SSD

SCIENCE FOR A SUSTAINABLE DEVELOPMENT

Development of Quality References in Distributed Renewable Energy Concepts in Belgium

Q-DIRECT

B. Huberlant, A. Woyte, N. Guidon, P.Van Den Bossche,
S. Caillou, V.Kumar Verma, J. De Ruyck G; Matthys,
W. Van Passel, B. Verbruggen, E. Haesen

ENERGY

TRANSPORT AND MOBILITY

AGRO-FOOD

HEALTH AND ENVIRONMENT

CLIMATE

BIODIVERSITY

ATMOSPHERE AND TERRESTRIAL AND MARINE ECOSYSTEMS

TRANSVERSAL ACTIONS

.be

SCIENCE FOR A SUSTAINABLE DEVELOPMENT

(SSD)

FINAL REPORT PHASE 1

DEVELOPMENT OF QUALITY REFERENCES IN DISTRIBUTED RENEWABLE ENERGY CONCEPTS IN BELGIUM

Q-DIRECT

SD/EN/04

PROMOTORS

Luc De Gheselle
3E Engineering office
Rue du Canal, 61
Tel. 32 2 217 58 68
Fax. 32 2219 79 89
e-mail: luc.degheselle@3E.eu

Luk Vandaele
Belgian Building Research Institute
Dept. Energy & Climate

Jacques De Ruyck
Vrije Universiteit Brussel
Faculty of Applied Science, dept. Mechanical Engineering (MECH)

Willy Van Passel
Lessius – Campus De Nayer

Johan Driesen
Katholieke Universiteit Leuven
Dept. Electrical Engineering (ESAT), Div. ELECTA

AUTHORS

Bernard Huberlant, Achim Woyte & Nicolaz Guidon - **3E**
Paul Van den Bossche & Samuel Caillou – **BBRI**
Vijay Kumar Verma & Jacques De Ruyck – **VUB**
Geert Matthys & Willy Van Passel - **DNI**
Bart Verbruggen & Edwin Haesen - **KUL**

December 2009

BELGIAN SCIENCE POLICY

Rue de la Science 8
Wetenschapsstraat 8
B-1000 Brussels
Belgium
Tel: +32 (0)2 238 34 11 – Fax: +32 (0)2 230 59 12
http://www.belspo.be

Contact person:
Mr Igor Struyf : +32 (0)2 238 35 07

B. HUBERLANT, A. WOYTE, N. GUIDON, P.VAN DEN BOSSCHE, S. CAILLOU, V.KUMAR VERMA, J. DE RUYCK G; MATTHYS, W. VAN PASSEL, B. VERBRUGGEN, E. HAESEN. "***Development of quality references in distributed renewable energy concepts in belgium Q-DIRECT"* -** Final Report Phase 1. Brussels : Belgian Science Policy 2009 – 100 p. (Research Programme Science for a Sustainable Development)

TABLE OF CONTENT

1 EXECUTIVE SUMMARY

1.1 CONTEXT

At EU level, some Renewable Energy Technology (RET) markets are increasing at a fast pace, giving rise to rapid technical evolutions. In Belgium, major differences exist in terms of market penetration and supply chain, partly due to differentiated financial schemes by public authorities. Some support schemes (i.e. PV), attracted large numbers of suppliers and installers, leading to a highly diversified offer of products and to a lack of qualified professional structures.

On the other hand, end-users wishing to buy or lease small generation units usually expect good to high quality of related products and services. Quality insurance for (emerging) RET have proven to be of utmost importance for their sustainable market deployment.

1.2 OBJECTIVES

The main objective of the project is to define guidelines for policymakers to encompass the growth of the renewable energy industry in Belgium according to high quality standards.

The first phase of the project is designed to lay down the technical basis of an integrated quality scheme through a review of the state of the art of 6 RET, leading to quality references & roadmaps, respectively for Biomass Energy Systems, Heat Pumps, Ventilation systems with Heat Recovery, Solar Domestic Hot Water System, Photovoltaics and Small (Urban) Wind Turbine.

The second phase will consist in designing common organizational basis and institutional framework in order to implement a harmonized quality scheme in a later phase.

1.3 METHODOLOGY

Quality schemes with self-commitment and generic content can be considered as an initial ambition level in quality assurance. Those with independent control and based on specific references can be recommended as a higher ambition level. Generic & specific quality commitments and requirements corresponding to initial & future ambition levels have therefore been identified; covering the whole market chain, from component level to system design, up to commissioning, monitoring and maintenance of installations in operation. The research partly consisted in identifying common technical basis for building integration, HVAC integration and grid integration of RETs.

1.4 RESULTS OF THE FIRST PHASE OF THE PROJECT (2007-2008)

The deliverables of the project are available on the project's intranet website; detailed results are shown in chapter 6 of the final report. The network agreed that an effective quality scheme for small-scale distributed RET should:

- Cover a range of RE technologies and services able to achieve substantial CO_2 emission reductions in the residential housing sector;
- Provide consumers with independent certification of products and services ;
- Remain independent from the professional sector ;
- Be designed to follow rapidly evolving technology and evaluate installers against robust criteria, providing long term guarantees to end consumers ;
- Certify technologies and installers in accordance with harmonized standards;
- Get full support from major stakeholders (regional public authorities, microgeneration sector, consumer associations, environmental protection groups…)

Training, education and third party evaluation are essentials to reach those targets. Specific technical background is required from the installers and must be updated and regularly controlled. The EU RES directive has been identified as a strong incentive to move ahead from promotion of voluntary labeling initiatives towards true certification schemes.

The roadmaps should go along the following directions:

- Content: from general commitment to specific technical requirements beyond existing standards and regulations;
- Control: from self commitment to independent third party evaluation and certification;
- Implementation: from quality insurance of product to certified management process of companies

1.4.1 Technological state of the art and Roadmaps

The network reviewed each of the 6 RET at:

- Technology level: component, system…
- Market level: status of the supply chain, market evolution…
- Quality level: standardisation & labelling, quality insurance…

Many quality schemes reviewed in other countries rely on quality of materials, installation and information by means of simple technical criteria, cooperation with associations of installers and effective control mechanisms. Most of them are still in early stage of implementation. Hence, a common basis for quality requirements of several technologies seems essential in order to set up and organize further implementation of a RET quality scheme throughout Belgium. This in turn resulted in a range of technical requirements for each technology, organized in roadmaps over a timeframe of five years, in order to give enough time and market perspective to the RE sector to organize itself and to initiate a collective dynamic process of quality improvement.

Defining common ambition levels and quality requirements resulted in an integrated but differentiated scheme respectively dealing with domestic applications of solar and biomass energy systems on the one hand, and Heat pumps & ventilation systems with heat recovery on the other hand.

Domestic Solar (thermal & PV) Biomass energy systems	Heat pumps & ventilation systems with heat recovery	Small Wind Turbines
	additional requirements on building physics	Handled separately Low market penetration

Quality requirements should cover the following areas (cross-technology):

- Components and system design
- Installation works, guarantee and after sale service
- Function control and monitoring of performance or guaranteed performance result
- Third party evaluation of a sample of systems in operation.

Biomass Energy System (BES)

BES acquired enough maturity to compete with existing oil and gas heating devices and provide an attractive option to cover the whole heating demand in residential housing in Belgium. Current technology is reliable and most of the products were tested and certified according to EN or national standards. Minimizing gas and particulate matters emissions remains a major quality concern since the emission level of a pellet boiler reflects the quality of combustion and the overall efficiency of the system.

Belgium did not issue any specific quality label for BES so far. Hence, quality insurance implies the use of codes of good practice and generic (voluntary) commitments of suppliers and installers. The same applies to pellet fuel, as our market is dominated by *DINplus* certified pellets.

BES Roadmap

The proposed set of requirements for a Belgian BES label is summarized in the table below :

Pellet Boiler		Level***		Level**		Level*	
		Nominal Load	Partial Load	Nominal Load	Partial Load	Nominal Load	Partial Load
Heat out put range		≤ 70 KW	30 % of nominal load	≤ 70 KW	30 % of nominal load	≤ 70 KW	30 % of nominal load
NO_x (mg m^{-3})		150	150	150	150	200	250
CO (mg m^{-3})		80	100	90	200	200	300
Dust (mg m^{-3})		20	SV	20	SV	50	75/SV
OGC (mg m^{-3})		5	5	5	5	25	40
Efficiency (%)		≥ 97	≥ 95	≥90	≥ 88	≥85	≥ 80
Noise (db)		≤ 50 Day	≤ 35 Night	≤ 50 Day	≤ 35Night	≤ 50 Day	≤ 35Night
Halogenated plastic component (g, maximum)		50		50		50	
Surface treatments	Heavy metal pigment	Not allowed	Not allowed			Not allowed	
	Organic solvents	Not allowed	Not allowed			Not allowed	
Packing (halogenated plastic)		Cl-plastic-Guideline		Cl-plastic-Guideline		Cl-plastic-Guideline	
Auxiliary power demand (% of heat output)		≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0	≤ 2.5	≤ 3.0
Heat Losses (% of heat output)		0.8	0.8	1.5	1.5	2.5	2.5
Surface temperature (°$C_{maximum}$)		35 at 20 ambiant temperature		35 at 20 armbant temperature		35 at 20 ambiant temperature	
Hot Water Tank		yes		yes		yes	
Laboratory testings		ISO 17025		ISO 17025		ISO 17025	
Recommendation for fuel		prEN 14961/ DINplus	prEN 14961 DINplus	prEN 14961 DINplus	prEN 14961 DINplus	prEN 14961 DINplus	prEN 14961 DINplus

Note: Limit values are defined for 13 volume % O_2 in the dry flue gas, 0°C at 1013 mbar. SV = Specify the values.

The quality requirements for pellet fuel used under a Belgian quality scheme should equal those of the DIN*plus* mark.

