

Pros and Cons of the Options

**Improved HFC-134a
HFC-152a
CO₂ (R-744)**

**Summary by
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HFC-134a

Pros

- Known and established technology
- Non-flammable
- Non-toxic
- Potential for improved energy efficiency has been demonstrated (SAE ARCRP)
- Potential for reduced direct refrigerant emissions

Cons

- High direct greenhouse effect
- Cost of recycling/recovery
- Cost of design improvements to reduce leakage
- Cost of refrigerant, including tax?
- Limited heat pump performance
- Compressor and line dimensions

HFC-152a

Pros

- Similar components/systems as HFC-134a (direct expansion), i.e. easy to introduce
- Potential for improved efficiency (direct expansion)
- Moderate/Low-GWP refrigerant
- Reduced refrigerant charge and emission rate

Cons

- Flammability – safety concerns
- Additional safety equipment needed
- Secondary circuit needed?
If so, cost, size, weight increases
- GWP = 120 (140)
- HF issues
- Would still require recycling/recovery (HFC fluid)?
- Training of personnel

CO₂ (R-744)

Pros

- GWP=1
- Non-HFC / Natural fluid
- Non-flammable
- Good heat pump performance
- More rapid pull-down
- Reduced size of compressor and lines
- Eliminated cost of recycling
- Potential cost savings in heating system
- Low refrigerant cost

Cons

- New system/component design
- Additional safety equipment needed
- High production cost
- Flexible lines still unresolved
- Internal heat exchanger needed
- Higher weight?
- Full efficiency potential needs to be demonstrated
- Leakage sensor to be developed
- Training of personnel

MAC Summit Preview

(Future costs uncertain, not including servicing and retooling)

Not including added/reduced cost for training, recycling/recovery, refrigerant charge, refrig. tax, inspections, integrated heating functions



AC System Choice	Reduced Direct Emissions	Reduced Indirect Emissions	Added Cost (Euros)
HFC-134a	Baseline	Baseline	Baseline
Enhanced 134a	50%	25%	20
HFC-152a	95%	0-10%	15
Future 152a	95+%	30+%	40
CO ₂	100%	<20%	40-180?
Future CO ₂	100%	30+%	?

Some key questions

- Cost of improving HFC-134a energy efficiency and reducing refrigerant emissions (Development, production, servicing, scrapping)?
- Older used cars with HFC-134a systems: Will leakage scenarios be valid?
- Increased use in "less developed" areas - What are the consequences?
- Irregular emissions – unknown and uncontrollable?

- Will car manufacturers use flammable refrigerants?
- Will HFC-152a be available as refrigerant?
- Implications of "mild flammability" of HFC-152a: Direct or indirect system?
- Extent of safety equipment needed for HFC-152a, and cost implications?

- Extent of safety equipment needed for CO₂, and cost implications?
- Additional production cost of CO₂ system – how much and under which assumptions? What about total cost picture?
- Can we ever reach a consensus on energy efficiency of CO₂ vs HFC-134a?

- Importance of heat pump function in future cars?