

Evaluation of Low-GWP Refrigerants for the AC Sector

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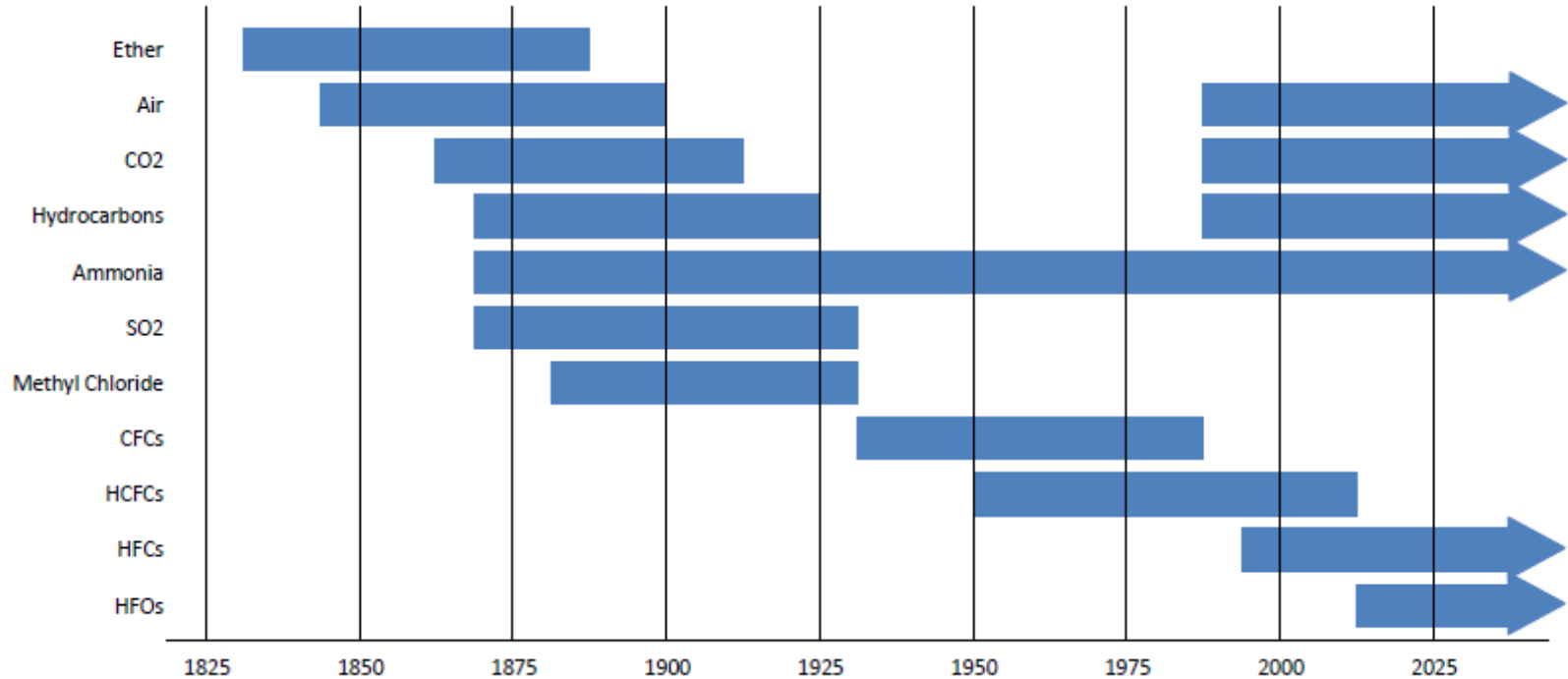
18 November 2017