Heat Pumps (HP)

Recent technological evolution as scroll compressors, inverter DC engines, electronic expansion valves and CO_2 heat pumps for high temperature heat release improved the overall quality of HP. An important market barrier to their growth lies in their complex character, more than (any) other heating systems. HP requires a mixture of skills usually covered by different craftsmen (electro-technical engineer, driller, heating installer, refrigeration engineering...). Their efficiency and quality depend upon the unit and the installation work but is also strongly influenced by the whole planning and installation design. Belgian market is growing faster than the pool of qualified installers, resulting in poor level installations, threatening further market development. The need for quality insurance at EU level would help this technology much more than national action plans. Quality labeling occurs thus best at EU level through existing tools like the HP Eco-label or a European quality label for HP manufacturers (EHPA label). Higher customer satisfaction could be reached by an integrated quality scheme designed for HP heating systems (heat-source + HP-unit + heat-release) including requirements towards the HP-unit efficiency expressed by the COP and towards the HP-system yearly efficiency expressed by the SPF or the APF.

HP Roadmap

The quality of a heat pump installation depends on three main factors: the design of the system; the practical execution of the installation and the efficiency of the HP-unit. A comprehensive quality scheme for HP units might articulate as illustrated in the table below, with level 1 corresponding to the current situation; level 2 corresponding to a start level for quality installation and level 3 being an objective for the coming 5 years.

	level 1	**level 2** = level 1 + …	**level 3** = level 2 + …
Component	**Minimum COP** **COP certified acc to EN14511**	European Eco-label	European Eco-label
Concept & Design	**Fulfilling the Code of good Practice for HP applications in the housing sector**	Mandatory training for HP **design** provided by the **manufacturer**. Yearly random inspection of one installation. Follow-up of complaints	EU Certified HP designer (mutually recognized training & examination). Minimum number of reference installations.
Installation	**Fulfilling the Code of good practice for HP applications in the housing sector'** **Using checklists** **Documentation**	Mandatory training for HP **installation** provided by the **manufacturer** to the **installer**. Installation instructions must be provided according to EU Eco-label. User manual must be provided according to EU Eco-label. 2 years warranty on installation work. Checklist for commissioning according to EU Eco-label. ID-plate with CE-label and COP values according to EN1451. Minimum 10% of yearly installation to be reported for random inspection. Follow-up of complaints.	**EU Certified HP Installer** (mutually recognized training & examination Retraining every 5 years. Minimum number of reference installations. given % of yearly installations to be reported for random inspections. After sale service has to be guaranteed during 10 years. SPF warranty (SLA contract). Checklist for commissioning according to EU Eco-label.
Maintenance & monitoring	**Maintenance manual stays with the installation**	One year standard monitoring of electricity use (HP-unit, pumps, electronics) Maintenance manual keeps track of electrical consumption and corresponding dates. Evaluation after the first year.	SPF warranty and monitoring. After sale service guaranteed if initial installer is no longer available: other certified HP-installer takes it over Every installation available for random inspection.

Ventilation system with Heat Recovery (VwHR)

The main recent technological developments that improved overall quality of VwHR regard:

- Design of the system to decrease the noise generation
- Higher efficiency of the fans (more efficient DC motors are now commonly available)
- Development of small Air Handling Units (AHU), adapted to low flow rates

Further technological improvements consist of greater availability of design tools, simplified commissioning methods for flow measurement and adjustment and the availability of decentralized ventilation control systems. A common uniterm definition of AHU performance in a harmonized standard is definitely a must.

In Belgium, VwHR is not largely used in residential buildings yet. However, it is developing thanks to EPB regulation and financial support schemes. Several quality issues re design and installation were reported in residential buildings, such as inadequate flow rate, high electric consumption, pressure drop, air leakages… Those are mainly due to the heterogeneity and the lack of maturity of the market. The availability of component performance data should be improved, as well as the performance of systems in operation that are often below expectations.

VwHR roadmap

The table below summarize the relation between the global and the specific requirements developed for VwHR.

		Global requirements					Responsibility				
		Indoor climate comfort			Energy Perf.						
	Specific requirements	Indoor Air Quality	Thermal and humidity comfort	Acoustical comfort	Energy Recovery	Auxiliary Electric Consumption	Product Manufacturing	Basic design	Detailed design	Installation	Commissionning
Whole system											
	Design flow rates	x			x	x		x	x		x
	Flow balance and recirculation	x	x		x	x		x	x		x
	Transfer capacity	x			x	x	x	x	x		
	Effectiveness of ventilation	x	x	x				x	x		
	Control strategy	x	x		x	x	x	x	x	x	x
	Airtightness of Ductwork and AHU	x		x	x	x	x	x	x	x	
	Cooking hood and tumble dryer	x			x			x			
	Ventilation of other spaces	x			x	x		x			
	Documentation: as built folder	x	x	x	x	x	x	x	x	x	x
Air transfer and air terminal devices		x	x				x	x	x		x
Noise											
	Limitation of noise from the air terminal devices	x		x			x	x	x		x
	Limitation of noise from the ductwork			x			x	x	x		
	Limitation of noise from the AHU	x		x		x	x	x	x		
	Limitation of noise transfer between spaces			x			x	x	x		
Ductwork											
	Air velocity in ductwork			x		x		x	x		
	Pressure drop in ductwork			x		x	x	x	x	x	x
	Thermal insulation of ductwork	x			x		x	x	x	x	
	Ease of ductwork cleaning	x			x		x	x	x		x
	Cleanliness of ductwork	x			x		x	x		x	x
	Documentation on the ductwork						x	x	x		
AHU											
	Documentaton on the AHU						x		x		
	Air filtration	x			x	x	x	x	x		
	Internal Leakages	x			x	x	x		x		
	Temperature efficiency		x		x		x	x	x		
	Fan selection and regulation	x		x		x	x		x		
	Fan electric consumption					x	x		x		
	Ease of cleaning of the AHU	x					x	x			
	Thermal Insulation of the AHU				x		x		x		
Air inlet/outlet											
	Min distance for inlet and outlet	x						x	x		
	Position of air inlet	x						x	x		
	Protection of air inlet	x					x	x	x	x	
	Ease of cleaning of air inlet/outlet	x					x	x	x		
	Ground coupled heat-exchanger	x				x	x	x	x		

Solar Domestic Hot Water System (SDHWS)

The evolution from a common on/off control strategy for stoves to more advanced control systems as well as the improved thermal stratification and component integration of storage tanks are recent technological developments improving the overall quality and reducing installation cost and risks of failure of SDHWS on the Belgian market. New heat transfer media, better integration into conventional HVAC systems and advanced design of concentrators for CPC tube are R&D topics amongst the most susceptible to improve overall quality of SDHWS.

The solar thermal market development is strongly influenced by the usual heating equipment market. Ups-and-downs encountered by the industry over the years in several countries are partly due to a stop-and-go of some public support schemes. Another explaining factor is that consumers are overwhelmed with too many technologies likely to reduce their energy demand, some competing against each other (PV Vs solar thermal collectors).

Two important EU standards (registered as Belgian standards) concern solar thermal collectors and factory made solar thermal systems respectively: EN 12975 and EN 12976. A pre standard does exist for custom built systems. Beside some general requirements, those standards define procedures & guidelines to run performance and quality tests. They are not real *product standards* but rather *standard test methods* of voluntary application.

A European harmonized certification procedure was put in place for solar thermal collectors and factory made systems: the CEN KEYMARK Scheme Rules for Solar Thermal Products or. This Solar Keymark specifies that manufacturers have their products been tested and surveyed according to common European quality criteria by neutral, independent and competent bodies and that respective standards are fulfilled by a collector or a factory made system.

Solar Thermal Roadmap

The ST Roadmap identifies requirements corresponding to given standards, marks or regulations, at the level of manufacturer, supplier, Installer, Installation set-up, performance and quality control:

Stake-holder	**Quality requirements**	**Corresponding Standard / mark or regulation**	**Quality control**	**Observation**
Manu-facturer /supplier	Product / component	Solar Keymark collector / ATG level 2	Solar Keymark licence from Certification Bodies; Technical Agreement from associations accredited by Belgian Accreditation Body	Solar keymark collector broadly accepted Technical Agreement still have good notoriety
	SDHW System	Solar Keymark System ATG level 3, 4		Solar keymark system not broadly accepted yet, expensive, practical difficulties (≠ factories)
Installer	Installer	(EU) Certification of small scale renewable energy equipment installers / ATG level 5 or 6	Conformity with art.13 (Information and training) of EU RES DIR & annex 4 (Certification of installers) requirements	Training schemes vary from Flanders to Walloon and are not in line with EU RES DIR yet,
	Installation	Installation control (performance and set-up)	Inspection by accredited inspection agency or technical control body	Accredited inspection agency not trained yet to assess SDHWS set-up & performance Monitoring of SDHWS not standard yet

Photovoltaics (PV)

PV systems are characterized by a large number of parameters. Due to their modular set-up, most options are applicable to different system types. Nevertheless, a few options are dominating the current PV market. The main feature of grid-connected PV compared to other RET is the absence of energy storage. Grid-connected PV always generates the maximal available power.

Grid-connected PV is the most strongly growing market segment of PV worldwide. Although EU markets determine to a large extend the current evolution, PV production is an international business with Europe, Japan and China each covering 25% of the worldwide production.

In Belgium, most PV modules are mounted on sloped building roofs. Hence, the PV generator does not make part of the building but is usually mounted on hooks, several centimetres above the tiles. Historically, three topologies for the DC connection of PV arrays were designed; namely, the central bus bar- the string-oriented- and the module-based topology. Recently, multi-string topologies become increasingly applied for small- to medium-sized systems.

PV standards exist on component and installation level (although limited to installation safety aspects). Issues related to system performance, reliability and lifetime are not handled so far in international standards.

There are several (inter)national PV quality initiatives at system level. Most of them were initiated by national organizations representing the PV component industry, suppliers or customers. The existing schemes differ in ambition level and approach. Many of those rely on quality of materials, installation and information by means of simple technical criteria, co-operation with associations of installers and effective control mechanisms. Different criteria exist for different segments of the PV supply chain. Distinctive labels are available at the level of component manufacturers; system designers; system installers and system operators.

