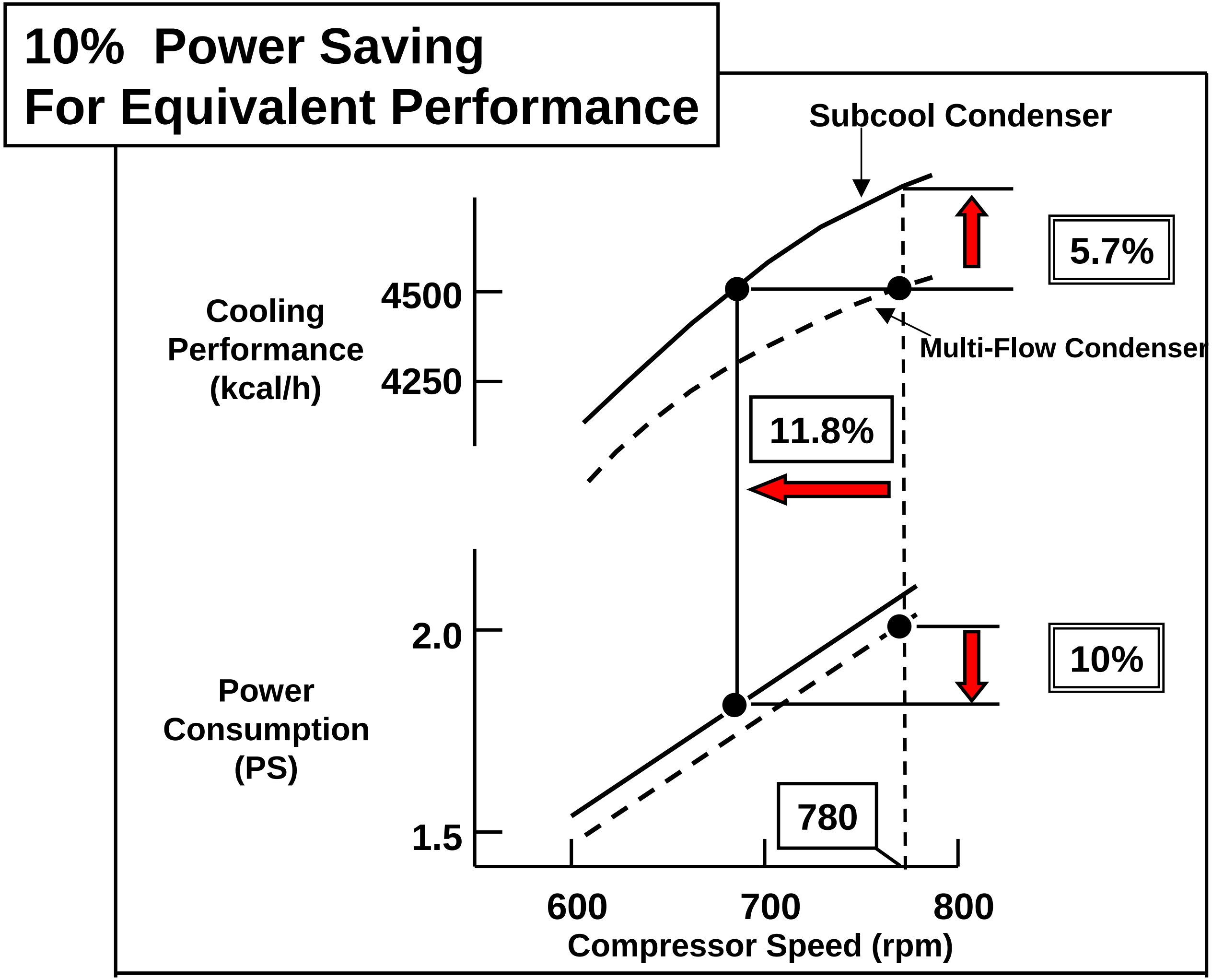
Operating Principle of Subcool Cycle

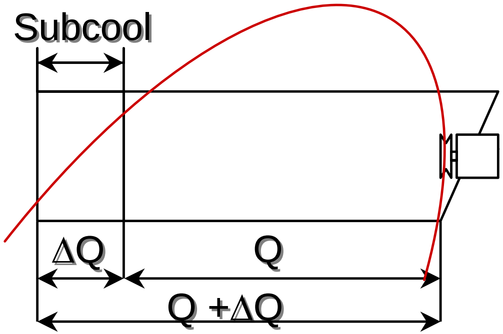


Effect of Subcool Condenser



Condenser Performance Improvement

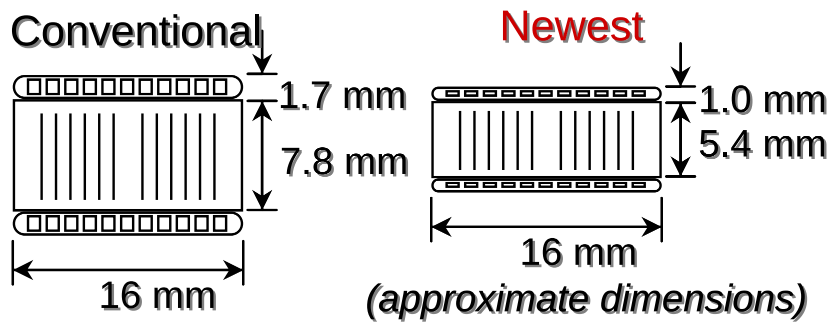
Mollier Diagram – Subcool Effect



Subcool Effect Gives ΔQ Extra Cooling

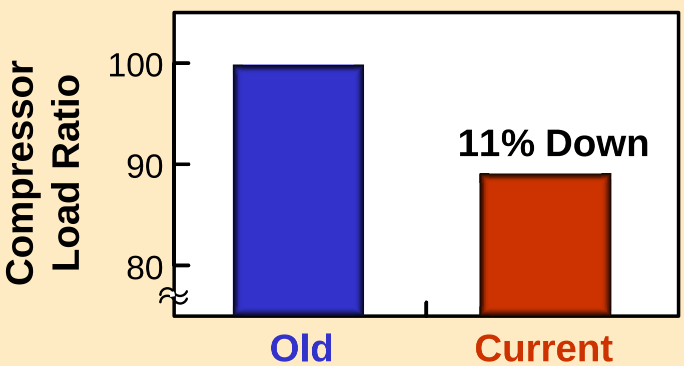
1. Enhance Heat Transfer

(Improved Tube & Fin Efficiency)