Ideal Refrigerant

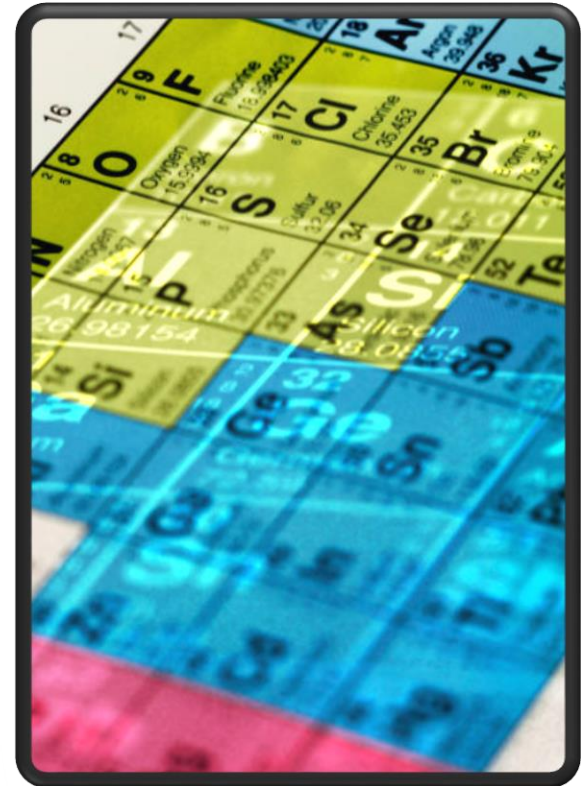
- Finding the ideal refrigerant is a never-ending challenge
- Characteristics of ideal refrigerant
 - Low cost
 - Nontoxic, nonflammable
 - Environmentally safe
 - Nonreactive
 - Thermodynamically efficient
 - Chemically stable
 - Compatible with a wide range of materials
- Refrigerant selection requires trade-offs

History of Refrigerants



Next Generation Refrigerants

- Hydrofluoro-olefins (HFOs)
 - Fluorinated propene isomers
 - R-1234yf ($\text{CF}_3\text{CF}=\text{CH}_2$)
 - R-1234ze ($\text{CF}_3\text{CH}=\text{CHF}$)
 - GWP ≈ 1
 - Mildly flammable
- Natural Refrigerants
 - What's old is new again?
 - CO_2 , hydrocarbons, ammonia
 - Very low global warming potential
 - Toxicity, flammability?



Refrigerant Options for Air Conditioning

Today	Future		
Refrigerant	Refrigerant	GWP	Safety Classification
R-22 GWP=1760 A1	444B	295	A2L
	449A	1282	A1
	454A	238	A2L
	454C	146	A2L
	457A	139	A2L
R-134a GWP=1924 A1	R-450A	547	A1
	R-451A	133	A2L
	R-451B	146	A2L
	R-513A	573	A1
	R-515A	403	A1
	R-1234yf	1	A2L
	R-1234ze(E)	1	A2L
R-410A GWP=1924 A1	R-32	677	A2L
	R-446A	461	A2L
	R-447A	572	A2L
	R-447B	714	A2L
	R-452B	676	A2L
	R-454B	467	A2L
	R-459A	461	A2L

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Few non-flammable options
Generally higher GWP
Acceptable in all equipment

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Numerous mildly flammable options
 Generally lower GWP
 Limited to smaller systems?

Refrigerant Options for Air Conditioning

- Hydrocarbon Options
 - Higher flammability
 - Suitable for small equipment

Refrigerant	GWP	Safety Classification
R-290 (propane)	3	A3
R-600a (isobutane)	3	A3
R-441A	3	A3