PV roadmap

Specific requirements corresponding to initial and future ambition levels are summarized below:

		Initial Ambition Level	Future (High) Ambition Level (Initial +…)
Supplier / installer	Offer and contract	Contract is based on a binding offer, including: • Estimated yield • estimated yield reductions due to suboptimal orientation or shadowing • Warranties • Ddetailed list of applied materials • Terms and delays for commissioning The price is subdivided per: • Modules • Inverter • Other material • Working hours and documentation • Options	
Manu-facturer/ Importer	Component - Module	• Qualification according to IEC61215 or IEC61646 • Safety according to IEC61730 • Data sheet according to EN50380 • Specification of power tolerances	• Electrical specifications at low irradiance • Specification of flash test data • Independent verification of tolerances based on random samples • Material specification: glass and other materials
Manu-facturer / Importer	Component – Inverter	• Comprehensive data sheet, including Pac, r, η values required for ηEuro at UDC,r • ηEuro at UDC,r • All efficiencies according to IEC 61683 • IP class • Indication of galvanic seperation • CE declaration • EN 60146 conformity (Inverters) • Proof of grid-code compliance (Synergrid C10/11 by means of DIN VDE 0126-1) • Safety according to IEC 62093 and EN 50178 • Short manual for end user	• η values for 3 different DC voltages • Basic monitoring function indicating operation or failure mode (internal or external)
System integrator installer	DC cabling, connection boxes, connectors	• Double insulated cabling (ground and short circuit proof) • Temperature and UV resistance (outdoor) • Cable ducts according to AREI/RGIE • Suited IP class for connectors	• Bypass diodes replaceable
Installer	Component – Lighting protection & earthing	• Effective grounding and lightning protection	
System integrator / supplier	Mounting system	• Statics • Corrosion • Ventilation • Module mounting, • Proof of water tightness for roof-integrated systems	• Specification of static properties of the mounting system, possibly based on tables or sizing tools • The mounting system should contain cable ducts
System integrator	System	• Installation according to IEC 60364-7-712 • No string diodes • Proper sizing of conductors, switches, plugs… • Proper sizing of invertor with regard to PV arrays • Good practice in earthing and lithning protection	
	Installation	Installation by qualified staff: • Full qualification for electrical installations • Basic qualification for roofing works • All interactions with the roof according to good practice in roofing Technical documentation of the installation including: • Technical specifications of modules and inverters • Checklist from commissioning • Technical certification (technische keuring AC) • Technical Drawings • Short manual for end user	
	Maintenance	n.a.	• Maintenance guide

Small Wind Turbine (SWT)

More and more small-sized wind turbine systems with a power rating less than 100 kW per unit are coming on the market. They are considered as renewable generator units to be mounted in the vicinity of buildings or on building roofs, offering an alternative for e.g. Photovoltaics, or combined with PV into hybrid systems. The wind industry recommends customer property sizes of 2000 m² or more for horizontal axes wind turbines (HAWT) up to approximately 3 kW and 4000 m² or more for wind turbines above this size. Vertical axis wind turbines (VAWT) are usually better suited for changing wind direction and turbulence (common to the built environment) than horizontal ones (HAWT). VAWT does not need to be positioned into the wind direction, but their overall efficiency is usually lower. The building is preferably used as support structure.

The market for small wind turbines can be defined as *emerging* or *growing* rather than *stable* or *mature* compared with other technologies such as solar thermal or heat pumps. It is a niche market with a very large number of manufacturers and a variety of technologies. There are very big differences between SWT in terms of quality, technological characteristics and price. SWTs cover the complete scope from rickety DIY[1] home-built turbines to fully-certified tried-and-tested products. In comparison with large wind turbines the performance of small wind turbines tends to be rather disappointing and only a small number of models have a design certification and calculations. The normative process needs to be accelerated in all countries to avoid poor quality products and installations ruining the market and consumer’s confidence.

There is very little experience so far with SWT installations in Belgium, and thus very few skilled installers on the market. More, there is no legal framework for SWT, the authorization procedure is dealt with on a municipal level and no specific feed-in tariffs exist, except the compensation principle in some regions for units below 10 kW. The *Briefing Sheet Small Wind Energy Systems* published in 2006 by the British Wind Energy Agency and other requirements added up re SWT installation like an installer certification scheme and an installation standard were used as basis for the SWT roadmap.

SWT Roadmap

A sustainable roadmap for SWT quality development in Belgium might look like this:

Level		Initial ambition level	Future ambition level (intial+…)
Manu-facturer	System	BWEA standard requirements: - Electronics (IEC wind generator standard) - Strength (IEC 61400-2:2006), Safety and function (IEC 61400-2:2006) - Provisions for operation in high wind and to slow or stop the turbine in an emergency or for maintenance - Noise (IEC 61400-11:2003), Performance (IEC 61400-12-1)	- Compliance with requirements of IEC 61400-1:2005 (turbulence) - Testing of weight and natural frequency of systems AWEA standard requirement: - Compliance with requirements of IEC 61400-21 (power quality)
	Services	BWEA standard requirements: - Maintenance and component replacement provisions Energy Trust of Oregon: - Warranties on wind turbine, inverter and controller for 5 years	
Installer	Installation	BERR “Microgeneration installation standard”: - Distance to public, restriction of access, safe sitting - Tower suitability, foundations (BS8004 and 8110-1) - Guys, shackles and turnbuckles, output cables (BS7671) - Isolation, earthing, lightning protection, Labeling, Metering - Control and circuit protection (BS 7671), control, battery cables, selection, sizing and installation (BS 7671 and BS6133), control, inverters, isolator, cabling, current protection (G83/I, BS EN 60947-3, BS7671) - Extreme winds (suitable class of turbine for the site conditions), Structural (fixing method if on building)	- Resource evaluation similarly to the NOABL’s based method
	Maintenance	Energy Trust of Oregon : Installer’s warranty covering workmanship for 2 years.	

[1] DIY does not necessarily mean the design is unreliable or faulty

1.4.2 Common basis for RET integration

Grid Integration of PV and SWT

For Distributed Generation (DG) to have a positive impact on the emission level of the electricity production system, units must be installed by consumers in their hundreds of thousands. This requires a new highly decentralised approach to energy planning and policy. In addition, a new understanding of the likely interaction between DG technology and its multitude of potential end users must be developed. Hence, **a transition of passive to active grid operation is essential** to facilitate the integration of DG.

HVAC integration and Building integration of RET

Integrating RET - especially BES, ST and HP - into residential buildings entails several interactions with the Heating, Ventilation and Air Conditioning system and with the sanitary hot water production. The installation of RET in a residential building might have an impact on the building envelope, (solar panel integration, SWT securing on the building roof...) and perforation for connections (electrical, water ducts, air ducts...) through the building envelope. However, RET integration cannot compromise the primary functions of the building envelope, i.e water tightness, air tightness and thermal insulation of the envelope.

The main interactions of RET on buildings are summarized in the table below:

	Renewable energy technologies					
	1	2	3	4	5	6
	ST	PV	Wind	Biomass	HP	Ventilation
Building pre-requirements						
Envelope airtightness				x	x	x
Envelope insulation				x	x	
Space required	x	x	x	x	x	x
Building orientation and position	x	x	x			
Building structure/stability	x	x	x			
Installation requirements towards building integration						
Building envelope						
Water tightness of the building envelope	x	x	x	x		x
Air tightness of building envelope	x	x	x	x	x	x
Insulation layer of the building envelope	x	x	x	x	x	x
Acoustical comfort						
Limitation of noise		x	x	x	x	x
Indoor air quality						
Exhaust of used air close to opening				x		x
Safety						
Fire safety	x			x		
Electrical safety		x				
Mechanical safety						
Lightning protection	x	x	x			

1.4.3 Opportunity for analysis of new technologies

In the perspective of a project scope enlargement, new technological development that would be worth investigating are:

- Suitability of agro-pellets for residential heat generation
- BEST (Combined Biomass Solar Thermal Energy System)
- the combination and subsequent product integration of Heat Pumps and Solar panels
- HP + PV system: photovoltaic solar panels can cover the electricity consumption of electrically driven HP
- Interactions of (reversible) heat pumps with ventilation systems
- air/water HP and condensing gas boiler sold as one-package combinations
- CO_2 ground heat-exchanger of HP

- Static air heat exchanger (DX or brine) of HP
- development of medium temperature solar thermal collectors
- Reducing heat losses of solar thermal storage tanks
- hybrid system combining grid-connected SWT with a PV installation
- to define standards for small hydropower based on wind energy normative requirements

1.5 PRELIMINARY CONCLUSIONS AND GUIDELINES FOR POLICY MAKERS

In order not to slow down the pace of technological innovation in the microgeneration sector, it is recommended to implement a flexible quality scheme relying on a broad set of common mandatory requirements which can be complemented or adjusted to the innovative character of each market and the quality requirements specific to each RET.

In such perspective:

- Regional authorities should gather efforts and experiences in order to set up and operate a shared Quality Scheme at federal scale. The logical ad hoc structure to formalize such a scheme might be the CONCERE[2] group.

- A quality scheme with independent third party control and certification, based on specific references documents is recommended for five out of the six RETs (SWT would be handled separately).

- A Quality chart with self-commitment and generic content would be an initial ambition level for SWT. Indeed, urban wind turbines have a very low market penetration and are is not covered by the EU RES Directive as a building integrated RET.

- Policymakers should turn relevant standards into *strongly advisable* or *mandatory* requirements in order to ensure well defined quality level of the product installed. STS (Unified Technical Specifications) seem to be the appropriate tool to do so.

- A national quality label for RET installers should rely on quality requirements based on appropriate technical references, with particular emphasize on:

- Conformity of components and products with international standards;
- Guarantee of performance and availability of components used;
- Regular training and third party certification of installers;
- On site inspections of systems in operation and quality/performance control.

- Research about new heat storage media should be heavily promoted since it would benefit several technologies for which energy storage is key, such as BES, HP for sanitary hot water and ST.

