Life Cycle Assessment of air conditioning and heat pumps, manufacturers experience

IIR WP Delft 28 June2012

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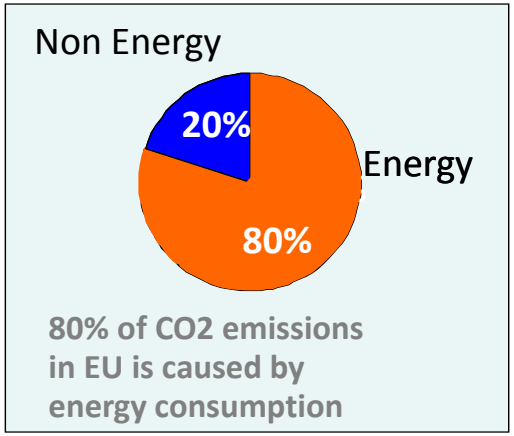
General business drivers in the EU

EU policies **“20 – 20 – 20”**



80% of CO2 emissions in EU is caused by energy consumption

20% less primary energy use compared to 2020 projections

Economy

Global Warming

ENERGY

Security of supply

CO_2 eq. emissions :

20% (~30%) reduction by 2020

20% share of Renewable Energy sources by 2020

2050 Roadmap for EU

Figure 2: EU GHG emissions towards an 80% domestic reduction (100% =1990)

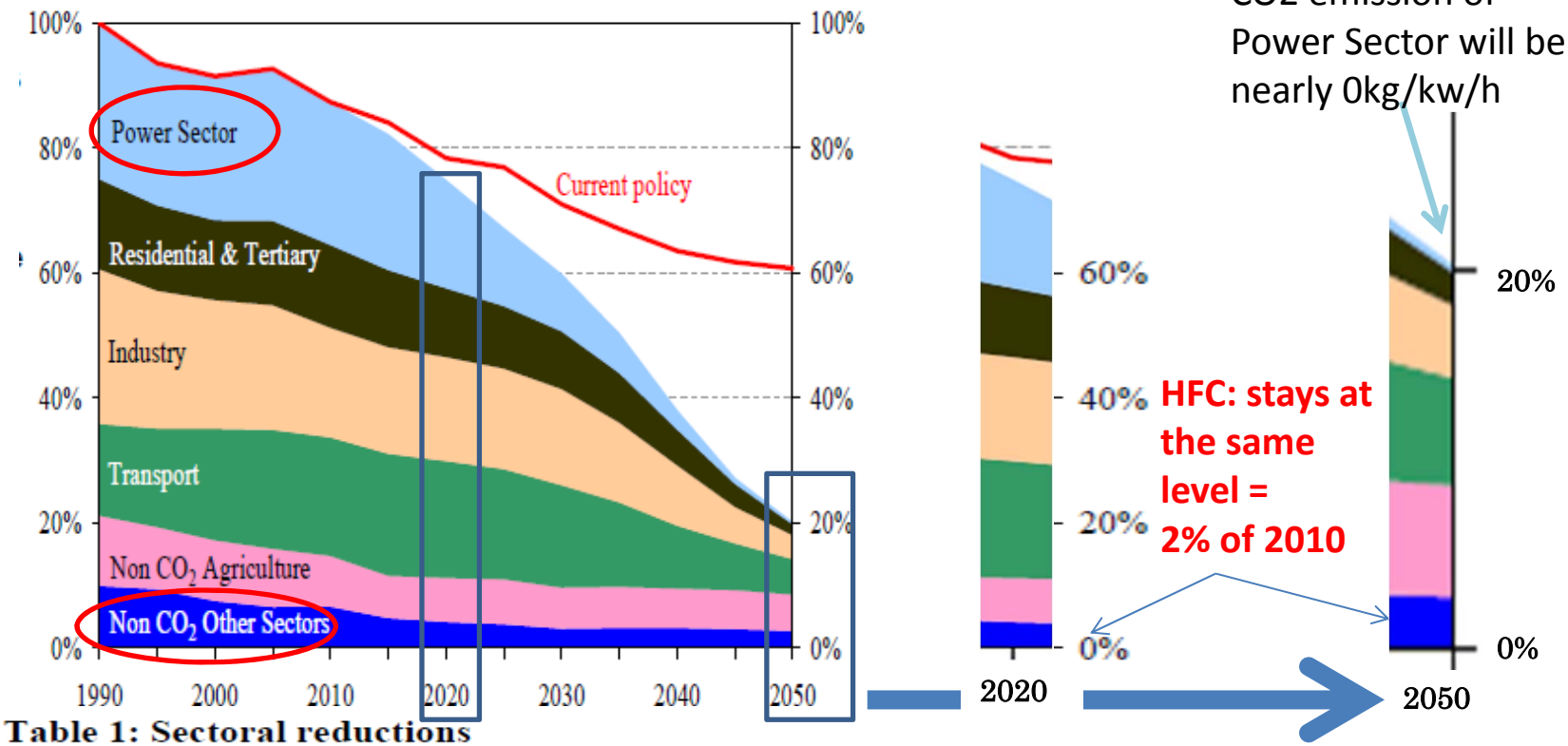
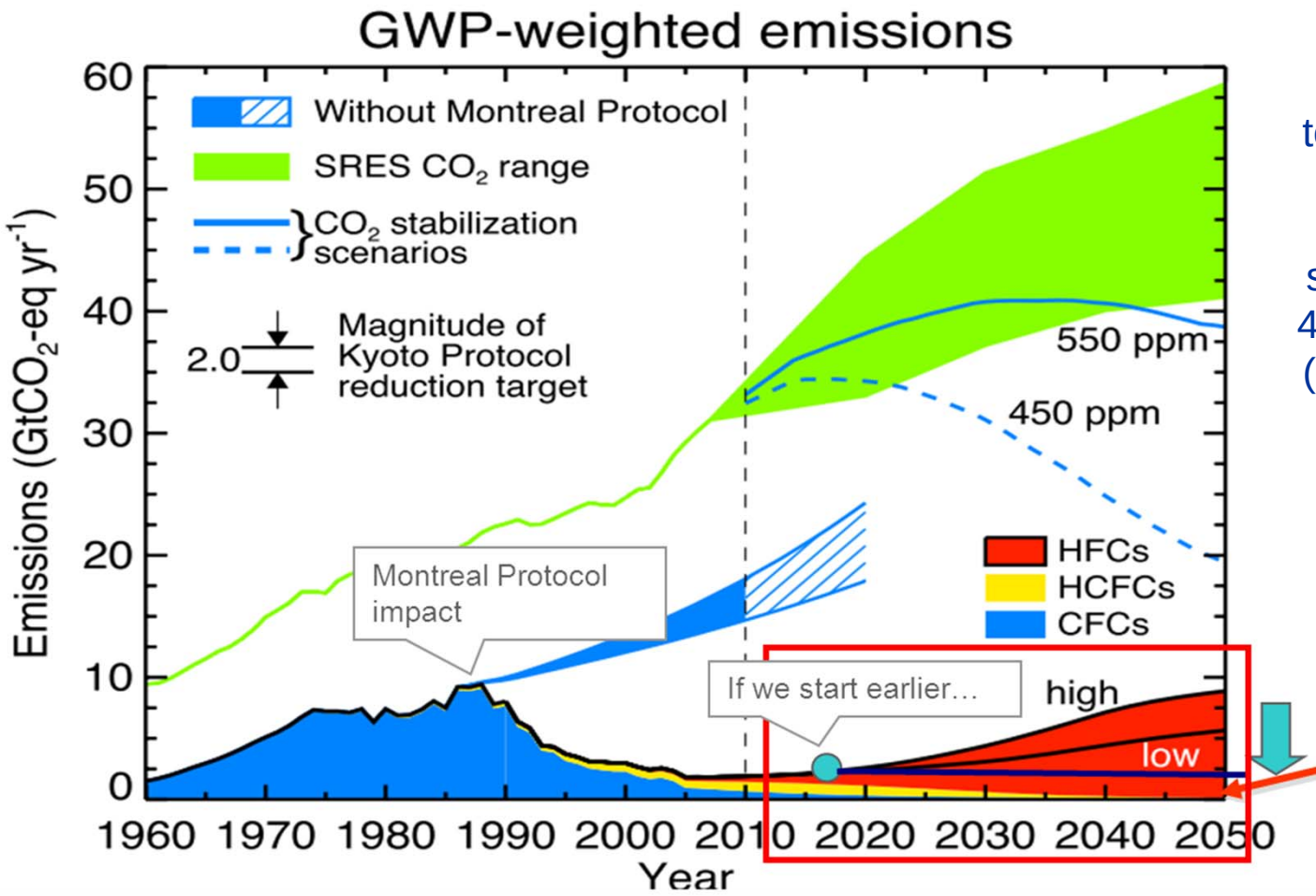


