Annex to Module 4
Economic Assessment

NAMAs in the refrigeration, air conditioning and foam sectors. A technical handbook.

On behalf of

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1. Quantification of costs for RAC sectors

1.1 Cost group: Technician assessment, certification and registration scheme

The different technical options (TOs) which are recommended to have competence schemes associated with them are identified in the table below.

TABLE 1
Technical options where associated competence schemes are recommended

Technical option	Technician assessment	Technician certification	Technician registration	Company registration
Leak reduction (design/const)				
Leak reduction (maintenance)	×	×	×	×
Charge size reduction				
Recovery and recycling	×	×	×	×
HC R600a	×	×	×	×
HC R290/ R1270	×	×	×	×
R717	×	×	×	×
R744	×	×	×	×
unsat-HFC				
HFC/unsat-HFC blends				
Low-GWP + liquid secondary				
Low-GWP + evap secondary	×	×	×	×
Low-GWP + cascade				
Distributed water-cooled				
District heating/cooling	×	×	×	×
Minimum efficiency rules				

For each of the cost elements, one would account for a fixed annual baseline cost, necessary for administrating the system. In addition, there would be an individual cost assigned for each technician or company that has to be processed. It is also appropriate to limit the period of validity, since the competence of technicians or indeed the enterprise can degrade over time. Thus recommended range of time is also provided.

The costs may be quantified as follows:

TABLE 2
Cost elements for competence schemes

Technician assessment	€ 10,000	€ 150 per technician	3 – 5 years
Technician certification	€ 5,000	€ 50 per technician	3 – 5 years
Technician registration	€ 15,000	€ 50 per technician	3 – 5 years
Company registration	€ 15,000	€ 50 per technician	Every year

1.2 Cost group: Research and development

Research and development (R&D) expenditure is often a function of the revenue or anticipated revenue arising from a particular product group. It is also dependent on the extent of R&D already carried out on a given refrigerant/product combination, for example, where a refrigerant is already widely used in a particular type of system, the need for additional R&D diminishes. Also, different companies have a tendency to carry out different degrees of R&D depending on their internal philosophy.

Depending on the refrigerant used, different levels of R&D are needed for different aspects. In general, the R&D expenditure may vary from around 2 to 5% of the development of a new product, so given a production life of about five years for a given model the additional cost averaged for one unit could be around 1% of the overall cost.

For each of the main areas of R&D, a nominal expenditure has been allocated, as a proportion of the sales revenue for the annual output of the product type. The proportions depend on whether the R&D area is considered to be of low or high importance (Table 3).

TABLE 3
Nominal expenditure for individual R&D elements

	Medium effort	High effort
Low importance	0.1% of product annual revenue	0.2% of product annual revenue
High importance	0.5% of product annual revenue	1.5% of product annual revenue

The additional R&D cost applied to each product is the sum of the R&D costs for the individual areas divided by the total number of products output over a given time period

$$RDC = \frac{1}{N_{prod/y} \times T_{prod}} \sum_i C_{RD,i}$$

Where:
$N_{prod/y}$ = number of units produced in one year
T_{prod} = production period for the applicable models
C_{RD} = R&D cost for the individual area

1.3 Cost group: Production line equipment

Actual costs will vary widely depending on type and size of the enterprise, design of the systems and the specific production techniques normally in place.

In order to quantify costs, three scenarios are established:

- Small-scale production: around 1,000 units/yr
- Medium-scale production: around 10,000 units/yr
- Large-scale production: around 100,000 units/yr

Typical costs for the various main elements are provided in Table 4. These are based on prices from production equipment suppliers.

