Ecodesign Preparatory Studies

Lot 21: Central heating products using hot air to distribute heat (other than CHP)

2nd Stakeholder Meeting
Brussels – September 27th 2011

A study being conducted for DG ENER by BIO Intelligence Service and TÜV Rheinland

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Agenda

10:00 – 10:20	Welcome & "Tour de table"
10:20 - 10:30	Introduction to the study and recapitulation of the Ecodesign Directive
10:30 – 11:10	Main outcomes of: •Task 1 – Product definitions •Task 2 – Economic and market analysis •Task 3 – Consumer behaviour
	Scope proposal for the heating function of Air Handling Units (AHUs)
	COFFEE BREAK
	Task 4 – Technical analysis of existing products
	LUNCH BREAK
	Task 5 – Definition of Base-Cases
	Task 6 – Technical analysis of Best Available Technologies (BAT)
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16:00 – 16:45	Next steps: •Task 7 – Improvement potential •Task 8 – Scenario, policy, impact and sensitivity analysis
16:45 – 17:00	Conclusion and wrap up

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ENER Lot 21 team

Policy Officer:

- Guido de Wilt (DG ENER)

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Ecodesign Directive

The Ecodesign Directive (2009/125/EC) is a **Framework Directive** for the setting of ecodesign requirements for **E**nergy-**r**elated **P**roducts (ErP)

- **Ecodesign**: the integration of environmental aspects into product design with the aim of improving the environmental performance of the product throughout its whole life cycle

- The majority of environmental and cost impacts of a product are determined during the design phase

This Directive (2009/125/EC) supersedes the former Directive (2005/32/EC) which covered only Energy-using Products (EuP).

Ecodesign Directive

Ecodesign Directive **Implementing Measures (IM)**

- Could be proposed for product categories which:
  - Represent a significant volume of products placed on the EU market (indicatively > 200.000 units/year)
  - Involve a significant environmental impact
  - Present a significant potential for improvement

- Are to be based on:
  - Environmental assessments / relevant product characteristics and functionality
  - Products and technologies available on the market should be taken as reference

- IM should preserve the interests of industry, consumers and other stakeholders, but should not add any excessive administrative burdens

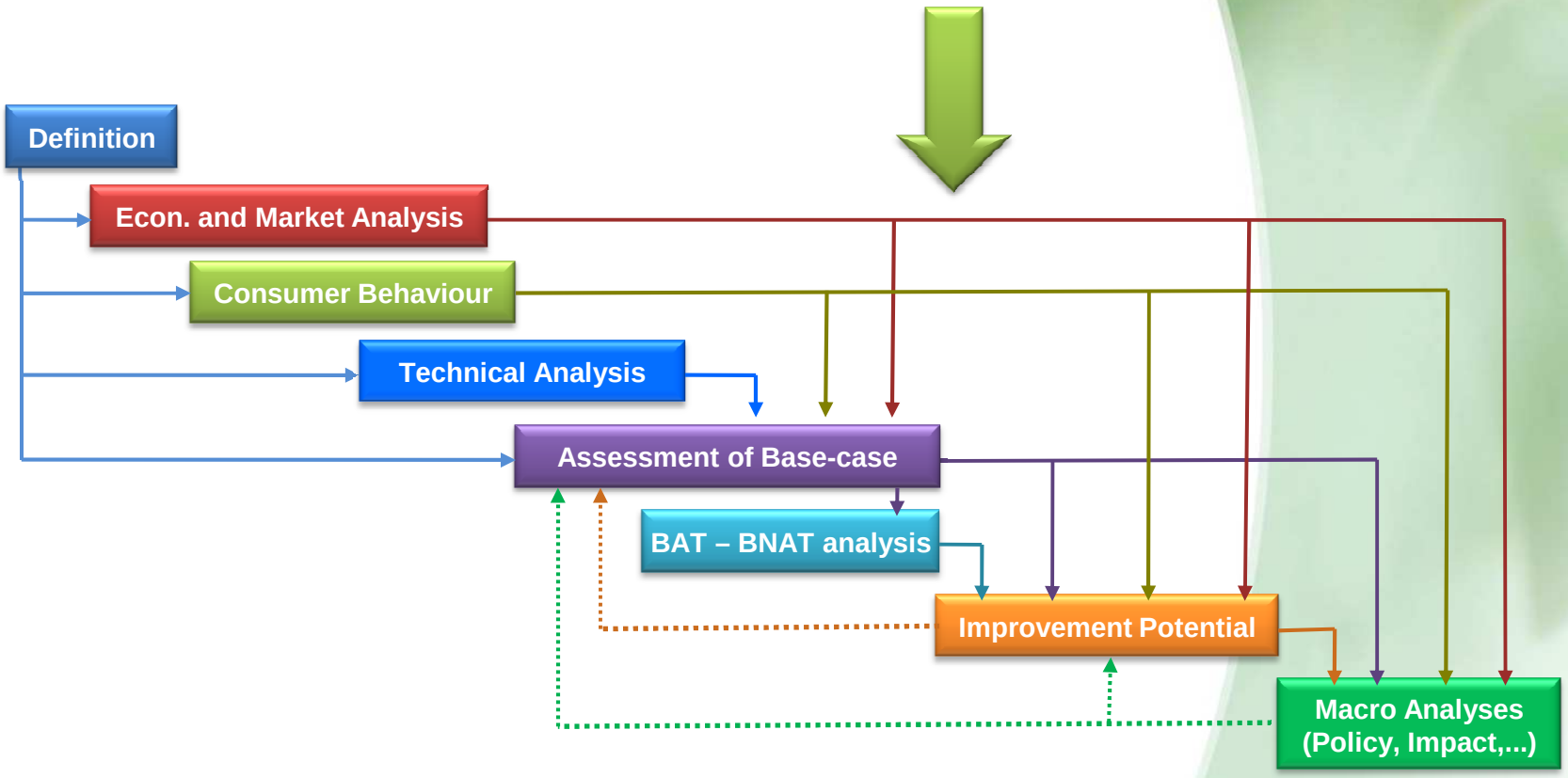
Methodology

- A uniform approach adopted for all the lots, Methodology for Eco-design of Energy-using Products - MEEuP:

Tasks 1 to 5	Present situation
Tasks 6 to 8	Improvement potential

Schedule for Lot 21

2nd Stakeholder meeting



Task 1 | Task 2 | Task 3 | Task 4 | Task 5 | Task 6 | Task 7 | Task 8

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Task 1 – Product definition:

- Define the product category and define the system boundaries of the 'playing field' for ecodesign
- Identify the harmonised test standards and additional sector-specific procedures for product-testing
- Identify the existing relevant legislation, voluntary agreements, and labelling initiatives at the EU and MS level, as well as outside Europe

Classification of the products

<table>
<tr><th colspan="3">Lot 21 products</th></tr>
<tr><td>Furnaces:
➢ Gas-fired
➢ Liquid fuel-fired
➢ Electric
➢ Multi fuel (wood, coal or oil)</td><td colspan="2">Heat pumps:</td></tr>
<tr><td></td><td>➢ VRF
➢ Multi split
➢ Ducted single split
➢ Non-ducted single split</td><td>➢ Packaged/rooftops?
➢ Ground source
➢ Water source
➢ Absorption heat pumps</td></tr>
<tr><th colspan="3">Lot 21 system components</th></tr>
<tr><td colspan="3">Air handling units
(including rooftops)</td></tr>
<tr><th colspan="3">Out of the scope of Lot 21 (proposed)</th></tr>
<tr><td colspan="2">Fan coils
(heat emitter of hydronic system)</td><td>Air curtains (in Lot 20)
(air blower)</td></tr>
</table>

Legislation

Scope	Reference	Details
EU	EPBD 2010/31/EU	Energy Performance of Buildings Directive (system level)
	Ecodesign Directive 2009/125/EC	Product level

Test standards (I)

Scope	Reference	Details
Building energy requirement	EN 13790	Thermal performance of buildings
	EN 15316	Heating systems in buildings – Method of calculation of system energy requirements and system efficiencies
	DIN V 18599	Energy efficiency of buildings
Heat pumps	EN 14511-2	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling. Part 2: Test conditions
	prEN 14825	Air conditioners, liquid chilling packages and heat pumps, with electrically compressors, for space heating and cooling- Testing and rating at part load conditions and calculation of seasonal performance

Test standards (II)

Scope	Reference	Details
Furnaces	EN 267	Forced draught oil burners. Definitions, requirements, testing, marking
	DIN 4794	Stationary fan-assisted air heaters; gas fired air heaters without interchange of heat, safety requirements, testing
	EN 1319	Domestic gas-fired forced convection air heaters for space heating, with fan-assisted burners not exceeding a net heat input of 70 kW
	EN 778	Domestic gas-fired forced convection air heaters for space heating not exceeding a net heat input of 70 kW, without a fan to assist transportation of combustion air and/or combustion products
	EN 1020	Non-domestic forced convection gas-fired air heaters for space heating not exceeding a net heat input of 300 kW incorporating a fan to assist transportation of combustion air or combustion products
	EN 1196	Domestic and non-domestic gas-fired air heaters - Supplementary requirements for condensing air heaters