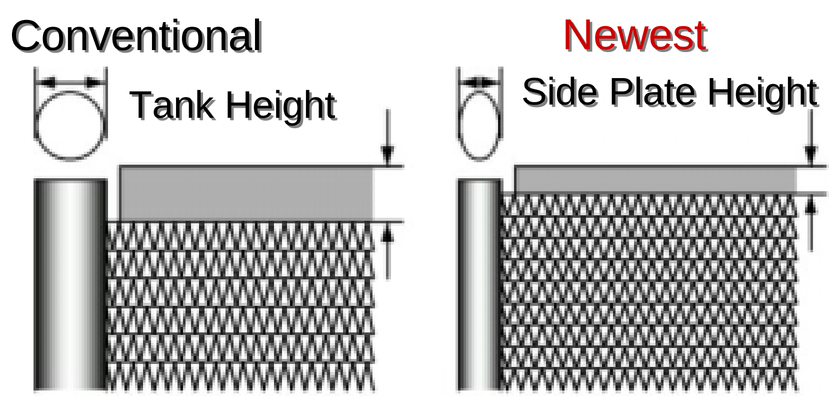


(approximate dimensions)

Effect



2. Increased Core Effective Area



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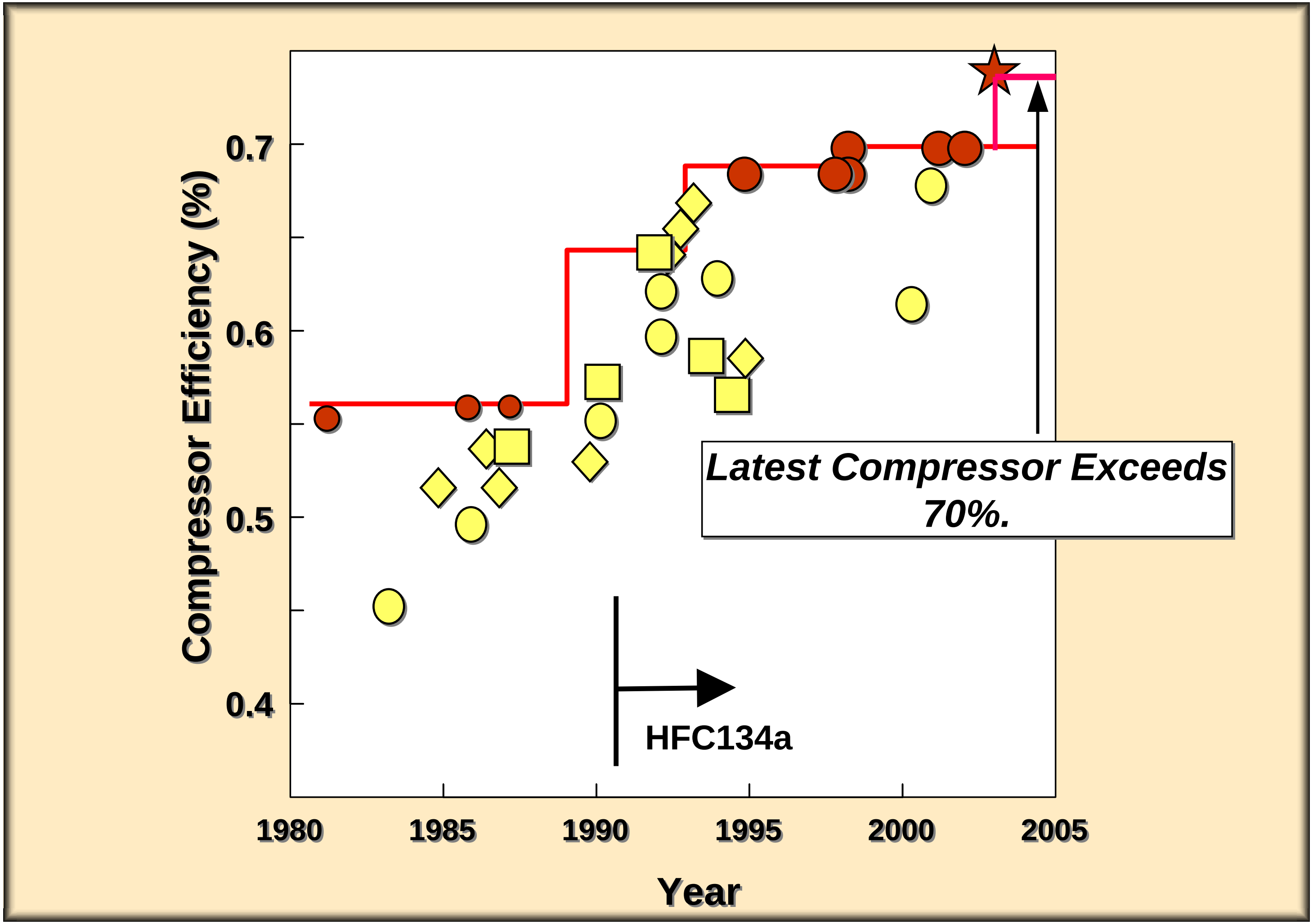
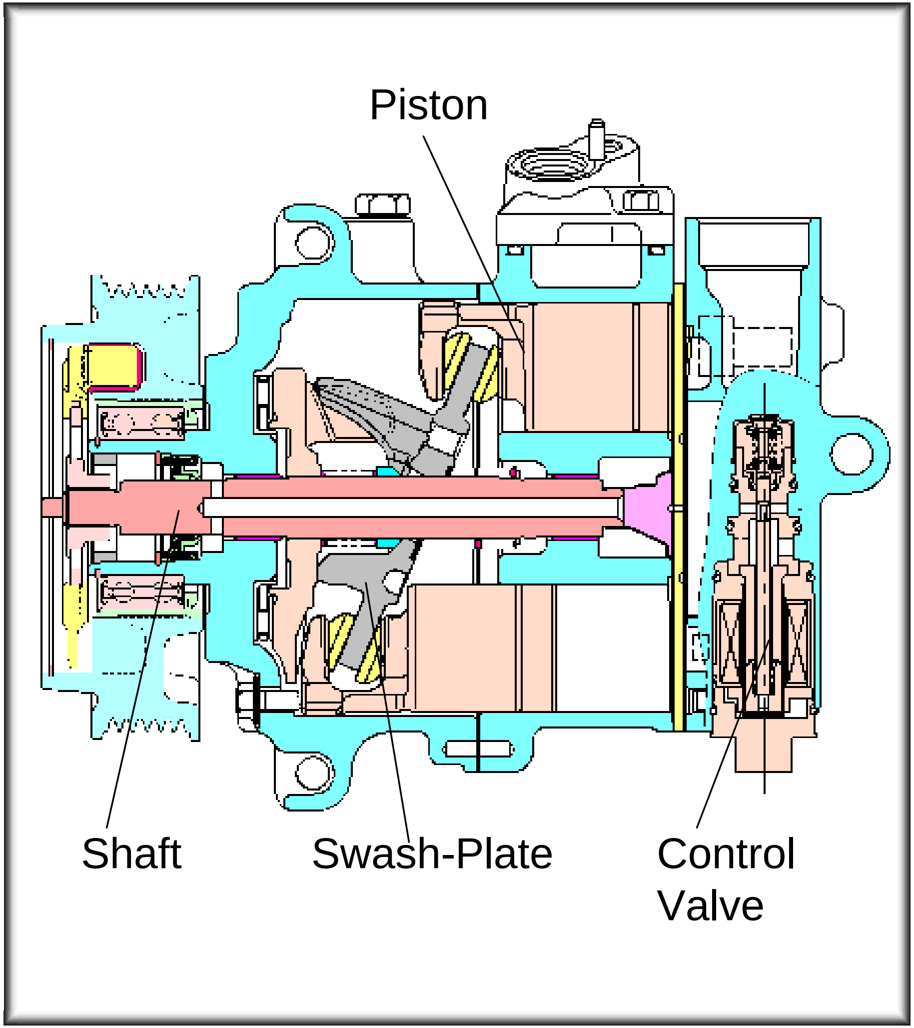
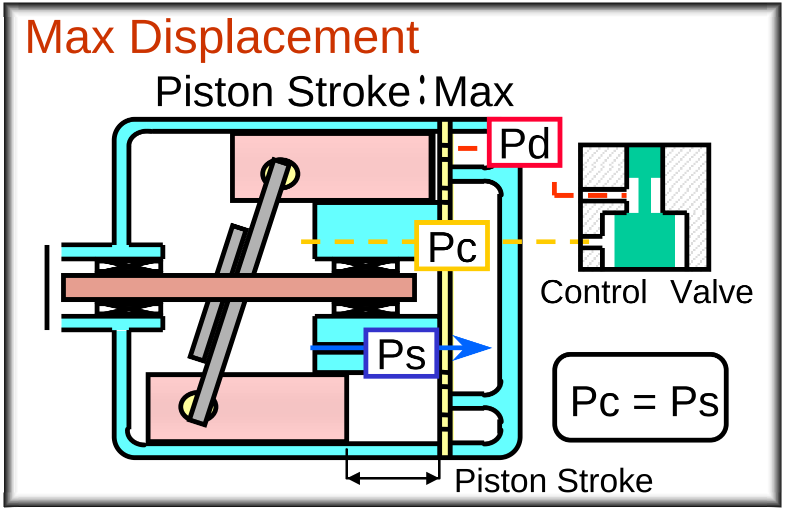
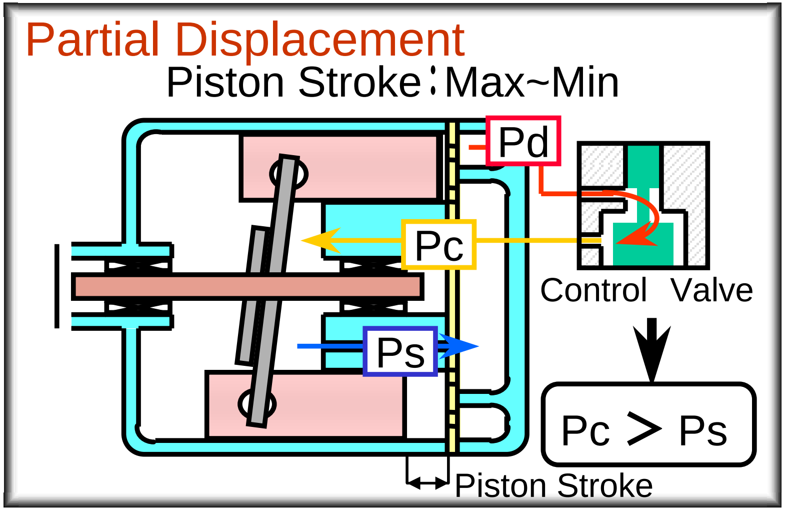
Compressor Efficiency Improvement



