



# Refrigerant Choices

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Chairman – Institute of Refrigeration Technical Committee

# Refrigerant Choices

- **Introductory remarks**
- **The bumpy road so far**
- **Refrigerant choices**
- **Detour from the road**
- **The next destinations**
- **Conclusions**
- **Q&A**



# The road so far.....

## Organic Refrigerants

- 1980s: CFC&HCFC
- 1990s: HCFC&HFC
- 2000s: HCFC&HFC
- 2010s: HFC&HFO

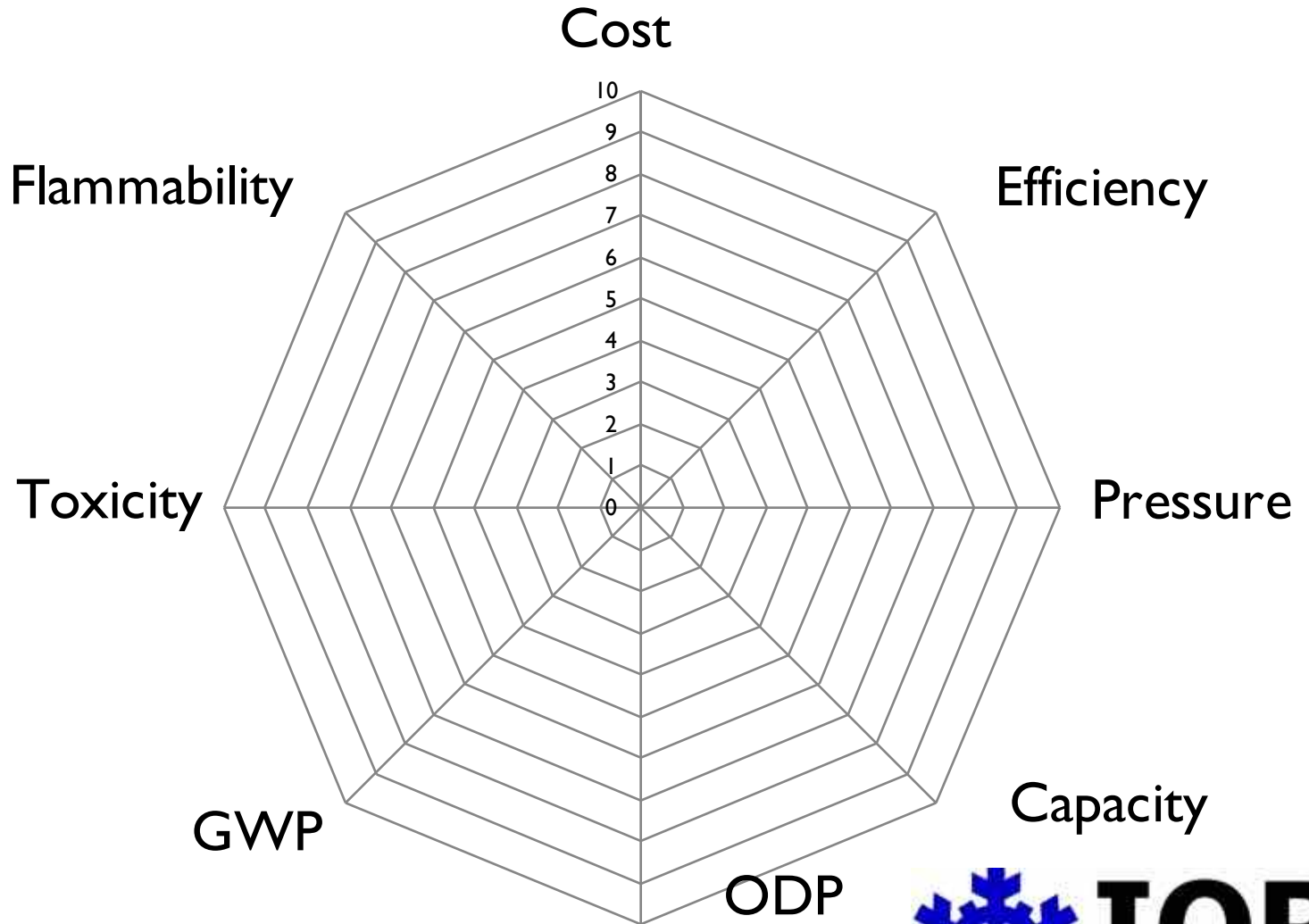
## Natural Refrigerants

- 1980s: NH<sub>3</sub>&HC
- 1990s: NH<sub>3</sub>, CO<sub>2</sub>&HC
- 2000s: NH<sub>3</sub>, CO<sub>2</sub>&HC
- 2010s: NH<sub>3</sub>, H<sub>2</sub>O, CO<sub>2</sub>&HC

# Refrigerant Choices

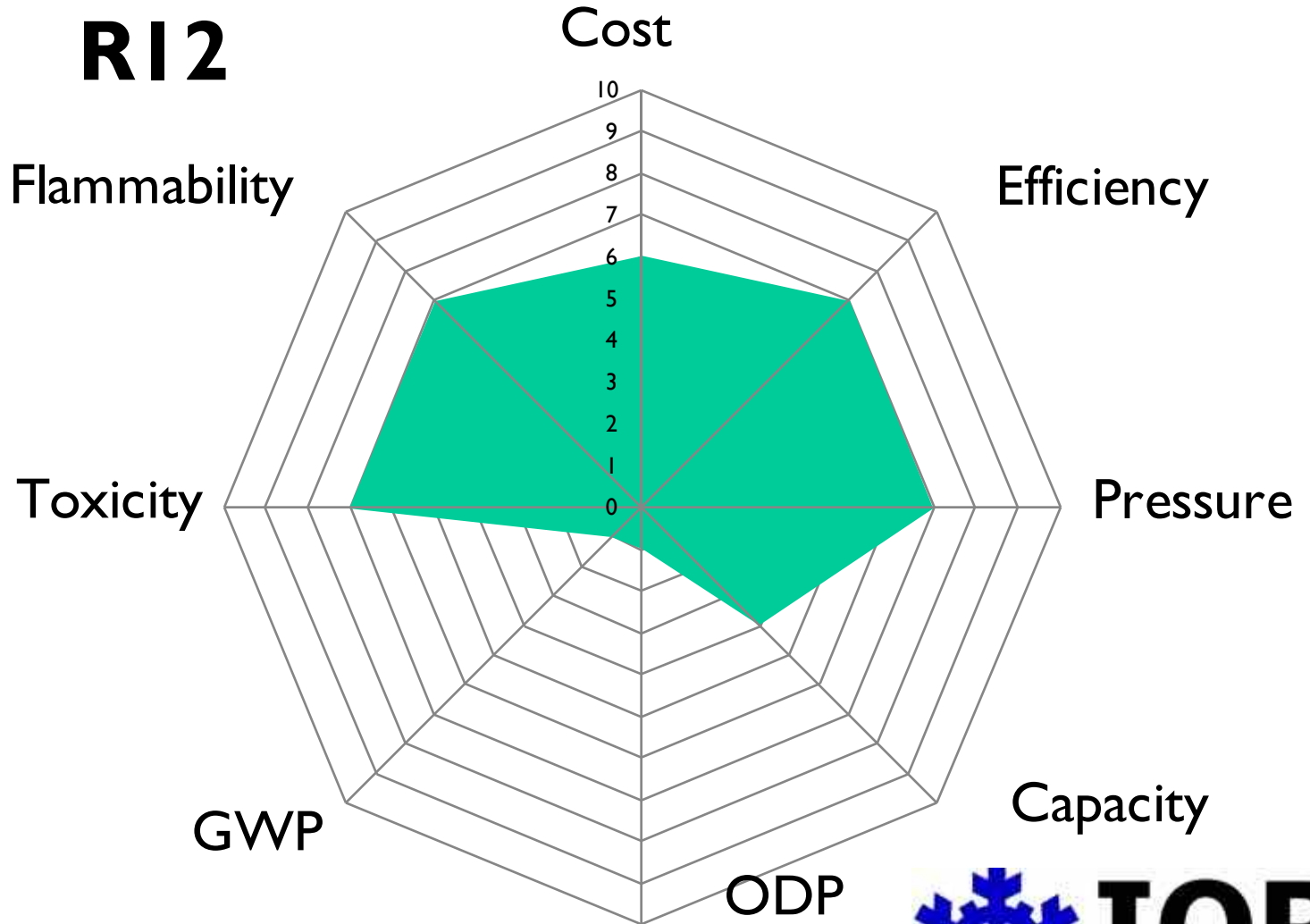
- **Cost of the refrigerant (or system)**
- **Efficiency**
- **Operating Pressure**
- **Cooling Capacity**
- **Ozone Depletion Potential**
- **Global Warming Potential**
- **Toxicity**
- **Flammability**