Table 1: Sectoral reductions

GHG reductions compared to 1990	2005	2030	2050
Total	-7%	-40 to -44%	-79 to -82%
Sectors			
Power (CO_2)	-7%	-54 to -68%	-93 to -99%
Industry (CO_2)	-20%	-34 to -40%	-83 to -87%
Transport (incl. CO2 aviation, excl. maritime)	+30%	+20 to -9%	-54 to -67%
Residential and services (CO_2)	-12%	-37 to -53%	-88 to-91%
Agriculture (non-CO_2)	-20%	-36 to -37%	-42 to -49%
Other non-CO_2 emissions	-30%	-72 to -73%	-70 to -78%

Global greenhouse gas emission tendency



To avoid global temperature rise, CO2 concentration in the atmosphere must be stabilized at 550 ppm, 450 ppm or even lower (depending on various policy targets)

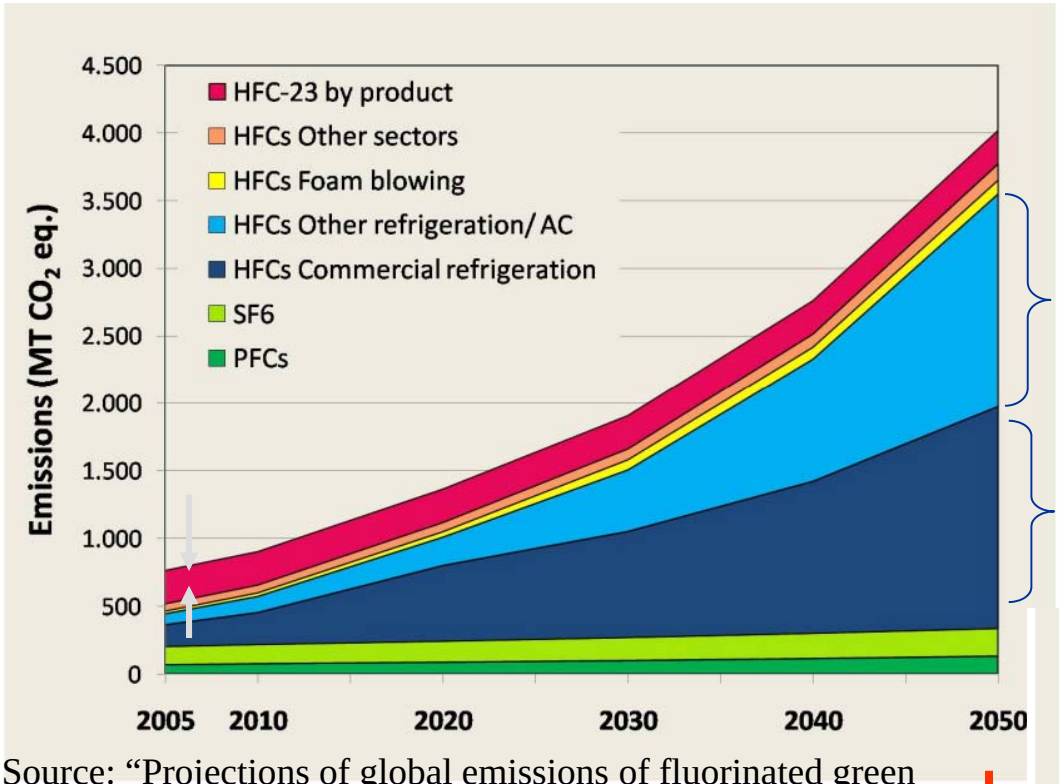
The sooner we introduce better alternatives for today's HFCs, the lower the global warming impact will be

