

Large AC units using a variety of low-GWP options

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The Workshop on Management of HFCs: Technical Issues

Bangkok, Thailand, 20 and 21 April 2015.

Alternatives to currently used HFC refrigerants with low GWP (air to air)

Refrigerant	GWP		Comments
HFC-32	675		HFC-32 has been used for small split systems in Japan since 2012 and in Europe since 2013. It is also suitable for multi-splits, VRF and ducted systems subject to compliance with refrigerant charge restrictions in safety regulations.
R-446 A R-447 A	460 582		Newly developed blends with properties similar to R-410A. These are a possible alternative for multi-splits, VRF and ducted systems subject to compliance with refrigerant charge restrictions in safety regulations.
R-450A R-513A R-451A R-451B	601 631 140 150		Newly developed blends with properties similar to HFC-134a. The non-flammable options are possible alternatives for ducted and packaged roof top units. The lower flammability options may also be suitable for these applications subject to compliance with refrigerant charge restrictions in safety regulations. These options are not considered suitable for multi-split and VRF systems, due to a negative impact on capital cost and efficiency.
HFO-1234yf HFO-1234ze	4 7		These HFOs also have properties similar to HFC-134a and could be considered for ducted and roof top units subject to compliance with refrigerant charge restrictions in safety regulations
R-744	1		R-744 can be used for larger air conditioning typically in ducted type systems. Efficiency is only acceptable in cool weather conditions.

Application

- For **split systems and VRF systems**, R-410A is currently the only non-flammable option. The use of a non-flammable alternative to HFC-134a is not an option for these sub-sectors as it would lead to increased capital cost and reduced efficiency.
- For **ducted and rooftop packaged units** HFC-134a is sometimes used, so one of the lower flammability alternatives with a GWP around 600 may be considered. In some circumstances (depending on system design and compliance with safety regulations) a lower flammability blend with a GWP around 150 or an HFO with a GWP of 1 could also be considered

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Safety and practicality

- **HCs:** Cannot be used as the refrigerant charges are too high.
- **HFC-32, R-446A and R447A:** These have lower flammability and may be safe to use in multi-splits, VRF and ducted systems. Refrigerant charges in the 15 to 60 kg region may be acceptable.
- For ducted systems it may be possible to use R-450A and R-513A.

Commercial availability

- Some larger splits using HFC-32 have already been sold in Japan.
- R-446A and R-447A units are being considered.

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- **Cost**

HFC-32 systems are cost competitive with R-410A equivalents for smaller systems. The higher cost of the HFO / HFC blends may have some impact due to the larger charges of multi-split, VRF and ducted systems. In order to satisfy the safety requirements of these much larger systems, there could be incremental costs for additional safety features, such as gas detectors, ventilation and shut off valves.

- **Energy efficiency**

HFC-32 systems can achieve better energy efficiency than R-410A equivalents.

Efficiency is not yet known for R-446A and R-447A but these are expected to have equal or better

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Applicability in high ambient

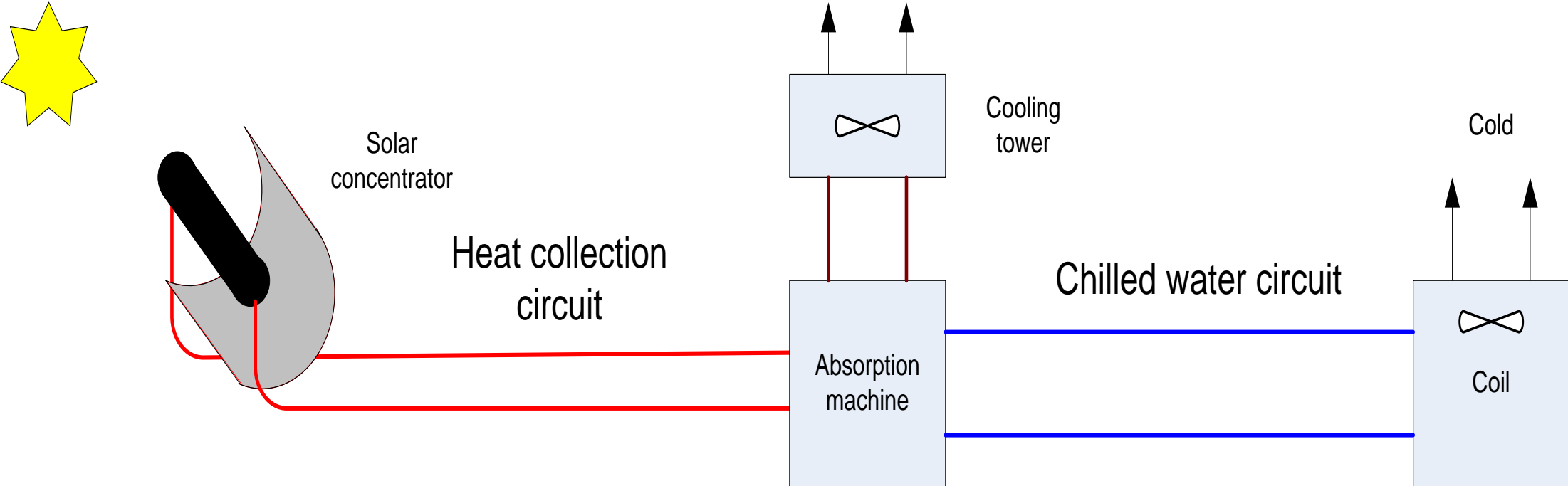
- HFC-32, R-446A, R-447A, R-450A, R-513A, R-451A, R-451B have a higher critical temperature than R-410A which makes them better suited to operation in high ambient temperature than R-410A.