# Refrigerant Choices



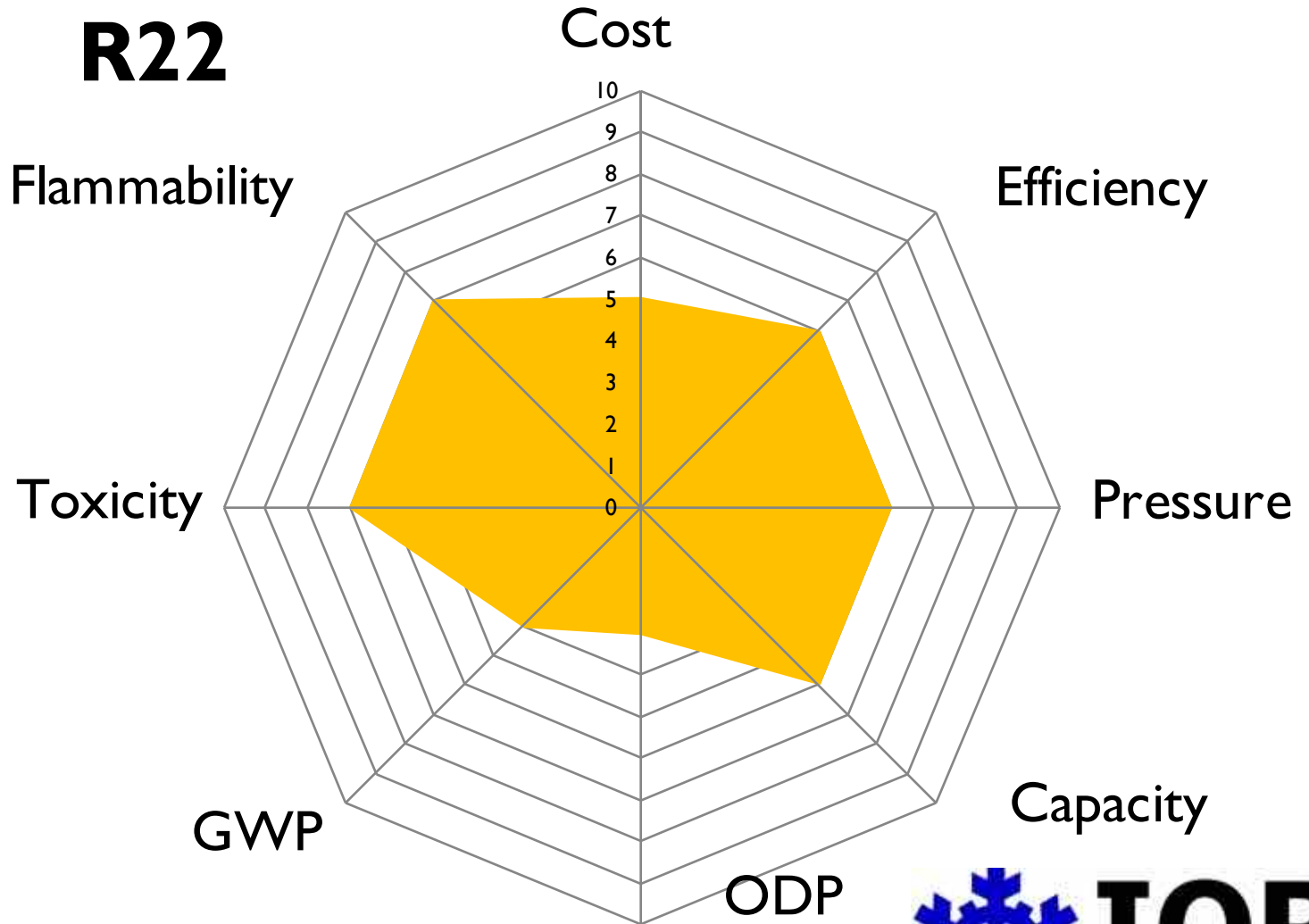
# Refrigerant Choices

## R12



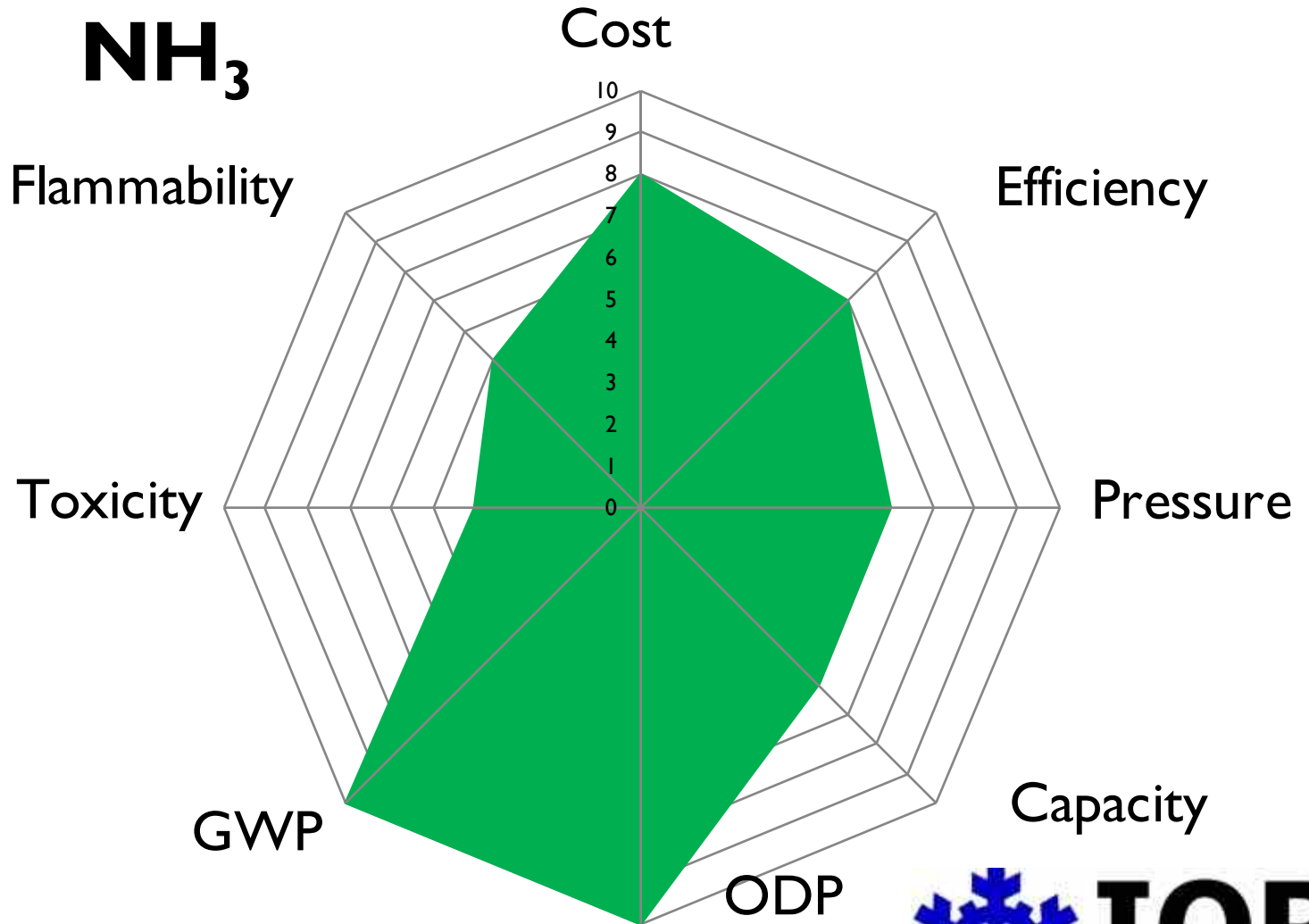
# Refrigerant Choices

## R22



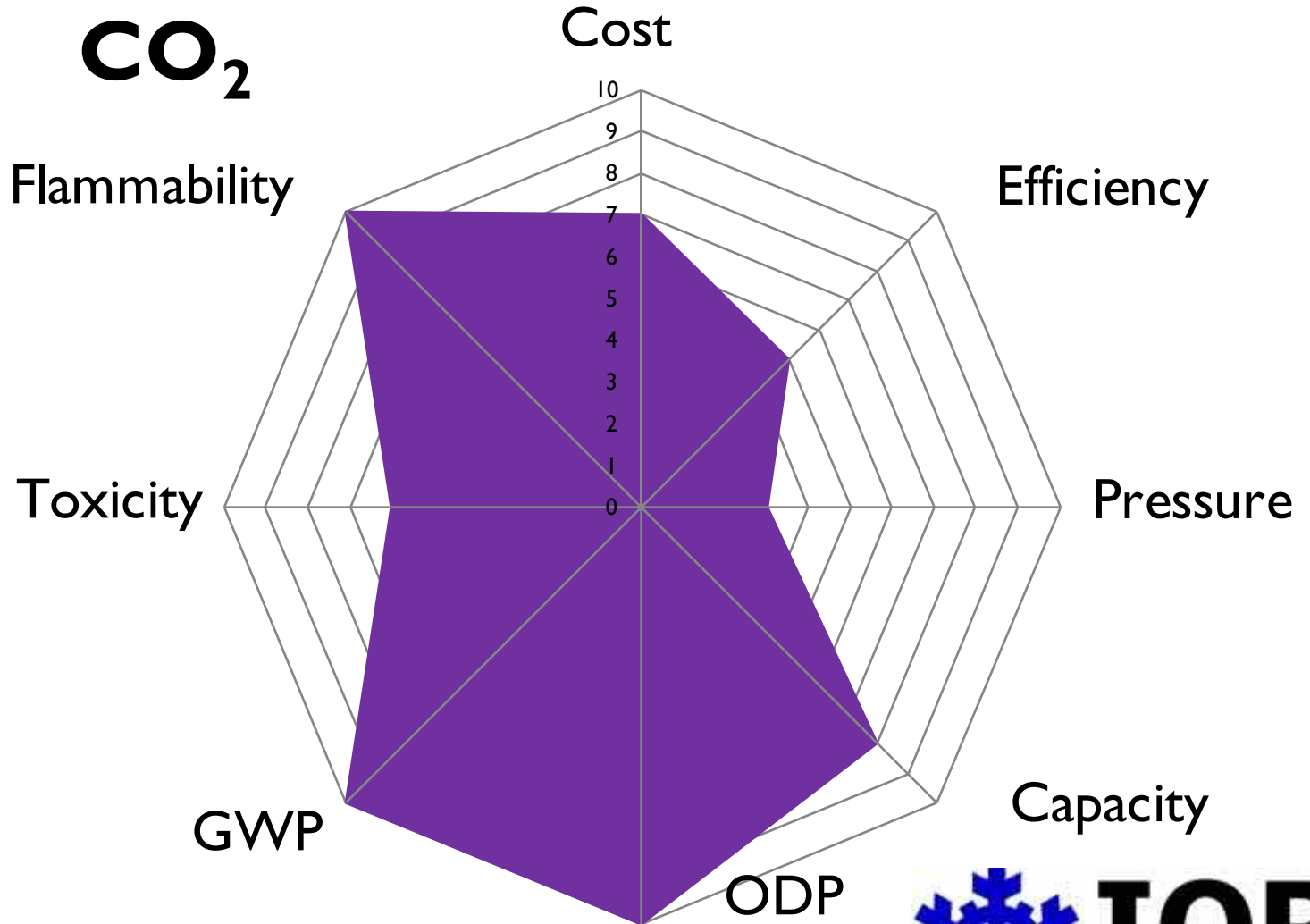
# Refrigerant Choices

**NH<sub>3</sub>**



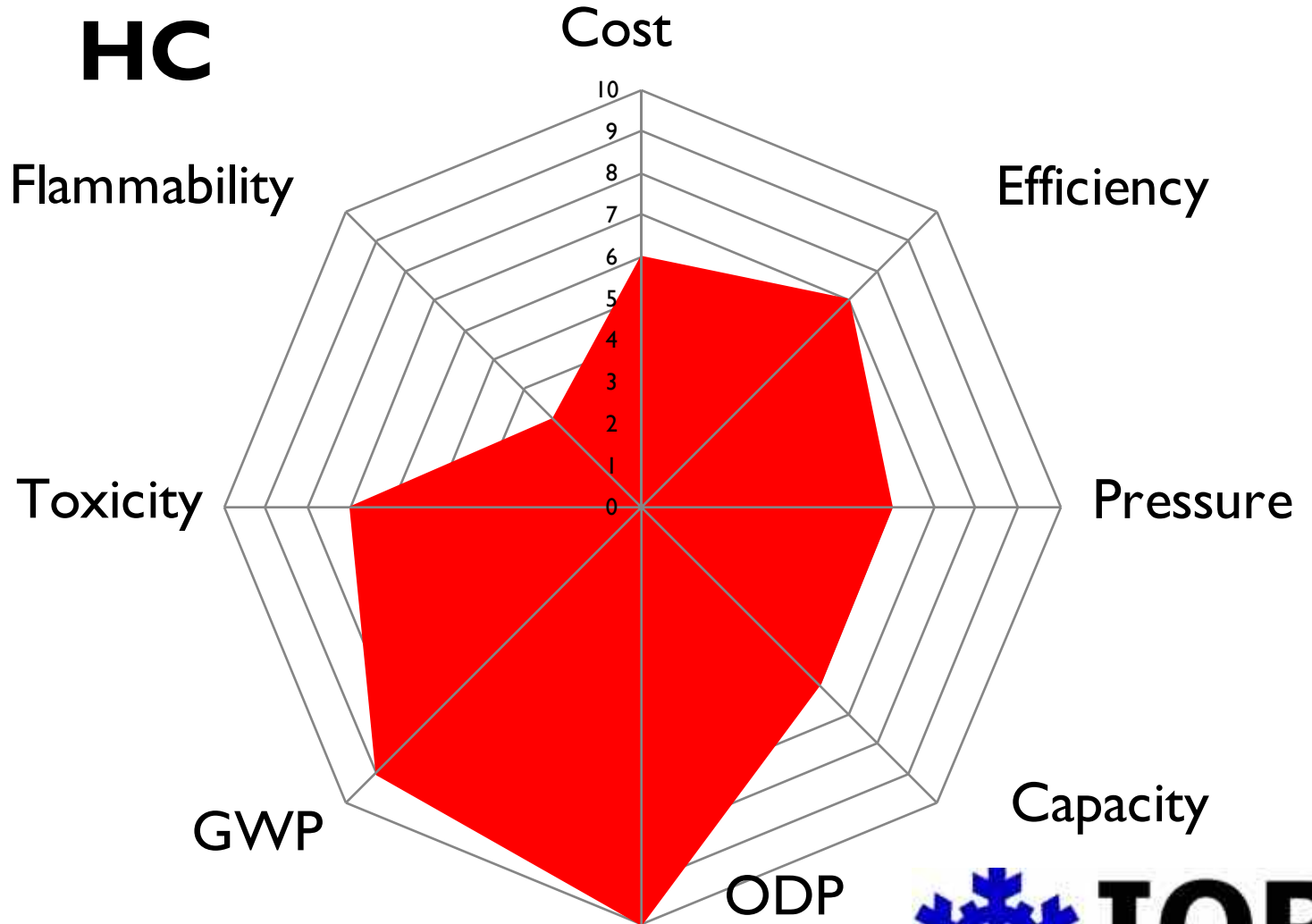


# Refrigerant Choices



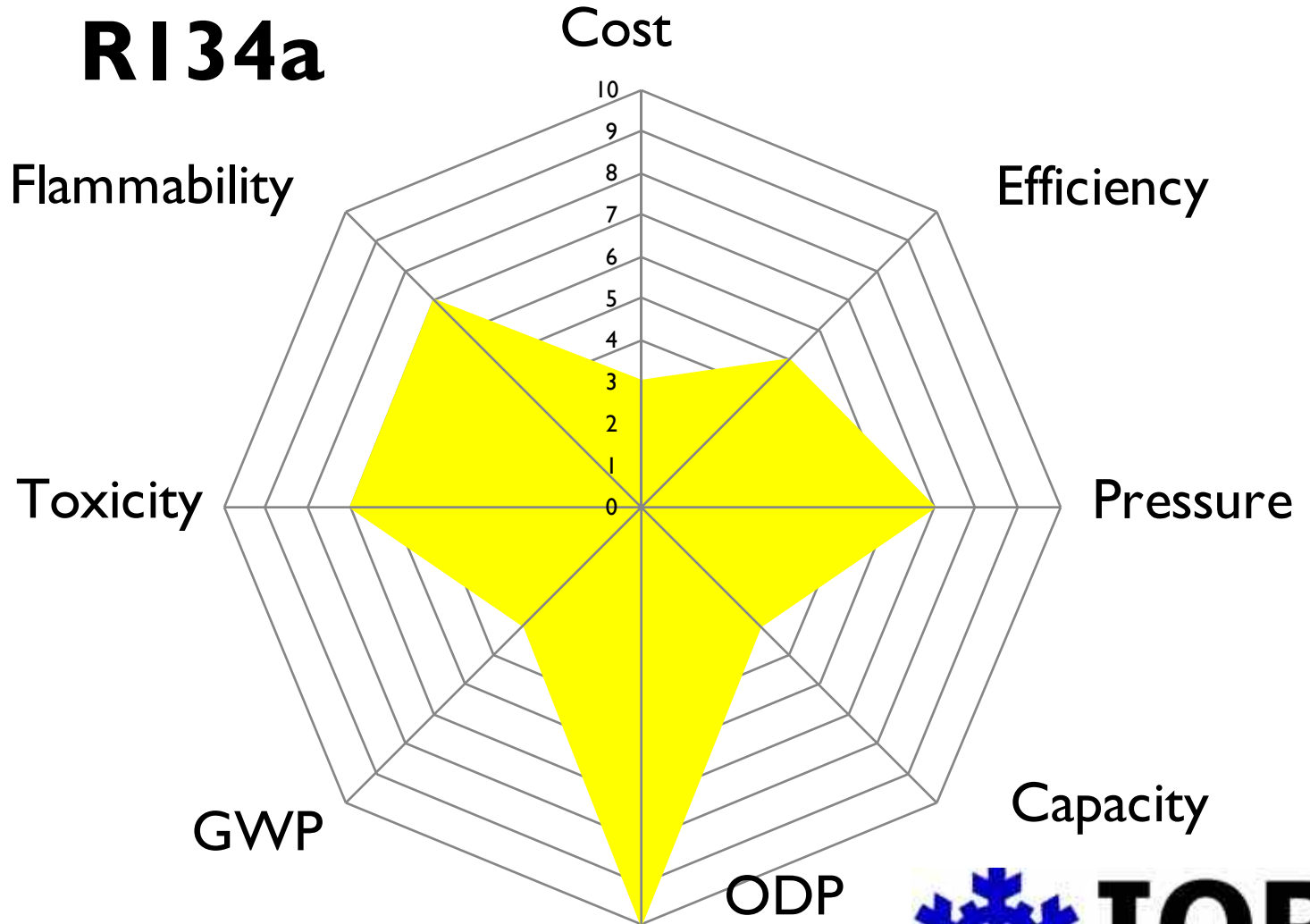
# Refrigerant Choices

**HC**



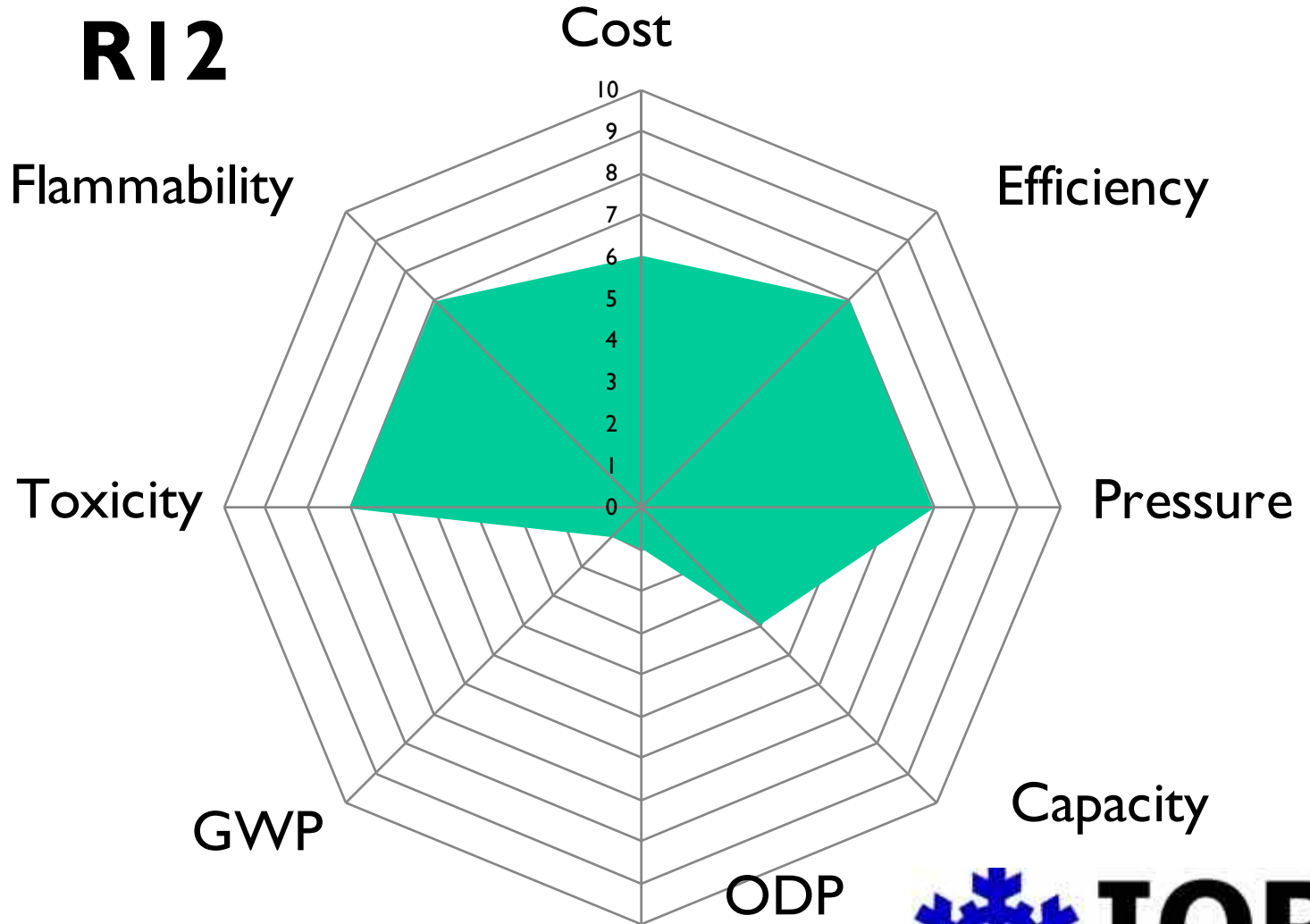