Continuously Variable Displacement Compressor







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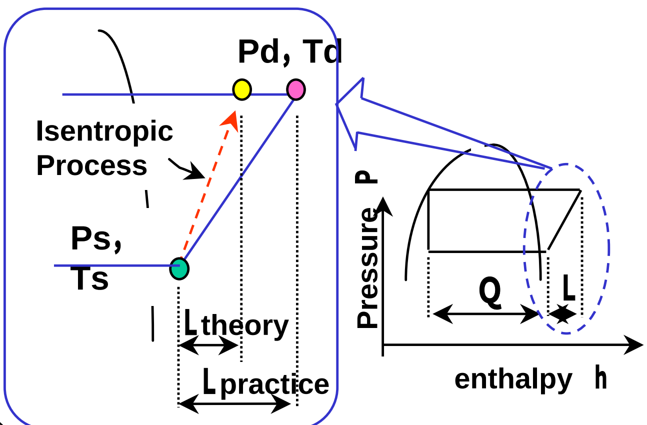
Characteristics of Variable Displacement Compressor

<Analysis Method>

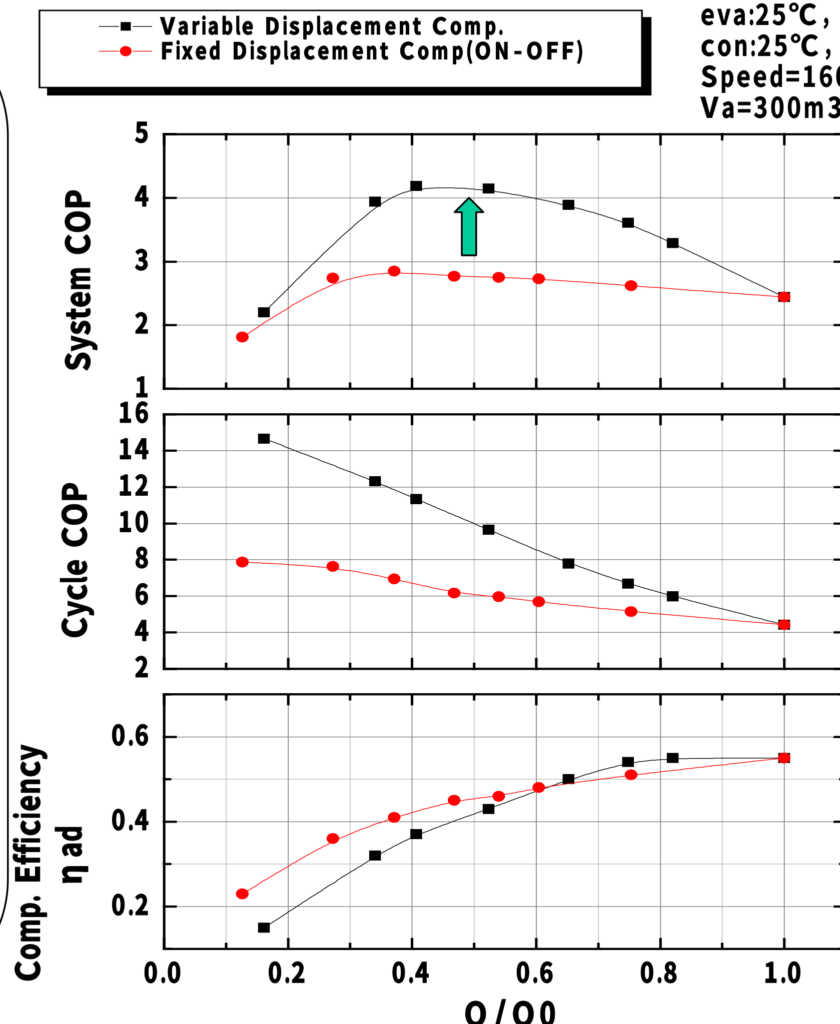
Divide into Compressor Efficiency and Cycle Performance