TABLE 4
Cost breakdown of various production line equipment

Element	Small-scale production (1,000 units/yr)		Medium-scale production (10,000 units/yr)		Large-scale production (100,000 units/yr)	
	Component	Cost (in Euro)	Component	Cost (in Euro)	Component	Cost (in Euro)
Refrigerant storage	Cylinders	500	Cylinders	1,500	Bulk tank	8,000
Refrigerant feeding system	Direct	0	Piping	20,000	Piping	20,000
Refrigerant charging machines	1 × machine	20,000	1 × machine	20,000	2 × machines	40,000
Refrigerant leak checking (gas detectors)	1 × detector	5,000	1 × detector	10,000	2 × detectors	25,000
System tightness/ pressure testing (helium, nitrogen, etc.)	Basic nitrogen kit	3,000	Nitrogen system	30,000	Helium/ nitrogen system	60,000
Repair area (venting/ recovery equipment)		2,000		2,000	Plus vent stacks, etc	10,000
Evacuation lines (vac pumps)	1 × vac pumps	2,000	2 × vac pumps	4,000	40 × vac pumps	80,000
Safety system (detectors, ventilation, alarms)	Simple layout	5,000	Simple layout	10,000	Extensive layout	45,000
Electrical safety testing		2,000		2,000		20,000
Performance testing		3,000		5,000		50,000
Ultrasonic welding	n/a	0	n/a	0	2 × welding sets	60,000
Heat exchanger production	n/a (externally sourced)	0	n/a (externally sourced)	0	New dyes	500,000
Facilities for steel piping (welding equipment)		5,000		10,000		50,000
District heating/cooling	×	×			×	×
Minimum efficiency rules						

Given the wide variation of different equipment in terms of style, functionality, sophistication, etc., as well as amongst suppliers, the costs included in Table 4 can easily vary by ±50%.

1.4 Cost group: Regulations, standards (restrictions)

It is difficult to estimate the costs since the adoption or development of rules depend strongly on the size of the country, the organisation responsible for drafting and implementation, the depth to which the requirements are analysed and so on. Therefore a simplistic approach is taken and a nominal cost is applied for any country.

The following table summarises the nominal costs for the different rules, whether newly developed or adopted from elsewhere.

TABLE 5
Nominal costs for producing new rules

Rule	Develop new	Adopt existing
Regulation	€ 150,000	€ 100,000
Standard	€ 200,000	€ 50,000
Technical guideline	€ 100,000	€ 25,000

The cost is averaged out over the entire number of products which employ the respective technical option.

$$COR = \frac{C_{reg} + C_{std} + C_{tg}}{N_{prod/t} \times T_{refy}}$$

Where:

C_{reg} ,C_{std} ,C_{tg} = nominal costs for the regulation, standard and technical guidelines, respectively; the appropriate cost for developing a new or adopting an existing set of rules applies accordingly

$N_{prod/t}$ = estimated number of products of a particular type that are consumed by the country in one year

T_{refy} = reference time period (in years) over which the cost is averaged

1.5 Cost group: Technician training

For a given annual output of a specific system/technical option combination for an enterprise, the training cost can be estimated. This is based on the number of technician days that are needed for working on that population of systems. The number of days can vary according to certain characteristics of the systems and technical options under consideration.

The number of technicians required can be estimated based on a given annual output of a fixed number of systems.

The number of technicians required for installation of systems is

$$N_{tchn,inst} = \frac{T_{inst/kW} \times Q_{sys} \times N_{prod/y} \times \varphi_{size}}{T_{wd/y}}$$

Where:

$T_{inst/kW}$ = average installation time per kW of cooling capacity (days)

Q_{sys} x $N_{prod/y}$ = product of the nominal system capacity and the annual production output

φ_{size} = factor to account for the size and complexity of the system

Twd/y = the average working days per year

φ_{size} is listed in Table 6 and is based on the assumption that larger systems are more compact so less time is required per unit of capacity.

The number of technicians required for providing routine maintenance is

$$N_{tchn,mntc} = \frac{T_{mntc/kW} \times Q_{sys} \times N_{prod/y} \times T_{life} \times P_{mntc} \times \varphi_{size}}{T_{wd/y}}$$

Where:
$T_{mntc/kW}$ = average maintenance time per kW of cooling capacity (days)
T_{life} = average lifetime of the system (years)
P_{mntc} = proportion of installed systems that receive regular maintenance

The lifetime of the systems is included in order to represent the steady number of systems in operation at any one time. For example, if an enterprise continuously produces 100 systems per year which have an average lifetime of 10 years, there will always be approximately 1000 systems in operation at any one time.

