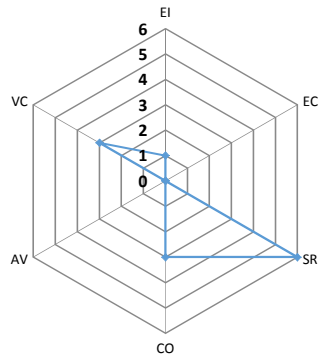
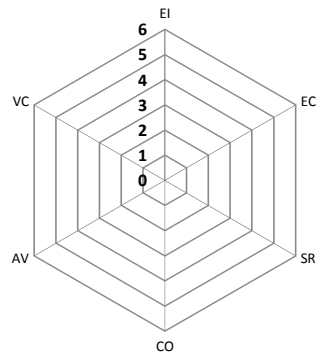
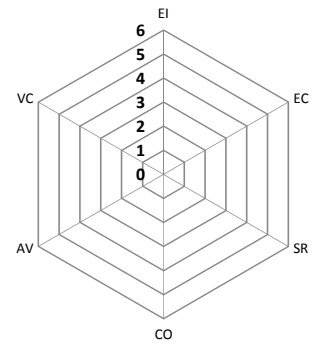
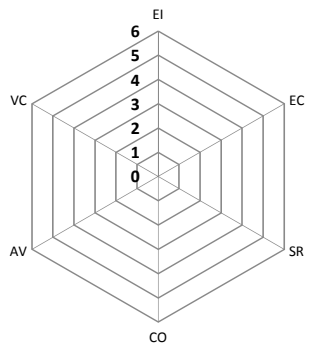
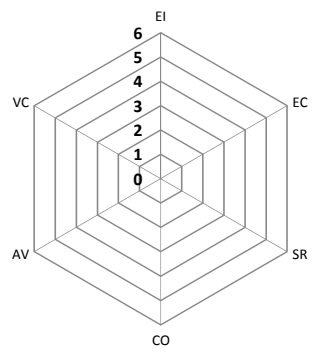
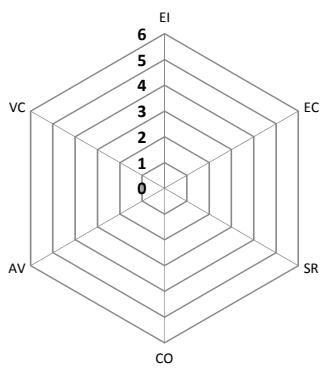
Application Factsheet: REFRIGERATORS AND REFRIGERATORS/FREEZERS			DR1
SECTOR	DOMESTIC REFRIGERATION	**Sub-sector**	Refrigerators only Refrigerators / freezers
Usage / Standard application	Cool and maintain food at low temperature		
Temperature range	-18 à +6 °C		
DESCRIPTION OF THE REFRENCE SYSTEM			
Refrigerant type commonly used / GWP	R-134a GWP = 1370	**Average charge by equipment (kg)**	0.127
Data relative to the refrigerant used	A1		
Installed base			
in France :	9,180,000	**Refrigerant bank in France (t):**	1,161 t (total end 2011)
in Europe :	87,500,000	**Refrigerant bank in Europe (t) :**	11,065 t (total EU27 end 2011)
Average equipment lifetime (years)	15		
Main providers of technologies			
in France :	Brandt-Fagor		
in Europe :	Bosch, Brandt-Fagor, Whirlpool, Electrolux, Siemens, Indesit, Liebherr, Candy		
Main owners of equipment			
in France :			
in Europe :			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable, ODP = 0 R-12 replacement fluid Discharge temperature 8-10 K lower than R-12 Adapted to medium-temperature equipment, performance close to R-12 Good material compatibility Type POE lubricant		
Specific applicable regulations and standards			
in France :	Decree n° 2011-764 of 28 June 2011 Art.3 related to the energy consumption of refrigeration equipment NF EN 60335-2-24 January 2010 specific rules for refrigeration equipment, ice cream machines and ice maker NF EN 378-2 on safety an environmental requirements for refrigeration systems and heat pumps		
in Europe :	Regulation 842/2006/CE EN 378 EN 60335-2-89 Regulation 643/2009/Ececo design requirements applicable to domestic refrigerators 2006/95/EC directive relative to low tension tension 2004/108/EC directive relative to electromagnetic compatibility		
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: HC-600a direct system	**Case 2:**	**Case 3:**
Technical principle	Vapor compression system		
Installed base in operation			
in France :	Significant installed base, 8,457,000 end 2011		
in Europe :	Significant installed base, 64,117,000 EU27 end 2012		
Applicable regulations and existing standards			
in France :	Order TMD related to transport of hazardous goods		
in Europe :	67/548/EEC directive related to the classification, packaging and labelling of hazardous substances ADR Regulation related to road transport of hazardous goods EN378 related to the safety of domestic equipments		
GWP	4		
Energy efficiency	Slightly better than R-134a		
Volumetric capacity	40% lower than R-134a		
Availability	Widely available		
Main barriers to the solution expansion	Flammable Low volumetric capacity High compression ratio Limited to low refrigeration capacity		
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	45% charge reduction compared to R-134a Operation pressures lower than that of R-134a Discharge temperature lower than that of R-134a		
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			
TECHNICAL ALTERNATIVES UNDER DEVELOPMENT			
	Case 1:	**Case 2:**	**Case 3:**
Technical principle			
Industrial availability			
Existence of demonstrators or operational prototypes			
Regulation and standard status			
en France :			
en Europe :			
GWP			
Energy efficiency			
Volumetric capacity			
Probable date of commercial availability			
Main barriers to the solution expansion			
Context promoting this technique implementation (Drop in or not, impact on the charge, …)			
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			
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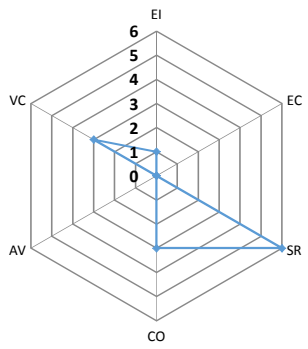
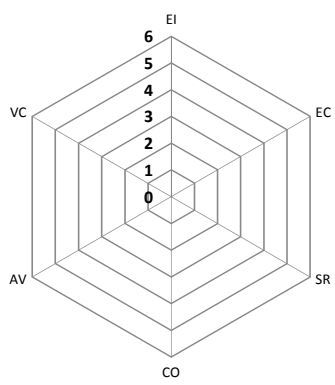
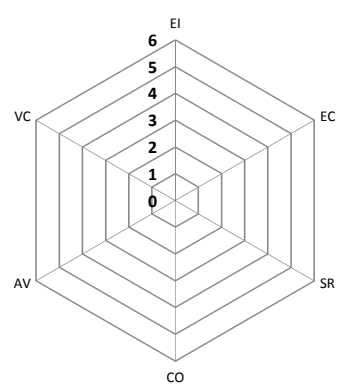
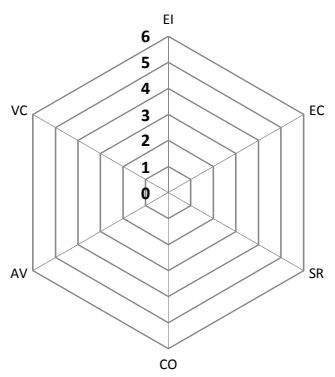
Application Factsheet: FREEZERS			DR2
SECTOR	DOMESTIC REFRIGERATION	**Sub-sector**	Freezers
Usage / Standard application	Cool and maintain food at below zero temperatures		
Temperature range	-18°C		
DESCRIPTION OF THE REFRENCE SYSTEM			
Refrigerant type commonly used / GWP	R-134a GWP = 1370	**Average charge by equipment (kg)**	0.135
Data relative to the refrigerant used	A1 On the market, 5% in France and 20% in Europe Installed base, 88% in France and 54% in Europe		
Installed base			
in France :	3,015,000	**Refrigerant bank in France (t):**	408 t (total end 2011)
in Europe :	23,100,800	**Refrigerant bank in Europe (t) :**	3,127 t (total EU27 end 2011)
Average equipment lifetime (years)	15		
Main providers of technologies			
in France :	Brandt-Fagor		
in Europe :	Bosch, Brandt-Fagor, Whirlpool, Electrolux, Siemens, Indesit, Liebherr, Candy		
Main owners of equipment			
in France :			
in Europe :			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable, ODP = 0 R-12 replacement fluid Discharge temperature 8-10 K lower than R-12 Adapted to medium-temperature equipment, performance close to R-12 Good material compatibility Type POE lubricant		
Specific applicable regulations and standards			
in France :	Decree n° 2011-764 of 28 June 2011 Art.3 related to the energy consumption of refrigeration equipment NF EN 60335-2-24 January 2010 specific rules for refrigeration equipment, ice cream machines and ice maker NF EN 378-2 on safety an environmental requirements for refrigeration systems and heat pumps		
in Europe :	Regulation 842/2006/CE EN 378 EN 60335-2-89 Regulation 643/2009/Ececo design requirements applicable to domestic refrigerators 2006/95/EC directive relative to low tension tension 2004/108/EC directive relative to electromagnetic compatibility		
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: HC-600a direct system	**Case 2:**	**Case 3:**
Technical principle	Vapor compression system		
Parc d'équipements en service			
in France :	Significant installed based: 8,457,000 end		
in Europe :	Significant installed based: 64,117,000 EU27 end 2012		
Applicable regulation and existing standards			
in France :	Order TMD related to transport of hazardous goods		
in Europe :	67/548/EEC directive related to the classification, packaging and labelling of hazardous substances ADR Regulation related to road transport of hazardous goods EN378 related to the safety of domestic equipments		
GWP	4		
Energy efficiency	Slightly better than R-134a		
Volumetric capacity	40% lower than R-134a		
Availability	Widely available		
Main barriers to the solution expansion	Flammable Low volumetric capacity High compression ratio Limited to low refrigeration capacity		
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	45% charge reduction compared to R-134a Service pressures lower than that of R-134a Discharge temperature lower than that of R-134a		
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			
ALTERNATIVES TECHNIQUES EN COURS DE DEVELOPPEMENT			
	Case 1:	**Case 2:**	**Case 3:**
Technical principle			
Industrial availability			
Existence of demonstrators or operational prototypes			
Règlementation et état des normes			
en France :			
en Europe :			
GWP			
Energy efficiency			
Volumetric capacity			
Probable date of commercial availability			
Main barriers to the solution expansion			
Context promoting this technique implementation (Drop in or not, impact on the charge, …)			
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			

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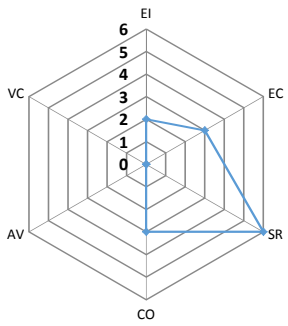
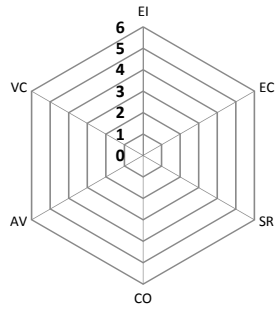
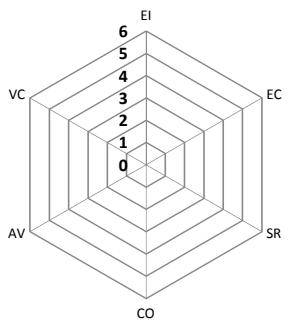
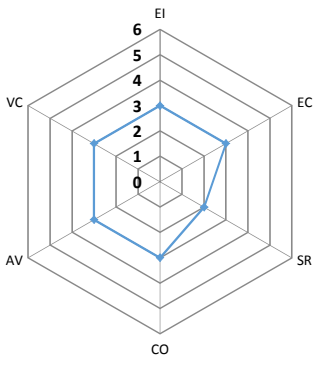
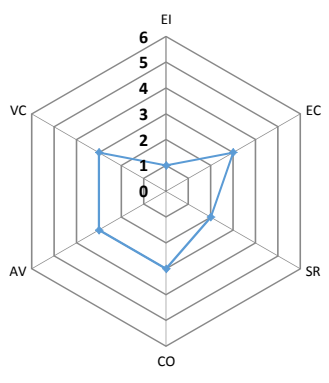
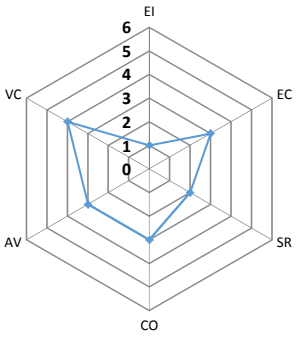
Application Factsheet: Stand-alone display cases			CR1
SECTOR	COMMERCIAL REFRIGERATION	**Sub-sector**	Small stores
Usage / Standard application	Mini-markets, general food stores, vending machines		
Temperature range	-18 à +6°C		
DESCRIPTION OF THE REFRENCE SYSTEM			
Refrigerant type commonly used / GWP	R-134a GWP = 1 370	**Charge moyenne par équipement (kg)**	1.23
Data relative to the refrigerant used	A1 99% sur le marché et dans le parc en France et en Europe		
Installed base			
in France :	406	**Refrigerant bank in France (t):**	498 t (total end 2011)
in Europe :	4,795,000	**Refrigerant bank in Europe (t) :**	4,53 t (total EU27 end 2011)
Average equipment lifetime (years)	15		
Main providers of technologies			
in France :	Foster		
in Europe :	Foster, Gamgo, Unifrigor, IGLOO, Hussmann, SARO, True, Randel, Frost Tech		
Main owners of equipment			
in France :			
in Europe :			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable, ODP = 0 R-12 replacement fluid Discharge temperature 8-10 K lower than R-12 Adapted to medium-temperature equipment, performance close to R-12 Good material compatibility Type POE lubricant		
Règlementations et normes spécifiques applicables			
in France :	NF EN 378 related to safety and environmental requirements of refrigerations systems and heat pumps NF EN 60335-2-89 related so specific sagety rules for refrigeration equipment of commercial use including a condensing unit or an integrated or remote compressor		
in Europe :	Regulation 842/2006/CE EN 441 for refrigerated display cases EN 378 EN 60335-2-89 EN 14276-1 and 14276-2		
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: HC-290	**Case 2:**	**Case 3:**
Technical principle	Vapor compression, direct expansion		
Installed base			
in France :	Significant: 8,457,000 end 2011		
in Europe :	Significant: 64,117,000 EU27 end 2012		
Applicable regulation and existing standards			
in France :			
in Europe :	EN378		
GWP	6		
Energy efficiency	Slightly better thanR-134a		
Volumetric capacity	30% higher than R-134a		
Availability	Available		
Main barriers to the solution expansion	Flammable and explosive Limited to low refrigeration capacity Service pressure similar to that of R-22		
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	40% charge reduction vs. R-134a Adapted to higher ambient temperature (up to 43°C) Compactness of equipment (compressor, heat exchangers, piping …) Cost reduction		
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			
ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: refrigerant blend GWP < 700	**Case 2: R-1234yf**	**Case 3 : R-1234ze [E]**
Technical principle	XP-10: R-134a/1234yf (44/56) N-13a: R-134a/1234yf/1234ze (42/18/40)		
Industrial availability	No	No	No
Existence of demonstrators or operational prototypes	Yes	Yes	Yes
Applicable reguLation and status of standards			
in France :			
in Europe :	EN378	EN378	EN378
GWP	605 for XP-10, 579 for N-13a	4	6
Energy efficiency	COP -5 at -10% vs. R-134a	COP -10% vs. R-134a	COP -3 %
Volumetric capacity	-5% refrigeration capacity vs. R-134a	-6 à -10% refrigeration capacity vs. R-134a	-25% refrigerating capacity vs. R-134a
Probable date of commercial availability	XP-10 in 2013	In 2013, R-1234yf for MAC + RAC	2015 en masse
Main barriers to the solution expansion	Slightly flammable A2L	Slightly flammable A2L	Slightly flammable A2L
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Charge similar to that of R-134a	Charge similar to that of R-134a	Refrigerant charge similar to that of R-134a
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			
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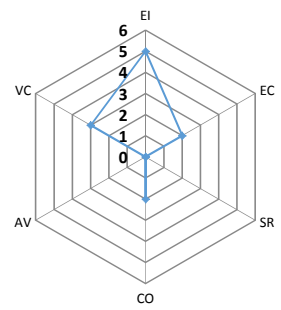
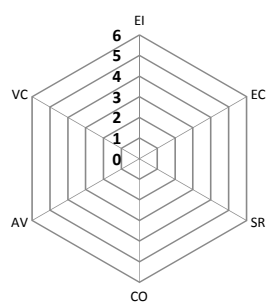
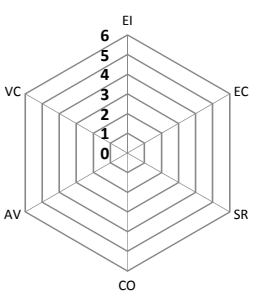
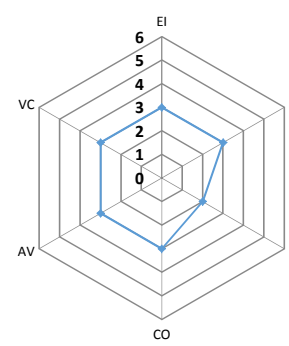
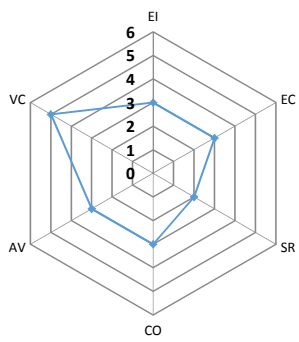
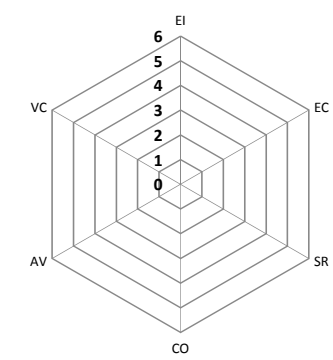
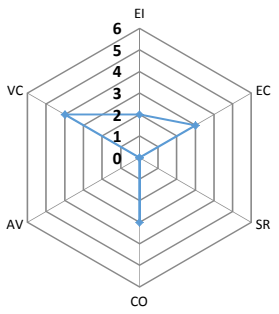
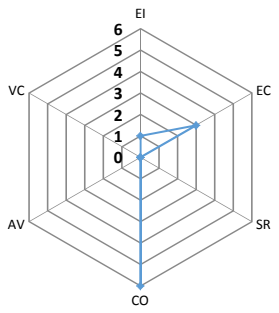
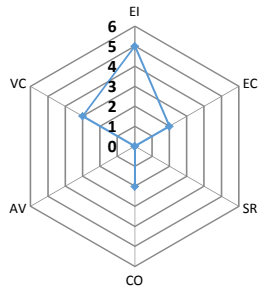
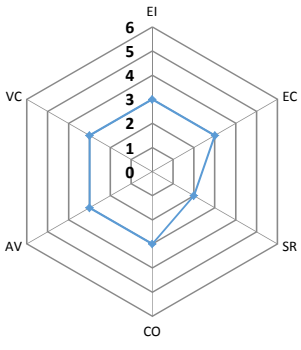
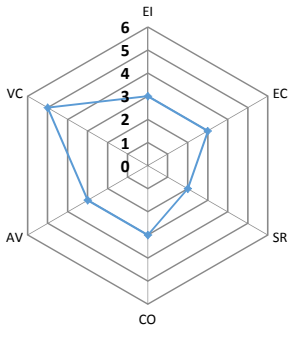
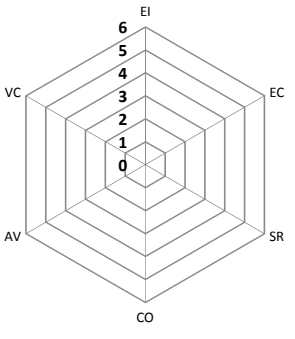
Application Factsheet: Condensing units for commercial refrigeration			CR2
SECTOR	Commercial Refrigeration	**Sub-sector**	Small stores
Usage / Standard application	Mini-markets, general food stores, bars and restaurants, butcheries		
Temperature range	-18 à +6 °C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-404A GWP = 3 700	**Average charge by equipment (kg)**	1 to 5 kg
Data relative to the refrigerant used	A1 On the market, 100% in France and in Europe In the installed base, 86.8% in France, 97.4% in Europe		
Parc d'équipements en service			
in France :	285	**Refrigerant bank in France (t):**	2,086 t (total end 2011)
in Europe :	3,331,100	**Refrigerant bank in Europe (t) :**	22,014 t (total EU27 end 2011)
Average equipment lifetime (years)	15		
Main providers of technologies			
in France :	Tournus		
in Europe :	Sagi, Foster, Saro, Williams, Randell, Tecfrigo, Mafirol, Tournus, Igloo, Hussmann		
Main owners of equipment			
in France :			
in Europe :			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable ODP = 0 Adapted to medium and low-temperature equipement Decrease of the energy consumption		
Regulations and applicable specific standards			
in France :	NF EN 378 related to safety and environmental requirements of refrigerations systems and heat pumps NF EN 60335-2-89 related so specific sagety rules for refrigeration equipment of commercial use including a condensing unit or an integrated or remote compressor NF EN 14276-1 et 14276-2 related to reservoirs and piping of equipment under pressure for refrigeration systems and heat pumps		
in Europe :	Regulation 842/2006/CE EN 441 for refrigerated display cases EN 378 EN 60335-2-89 EN 14276-1 and 14276-2		
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1 : R-407A or R-407F direct expansion system (new and retrofit)	**Case 2 :**	**Case 3 :**
Technical principle	R-407A - R-32/125/134a (20/40/40) R-407F - R-32/125/134a (30/30/60)		
Installed base			
in France :	First cases in 2013		
in Europe :	First cases in 2013		
Applicable regulations and existing standards			
in France :			
in Europe :			
GWP	R-407A 2100 / R-407F 2060		
Energy efficiency	Similar to R-404A at medium temperature		
Volumetric capacity	Similar to R-404A at medium temperature		
Availability	Available		
Main barriers to the solution expansion	Environmental impact: GWP and hagh chargebecausze retrofit Uncertainty on the refrigerant price		
Context promoting this technique implementation (Drop in or not, impact on the charge, ...)	Solutions available in retrofit		
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			
ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: refrigerant blend GWP in the range of 300	**Case 2: ARM-31a**	**Case 3 :**
Technical principle	ARM-30a : R-32/1234yf (29/71) L-40 : R-32/152a/1234yf/1234ze (40/10/20/30) D2Y-65 : R-32/1234yf (35/65) DR-7 : R-32/1234yf (36/64)	R-32/134a/1234yf (28/21/51)	
Industrial availability	No	No	
Existence of demonstrators or operational prototypes	Yes	Yes	
Regulation and status of standards			
in France :			
in Europe :	EN378	EN378	
GWP	ARM-30a: 210 L-40: 302 D2Y-65: 253 DR-7: 260	490	
Energy efficiency	L-ARM-30a: COP - 11% vs. R-404A L-40: COP - 14% vs. R-404A DR-7: COP + 7% vs. R-404A	COP +6% vs. R-404A	
Volumetric capacity	ARM-30a: - 19% vs. R-404A L-40: -17% vs. R-404A DR-7:+ 2% vs. R-404A	-9% vs. R-404A	
Probable date of commercial availability	2014 - 2015 ?		
Main barriers to the solution expansion	Slightly flammable A2L Uncertainty on the refrigerant price	Slightly flammable A2L	
Context promoting this technique implementation (Drop in or not, impact on the charge, ...)	L-40: +5% charge vs. R-404A D2Y-65: -5% charge vs. R-404A	Charge similar to that of R-404A	
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			
AFCE, UNICLIMA, ADEME Report: Alternatives to high-GWP HFCs in refrigeration and air-conditioning applications, 2013			