- More research is also needed in the field of ventilation, especially to define the ventilation requirements in term of performance and indoor air quality.

- Financial support schemes to RETs are nearly always regional ones[3], with no consideration for requirements made by other regions. Beside that, some municipalities and provinces give additional incentives. On top of that, the federal government is giving tax credits to a range of energy efficiency investments, including most of the reviewed RETs. Last but not least, distributed energy resources (DER) (PV, SWT) benefit from Green Certificates that are calculated and issued following four different methods.

- The federal tax credit mechanism seems to be the easiest way to make a voluntary quality scheme attractive for both installers and users throughout the country; by making the fulfilment of the scheme's requirements a precondition to benefit from tax credit or itemized deduction.

---

[2] Groupe de concertation Etat-Régions pour l'énergie

[3] their requirements are usually based on those of the Region

2 ABREVIATIONS & ACRONYMS

ADEME: Agence de l’Environnement et de la Maîtrise de l’Energie
AHU: Air Handling Unit
AMWS: Average Mean Wind Speed
ANSI: American National Standards Institute
APF: Annual Performance Factor
AREI: Algemeen Reglement op de Elektrische Installaties
ATG: Agrément Technique – Technische Goedkeuring
AWEA: American Wind Energy Association
BAWT: Building Augmented Wind Turbine
BOVERKET: The National Board of Housing, Building and Planning (Sweden)
BBRI: Belgian Building Research Institute
BES: Biomass Energy System
BIPV: Building Integrated Photovoltaics
BMS: Boiler Management System
BUWT: Building mounted/augmented Urban Wind Turbine
BRUGEL: Régulateur Bruxellois pour le marché du Gaz et de l’Electricité
BWEA: British Wind Energy Association
CEN: European Committee for Standardization
COP: Coefficient of Performance
CPC : Concentrateur Parabolique Composé
CRA : Centre de Recherche Agronomique (Gembloux)
CWaPE: Commission Wallonne pour l’Energie
DER: Distributed Energy Resource[4]
DG: Distributed Generation[5]
DGS: Deutsche Gesellschaft für Sonnenenergie
DNI: De Nayer Instituut
DIN: German Institute for Standardization
DIN CERTCO: Certification organisation of TÜV Rheinland Group
DSO: Distribution System Operators
EN: European standards
ENEA: Ente per le Nuove tecnologie, l’Energia e l’Ambiente/Italian (National Agency for New Technologies, Energy and the Environment)
EER: Energy Efficiency Ratio
EHPA: European Heat Pump Association
EPB: Energy Performance in Buildings
EPBD: Energy Performance of Buildings Directive of the EU Council and the European Parliament
ESTIF: European Solar Thermal Industry Federation
ESTTP: European Solar Thermal Technology Platform
ETA: European Technical Agreement
EU: European Union
EU-RES: European Directive re the promotion of the use of energy from renewable sources, COM (2008) 19. European Commission, Brussels, Belgium, January 23, 2008

[4] small-scale power generation technologies (typically in the range of 3 kW to 10,000 kW) used to provide an alternative to or an enhancement of the traditional electric power system.

[5] also called on-site generation, dispersed generation, embedded generation, decentralized generation, decentralized energy or distributed energy, generates electricity from many small energy sources

EWEA: European Wind energy Association
FUC: Follow-Up Committee Q-Direct
GCS: Green Certificate Scheme
HAWT: Horizontal Axis Wind Turbine
HP: Heat Pump
HVAC: heating ventilation and air conditioning
HX: Heat Exchanger
IEC: International Electro-technical Commission
ISO: International Standard Organization
KAPE: Krajowa Agencja Poszanowania Energii (Polish National Energy Conservation Agency)
KUL: Katholieke Universiteit Leuven
LTC: Load Tap-Changing transformers
MicroCHP : Micro Combined Heat and Power
Microgeneration[6]: generation of zero or low-carbon heat and power by individuals, small businesses and communities to meet their own needs
MQS: Microgeneration Quality Scheme
MPP: Maximum Power Point
NBN: Norme Belge / Belgische Norm (by extension, institut belge de normalisation)
NIT: Note d'Information Technique
NOABL : Numerical Objective Analysis of Boundary Layer
OLTC: On-Load Tap-Changing transformer
PER: Primary Energy Ratio
PV: Photovoltaic
PVPS: Photovoltaic Power System
QUEST: Quality Centre for Sustainable Energy Technologies
RES: Renewable Energy Systems
RET: Renewable Energy Technology
SDHWS: Solar Domestic Hot Water Systems
SHW: Sanitary Hot Water
SHWS: Solar Hot Water System
SIS: Swedish Standards Institute
SME: Small and Medium Energy Systems
SOA: State Of the Art
SPF: Seasonal Performance Factor
STC: Standard Test Conditions
SWT: Small Wind Turbines
SWIIS: Small Wind Industry Implementation Strategy
TEWI: Total Equivalent Warming Impact
THD: Total Harmonic Distortion
UWT: Urban Wind Turbines
VAWT: Vertical Axis Wind Turbine
VREG: Vlaamse Reguleringsinstantie voor de Elektriciteits- en Gasmarkt
VUB: Vrije Universiteit Brussel
VwHR: Ventilation with Heat Recovery
WP: Work Package
WPP: Warmtepomp platform

[6] Domestic microgeneration technologies include: photovoltaic solar systems, small scale wind turbines, ground source heat pumps, micro combined heat and power installations, biodiesel and biogas

3 CONTEXT OF THE RESEARCH

Some Renewable energy markets are increasing at a fast pace, in Belgium and at EU level, giving rise to constant technical evolutions. Still, major differences exist in terms of market penetration of RETs in Belgium; hence it will take some time before the renewable energy market organises and structures itself with respect to those differences in market penetration and technological evolution.

On the other hand, high incentives given to RES by public bodies and authorities in Belgium attract a growing number of RET suppliers and, sometimes self-declared, installers. This leads to a highly diversified offer of products & services; but also to a lack of qualified professional structures.

The Q-Direct project was submitted in 2006, while a limited number of operable quality systems & recognized labels for small scale distributed renewable energy systems existed on an international level.

For end-users wishing to buy or lease small generation units (from renewable or conventional sources) for their home, for a community building or for a small business, quality of the product and service is still a high expectation, whose fulfilment is essential for the sustainable growth of the RE sector.

Quality insurance for (emerging) renewable energy technologies have proven to be of utmost importance for a sustainable market deployment. It appears to be the best way to counter negative examples of poor quality installations, thereby reinforcing the acceptance of those relatively new and rapidly evolving technologies.

Based on those assumptions, the Q-Direct project considered the development of Quality References of distributed small scale renewable energy concepts and applications in Belgium.

The scope of the technologies under review covers:

- Solar Thermal Energy for Domestic Hot Water Systems (ST)
- Solar Photovoltaic systems for residential applications (PV)
- Small-scale Biomass Energy Systems (pellet boilers, biomass burners, …) (BES)
- Urban Wind Turbines (small wind turbines integrated into the built environment) (SWT)
- Geothermal Heat Pump systems (HP)
- Building ventilation systems with heat recuperation (VwHR)

E-Demand / **E-Source**	**Space heating Distribution system**			**DHW**	**Electric power**	**Swimming pool**
	Direct radiation / convection	**Supply air**	**hydronic**			
Extract air	-	**VwHR t1,2 / VwHR+HP t3 / (HP t6)**	**VwHR+HP t4,5 (HP t8)**	**(HP boiler)**	-	**()**
Outside air	**(HP-split air)**	**(HP)**	**(HP)**	**(HP boiler?)**	-	**(HP)**
Geothermal	-					
Vertical	-	**(HP)**	**HP**	**HP**	-	**(HP)**
Horizontal	-	**(soil to air HX, t7) (HP)**	**HP**	**HP**	-	**(HP)**
water	-	**(HP)**	**HP**	**HP**	-	**(HP)**
Solar radiation	**(Passive Solar)**	**(Double facades / extraction out of greenhouse / air collectors)**	**(solar thermal space heating)**	**Solar Thermal**	**PV grid-connected**	**(Solar Thermal plastic)**
Biomass	**stoves**	**boilers**	**boilers**	**(+)**	**(CHP)**	**()**
Wind	-	-	-	-	**urban wind turbine**	**()**

The quality references also include technical issues and requirements common to several technologies, regarding their integration in the building envelope, the HVAC system and / or the electrical grid, as well as the respective international standards encompassing them.

4 OBJECTIVES

The main objective of Q-Direct is to define guidelines for policymakers to encompass the growth of the renewable energy industry in Belgium according to high quality standards.

A crucial part of the research consists in itemising the quality requirements that should apply to the manufacture and installation of proven RETs, in order to give confidence to end-users that the product/system and the installer they choose meet a high quality standard and achieve a high operation lifetime.

The specific objective of the first phase of Q-Direct is to structure the quality requirements for each technology in order to provide policy and market instruments allowing policymakers and the professional sector to help the renewable energy sector to meet higher quality standards.

An integrated quality scheme including a range of RETs, and eventually other microgeneration technology such as micro CHP, might be one of those instruments.

5 METHODOLOGY

The first phase of the project is designed to lay down the technical basis of an integrated RET quality scheme through a review of the state of the art of 6 technologies, leading to the set up of quality references & roadmaps.

The development of the quality references relied upon the following steps, followed by each project partners:

1. Thorough review of the state of the art of technology, (the core of WP2), including status of the RE supply chain, status of product standardisation, as well as an assessment of several quality systems for microgeneration used in other countries and a review of technological evolutions having an effect on quality requirements ;
2. Pooling of the technical quality requirements common to several RETs, including building integration, HVAC integration and electro technical (grid) integration of RE systems;
3. Design of the quality level, common to the six RETs, at a start phase and in the longer term, through technological roadmaps (the core of WP3)
4. Preliminary assessment of the institutional & organisational path to follow by policymakers, in order to implement those quality references through policy and/or market instruments (the core of WP4, to deepen/examine in more details during the second phase of the project).