The number of technicians required for providing servicing is

$$N_{tchn,serv} = \frac{T_{serv/kW} \times Q_{sys} \times N_{prod/y} \times T_{life} \times P_{fail} \times \varphi_{size}}{T_{wd/y}}$$

Where:
$T_{serv/kW}$ = average time required for servicing a system per kW of cooling capacity (days)
P_{fail} = proportion of installed systems that fail

The number of technicians required for dismantling at end of life is

$$N_{tchn,dsmtl} = \frac{T_{dsmtl/kW} \times Q_{sys} \times N_{prod/y} \times \varphi_{size}}{T_{wd/y}}$$

$T_{dsmtl/kW}$ = average time required for dismantling a system per kW of cooling capacity (days)

The total number of technicians that are needed to be available and trained per year for a continuous output of systems is

$$N_{tchn,tot} = \left(N_{tchn,instl} + N_{tchn,mntc} + N_{tchn,serv} + N_{tchn,dsmtl}\right) \times \left(1 + R\right)$$

Where:
R = redundancy factor, say 50%, to account for the technicians that move from the relevant job
Where $N_{tchn,instl}$, $N_{tchn,mntc}$, $N_{tchn,instl}$, and $N_{tchn,instl}$ are as above

The training cost is a function of the number of initial training days ($T_{train,init}$) a technician requires for a specific system/technical option and also the cumulative additional top-up training days ($T_{train,top}$), which are largely based on how important the additional information is for carrying out the appropriate activities. These are listed in Table 6.

The average technician training cost per technician is

$$CTPS = \frac{C_{train/day} \times N_{techn,tot} \times (T_{train,init} + T_{train,top})}{N_{prod/y}}$$

$C_{train/day}$ = average daily cost for the training (including that of the technician's time, trainer and facilities)

TABLE 6
Technician training parameters

Technical option	System size reduction factor (φ_{size})	Maintenance time ($T_{mntc/kW}$) (day per kW)	Dismantling time ($T_{dsmtl/kW}$) (day per kW)	Initial specialised training (days)	Additional training top-up (days per year)
BAU (HFC)	1	0.2	0.15	0	0.25
Leak reduction (design/const)	1	0.2	0.15	2	0.5
Leak reduction (maintenance)	1	0.5	0.15	3	0.5
Charge size reduction	1	0.2	0.15	0	0.5
Recovery and recycling	1	0.5	0.5	2	0.5
HC R600a	1	0.2	0.15	2	0.5
HC R290/ R1270	1	0.2	0.15	2	0.5
R717	1	0.2	0.15	4	0.5
R744	1	0.2	0.15	3	0.5
unsat-HFC	1	0.2	0.15	1	0.3
HFC/unsat-HFC blends	1	0.2	0.15	1	0.3
Low-GWP + liquid secondary	1/2	0.2	0.15	3	0.3
Low-GWP + evap secondary	1/2	0.2	0.15	5	0.5
Low-GWP + cascade	1/2	0.2	0.15	3	0.3
Distributed water-cooled	1/2	0.2	0.15	3	0.3
District heating/cooling	1/3	0.2	0.15	5	1
Minimum efficiency rules	1/2	0.2	0.15	0	0

1.6 Cost group: Engineer training

The number of engineers required to implement a new technical option technology within a particular enterprise is approximated from

$$N_{eng} = \left(\frac{Q_{tot} \times T_{despkW} \times \varphi_{complex}}{N_{days/y}} \right) (1 + R)$$

Where:

Q_{tot} = total cooling capacity (kW) of the annual output of all systems
T_{despkW} = average design time per kW of system cooling capacity (set at 0.05 days/kW)
$\varphi_{complex}$ = system complexity factor, set at 1 for most single circuit systems, 2 for indirect or secondary system and 3 for district cooling systems
$N_{days/y}$ = number of working days per year, say 250
R = redundancy factor, say 50%, to account for the engineers that move from the relevant job

Depending upon the technical option, different amounts of training focused on subject areas would be required.