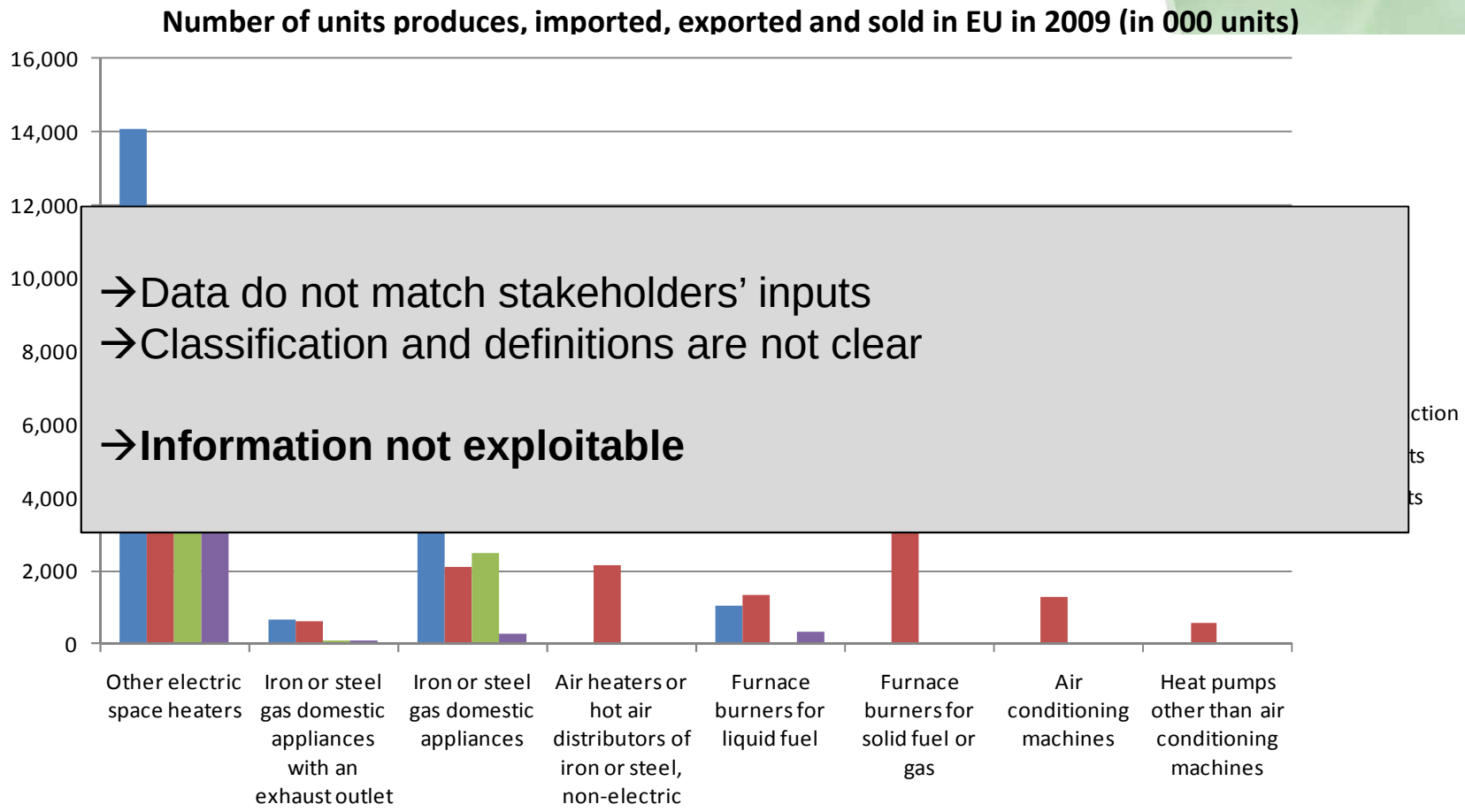
Voluntary schemes

Programme	Country	Product
EU Ecolabel	EU	Heat pumps
Eurovent	EU	Air handling units
		Comfort air conditioners
		Rooftops
Nordic swan	Nordic countries	Heat pump units
		Heat pump systems
Blue angel	DE	Electric powered heat pumps
		Heat pumps gas operated
Energy Saving Recommended scheme	UK	Heating controls
Enhanced Capital Allowance	UK	Warm Air Heating Equipment (gas or oil fired)
		Heat pumps
Milieukeur programme	NL	Central heating appliances
Kwaliteitskeur warmtepompen	NL	Heat pumps for heating purposes
P-Mark	SE	Heat pumps
Promotelec	FR	Heat pumps

Task 2 – Economic & market analysis

- Place the ENER Lot 21 product group within the total context of EU industry and trade
- Provide market (sales and installed stock) and energy consumption inputs for the EU-wide environmental impact of the ENER Lot 21 product group
- Provide insight in the latest market trends concerning market structure and ongoing trends in product design
- Provide data on consumer prices and rates to be used in a Life Cycle Cost (LCC) calculation

Prodcom 2009 data:



Sales of air-based central heating furnaces (EU-27, 2010)

Source : estimate based on one manufacturer

Furnace type	Sales [units]	Installed stock [units]
Direct-fired gas furnace		
Indirect-fired gas furnace (total)	29,000	850,000
Indirect-fired gas furnace (only residential)	10,000	
Liquid fuel-fired furnace	4,500	
Electric furnace		
Multi fuel-fired furnaces (wood/coal and fuel oil)		
Total Furnaces	43,500	

Sales and stock of heat pumps (EU-27, 2010)

Source : DG ENTR Lot 6

Type	Sales [units]	Sales [kW]	Installed stock [units]	Installed stock [kW]
VRF	79,200	2,288,000	557,920	16,192,000
Multi split	19,200	320,000	250,880	4,032,000
Ducted single split	36,900	656,000	379,660	7,790,000
Non-ducted single split	151,800	1,815,000	1,533,840	18,414,000
Water-loop				
Rooftop			200,000	14,000,000
Total heat pumps	287,100	5,079,000	2,722,300	46,428,000

Consumer expenditure for furnaces

Source : industry

	Direct-gas-fired	Indirect-gas-fired	Liquid fuel-fired	Electric	Multi-fuel
Average power capacity (kW)	100-300 kW	20-120 kW	100-300 kW		
European product price range (€/kW)	35-120 €/kW	80 €/kW - 300 €/kW	25-100 €/kW		
Average European product price (€)	€ 4,000	€ 3,000 – € 4500	€ 3,800		
Installation cost (€)	€ 11,000 – 12,500	€ 4,000 – 20,000			
Maintenance and repair cost (€/year)		€ 250 - € 1,100			
Disposal cost (€)		€ 5 - € 100			

Consumer expenditure for heat pumps

Source : industry

	VRF	Multi split	Ducted single split	Non-ducted single split	Water-loop	Rooftop
Average power capacity (kW)	50 kW	35 kW		16 kW	35 kW	
European product price range (€/kW)	430 €/kW	430 €/kW		400 €/kW	687 €/kW	
Average European product price (€)	€ 23,650	€ 15,200		€ 6,450	€ 4,810	
Installation cost (€)	€ 5,300	€ 5,300		€ 5,300	€ 5,000	
Maintenance and repair cost (€/year)	€ 900	€ 1,200		€ 900	€ 250	
Disposal cost (€)	€ 20	€ 20		€ 20	€ 5	

Task 3 – Consumer Behaviour and Local Infrastructure:

- Quantify relevant user-parameters that influence the environmental impact during product-life and that are different from standard test conditions
- Identify barriers and restrictions to possible ecodesign measures, due to social, cultural or infrastructural factors

3.1 Real life efficiency

3.2 End-of-life behaviour

3.3 Local infrastructure

Climatic conditions

Country	Heating time duration for central heating units (yearly)						Source
	Hours/per day (in heating season)*			Days/year (duration of heating season)			
	Residential	Commercial	Industrial	Residential	Commercial	Industrial	
Group 1	9.5	11.5	11.5	288	288	288	Industry
Group 2	7	10	10	214	214	214	Industry
Group 3	6.5	7	7	138	138	138	Industry
Total EU-27 (average)				216	216	216	Estimate

* The heater running hours can be reduced by thermostat or modulating controls

Group 1, commercial: 3,312 h/year
Group 2, commercial: 2,140 h/year
Group 3, commercial: 966 h/year

Use pattern

Product		Average hours per year in "on mode"	Average hours per year in "stand-by mode"	Average hours per year in "off mode"	
Furnaces	Direct-fired gas furnaces	1,263	842.4	6,654.0	*
	Indirect-fired gas furnaces	1,263	842.4	6,654.0	
	Liquid fuel-fired furnaces				
	Electric furnaces				
	Multi fuel-fired furnaces (wood/coal and fuel oil)				
Heat pumps	VRF	1,995	6,132	633	
	Multi split	1,995	6,132	633	**
	Ducted single split	1,995	6,132	633	
	Non-ducted single split	1,995	6,132	633	
	Water-loop				
	Rooftop				

* Inputs from one stakeholder

** Johnson, E.P., Air-source heat pump carbon footprints: HFC impacts and comparison to other heat sources. Energy Policy (2011)

Product economic and technical life

Type of appliance	Heat generation source	Average product life (in years)	
		Economic life	Technical life
Furnace	Direct- fired gas	10	15
	Indirect-fired gas	15	20
	Liquid fuel-fired	10	20
	Electric		
	Multi fuel-fired		
Heat pump	VRF	15	20
	Multi split		
	Ducted single split		
	Non-ducted single split		
	Packaged		
	Water source		
	Ground source		

* source: stakeholders' inputs

Air Handling Units

- An AHU is a ventilation product
- AHUs can integrate cooling/heating devices, which can be evaluated separately
- Together with ARMINES, we proposed to evaluate AHU only in the ventilation part of DG ENTR Lot 6. The cooling/heating devices are already considered within the scopes of ENER Lot 21 and ENTR Lot 6.

Questions

- Any objection to the information presented?
- Any other comments?

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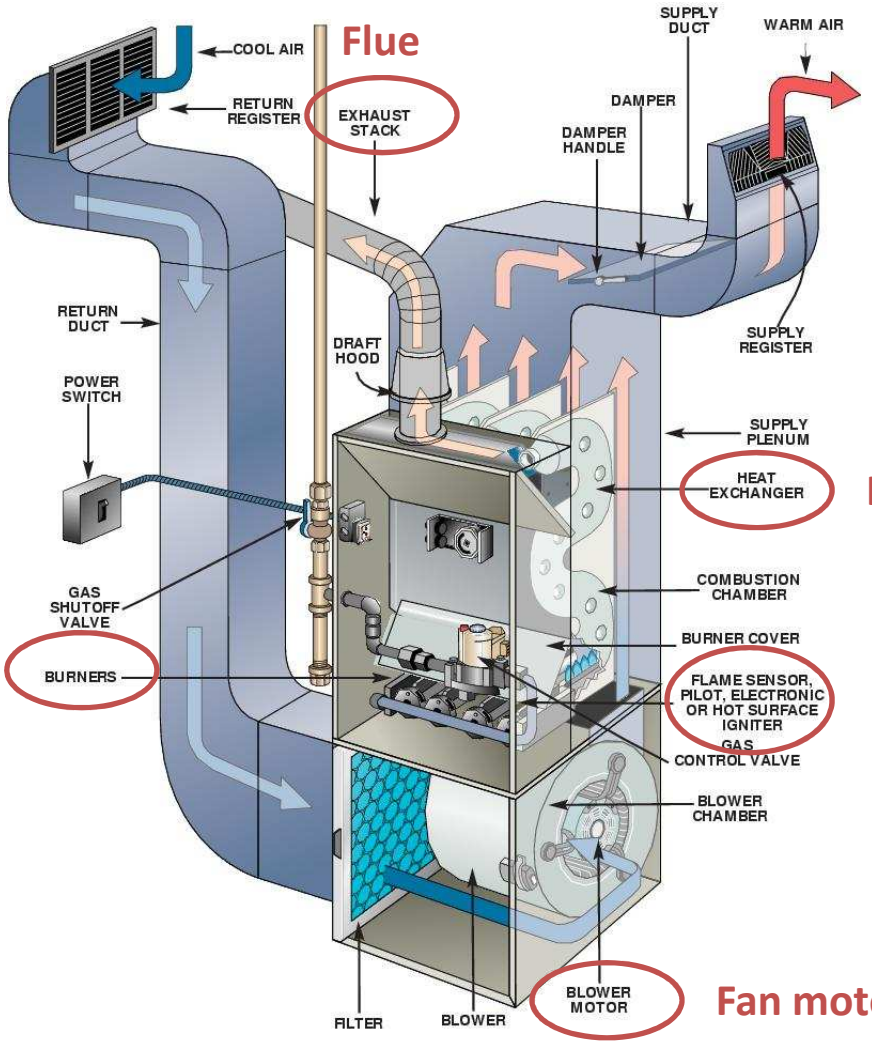
Task 4 – Technical Analysis Existing Products:

- General technical analysis of current products on the EU market during the whole life cycle
- Objective is to capture the market on the whole, both “good” and “bad” products
- Functional analysis of the system to which the product belongs (e.g. heating/ventilation), including a rough estimate of the overall impacts

4.1 Production phase
4.2 Distribution phase
4.3 Use phase (product)
4.4 Use phase (system)
4.5 End-of-life phase
4.6 Recommendations on mandates for measurement standards

General product description – Furnace



Flue

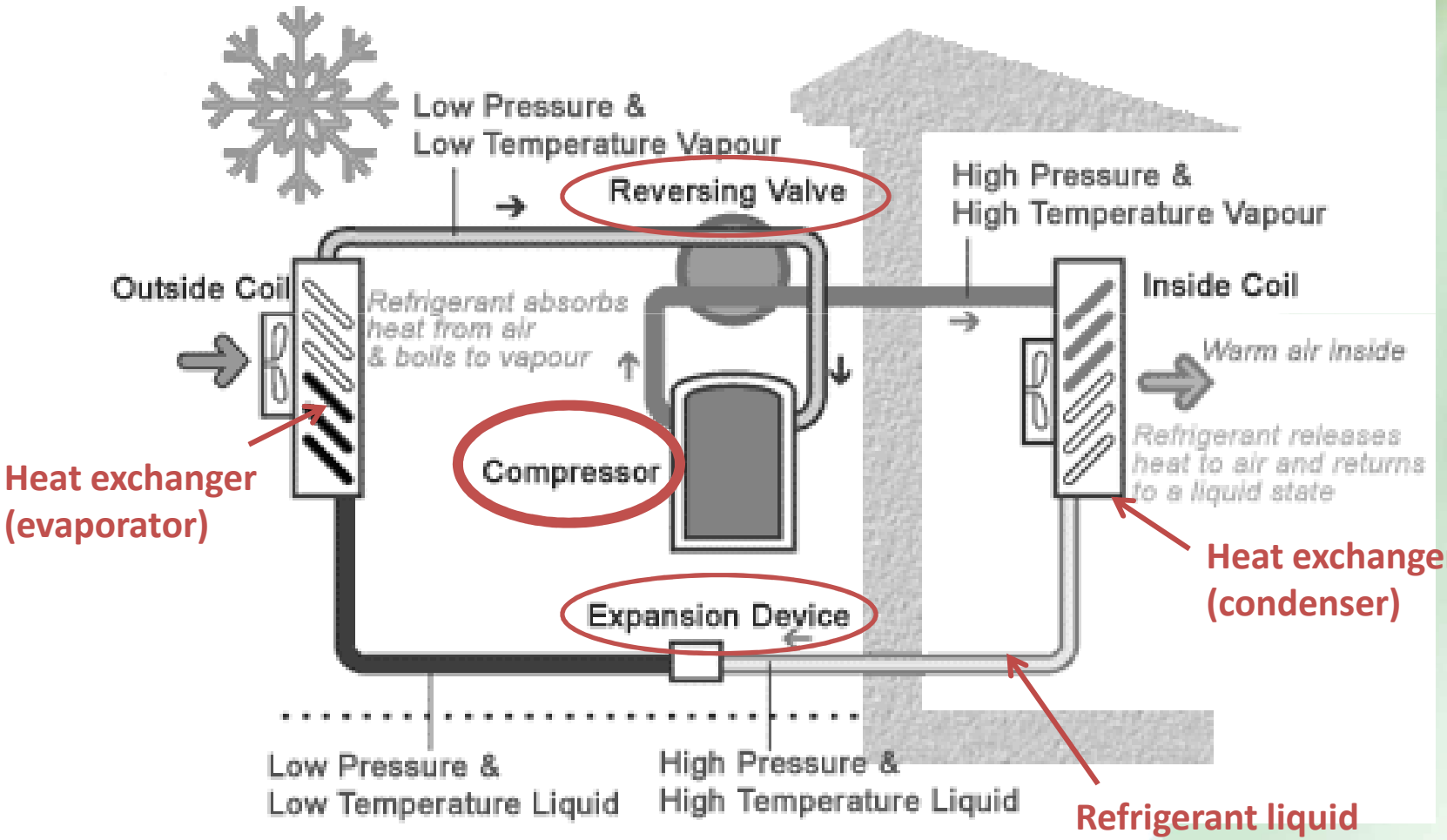
Heat exchanger (primary)

Burner

Ignition

Fan motor

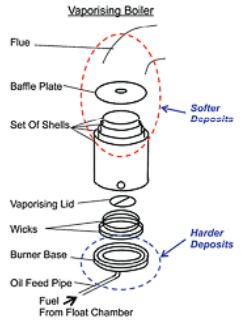
General product description – Heat pump



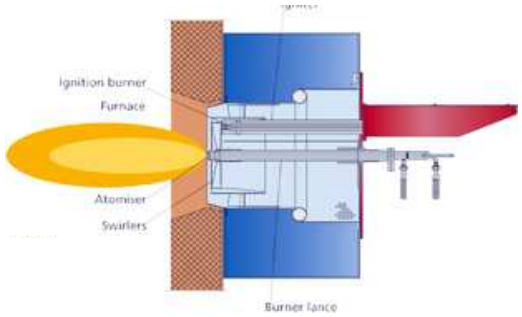
Main components – Furnace - Heat generation unit

Oil burner

Vaporising oil

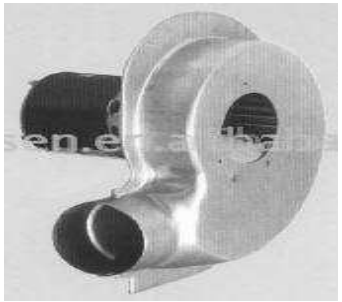


Atomising oil burner

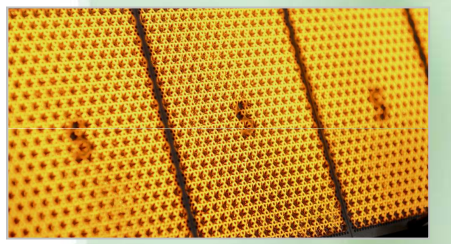


Gas burner

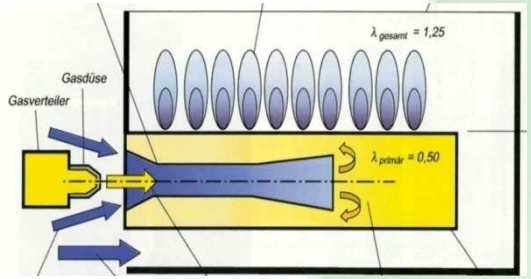
Gas diffusion burner (fan burner)



Gas premix burner



Atmospheric gas burner (fan-less injector



Main components – Furnace - Heat generation unit

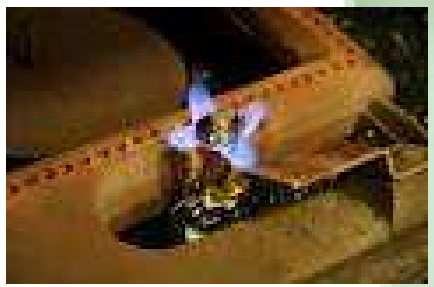
Electric furnace

Heating wire

Tubular heating elements

Main components – Furnace - Ignition device

- Pilot light
  - Energy consumption not negligible



Main components – Furnace - Exhaust gas system

- Duct, pipe, chimney
- Stack effect is normally driven by buoyancy
- Otherwise : flue draft inducer
  - purge the gas
  - prevent soot
  - Influences fuel-air ratio → impacts on combustion quality

Main components – Furnace - Motors

- Permanent split capacitor (PSC) – single phase AC motor
- Brushless permanent magnet (BPM) – DC motor with built-in inverter

Main components – Furnace - Fans

- Forward-curved blades
- Backward-curved blades
- Radial fan blades

Main components – Heat pump - Compressor

- Centerpiece of heat pumps
  - Piston compressors (e.g. reciprocating compressor) and
  - Rotary compressors
    - screw compressor
    - scroll compressor
    - rolling piston compressor

- Different advantages and disadvantages, depending on the type of application area

Main components – Heat pump - Refrigerant fluid

Overview of refrigerant groups :

CFCs Chlorofluorcarbons	HCFCs Hydrochlorofluoro-carbons	HFCs Hydrofluorocarbons	natural refrigerants
R-11 R-12 R-502 …	R-22 R-123 R-124 R-401A R-402A …	R-134a R125 R-404A (blend) R-407C (blend) R-410A (blend) …	R-717 (ammonia) R290 (propane) R-718 (water) R-744 (CO_2) * …
Prohibited for new appliances, extension and modifications.	Prohibited for new appliances, extension and modifications.	Permitted* in the EU. Regulation EC No. 842/2006 has to be followed.	Permitted for all kinds of appliances.

** Some changes have been made from the presentation in the Second Stakeholder Meeting*

Main components – Heat pump - Expansion device

- Thermostatic expansion valve (TEV)
- Electronic expansion valve (EEV)

Main components – Heat pump - Auxiliary heater

- To cover peak load

Main components – Both - Heat exchanger

In furnaces	In heat pumps
❖ Primary heat exchanger : →Transfer heat generated by the combustion to circulating air	❖ Evaporator: →Transfer heat from the heat source to the refrigerant fluid
❖ Secondary heat exchanger : → Recovers latent heat of the water vapor contained the flue gases	❖ Condenser: →Transfer heat from the refrigerant fluid to the heat sink (the room)

Main components – Both - Safety devices

In furnaces	In heat pumps
• Fan limit switch	• Safety pressure limiter
• Flame sensors	• Low pressure protection
• Stack relay controls	• Frost protection
• Spill switches	• Oil pressure supervision
• Pressure switches	• Hot gas monitoring
	• Refrigerant level surveillance
	• Flow surveillance

Main components – Both - Control

- **Manual control**
  - Response of the user to his/her own perception of thermal comfort
  - Not automated, dependant on user behaviour

- **Automated control**
  - Response to a physical measurement of thermal comfort:
    - Actual room air temperature measured with a thermostat
  - More or less sophisticated:
    - Zone control
    - Programmable thermostat
    - Remote control thermostat

Main components – Both - Control

➢ **Levels of sophistication of automated control**

Types of control	Details	Application for furnaces	Application for heat pumps
Two-step controllers	• unsteady control elements • 2 output variables: **on/off**	Single stage burner	Single stage compressor
One pair of two-step controllers	• unsteady control elements • 3 output variables: **off/stage1/stage2**	Two stages burner	2-stage compressor
P, PI or PID controller Proportional Integral Derivative	• Steady control elements • Calculation of the "**error**" • Calculation of the output (depends if P, PI or PID function is used)	**Modulating** burner (modulation of the fuel input flow rate)	Variable speed compressor Variable refrigerant flow

Production phase – Bill of material

- Bills of material (BoM) gathered via questionnaires for each product will be presented in Task 5.