SRES = Special Report on Emissions Scenarios, prepared by the IPCC (intergovernmental panel on climate change)

Source: "The large contribution of projected HFC emissions to future climate forcing" by Guus J.M.Velders et.al.

Climate change : developing countries are key

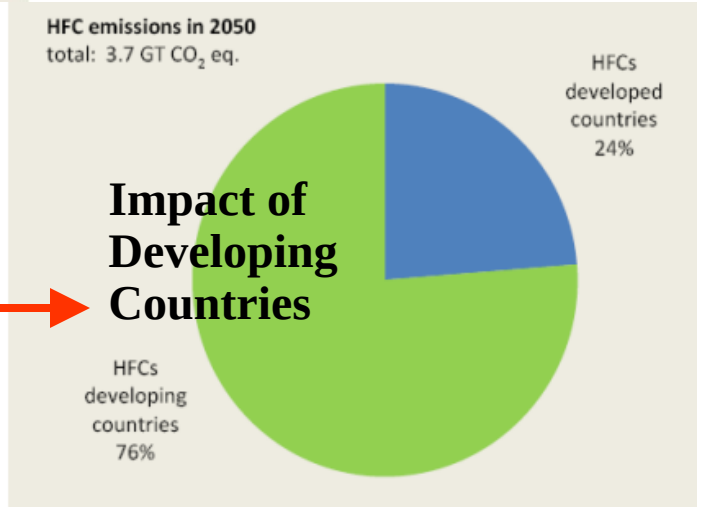
2050 estimation: 76% of all HFC emissions is coming from developing countries



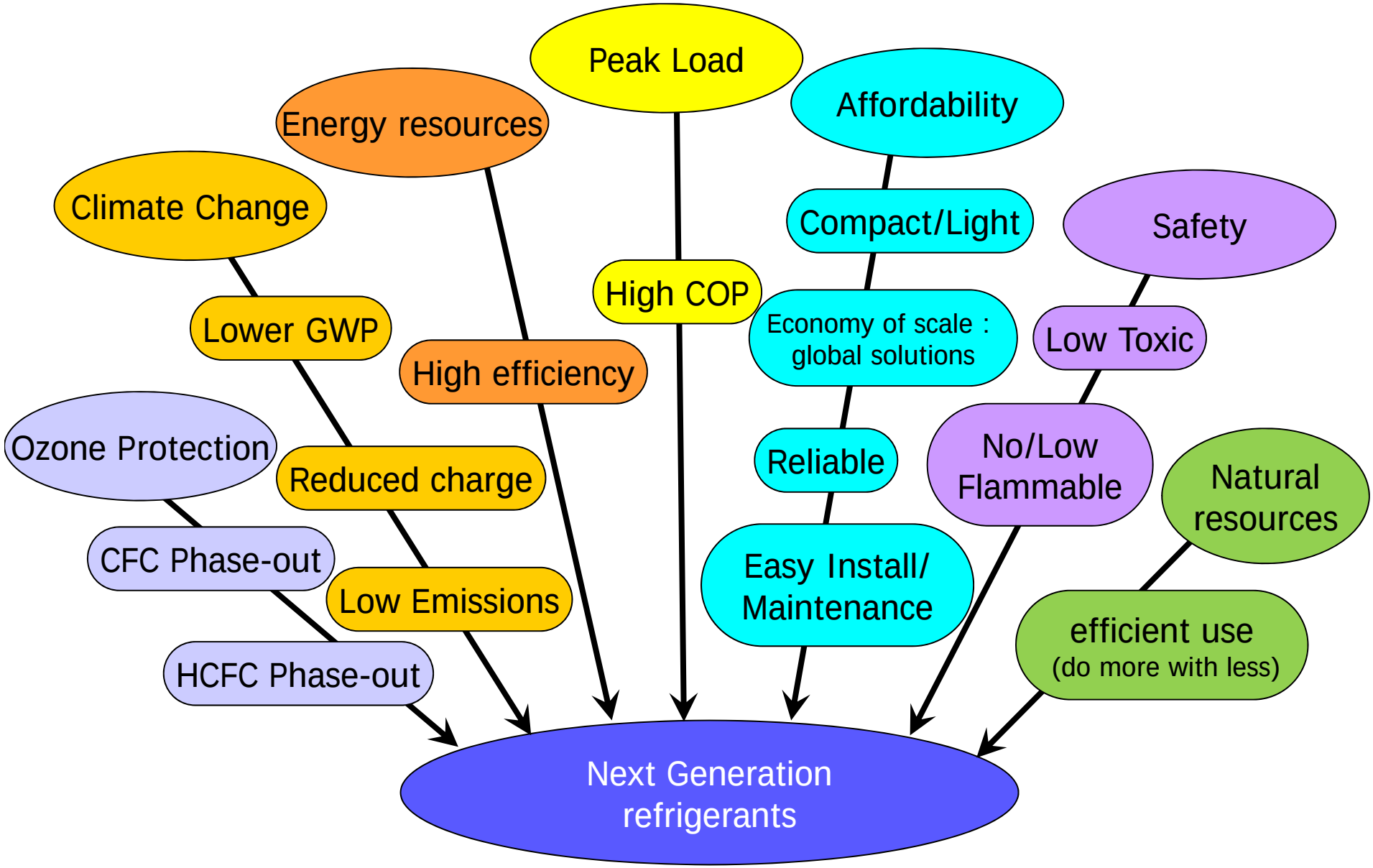
Source: "Projections of global emissions of fluorinated green house gases in 2050" by Öko Recherche