TABLE 7
R&D training time requirements

Technical option	Component selection	Circuit design	Special software	Standards	Safety	Cycle concepts	Total days
BAU	0.5	0	0	0	0.5	0	1
Leak reduction (design/const)	2	1	0	2	0	0	5
Leak reduction (maintenance)	1	1	0	1	0	0	3
Charge size reduction	1	1	0	0	0	0.5	2.5
Recovery and recycling	0.5	0	0	0	0	0	0.5
HC R600a	1	0.5	0	2	2	0	5.5
HC R290/ R1270	1	0.5	0	2	2	0	5.5
R717	1	1	0	1	2	0.5	5.5
R744	1.5	2	0	0	1	2	6.5
unsat-HFC	0.5	0	0	0.5	0.5	0	1.5
HFC/unsat-HFC blends	0.5	0	0	0.5	0.5	0	1.5
Low-GWP + liquid secondary	2	2	2	0	0.5	2	8.5
Low-GWP + evap secondary	2	2	2	0	1.5	2	9.5
Low-GWP + cascade	2	2	2	0	1.5	2	9.5
Distributed water-cooled	2	2	2	0	0.5	2	8.5
District heating/cooling	3	3	3	1	1	2	13
Minimum efficiency rules	1	1	3	1	0	0	6

Finally, the additional engineer training cost per system of the produced technical option is estimated from

$$SADC = \frac{N_{eng} \times N_{traindays} \times C_{train/day}}{Q_{tot}} Q_{sys}$$

Where:
$N_{traindays}$ = number of training days required (Table 7)
$C_{train/day}$ = average daily cost for the training (including that of the engineer's time, trainer and facilities)
Q_{sys} = rated capacity of the system

1.7 Cost group: Technician tools and equipment

The following table is a list of common items that may be used by technicians, when handling a business-as-usual (BAU) refrigerant system.

TABLE 8
Technician tools and equipment

No	Item
1	Tool box (metal)
2	Pair of safety gloves for refrigerant handling (acid-resistant)
3	Pair of safety gloves for mechanical work
4	Safety goggles
5	Folding rules (2 m)
6	Steel ruler (40 cm)
7	Spirit level
8	Quick square
9	Digital calliper
10	Flashlight
11	Centre punch
12	Cable knife
13	Cable reel (about 10 m)
14	Hacksaw and extra blades (wide ca. 30 cm)
15	Hammer (300 gram)
16	Sets of files (round, flat, triangle)
17	Scratch awl
18	Hex key set
19	Combination wrenches set (9 pieces)
20	Adjustable wrenches (set of 3 different sizes)
21	Pipe wrench (35 cm)
22	Ratchet wrench (rota-lock)
23	Torque wrench set (3 sizes)
24	Socket wrench and bit set
25	Vice grip pliers
26	Pinch-off pliers
27	Piercing pliers (6 to 22 mm) with spare gaskets and needle
28	Swaging tool set
29	Tube expander set (10 – 22 mm)
30	Tube bender lever type or hydraulic set (10, 12, 16, 18, 22)
31	Tube cutter, midget and large
32	Flaring tool set
33	Inspection mirror
34	Set of inner/outer tube reamer & one pen type reamer
35	Capillary tube cutter
36	Capillary tube gauge
37	Steel brush
38	Set of two process tube quick connector (for 6 mm / ¼")
39	Brazing kit (propane/oxygen, oxygen/acetylene)
40	Brazing heat shield (silicate fibre)