Evaluation of Alternative Refrigerants in Mini-Split and Rooftop AC Units

- Mini Split

- Capacity: 5.5 kW
- Refrigerant: R-410A
- EER: 12.0



- Rooftop AC

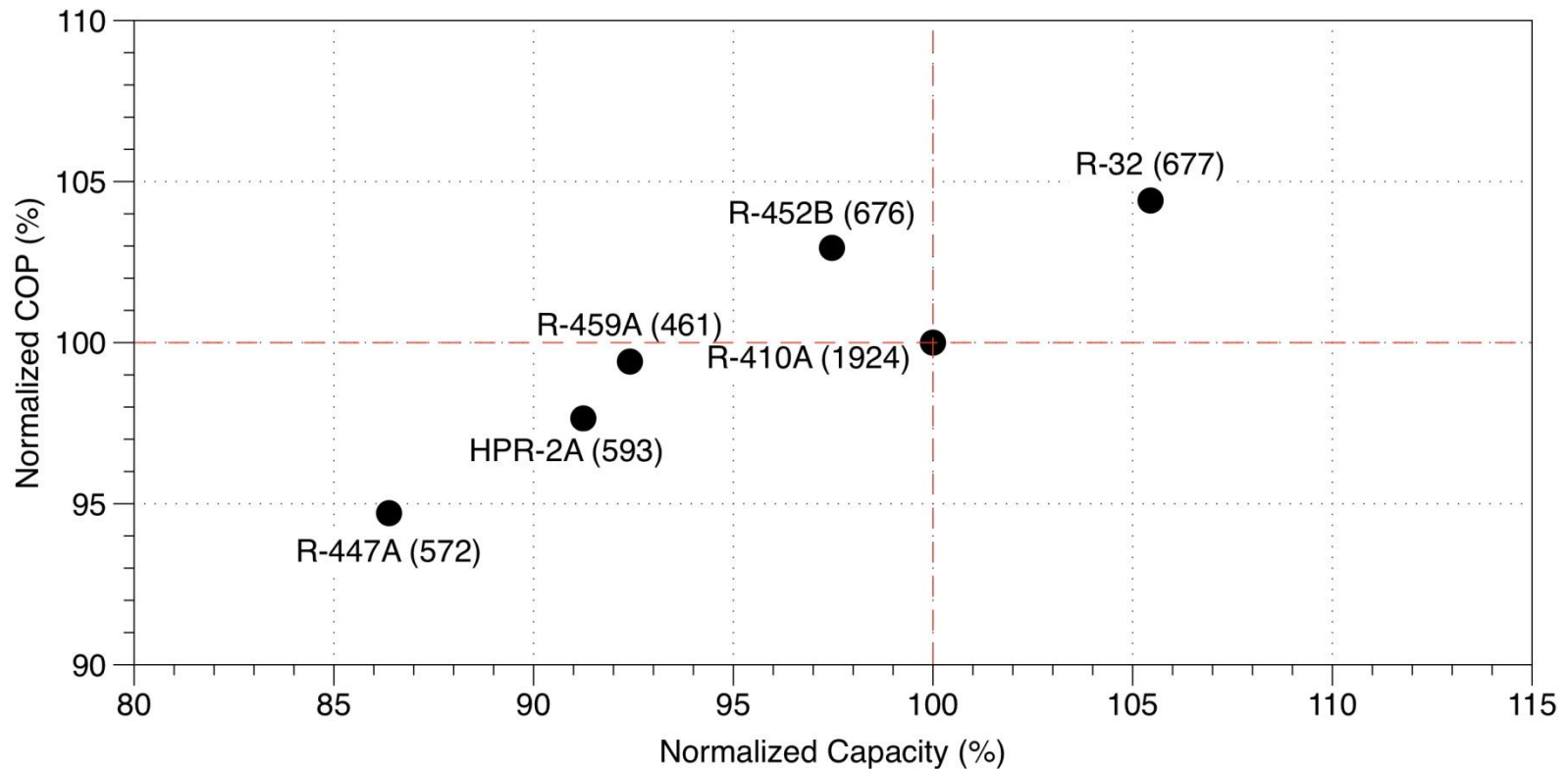
- Capacity: 38.7 kW
- Refrigerant: R-410A
- EER: 10.7