# Refrigerant Choices

## R134a



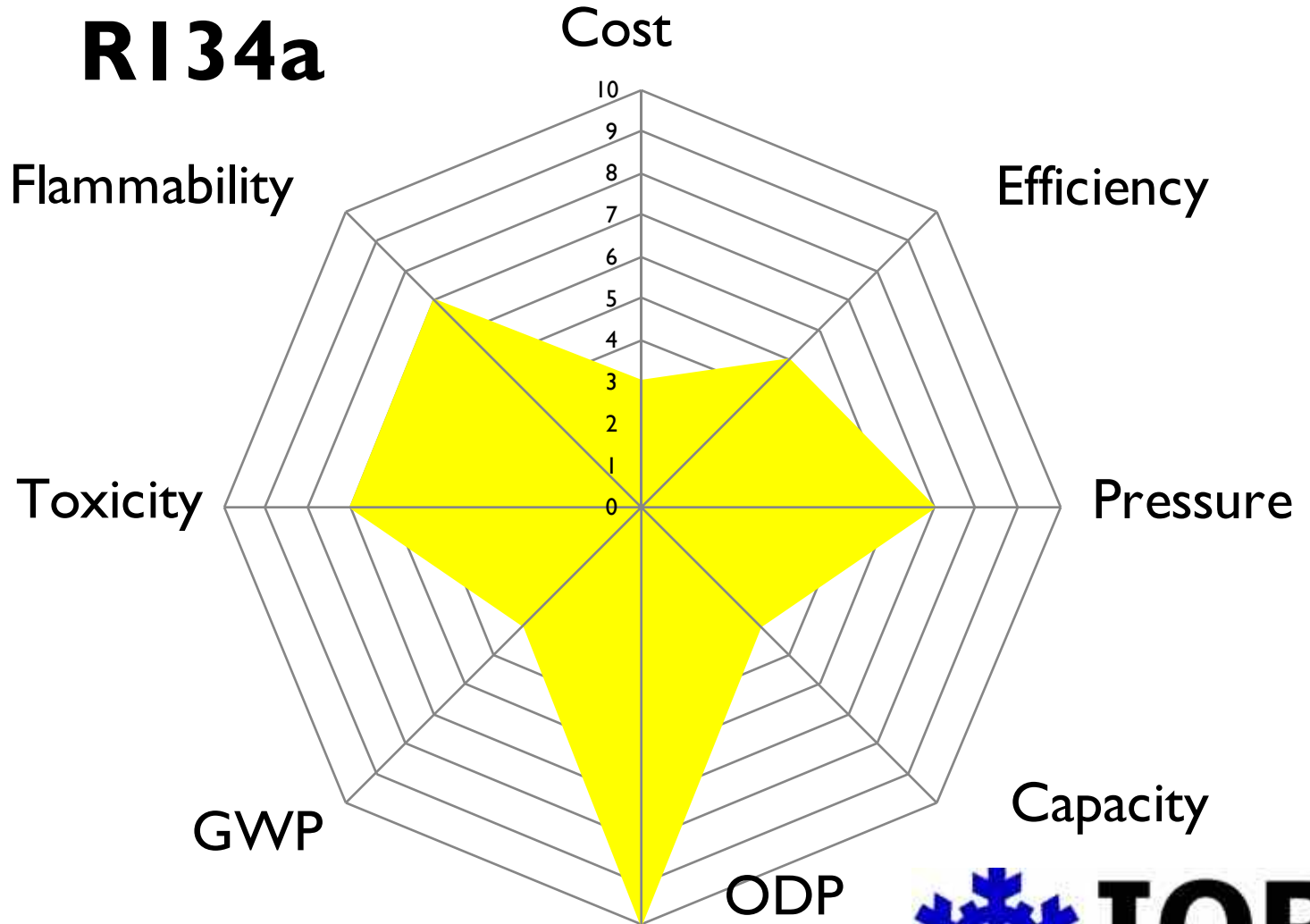
# Refrigerant Choices

## R12



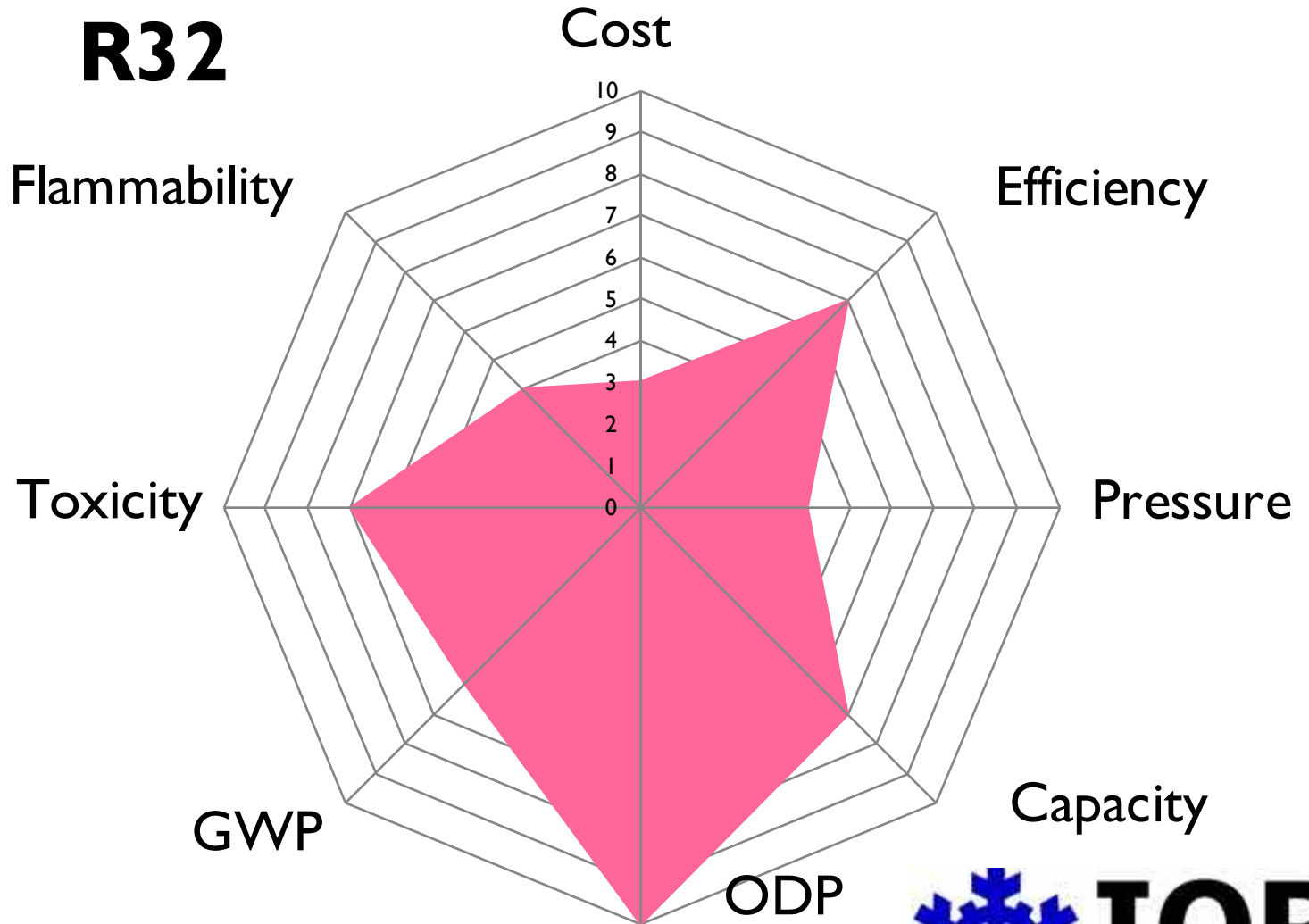
# Refrigerant Choices

## R134a



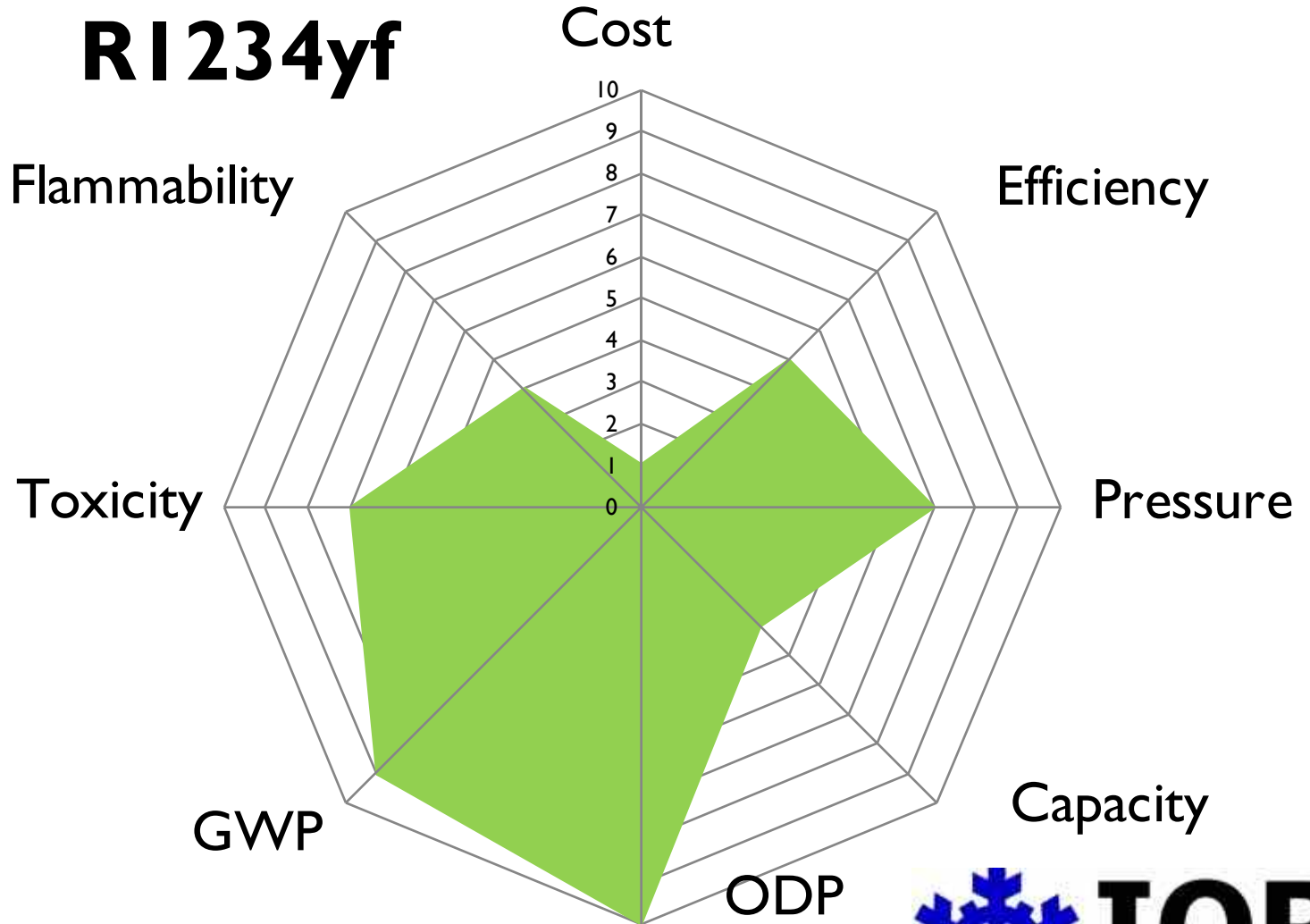
# Refrigerant Choices

## R32



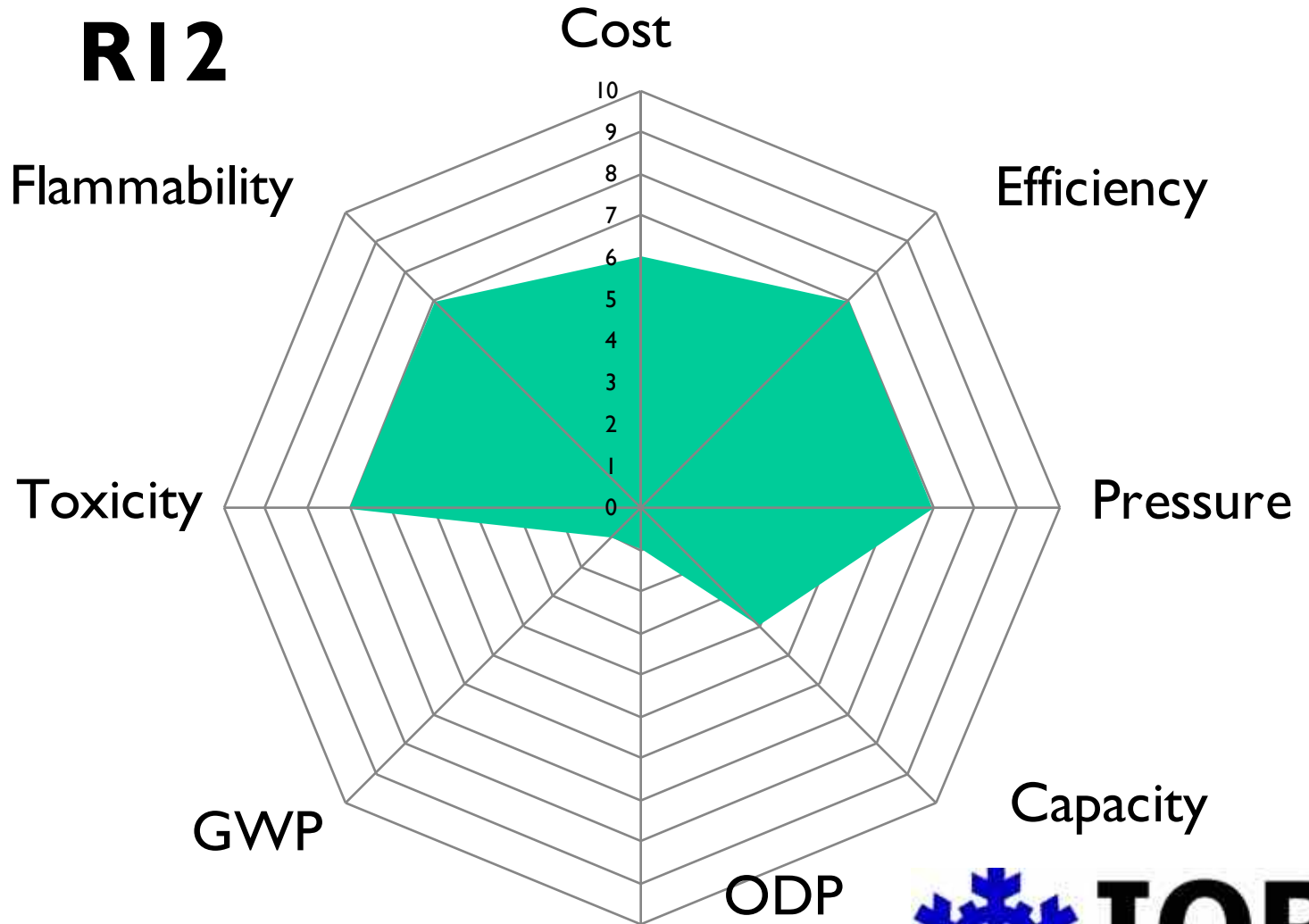
# Refrigerant Choices

## RI234yf



# Refrigerant Choices

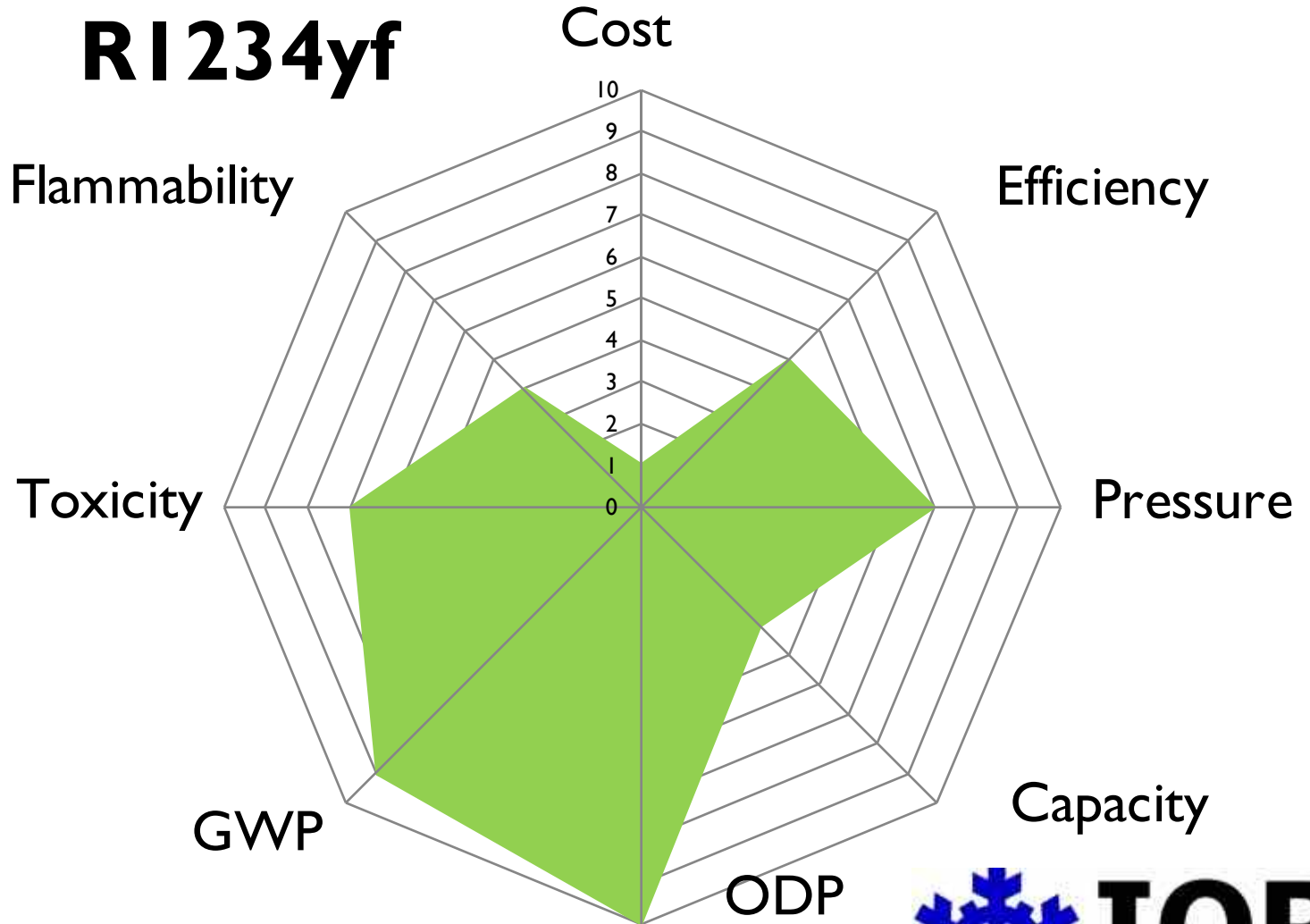