$$\frac{Q_{practice}}{L_{practice}} = \frac{L_{theory}}{L_{practice}} \times \frac{Q_{practice}}{L_{theory}}$$

System COP = Comp. efficiency η_{ad} × Cycle COP



<Condition>
eva:25℃, 50%
con:25℃, 2.5m/s
Speed=1600rpm
Va=300m3/h(M1)



<u>Variable Displacement Comp System is improved</u>.

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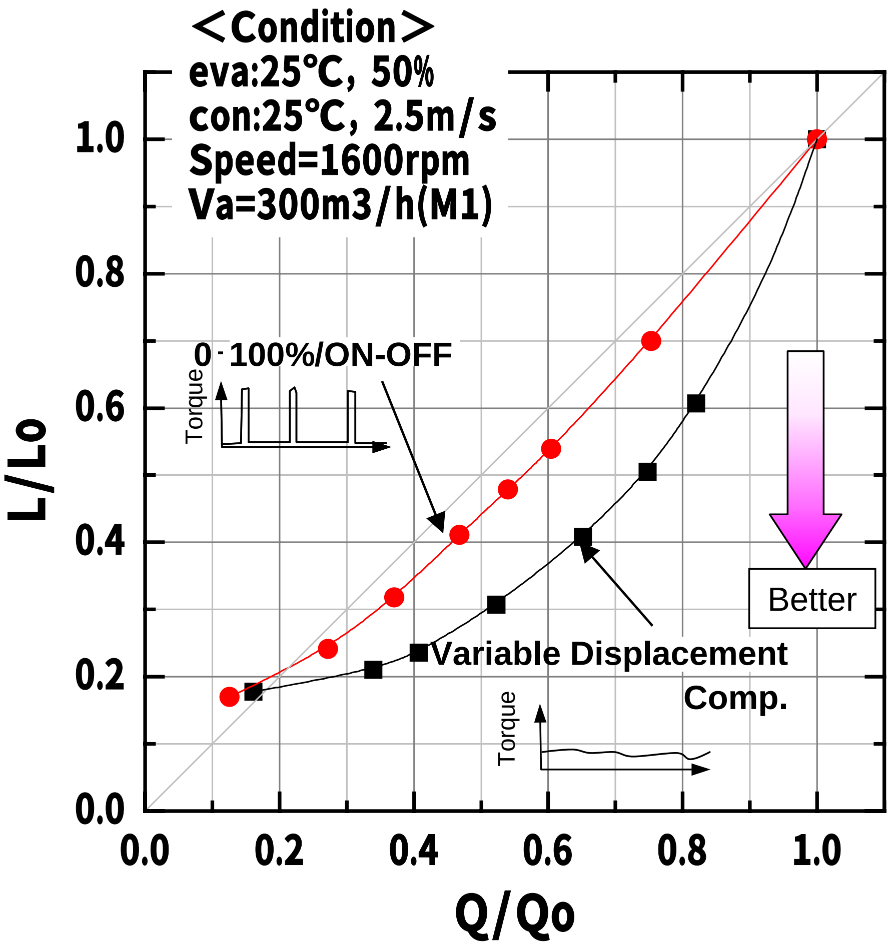
Effect of Variable Displacement Compressor System

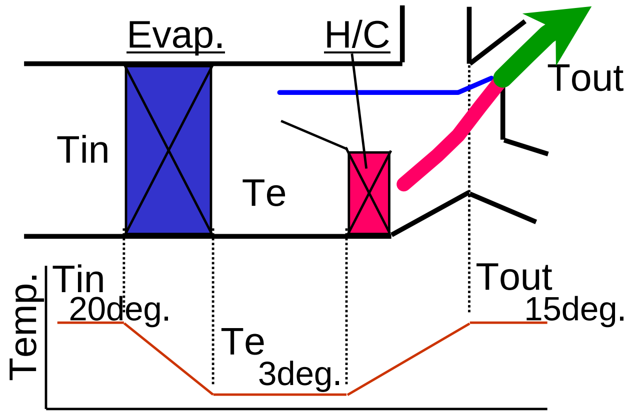


In the performance controlled region, the variable displacement compressor system shows a better performance than the fixed compressor system

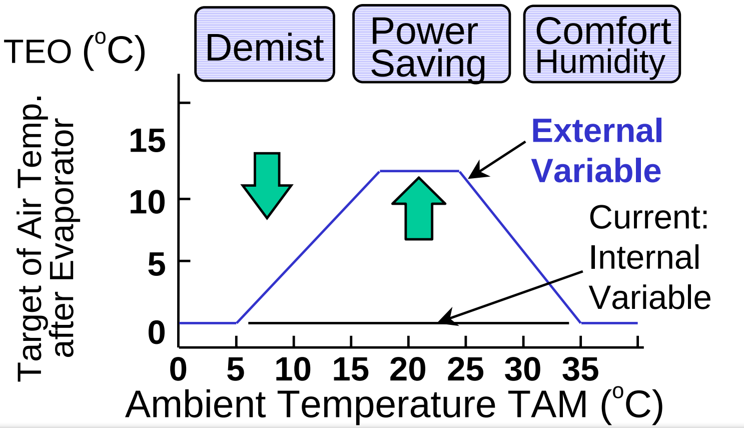
- A/C Cycle & System efficiency improvement
- **A/C Control improvement**
  - ➢ **Power saving control**
  - ➢ **Humidity control**
- Coordination with Powertrain
- Vehicle Thermal Management Improvement