Impact of
AC and other Refrigeration
Note: includes stationary and mobile AC

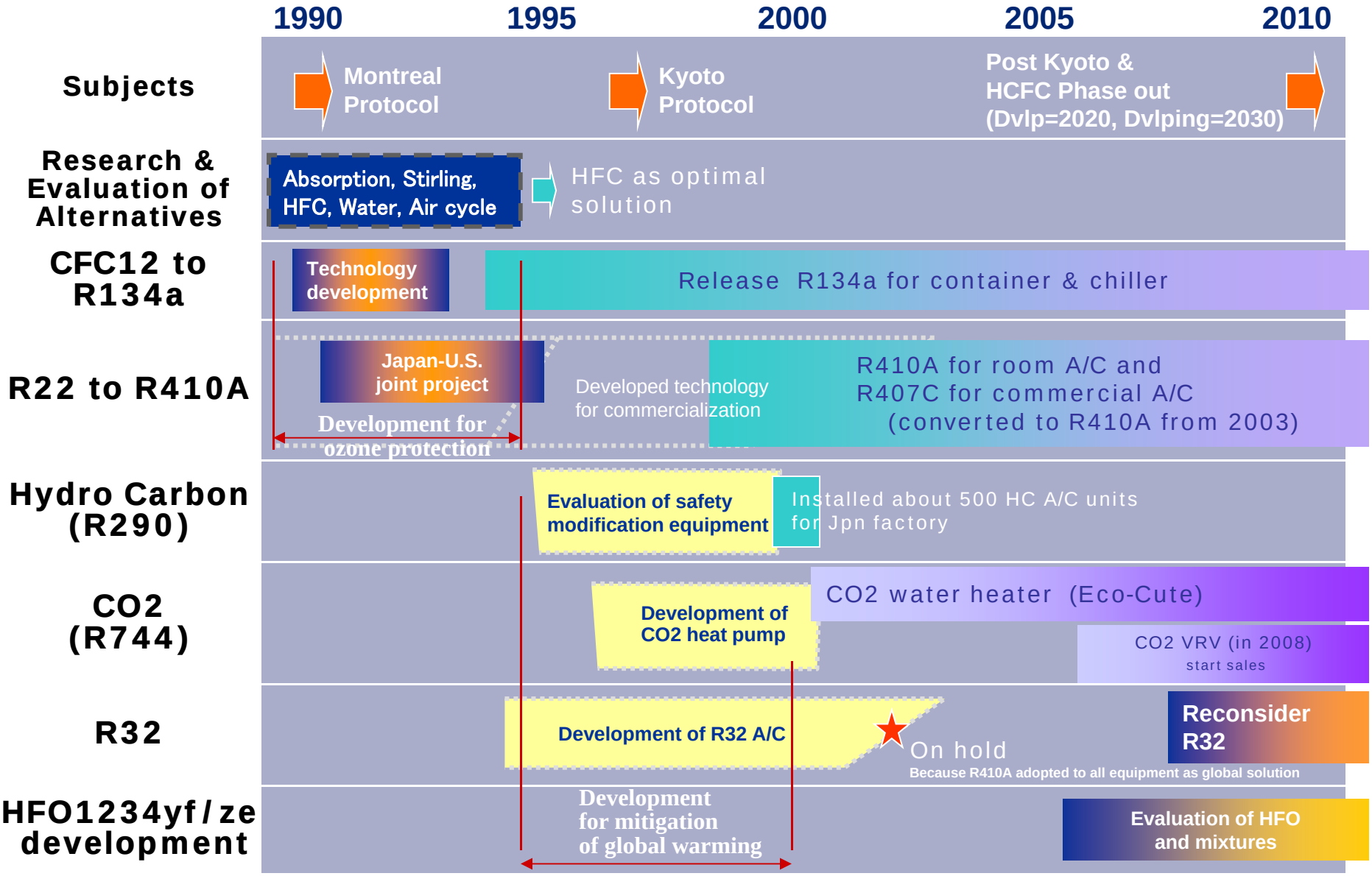
Impact of
Commercial Refrigeration



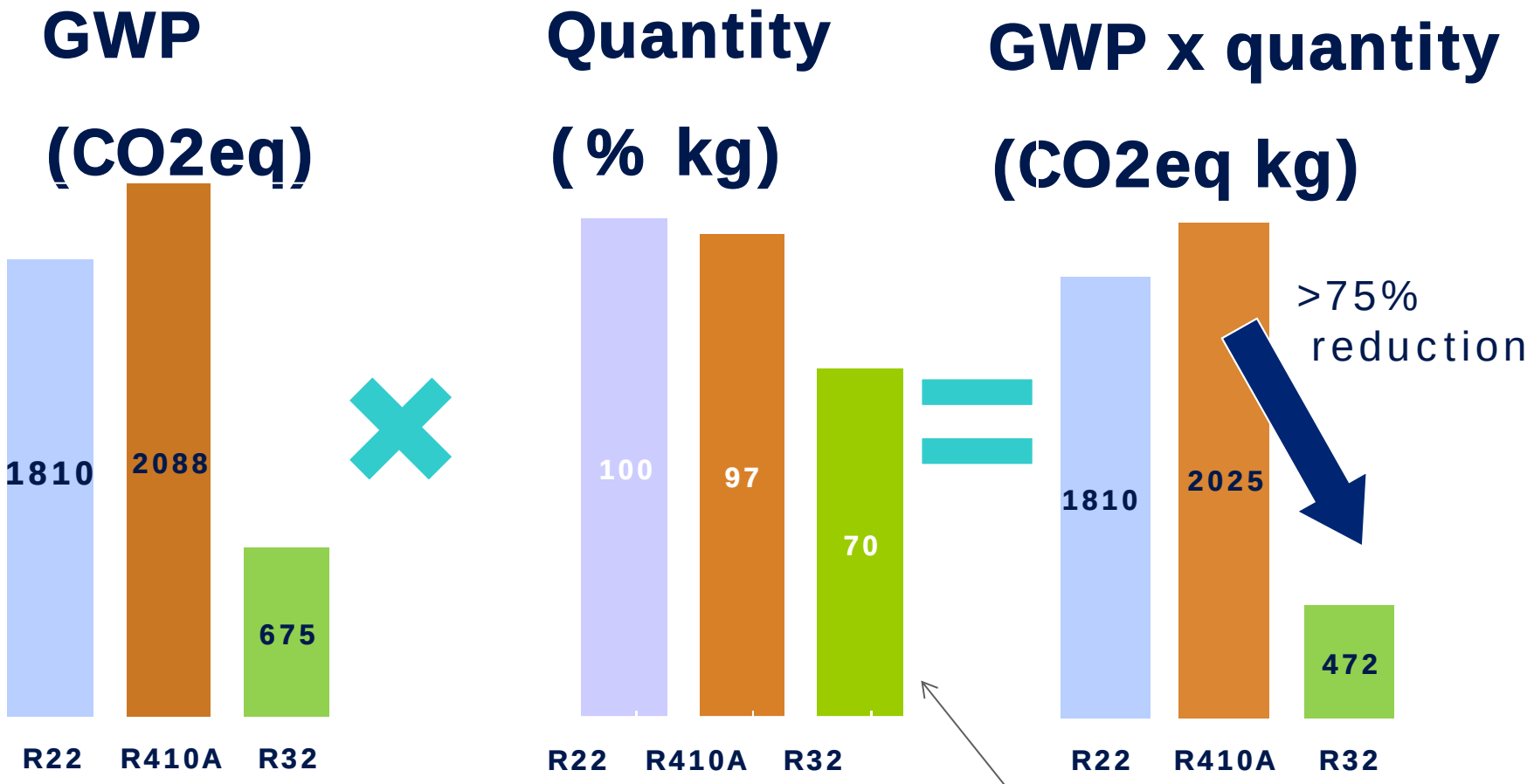
Factors to Consider When Making a Refrigerant Choice



Refrigerant options : Daikin's Experience



Not only GWP but GWP x quantity matters…