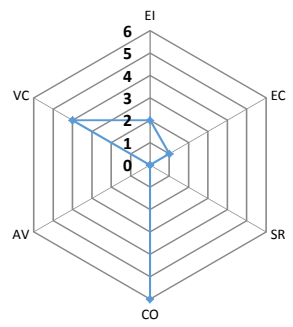
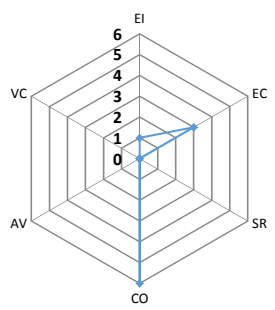
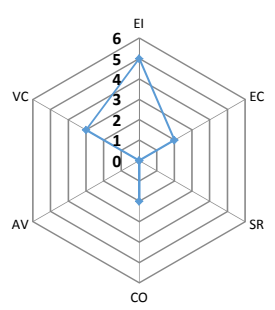
Fiche Application : Système centralisé à détente directe ou indirecte en froid positif seul			CR3
SECTOR	Commercial refrigeration	**Sub-sector**	Supermarkets
Usage / Standard application	Supermarkets		
Temperature range	0 à +6°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-404A GWP = 3700; R-507A GWP = 3800	**Average charge by equipment (kg)**	300
Data relative to the refrigerant used	A1 On the market: 86% in France, 82% in Europe In the installed base: 80% in France and 76% in Europe		
Installed base in operation			
in France :	90% of the installed base	**Refrigerant bank in France (t):**	1,279 t (total end 2011)
in Europe :	90% of the installed base	**Refrigerant bank in Europe (t) :**	20,24 t (total EU27 end 2011)
Average equipment lifetime (years)	15		
Main providers of technologies			
in France :	Bonnet Névé, Synergies, Tournus		
in Europe :	Bonnet Névé, Costan, Frost trol, Koxka, Forgel, CoolPac, Synergies, Mafirol, Frigomeccanica, Tournus, Enofrigo, Hussmann, Tecfrigo		
Main owners of equipment			
in France :	Large supermarket chains		
in Europe :	Large supermarket chains		
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable ODP = 0 Adapted to medium and low-temperature equipement Decrease of the energy consumption		
Regulations and applicable specific standards			
in France :	NF EN 378 related to safety and environmental requirements of refrigerations systems and heat pumps NF EN 60335-2-89 related so specific sagety rules for refrigeration equipment of commercial use including a condensing unit or an integrated or remote compressor NF EN 14276-1 et 14276-2 related to reservoirs and piping of equipment under pressure for refrigeration systems and heat pumps		
in Europe :	Regulation 842/2006/CE EN 441 for refrigerated display cases EN 378 EN 60335-2-89 EN 14276-1 and 14276-2		

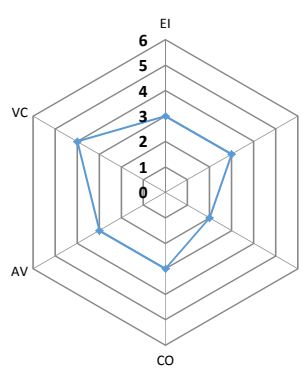
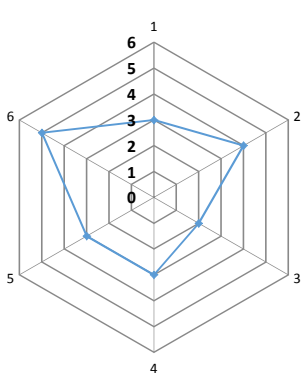
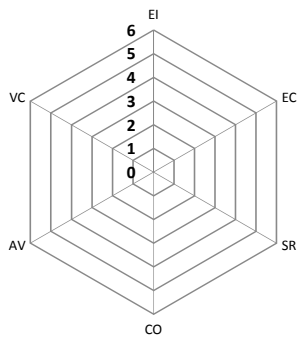
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: R-134a + indirect system Heat transfer fluid	**Case 2: R-744 transcritical**	**Case 3: R-407A or R-407F in direct expansion system (new and retrofit)**
Technical principle			R-407A - R-32/125/134a (20/40/40) R-407F - R-32/125/134a (30/30/60)
Parc d'équipements en service			
in France :	50	4 under development	First cases in2013
in Europe :	Not communicated	Not communicated	First cases in2013
Applicable regulations and existing standards			
in France :	Regulation 842/2006/CE	PED	
in Europe :	Regulation 842/2006/CE		
GWP	1370 / 1	1	R-407A 2100 / R-407F 2060
Energy efficiency	At medium temperature, +5% vs. R-404A	Equivalent if not better than R-404A in clod climate, lower in south of Loire	Similar to R-404A at medium temperature
Volumetric capacity	-20 à -30% R-134a vs. R-404A	+10% vs. R-404A	Similar to R-404A at medium temperature
Availability	Available	Available	Available
Main barriers to the solution expansion	No barrier if designed for R-1234yf retrofit	Low COP in transcritical, not adapted for hot climate High service pressure Cost +50%	Environmental impact: GWP and hagh chargebecausze retrofit Uncertainty on the refrigerant price
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Lower HP Possibility of retrofit R-134a/ R-1234yf or R-1234ze at medium term depending on the evolution of regulation on flammables.	Good heat transfer properties, low pinch HX Compactness	Solutions available in retrofit
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			

ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: Refrigerant blend GWP around 300	**Case 2: ARM-31a**	**Case 3 :**
Technical principle	L-40: R-32/152a/1234yf/1234ze (40/10/20/30) D2Y-65: R-32/1234yf (35/65) DR-7: R-32/1234yf (36/64) ARM-30a: R-32/1234yf (29/71)	R-32/134a/1234yf (28/21/51)	
Industrial availability	No	No	
Existence of demonstrators or operational prototypes	Yes	Yes	
Regulation and status of standards			
in France :			
in Europe :	EN 378	EN 378	
GWP	ARM-30a : 210 L-40 : 302 D2Y-65 : 253 DR-7 : 260	490	
Energy efficiency with evaporation at 0°C	'ARM-30a : + 6 % vs. R-404A L-40 : COP + 5 % vs. R-404A DR-7 : COP + 7 % vs. R-404A	COP +6% vs. R-404A	
Volumetric capacity with evaporation at 0°C	ARM-30a : +4 % vs. R-404A L-40 : +2 % vs. R-404A DR-7 : +11 % vs. R-404A	-9% vs. R-404A	
Probable date of commercial availability	2014- 2015 ?		
Main barriers to the solution expansion	Slightly flammable A2L Uncertainty on the refrigerant price	Slightly flammable A2L Uncertainty on the refrigerant price	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Drop in L-40: +5% charge vs. R404A D2Y-65: -5% charge vs. R404A	Charge similar to that of R-404A	
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			

AFCE, UNICLIMA, ADEME Report: Alternatives to high-GWP HFCs in refrigeration and air-conditioning applications, 2013

Application factsheet: Direct or indirect centralized systems (low and medium-temperatures)			CR4
SECTOR	Commercial refrigeration	**Sub-sector**	Supermarkets Large supermarkets
Usage / Standard application	Supermarchés, hypermarchés		
Temperature range	-18 à +6°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-404A GWP = 3700; R-507A GWP = 3800	**Average charge by equipment (kg)**	1000
Data relative to the refrigerant used	A1 On the market: 86% in France, 94% in Europe In the installed base: 85% in France and 84% in Europe		
Installed base in operation			
in France :	95% of the installed base	**Refrigerant bank in France (t):**	1,780 t (total end 2011)
in Europe :	90% of the installed base	**Refrigerant bank in Europe (t) :**	12,170 t (total EU27 end 2011)
Average equipment lifetime (years)	15		
Main providers of technologies			
in France :	Bonnet Névé, Synergies, Tournus		
in Europe :	Bonnet Névé, Costan, Frost trol, Koxka, Forgel, CoolPac, Synergies, Mafirol, Frigomeccanica, Tournus, Enofrigo, Hussmann, Tecfrigo		
Main owners of equipment			
in France :	Large chaines of supermarkets and large supermarkets		
in Europe :	Large chaines of supermarkets and large supermarkets		
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable ODP = 0 Adapted to medium and low-temperature equipement Decrease of the energy consumption		
Regulations and specific applicable standards			
in France :	NF EN 378 related to safety and environmental requirements of refrigerations systems and heat pumps NF EN 60335-2-89 related so specific sagety rules for refrigeration equipment of commercial use including a condensing unit or an integrated or remote compressor NF EN 14276-1 et 14276-2 related to reservoirs and piping of equipment under pressure for refrigeration systems and heat pumps		
in Europe :	Regulation 842/2006/CE EN 441 for refrigerated display cases EN 378 EN 60335-2-89 EN 14276-1 and 14276-2		

EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: R-134a/CO_2 cascade can be retrofitted in R-1234yf/CO_2	**Case 2: transcritical R-744**	**Case 3: R-407A or R-407F in direct expansion system (new and retrofit)**
Technical principle	Vapor compression	Vapor compression	R-407A - R-32/125/134a (20/40/40) R-407F - R-32/125/134a (30/30/60)
Installed base in operation			
in France :	450	3	First cases in2013
in Europe :	Not communicated	1 000	First cases in2013
Applicable regulations and existing standards			
in France :	'Regulation 842/2006/CE	PED	
in Europe :	'Regulation 842/2006/CE		
GWP	1370 / 1 then 4/1	1	R-407A 2100 / R-407F 2060
Energy efficiency	Good energy efficiency of "cascade" systems	Equivalent if not better than R-404A in clod climate, lower in south of Loire	Similar to R-404A at medium temperature
Volumetric capacity	-20 à -30% vs. R-404A	+10% vs. R-404A	Similar to R-404A at medium temperature
Availability	Available	Available	Available
Main barriers to the solution expansion	Cost	Low COP in transcritical, not adapted to hot climates High service pressure Cost +50%	Environmental impact: GWP and hagh chargebecausze retrofit Uncertainty on the refrigerant price
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Lower HP Retrofit possibility R-134a/ R-1234yf or R-1234ze at medium term depending on the evolutoin on flammable regulation.	Good properties of heat transfer, low pinch HX Compactness	Solutions available in retrofit
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			

ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: refrigerant blend GWP around 300	**Case 2: ARM-31a**	**Case 3:**
Technical principle	L-40 : R-32/152a/1234yf/1234ze (40/10/20/30) D2Y-65 : R-32/1234yf (35/65) DR-7 : R-32/1234yf (36/64) ARM-30a : R-32/1234yf (29/71)	R-32/134a/1234yf (28/21/51)	
Industrial availability	No	No	
Existence of demonstrators or operational prototypes	Yes	Yes	
Regulation and status of standards			
in France :			
in Europe :	EN 378	EN 378	
GWP	L-40: 302 D2Y-65: 253 DR-7: 260 ARM-30a: 210	490	
Energy efficiency at -30°C	L-40: COP - 14% vs. R-404A DR-7: COP + 7% vs. R-404A ARM-30a: COP - 11% vs. R-404A	COP +6% vs. R-404A	
Volumetric capacity at -30°C	L-40: -17% vs. R-404A DR-7:+ 2% vs. R-404A ARM-30a: - 19% vs. R-404A	-9% vs. R-404A	
Probable date of commercial availability	2014 - 2015 ?		
Main barriers to the solution expansion	Slightly flammable A2L Uncertainty on the refrigerant price	Slightly flammable A2L Uncertainty on the refrigerant price	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	L-40: +5% charge vs. R404A D2Y-65: -5% charge vs. R404A	Charge similar to that of R-404A	
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			