The main challenge for high ambient conditions

- The heat load per m² is higher than in cooler climates which leads to higher refrigerant charges per m² of occupied space.
- Increase the MEPS (minimum energy performance standards), leading to higher refrigerant charges flammable in high ambient climates.

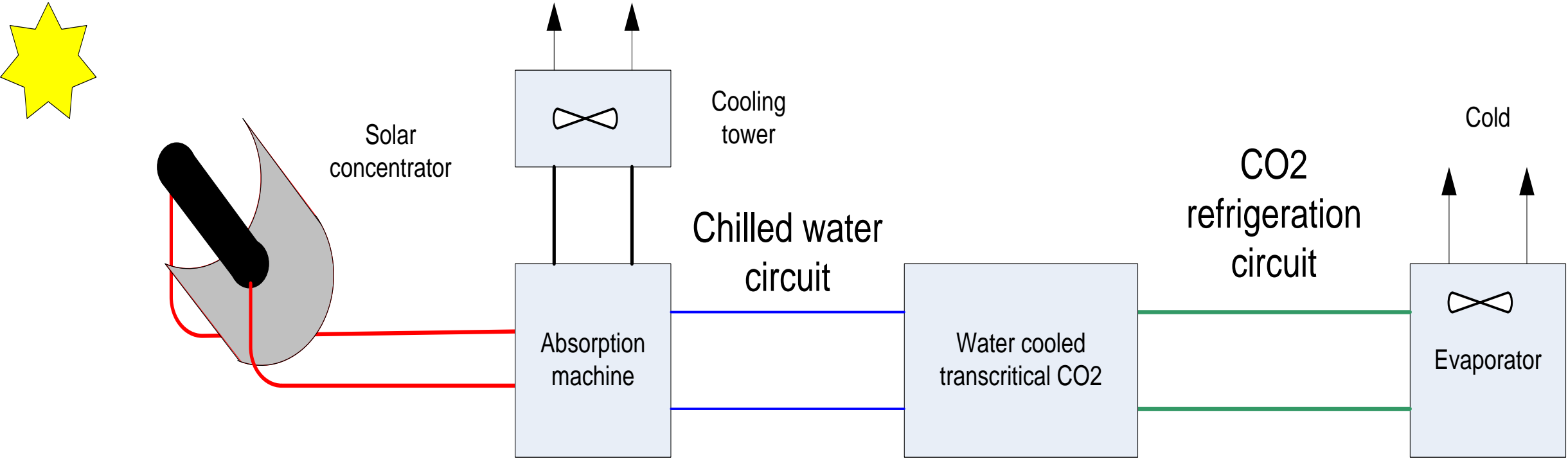
Alternative Technologies for large AC applications

Solar thermal absorption chilling



Alternative Technologies for large AC applications

Solar thermal cascade refrigeration



Conclusions:

- 1- There are a number of low-GWP refrigerants available for large AC units (air to air), these are not yet commercially available for high ambient countries.
- 2- Charge limitation applies for all flammable refrigerants options in H.A. countries, due to large kW/m².
- 3- Economics of lower GWP options not yet assessed.
- 4- There are alternative technologies, non-fluorinated solutions to be seriously examined as they can be an answer to high ambient countries in this category.

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Thank you.

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