- **The direct global warming effect of R32 is only 26% of R22, and 23% of R410A**

	Capacity (kJ/Kg)	Circulate Vol. Ratio
R22	141.7	96%
R410A	136.7	100%
R32	219.8	**52%**

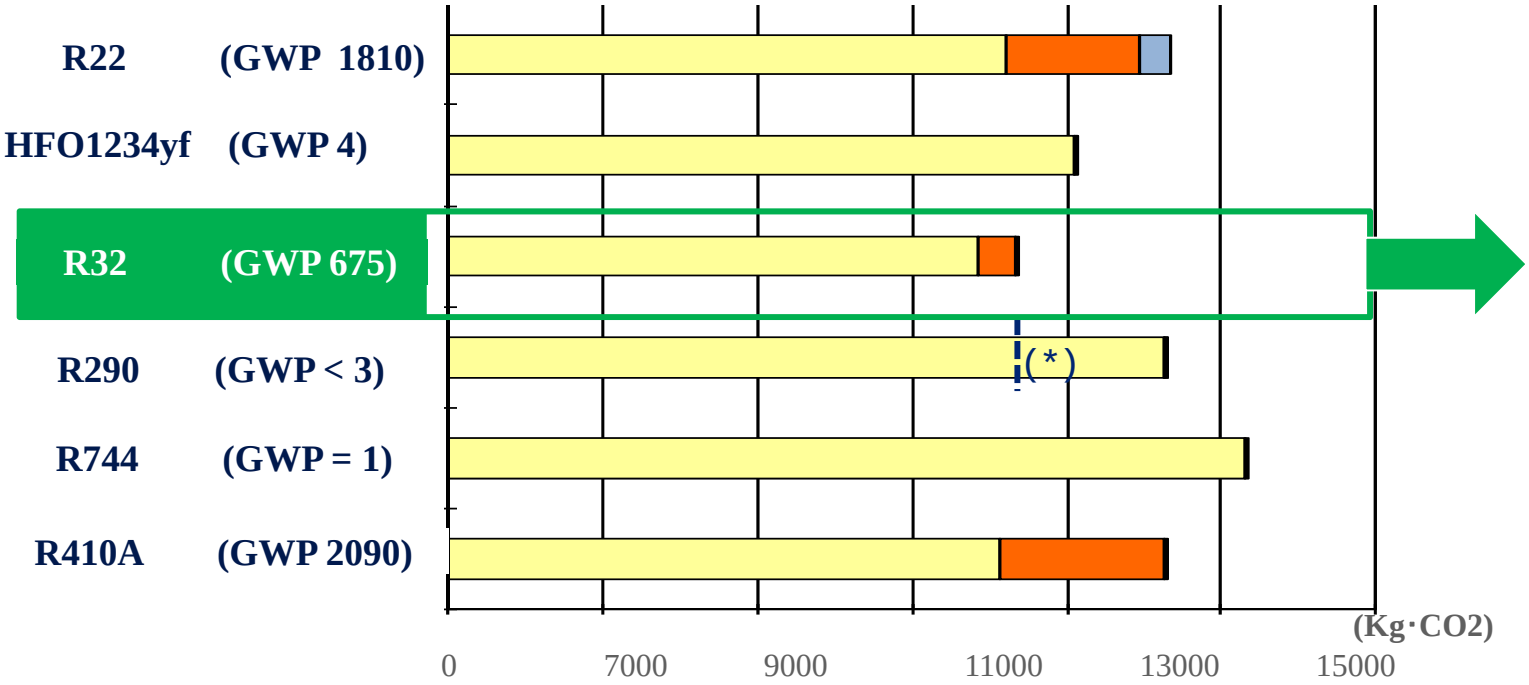
GWP values are based on IPCC 4th report.
(Note : for the EU F gas regulation, the GWP values of the IPCC3 apply where R410A is 1975)