Mini-Split Evaluation: Alternatives for R-410A



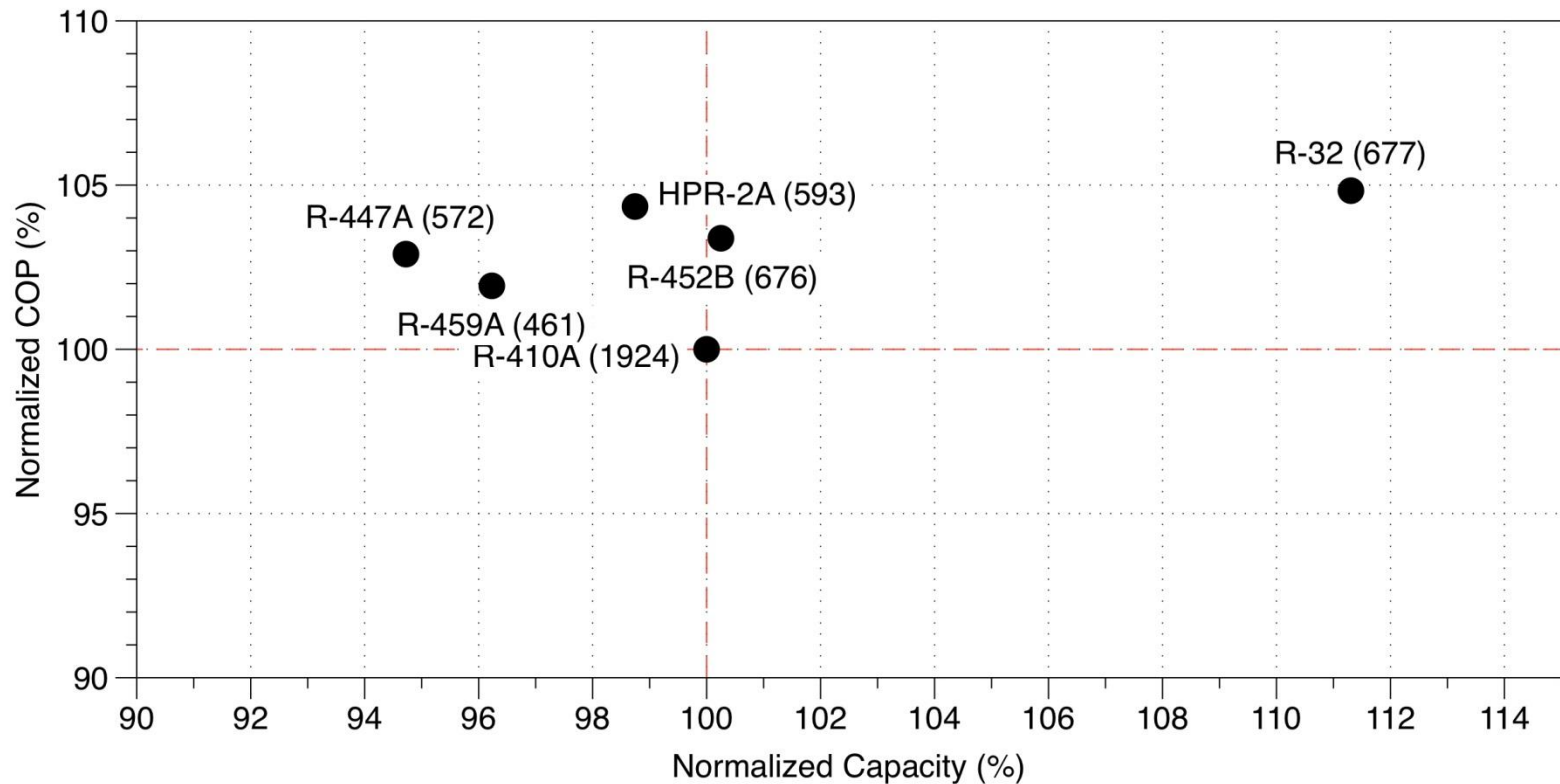
- AHRI Conditions: 35.0°C outdoor, 26.7°C indoor