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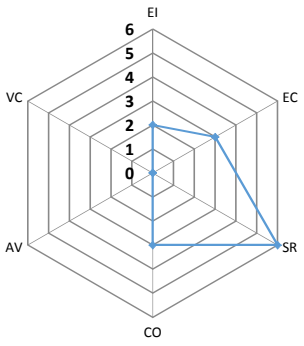
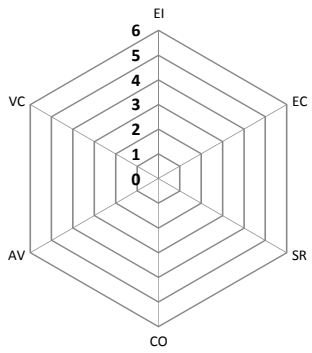
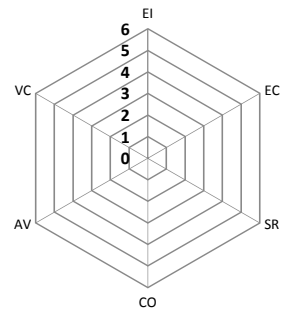
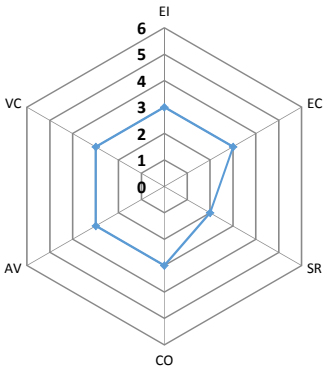
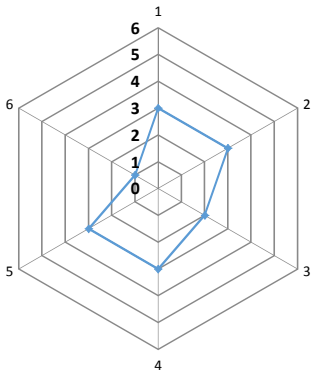
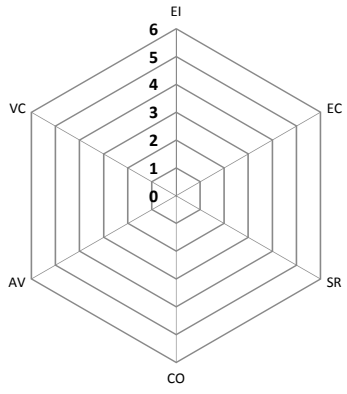
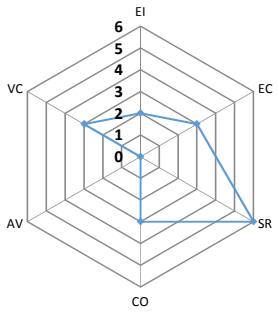
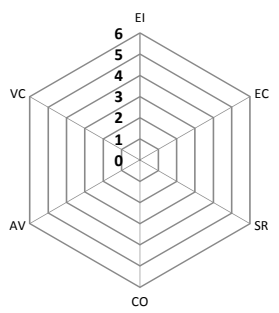
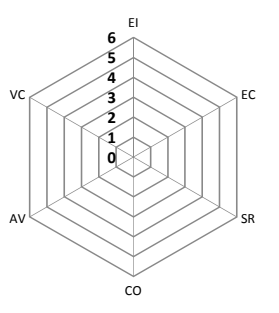
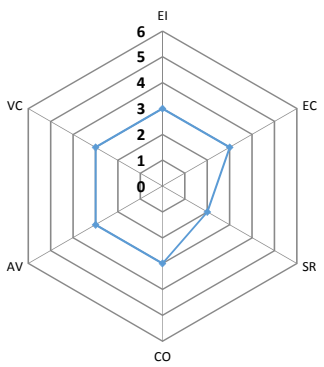
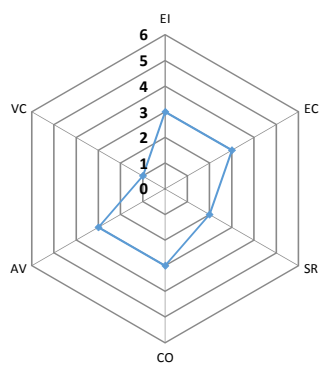
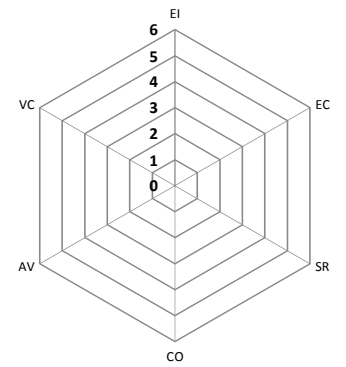
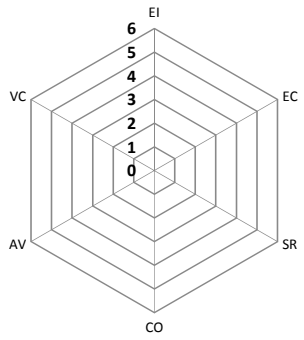
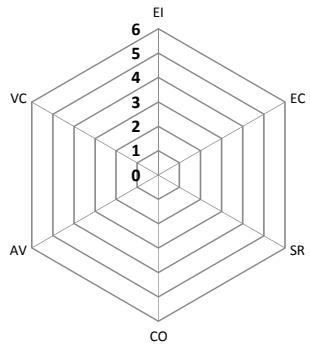
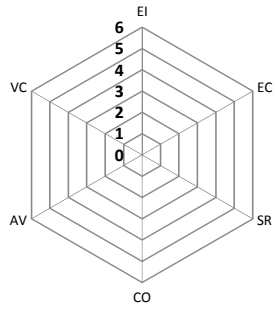
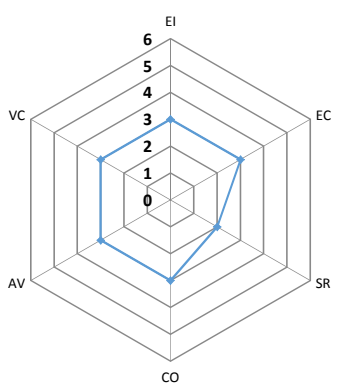
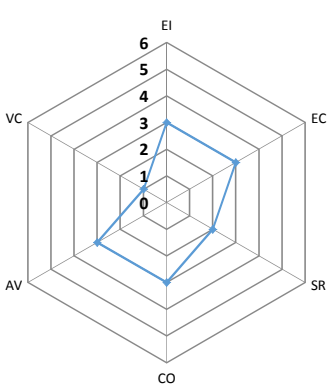
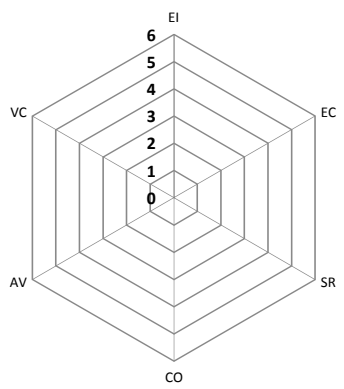
Application Factsheet: Self-contained AC units (windows, through the wall or movable)			SAC1
SECTOR	Air-to-air conditioning	**Sub-sector**	Domestic air conditioning
Usage / Standard application	Movable, Windows		
Temperature range	15 à 32°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-410A GWP = 2100	**Average charge by equipment (kg)**	0.482
Data relative to the refrigerant used	A1 On the market: 100% in France since 2001, in Europe since 2006 In the installed base: 96% in France and 88% in Europe		
Installed base in operation			
in France :	1,223,003	**Refrigerant bank in France (t):**	590 t (total end 2011)
in Europe :	5,371,829	**Refrigerant bank in Europe (t) :**	2,689 t (total EU27 end 2011)
Average equipment lifetime (years)	10		
Main providers of technologies			
in France :	Airwell, Ciat, Technibel, Argo		
in Europe :	Carrier,Airwell, Ciat, Aermec, Technibel, ATA, Norcool, Alpatech, Argo, Electrolux, Delonghi, Whirlpool, Zenith		
Main owners of equipment			
in France :			
in Europe :			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable ODP = 0 Adapted to medium-temperature equipments Efficient and profitable system		
Regulations and specific applicable standards			
in France :	NF EN 14511-4 related to the energy consumption of air conditioners, chillers and heat pumps NF EN 14825 related to the efficiency at partial load of air conditioners, chillers and heat pumps		
in Europe :	Directive ERP 2013 relative to the efficiency of stationary air conditioners ≤ 12 kW		
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: R-290 replacing R-22 and not R-410A	**Case 2:**	**Case 3:**
Technical principle			
Installed base in operation			
in France :			
in Europe :			
Applicable regulatoins and existing standards			
in France :			
in Europe :	EN378		
GWP	6		
Energy efficiency	COP higher than that of R-22		
Volumetric capacity	50% higher than that of R-22		
Availability	Available		
Main barriers to the solution expansion	A3 Flammable and explosive Limited to low refrigeration capacity Service pressures higher than that of R-600a		
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	40% charge reduction vs. R-22 Adapted to higher ambient temperature (up to 43°C) Compactness of equipment (compressor, heat exchangers, piping …) Cost reduction Silent		
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			
ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: refrigerant blend GWP 500	**Case 2 : refrigerant blend GWP 700**	**Case 3 :**
Technical principle	L-41a : R-32/1234yf/1234ze (73/15/12) L-41b : R-32/1234ze (73/27) DR-5 : R-32/1234yf (72,5/27,5) ARM-70a : R-32/134a/1234yf (50/10/40)	ARM-70 (R-32/134a/1234yf) (50/10/40)	
Industrial availability	No	No	
Existence of demonstrators or operational prototypes	Yes	Yes	
Regulation and status of standards			
in France :			
in Europe :	EN 378	EN 378	
GWP	L-41a et L-41b: 524 DR-5: 520 ARM-70: 497	R32: 716 R-32/134a: 749 R-32/152a: 687	
Energy efficiency	L-41a: COP similar to R-410A L-41b: COP -3 % vs. R-410A DR-5: COP slightly higher than R-410A ARM-70a: COP -3 % vs. R-410A	R-32: COP similar to R-410A and +3% in heating mode R-32/R-134a: COP -7% and similar to R-410A in heating mode R-32/R-152a: COP similar to R-410A and +8% in heating mode	
Volumetric capacity	L-41a: -5% L-41b: -10 % DR-5: -3% ARM-70: -10 à -15% vs. R-410A	R-32: +2 to +8% vs. R-410A R-32/152a and R-32/134a: +5 to +10 % vs. R-410A	
Probable date of commercial availability			
Main barriers to the solution expansion	Slightly flammable A2L L-41a : T discharge + 6 à +8 K L-41b : T discharge +12 K DR-5 : T discharge +4 K vs. R-410A ARM-70a : T discharge similar toR-410A	Slightly flammable A2L R-32: T discharge at leat +25 K vs. R-410A R-32/152a: T discharge +10 K vs. R-410A	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	L-41a: charge +4% L-41b: charge -10% DR-5: charge -10% ARM-70a: similir to R-410A	R-32: charge - 20% vs. R-410A R-32/152a: charge +3% vs. R-410A	
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			
AFCE, UNICLIMA, ADEME Report: Alternatives to high-GWP HFCs in refrigeration and air-conditioning applications, 2013			

Application factsheet: Splits and multi-splits (P < 17.5 kW) R-410A			SAC2
SECTOR	Air-to-air conditioning	**Sub-sector**	Domestic air conditioning Non-residential air conditioning
Usage / Standard application	France: Split, Multi-Split Europe: Split < 5 kW, Ducted Split < 18 kW		
Temperature range	15 à 32°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-410A GWP = 2100	**Average charge by equipment (kg)**	1.114
Data relative to the refrigerant used	A1 On ther market: 96% in France and 76% in Europe Oin the installed base: 57% in France and 54% in Europe		
Installed base in operation			
in France :	2,475,607	**Refrigerant bank in France (t):**	2,759 t (total end 2011)
in Europe :	20,600,658	**Refrigerant bank in Europe (t) :**	22,475 t (total EU27 end 2011)
Average equipment lifetime (years)	15		
Main providers of technologies			
in France :	Airwell, Ciat, Technibel		
in Europe :	Ciat, Technibel, Airwell, Aermec, Olimpia Splendid		
Main owners of technologies			
in France :			
in Europe :			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable ODP = 0 Adapted to medium-temperature equipments Efficient and profitable system		
Regulations and specific applicable standards			
in France :	NF EN 14825 related to the efficiency at partial load of air conditioners, chillers and heat pumps NF EN 60335-2-89 related so specific sagety rules for refrigeration equipment of commercial use including a condensing unit or an integrated or remote compressor NF EN 14276-1 et 14276-2 related to reservoirs and piping of equipment under pressure for refrigeration systems and heat pumps		
in Europe :	Regulation 842/2006/CE EN 441 for refrigerated display cases EN 378 EN 60335-2-89 EN 14276-1 and 14276-2 Directive ER-P 2013 relative to the efficiency of stationary air conditioners≤ 12 kW		
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: R-290	**Case 2:**	**Case 3:**
Technical principle	Vapor compression, direct expansion		
Installed base in operation			
in France :			
in Europe :			
Règlementations applicables et normes existantes			
in France :			
in Europe :	EN 378		
GWP	6		
Energy efficiency	Slightly lower than R-410A		
Volumetric capacity	Lower than R-410A		
Availability	Available		
Main barriers to the solution expansion	Flammable and explosive Limited to low refrigerating capacity, charge < 2.5 kg Lower HP		
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	40% charge reduction vs. R-134a Adapted to higher ambient temperature (up to 43°C) Compactness of equipement (compressor, heat exchangers, piping …) Cost reduction		
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			
ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: refrigerant blend GWP 500	**Case 2: refrigerant blend GWP 700**	**Case 3 :**
Technical principle	L-41a: R-32/1234yf/1234ze (73/15/12) L-41b: R-32/1234ze (73/27) DR-5: R-32/1234yf (72,5/27,5) ARM-70a: R-32/134a/1234yf (50/10/40)	R-32 R-32/134a (95/5) R-32/152a (95/5)	
Industrial availability	No	Yes	
Existence of demonstrators or operational prototypes	Yes	Yes	
Regulation and status of standards			
in France :			
in Europe :	EN 378	EN 378	
GWP	L-41a et L-41b: 524 DR-5: 520 ARM-70: 497	R-32: 716 R-32/134a: 749 R-32/152a: 687	
Energy efficiency	L-41a: COP similar to R-410A L-41b: COP -3% vs. R-410A DR-5: COP slightly higher than R-410A ARM-70a: COP -3% vs. R-410A	R-32: COP similar to R-410A R-32/R-152a: COP slightly higher	
Volumetric capacity	L-41a: -5% L-41b: -10% DR-5: -3% ARM-70: -10 à -15% vs. R-410A	R-32: +2 à +8% vs. R-410A R-32/152a et R-32/134a: +5 à +10 % vs. R-410A	
Probable date of commercial availability			
Main barriers to the solution expansion	Slightly flammable A2L L-41a: Discharge temperature + 6 à +8 K L-41b: Discharge temperature +12 K DR-5: Discharge temperature +4 K vs. R-410A ARM-70a: Discharge temperature similar to R-410A	Slightly flammable A2L R-32: T discharge +15 K vs. R-410A	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	L-41a: charge +4% L-41b: charge -10% DR-5: charge -10% ARM-70a: similar to R-410A	R-32: charge - 10% R-32/152a and R-32/134a: charge similar to R-410A	
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			
AFCE, UNICLIMA, ADEME Report: Alternatives to high-GWP HFCs in refrigeration and air-conditioning applications, 2013			

Application factsheet: Multi-splits P >17.W Systèmes VRV and Roofops R-410A			SAC3
SECTOR	Air-to-air air conditioning	**Sub-sector**	Non-residential air conditioning Commercial air conditioning
Usage / Standard application			
Temperature range	15 à 32°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-410A GWP = 2100 et R-407C GWP = 1700	**Average charge by equipment (kg)**	9.547
Data relative to the refrigerant used	A1 Sur le marché, 98 % en France, 56 % en Europe Dans la parc, 31 % en France et 38 % en Europe		
Parc d'équipements en service			
in France :	72	**Refrigerant bank in France (t):**	686 t (total end 2011)
in Europe :	7,535,545	**Refrigerant bank in Europe (t) :**	56,370 t (total EU27 end 2011)
Average equipment lifetime (years)	15		
Main providers of technologies			
in France :	Airwell, Ciat, Trane		
in Europe :	Ciat, Trane, Lennox, York, Climaveneta, Aermec, Emat, Airwell, Solaronics		
Main owners of technologies			
in France :			
in Europe :			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable ODP = 0 Adapted to medium-temperature equipments Efficient and profitable system		
Regulations and specific applicable standards			
in France :	NF EN 60335-2-89 related so specific sagety rules for refrigeration equipment of commercial use including a condensing unit or an integrated or remote compressor NF EN 14276-1 et 14276-2 related to reservoirs and piping of equipment under pressure for refrigeration systems and heat pumps NF EN 14825 related to the efficiency at partial load of air conditioners, chillers and heat pumps		
in Europe :	Regulation 842/2006/CE Directive 2010/31/EU on energy efficiency in buildings EN 378 EN 60335-2-89 EN 14276-1 and 14276-2		

EXISTING ALTERNATIVE TECHNIQUES			
	Case 1:	**Case 2:**	**Case 3:**
Technical principle			
Parc d'équipements en service			
in France :			
in Europe :			
Applicable regulations and existing standards			
in France :			
in Europe :			
GWP			
Energy efficiency			
Volumetric capacity			
Availability			
Main barriers to the solution expansion			
Context promoting this technique implementation (Drop in or not, impact on the charge, …)			
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			

ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: refrigerant blend GWP 500	**Case 2: refrigerant blend GWP 700**	**Case 3 :**
Technical principle	L-41a: R-32/1234yf/1234ze (73/15/12) L-41b: R-32/1234ze (73/27) DR-5: R-32/1234yf (72,5/27,5) ARM-70a: R-32/134a/1234yf (50/10/40)	R-32 R-32/134a (95/5) R-32/152a (95/5)	
Industrial availability	No	Yes	
Existence of demonstrators or operational prototypes	Yes	Yes	
Regulation and status of standards			
in France :			
in Europe :	EN 378	EN 378	
GWP	L-41a et L-41b: 524 DR-5: 520 ARM-70: 497	R-32: 716 R-32/134a: 749 R-32/152a: 687	
Energy efficiency	L-41a: COP similar to R-410A L-41b: COP -3% vs. R-410A DR-5: COP slightly higher than R-410A ARM-70a: COP -3% vs. R-410A	R-32: COP similar to R-410A R-32/R-152a: COP slightly higher	
Volumetric capacity	L-41a: -5% L-41b: -10% DR-5: -3% ARM-70: -10 à -15% vs. R-410A	R-32: +2 à +8% vs. R-410A R-32/152a et R-32/134a: +5 à +10 % vs. R-410A	
Probable date of commercial availability			
Main barriers to the solution expansion	Slightly flammable A2L L-41a: Discharge temperature + 6 à +8 K L-41b: Discharge temperature +12 K DR-5: Discharge temperature +4 K vs. R-410A ARM-70a: Discharge temperature similar to R-410A	Slightly flammable A2L R-32: T discharge +15 K vs. R-410A	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	L-41a: charge +4% L-41b: charge -10% DR-5: charge -10% ARM-70a: similar to R-410A	R-32: charge - 10% R-32/152a and R-32/134a: charge similar to R-410A	
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			

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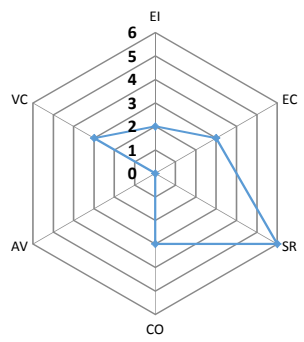
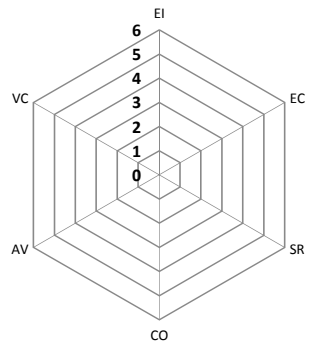
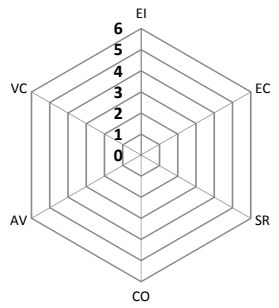
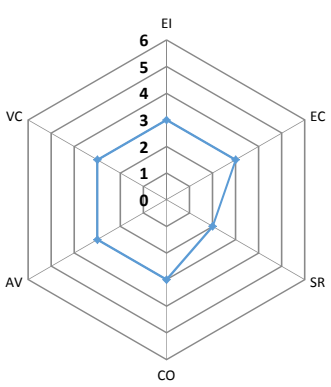
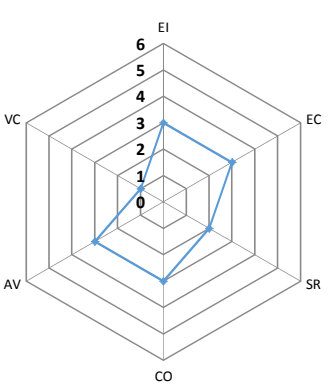
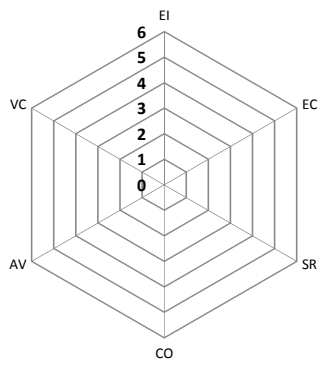
Application factsheet: Air-to-water heat pump using R-410A			HP1
SECTOR	Residential heat pumps	**Sub-sector**	Domestic air contidioning and heating
Usage / Standard application			
Temperature range	15 à 32°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-410A GWP = 2100	**Average charge by equipment (kg)**	3;47
Data relative to the refrigerant used	A1 On the market: 80% in France and i en Europe In the installed base: 72% in France and 65% in Europe		
Installed base in operation			
in France :	342	**Refrigerant bank in France (t):**	1,188 t (total end 2011)
in Europe :	1,781,006	**Refrigerant bank in Europe (t) :**	4,390 t (total EU27 end 2011)
Average equipment lifetime (years)	15		
Main providers of technologies			
in France :	Technibel, Ciat, Atlantic		
in Europe :	Technibel, Viessmann, Ciat, Atlantic, Stiebel eltron, Dimplex		
Main owners of technologies			
in France :			
in Europe :			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable ODP = 0 Adapted to medium-temperature equipments Efficient and profitable system		
Regulations and specific applicable standards			
in France :	NF EN 378 related to safety and environmental requirements of refrigerations systems and heat pumps NF 414 related to HP performance NF EN 14825 related to the efficiency at partial load of air conditioners, chillers and heat pumps		
in Europe :	EN 378 on safety and environmental requirements of refrigeration systems and heat pumps EN 14825 relative to partial load energy efficiency of air-conditioners, chillers and heat pumps		
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: R-290 replacing R-22	**Case 2:**	**Case 3:**
Technical principle			
Installed base in operation			
in France :			
in Europe :			
Applicable regulations and existing standards			
in France :			
in Europe :	EN 378		
GWP	6		
Energy efficiency	COP equivalent to that of R-22		
Volumetric capacity	10% lower than that of R-22		
Availability	Available		
Main barriers to the solution expansion	Flammable and explosive Limited to low refrigeration capacity		
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Adapted to higher ambient temperature (up to 43°C) Compactness of equipement (compressor, heat exchangers, piping …) Cost reduction		
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			
ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: refrigerant blend GWP 500	**Case 2: refrigerant blend GWP 700**	**Case 3 :**
Technical principle	D2Y-60: R-32/1234yf (40/60) L-41a: R-32/1234yf/1234ze (73/15/12) DR-5: R-32/1234yf (72,5/27,5) ARM-70: R-32/134a/1234yf (50/10/40)	ARM-70 (R-32/134a/1234yf) (50/10/40)	
Industrial availability	No	No	
Existence of demonstrators or operational prototypes	Yes	Yes	
Regulation and status of standards			
in France :			
in Europe :	EN 378	EN 378	
GWP	D2Y-60: 289 L-41a: 524 DR-5: 520 ARM-70: 497	R32: 716 R-32/134a: 749 R-32/152a: 687	
Energy efficiency	COP similar to R-410A for the four candidates	R-32: COP similar to R-410A and +3% in heating mode R-32/R-134a: COP -7% and similar to R-410A in heating mode R-32/R-152a: COP similar to R-410A and +8% in heating mode	
Volumetric capacity	D2Y-60: -15 à -20% L-41a: -5 à -10% DR-5: -3% vs. R-410A ARM-70: - 10% vs. R-410A	R-32: +2 à +8% vs. R-410A R-32/R-152a and R-32/R-134a: +5 à +10 % vs. R-410A	
Probable date of commercial availability			
Main barriers to the solution expansion	Slightly flammable A2L D2Y-60: Discharge temperature lower than that of R-410A L-41a: Discharge temperature +7 Kand similar to R-410A in heating mode	Slightly flammable A2L R-32: Discharge temperature at leats +15 K vs R-410A R-32/152a: Discharge temperature +10 K vs R-410A	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	D2Y-60: charge similar to R-410A L-41a: charge -10%	R-32: charge - 20% vs. R-410A R-32/152a: charge +3% vs. R-410A	
Multicriteria indicators **EI: Environmental Impact - GWP** 1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750) 4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500) **EC: Energy Consumption** 0 = Low 3 = Medium 6 = High **SR: Safety Risk** 0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3 **CO : Cost of the solution (out of maintenance)** 0 = Low 3 = Medium 6 = High **AV : Availability** 6 = Laboratory 3 = Field demonstration 0 = Industrial **VC : Volumetric Capacity** 0 = Sufficient 3 = Medium 6 = Unsatisfying			
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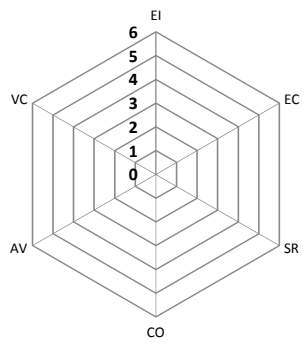
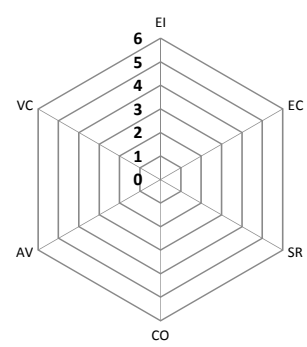
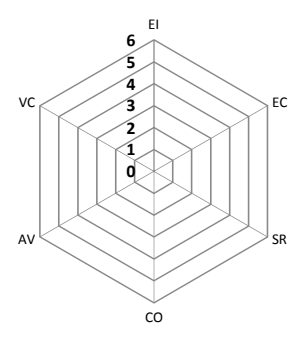
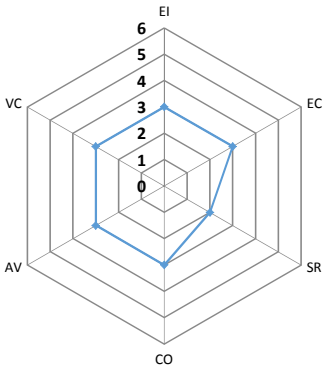
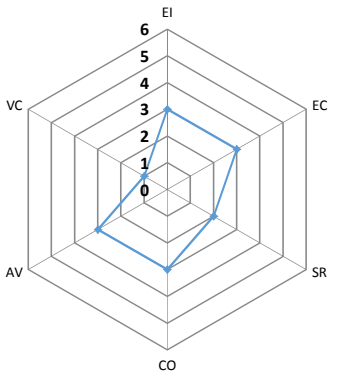
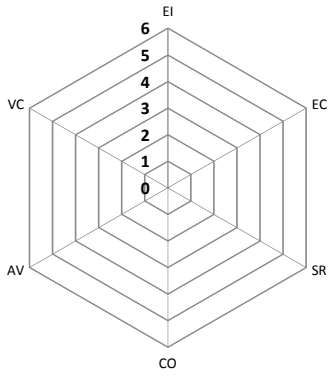
Application factsheet: Hydronic ground-source heat pump using R-410A			HP2
SECTOR	Residential heat pumps	**Sub-sector**	Domestic air contidioning and heating
Usage / Standard application			
Temperature range	15 at 32°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-410A GWP = 2100	**Average charge by equipment (kg)**	2.446
Data relative to the refrigerant used	A1 Sur le marché, 80% en France and en Europe Dans le parc, 49% en France and 83% en Europe		
Installed base in operation			
in France:	13	**Refrigerant bank in France (t):**	32 t (total end 2011)
in Europe:	89	**Refrigerant bank in Europe (t):**	1,310 t (total EU27 end 2011)
Average equipment lifetime (years)	15		
Main providers of technologies			
in France:	Ciat, Heliotherm, Géothermie, France PAC		
in Europe:	Heliotherm, Erset, Enalsa, Géothermie, Ciat, Dimplex, Stiebel eltron, Sofath, Visseman, Vaillant, France PAC		
Main owners of technologies			
in France:			
in Europe:			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable ODP = 0 Adapted to medium-temperature equipments Efficient and profitable system		
Regulations and specific applicable standards			
in France:	NF EN 378 related to safety and environmental requirements of refrigerations systems and heat pumps		
in Europe:	Directive ER-P 2013 relative to the efficiency of stationary air conditioners ≤ 12 kW		
ALTERNATIVES TECHNIQUES EXISTANTES			
	Case 1:	**Case 2:**	**Case 3:**
Technical principle			
Installed base in operation			
in France:			
in Europe:			
Applicable regulations and existing standards			
in France:			
in Europe:			
GWP			
Energy efficiency			
Volumetric capacity			
Availability			
Main barriers to the solution expansion			
Context promoting this technique implementation (Drop in or not, impact on the charge, …)			
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: refrigerant blend GWP 500	**Case 2: refrigerant blend GWP 700**	**Case 3:**
Technical principle	L-41a: R-32/1234yf/1234ze (73/15/12) DR-5: R-32/1234yf (72,5/27,5) ARM-70a: R-32/134a/1234yf (50/10/40)	R-32 R-32/134a (95/5) R-32/152a (95/5)	
Industrial availability	No	No	
Existence of demonstrators or operational prototypes	Yes	Yes	
Applicable regulations and existing standards			
in France:			
in Europe:	EN378	EN378	
GWP	4L-41a: 524 DR-5: 520 ARM-70: 497	R32: 716 R-32/134a: 749 R-32/152a: 687	
Energy efficiency	L-41a: COP similar to R-410A DR-5: COP +3% in heating mode ARM-70a: COP +2% in heating mode	R-32: COP similar to R-410A and +3% in heating mode R-32/134a: COP -7% and similar to R-410A in heating mode R-32/152a: COP similar to R-410A and +8% in heating mode	
Volumetric capacity	L-41a: -5 to -10% DR-5: -3% vs. R-410A ARM-70: -10 to -15% vs. R-410A	R-32: +2 to +8% vs. R-410A R-32/152a and R-32/134a: +5 to +10% vs. R-410A	
Probable date of commercial availability			
Main barriers to the solution expansion	Slightly flammable A2L L-41a: Discharge temperature + 6 to +8 K DR-5: Discharge temperature +4 K vs. R-410A ARM-70a: Discharge temperature similar to R-410A	Slightly flammable A2L R-32: Discharge temperature at least +25 K vs R-410A R-32/134a: Discharge temperature +105 K in heating mode vs. R-410A R-32/152a: Discharge temperature +10 K vs. R-410A	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	L-41a: charge +4% DR-5: charge -10% ARM-70a: similar to -R410A	R-32: charge -20% R-32/134a: charge similar to R-410A R-32/152a: charge +3% vs. R-410A	
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
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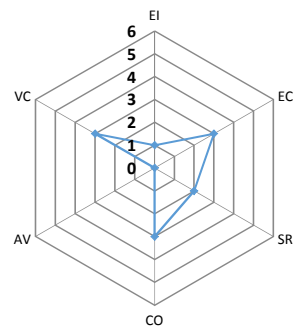
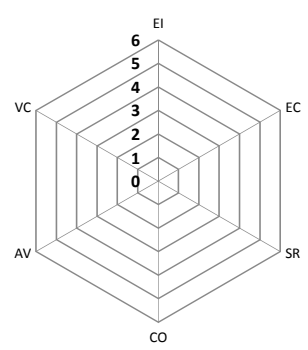
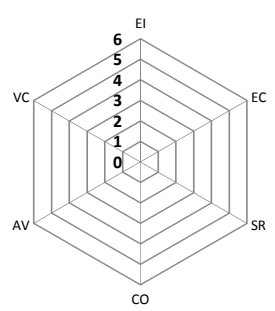
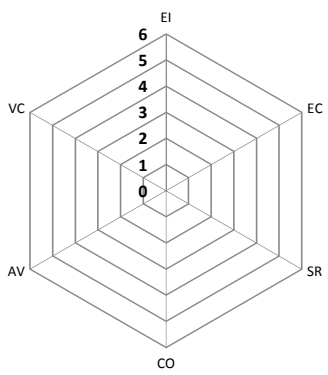
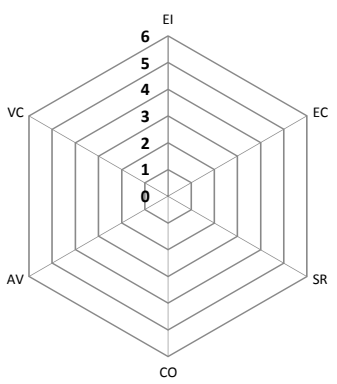
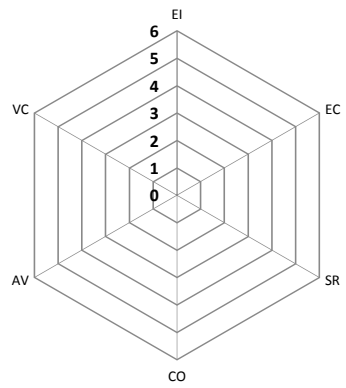
Application factsheet: MAC systems			MAC1
SECTOR	Mobile air conditioning	**Sub-sector**	Cars, vans and industrial vehicles
Usage / Standard application			
Temperature range	15 à 32°C		
DESCRIPTION OF THE REFERENCE SYSTÈME			
Refrigerant type commonly used / GWP	R-134a GWP = 1370	**Average charge by equipment (kg)**	0;64
Data relative to the refrigerant used	A1 100% sur le marché et dans le parc en France et en Europe		
Parc d'équipements en service			
in France:	23,088,712	**Refrigerant bank in France (t):**	14,709 t (total end 2011)
in Europe:	160,251,625	**Refrigerant bank in Europe (t):**	100,947 t (total EU27 end 2011)
Average equipment lifetime (years)	9		
Main providers of technologies			
in France:			
in Europe:			
Main owners of technologies			
in France:			
in Europe:			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable, ODP = 0 Adapted to medium-temperature equipments Good material compatibility Lubricant POE type		
Regulations and specific applicable standards			
in France:	Decree 2007-737 related to certain refrigerants ued in refrigeration and air-conditioning equipement		
in Europe:	Regulation 842/2006/CE and 307/2008 qualifications required for handling certain fluorinated greenhouse gases		
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: R-1234yf	**Case 2:**	**Case 3:**
Technical principle			
Installed base in operation			
in France:			
in Europe:			
Regulations and specific applicable standards			
in France:			
in Europe:	EN 378		
GWP	4		
Energy efficiency	COP similar to R-134a		
Volumetric capacity	Similar to R-134a		
Availability	2013		
Main barriers to the solution expansion	Slightly flammable A2L not Drop in ΔP higher in the evaporator charge +5% vs. R-134a		
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Discharge temperature -8 to -10 K		
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
ALTERNATIVES TECHNIQUES EN COURS DE DEVELOPPEMENT			
	Case 1:	**Case 2:**	**Case 3:**
Technical principle			
Industrial availability			
Existence of demonstrators or operational prototypes			
Regulation and status of standards			
in France:			
in Europe:			
GWP			
Energy efficiency			
Volumetric capacity			
Probable date of commercial availability			
Main barriers to the solution expansion			
Context promoting this technique implementation (Drop in or not, impact on the charge, …)			
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
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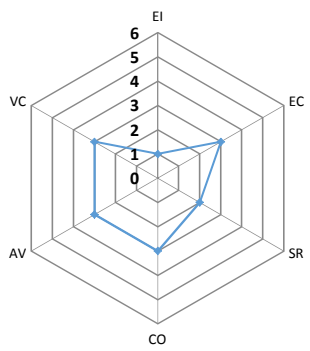
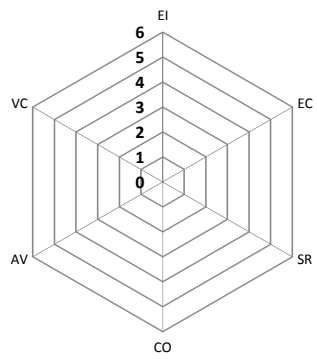
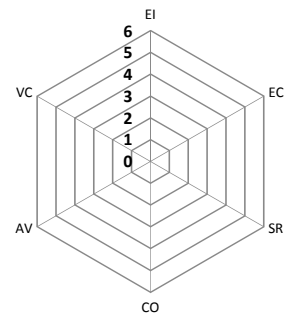
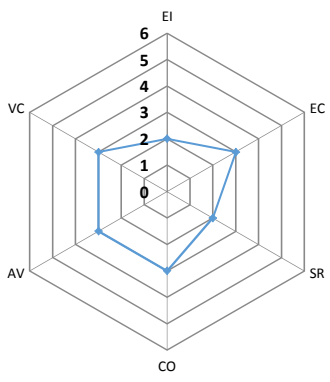
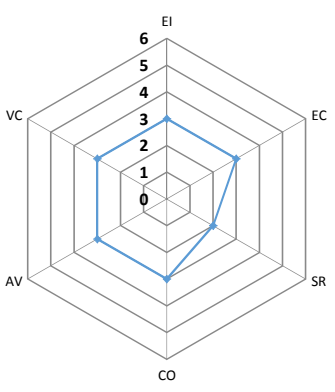
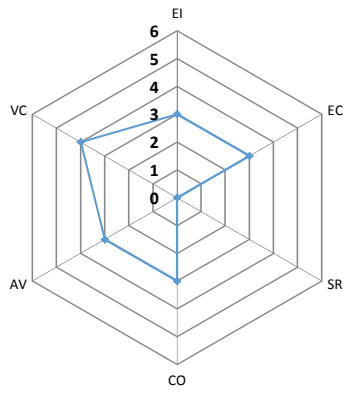
Application factsheet: Centrifugal chillers - R-134a (Pfrigo > 350 kW)			CH1
SECTOR	Chillers	**Sub-sector**	Centrifugal chillers
Usage / Standard application			
Temperature range	2 à 10°C		
DESCRIPTION DU SYSTÈME DE REFERENCE			
Refrigerant type commonly used / GWP	R-134a GWP = 1370	**Average charge by equipment (kg)**	0.3 kg/kW
Data relative to the refrigerant used	A1 100% on the market in France and in Europe, 81% in France and 94% in Europe in the installed base		
Installed base in operation			
in France:	1	**Refrigerant bank in France (t):**	790 t (total end 2011)
in Europe:	12	**Refrigerant bank in Europe (t):**	9,000 t (total EU27 end 2011)
Average equipment lifetime (years)	25		
Main providers of technologies			
in France:	Ciat, Trane, Airwell		
in Europe:	Ciat, Trane, Carrier, Lennox, Heatcraft, Stulz, GWK, Sorema, Eurodifroid, Olaer, AEC, Frigofluid, Wesper, MTA, Thermal care, Mokon, Euroklimat, J& E hall		
Main owners of technologies			
in France:			
in Europe:			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable, ODP = 0 R-12 refrigerant replacement Discharge temperature 8 to 10 K lower than that of R-12 Adapted to medium-temperature equipments, efficiency close to that of R-12 Good material compatibility Lubricant POE type		
Regulations and specific applicable standards			
in France:			
in Europe:	EN 378 ISO 3744 acoustic power EN 14511 COP efficiency NFC 15-100 relative to the connecting and operation of electrical equipment in buildings		

EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: R-1234ze [E]	**Case 2:**	**Case 3:**
Technical principle			
Installed base in operation			
in France:			
in Europe:			
Applicable regulations and existing standards			
in France:			
in Europe:	EN 378		
GWP	6		
Energy efficiency	R-1234ze: COP -3%		
Volumetric capacity	-25% refrigerant capacity vs. R-134a		
Availability	2013		
Main barriers to the solution expansion	Slightly flammable A2L		
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Charge similar to that of R-134a		
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			

ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: ARM-42a	**Case 2: XP-10**	**Case 3: refrigerant blend GWP < 700**
Technical principle	R-134a/152a/1234yf (7/11/82)	R-134a/1234yf (44/56)	N-13a: R-134a/1234yf/1234ze (42/18/40) N-13b: R-134a/1234ze (42/58)
Industrial availability			
Existence of demonstrators or operational prototypes	Yes	Yes	Yes
Regulation and status of standards			
in France:			
in Europe:	EN 378	EN 378	
GWP	114	605	579
Energy efficiency	COP -3 to -7% vs. R-134a	COP -4% vs. R-134a	COP similar to that of R-134a
Volumetric capacity	Similar to that of R-134a	Similar to that of R-134a	N-13a: -10% N-13b: -12% vs. R-134a
Probable date of commercial availability			
Main barriers to the solution expansion	Slightly flammable A2L	Slightly flammable A2L	A1
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	ARM-42a: charge -5% vs. R-134a	charge -3% vs. R-134a	charge -3% vs. R-134a
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			

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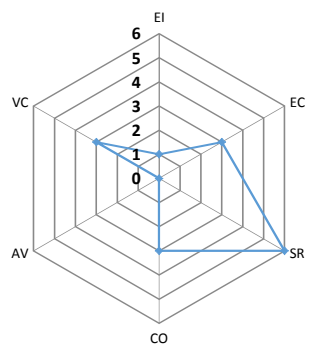
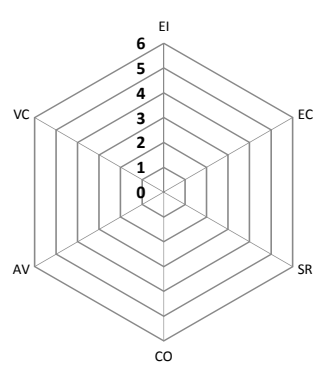
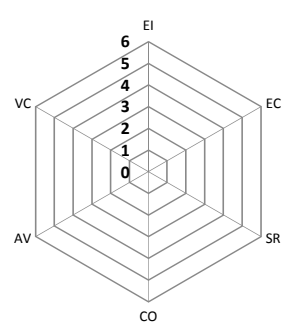
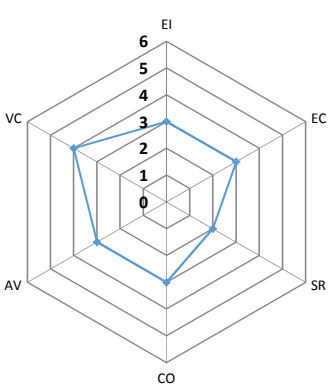
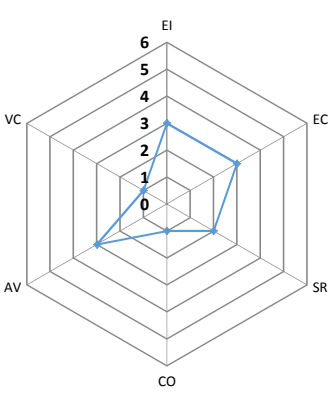
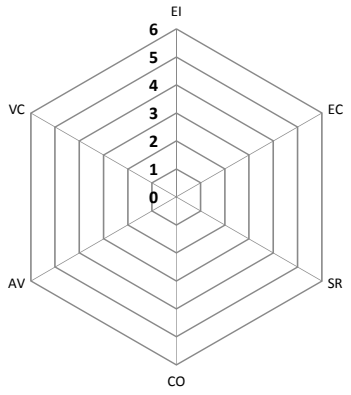
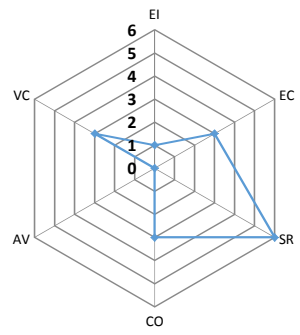
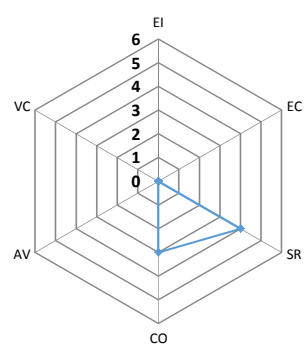
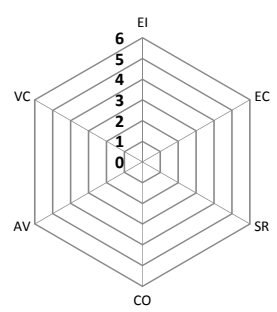
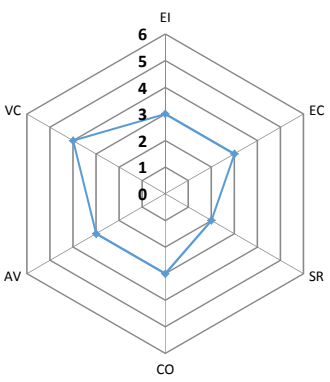
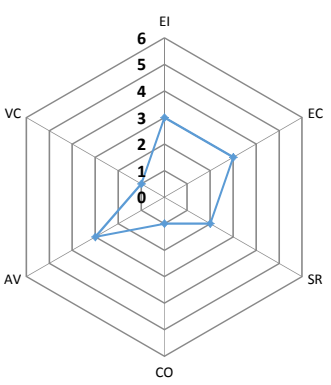
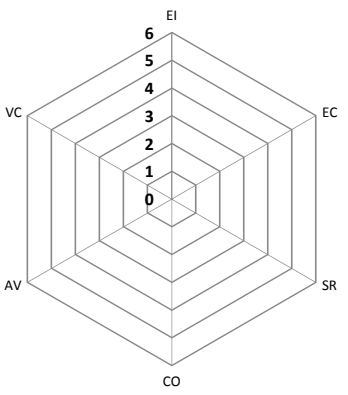
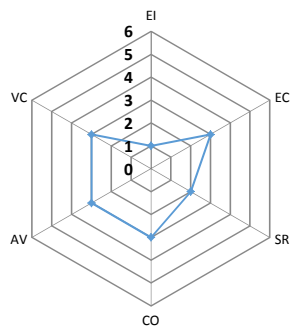
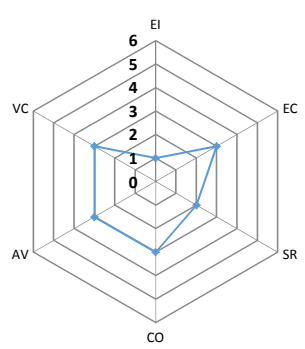
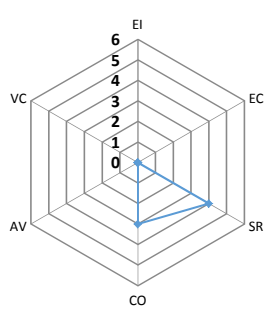
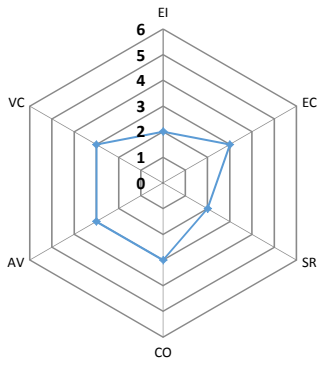
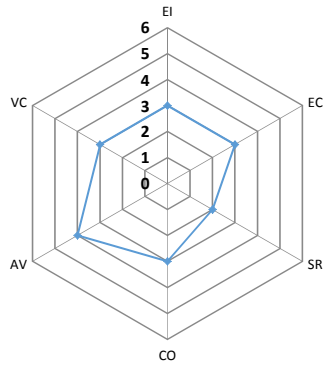
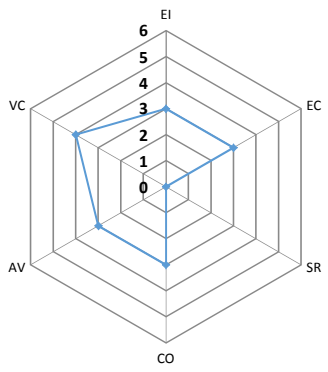
Application factsheet: Low-capacity volumetric chillers - R-410A (P < 150 kW)			CH2
SECTOR	Chillers	**Sub-sector**	Volumetric chillers
Usage / Standard application			
Temperature range	2 to 10°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-410A GWP = 2100	**Average charge by equipment (kg)**	0.3 kg/kW
Data relative to the refrigerant used	A1 On the market: 71% in France On the installed base: 35% in France		
Installed base in operation			
in France:	19	**Refrigerant bank in France (t):**	137 t (total end 2011)
in Europe:	Not communicated	**Refrigerant bank in Europe (t):**	Not communicated
Average equipment lifetime (years)	15		
Main providers of technologies			
in France:	Ciat, Trane, Airwell		
in Europe:	Ciat, Trane, Carrier, Lennox, Heatcraft, Stulz, GWK, Sorema, Eurodifroid, Olaer, AEC, Frigofluid, Wesper, MTA, Thermal care, Mokon, Euroklimat, J& E hall		
Main owners of technologies			
in France:			
in Europe:			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable, ODP = 0 Adapted to medium-temperature equipments Lubricant POE type		
Regulations and specific applicable standards			
in France:			
in Europe:	EN 378 ISO 3744 acoustic power EN 14511 COP efficiency NFC 15-100 relative to the connecting and operation of electrical equipment in buildings		
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: R-290 replacing R-22	**Case 2:**	**Case 3:**
Technical principle	Vapor compression		
Installed base in operation			
in France:			
in Europe:			
Applicable regulations and existing standards			
in France:			
in Europe:	EN378 ATEX regulation 99/92/CE		
GWP	6		
Energy efficiency	Slightly lower than that of R-410A		
Volumetric capacity	- 30% vs. R-410A		
Availability	Available		
Main barriers to the solution expansion	Flammable (A3) Limitation due to the refrigerant charge Additional cost linked to ATEX		
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Adapted to higher ambient temperature (up to 43°C)		
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: refrigerant blend GWP 500	**Case 2: R-32**	**Case 3:**
Technical principle	DR-5: R-32/1234yf (72,5/27,5) ARM-70a: -R32/134a/1234yf (50/10/40) L-41a: R-32/1234yf/1234ze (73/15/12) L-41b: R-32/1234ze (73/27) HPR1D: R-32/744/1234ze (60/6/34)		
Industrial availability	No	No	
Existence of demonstrators or operational prototypes	Yes	Yes	
Regulation and status of standards			
in France:			
in Europe:	EN 378	EN 378	
GWP	DR-5: 520, ARM-70a: 497, L-41a and L-41b: 524 HPR1D: 432	716	
Energy efficiency	L-41a and L-41b: +3% DR-5: +3% ARM-70a: +6% HPR-1D: -8% vs. R-410A	Similar to R-410A	
Volumetric capacity	L-41a: -3%; L-41b: -5% ARM-70a: -10% DR-5: similar to R-410A HPR-1D: -8%	+10%	
Probable date of commercial availability			
Main barriers to the solution expansion	Slightly flammable A2L	T discharge at least > 25 K vs. R-410A Slightly flammable A2L	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Drop in L41a et L41b: charge -12% ARM-70a: charge - 4% DR-5: charge -8% HPR1D: charge -4%	R-32: charge -20%	
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
AFCE, UNICLIMA, ADEME Report: Alternatives to high-GWP HFCs in refrigeration and air-conditioning applications, 2013			

Application factsheet: Medium-capacity volumetric chillers - R-410A (150 kW < P < 800 kW)			CH3
SECTOR	Chillers	**Sub-sector**	Volumetric chillers
Usage / Standard application			
Temperature range	2 à 10°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-410A GWP = 2100	**Average charge by equipment (kg)**	0.3 kg/kW
Data relative to the refrigerant used	A1 On the market: 54% en France and 23% en Europe In the installed base: 21% en France and 11% en Europe		
Installed base in operation			
in France:	17	**Refrigerant bank in France (t):**	635 t (total end 2011)
in Europe:	125	**Refrigerant bank in Europe (t):**	4,200 t (total EU27 end 2011)
Average equipment lifetime (years)	15		
Main providers of technologies			
in France:	Ciat, Trane, Airwell		
in Europe:	Ciat, Trane, Carrier, Lennox, Heatcraft, Stulz, GWK, Sorema, Eurodifroid, Olaer, AEC, Frigofluid, Wesper, MTA, Thermal care, Mokon, Euroklimat, J& E hall		
Main OWNers of technologies			
in France:			
in Europe:			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable ODP = 0 Adapted to medium-temperature equipments Efficient and profitable system		
Regulations and specific applicable standards			
in France:			
in Europe:	EN 378 ISO 3744 acoustic power EN 14511 COP efficiency NFC 15-100 relative to the connecting and operation of electrical equipment in buildings		
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: R-290	**Case 2: R-717**	**Case 3:**
Technical principle	Vapor compression	Vapor compression	
Installed base in operation			
in France:			
in Europe:			
Applicable regulations and existing standards			
in France:		Ammonia regulation	
in Europe:	EN 378 ATEX regulation 99/92/CE	EN 378	
GWP	6	0	
Energy efficiency	Slightly lower than R-410A	COP +8% vs. R-410A	
Volumetric capacity	-30% vs. R-410A	+25% vs.n R-410A	
Availability	Available	Available	
Main barriers to the solution expansion	Flammable (A3) Limitation due to the refrigerant charge Additional cost linked to ATEX	B2 Cost (investment and safety) higher than that of R-410A	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Adapted to higher ambient temperature (up to 43°C)	Higher energy efficiency that R-410A system Mature technology	
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: refrigerant blend GWP < 500	**Case 2: R-32**	
Technical principle	DR-5: R-32/1234yf (72,5/27,5) ARM-70a: R-32/134a/1234yf (50/10/40) L-41a: R-32/1234yf/1234ze (73/15/12) L-41b: R-32/1234ze (73/27) HPR1D: R-32/744/1234ze (60/6/34)		
Industrial availability	Non toxic, non flammable ODP = 0 Adapted to medium-temperature equipments Efficient and profitable system	No	
Existence of demonstrators or operational prototypes	Yes	Yes	
Regulation and status of standards			
in France:			
in Europe:	EN 378	EN 378	
GWP	DR-5: 520, ARM-70a: 497, L-41a and L-41b: 524 HPR1D: 432	716	
Energy efficiency	L-41a and L-41b: +3% DR-5: +3% ARM-70a: +6% HPR-1D: -8% vs. R-410A	Similar to R-410A	
Volumetric capacity	L-41a: -3%; L-41b: -5% ARM-70a: -10% DR-5: similar to R-410A HPR-1D: -8%	+10% vs. R-410A	
Probable date of commercial availability			
Main barriers to the solution expansion	Slightly flammable A2L	T discharge at least +25 K vs. R-410A Slightly flammable A2L	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	L41a and L41b: charge -12% ARM-70a: charge - 4% DR-5: charge -8% HPR1D: charge -4%	R-32: charge -20%	
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
AFCE, UNICLIMA, ADEME Report: Alternatives to high-GWP HFCs in refrigeration and air-conditioning applications, 2013			