The partners involved in the research are Universities, research centres or engineering office. Each of the partners possesses sufficient expertise in the considered RETs and has to deal specifically with one or two technologies (as shown in the table below) and report to the project group.

Solar energy systems (3E)	Bio-energy systems (VUB - CRA)	Heat pumps (DNI)	Ventilation systems with heat recovery (BBRI - DNI)	Urban wind turbines (3E)

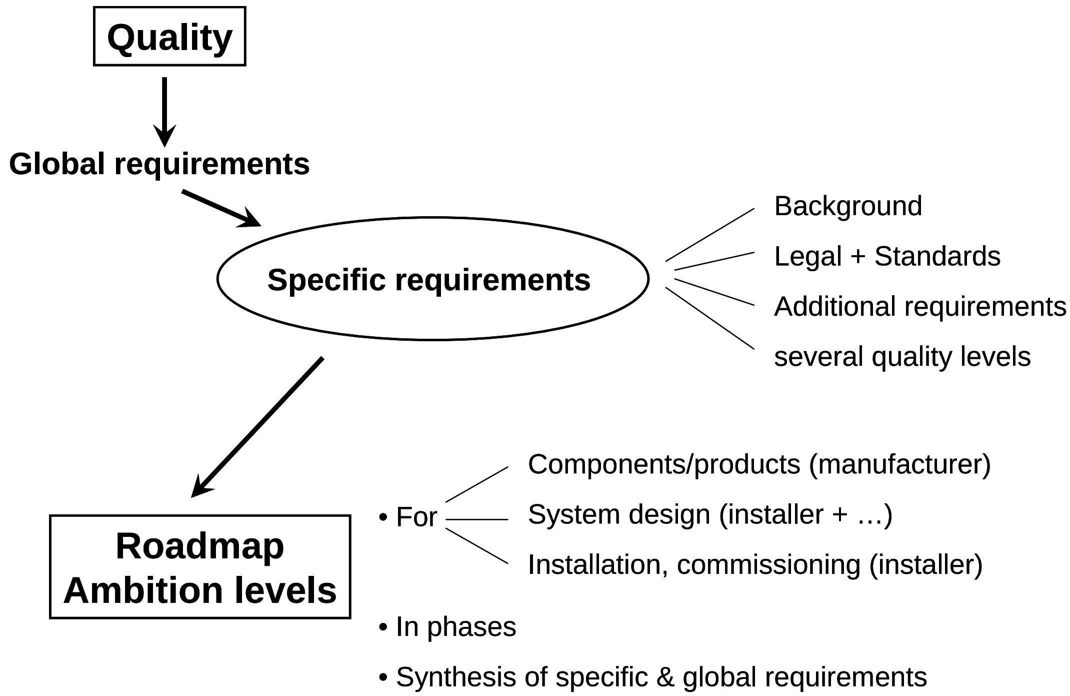
Integration and interfaces:
- Electric grid interfaces (KUL-ELECTA)
- Building physics integration(BBRI- 3E)
- HVAC Integration (BBRI - 3E)

The project analyzes the scope and the opportunity to set up a single quality scheme for the six RETs at federal level in Belgium, compared to separate quality schemes, each relating to one or some of the technologies under review. Indeed, the considered technologies have common requirements and shared aspects, therefore a kind of *integrated microgeneration quality scheme* might be advisable as it offers several advantages:

- Unique current & future quality references & requirements set for several technologies, at Belgian level
- Cost savings for Quality application procedure for companies supplying and/or installing several or combined RETs
- Higher visibility of a quality scheme shared by the whole RE sector in Belgium
- More efficient communication process towards the whole RE sector
- Higher credibility and cost savings associated with the participation of the operators of the scheme in international/European standardization and certification initiatives

Two basic types of quality requirements were considered in the research, as illustrated by the figure below:

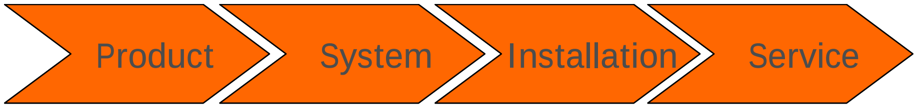
- Global requirements: expressed in terms of end user expectations such as thermal comfort, energy & environmental performance, ease of installation, use and maintenance, safety... for which the results can be controlled/monitored;
- Specific requirements: expressed in terms of measurable means to fulfil a global requirement if the result of a global requirement is not controllable.



Quality requirements were initially worked out following a *'technology push'* approach. This is the usual way of working of the project partners, but it showed some limitations. Hence, this was gradually replaced by an *'objective pull'* approach where requirements are worked out starting from quality expectations as they might be expressed by the end user. The table below illustrates the broad range of expectations from an end user perspective.

DESIGN	COMPONENT /PRODUCT	SYSTEM	INSTALLATION	← END USER PERSPECTIVE→	USE	MAINTENANCE
X				Heat/ Power needs		
	X			Availability		X
	X			Durability		
	X			Safety	X	
		X		Performance results	X	
				Comfort	X	
			X	Building/HVAC Integration		
				Easyness	X	X
		X	X	Quality/price		X
	X			Environmental impact	X	

The designed requirements must cover the whole market chain, from component level to system design, up to commissioning, monitoring and maintenance of the installation in operation.



The second phase will consist in designing common organizational basis and institutional framework in order to implement such a scheme in a later phase. Indeed, the various technical, organizational, regulatory and policy components of a microgeneration quality system need to be harmonised and mutually streamlined, as they are evolving following their own principles, laws and timelines.

6 RESULTS OF THE FIRST PHASE OF THE PROJECT

6.1 EXPECTED RESULTS OF THE FIRST PHASE OF THE PROJECT

The expected outcome of the research was to yield reference documents & policy recommendations, considering the set up of a microgeneration quality scheme in Belgium and to identify synergies between technologies, leading to integrated policy measures helping the RE sector to meet higher quality standards re domestic RET installations in operation.

The expected results of the first phase of the project for the six reviewed technologies involved the development and provision of:

- An integrative basis for further normative work;
- An exhaustive set of common and differentiated quality requirements;
- A coordinated roadmap to give the quality scheme a timeline for implementation;
- Preliminary policy recommendations to proceed organize and finance the implementation of such a quality scheme.

The quality reference documents & roadmaps put forward technical and normative requirement being of use in a subsequent implementation phase by third parties (testing institute, certification institute, public body, sector federation…).

Nonetheless, the true implementation of the quality system as such is not part of the research, which does therefore not include any real certification scheme or procedure to operate a MQS on the Belgian market. The deliverables of the project are available to BELSPO on the project's intranet website:

Work package 1 and its subtasks:

- Detailed project planning per phase and per work package (half yearly update).
- Project website containing all internal working documents, project reports and references
- Meeting reports of project group meetings, bilateral meetings and follow up committees

Work package 2 and its subtasks:

- Summary report of state of the art of each technology, market & quality insurance
- Policy document assessing the current status re standardisation, quality insurance & labelling for the technologies under consideration.
- Updated report on status of supply and market chain, standardisation, normative framework & quality systems (phase 2).

Work Package 3 and its subtasks:

- Reference document including a complete set of technical quality requirements re grid (electro technical) integration of considered RET.
- Reference document including a complete set of technical quality requirements re HVAC integration of considered RET.
- Reference document including a complete set of technical quality requirements re building integration of considered RET.
- Technological roadmap per RET, listing the quality requirements and their implementation in time.
- Opportunity analysis report of technological evolution that would need to be included in the quality scheme
- Reference document per RET including technical, technological and normative criteria on component, product and system level.

Work Package 4 and its subtasks:

- Reference document including a complete set of organisational requirements re the institutional context & market impact directly linked to the operation of the quality scheme (phase 2).
- Organisational roadmap per technology listing the quality requirements and their implementation in time (phase 2).
- Report memo including cost/benefit analysis, conclusion and headlines of a business plan for EU accreditation of a test facility in Belgium.
- Business plan for the operation phase of the quality scheme over a time frame of 5 years (phase 2).

- Policy document including the considered initiatives re standardisation, quality insurance & labelling for the technologies under consideration.

6.2 PRELIMINARY CONCLUSIONS OF THE PARTNERS

For the six RETs under consideration, major differences exist at level of market penetration: inexistent, emerging, stable, mature and supply chain:

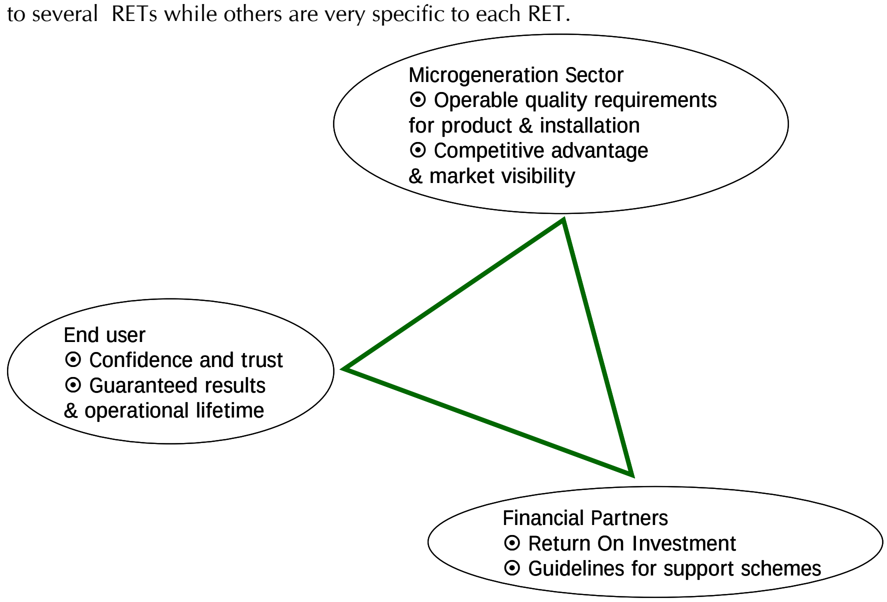
- presence or lack of local manufacturers/suppliers/wholesalers,
- existence of (national) sector federation(s),
- availability of distribution network for spare parts,
- availability of skilled technicians and installers,...