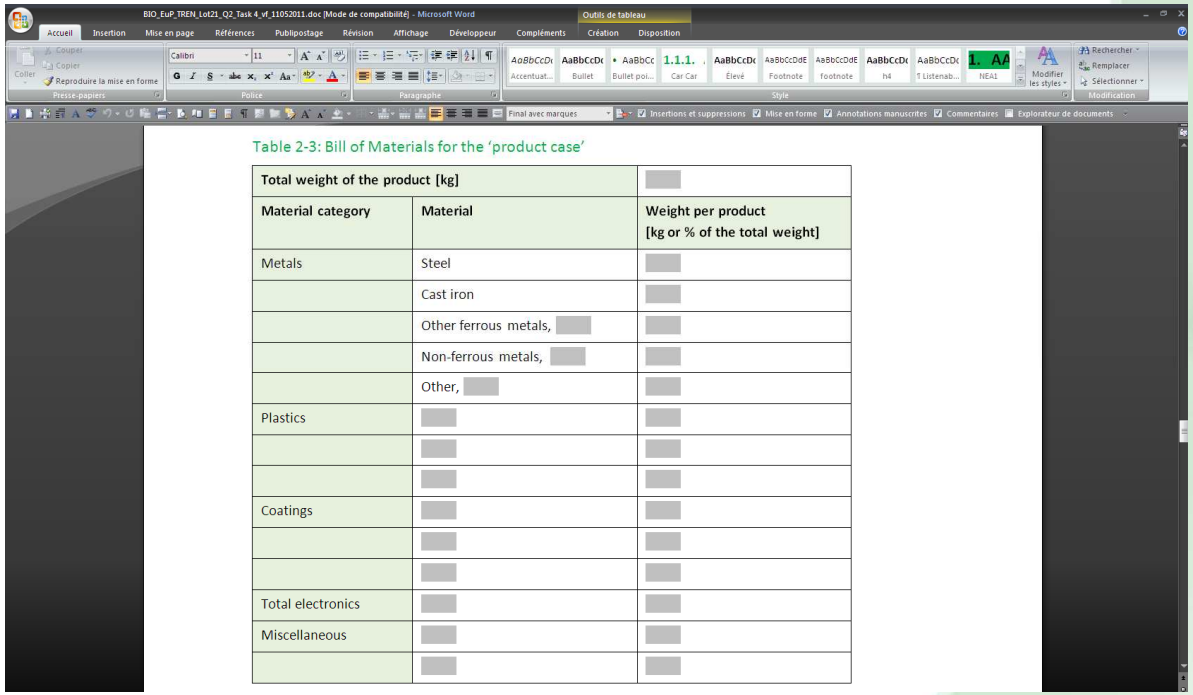
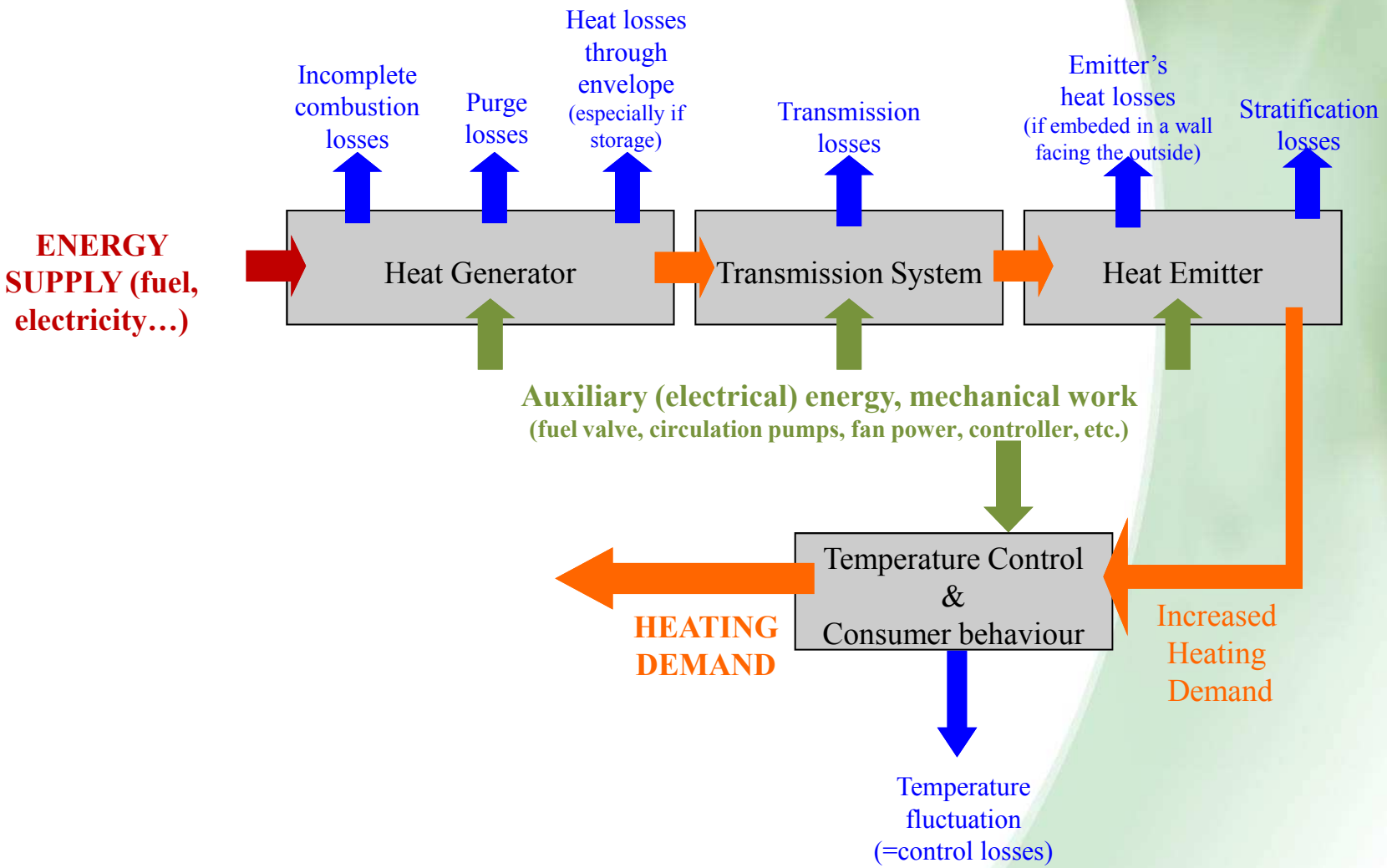


Table 2-3: Bill of Materials for the 'product case'

Total weight of the product [kg]		
Material category	**Material**	**Weight per product [kg or % of the total weight]**
Metals	Steel	
	Cast iron	
	Other ferrous metals,	
	Non-ferrous metals,	
	Other,	
Plastics		
Coatings		
Total electronics		
Miscellaneous		

Use phase – Energy input to delivered energy



Use phase – Overall efficiency

$$\eta_{overall} = \frac{\phi_{demand}}{\phi_{supply}}$$

With : $\eta_{overall} = \eta_{heat\,generation} \times \eta_{transmission} \times \eta_{emitter} \times \eta_{control}$

Products – fuel/electric furnaces

Heat generation and emission efficiency: η=70%-100%

Heat generation :
- gas burner
- oil burners
- electric resistance

Heat emission:
- Heat exchanger (indirect-fired furnaces)
- Mass transfer (release flue gases directly into the room)
- With or without ducts

Higher heat requirement due to ventilation losses

Caution with emission levels (risk of indoor air pollution)
→ Need for ventilation

Control:
- No thermostat (manual control)
- With thermostat (automatic control)

Products – Heat pumps

Dependent on climatic conditions

Heat extraction :
- ambient air
- exhaust air
- water
- ground

Heat emission:
- heat exchanger *
- with or without ducts

More functionalities
Higher energy consumption

→ *Ventilation*
→ *Cooling*

Higher possibilities of controls
Higher seasonal efficiency (possible lower efficiency at full load)

Controls:
- TEV / EEV
- one stage/2-stage/VSD

** Some changes have been made from the presentation in the Second Stakeholder Meeting*

End-of-life phase

Source	Landfill rate	Recycling rate		Incineration rate	
		Material recycling	Other recycling	Energy recovery	Without energy recovery
Stakeholder's inputs	5%	100%		0%	
Eurostat WEEE statistics	20%	75%		5%	0%
Eurostat MSW statistics	37%	23%	17%	16%	4%

Mandates

→ No need for new standards was identified

→ The EC gave an horizontal mandate to CEN/CENELEC on standarisation work in the field of ecodesign of energy-using products

→ No recommendation of mandates is expressed

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Task 5 – Assessment of Base-Cases:

- Selection of the base cases
- Assessment of the environmental impacts, both at product and EU level
- Assessment of LCC, both at product and EU level

Base-Case (BC) selection:

- Conscious abstraction of reality
- Technical differences can justify the distinction of a new BC
- Number of BC selected must best represent the broadest categories of the air-based central heating products market in EU

Base-Case (BC) selection: rough estimates

		2010			
	Average capacity (ESTIMATE)	Annual energy consumption (estimate)	Stock 2010	Total energy consumption at EU-27 level	Base-Cases
Furnaces	[kW/unit]	[kWh/unit/year]	[units]	[MWh/year]	
Direct-fired gas furnaces	150	388,800	-	-	-
Indirect-fired gas furnaces	15	38,880	850,000	33,048,000	BC-1
Liquid-fuel furnaces	20	51,840	-	-	-
Electric furnaces	15	38,880	-	-	-
Multi-fuel-fired furnaces	15	38,880	-	-	-
Heat pumps					
VRF	50	129,600	634,000	82,166,400	BC-3
Multi split	15	38,880	392,000	15,240,960	-
Ducted split	16	41,472	463,000	19,201,536	-
Non-ducted single split > 12 kW	16	41,472	2,324,000	96,380,928	BC-2
Water-loop			200,650	-	-

- : no data available

Description of BC-1- Indirect-fired gas furnace

	Used in Task 5	Recent inputs
Product type	Indirect-fired gas furnace	Indirect-fired gas furnace
Application	Residential heating	Residential heating
Heating capacity	15 kW	15 kW
Fuel used	Natural gas	Natural gas
Burner type	Atmospheric	Atmospheric
Type of draught	Fan assisted	Natural
Control	Modulating	on/off
Average efficiency	94%*	84% NET

* source: EcoReport value**

*** Some changes have been made from the presentation in the Second Stakeholder Meeting*

Description of BC-2- Single split heat pump

Product type	Single spit heat pump
Application	Non-residential heating
Heating capacity	16 kW
Heat source	Air
Compressor type	Scroll
Refrigerant used	R410A
Number of units outdoor:indoor	1:1
Type of draught	Fan assisted
Control	Compressor speed control
Average COP (7°C/20°C)	3.34