## R12





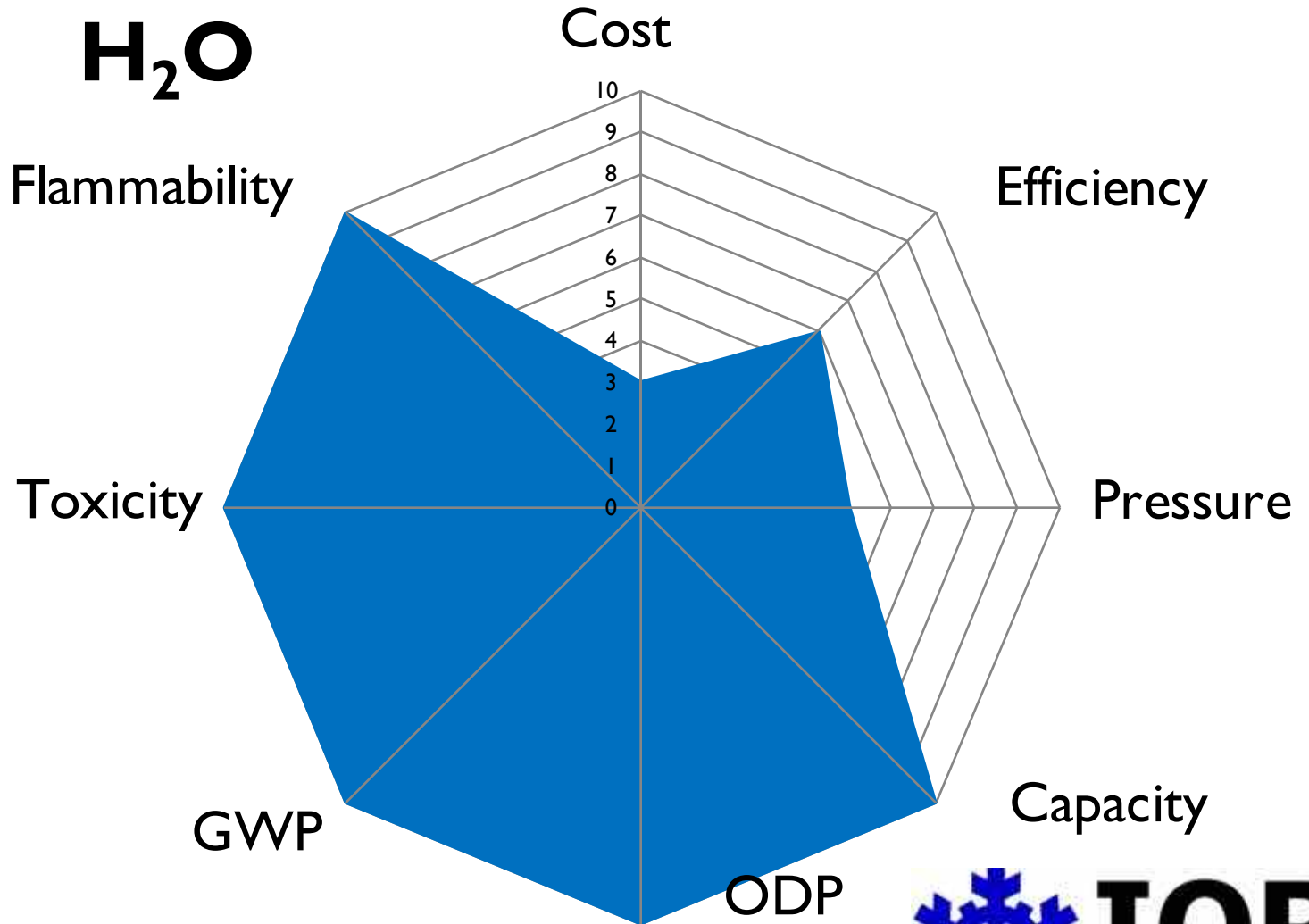
# Refrigerant Choices

## RI234yf



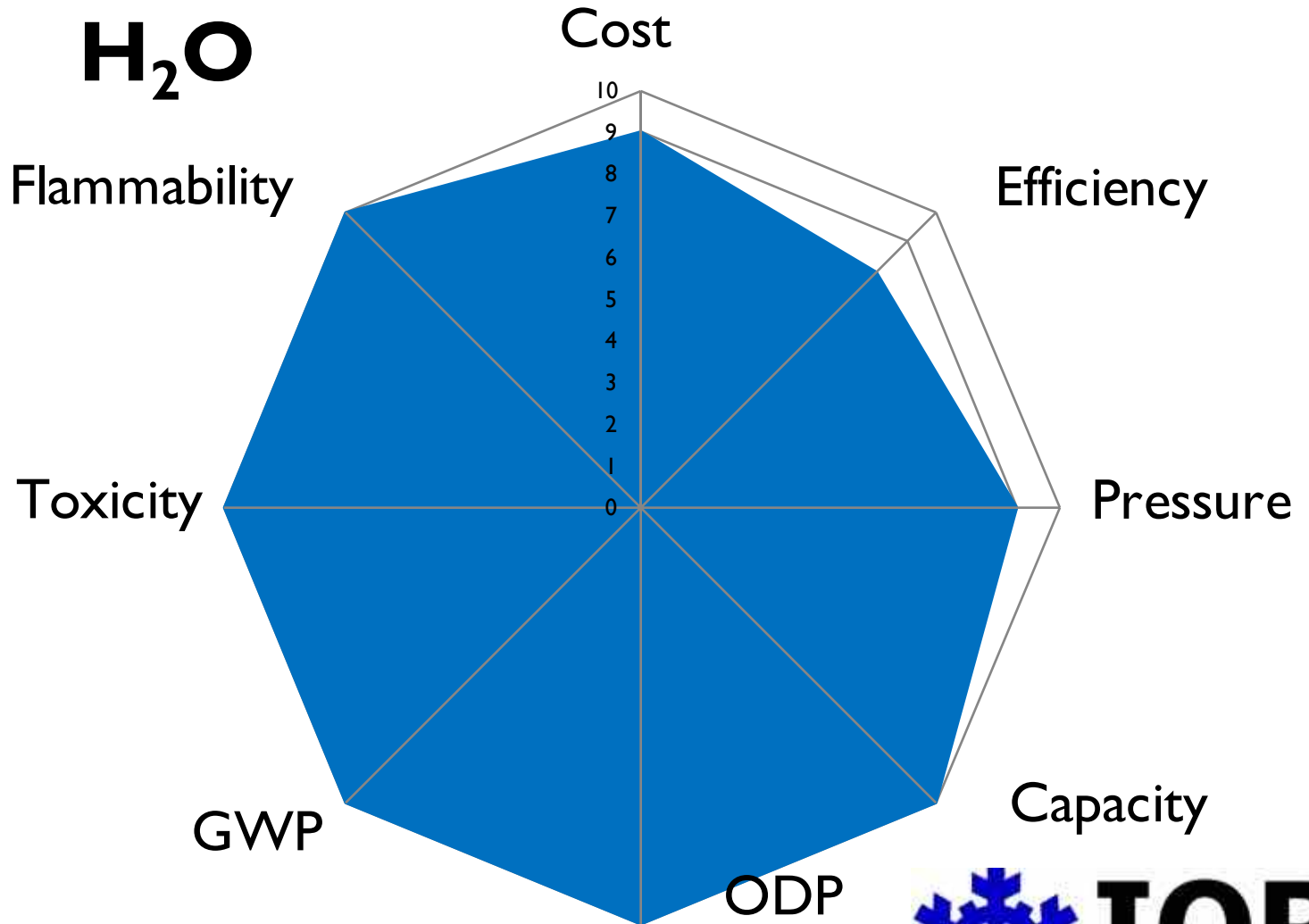
# Refrigerant Choices

**H<sub>2</sub>O**

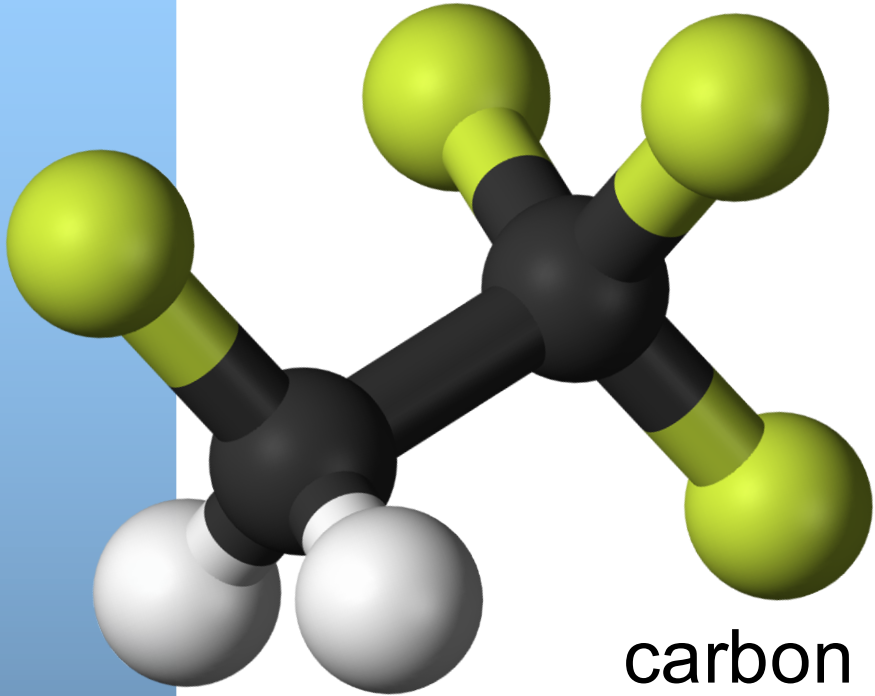


# Refrigerant Choices

**H<sub>2</sub>O**



# A brief word on R numbers



- **Black = carbon**
- **White = hydrogen**
- **Yellow = fluorine**
- **R-134a**

**+90**

**224**

carbon

hydrogen

fluorine

less

symmetry



