



Alternatives to HCFC/HFC refrigerants for high ambient temperatures

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Shecco side event 36th OEWG

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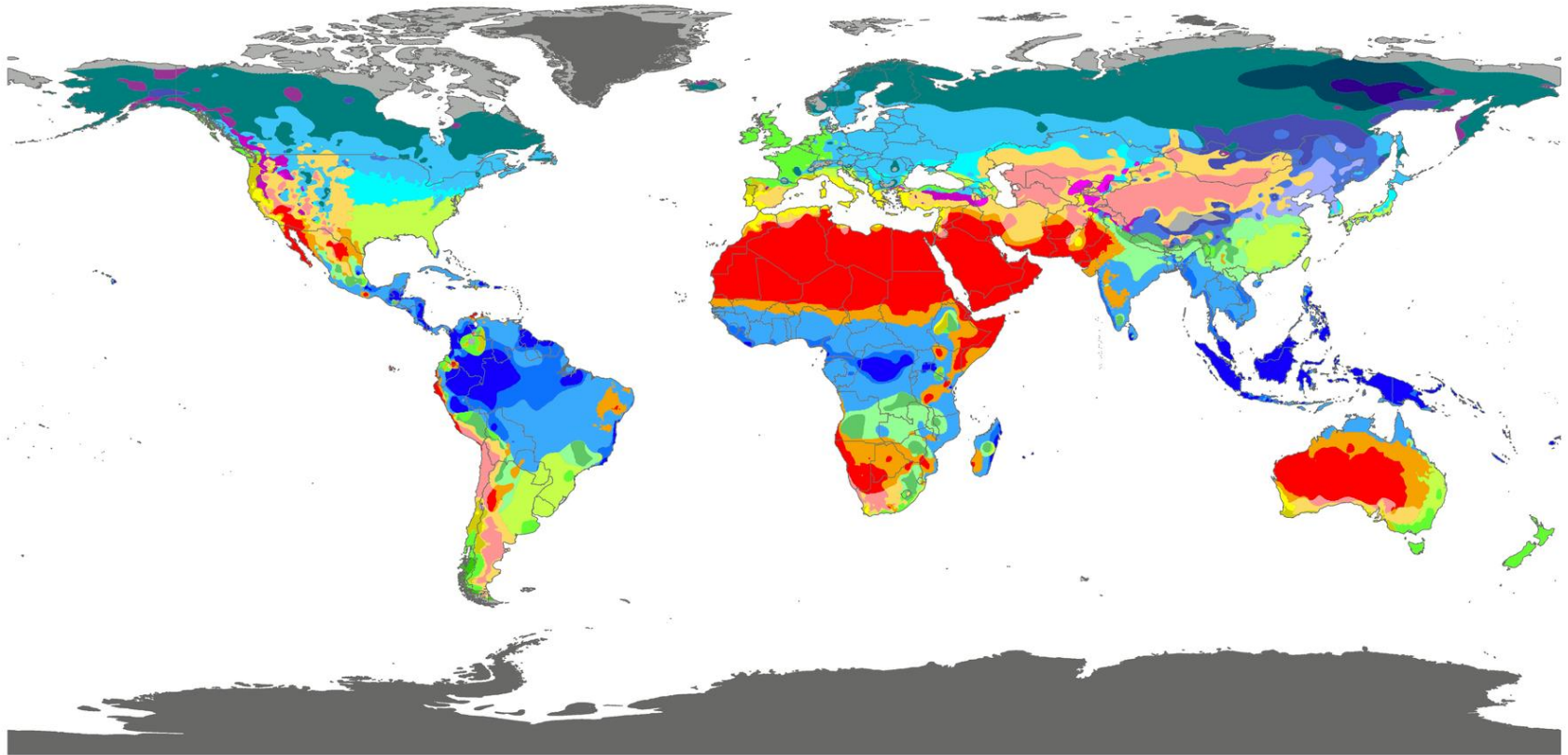
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Content

- High ambient temperatures
- Potential of natural refrigerants
- Close-up: unitary AC
- Next steps for A5 countries
- Key messages



High ambient temperatures...