Example : total global warming impact

- **from energy use : Indirect emissions**
- **from refrigerant : Direct emissions (= emissions during refrigerant production, leakage during the lifetime of the product + non recovery at end of life)**

(1) Indirect emissions | (2) Direct emissions | (3) Emissions during refrigerant production

Example : 3.5kW Room A/C in Europe – Ecodesign SEER calculation
(EU Average emissions from electricity = 0.43Kg/kWh)

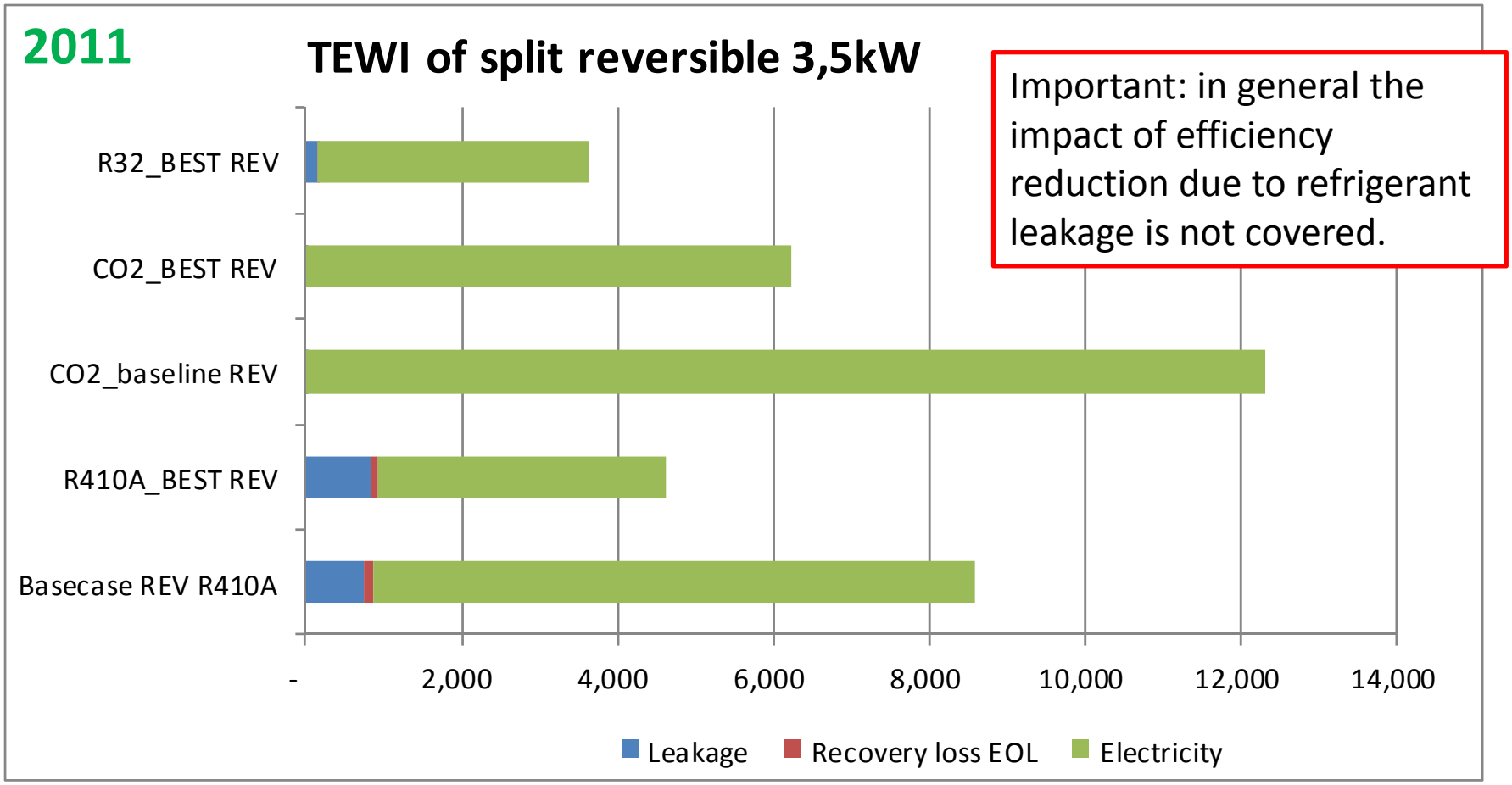


In this case, a refrigerant with a medium GWP has a lower global warming impact than a refrigerant with a low GWP

(*) Note : adding more R290 could achieve same impact as R32, but would be considered unsafe by IEC standards