Description of BC-3- VRF heat pump

Product type	VRF heat pump
Application	Non-residential heating
Heating capacity	50 kW
Heat source	Air
Compressor type	Scroll
Refrigerant used	R410A
Number of units outdoor:indoor	1:9
Type of draught	Fan assisted
Control	Compressor speed control
Average COP (7°C/20°C)	4.00

Inputs in the production phase

		BC-1 – Indirect-fired gas furnace	BC-2 – Single split heat pump	BC-3 – VRF heat pump
Packaged product weight [kg]		88.18 kg	139.50 kg	462.25 kg
Product weight [kg]		82.43 kg	128.00 kg	411.45 kg
Product weight share [%]	Steel	72.14 %	45.00 %	56.13 %
	Cast iron	0.50 %	0.00 %	2.65 %
	Other ferrous metals	0.00 %	0.00 %	1.72 %
	Non-ferrous metals	11.00 %	30.50 %	18.34 %
	Plastics	5.94 %	13.50 %	9.33 %
	Coatings	1.33 %	0.00 %	0.94 %
	Electronics	6.65 %	9.50 %	4.90 %
	Other materials	2.43 %	1.50 %	5.98 %
Packaging weight [kg]		5.75 kg	11.50 kg	50.80 kg
Packaging weight share [%]	Plastics	4.17 %	17.50 %	5.51 %
	Cardboard	43.33 %	60.50 %	76.38 %
	Paper	0.00 %	0.00 %	0.00 %
	Other	52.50 %	21.50 %	0.00 %

Inputs in the distribution phase

	Base-cases	Volume of the packaged product [m3]
BC-1	Indirect-fired gas furnace	0.705
BC-2	Single split heat pump	0.77
BC-3	VRF Heat pump	2.64

*source: stakeholders' inputs

Inputs in the use phase

	BC-1 – Indirect-fired gas furnace	BC-2 – Single split heat pump	BC-3 – VRF heat pump
Product life in years	15	15	15
On-mode: Consumption per hour (kW)*	0.2	4.2	7.0
On-mode: No. of hours / year	1,263.6	1,995	1,995
Standby-mode: Consumption per hour (kW)*	0.02	0.04	0.07
Standby-mode: No. of hours / year	842.4	6,132	6,132
Off-mode: Consumption per hour (kW)*	0.0	0.015	0.0
Off-mode: No. of hours / year	6,654.0	633	633
No. of km by maintenance services over product-life**	90	90	90

* source: inputs from stakeholders

** source: DG ENER Lot 1

Inputs in the end-of-life phase

	BC-1 – Indirect-fired gas furnace	BC-2 – Single split heat pump	BC-3 – VRF heat pump
Refrigerant charge (kg)*	-	4.80	15
Type of refrigerant**	-	R410A	R410A
Fugitive refrigerant per year (%)*	-	6%	6%
Dumped refrigerant at end-of-life (%)*	-	55%	55%
Total fugitive and dumped refrigerant (%)	-	145%	145%
Landfill (fraction products not recovered) (%)***	20%	20%	20%
Re-use, recycling			
Plastics: Re-use, Closed Loop Recycling (%)***	0%	0%	0%
Plastics: Materials Recycling (%)***	94%	94%	94%
Plastics: Thermal Recycling (%)***	6%	6%	6%

* source: UNEP Refrigeration, air conditioning and heat pumps Technical Options Committee

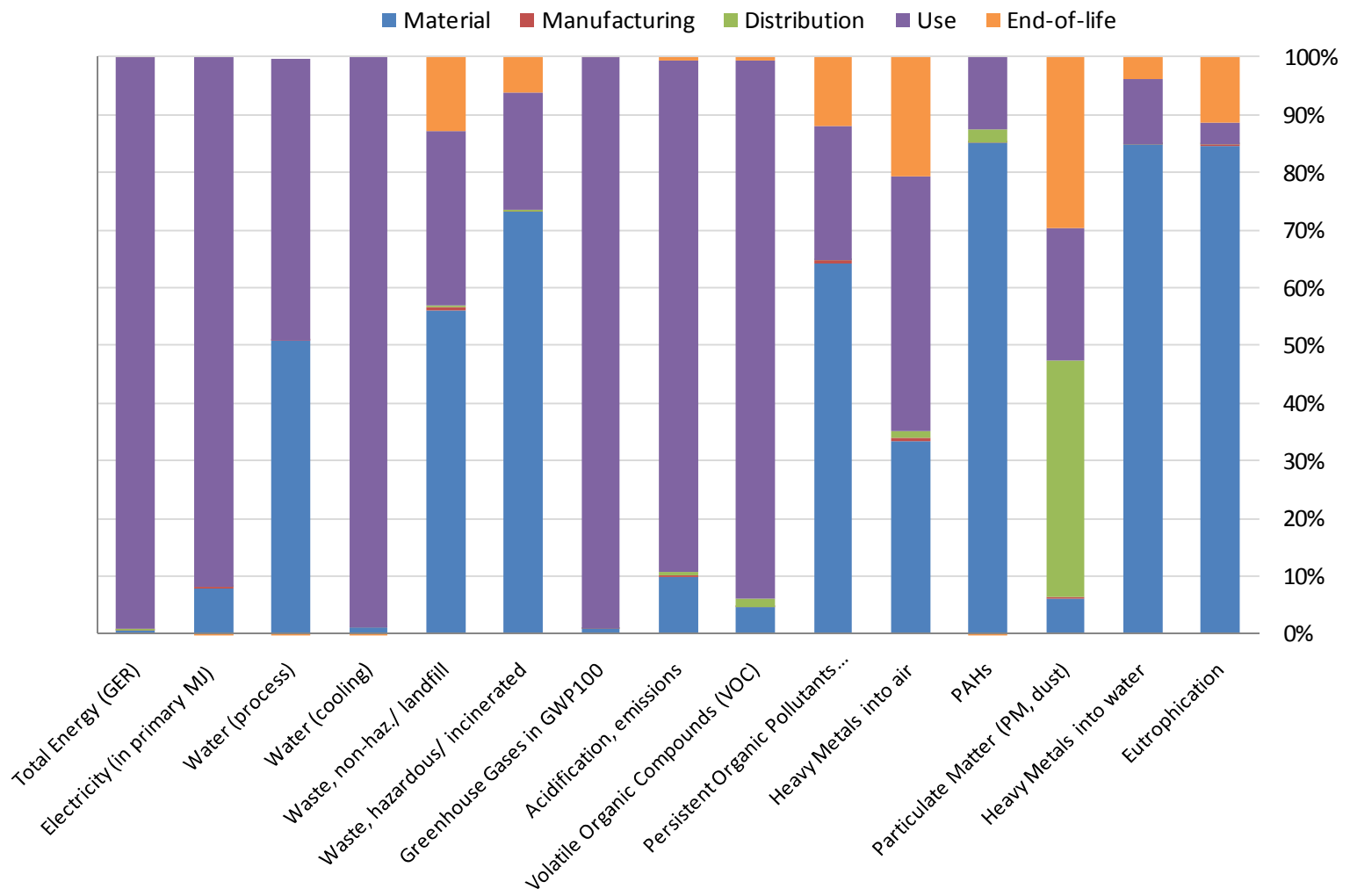
** source: inputs from stakeholders

*** source: Eurostat WEEE statistics

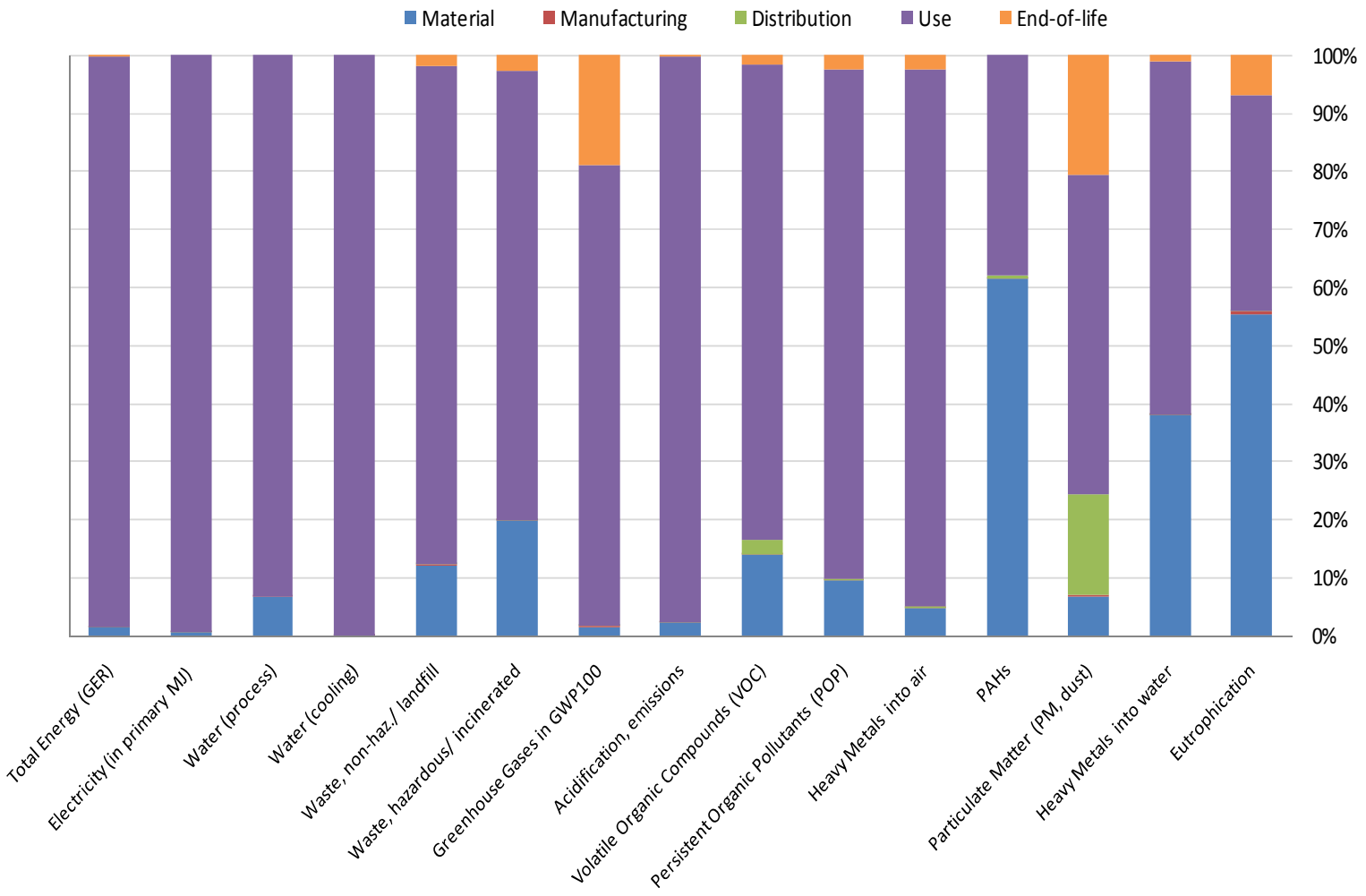
Economic inputs

	BC-1 – Indirect-fired gas furnace	BC-2 – Single split heat pump	BC-3 – VRF heat pump
Annual sales 2010 (million units)	0.029	0.15	0.08
EU stock 2010 (million units)	0.85	1.53	0.56
Average product purchase price (€)	4,000	6,450	23,650
Installation/acquisition costs (€)	12,000	5,300	5,300
Fuel rate (gas) (€/kWh)	12.45	-	-
Electricity rate (€/kWh)	0.1599	0.1599	0.1599
Repair & maintenance costs (€ over life span)	10,125	18,000	18,000
Discount rate (interest minus inflation) (%)	4.0%	4.0%	4.0%