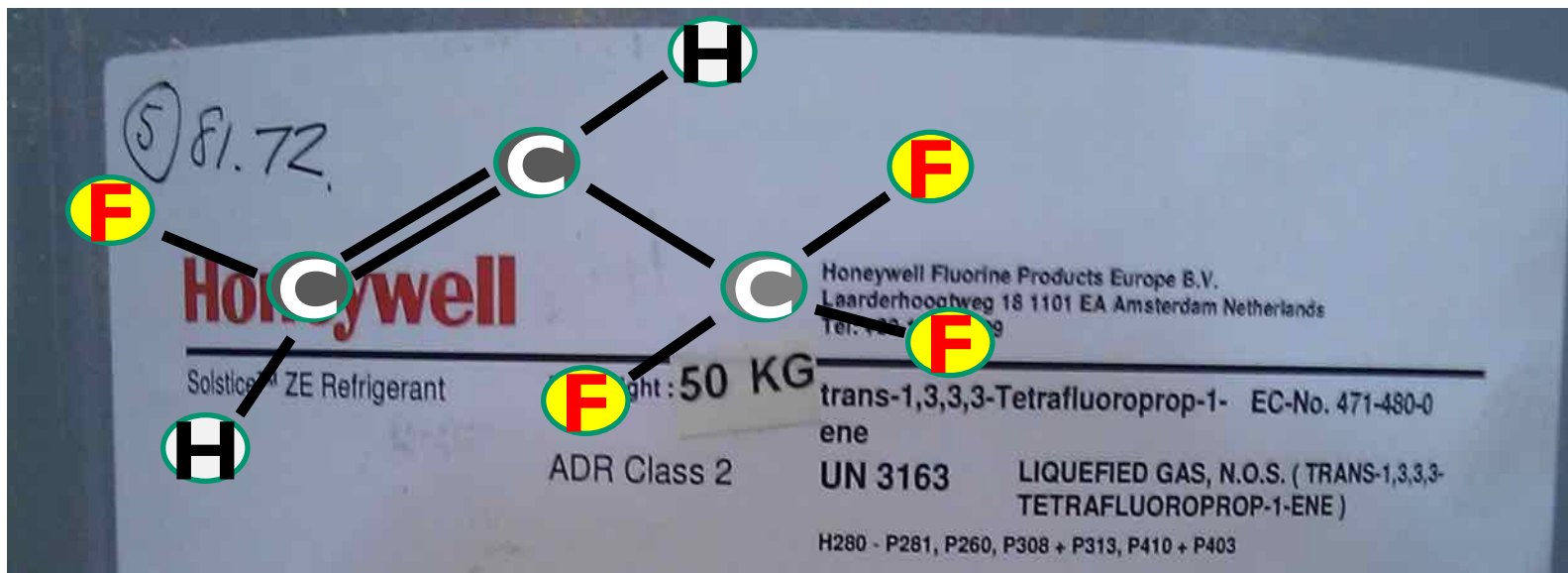
**IOR**  
ior.org.uk

# Another word on R numbers

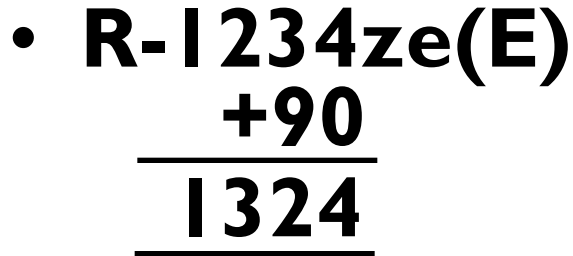
- **400 series = blends with glide**
- **500 series = blends with no glide (azeotropes)**
- **600 series = mixed bag that doesn't fit elsewhere**
- **700 series = inorganic compounds**  
(numbered by molecular weight, inc >7000!)
- **4th-digit indicates a double bond (eg R-1270)**
- **a is for isomer (eg R-152a)**