Power saving Control using external variable compressor

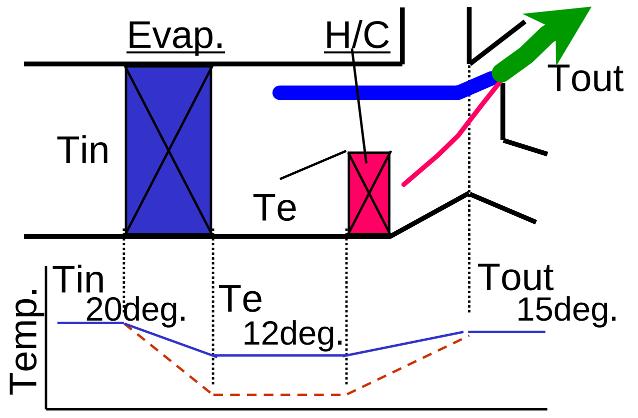
Conventional Control *(Internal Variable Compressor)*



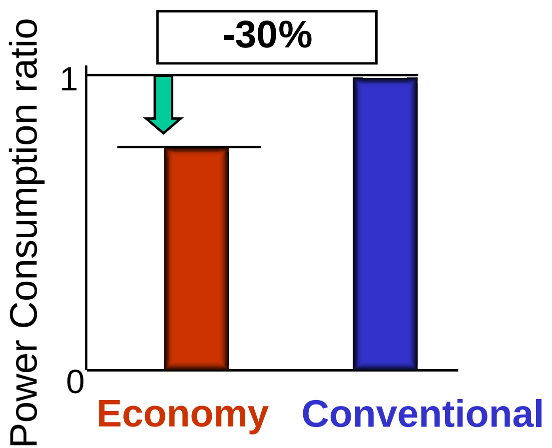
Economy Control Logic



Power saving Control *(External Variable Compressor)*



Effect



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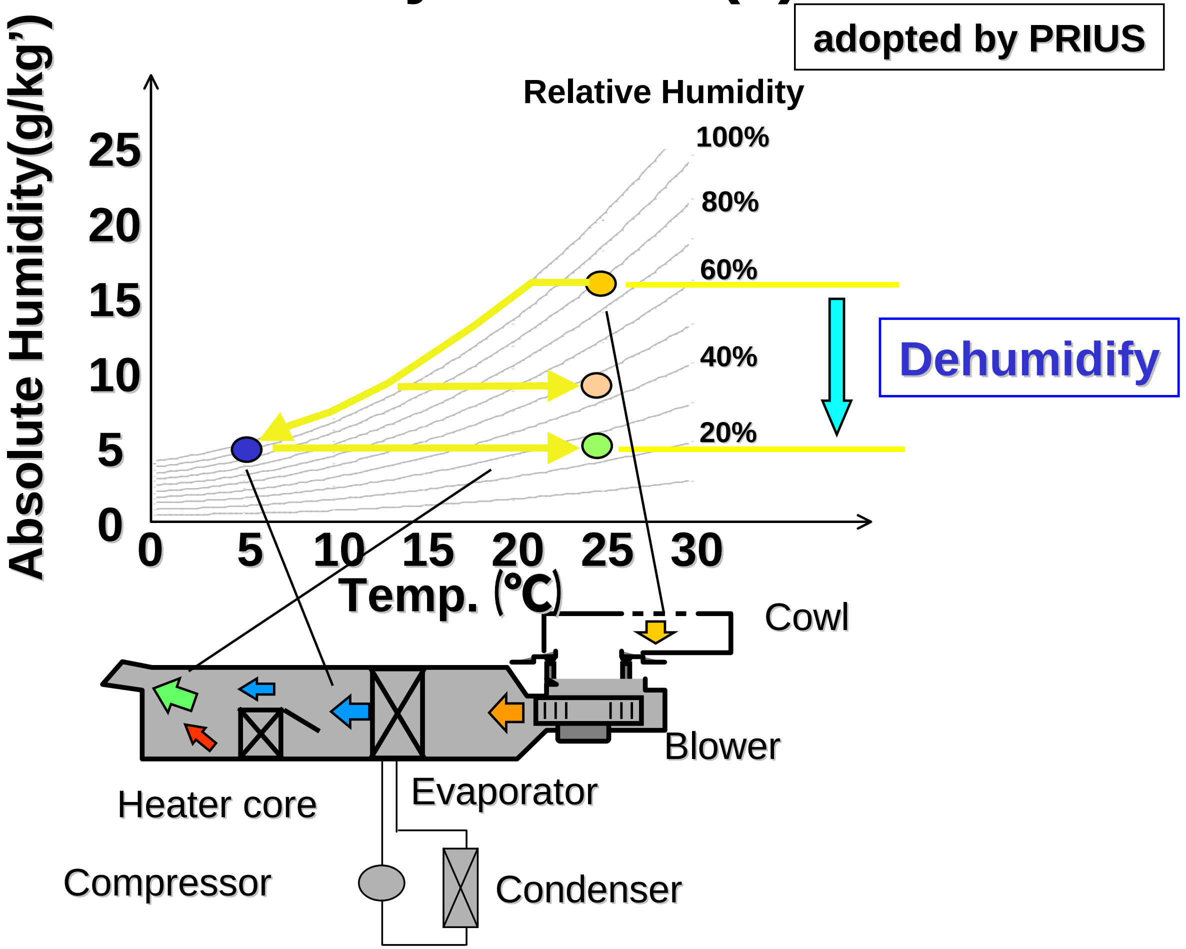
Humidity Control (1)



-Control the outlet air temp. & humidity by changing the evaporator temperature (TEO)

