Öko-Recherche
Büro für Umweltforschung und- beratung GmbH

Alternatives to HCFC/HFC refrigerants for high ambient temperatures

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Shecco side event 36th OEWG

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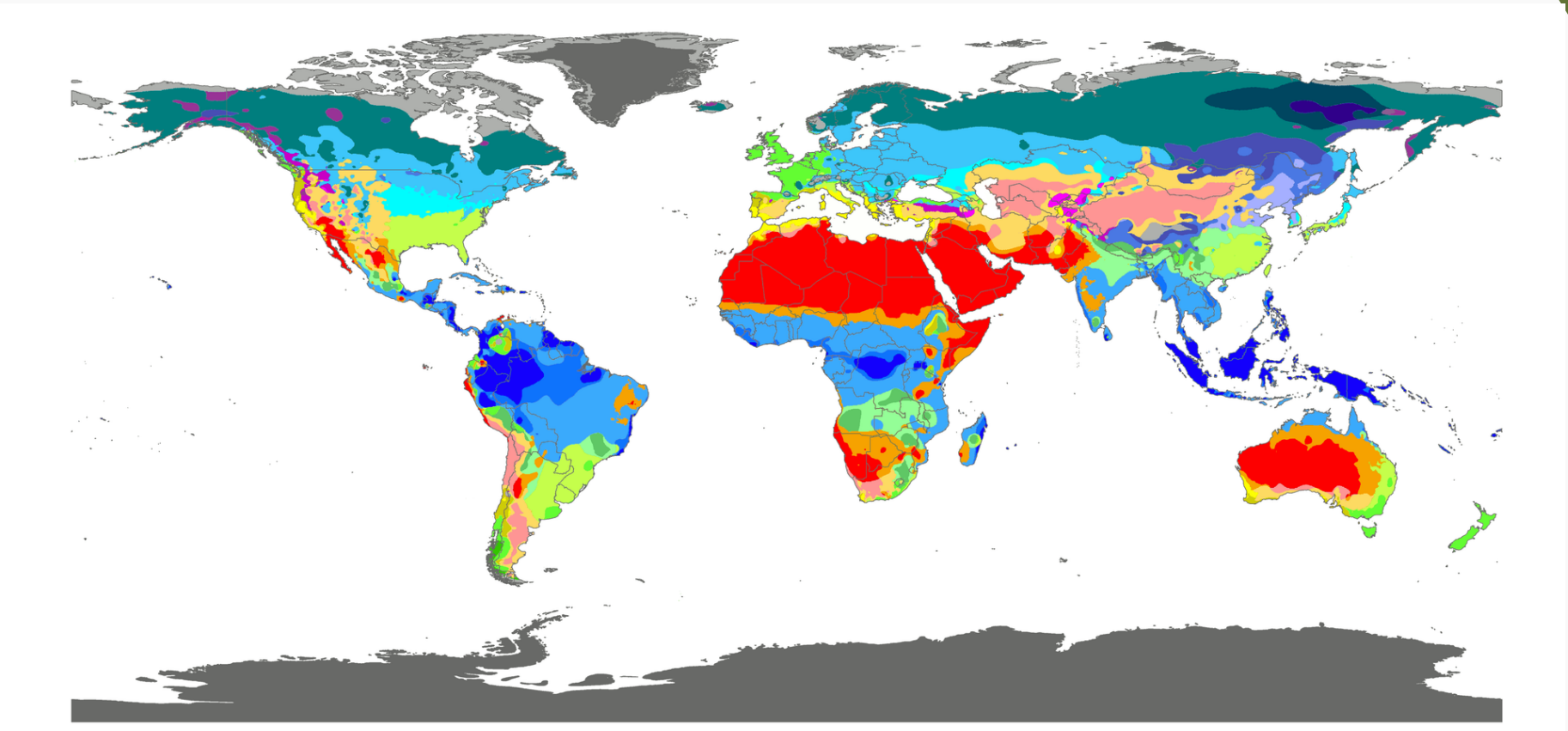
UNESCO Building

Content

- High ambient temperatures
- Potential of natural refrigerants
- Case: 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: mean max daily temps of >40°C
- 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
HCFC-22	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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Source: Öko-Recherche et al., 2014

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
- 100% replacement possible in AC and 90% in all sectors

	Common gas	Cons. A5 2015	HC	HFO	R32	R32/HFO
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	🔴	🔴	🔴	🟢

🔴 Efficiency too low or cost too high compared to other alternatives
🟡 Efficient. Safe. But costly and no short term availability
🟢 Efficiency high. No or acceptable additional cost. Short term availability

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 messages

Overall:

- HAT decreases efficiency of all refrigerants
- Natural refrigerants can overall replace 55% of HCFC demand in A5 countries in the short and medium term including at HAT

Unitary AC:

- R290 is efficient at HAT, compatible with R22 unit design and can operate at HAT without additional cost
- Although less efficient R32 is a transitional option for multisplits but jeopardizes CO_2-eq savings
- Reliability of R290 technology higher than for R32

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