- **A is for variant (eg R-404A or R-744A)**

# What about other stuff?

- **R-1234ze(E)**  
**+90**  
**1324**
- The methylene group is CHF  
This is the “Entgegen” version  
The central C has hydrogen  
4 fluorine atoms  
2 hydrogen atoms  
3 carbon atoms  
1 double bond



# Isomers



trans-1,3,3,3-Tetrafluoroprop-1-ene

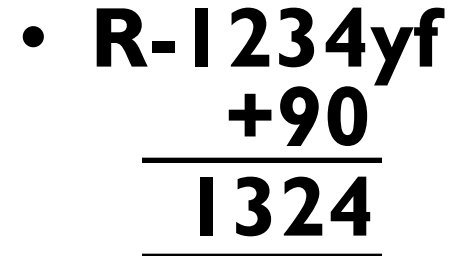
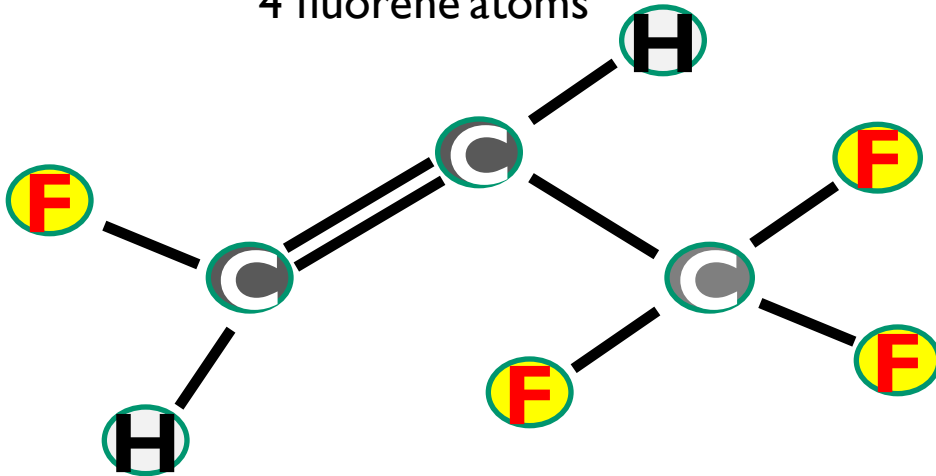