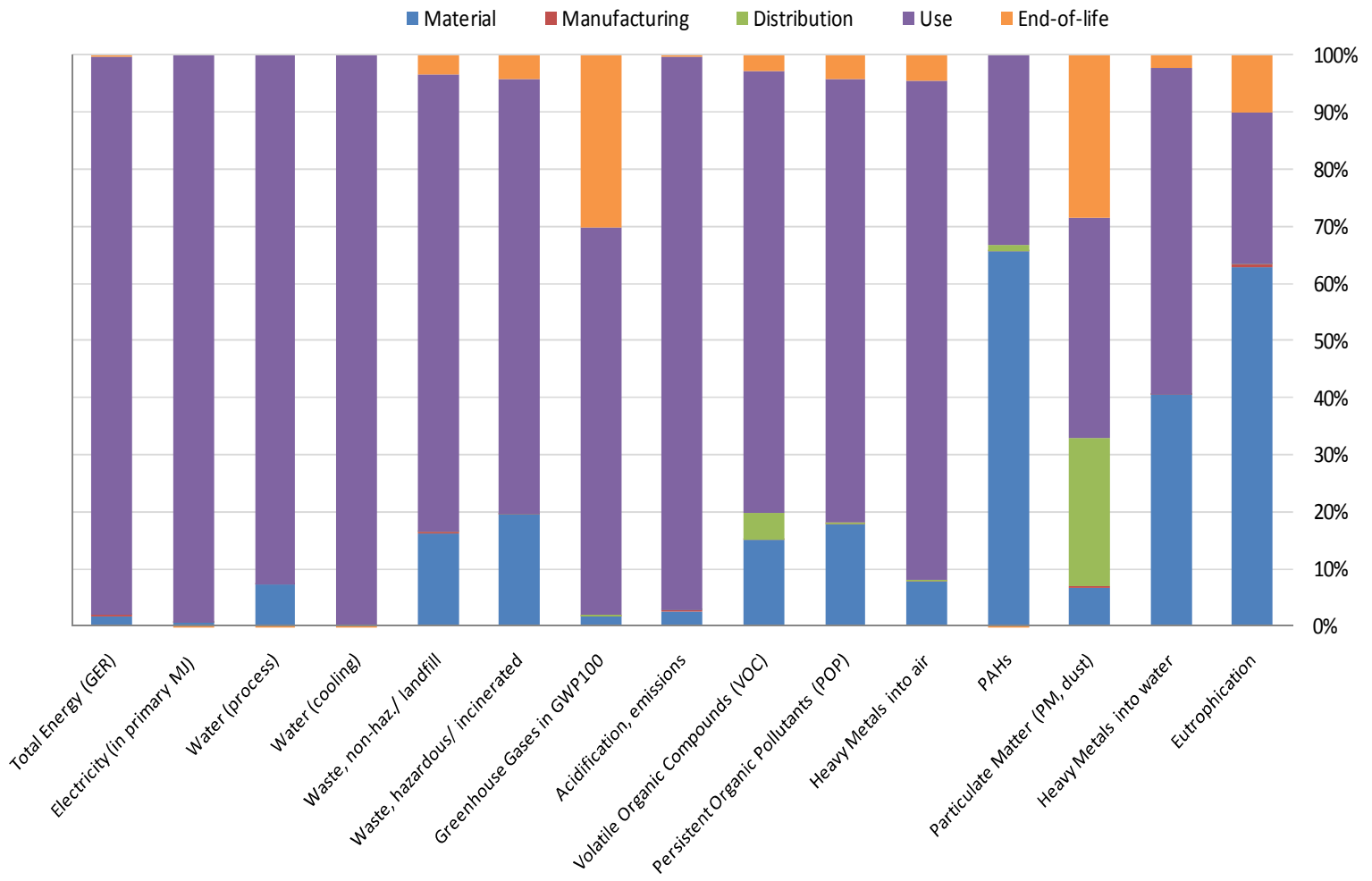
BC-1 – Indirect-fired gas furnace



BC-2 – single split heat pump



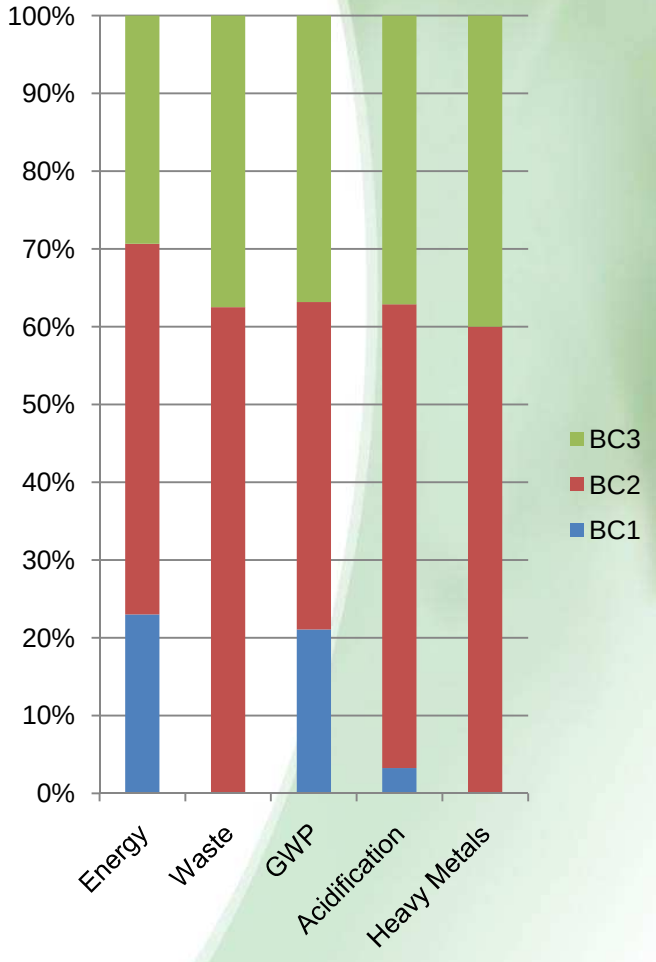
BC-3 – VRF heat pump



Summary of the main impacts of the BC stock at EU-27 level

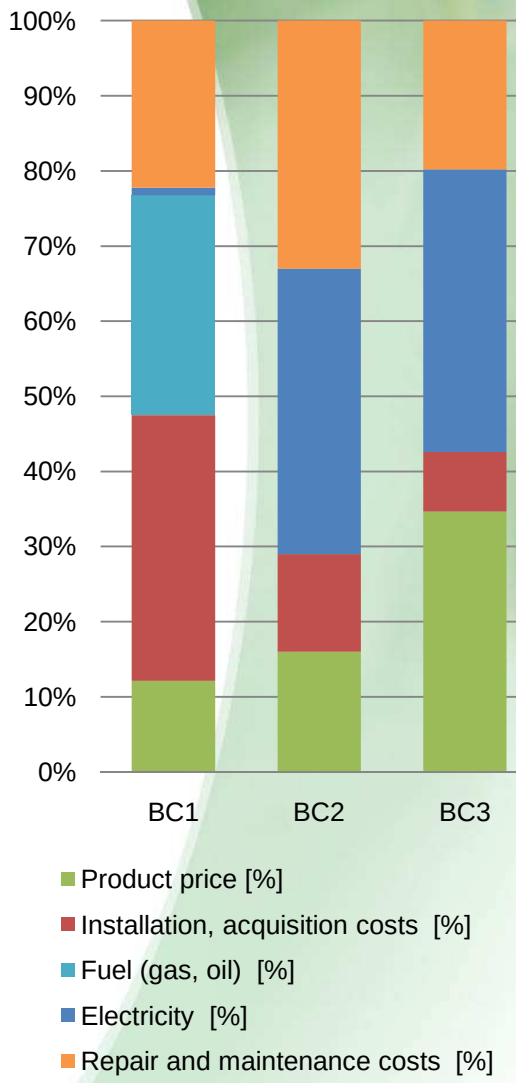
(over their life time)

	Total	BC-1	BC-2	BC-3
Total Energy (GER)	300 PJ	23%	48%	29%
Waste hazardous/ incinerated	8 kt	0%	63%	38%
Greenhouse Gases in GWP100	19 mt CO2 eq.	21%	42%	37%
Acidification emissions	62 kt SO2 eq.	3%	60%	37%
Heavy Metals	5 ton Ni eq.	0%	60%	40%



Life cycle costs of BCs

	BC-1	BC-2	BC-3
Total [€]	48,259	40,441	67,883
Product price [%]	12%	16%	35%
Installation, acquisition costs [%]	35%	13%	8%
Fuel (gas, oil) [%]*	29%	0%	0%
Electricity [%]	1%	38%	38%
Repair and maintenance costs [%]	22%	33%	20%



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Questions

- Any objection to the information provided?

- Any other comments?

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Task 6 – Technical Analysis BAT:

- Technical analysis of advanced technologies ("BAT candidates")
- Provides part of the input for Task 7 (identification of BAT)

6.1 State of the art in applied research for the product: **BAT** *(prototype level)*

6.2 State of the art at component level: **BNAT** *(prototype, test and field trial level)*

6.3 State of the art of best existing product technology outside the EU: **BAT**

BAT options – Component level - Furnace

Gas and oil burners

- **Low NOx burners**
  - Flame cooling ← No energy efficiency improvement to be expected
  - Premix burner
  - Premixing surface burner

- **Low capacity modulating oil burner**
  - being currently development

Industrial burners

- **Regenerative burners**
  - 2 burners alternatively fired → high efficiency and low NOx emission.