The objectives pursued by setting up a quality scheme for RETs are multiple, and different expectations arise depending on the stakeholder, as illustrated in the figure below.

A pre condition to succeed in implementing a quality scheme requiring efforts from RET manufacturers, system designers, wholesalers, dealers and/or installers is to get it:

- Endorsed by the renewable energy sector,
- Claimed by the end user
- Recognized by the alleged financing entities.

Hence, the considered quality requirements must seek after complementarities between the expectations of those stakeholders that are the most relevant market players; knowing that some quality issues are common to several RETs while others are very specific to each RET.



The network agreed that an effective Quality Scheme should:

- Provide consumers with independent certification of microgeneration products and services (and a route for complaints);
- Be independent from the professional sector
- Be designed to evaluate RETs and installers against robust criteria providing greater protection for consumers
- Certify RETs and installers in accordance with consistent standards.
- Cover a range of RE technologies and services,
- Get entire support from the public authorities of the three regions, the microgeneration sector, the consumer associations and the environmental protection groups as an efficient way to achieve substantial CO_2 emission reductions in the residential housing sector.

6.3 TECHNOLOGICAL STATE OF THE ART (WP2)

6.3.1 General considerations/foreword

Wide technological and market differences exist between some of the reviewed technologies, affecting regulations, quality standards requirements and normative framework that are developed within standardisation committee such as NBN in Belgium, CEN at EU level and ISO or ASHRAE at international level.

The network devoted important efforts to deliver a thorough state of the art for each technology, as this was seen as the basis for the technical requirements and roadmap of WP3.

Work package 2 resulted in six extended reference documents (one per technology), explaining the state of the art of each technology at three different levels:

- Technology level: component, system…
- Market level: status of the supply chain, market evolution…
- Quality level: standardisation & labelling, quality insurance…

The full content of each technological SOA is available on the project intranet website and as annex to the activity report intended for the intermediary evaluation[7]. A short description of each SOA deliverable is given in the G-form (point 4. Report on the Progress and implementation).

6.3.2 Integrated results of WP2

Getting full information about the upfront costs, the running costs and the expected performance was identified as a decisive factor for consumers before they agree to buy or lease a given technology.

Some stakeholders amongst the key market players (mainly prescribers and developers) underlined key obstacles to high quality building integration of some of the reviewed technologies:

- Inherent technical difficulties linked to system design, integration and regulation mainly for HP and VwHR;
- Lack of skilled workers (designers, installers, system integrators);
- Lack of availability of some spare parts (for HP & BES) on the local market;
- Lack of Technical Agreement for components and most of the RE systems, while those agreements are typical for the building sector throughout the EU
- Lack of acknowledged Technical Specifications re implementation of RETs
- Need for a coherent, homogenous labelling scheme for RETs

The EU RES directive was identified as a strong incentive for policymakers to move ahead from promotion or acknowledgment of voluntary labeling initiatives towards true certification schemes. A well-defined national framework for training and certification of small-scale RES installers will be required by the EC from December 2012 onwards, as part of the obligation for member states to set up accreditation systems in order to achieve a common and competitive quality level of RE technologies and related services all over EU.

The research concluded that there is actually no official training scheme (i.e. complementary training, technical schools or institutes) for RET installers specifically (except the Soltherm training program for SDHWS in Walloon), however, some companies working with their own installers network offer technical and/or commercial trainings that are specific to their product.

[7] G-form; July 2008

6.3.3 Small-Scale Biomass-Energy System

State of the Art of BES technology

The research showed that:

- From an energy perspective, BES can provide an attractive and feasible option to cover the whole heating demand (sanitary hot water and space heating) in residential housing in Belgium.

- Existing technology is working reliably and most of the products were tested and certified according to EN and/or national standards. Technology & design of pellet stoves/boilers marked throughout Europe goes from simple and cheap craft work towards sophisticated and expensive high-tech systems while standardized quality of pellet fuels sold across dominant market like Sweden, Austria, Switzerland, Italy and Germany, only marginally differs.

- Since the introduction of pellet fuels and pellet burners, BES acquired enough technological maturity to compete with existing oil and gas heating devices.

- The main recent technological developments improving the overall quality of BES on the Belgian market are:

1. the emergence of multi-heat boilers
2. the emergence of agro-pellets company (e.g. AgroPellets sprl)
3. the accreditation of ARGB by DIN CERTCO as test lab for room heaters (solid fuel stoves) with low pollutants combustion according to DIN EN-13240 and for insert appliances including open fires fired with solid fuels according to DIN-13229.

- Further technological evolution that would improve BES quality on the Belgian market are:

1. Multi-heat boilers in with condensing technology, lambda control for combustion airs and automatic ash removal systems
2. Foreseen accreditation of ARGB test lab by DIN CERTCO to test/certify heating boilers for solid fuels, hand and automatically fired, with a nominal heat output of up to 300 kW according to EN-303-5.

- The most effective RET combination, improving the overall quality performance of the whole BES is the Pellet-solar boiler combined system (Cfr. 7.4.6),

Status of supply chain and market

The research showed that:

- The BES market is booming in several EU countries, the majority of today's small-scale BES is installed in Sweden, France, Austria, and Germany. In Belgium, Wallonia is the prominent region for biomass energy use (83.5 MW installed for residential heating in 2007).

- In most EU countries, pellet fuel is cheaper than fossil fuels, even though a few key factors may hamper or boost BES market development. At member state level, the two most important ones being regulations policies and financial incentives

- Several measures supporting this green energy market in the active countries were investigated. It was found that policies and financial incentives such as the Finance Law (2005-2009) in France and Market Incentives Program (1999-2006) in Germany were the most successful.

- Generally speaking, the predictable rise of fuel prices and taxes, the high technical standards for Biomass Heating Systems associated with their environmental friendly image and government incentives stimulate end-users of the countries considered to invest in this green energy technology.

- On the other hand, the lack of sufficient information/promotion for general public and stable governmental support (ie financial incentives) are slowing down this growth, in spite of the great biomass resource potential, e.g. Belgium.

- Practical experience of BES installers is lacking in Belgium, there is no further official training scheme (i.e. complementary training, technical schools or institutes) for BES installers, though some BES suppliers working with their own installers network offer them a product specific training.

- Hence, a stable financial incentive mechanism associated with an acknowledged quality scheme for biomass energy systems and fuel play a key role in the further development of a quality market in Belgium.

- The most important quality requirement to set at each level of the market chain in order to improve quality of BES as a whole was found to be:

▪ At component, product & system design level: to meet the quality requirements of EN standards.
▪ At installation level: certification and training of installers, since overall efficiency of the pellet boiler is depends on the quality of installation.

- At operation and maintenance level: demonstration and instructions for safe and efficient operation of the BES by the installer to the end consumer, including recommendations on:
  - Which parts of boiler is maintenance prone and why (e.g. protection of pellet supply system from water/humidity to avoid blocking of augur…).
  - Which parts of the boilers need regular inspection and cleaning (e.g. heat exchangers, combustion air holes, combustion chamber, chimney, pellet storage and supply system to remove accumulated fines…).
  - Inspection and cleaning interval (according to the heat load and type of boiler).

BES Standards

Relevant standards are:

- EN 12809:2001/A1:2004/AC:2007 : Residential independent boilers fired by solid fuel - Nominal heat output up to 50 kW - Requirements and test methods
- EN 12815:2001/A1:2004/AC:2007 : Residential cookers fired by solid fuel - Requirements and test methods
- EN 13229:2001/AC:2006 : Inset appliances including open fires fired by solid fuels - Requirements and test methods
- EN 15250:2007 : Slow heat release appliances fired by solid fuel - Requirements and test methods
- EN 14785:2006 : Residential space heating appliances fired by wood pellets - Requirements and test methods
- EN 13240:2001/A2:2004/AC:2007 : Room heaters fired by solid fuel - Requirements and test methods

The research showed that:

- Several technical requirements for BES exist at EU level; most of them are applicable on a voluntary basis through EN standards.

- EN standards operate at the system level which also covers part of the installation process, limited to chimney installation and fire safety.

- All applicable standards are international standards, published by the technical committee of CEN. At the moment EN 303-5, EN 12809, EN 15250, EN 12809 and prEN 15270 are the appropriate standards providing minimum requirements regarding system performance and reliability.

- Particular Belgian biomass standards do not exist; however, EN 303-5 re performance and reliability of BES has been registered as Belgian standard (NBN-EN-303-5) for the solid fuel burning boilers. This standard does not cover the operational lifetime issue and there is no (pre-) standard establishing a minimum operational lifetime of such systems, which makes any requirement regarding operational lifetime pretty valuable.

- In addition to those standards, BES must comply with the Low Voltage Directive (TH 42075; Directive 73/23/EEC) and Machinery Directive (TH 42073; Directive 98/37/EC) of CE marking for a good practice.

- No representatives from the Belgian Biomass industry are actively participating in any of those standardization committees, which means that the Belgian industry might implicitly accept the standards that are being defined by their international competitors (ownership of DIN*plus* certified wood pellets over the Belgian market provide a good example in that respect).

- Most relevant existing standards ensuring quality improvement of BES on the Belgian market are:

- EN 12809 and EN 303-5 for pellet boilers; because those are the only existing EN standards applying to the 'residential boilers fired with solid biofuel' (prominent part of the project scope) which are registered as Belgian standard NBN EN-12809 and NBN EN 303-5,
- prEN-14961 or DINplus for pellet fuel; because
  - Both guarantee the best quality wood pellets among EU countries;
  - Quality requirements imposed by DINplus are pretty close to those of prEN-14961. Hence, as EN standard 14961 comes into force, it should easily be accepted by the biomass industry and the consumers.
  - DINplus is currently the most popular wood pellet certification scheme among the EU countries, which is also key for a Belgian microgeneration quality scheme;
  - the Belgian market of pellets is currently dominated by DINplus (http://www.pellets-mandi.be; http://www.badgerpellets.com ; http://www.granilux.eu ; http://www.distripellet.be …)

BES Quality insurance & labeling

Minimizing gas and particulate matters emissions is a major quality concern. The emission level of a pellet boiler reflects the quality of combustion and the efficiency of the system; it depends upon two main factors:

- a) Combustion quality: High temperature in the combustion chamber, turbulence and long residence time are required
- b) Pellet fuel quality: in order to minimize emissions of pollutants and to raise combustion efficiency.