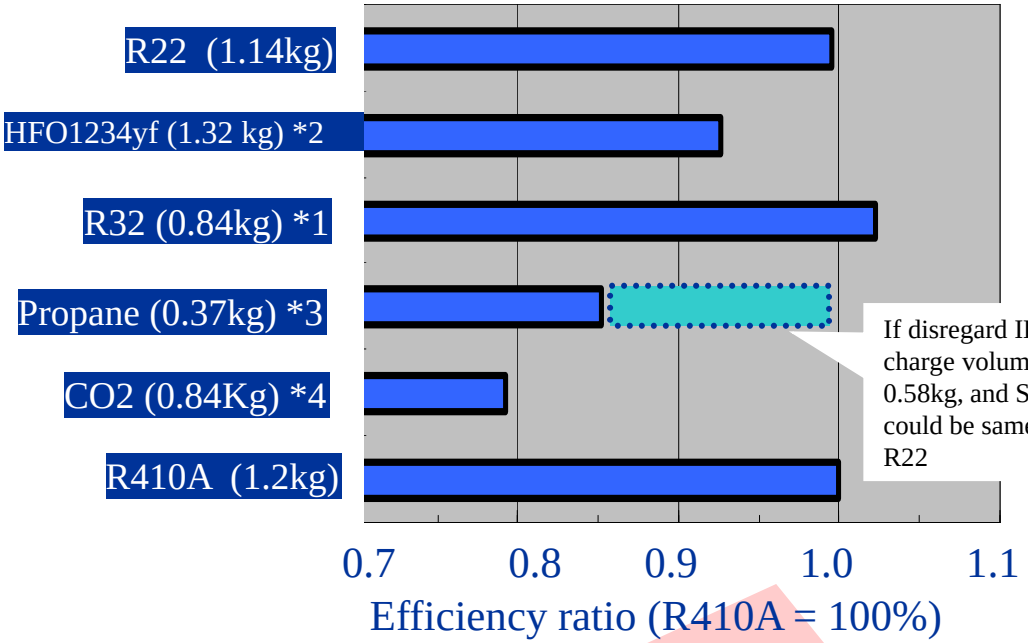
Total Emissions during lifetime: TEWI

Figure 3: TEWI (Total Equivalent Warming Impact) Comparison for 3.5kW Air-Air heat pumps Best Available technology based on Eco-design study Lot 10



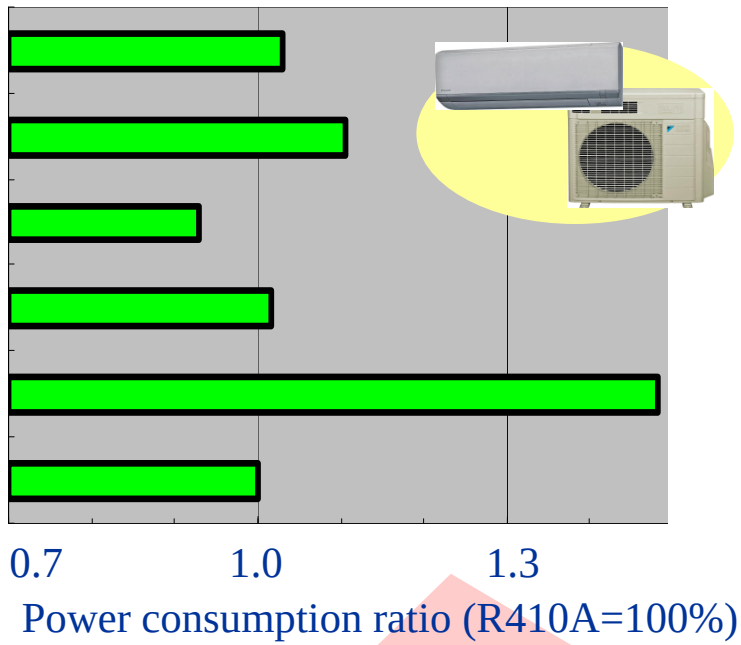
EU Seasonal Energy-efficiencies and peak power conditions

•SEER Comparison (cooling mode)
HPs（Reversible）- 3.5kW-Room AC in Europe



Consideration:
In terms of SEER, CO2 is the worst, and the rest of candidates are equivalent to R410A.

Peak power comparison
(R410A ratio) under cooling condition
Outside 35° C, room 27° CDB/19° CWB