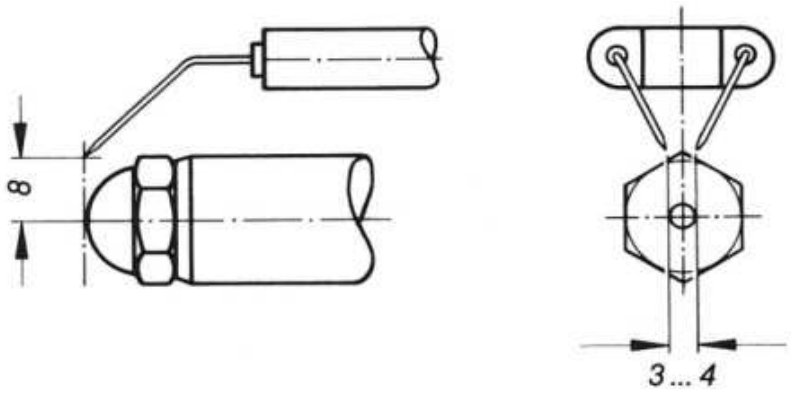
- **Recuperative burners**
  - single-ended burner

BAT options – Component level - Furnace

Ignition device

- **Electric spark igniter**

(instead of burning pilot light)



BAT options – Component level - Furnace

Heat exchanger

- **Primary exchanger**
  - BAT for gas-fired furnace: tubular shaped
  - BAT for oil-fired furnace: made of heavy gauge stainless steel or aluminized steel

- **Secondary heat exchanger**

  →To recover latent heat (in vapour) of the flue gases

BAT options – Component level - Furnace

Blowers and motors

- Backward-curved 'air foil' centrifugal fans;
- Variable speed drives;
- Direct transmission (no belt drive);
- Brushless DC (BLDC) motors >95% efficiency for fans up to 10 kW, 'IE3' level AC for > 10 kW (also ca. 95% at 100 kW) ;
- Pre-dominantly low speed (25-30% of design air flow) fan operation;
- Minimal short-circuiting and low leakage rates and, i.e. fan casing leakage.

BAT options – Component level – Heat pump

Compressor

- For residential HP:
  - ✓capacity modulating scroll compressors with high efficiency DC motors
- For split and multi-split HP systems:
  - ✓inverter controlled twin rotary compressors
- For high capacity non-residential HP:
  - ✓screw compressor
- Perspectives:
  - Linear compressors
  - Oil-free compressors
  - Small radial compressors

BAT options – Component level – Heat pump

Refrigerant

- Traditional (hydrofluorocarbons (HFCs))
  - most used : R410A
- Natural
  - propane: R290
  - ammonia: R717
  - CO2 : R744
- Recent development
  - unsaturated HFCs

BAT options – Component level – Heat pump

Heat exchanger

- Design adapted to the system
- Micro-fin tubes that have small fins on the inside
- Perspective: microchannel heat exchanger (MCHE)

BAT options – Component level – Heat pump

Fan and motors

- Axial fan blade design option
  - ✓e.g.: swept and airfoil-profiled impeller blades with attached winglets

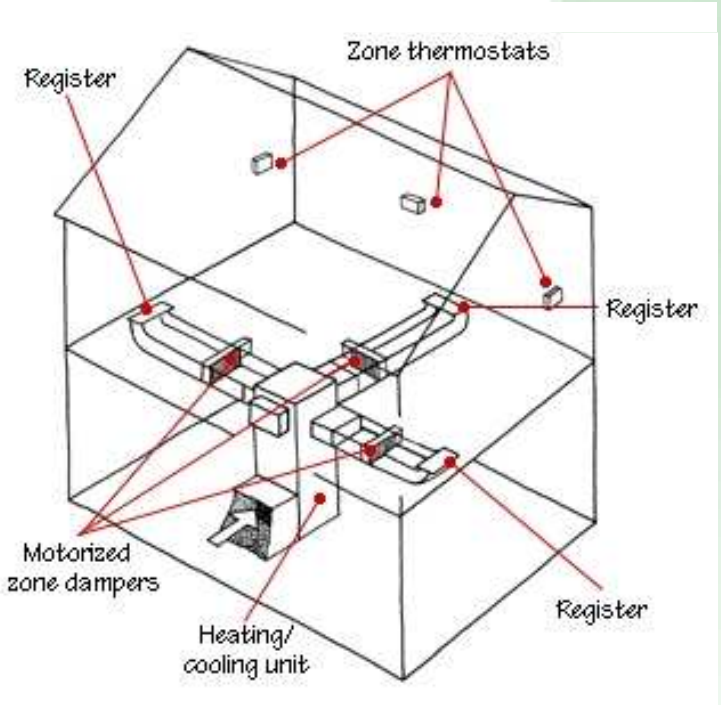
- Centrifugal fan
  - ✓backward-inclined centrifugal airfoil fans

BAT options – Component level – Both furnaces and HPs

Controls

- Weather compensated control mechanisms

- Zone control
  - Energy savings up to 20%



BAT options – Indirect-fired gas furnace

	Electricity consumption change [%]	Fuel consumption change [%]	Thermal Efficiency change [%]	Consumer price change [€]
Condensing secondary heat exchanger	n.a.	?	+ 15	+ 400
High efficiency fan	-5	n.a.	n.a.	+ 50
High efficiency fan motor	-40	n.a.	n.a.	+ 200
Electric ignition device	?	?	+ 5	?
High efficiency gas burner	n.a.	?	+ 20	+ 100
Sophisticated Controls (e.g. zoned controls)	n.a.	- 20	n.a.	+ 300

BAT options – Electric furnace

	Electricity consumption change [%]	Fuel consumption change [%]	Thermal Efficiency change [%]	Consumer price change [€]
High efficiency fan	- 5	n.a.	n.a.	+ 50
High efficiency fan motor	- 40	n.a.	n.a.	+ 200
Sophisticated Controls (e.g. zoned controls)	?	- 20	n.a.	+ 300

BAT options – Liquid fuel-fired furnace

	Electricity consumption change [%]	Fuel consumption change [%]	Thermal Efficiency change [%]	Consumer price change [€]
Condensing secondary heat exchanger	n.a.	?	+ 8	+ 400
High efficiency fan	- 5	n.a.	n.a.	+ 50
High efficiency fan motor	- 40	n.a.	n.a.	+ 200
Electric ignition device	?	?	+ 5	?
High efficiency oil burner	n.a.	?	+ 20	+ 100
Sophisticated Controls (e.g. zoned controls)	n.a.	- 20	n.a.	+ 300

BAT options – Heat Pump (air-to-air) ~30kW

	Electricity consumption change [%]	Thermal Efficiency change [%]	Consumer price change [€]
High efficiency compressor and motor	-45	?	+ 500
High efficiency fans	-5	?	+ 150
High efficiency fan motors	-40	?	+ 300
Modern Heat Exchanger Technology	n.a.	?	?
Use of electronic expansion valves	?	?	?
Use of alternative refrigerants	?	?	?
Controls	?	?	?

BAT options – Heat Pump (air-to-air) ~100kW

	Electricity consumption change [%]	Thermal Efficiency change [%]	Consumer price change [€]
High efficiency compressor and motor	-45	?	+ 1,500
High efficiency fans	-5	?	+ 300
High efficiency fan motors	-40	?	+ 800
Modern Heat Exchanger Technology	n.a.	?	?
Use of electronic expansion valves	?	?	?
Use of alternative refrigerants	?	?	?
Controls	?	?	?

BAT options – Heat Pump (air-to-air) ~400kW

	Electricity consumption change [%]	Thermal Efficiency change [%]	Consumer price change [€]
High efficiency compressor and motor	-45	?	+ 3,000
High efficiency fans	-5	?	+ 500
High efficiency fan motors	-40	?	+ 1,500
Modern Heat Exchanger Technology	n.a.	?	?
Use of electronic expansion valves	?	?	?
Use of alternative refrigerants	?	?	?
Controls	?	?	?

Questions:

- Do you agree with the description of BAT at component level?
- Are there BAT which have not yet been covered in the list provided in earlier slides?
- Any other comments?

Inputs wished:

- Please provide information about the impact of BAT in terms of:
  - Electricity/fuel consumption
  - Efficiency
  - Consumer price

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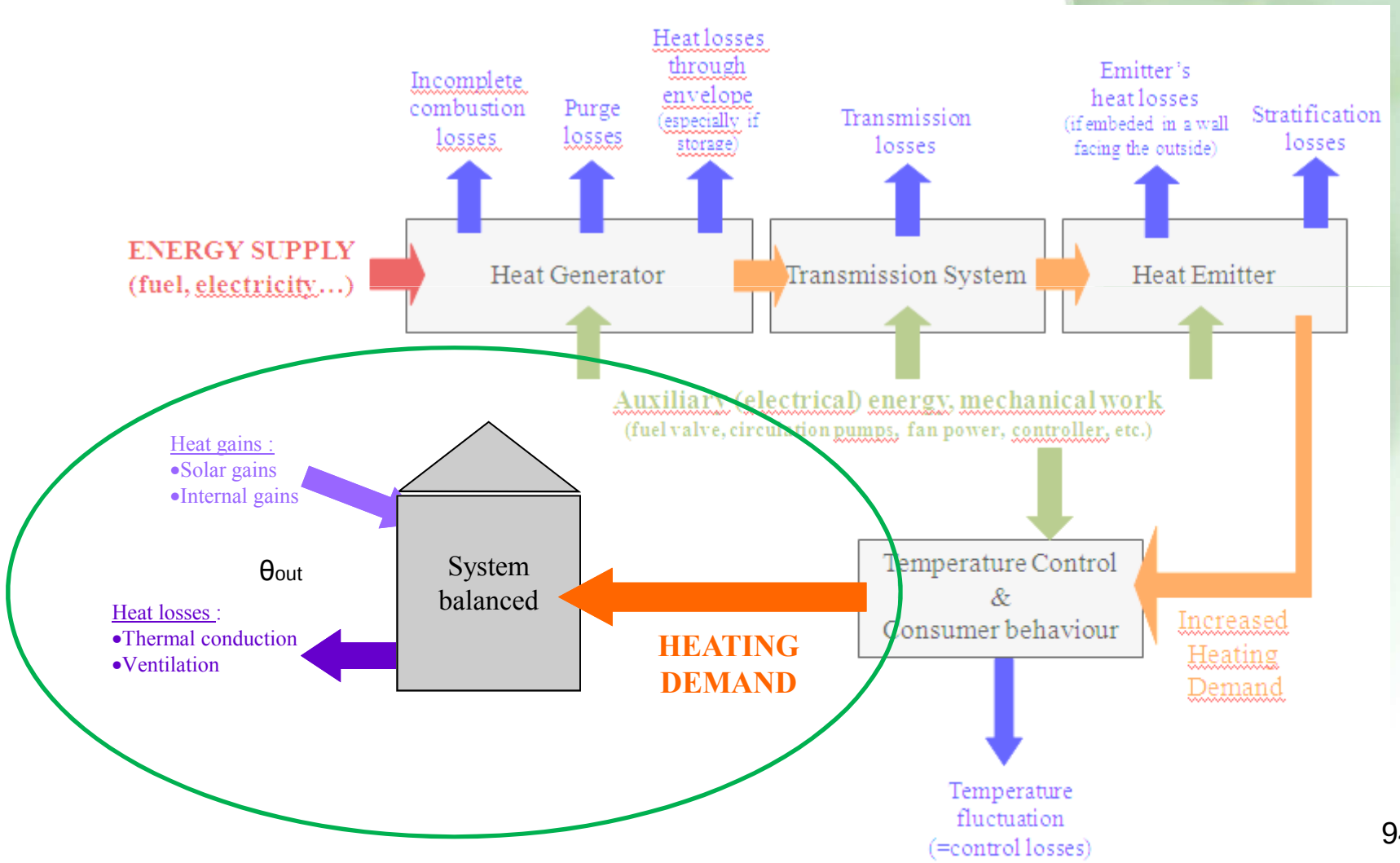
Next steps ...