Application factsheet: High-capacity volumetric chillers (screw compressors)			CH4
SECTOR	Chillers	**Sub-sector**	Volumetric chillers
Usage / Standard application			
Temperature range	2 à 10°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-134a GWP = 1370	**Average charge by equipment (kg)**	0.3 kg/kW
Data relative to the refrigerant used	A1 On the market: 26% in France In the installed base: 6% in France		
Installed base in operation			
in France:	2	**Refrigerant bank in France (t):**	300 t (total end 2011)
in Europe:	Not communicated	**Refrigerant bank in Europe (t):**	Not communicated
Average equipment lifetime (years)	20		
Main providers of technologies			
in France:	Ciat, Trane, Airwell		
in Europe:	Ciat, Trane, Carrier, Lennox, Heatcraft, Stulz, GWK, Sorema, Eurodifroid, Olaer, AEC, Frigofluid, Wesper, MTA, Thermal care, Mokon, Euroklimat, J& E hall		
Main owners of technologies			
in France:			
in Europe:			
Technical justification and particular conditions of the application with respect to the HFC type used	Non toxic, non flammable ODP = 0 Adapted to medium-temperature equipments Lubricant POE type		
Regulations and specific applicable standards			
in France:			
in Europe:	EN 378 ISO 3744 acoustic power EN 14511 COP efficiency NFC 15-100 relative to the connecting and operation of electrical equipment in buildings		

EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: R-1234ze [E]	**Case 2: R-1234yf**	**Case 3: R-717**
Technical principle			
Installed base in operation			
in France:			Yes
in Europe:			Yes
Applicable regulations and existing standards			
in France:			
in Europe:	EN 378	EN 378	EN 378
GWP	6	4	0
Energy efficiency	COP - 3% vs. R-134a	COP similar to R-134a	COP + 10% vs. R-134a
Volumetric capacity	-25% vs. R-134a	-5% vs R-134a	+ 30% vs.R-134a
Availability	2013	2015	Available
Main barriers to the solution expansion	Slightly flammable A2L	Slightly flammable A2L	B2
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Charge similar to R-134a	Charge similar to R-134a	Mature technonlogy
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			

ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: ARM-42a	**Case 2: XP-10**	**Case 3: GWP <700**
Technical principle	DR-5: R-32/1234yf (72,5/27,5) ARM-70a: -R32/134a/1234yf (50/10/40) L-41a: R-32/1234yf/1234ze (73/15/12) L-41b: R-32/1234ze (73/27) HPR1D: R-32/744/1234ze (60/6/34)		DR-7: R32/1234yf (36/64) L-20: R-32/152a/1234ze (45/20/35)
Industrial availability	?	?	?
Existence of demonstrators or operational prototypes	Yes	Yes	Yes
Regulation and status of standards			
in France:			
in Europe:	EN 378	EN 378	EN378
GWP	114	605	604
Energy efficiency	COP -3 to -7% vs. R-134a	COP -4% vs. R-134a	COP similar to R-134a
Volumetric capacity	Similar to R-134a	Similar to R-134a	N-13a: -10% vs. R-134a N-13b: -12% vs. R-134a
Probable date of commercial availability			
Main barriers to the solution expansion	Slightly flammable A2L	Slightly flammable A2L	A1
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Charge -5% vs. R-134a	Charge -3% vs. R-134a	Charge -3% vs. R-134a
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			

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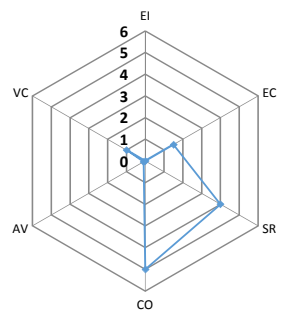
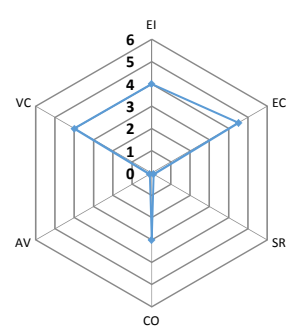
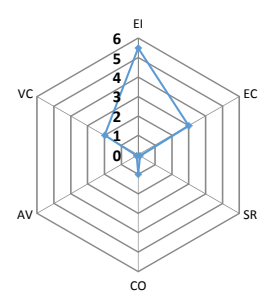
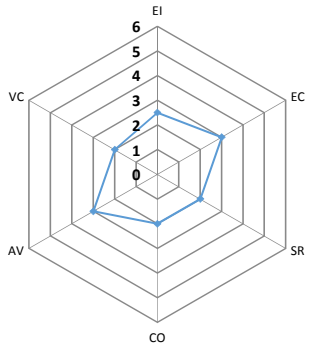
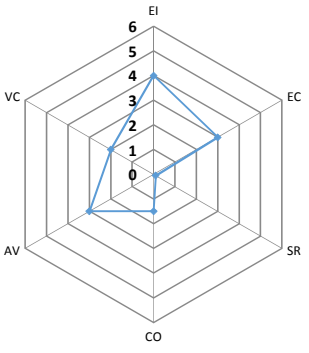
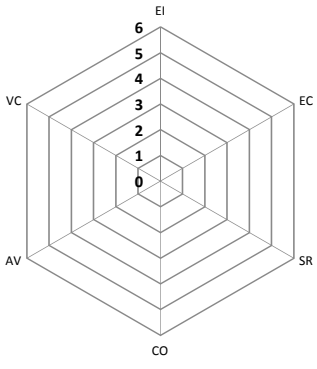
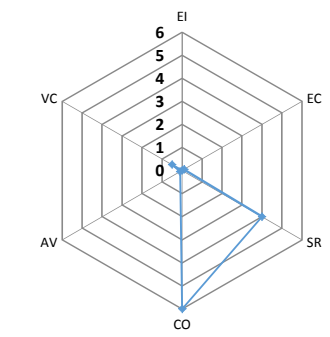
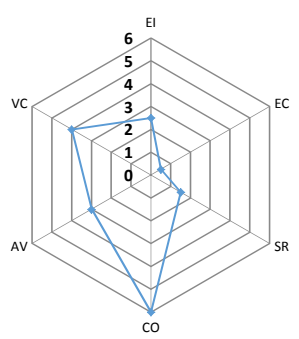
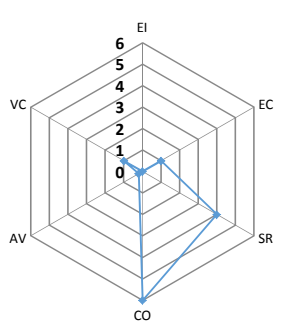
Application factsheet: Medium-temperature direct expansion systems using R-404A			FP1
SECTOR	Refrigeration in food processes	**Sub-sectors**	Milk industry Chocolate industry Warehouses Beer and wine industries Sparling beverages
Usage / Standard application	Centralized refrigeration system of a food process. Various applications cases can be observed, depending on the industry: - product cooling during processes: 37°C to 4°C - slaughterhouses: meat conservation at +4°C - warehouse, product storage at +4°C - cooling of pre-cooked dishes, possibly prior freezing - industrial air conditioning		
Temperature range	0 à +4°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-404A GWP = 3700	**Average charge by equipment (kg)**	Strong variation according to the production level. Can be up to 3 t
Data relative to the refrigerant used	R-125/ 143a/ 134a (44/52/4) A1		
Installed base in operation			
in France:	Not communicated	**Refrigerant bank in France (t):**	2,500 t (total agricultural end 2011)
in Europe:	Not communicated	**Refrigerant bank in Europe (t):**	15,000 t (total industry EU27 end 2012)
Average equipment lifetime (years)	30 ans		
Main providers of technologies			
in France:	Johnson Control, Clauger, GEA Mattal, Diatec, Synergies, Tecnal		
in Europe:	Diatec, Packo, Synergies, Tecnal, DIMA		
Main owners of technologies			
in France:	Johnson Control, Clauger, GEA Mattal		
in Europe:	Nestlé, Bell, Danone, etc. Interviewed groups are: Bel (30% milk industry France), LDC (Leader poultry, pre-cooked dishes) and Bonduelle (world leader for vegetables)		
Technical justification and particular conditions of the application with respect to the HFC type used	Adaptedto medium and low-temperature equipments Evolution of old R-22 installations: compatibility of components, retrofit easiness, no temperature glide of R-404A, drop-in possible		
Regulations and specific applicable standards			
in France:	NF EN 378 related to safety and environmental requirements of refrigerations systems and heat pumps NF EN 60335-2-89 related so specific sagety rules for refrigeration equipment of commercial use including a condensing unit or an integrated or remote compressor NF EN 14276-1 et 14276-2 related to reservoirs and piping of equipment under pressure for refrigeration systems and heat pumps		
in Europe:	Regulation 842/2006/EC EN 378 EN 60335-2-89 EN 14276-1 et 14276-2		

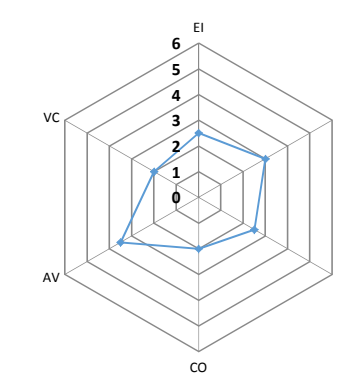
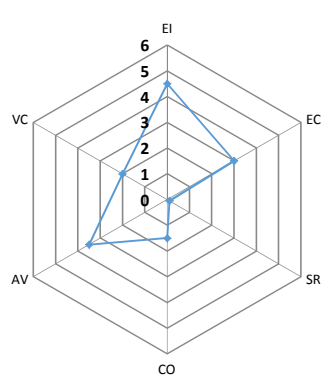
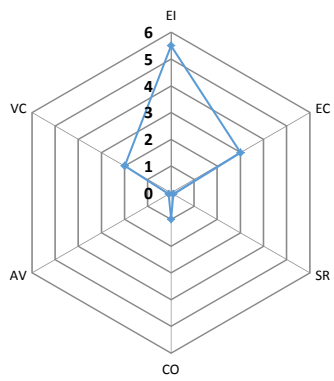
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: R-717 direct expansion system (or with HTF)	**Case 2: R-134a direct expansion system (or with HTF)**	**Case 3: R-407A or R-407F in new and in retrofit**
Technical principle	Unchanged. Vapor compression	Unchanged. Vapor compression	R-407A - R-32/125/134a (20/40/40) R-407F - R-32/125/134a (30/30/60)
Installed base in operation			
in France:	Significant, about 3,500 t R-717 total agri. end 2011	R-134a bank evaluated at 210 t total agri end 2011	First installations in 2012
in Europe:	Significant, about 22,400 t R-717 total agri EU27 end 2012	R-134a bank of 2,200 t total agri EU27 end 2012	First installations in 2012
Applicable regulations and existing standards			
in France:	Ammonia regulation	Regulation 842/2006/CE	Regulation 842/2006/CE
in Europe:		Regulation 842/2006/CE	Regulation 842/2006/CE
GWP	0	1370	R-407A 2100 / R-407F 2060
Energy efficiency	Similar (indirect system) or higher (direct) thant that of the reference system especially for a R-717 direct system.	Lower than that of R-404A	Similar to medium temperature
Volumetric capacity	Similar	30% lower than that of R-404A	Similar
Availability			Immediate
Main barriers to the solution expansion	Toxic and moderately flammable (B2L). Cost (investment and safety) higher,up to 50%, than R-404A installation	GWP within the scope of the F-Gas evaolution at medium term.	GWP relatively high.
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Flexibility of the ammonia regulation Lasting solution regardless of the F-Gas evolution. Similar or higher energy efficiency than the R-404A reference system.	**Possible retrofit: R-134a/ R-1234yf or R-1234ze at medium term** depending on the flammable regulation evolution. Design characteristics in the specifications (lower refrigerating capacity of R-134a) Cost similar to that of R-404A installation, except further retrofit,	Both refrigerant blends are adapted to R-404A retrofit
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			

ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: Retrofit by HFO-HFC blend, slightly flammable, GWP around 250	**Case 2: Retrofit by non flammable blend, GWP around 1300**	**Case 3:**
Technical principle	Unchanged. Vapor compression. HFO-HFC blends (R-32/1234yf or R-32/152a/1234yf/1234ze)	Unchanged. Vapor compression. HFO-HFC blends (R-32/125/134a/1234yf and possibly R-1234ze)	
Industrial availability	No	No	
Existence of demonstrators or operational prototypes	No but AHRI tests for other applications	No - communications of refrigerant producers not dedicated to agri.	
Regulation and status of standards			
in France:	Flammable regulations (no A2L standard)	F-Gas	
in Europe:	Flammable regulations (no A2L standard)	F-Gas	
GWP	L-40: 302 D2Y-65: 253 DR-7: 260 ARM-30: 210	1300 à 1400	
Energy efficiency	Good performances of blends compared to R-404A, variations depending on proposed refrigerants (L-40, D-R7, ARM-30)	Good performances of blends compared to R-404A, variations depending on proposed refrigerants (N-40, DR-33, ARM-32)	
Volumetric capacity			
Probable date of commercial availability			
Main barriers to the solution expansion	A2L Temperature glide from 2 à 4 K	Lack of durability High charge because of retrofit Temperature glide from 2 to 4 K	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Drop-in R-404A or R-22 GWP low enough	A1 Performances similar to R-404A Drop in (to be confirmed) less costly	
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			

AFCE, UNICLIMA, ADEME Report: Alternatives to high-GWP HFCs in refrigeration and air-conditioning applications, 2013

Application factsheet: Direct expansion system R-404A Low-temperature or medium and low-temperatures			FP2
Industrie de la viandeAbattoirsSurgelésPlats cuisinésEntrepôts			
SECTOR	Refrigeration in food processes	**Sub-sector**	Meat industry Slaughterhouses Frozen food Pre-cooked dishes Warehouses
Usage / Standard application			
Temperature range	-18 à +6°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-404A GWP = 3700	**Average charge by equipment (kg)**	Very variable depending on the production level. Up to 3 t
Data relative to the refrigerant used	R-125/143a/134a (44/52/4) A1		
Installed base in operation			
in France:	Not communicated	**Refrigerant bank in France (t):**	2,500 t (total agri end 2011)
in Europe:	Not communicated	**Refrigerant bank in Europe (t):**	15,000 t (total industry EU27 end 2012)
Average equipment lifetime (years)	30 years		
Main providers of technologies			
in France:	Johnson Control, Clauger, GEA Mattal		
in Europe:	Nestlé, Bell, Danone, etc. Interviewed groups are: Bel (30% milk industry France), LDC (Leader poultry, pre-cooked dishes) and Bonduelle (world leader for vegetables)		
Main owners of technologies			
in France:	Johnson Control, Clauger, GEA Mattal		
in Europe:			
Technical justification and particular conditions of the application with respect to the HFC type used	Evolution of old R-22 installations: compatibility of components, retrofit easiness, no temperature glide of R-404A, drop-in possible		
Regulations and specific applicable standards			
in France:	Regulation 842/2006/EC		
in Europe:	Regulation 842/2006/EC		

EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: Cascade system R-717/CO_2	**Case 2: Cascade system R-134a/ CO_2 can be retrofitted in R-1234yf/CO_2**	**Case 3: Booster system R-717/R-717**
Technical principle	Unchanged. Vapor compression	Unchanged. Vapor compression	Unchanged. Vapor compression
Installed base in operation			
in France:	Strong growth of the installed base, first installations in 2010	Strong growth of the installed base, first installations in 2010	First installations in 2012
in Europe:	Strong growth of the installed base, first installations in 2010	Strong growth of the installed base, first installations in 2010	First installations in 2012
Applicable regulations and existing standards			
in France:	Ammonia regulation	Regulation 842/2006/EC	Ammonia regulation
in Europe:		Regulation 842/2006/EC	
GWP	0/1	1370 / 1	0/0
Energy efficiency	Energy consumption reduction of cascade systems compared to direct systems, and better energy efficiency of ammonia and CO_2,	Better energy efficiency of cascade systems,	Good energy efficiency of ammonia. Booster systems allow energy consumption reduction compared to simple direct systems.
Volumetric capacity			
Availability	Immediate	Immediate	Immediate
Main barriers to the solution expansion	Toxic and moderately flammable (B2L). Cost (investment and safety) higher,up to 50%, than R-404A installation	R-134a GWP within the scope of Regulation 842/2006/EC evolution in the medium term	Toxic and moderately flammable (B2L). Cost (investment and safety) higher,up to 50%, than R-404A installation
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Flexibility of the ammonia regulation Lasting solution regardless of the Regulation 842/2006/EC evolution. Similar or higher energy efficiency than the R-404A reference system.	Possible retrofit: R-134a/ R-1234yf or R-1234ze at medium term depending on the flammable regulation evolution. Design characteristics in the specifications (lower refrigerating capacity of R-134a) Cost similar to that of R-404A installation, except further retrofit,	Flexibility of the ammonia regulation Lasting solution regardless of the F-Gas evolution. Similar or higher energy efficiency than the R-404A reference system.
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			

ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: Retrofit by an HFO-HFC blend slightly flammable, GWP around 250	**Case 2: Retrofit by a non-flammable blend, GWP around 1300**	**Existing Case 4: R-407A or R-407F in new and in retrofit**
Technical principle	Unchanged. Vapor compression. HFO-HFC blends (R-32/1234yf or R-32/152a/1234yf/1234ze)	Unchanged. Vapor compression. HFO-HFC blends (R-32/125/134a/1234yf and possibly R-1234ze)	R-407A - R-32/125/134a (20/40/40) R-407F - R-32/125/134a (30/30/60)
Industrial availability	No	No	No
Existence of demonstrators or operational prototypes	No but AHRI tests for other applications	No-communications of refrigerant producers not dedicated to food process	First installations in 2012
Regulation and status of standards			
in France:	Flammable regulations (no A2L standard)	Regulation 842/2006/CE	Regulation 842/2006/CE
in Europe:	Flammable regulations (no A2L standard)	Regulation 842/2006/CE	Regulation 842/2006/CE
GWP	about 200	1300 to 1400	R-407A 2100 / R-407F 2060
Energy efficiency	Good performances of blends compared to R-404A, variations depending on proposed refrigerants (L-40, DR-7, ARM-30)	Good performances of blends compared to R-404A, variations depending on proposed refrigerants (N-40, DR-33, ARM-32)	Similar to medium temperature
Volumetric capacity			Similar
Probable date of commercial availability			Immediate
Main barriers to the solution expansion	A2L Temperature glide from 2 à 4 K Uncertainty on the refrigreant price	Lack of durability High charge because of retrofit Temperature glide from 2 to 4 K Uncertainty on the refrigreant price	GWP relatively high.
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Drop-in R-404A or R-22 GWP low enough	A1 Performances similar to R-404A Drop in (to be confirmed) less costly	Both refrigerant blends are adapted to R-404A retrofit
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			

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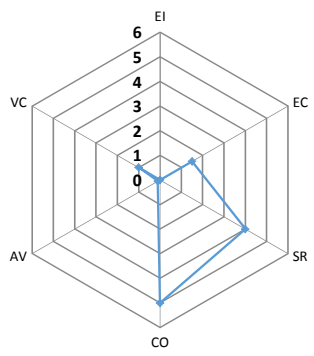
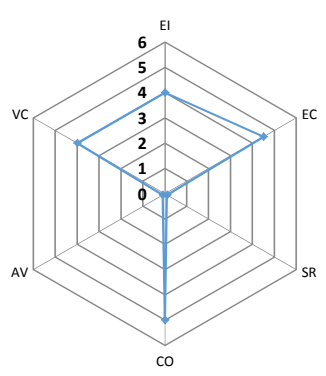
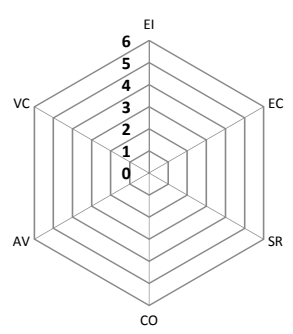
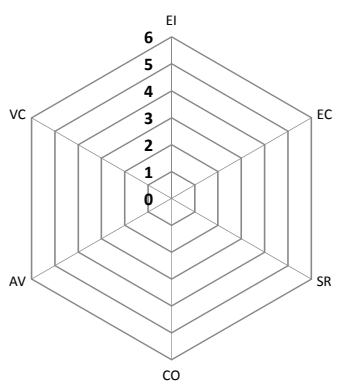
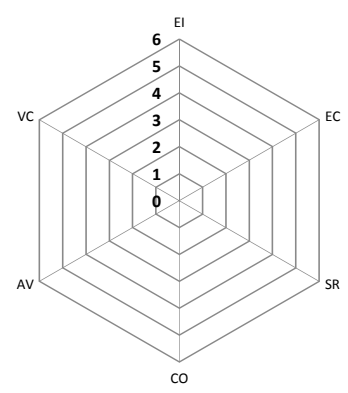
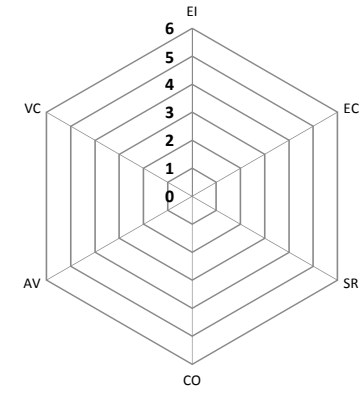
Application factsheet: Medium-temperature indirect system using R-404A			FP3
SECTOR	Refrigeration in food processes	**Sub-sectors**	Milk tanks Milk industry Chocolate industry Warehouses Beer and wine industries Sparking beverages
Usage / Standard application			
Temperature range	0 à +4°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-404A GWP = 3700	**Average charge by equipment (kg)**	Very variable depending on the production level. Up to 3 t
Data relative to the refrigerant used	R-125/ 143a/ 134a (44/52/4) A1		
Installed base in operation			
in France:	Not communicated	**Refrigerant bank in France (t):**	2,500 t (total agri end 2011)
in Europe:	Not communicated	**Refrigerant bank in Europe (t):**	15,000 t (total industry EU27 end 2012)
Average equipment lifetime (years)	30 years		
Main providers of technologies			
in France:	Johnson Control, Clauger, GEA Mattal, Diatec, Synergies, Tecnal		
in Europe:	Diatec, Packo, Synergies, Tecnal, DIMA		
Main owners of technologies			
in France:	Johnson Control, Clauger, GEA Mattal		
in Europe:	Nestlé, Bell, Danone, etc. Interviewed groups are: Bel (30% milk industry France), LDC (Leader poultry, pre-cooked dishes) and Bonduelle (world leader for vegetables)		
Technical justification and particular conditions of the application with respect to the HFC type used	Adaptedto medium and low-temperature equipments Evolution of old R-22 installations: compatibility of components, retrofit easiness, no temperature glide of R-404A, drop-in possible		
Regulations and specific applicable standards			
in France:	NF EN 378 related to safety and environmental requirements of refrigerations systems and heat pumps NF EN 60335-2-89 related so specific sagety rules for refrigeration equipment of commercial use including a condensing unit or an integrated or remote compressor NF EN 14276-1 et 14276-2 related to reservoirs and piping of equipment under pressure for refrigeration systems and heat pumps		
in Europe:	Regulation 842/2006/EC EN 378 EN 60335-2-89 EN 14276-1 et 14276-2		

EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: R-717 + indirect system with HTF (MPG or CO_2 or other)	**Case 2: R-134a + indirect system with HTF (MPG or CO2 or other)**	**No retrofit solution**
Technical principle	Unchanged. Vapor compression	Unchanged. Vapor compression	
Installed base in operation			
in France:	Not communicated	Not communicated	
in Europe:	Not communicated	Not communicated	
Applicable regulations and existing standards			
in France:	Ammonia regulation	Regulation 842/2006/CE	
in Europe:		Regulation 842/2006/CE	
GWP	0	1370	
Energy efficiency	Similar to the reference system	Lower than R-404A	
Volumetric capacity	Similar	Lower than R-404A	
Availability	Immediate	Immediate	
Main barriers to the solution expansion	Toxic and moderately flammable (B2L). Cost (investment and safety) higher,up to 50%, than R-404A installation	GWP within the scope of the F-Gas evaolution at medium term.	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Flexibility of the ammonia regulation Lasting solution (Regulation 842/2006/CE) Energy efficiency similar to R-404A. High cost of the shell-and-tube heat exchanger plu cost due to the necessary insulation of the circuit and pumps installation.	Possible retrofit R-134a/ R-1234yf or R-1234ze on the medium term High cost of the shell-and-tube heat exchanger plu cost due to the necessary insulation of the circuit and pumps installation.	
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			

ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1:	**Case 2:**	**Case 3:**
Technical principle			
Industrial availability			
Existence of demonstrators or operational prototypes			
Regulation and status of standards			
in France:			
in Europe:			
GWP			
Energy efficiency			
Volumetric capacity			
Probable date of commercial availability			
Main barriers to the solution expansion			
Context promoting this technique implementation (Drop in or not, impact on the charge, …)			
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			

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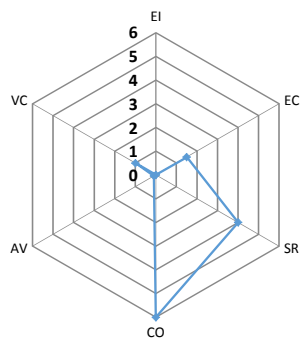
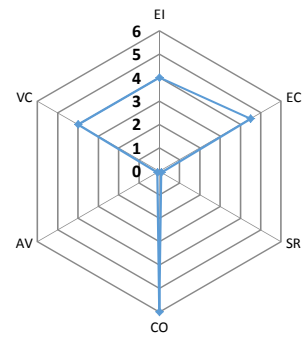
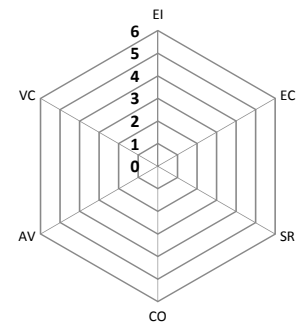
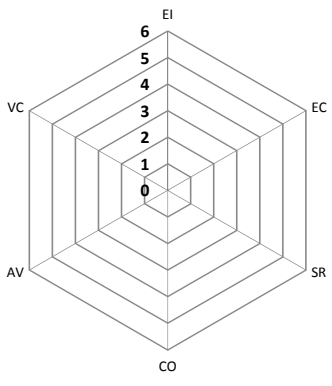
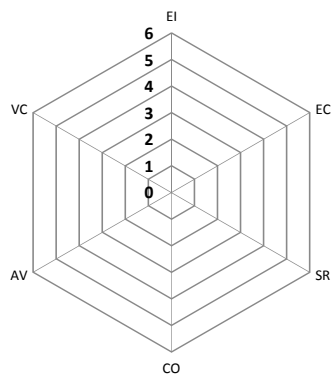
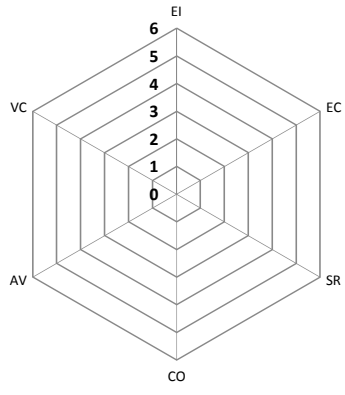
Application factsheet: Low-temperature flooded evaporator operating with R-404A			FP4
SECTOR	Refrigeration in food processes	**Sub-sectors**	Meat industry Slaughterhouses Frozen food Pre-cooked dishes Warehouses
Usage / Standard application			
Temperature range	-18 à +6°C		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-404A GWP = 3700	**Average charge by equipment (kg)**	Very variable depending on the production level. Up to 3 t
Data relative to the refrigerant used	R-125/ 143a/ 134a (44/52/4) A1		
Installed base in operation			
in France:	Not communicated	**Refrigerant bank in France (t):**	2,500 t (total agri end 2011)
in Europe:	Not communicated	**Refrigerant bank in Europe (t):**	15,000 t (total industry EU27 end 2012)
Average equipment lifetime (years)	30 years		
Main providers of technologies			
in France:	Johnson Control, Clauger, GEA Mattal, Diatec, Synergies, Tecnal		
in Europe:	Diatec, Packo, Synergies, Tecnal, DIMA		
Main owners of technologies			
in France:	Johnson Control, Clauger, GEA Mattal		
in Europe:	Nestlé, Bell, Danone, etc. Interviewed groups are: Bel (30% milk industry France), LDC (Leader poultry, pre-cooked dishes) and Bonduelle (world leader for vegetables)		
Technical justification and particular conditions of the application with respect to the HFC type used	Adaptedto medium and low-temperature equipments Evolution of old R-22 installations: compatibility of components, retrofit easiness, no temperature glide of R-404A, drop-in possible		
Regulations and specific applicable standards			
in France:	NF EN 378-2 related to safety and environmental requirements of refrigerations systems and heat pumps NF EN 60335-2-89 related so specific sagety rules for refrigeration equipment of commercial use including a condensing unit or an integrated or remote compressor NF EN 14276-1 et 14276-2 related to reservoirs and piping of equipment under pressure for refrigeration systems and heat pumps		
in Europe:	Regulation 842/2006/EC EN 378 EN 60335-2-89 EN 14276-1 et 14276-2		

EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: R-717 + indirect system with HTF (MPG or CO_2 or Temper)	**Case 2: R-134a + indirect system with HTF (MPG or CO_2 or Temper)**	**No retrofit solution**
Technical principle			
Parc d'équipements en service			
in France:	Not communicated	Not communicated	
in Europe:	Not communicated	Not communicated	
Applicable regulations and existing standards			
in France:	Ammonia regulation	Regulation 842/2006/CE	
in Europe:		Regulation 842/2006/CE	
GWP	0	1370	
Energy efficiency	Similar to the reference system	Lower than R-404A	
Volumetric capacity	Similar	Lower than R-404A	
Availability	Immediate	Immediate	
Main barriers to the solution expansion	Toxic and moderately flammable (B2L). Cost (investment and safety) higher,up to 50%, than R-404A installation	GWP within the scope of the F-Gas evaolution at medium term.	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Flexibility of the ammonia regulation Lasting solution (Regulation 842/2006/CE) Energy efficiency similar to R-404A. High cost of the shell-and-tube heat exchanger plu cost due to the necessary insulation of the circuit and pumps installation.	Possible retrofit R-134a/ R-1234yf or R-1234ze on the medium term High cost of the shell-and-tube heat exchanger plu cost due to the necessary insulation of the circuit and pumps installation.	
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			

ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1:	**Case 2:**	**Case 3:**
Technical principle			
Industrial availability			
Existence of demonstrators or operational prototypes			
Regulation and status of standards			
in France:			
in Europe:			
GWP			
Energy efficiency			
Volumetric capacity			
Probable date of commercial availability			
Main barriers to the solution expansion			
Context promoting this technique implementation (Drop in or not, impact on the charge, …)			
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			