TABLE 8
Technician tools and equipment

No	Item
41	Welding set (electric)
42	Nitrogen (N_2) cylinder, test pressure 300 bar, working pressure 200 bar, mounted on trolley
43	Pressure regulator (N_2) complete with transfer hose, entr. Pressure 200 bar, working pressure 40 bar
44	Set of screw driver (7 pieces) incl. straight, cross and Philips. Isolated 1000 Volt tested (EN60900)
45	Set of 4 pliers (Electro) isolated 1000 Volt tested (EN60900)
46	Wire stripper, isolated 1000 Volt tested (EN60900)
47	Pocket screw drivers set
48	Cable ripper
49	Socket, cable shoe, adapter set including iso. tape
50	Clamp on ampere-meter, current, voltage, resistance, etc.
51	Mains tester with LED
52	Capacitor tester
53	Test cord, compressor starting and testing device (hermetic compressors)
54	Solenoid valve operating magnet
55	Wire crimping tool, isolated 1000 Volt tested (EN60900)
56	Driller cordless, including set of bits and drill drivers
57	Valve core removal tool
58	4-valve manifold gauge set with hoses (ball valves) 3x ¼" SAE and 1x⅜" SAE & ⅜" vacuum hose
59	Set of two extra refrigerant hoses 150 cm with ball valve, spare gaskets and depressors
60	Liquid charging adapter
61	Electronic vacuum gauge (micron, Pa, mbar) 20 bar overpressure protection
62	Compressor tester (compression checking)
63	Pocket thermometer
64	Precise electronic thermometer with two probes connection (-50 °C to 50°C)
65	Temperature and humidity logger with PC interface and software
66	Electronic gas detector with visible and audible alarm, sensitivity 3 gram/year
67	Reference leak for leak detectors, rate of leak 5 gram/year
68	Leak detection fluid sprayer with solution for -6 °C to 120 °C surface detection temperature
69	Air velocity meter with extension handle air lock
70	Electronic charging scales 50 kg, resolution 2 gram, accuracy +/- 0,5%, battery powered
71	Refrigerant cylinder heating belt, about 400 Watt, 230 Volt, 60 °C
72	Can valve, ¼" SAE connection
73	Vacuum pump, two stage, 15 Micron rating, gas-ballast valve, ¼" and ⅜" SAE connections
74	Refrigerant recovery unit, transportable, oil-less, ½ HP, complete with hoses and inline filter
75	Portable charging station, vacuum pump, charging scales (0 – 2000 gram) 1 gram accuracy, refrigerant cylinder can support with valve, vacuum gauge, one LP gauge, all necessary charging hoses with ball-valve, one venting hose length 10 m and OD min. 15 mm with vacuum pump exhaust port adapter
76	Refrigerant recovery cylinder with two valve access. DOT or ADR P200 approval
77	Refrigerant analyser, portable, battery powered, with printer
78	Press connection tool set with fittings
79	Refrigerant venting hose

Approximate costs for particular items for each different technical option are listed in the following table, (Table 9) according to the technical option. The cost of such items varies widely, so an average cost based on internet price lists are included. It is also necessary to consider the proportion of technicians within an enterprise who would need a particular tool or piece of equipment. For example, it is usual for technicians to share certain tools regardless of which refrigerant it may be used for.

Thus, the final additional cost is

$$ADC = \left[\sum_i C_i \times P_i \right]_{AO} - \left[\sum_i C_i \times P_i \right]_{BAU}$$

Not all items listed may necessarily be needed for all of the applicable subsectors, however, it is assumed that the final result is representative of all sectors on average.