[World Koppen Map.png](#): Peel, M. C., Finlayson, B. L., and McMahon, T. A. (University of Melbourne)

- High ambient temperature = average maximum daily temperatures of $>40^{\circ}\text{C}$
- Not a constant issue, mostly during summer months
- Red and orange areas can approximately be affected

...and why they are an issue

- **Key problem:** capacity and efficiency decline at higher ambient temperatures (HAT)
- Among others, efficiency hinges on **critical temperature** of refrigerant
- High/medium GWP HFC replacements for R22 have a much lower critical temperature -> **HAT leads to either a decrease in efficiency or increased equipment cost** (larger condenser, evaporator etc.)
- Efficiency of natural refrigerants at HAT is better without addt'l cost

	Critical Temperature	
	°C	~ to R22
R22	96.1	100%
High/medium GWP options		
R407C	86	89%
R410A	71.4	74%
R404A	72	75%
HFC-134a	101.1	105%
HFC-32	78.1	81%
Low GWP HFC options		
HFC-1234yf	94.7	99%
HFC-1234ze[E]	109.4	114%
Natural refrigerants		
HC-290	96.7	101%
HC-600a	134.7	140%
Ammonia (NH ₃)	132.4	138%
CO ₂	31.1	32%

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Results from our study

Equipment sector ↓	Alternatives →	HC	Ammonia	HFO	R32 R32/HFO
Domestic fridges		●	●	●	●
Commercial plug-ins		●	●	●	●
Condensing units	< 5kW	●	●	●	●
Condensing units	> 5kW	●	●	●	●
Centralised system supermarket		●	●	●	●
Large industrial refrigeration		●	●	●	●
AC plug-ins		●	●	●	●
AC Single split	< 7kW	●	●	●	●
AC Single/Multi split	> 7kW	●	●	●	●
AC cars		●	●	●	●
Displacement Chillers		●	●	●	●
Centrifugal Chillers		●	●	●	●

Source: Öko-Recherche et al., 2014

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Displacement Chillers		●	●	●	●
Centrifugal Chillers		●	●	●	●

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A closer look at unitary AC

- R22 as benchmark, not high-GWP HFCs
- Evaluated: Hydrocarbons, HFOs, R32 and potentially R32/HFO blends
- Requirement: Energy efficiency equal to R22 and at acceptable cost
- Constraints: Flammability -> charge limits set by standards and codes
- 100% R22 replacement possible in AC including 60% by natural refrigerants

	Common gas	Cons. A5 2015	R290	HFOs	R32	R32/HFO blends
GWP			3	< 10	675	200-400
AC Portable/Windows	R22	30 kt/y	●	●	●	●
AC Single split < 7kW	R22	90 kt/y	●	●	●	●
AC Single/Multi split > 7kW	R22	80 kt/y	●	●	●	●

●	Too low efficiency or too high cost compared to other alternatives
●	Efficient. Safe application. High refrigerant cost. No short term availability
●	High efficiency: No or acceptable additional cost. Short term availability

Efficiency vs. ambient temperature

R410A and R32:

- Lower efficiency -> either increased operating or technical cost
- No/low climate benefit

R290:

- No additional technical cost
- Equal energy efficiency
- Large scale CO₂-eq savings
- Lower discharge temperature -> more reliable even than R22

COPs	Condensing temperature °C		
	35°C	60°C	65°C
R22	5.08	2.64	2.29
R290	5.09	2.58	2.23
R32	4.85	2.43	2.09
R410A	4.80	2.32	1.95

Source: Lambert Kuijpers, Roberto Peixoto: XIX/8 Report on HCFC Alternatives for High Ambient Temperature Regions, Presentation at OEWG-30, Geneva, 15-18 June 2010.

Next steps for A5 countries

- Projected growth in demand for RAC is high in A5 and energy efficiency is a concern
- Currently low adoption of high GWP HFCs -> chance for leapfrogging
- Natural refrigerants already present in smaller units (domestic, stand-alone commercial, portable AC)
- Build-up of manufacturing base for R290 ACs in China and India
- Conversion to natural refrigerants should play more central role for funding the transfer of technology



Key findings

Overall:

- HAT decreases efficiency of all refrigerants including R22 in any application
- Natural refrigerants can replace 55% of HCFC demand in A5 incl. at HAT
- Natural refrigerants already play a significant role in domestic, commercial and portable AC subsectors

Unitary AC:

- R290 is efficient at HAT, compatible with R22 unit design and can operate at HAT without additional technical cost
- R410A and R32 require redesign and thus higher cost without CO₂-eq savings

Cost of safe manufacture and operation for R290 lower than for efficiency improvements of HFC technology!

Thank you for your attention!

Questions...???

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More information:

Alternatives under HAT:

http://ec.europa.eu/clima/policies/f-gas/legislation/docs/alternatives_high_gwp_en.pdf

Our other studies:

<http://oekorecherche.de/en/publications/fluorinated-greenhouse-gases-and-alternatives>



Efficiency vs. ambient temperature