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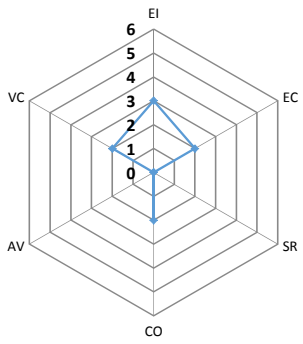
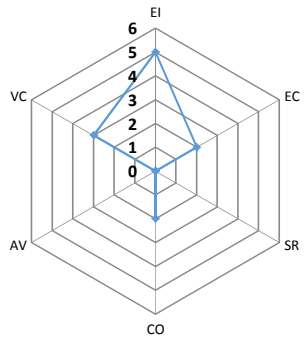
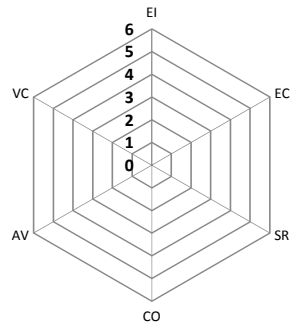
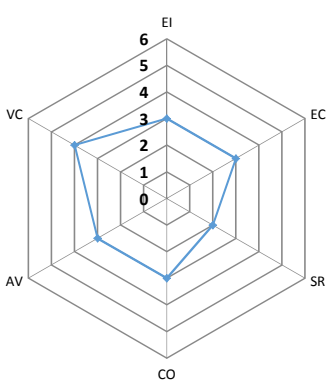
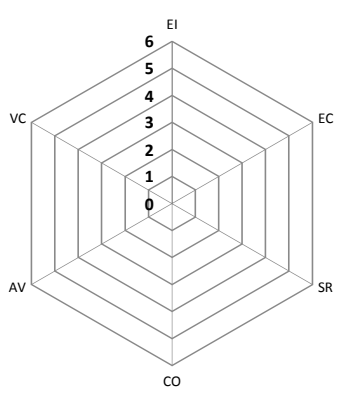
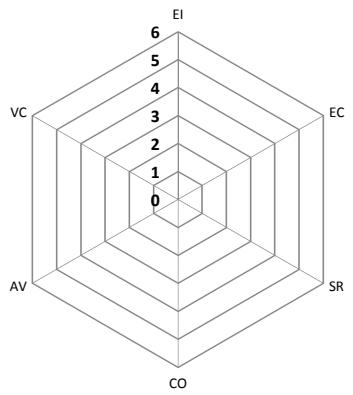
Application factsheet: Direct-drive unit using R-404A in medium and low-temperature systems			RT1
SECTOR	Refrigerated transport vehicles	**Sub-sector**	Direct drive
Usage / Standard application	Transport of perishable goods for different classes of temperatures (fresh, frozen). Small-size vehicles, they are used for local delivery of food of pharmaceutical products. The use needing multiple deliveries, these vehicles are equipped with oversized refrigeration units in order to compensate chrage ruptures implied by frequent opening of doors. In 2011, the French production was of 6,852 vehicles (small vans and refrigerated vans).		
Temperature range	[+ 12 °C et 0 °C] (classe A ATP) et [+ 12 °C et - 10 °C] (classe B ATP) et [+ 12 °C et - 20 °C] (classe C ATP)		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-404A GWP = 3700	**Average charge by equipment (kg)**	1.63
Data relative to the refrigerant used	A1, R-404A represents 92% of the global market of refrigerated transport		
Installed base in operation			
in France:	48	**Refrigerant bank in France (t):**	78.24
in Europe:	400	**Refrigerant bank in Europe (t):**	652
Average equipment lifetime (years)	10 years		
Main providers of technologies			
in France:	Carrier transicold (US), Thermoking, (US),		
in Europe:	Carrier transicold (US), Thermoking, (US), Frigoblock (DE)		
Main owners of technologies			
in France:			
in Europe:			
Technical justification and particular conditions of the application with respect to the HFC type used	Refrigerants well adapted to the range of temperatures (especially for low-temperature refrigeration) down to -20°C in food…Since the installed base includes 30% of multi-temperature vehicles, this refrigerant is used for vehicles adapted to transportation of fresh products.		
Regulations and specific applicable standards			
in France:	- Rural code (Article 231-59) on characteristics of vehicles for the transport of perishable goods - Environment Code applicable to refrigerants - Order of 2 June 2008, ATP Agreement -NF EN 378		
in Europe:	Local regulations not harmonized in Europe		
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: Eutectic cold source	**Case 2: R-407A or R-407F in new and in retrofit**	**Case 3 :**
Technical principle	Installed in an insulated vehicle, a cold source called Eutectic consisting of an aqueous solution previously frozen which allows delivery of refrigeration during transport. Cooler principle. The implementation of eutectic involves the use of a fixed refrigeration system which itself contains a HFC and compression technology	R-407A - R-32/125/134a (20/40/40) R-407F - R-32/125/134a (30/30/60)	
Installed base in operation			
in France:		First installations in 2013	
in Europe:		First installations in 2013	
Applicable regulations and existing standards			
in France:			
in Europe:			
GWP	0 (if one forgets the time forthe eutectic plates to reach the defined temperature)	R-407A 2100 / R-407F 2060	
Energy efficiency		Similar to R-404A for medium-temperature systems	
Volumetric capacity	Sufficient	Similar to R-404A for medium-temperature systems	
Availability	Immediate	Immediate	
Main barriers to the solution expansion	- Increase the vehicle weight and decrease the useful load - Difficult to reconcile with the desire to expand the park of electrical equipment for urban logistics - Does not solve the issue of cold storage that needs a cold room to lower the temperature	GWP relatively high.	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Technologie dedicated mainly to low-temperature refrigeration (ice)	Solutions available in retrofit	
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: Refrigerant blend GWP around 300	**Case 2 :**	**Case 3 :**
Technical principle	L-40: R-32/152a/1234yf/1234ze (40/10/20/30) D2Y-65: R-32/1234yf (35/65) DR-7: R-32/1234yf (36/64) ARM-30a: R-32/1234yf (29/71)		
Industrial availability	Non		
Existence of demonstrators or operational prototypes	Oui		
Regulation and status of standards			
in France:			
in Europe:	EN 378		
GWP	L-40: 302 D2Y-65: 253 DR-7: 260 ARM-30a: 210		
Energy efficiency	L-40: COP - 14% vs. R-404A DR-7: COP + 7% vs. R-404A ARM-30a: COP - 11% vs. R-404A		
Volumetric capacity	L-40: -17% vs. R-404A DR-7:+ 2% vs. R-404A ARM-30a: - 19% vs. R-404A		
Probable date of commercial availability			
Main barriers to the solution expansion	Slightly flammable A2L Uncertainty on the refrigerant price		
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	L-40 : +5% charge vs. R-404A D2Y-65: -5% charge vs. R-404A		
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
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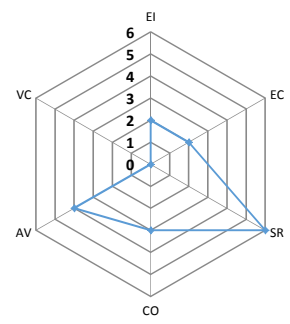
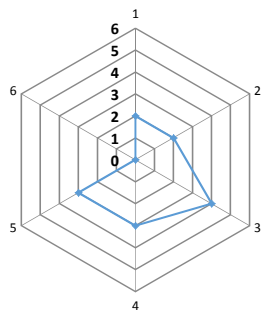
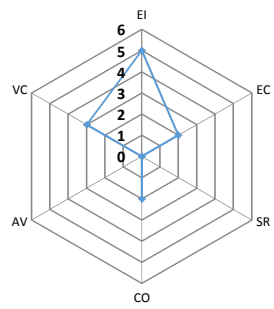
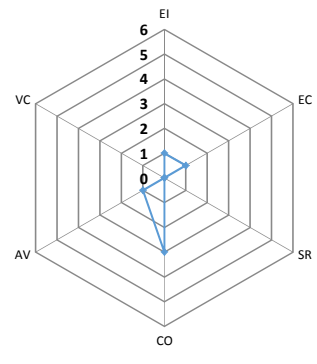
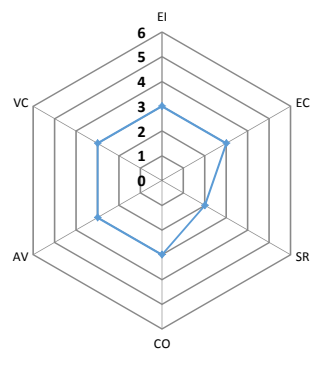
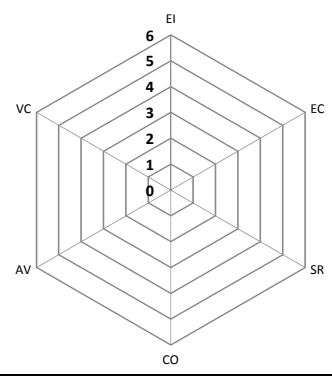
Application factsheet: Self-powered units for trucks and semi-trailers			RT2
SECTOR	Refrigerated transport vehicles	**Sub-sectors**	Self-powered units
Usage / Standard application	Transport of perishable goods for different classes of temperatures (fresh, frozen). Multi-temperature transport. Self-powered units are often used to equip large vehicles (> 12 t) and semi-trailers for long distance transport and delivery of large and medium-surface urban stores. In 2012,the French production represented 5,062 vehicles (refrigerated vehicles and semi-trailers)		
Temperature range	[+ 12°C et 0°C] (class A ATP) and [+ 12°C and - 10°C] (class B ATP) and [+ 12°C and - 20°C] (class C ATP)		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-404A GWP = 3700	**Average charge by equipment (kg)**	6.4
Data relative to the refrigerant used	A1, R-404A represents 92% of the global market of refrigerated transport		
Installed base in operation			
in France:	73	**Refrigerant bank in France (t):**	467.2
in Europe:	600	**Refrigerant bank in Europe (t):**	3840
Average equipment lifetime (years)	10 years		
Main providers of technologies			
in France:	Carrier transicold (US), Thermoking, (US),		
in Europe:	Carrier transicold (US), Thermoking, (US), Frigoblock (DE)		
Main owners of technologies			
in France:	Stef, STG, Delanchy, Staf, Olano …		
in Europe:	Stef		
Technical justification and particular conditions of the application with respect to the HFC type used	Refrigerants well adapted to the range of temperatures (especially for low-temperature refrigeration) down to -20°C in food…Since the installed base includes 30% of multi-temperature vehicles, this refrigerant is used for vehicles adapted to transportation of fresh products.		
Regulations and specific applicable standards			
in France:	- Rural code (Article 231-59) on characteristics of vehicles for the transport of perishable goods - Environment Code applicable to refrigerants - Order of 2 June 2008, ATP Agreement NF EN 378		
in Europe:	- EC labeling due to the Directiveon noise of refrigerating units - PIEK Protocole (noise of refrigerating units) - CEN standards: EN 16440-1, -2, -3, 4… (PC 413)		
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: Liquid nitrogen Direct expansion system	**Case 2: Liquid nitrogen Indirect system**	**Case 2: R-407A or R-407F in new and in retrofit**
Technical principle	The principle is based on the direct expansion of liquid nitrogen. Cold produced by the expansion of liquid nitrogen is transferred directly to the air to be cooled (that of the refrigerated vehicle compartment).	The principle is based on an open primary circuit with direct expansion of liquid nitrogen and a heat exchanger installed in the vehicle compartment. The compartment is qeuipped with forced ventilation.	R-407A - R-32/125/134a (20/40/40) R-407F - R-32/125/134a (30/30/60)
Installed base in operation			
in France:	Not communicated	Not communicated	First installations in 2013
in Europe:	Not communicated	Not communicated	First installations in 2013
Applicable regulations and existing standards			
in France:	Recommendation from the social security because of safety problems of personnel in charge of deliveries: in operation, air of the refrigerated vehicle compartment is replaced by nitrogen. Human intervention can begin only once the iar in the compartment is renewed, hence the setting of safety devices locking the doors.		
in Europe:			
GWP	0		R-407A 2100 / R-407F 2060
Energy efficiency	- Low energy consumption for a low ΔT - High energy consumption for significant ΔT	- Low energy consumption for a low ΔT - High energy consumption for significant ΔT	Similar to R-404A for medium-temperature systems
Volumetric capacity			Similar to R-404A for medium-temperature systems
Availability	Available	Available	Immediate
Main barriers to the solution expansion	- Aditional costs linked to the development and safety devices - Lack of a network for the distribution of liquid nitrogen - Safety aspects of persons for urban deliveries - Limited autonomy for high ambient temperatures. Cannot be adapted on an existing compartment by standard replacement (chassis, case modification...)	- Lack of a network for the distribution of liquid nitrogen - Safety of persons for deliveries in closed sas - Limited autonomy for high ambient temperatures. Cannot be adapted on an existing compartment by standard replacement (chassis, case modification...)	GWP relatively high.
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	- Silent technologie - No moving parts (robustness limiting the maintenance) - Low energy consumption for low ΔT - Good efficiency at partial load - Rapid decrease in temperature - Low maintenance cost - Adapted to urban logistic	- Silent technologie - No moving parts (robustness limiting the maintenance) - Low energy consumption for low ΔT - Good efficiency at partial load - Rapid decrease in temperature - Low maintenance cost	Solutions available in retrofit
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	Case 1: CO_2 compression unit	**Case 2: refrigerant blend GWP around 300**	
Technical principle	Same as compression unit	L-40: R-32/152a/1234yf/1234ze (40/10/20/30) DR-7: R-32/1234yf (36/64) ARM-30a: R-32/1234yf (29/71)	
Industrial availability	No	No	
Existence of demonstrators or operational prototypes	No	Yes	
Regulation and status of standards			
in France:			
in Europe:		EN 378	
GWP	1	ARM-30a: 210 L-40: 302 DR-7: 260	
Energy efficiency	+5% energy consumption vs. R-404A and losses of efficiencies at high outdoor temperatures	'ARM-30a : + 6% vs. R-404A L-40: COP + 5% vs. R-404A DR-7: COP + 7% vs. R-404A	
Volumetric capacity	+10% vs. R-404A	ARM-30a : +4 % vs. R-404A L-40 : +2 % vs. R-404A DR-7 : +11 % vs. R-404A	
Probable date of commercial availability			
Main barriers to the solution expansion	Development cost of components, training of maintenance operators	Slightly flammable A2L Uncertainty on the refrigerant price	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Successful experience for containers for very variable ambient temperatures. A1 refrigerant.	L-40: +5% charge vs. R404A	
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
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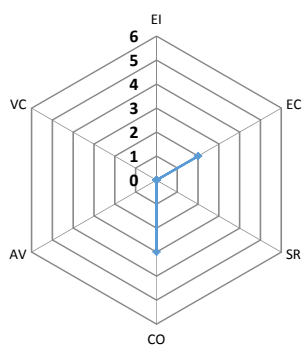
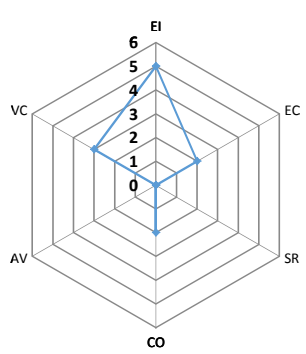
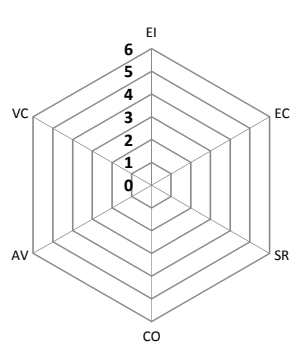
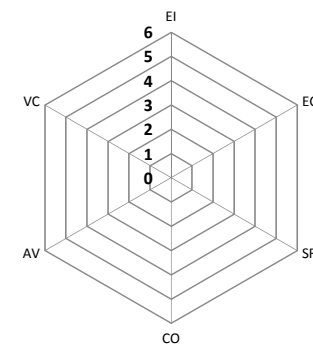
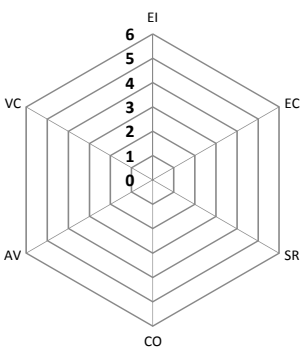
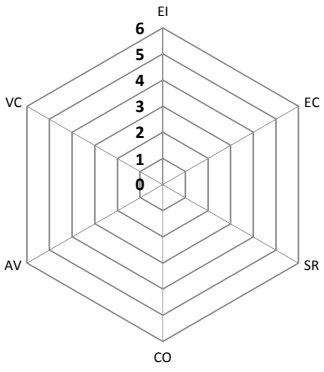
Application factsheet: Self-powered units for containers			RT3
SECTOR	Refrigerated transport	**Sub-sector**	Containers
Usage / Standard application	Dedicated to transport of refrigerated goods (from -25°C to +25°C), sea containers (20-feet or 40-feet) are equipped with an insulated compartment and a self-powered compression unit. Units are electrically-driven; equipement allow, on port terminals, on ships and on some road chassis, to power these units during the transport duration. The installed base is estimated at 1.1 million of refrigerated sea containers, of which 85% use R-134a and 15% R-404A. The large majority of transported goods are fresh and not frozen, which explains the massive quantity of R-134a.		
Temperature range	[+12°C et 0°C] (class A ATP) and [+12°C et -10°C] (class B ATP) and [+12°C et -20°C] (class C ATP)		
DESCRIPTION OF THE REFERENCE SYSTEM			
Refrigerant type commonly used / GWP	R-134a GWP = 1370	**Average charge by equipment (kg)**	4 to 4.9 kg for 20-ft containers
Data relative to the refrigerant used			
Installed base in operation			
in France:		**Refrigerant bank in France (t):**	
in Europe:		**Refrigerant bank in Europe (t):**	
Average equipment lifetime (years)	14 years		
Main providers of technologies			
in France:	Carrier transicold (US),Thermoking, (US)		
in Europe:	Carrier transicold (US), Thermoking, (US)		
Main owners of technologies			
in France:	CMA CGM,		
in Europe:			
Technical justification and particular conditions of the application with respect to the HFC type used	R-134A is well adapted to transportation of fresh products		
Regulations and specific applicable standards			
in France:	- Norme ISO 1496-2 specification and tests of containers with thermal characteristics - ATP, if used within multi-modal transport		
in Europe:			
EXISTING ALTERNATIVE TECHNIQUES			
	Case 1: CO_2	**Case 2: R-407A or R-407F in new and in retrofit**	**Case 3:**
Technical principle	CO_2 unit with Scroll or reciprocating compressor and air or water condensers	R-407A - R-32/125/134a (20/40/40) R-407F - R-32/125/134a (30/30/60)	
Installed base in operation			
in France:	Not communicated	First installations in 2013	
in Europe:	Not communicated	First installations in 2013	
Applicable regulations and existing standards			
in France:			
in Europe:			
GWP	1	R-407A 2100 / R-407F 2060	
Energy efficiency	COP (Tamb=38°C, Tint=-18°C) of R-12 units was of 0.73 in the 90s, 1.1 for R-134a units in 2008. Significant developments have been made in design of fans and scroll compressors in order to increase the efficiency of CO_2 units.	Similar to R-404A for medium-temperature systems	
Volumetric capacity	Sufficient	Similar to R-404A for medium-temperature systems	
Availability	Recently available. The NaturaLINE series has been launched officially at the Intermodal Salon early October 2013,	Immediate	
Main barriers to the solution expansion	Development cost of components, training of maintenance operators	GWP relatively high.	
Context promoting this technique implementation (Drop in or not, impact on the charge, …)	Low-GWP refrigerant. A1	Solutions available in retrofit	
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
ALTERNATIVE TECHNIQUES UNDER DEVELOPMENT			
	cas 1 :	**cas 2 :**	**cas 3 :**
Technical principle			
Industrial availability			
Existence of demonstrators or operational prototypes			
Regulation and status of standards			
in France:			
in Europe:			
GWP			
Energy efficiency			
Volumetric capacity			
Probable date of commercial availability			
Main barriers to the solution expansion			
Context promoting this technique implementation (Drop in or not, impact on the charge, …)			
Multicriteria indicators **EI: Environmental Impact - GWP** **1 = Very low (<10) 2 = Low (<150) 3 = Medium (< 750)** **4 = High (>750) 5 = Very high (>1500), 6 = Extremely high (>2500)** **EC: Energy Consumption** **0 = Low 3 = Medium 6 = High** **SR: Safety Risk** **0 = Class A1 2 = A2L 4 = A2 and B2 6 = A3 and B3** **CO: Cost of the solution (out of maintenance)** **0 = Low 3 = Medium 6 = High** **AV: Availability** **6 = Laboratory 3 = Field demonstration 0 = Industrial** **VC: Volumetric Capacity** **0 = Sufficient 3 = Medium 6 = Unsatisfying**			
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