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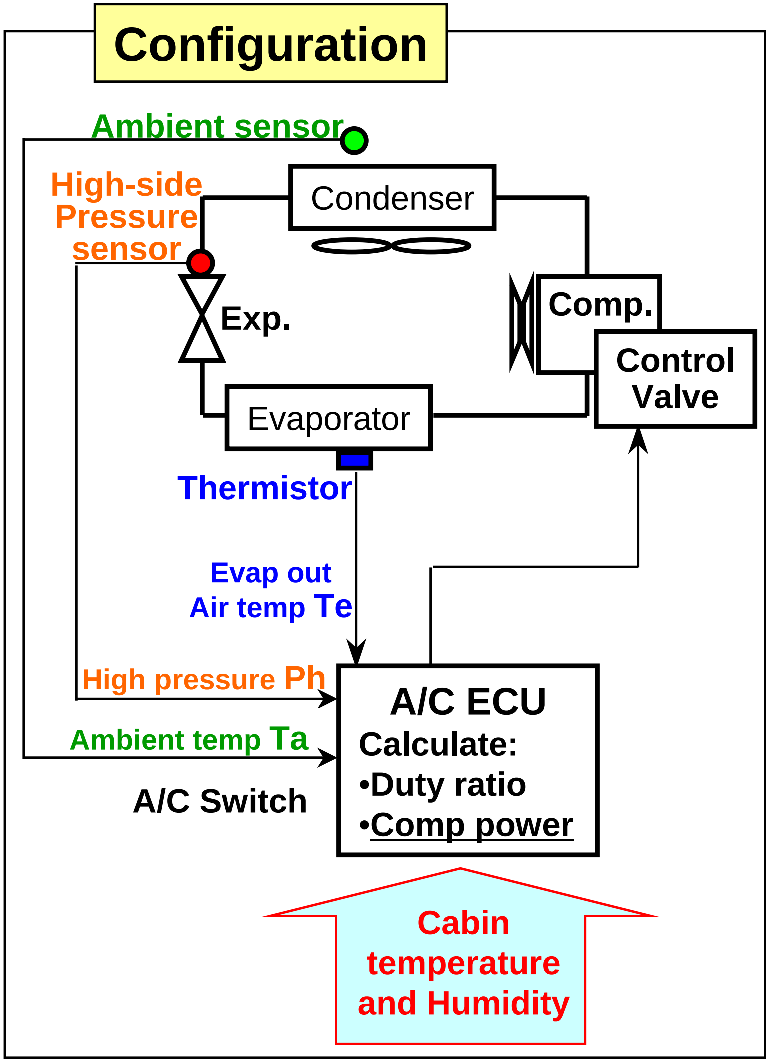
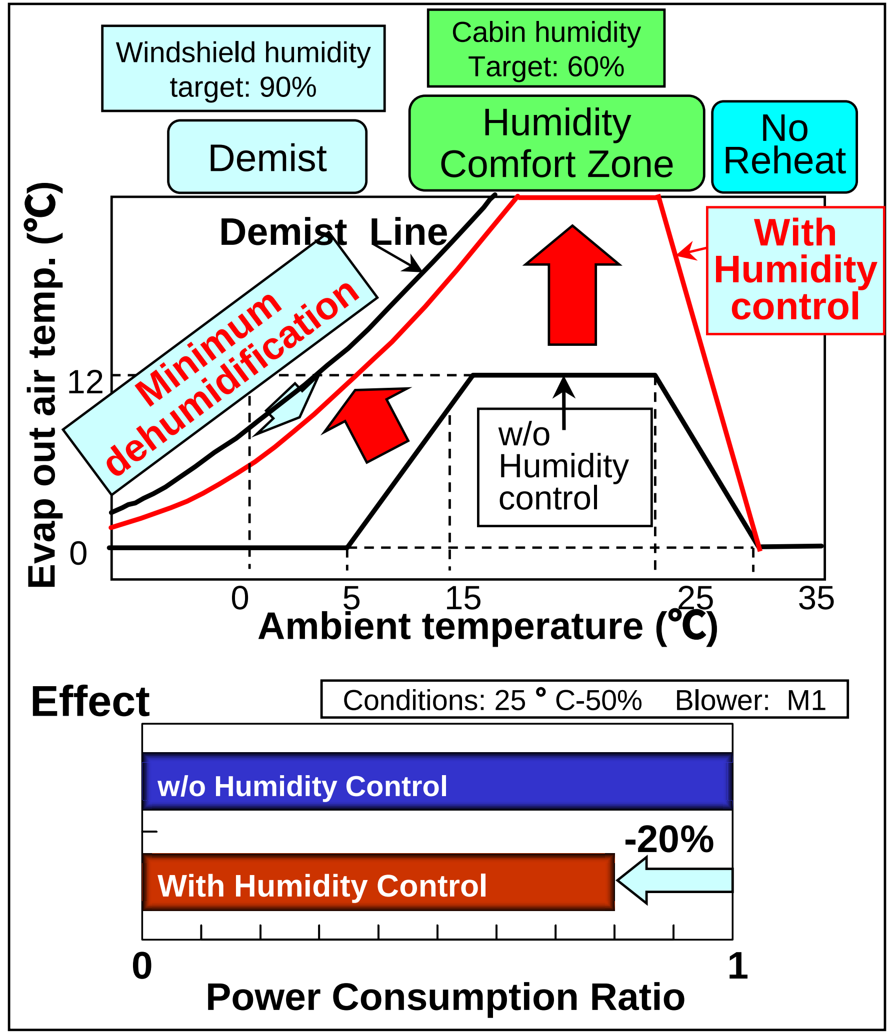
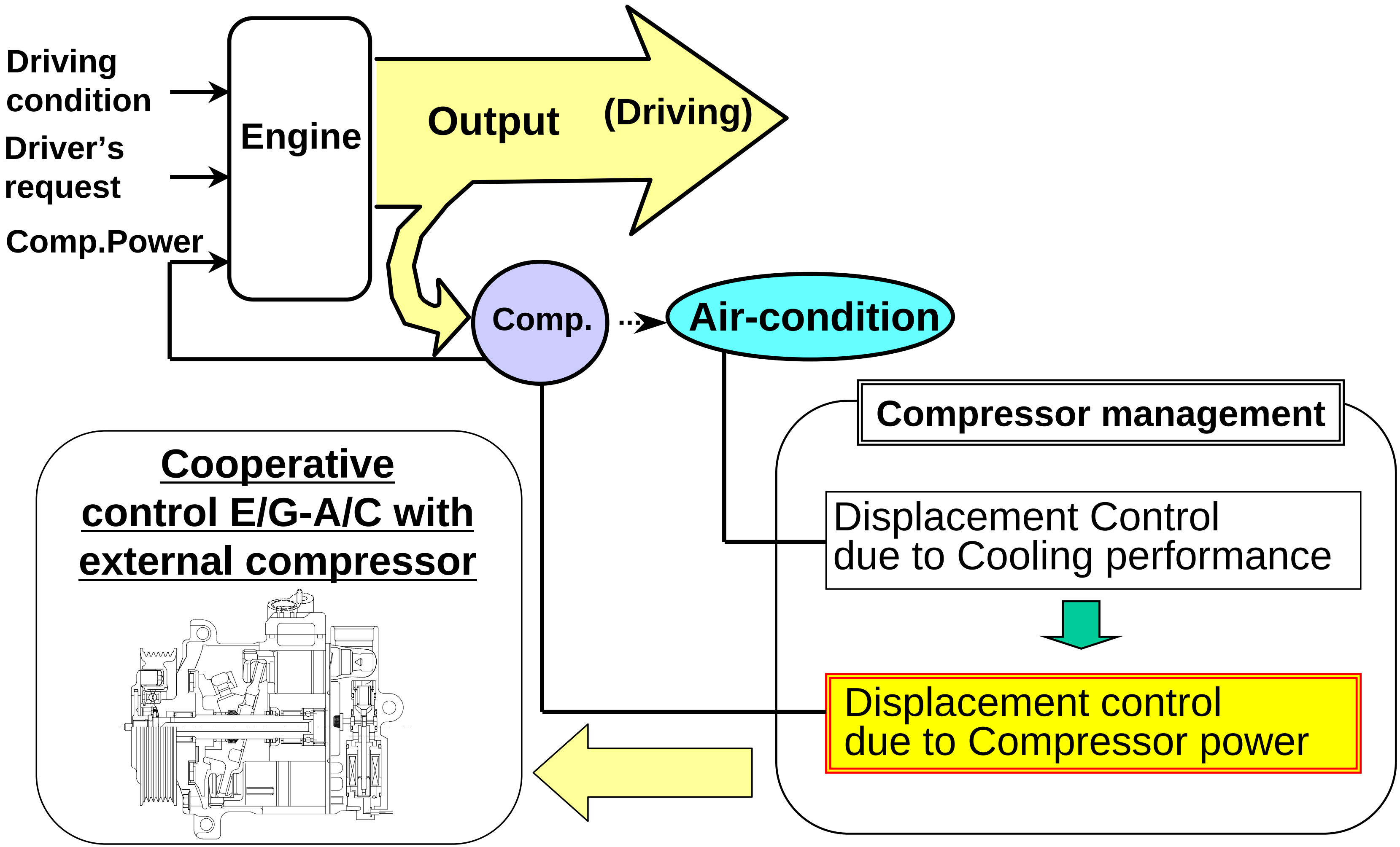
Humidity Control (2)