TABLE 9
R&D expenditure weightings for various alternatives

Item no	Baseline HFC		Leak reduction (maintenance)		Recovery and recycling		HC R600a		HC R290/ R1270		R717		R744		unsat-HFC		HFC/unsat-HFC blends	
	Have	cost	% need	cost	% need	cost	% need	cost	% need	cost	% need	cost	% need	cost	% need	cost	% need	cost
19	25%	€ 20	100%	€ 20	25%	€ 20	25%	€ 20	25%	€ 20	25%	€ 20	100%	€ 20	25%	€ 20	25%	€ 20
23	0%	€ 150	100%	€ 150	0%	€ 150	0%	€ 150	0%	€ 150	0%	€ 150	0%	€ 150	0%	€ 150	0%	€ 150
30	25%	€ 50	100%	€ 50	25%		25%		25%		25%		25%		25%		25%	
31	25%	€ 30	100%	€ 30	25%		25%		25%		25%		25%		25%		25%	
33	25%	€ 5	100%	€ 5	25%		25%		25%		25%		25%		25%		25%	
34	25%	€ 10	100%	€ 10	25%		25%		25%		25%		25%		25%		25%	
41	0%	€ 0	0%	€ 0	0%	€ 0	0%	€ 0	0%	€ 0	100%	€ 500	100%	€ 500	0%	€ 0	0%	€ 0
42	25%	€ 30	100%	€ 30	25%	€ 30	100%	€ 30	100%	€ 30	25%	€ 30	25%	€ 30	25%	€ 30	25%	€ 30
43	25%	€ 60	100%	€ 60	25%	€ 60	100%	€ 60	100%	€ 60	25%	€ 60	25%	€ 60	25%	€ 60	25%	€ 60
58	50%	€ 150	100%	€ 150	100%	€ 150	100%	€ 150	100%	€ 150	100%	€ 250	100%	€ 250	100%	€ 150	100%	€ 150
61	25%	€ 150	100%	€ 150			25%	€ 150	25%	€ 150	100%	€ 250	100%	€ 150	25%	€ 150	25%	€ 150
66	25%	€ 150	100%	€ 150	25%	€ 150	100%	€ 150	100%	€ 150	100%	€ 150	100%	€ 300	25%	€ 150	25%	€ 150
68	25%	€ 10	100%	€ 10	25%	€ 10	25%	€ 10	25%	€ 10	25%	€ 10	25%	€ 10	25%	€ 10	25%	€ 10
70	25%	€ 150	100%	€ 150			100%	€ 150	100%	€ 150	100%	€ 150	100%	€ 150	100%	€ 150	50%	€ 150
73	25%	€ 200	100%	€ 200			50%	€ 200	50%	€ 200	50%	€ 500	50%	€ 200	50%	€ 200	50%	€ 200
74	25%	€ 500	100%	€ 500	100%	€ 500	25%	€ 550	25%	€ 550	50%	€ 750	25%	€ 500	25%	€ 500	25%	€ 500
76	25%	€ 50	100%	€ 50	100%	€ 50	25%	€ 50	25%	€ 50	25%	€ 50	25%	€ 50	25%	€ 50	25%	€ 50
77	0%	€ 4,000	0%		50%	€ 4,000												
78	0%	€ 0	100%	€ 500	0%	€ 500	50%	€ 500	50%	€ 500	0%	€ 0	0%	€ 0	0%	€ 0	0%	€ 0
79	0%	€ 0	0%	€ 0	0%	€ 0	100%	€ 25	100%	€ 25	0%	€ 0	100%	€ 25	0%	€ 0	0%	€ 0

1.8 Cost group: Awareness-raising

In order to make the various target groups aware of the relevant BAU systems and technical options, certain expenditure is required. The extent of expenditure depends on who the target group is and what the application/ equipment sector is, since this determines the extent of necessary information.

To simplify the cost approximation, it is assumed to comprise of the following elements:
- Complexity of the system (which is assumed proportional to the nominal capacity)
- Amount of information flow
- Degree by which the particular technical option may affect the recipient

The amount of information needed for the recipient is ranked 1 to 3, with 1 being the least amount of information needed.

TABLE 10
Main theme and ranking of topics for awareness-raising

Technical option	Recipient					
	Seller		Technician		Consumer	
	Rank	Reason	Rank	Reason	Rank	Reason
Leak reduction (design/const)	1	Env. benefit	1	Handling	1	Env. benefit
Leak reduction (maintenance)	1	Env. benefit	3	Rules	1	Env. benefit
Charge size reduction	1	Env. benefit	1	Handling	1	Env. benefit
Recovery and recycling	1	Env. benefit	3	Rules	1	Env. benefit
HC R600a	1	Env. benefit	3	Safety	1	Env. benefit
HC R290/ R1270	1	Env. benefit	3	Safety	1	Env. benefit
R717	2	Env. benefit / install. issues	3	Safety	2	Env. benefit / install. issues
R744	2	Env. benefit	3	Safety / system complexity	1	Env. benefit
unsat-HFC	1	Env. benefit	1	Safety	1	Env. benefit
HFC/unsat-HFC blends	1	Env. benefit	1	Safety	1	Env. benefit
Low-GWP + liquid secondary (centralised)	2	Env. benefit / complexity	3	System complexity	2	Env. benefit / complexity
Low-GWP + evap. secondary (centralised)	2	Env. benefit / complexity	3	System complexity	2	Env. benefit / complexity
Low-GWP + cascade (centralised)	2	Env. benefit / complexity	3	System complexity	2	Env. benefit / complexity
Low-GWP + liquid secondary (discrete)	1	Env. benefit	2	System complexity	1	Env. benefit / complexity
Low-GWP + distrib water-cooled (central)	2	Env. benefit / complexity	3	System complexity	2	Env. benefit / complexity
Low-GWP + district cooling	3	Env. benefit / complexity	3	System complexity	3	Env. benefit / complexity