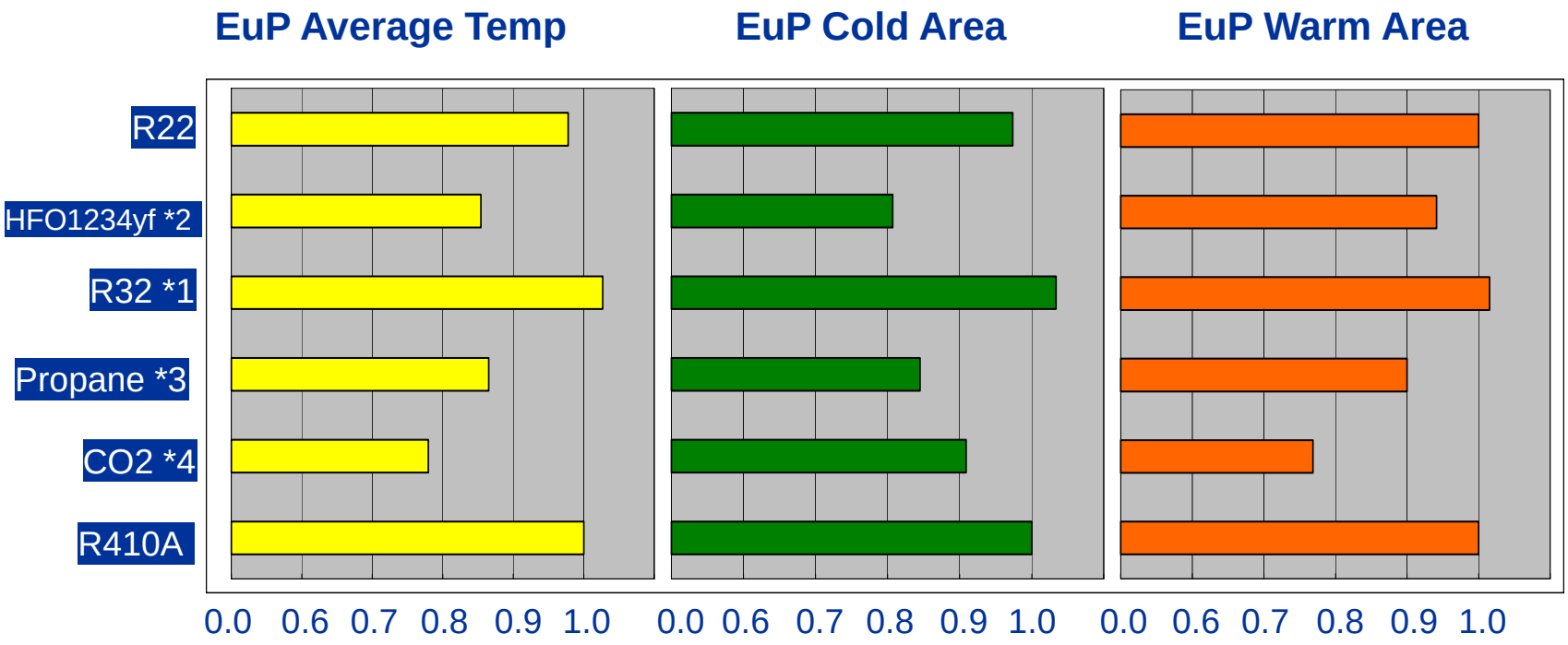


Consideration:
A big difference exists in the peak power under cooling condition. HFO and CO2 will cause the peak power problem in large cities.

(Precondition for Calculation) Note: HX= Heat Exchanger
*1 Taking low pressure loss into consideration, used narrower heat exchanger to reduce charge volume.
*2 To improve efficiency, changed sizes: Indoor HX x 1,1 + Path x 2, Outdoor HX x 1.2, and connecting pipe => 5/8
*3 To meet IEC requirements, charge volume was reduced: Indoor HX x 0.8, Outdoor HX x 0.5, and used narrower piping.
*4 To Improve efficiency: Outdoor unit HX x 1.1

Energy Efficiency: seasonal COP

SCOP Comparison for 3.5kW Air-Air heatpump (R410A Ratio)



R32 has highest SCOP in all climates

(Precondition for Calculation) Note: HX= Heat Exchanger

*1 Taking low pressure loss into consideration, narrower heat exchanger was used to reduce charge volume.

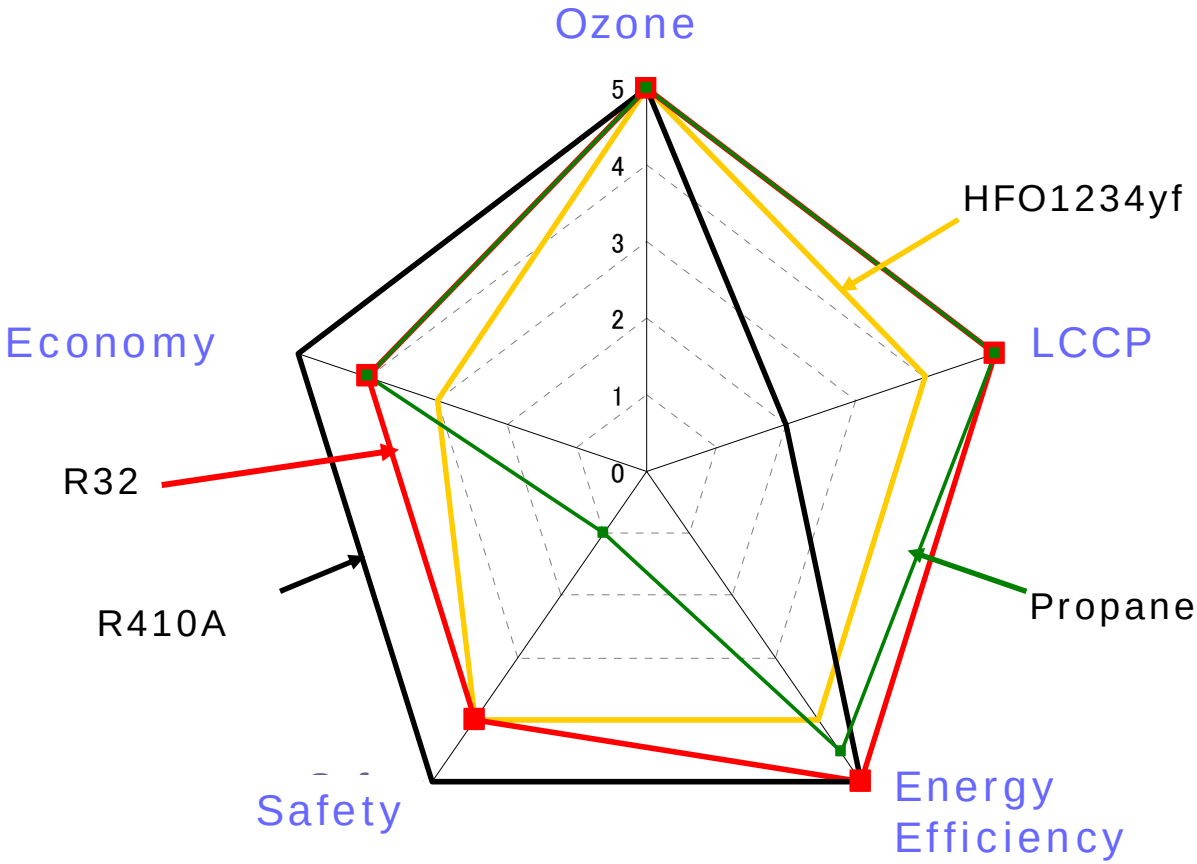
*2 To improve efficiency, HX size was increased : Indoor HX x 1,1 + Path x 2, Outdoor HX x 1.2, and connecting pipe increased from 3/8=> 5/8

*3 To meet IEC requirements, charge volume was reduced: Indoor HX x 0.8, Outdoor HX x 0.5, narrower piping was used.

*4 To Improve efficiency: Outdoor unit HX was increased x 1.1

Comprehensive Comparison

R32 is the Most Balanced



Characteristics of R32

- **Zero ODP**
- **Superior Energy Efficiency (10% better than R22)**
- **Small Global Warming Impact (LCCP)**
- **Small Conversion Cost (almost same as conversion to R410A)**
- **Acceptably Flammable (Class A2L)**
- **Supply capability is sufficient (Suppliers exist now)**