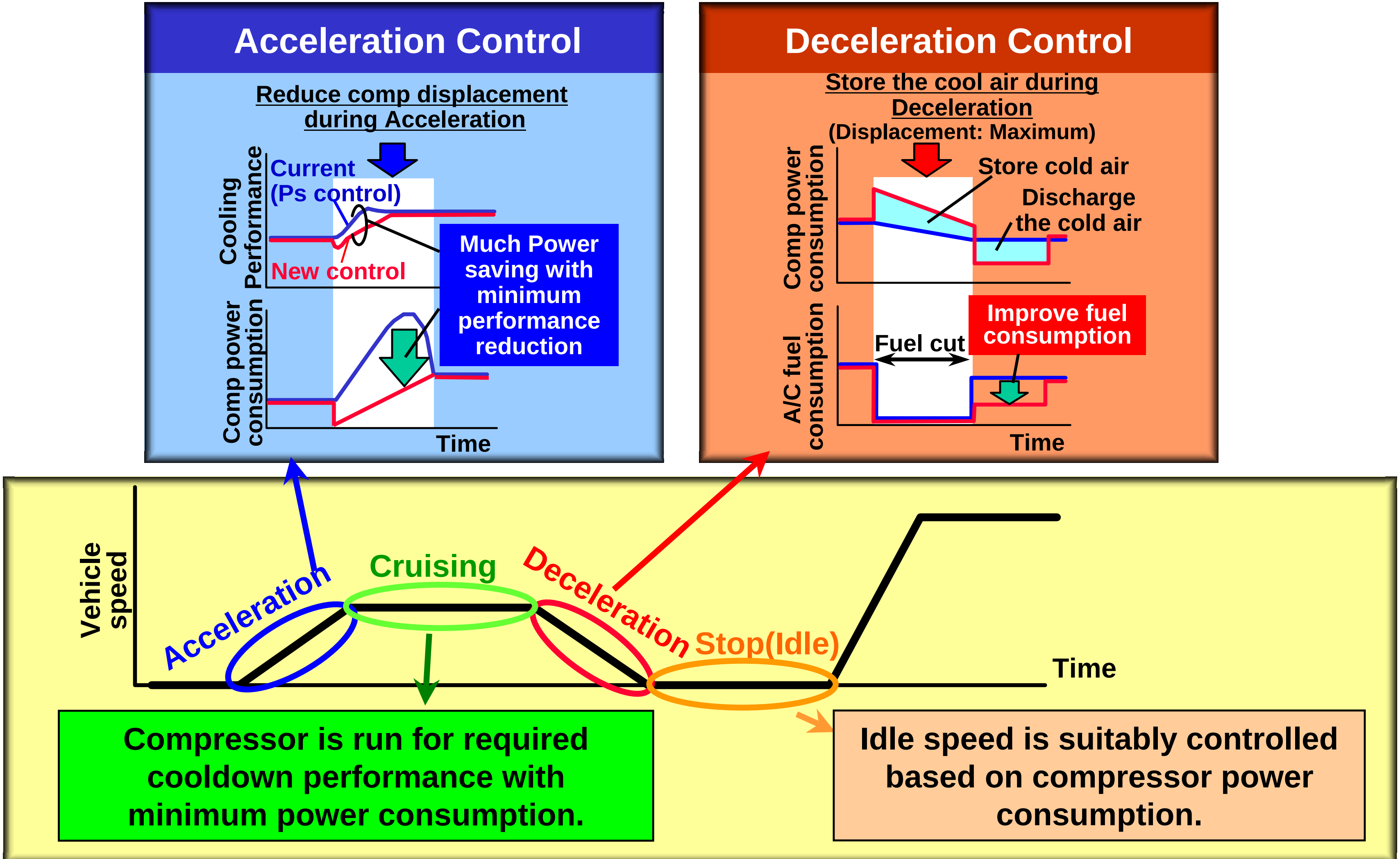


- A/C Cycle & System efficiency improvement
- A/C Control improvement
- **Coordination with Powertrain**
- Vehicle Thermal Management Improvement

Coordination with Powertrain Approach



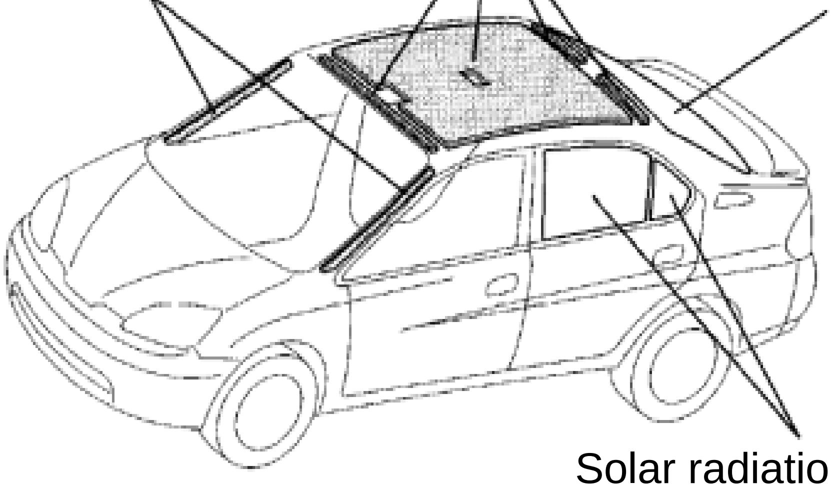
Control Pattern for Compressor Power Control