The type of recipient of the information is also considered to affect the cost, that it, getting the information to the seller or technician is fairly easy, since it may be done through industry routes, whereas the consumer typically requires greater resources. Therefore the following cost factors are applied:

- Cost per seller: × 1
- Cost per technician: × 1
- Cost per end user/consumer: × 2

For each technical option, the approximate cost for awareness-raising is from:

[information factor] × [info flow] × [application capacity] × [number of units/output]

2. Detailed cost quantification for technical options in the foam sector

TABLE 11
Detailed costs for XPS technical options

		XPS					
	TO Code	5.1	6.1	6.2	5.3	7.1	8.1
	BAU blowing agent	HFC 134a	HFC 152a	HFC 152a	HFC 134a	HFC 142b	HFC 22
	TO blowing agent	HC	HC	HFO	HFO	HC	HC
Incremental operating cost	Incremental cost Blowing agent [€/tBLA]	-4,413	-3,540	13,060	12,060	-2,626	-2,686
	Incremental cost raw material [€/tBLA]	788	600	1,575	1,575	475	386
	Cost for thickness increase for stable R value [€/tBLA]	1,078	-	-1,015	-	688	-
Incremental Capital Cost	[€/tBLA]	660	517	660	660	421	353
Cost for technology conversion	[€/tBLA]	35	28	35	35	22	19

TABLE 12
Detailed costs for technical options for refrigerated trucks

		Refrigerated trucks			
	TO Code	2.1	3.1	3.3	4.1
	BAU blowing agent	HFC245fa	365mfc/227ea	365mfc/227ea	HCFC141b
	TO blowing agent	HC	HC	HFO	HC
Incremental operating cost	Incremental cost Blowing agent [€/tBLA]	-7,433	-7,523	9,357	-2,637
	Incremental cost raw material [€/tBLA]	-	-	4,792	-
	Cost for thickness increase for stable R value [€/tBLA]	-	2,401	-	1,830
Incremental Capital Cost	[€/tBLA]	-	467	467	356
Cost for technology conversion	[€/tBLA]	-	93	93	71

TABLE 13
Detailed costs for technical options for integral foam

		Integral foam			
	TO Code	2.2	3.1	3.3	4.2
	BAU blowing agent	HFC 245fa	365mfc/227ea	365mfc/227ea	HCFC141b
	TO blowing agent	H2O	HC	HFO	H2O
Incremental operating cost	Incremental cost Blowing agent [€/tBLA]	-8,000	-7,674	7,000	-3,000
	Incremental cost raw material [€/tBLA]	5,156	-	8,250	4,125
	Cost for thickness increase for stable R value [€/tBLA]				
Incremental Capital Cost	[€/tBLA]	393	7,378	7,378	316
Cost for technology conversion	[€/tBLA]	4,191	3,373	3,373	3,373

TABLE 14
Detailed costs for technical options for spray foam

		Spray foam			
	TO Code	2.2	3.2	3.3	4.2
	BAU blowing agent	HFC 245fa	365mfc/227ea	365mfc/227ea	HCFC141b
	TO blowing agent	H2O	H2O	HFO	H2O
Incremental operating cost	Incremental cost Blowing agent [€/tBLA]	-8,000	-8,000	7,000	-3,000
	Incremental cost raw material [€/tBLA]	6,161	5,750	3,833	1,597
	Cost for thickness increase for stable R value [€/tBLA]	7,512	7,040	-	7,381
Incremental Capital Cost	[€/tBLA]	57	53	53	45
Cost for technology conversion	[€/tBLA]	57	53	53	45