NBP = -18.1°C

1 double bond

3 carbon atoms

2 hydrogen atoms

4 fluorine atoms



2,3,3,3-Tetrafluoroprop-1-ene

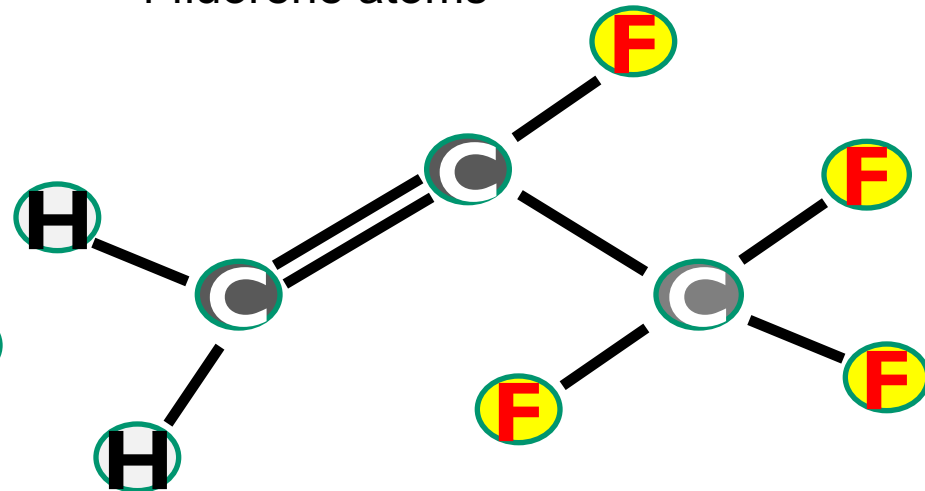
NBP = -29.4°C

1 double bond

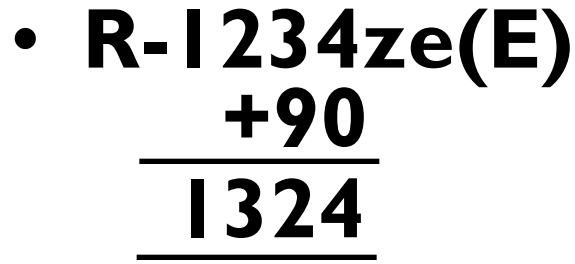
3 carbon atoms

2 hydrogen atoms

4 fluorine atoms



# Stereoisomers



trans-1,3,3,3-Tetrafluoroprop-1-ene

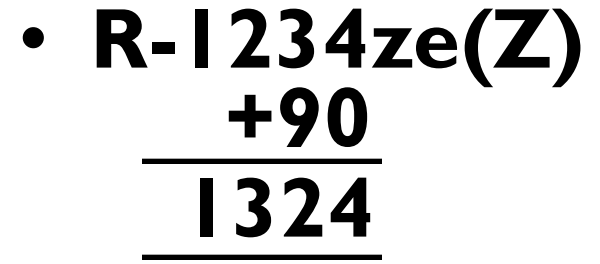
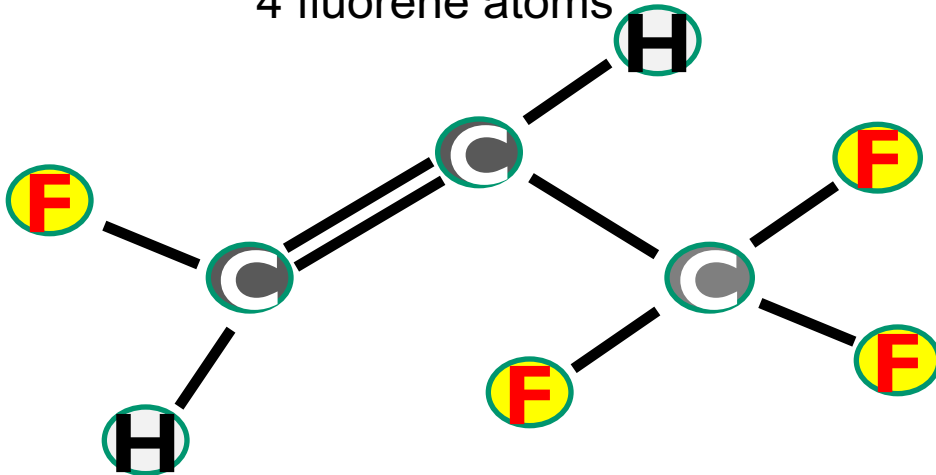
NBP = -18.1°C