- A/C Cycle & System efficiency improvement
- A/C Control improvement
- Coordination with Powertrain
- **Vehicle Thermal Management Improvement**
  - **Reduction of Vehicle Heat**
  - **Prevention of Heated Air Re-entry into Condenser**

Vehicle Thermal Management Improvement

1. Reduction of Vehicle Heat Load

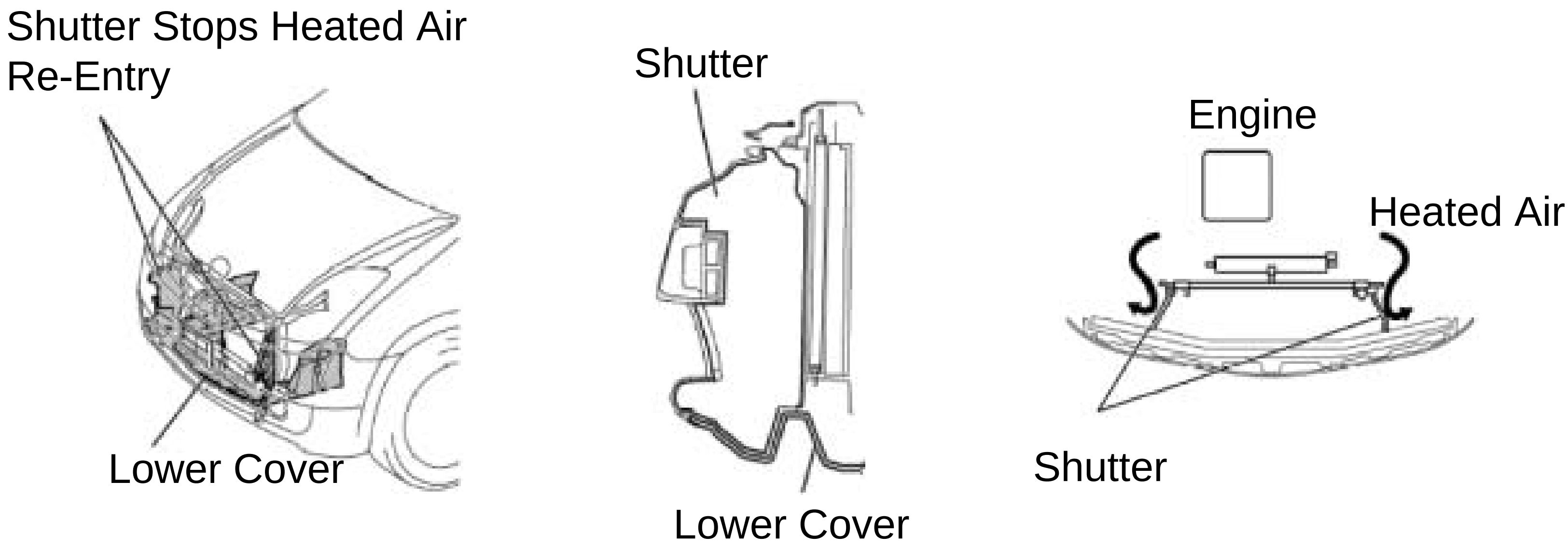


Effect

Item	Effect of Heat load reduction
Heat Insulation (Roof, Pillar)	- 6%
Solar Radiation Absorption Glass (Rear, Side)	- 3%

Vehicle Thermal Management Improvement

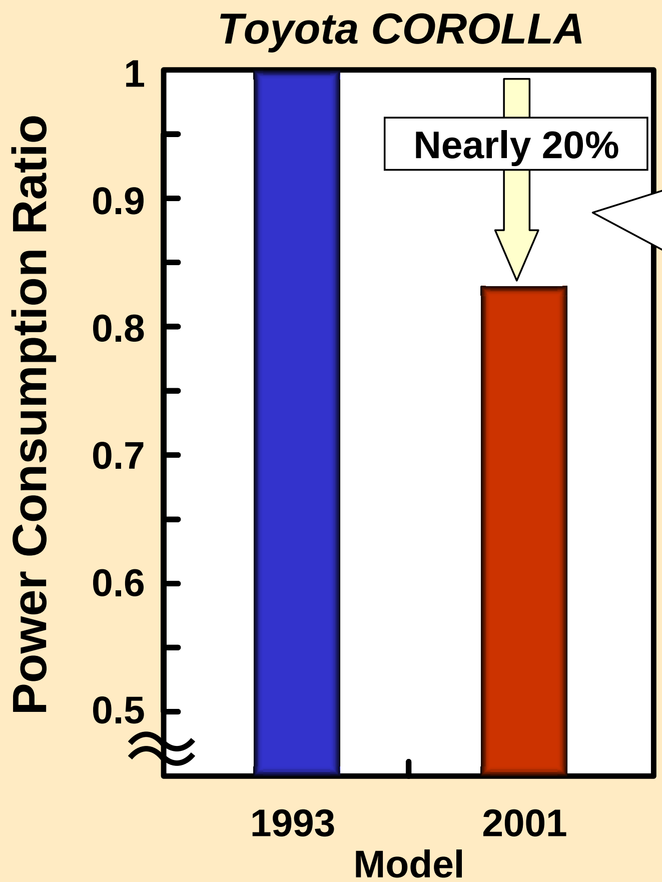
2. Prevention of Heated Air Re-entry into Condenser



Effect

Condenser Inlet Air Temperature Reduced by 6 ^{o}C

Example of Application to Vehicle



Subcool System

Serpentine Condenser

↓

Subcool Condenser

Compressor Improvement

$\eta ad = 0.62$

↓

$\eta ad = 0.68$

＊Power Consumption of Compressor After 30minutes at Idling

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Summary

◆Many A/C Power Saving Technologies Have Been Developed;

- A/C Cycle & System Efficiency Improvement
- A/C Control Efficiency Improvement
- Coordination With Powertrain
- Vehicle Thermal Management Improvement

◆Some Already Adopted in Mass-production Vehicles
Technologies Will Be Further Expanded in the Future.