TABLE 15
Detailed costs for technical options for commercial refrigeration

		Commercial refrigeration			
	TO Code	2.1	3.1	3.3	4.1
	BAU blowing agent	HFC245fa	365mfc/227ea	365mfc/227ea	HCFC141b
	TO blowing agent	HC	HC	HFO	HC
Incremental operating cost	Incremental cost Blowing agent [€/tBLA]	-7,433	-7,523	9,357	-2,637
	Incremental cost raw material [€/tBLA]	2,875	2,396	2,396	1,797
	Cost for thickness increase for stable R value [€/tBLA]	2,857	2,401	-	1,830
Incremental Capital Cost	[€/tBLA]	6,944	5,835	5,835	4,449
Cost for technology conversion	[€/tBLA]	1,389	1,167	1,167	890

TABLE 16
Detailed costs for technical options for discontinuous sandwich panel metal

		Discontinuous sandwich panel metal			
	TO Code	2.1	3.1	3.3	4.1
	BAU blowing agent	HFC245fa	365mfc/227ea	365mfc/227ea	HCFC141b
	TO blowing agent	HC	HC	HFO	HC
Incremental operating cost	Incremental cost Blowing agent [€/tBLA]	-7,433	-7,523	9,357	-3,000
	Incremental cost raw material [€/tBLA]	-	-	4,792	-
	Cost for thickness increase for stable R value [€/tBLA]	2,857	2,401	-	2,401
Incremental Capital Cost	[€/tBLA]	250	210	210	210
Cost for technology conversion	[€/tBLA]	50	42	42	42

TABLE 17
Detailed costs for technical options for domestic refrigeration

		Domestic refrigeration			
	TO Code	2.1	3.1	3.3	4.1
	BAU blowing agent	HFC245fa	365mfc/227ea	365mfc/227ea	HCFC141b
	TO blowing agent	HC	HC	HFO	HC
Incremental operating cost	Incremental cost Blowing agent [€/tBLA]	-7,433	-7,523	9,357	-2,637
	Incremental cost raw material [€/tBLA]	-	-	4,792	-
	Cost for thickness increase for stable R value [€/tBLA]	2,857	2,401	-	1,830
Incremental Capital Cost	[€/tBLA]	1,736	1,459	1,459	1,112
Cost for technology conversion	[€/tBLA]	347	292	292	222

TABLE 18
Detailed costs for technical options for continuous sandwich panel metal

		Continuous sandwich panel metal			
	TO Code	2.1	3.1	3.3	4.1
	BAU blowing agent	HFC245fa	365mfc/227ea	365mfc/227ea	HCFC141b
	TO blowing agent	HC	HC	HFO	HC
Incremental operating cost	Incremental cost Blowing agent [€/tBLA]	-7,433	-7,523	9,357	-3,000
	Incremental cost raw material [€/tBLA]	-	-	4,792	-
	Cost for thickness increase for stable R value [€/tBLA]	2,857	2,401	-	2,401
Incremental Capital Cost	[€/tBLA]	250	210	210	210
Cost for technology conversion	[€/tBLA]	50	42	42	42

TABLE 19
Detailed costs for technical options for continuous sandwich panel flexible

		Continuous sandwich panel flexible			
	TO Code	2.1	3.1	3.3	4.1
	BAU blowing agent	HFC245fa	365mfc/227ea	365mfc/227ea	HCFC141b
	TO blowing agent	HC	HC	HFO	HC
Incremental operating cost	Incremental cost Blowing agent [€/tBLA]	-7,433	-7,523	9,357	-3,000
	Incremental cost raw material [€/tBLA]	-	-	4,792	-
	Cost for thickness increase for stable R value [€/tBLA]	-	-	-	-
Incremental Capital Cost	[€/tBLA]	250	210	210	210
Cost for technology conversion	[€/tBLA]	50	42	42	42

4

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