1 double bond

3 carbon atoms

2 hydrogen atoms

4 fluorine atoms



cis-1,3,3,3-Tetrafluoroprop-1-ene

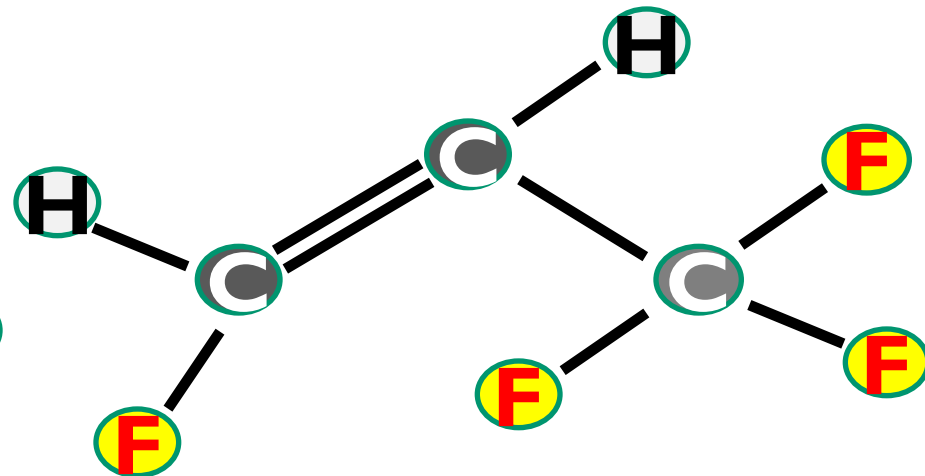
NBP = 9°C

1 double bond

3 carbon atoms

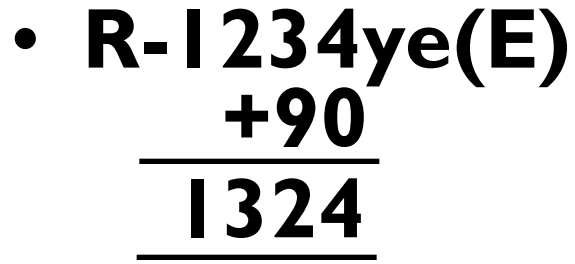
2 hydrogen atoms

4 fluorine atoms





# Stereoisomers



trans-1,2,3,3-Tetrafluoroprop-1-ene

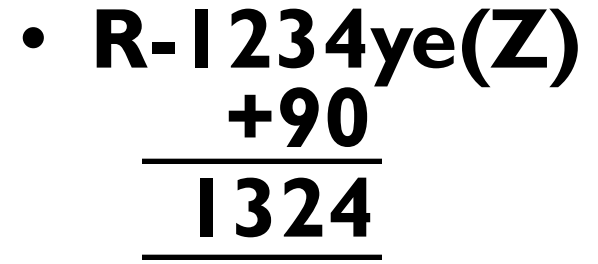
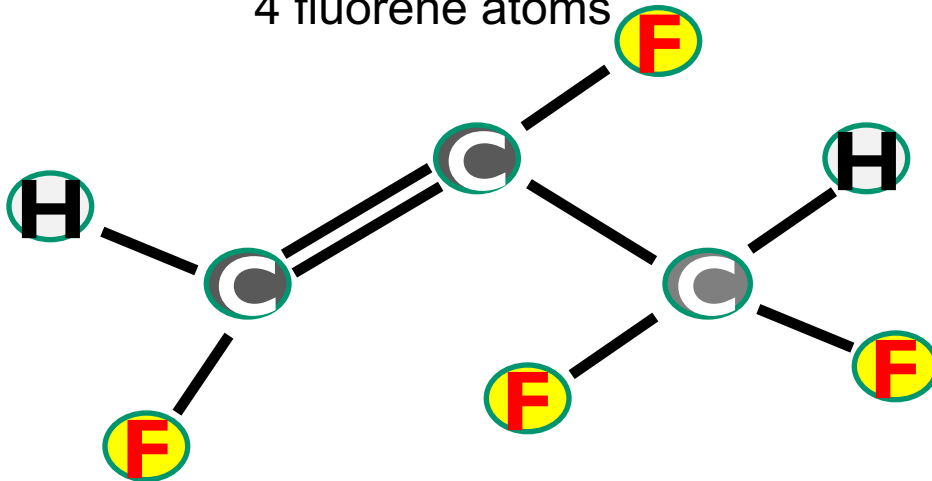
NBP = -22°C

1 double bond

3 carbon atoms

2 hydrogen atoms

4 fluorine atoms



cis-1,2,3,3-Tetrafluoroprop-1-ene

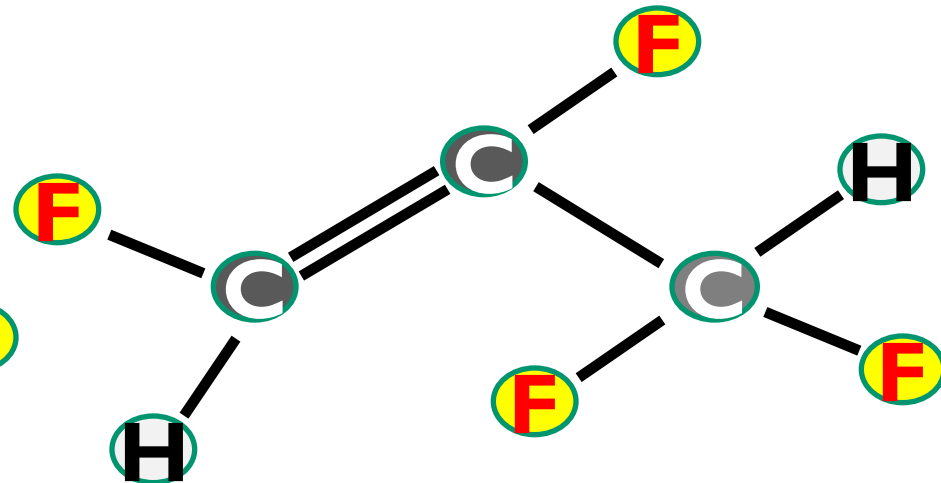
NBP = ???°C

1 double bond

3 carbon atoms

2 hydrogen atoms

4 fluorine atoms



# Isomers



# The next destinations.....

## Organic Refrigerants

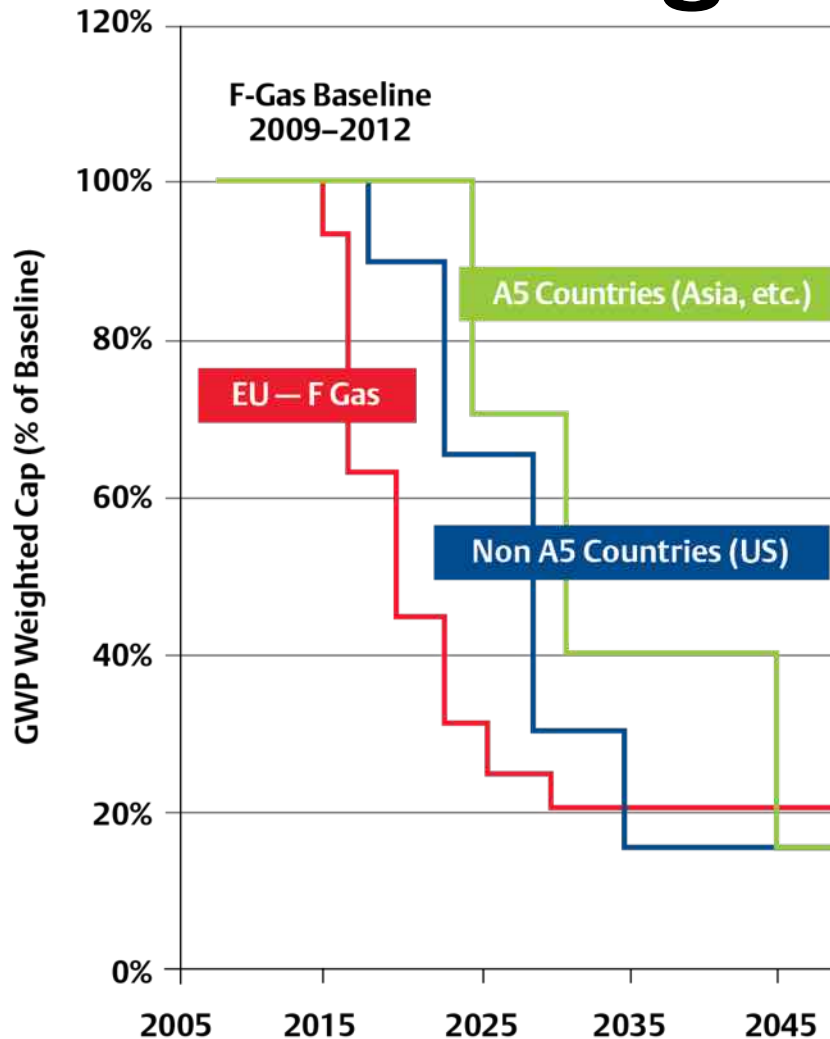
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- 1990s: HCFC&HFC
- 2000s: HCFC&HFC
- 2010s: HFC&HFO
- 2020s: HFC&HFO
- 2030s: HFO

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- 1980s: NH<sub>3</sub>&HC
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- 2000s: NH<sub>3</sub>, CO<sub>2</sub>&HC
- 2010s: NH<sub>3</sub>, H<sub>2</sub>O, CO<sub>2</sub>&HC
- 2020s: NH<sub>3</sub>, H<sub>2</sub>O, CO<sub>2</sub>&HC
- 2030s: NH<sub>3</sub>, H<sub>2</sub>O, CO<sub>2</sub>&HC

## What happens in Kigali.....

# The Kigali Amendment



- Introduces HFCs to the Montreal process
- Uses same process as CFC phase out
- Follows similar path to EU f-gas directive
- Ends up at a lower level than Europe
- Enters into force on 1 January 2019
- Applies everywhere

# Conclusions

- **The pace of change is increasing**
- **This is probably the last round**
- **The options for domestic and industrial are clear**
- **Commercial is less certain**
- **The choice for air-conditioners is much more difficult**

# Questions and Answers