Further requirements to ensure a high combustion quality include :

- sufficient primary and secondary combustion air supply (Lambda proof is one of the best solution)
- Large size (optimized) combustion chamber in order to provide sufficient residence time for the combustion gases to burn completely.
- Draft adjustment is required to draw the combustion exhaust out of the chimney. Most pellet boilers are equipped with fan to force the draft; in case of natural draft, proper installation and insulation of the chimney is required.

The research showed that:

- In Europe, Scandinavian countries (Swan label), Sweden (P-mark), France (Flamme Verte), Germany (Blue Angel), Austria (UZ-37) and Ireland (SEI) are actively involved in quality labeling of BES.

- The reviewed quality labeling schemes differ in:

- Permissible emission and efficiency limits i.e. system performance requirements;
- Minimum safety requirements;
- Definition of the fuel as a standard recommended fuel;
- Principle approach: self-commitment, independent evaluation, initial or regular control based on files or site visits;
- Target groups: system manufacturers, suppliers, installers.
- Technology: Swedish& French systems rely on simple and cheap technology; German and Austrian systems rely on more sophisticated and expensive technology.

- Relevant labeling work aiming at recommending ways to improve the environmental and energy performance of BES is ongoing through the EU Ecodesign Directive (http://www.ecosolidfuel.org/documents_15.php).

- Today, Belgium has no particular quality label for BES so far. As a consequence, quality insurance for BES implies the use of codes of good practice and a (voluntary) commitment of the suppliers and installers of BES to comply with those ones.

- State-of-the-art of technical reference guides for BES quality exist in Dutch, French German and English in the form of instructions manuals provided by system manufacturers, but no quality label is associated with those.

- In practice, the Belgian market is currently dominated by systems with a quality label from neighbouring countries. The same holds true for pellet fuel, as our market is dominated by DINplus certified pellets.

For more information, one can refer to a recent paper published by the project partner in the frame of the project[8].

6.3.4 Heat pumps

State of the Art of HP technology

The research showed that:

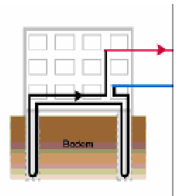
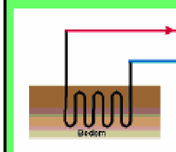
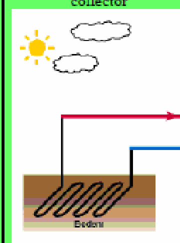
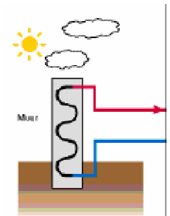
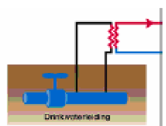
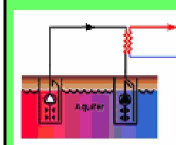
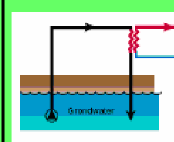
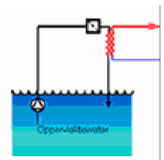
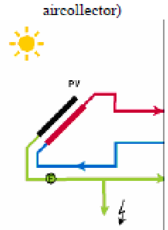
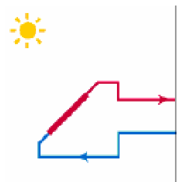
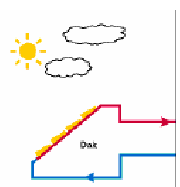
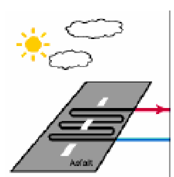
- For small scale HP systems operating in heating mode, the scope was pretty large, covering at least:

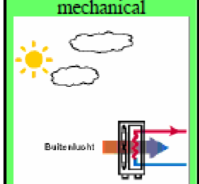
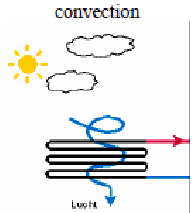
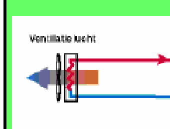
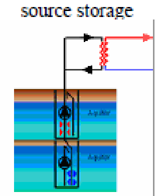
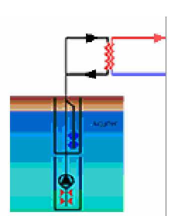
- 17 different heat-sources,
- 7 type of converters (3 Heat Pump types and combinations with boilers),
- 17 different heat-release systems,

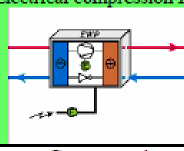
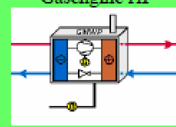
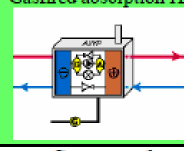
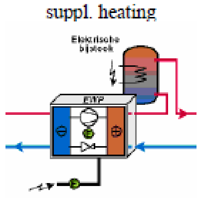
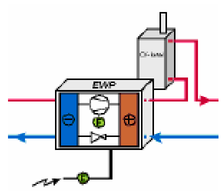
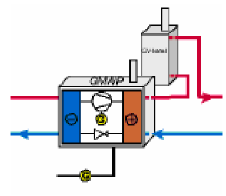
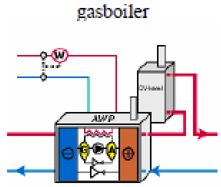
Verma V. K., S. Bram and J. De Ruyck (2009). Small Scale biomass heating systems : standards, Quality labelling and market driving factors – An EU outlook, Biomass and Bioenergy Volume 33, Issue 10, October 2009, Pages 1393-1402.[8]

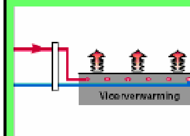
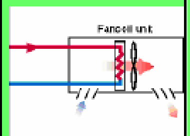
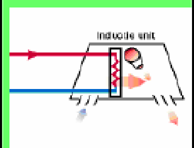
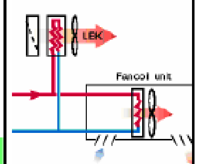
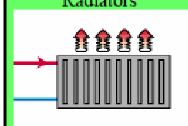
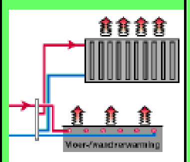
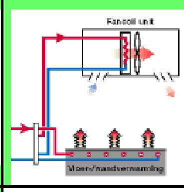
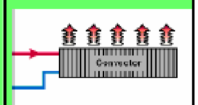
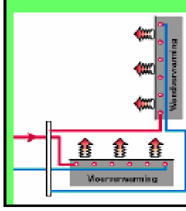
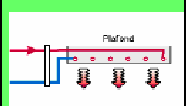
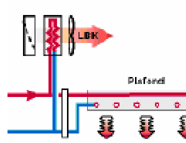
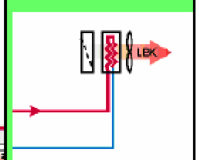
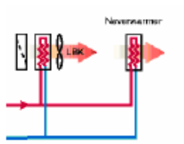
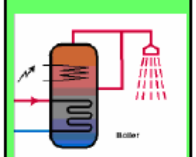
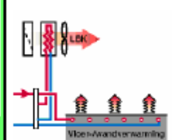
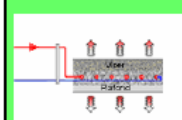
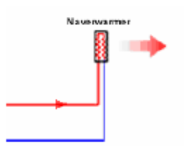
- Outside air is by far the most common heat source for heat pump applications worldwide due to the unlimited availability of the heat source and the relatively quick and easy installation.
- Commonly used systems in domestic applications appear in green in the table below:

HEAT SOURCES

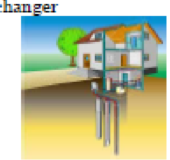
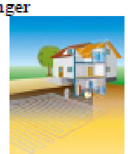
source 1 Ground support piles 	source 2 Ground vertical collector 	source 3 Ground horizontal collector 	source 4 concrete absorber (sun, air and ground) 
source 5 water supply system 	source 6 Groundwater (heat/cold storage) 	source 7 Groundwater recircul. (heat/cold storage) 	source 8 Surface water 
source 9 Sun + air (PV-panel with aircollector) 	source 10 Sun + air low temp aircollector 	source 11 Sun + air Energy-roof 	source 12 Sun + air Asphalt-collector 

Source 13 Outside-air mechanical 	Source 14 Outside-air natural convection 	Source 15 Ventilation-air 	Source 16 Ground mono-source storage 
Source 17 Ground mono-source recirculation 			

CONVERTERS		
Converter 1 Electrical compression HP 	**Converter 2** Gasengine HP 	**Converter 3** Gasfired absorption HP 
Converter 4 Electrical HP with electrical suppl. heating 	**Converter 5** Electrical HP + gasboiler 	**Converter 6** Gas engine HP + gasboiler 
Converter 7 Thermal absorption HP + gasboiler 		

HEAT RELEASE			
Heat Release 1 Floorheating 	**Heat Release 2** Fancoilunit 	**Heat Release 3** Induction unit 	**Heat Release 4** Central airheating + local fancoilunits 
Heat Release 5 Radiators 	**Heat Release 6** Floor/wallheating + radiators 	**Heat Release 7** Floor/wallheating + local fancoilunits 	**Heat Release 8** convectors 
Heat Release 9 Floor- and wallheating 	**Heat Release 10** Ceiling-heating 	**Heat Release 11** Central air-heating + local ceilingheating 	**Heat Release 12** Central air-heating 
Heat Release 13 Central air-heating + local post-heating 	**Heat Release 14** Sanitary boiler 	**Heat Release 15** Floor/Wallheating + central air-preheating 	**Heat Release 16** Actif concrete 
Heat Release 17 Decentral air-postheating 			