Mini-Split Evaluation: Alternatives for R-410A



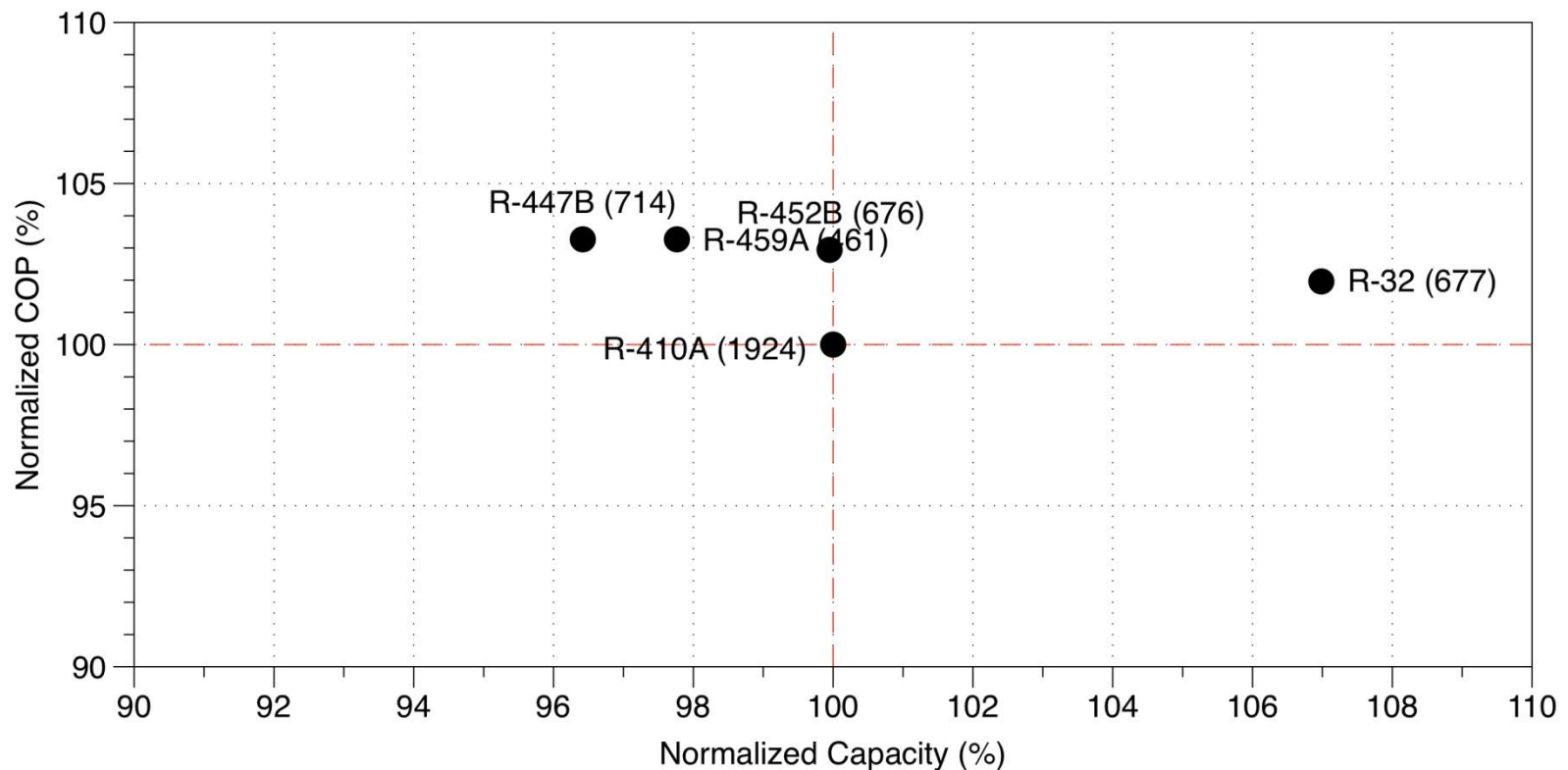
- Hot Ambient: 52.0°C outdoor, 28.9°C indoor