- System perspective
- Task 7: Improvement potential
- Task 8: Policy and impact analysis

System perspective

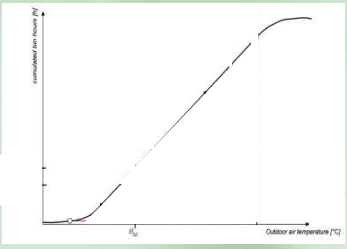
- Assess the products towards a “functional unit”
- Estimate the energy consumption at EU level

1. Parameters defining the heat demand

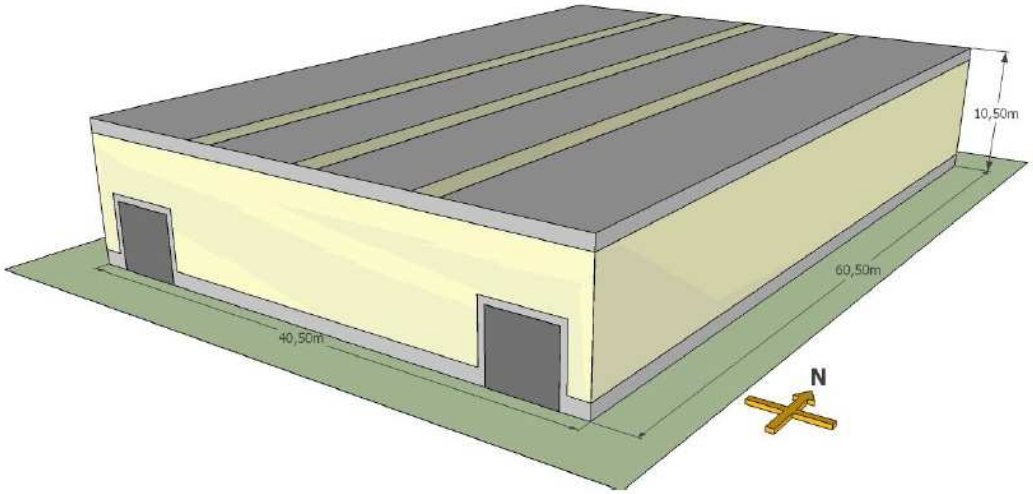


1. Parameters defining the heat demand

- **Outdoor condition (Athens, Strasbourg, Helsinski)**
  - -Temperature (variable with time)
  - - Average solar irradiance (assumed constant over the year)



- **Building parameters**
  - - Structure (wall surfaces, U-value, infiltration)
  - - Use pattern (ventilation, internal loads)



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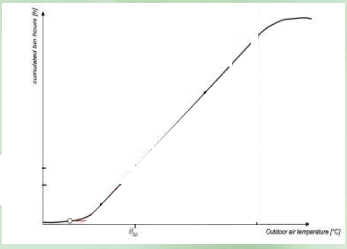

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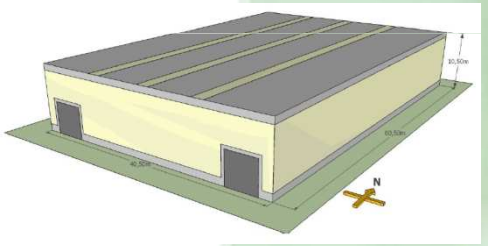


- **Thermal comfort**
  - - Operative temperature (average between air room temperature and mean radiant temperature)

Classification of the buildings

Product groups	Building types
Gas furnaces	Residential buildings: single family, multi family and high rises Industrial buildings Warehouses Sports halls Churches
Oil furnaces	Residential buildings Industrial buildings Warehouses Sports halls Churches
Electric furnaces	Residential buildings
Reversible heat pumps >12 kW	Service buildings (commercial and public sector) Sports halls Churches

Questions

- What do you think of the methodology described in the last slides?
  - Accuracy
  - Acceptability of the assumptions
  - Ease of understanding
  - Adjustment to the need
- Any comments?

Task 7 – Improvement potential :

- Identify design options, their monetary consequences in terms of LCC for the user and their environmental costs and benefits
- LCC: Indicate how design options might impact total EU user expenditure over the full product life (purchase cost + running costs)
- Point out the option with the lowest LCC and the one with BAT (ideally the same option)
- Robustness of the outcome (sensitivity analysis)

Example: analysis of the improvement potential

Task 8 – Policy and impact analysis

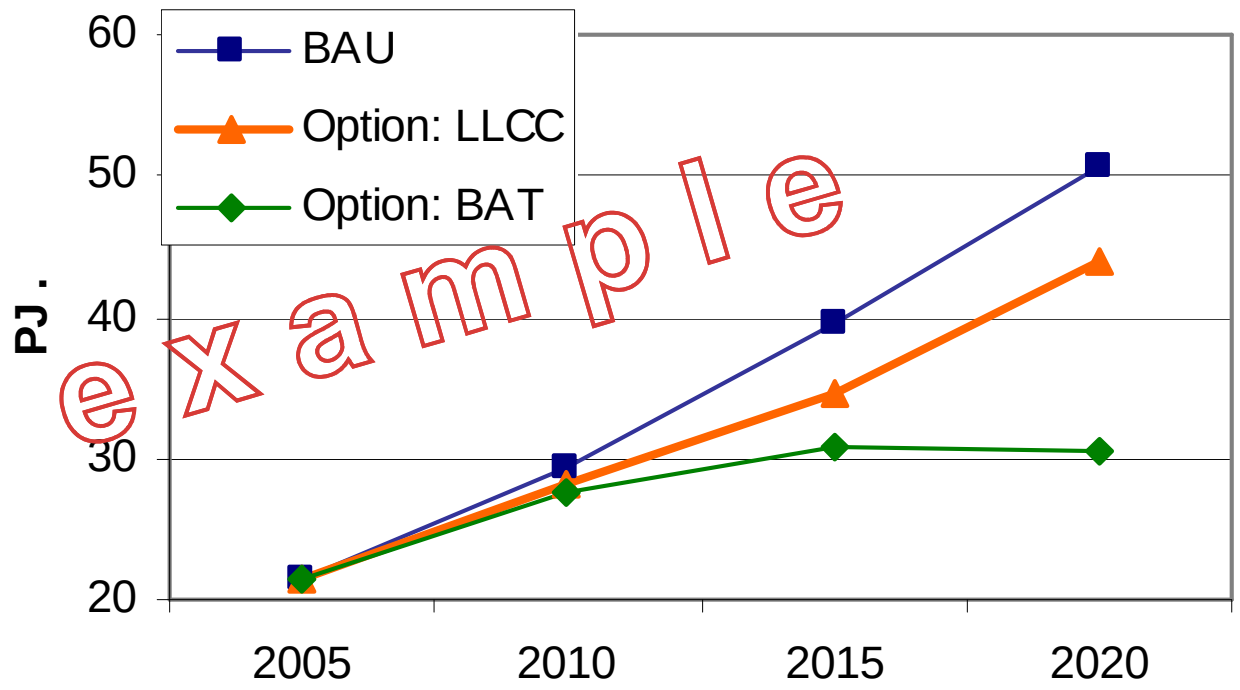
- Summarise the outcomes of the previous tasks

- Look at appropriate policy options to achieve the potential, e.g.
  - Minimum energy efficiency requirement
  - Information requirements (energy labels or other)
  - Incentives (to users)

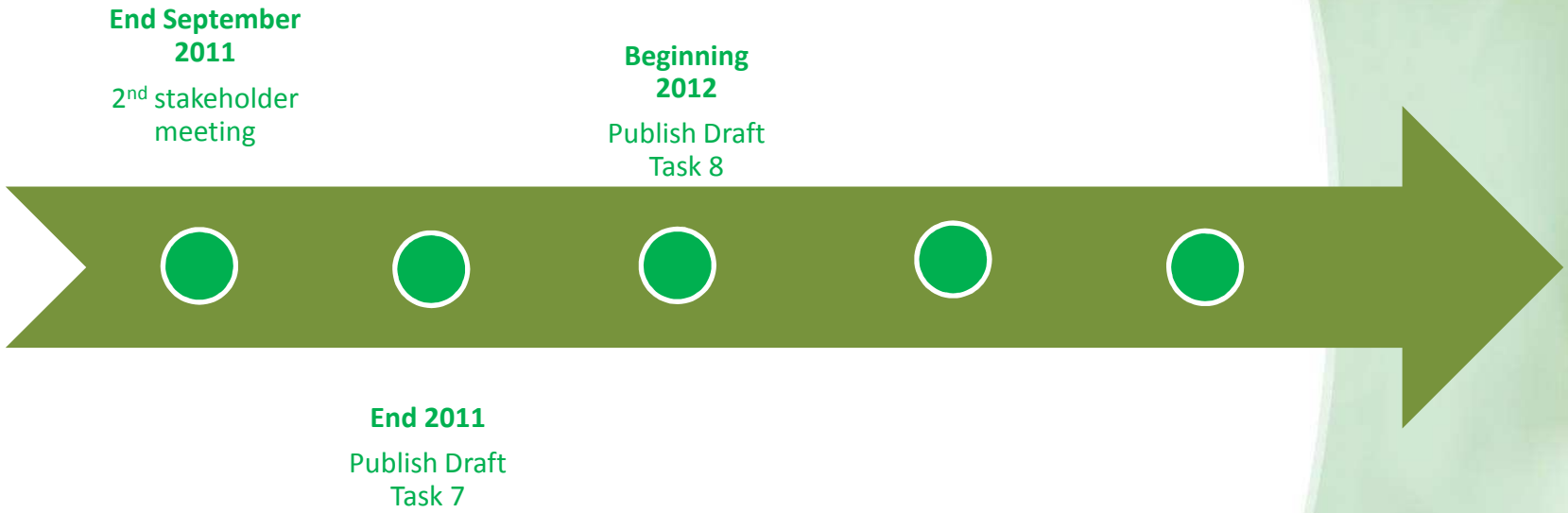
- Scenarios to 2020 and 2025 quantifying improvements that can be achieved compared to Business As Usual:
  - Monetary impacts (e.g. affordability) and LCC
  - Environmental impacts – energy consumption, etc.
  - Impact on function
  - Impact on the market and EU competitiveness

Example: comparison of scenarios against energy consumption

Total energy consumption



Timeline


End September 2011
2nd stakeholder meeting
End 2011
Publish Draft Task 7
Beginning 2012
Publish Draft Task 8

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Any other questions

- AOB
- Minutes will be drafted and circulated
- Presentation will be available online
- Comments can be sent using the template: http://ecoheater.org/lot21/documents.php

Contacts

Thank you for your participation!

www.ecoheater.org

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