Rooftop AC Evaluation: Alternatives for R-410A



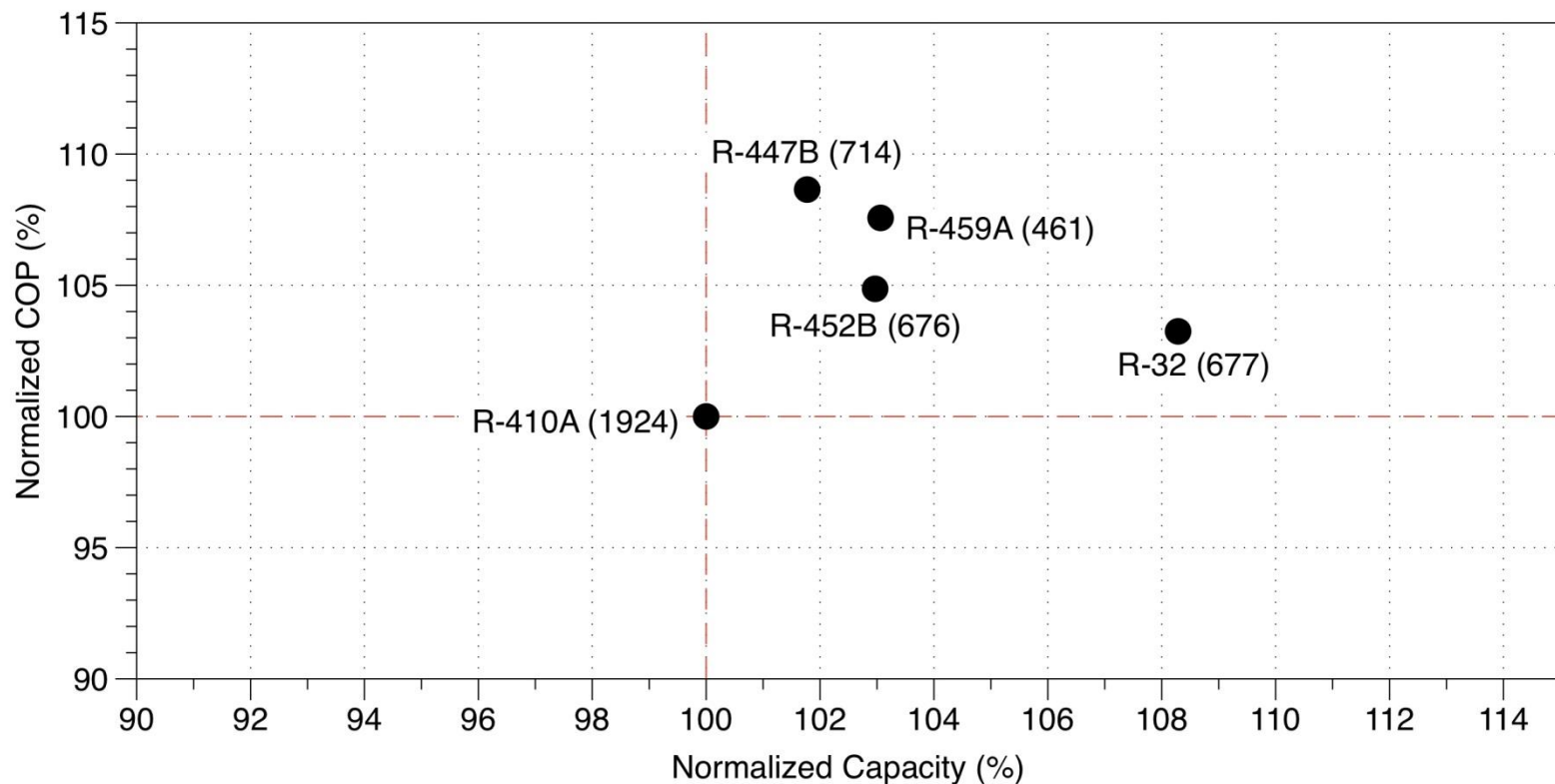
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Rooftop AC Evaluation: Alternatives for R-410A



- Hot Ambient: 52.0°C outdoor, 28.9°C indoor



Summary of Refrigerant Evaluations

- Many proposed HFO refrigerant blends perform similarly to current HFC refrigerants:
 - Comparable efficiency
 - Slightly lower capacity
- Many proposed HFO refrigerant blends show good performance at high ambient conditions
 - Slightly higher efficiency
 - Comparable or slightly higher capacity
- Flammability of many alternative refrigerants is an issue
 - Maximum safe refrigerant charge
 - Safe equipment design
 - Safe handling, servicing and transportation practices

Discussion

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