- The pros and cons from different heat sources were clearly identified:

	PRO	CONTRA
Vertical ground-heat-exchanger 	- not much ground-surface needed - almost everywhere applicable - always available - small variation in source-temperature - source temperature is relative high - closed system - free cooling is possible	- source-temperature goes down during the heating season - system has to be sealed (anti-freeze) - adapted computersoftware needed
Horizontal ground-heat-exchanger 	- almost everywhere applicable - always available - closed system - free cooling is possible	- needs surface - source-temperature changes - ground can get exhausted (frozen) - during the heating-season the source-temperature goes down - system has to be sealed (anti-freeze)
Ground-water 	- not much ground-surface needed - source-temperature is stable - source-temperature is relative high - inexhaustible - free cooling is possible	- water quality is not everywhere good - not everywhere available at acceptable depth - higher cost - open system - energy needed for groundwater-pump - environment-permission needed - separation refrigerant/groundwater has to be guaranteed - extraction-drilling, insertion-drilling and sealing need special attention - good knowledge of geohydraulics needed
Outside-air 	- not much ground-surface needed - almost everywhere applicable - always available - inexhaustible - low investment cost	- defrosting system for evaporator needed - sometimes low source-temperatures are possible
Exhaust air	- no ground surface needed - high source-temperature - source-temperature is stable	- noise-production - not always available - only applicable with certain ventilation-systems

- The main recent technological developments improving the overall quality of HP on the Belgian market are:

1. Scroll compressors that are widely used now in heat pumps for dwellings (1 to 50 kW)
2. Inverter DC engines, to allow power modulation. Old generation heat pumps had a reciprocating compressor with an electrical AC engine. Now most of the outside air heat pumps have a frequency variation converter and direct current engine.
3. Electronic expansion valves: the old generations were mechanical expansion valves
4. CO_2 heat pumps for high temperature heat release (up to 65°C) through conventional radiators and sanitary hot water production. Such devices use CO_2 as cooling gas and need about 100 bar pressure

- A further major technological evolution that would improve HP quality on the Belgian market on component level, regards the compressor technology (multiple-stage compressor, power-modulation) applied to air/water heat pumps with a high condensing temperature, especially designed for old dwellings retrofit.

Status of supply Chain and market

On the supply side, one finds several large manufacturer companies - mostly coming from countries where HP has a relevant market share - active in the cooling & heating sector and with international area of influence, like Daikin, Stiebel Eltron, Ochsner, Mitsubishi, Carrier, Airwell, Inventum, Ciat, Viessmann, Buderus…).

Leading countries are Sweden, Switzerland, Austria, Germany; whereas French markets are in a transition phase to become very important players. Other countries like Italy or Slovenia are emerging markets. The HP in Europe showed 52% market growth in 2006.

Re domestic applications of HP, Southern Europe mainly uses air-air split units for cooling (heating is an option); while Northern Europe mainly uses ground-water HP for heating, as illustrated below.

Type of HP	Capacity range	application	Dominant region
Air - air	3 – 5 kW	Cooling (+ heating)	Southern Europe
Air-water	4 – 40 kW	Heating	Central Europe
Exhaust air	2 – 3 kW	Heating	Sweden
Vertical ground	5 – 40 kW	Heating + free cooling	Northern + central
Horizontal ground	5 – 25 kW	Heating	Northern + central
Lake water	15 – 40 kW	Heating	Rare

Since the year 2000, HP manufacturers summoned in a European Heat Pump Association (EHPA), founded in order to facilitate international collaboration and to promote awareness and further deployment of the heat pump technology.

An important market barrier for heat pumps to date is the fact that these systems are more complex than (any) other heating systems. An installer who wants to start with HP technology needs a mixture of skills which are usually covered by different craftsmen (electro-technical engineer, driller, heating installer, refrigeration engineering...).

Additionally, the efficiency and quality of a HP heating system not only depends upon the unit and the installation work but is also strongly influenced by the whole planning and design.

One of the most important barriers on emerging markets is that HP technology markets are growing faster than the pool of qualified installers, resulting in poor level installations, which in turns threaten further development of those markets.

From there, the need for quality insurance arose as well as the belief that a European effort would help this technology much more than several national actions.

In Belgium:

- There is no large scale geothermal HP manufacturer. DAIKIN (in Oostende) is the only large scale heat-pump-manufacturer, generally using outside-air as heat source for its devices.

- Almost every distributor of cooling-installations in Belgium has reversible air-air split units that can optionally be reversed to a heat-pump.

- There are only a few HP installers active on the domestic heating market. MASSER is a well known one, which get about one third of the Belgian heat-pump market with its direct expansion systems [DX/DX].

- The appropriate knowledge and skills for state of the art HP installation is still lacking. Floor heating system has become fairly common, while wall heating is fairly new and not broadly available.

- The geothermal heat pumps market (around 1000 units sold in 2006) is currently raising, as well as air-sourced HP systems (single split, multi split, air/water) but there are no official figures available so far.

- The *Warmtepomp-platform Vlaanderen* was founded in 2006 to stimulate HP applications for building heating and sanitary hot water production in order to achieve global reduction in energy-consumption through HP technology. WPP is a consultative committee for the HP sector, knowledge centres, installers, architects, electricians, consumers associations and public authorities.

The research further showed that:

- the market for heat pumps in Belgium is very small compared to countries like Sweden, Switzerland, Austria, Germany, the Netherlands or France. Hence, only a few HP distributors and manufacturers are active yet. Discussions with the sector showed that they were apparently waiting for the local HP market to extend before investing in larger distribution channels.

- Many conventional boiler-manufacturers have heat pumps in their product range in other EU countries, but not easily available in Belgium (yet).

- The Belgian heat-pump market should grow, maybe double in the next 2 to 5 years, mainly due to:

- Increase of fossil fuel prices;
- Entry into force and/or strengthening of EPB regulations;

- Higher insulation levels of new buildings (<K45);
- Rising demand for (low temperature) floor heating;
- Higher COP requirements for new HP units;
- Rising environmental awareness of the end users;
- Structured financial support from public authorities;
- More efficient centralized electricity production leading to better PER of HP;
- Boosting demand for HP in neighbouring countries.

HP Standards

- The most relevant existing standard ensuring quality improvement of HP was found to be the EN 15450 for Heating systems in buildings, regarding design of heat pump heating systems. This standard (together with the Flemish code of good practice), lay the foundations of any requirement about HP design installations in Belgium.

- EN 14511 defines test conditions and methods to calculate the COP of heat pumps with electrically driven compressors for space heating and cooling, according to specific conditions

- EN 13313 establishes procedures for achieving and assessing the competence of persons who design, construct, install, inspect, test and commission, maintain, repair, decommission and dispose of refrigerating systems and heat pumps with respect to health, safety, environmental protection and energy conservation requirements.

- Training for HP installers/designers should include a heat losses calculation module according to NBN B 62-003

HP Quality insurance and labeling

The research showed that high customer satisfaction could be reached by fulfilling an integrated quality labeling scheme designed for HP heating systems (heat-source + HP unit + heat-release) commonly installed in Belgium.

Such quality scheme should include:

- Requirements towards the HP-unit according to its efficiency, expressed by the COP;
- Requirements towards the HP-system (source + HP-unit + release) according to its efficiency on yearly-basis, expressed by the SPF and /or the APF.

Labeling HP units occurs best at European level through existing tools like the Eco-label for goods and services which have a lower environmental impact than similar products. Requirements are based on a lifecycle analysis of the product.

The eco-label for heat pumps (2007/742/EG) set up ecological criteria for to electrically driven, gas driven and gas absorption heat pumps. HP being the first heating system to be eco-labelled, a number of generic issues had to be resolved to ensure that the benefits of the unit are carried over to the installation of the system in a building, including collector and distribution systems.

The first environmental criterion considered is the energy use. The used parameters are COP; It requires minimum COP values (in heating mode) and EER values (in cooling mode) for each type of HP at standard temperature sources and release temperatures. Minimum COP-values are stringent. The second criterion regards the use of refrigerant[9], which should have a low ozone depletion potential (ODP) and a low global warming potential (GWP). The third criterion restricts the use of specific hazardous substances. The fourth criterion aims at ensuring that proper information on the heat pump and its efficient operation is provided to the customer and the installer of the HP. Other requirements such as noise level contribute to improve the overall quality.

The HP Eco label follows the requirements of the EPB directive; the installer has to calculate the heat loss of the building and should consider the cost effectiveness of adding any further insulation in accordance with the building regulation. If the HP can be used in cooling mode, the solar gain of the building has to be calculated. Those calculations being made, the installer has to recommend cost effective measures to reduce heat losses and solar gain before sizing the heat pump system. The installer has to calculate the (approximate) SPF based on the VDI 4650 (Verein Deutscher Ingenieure), the CO_2 emissions associated with the energy use in order to enable a qualified installer to design the heating and/or cooling system in a way that the benefits of the HP unit are carried over to the system. This in turn would benefit the customer, society and the environment and will help to limit the impact of global warming.

[9] The EU fluorinated gas directive prevent the use of certain types of such gases

The EHPA recently proposed a European quality label for HP manufacturers (EHPA label), based on the German-speaking countries common quality requirement (D-A-CH Gütesiegel). While using similar COP values than the HP Eco label, it is less substantial than the EU Eco label that is awarded to the most efficient and environmentally friendly models in a product group; for example, it does not cover the air-air HP unit and requires no maximum GWP values. A short comparison between COP requirements of both labels is showed in the table below.

	EHPA	Eco label
COP:		
air/air	/	2,9
air/water	3	2,6-3,1 (depending on inlet/outlet t°)
water/water	4,5	4,2-5,1 (depending on inlet/outlet t°)
brine/water	4	3,5-4,3 (depending on inlet/outlet t°)
ground/water	4	/
GWP value for refrigerants	no maximum allowed	maximum GWP value allowed

- The tenants of the EHPA label argue that greenhouse effect due to the energy-consumption of a HP is about 10.000 times higher than the impact of the refrigerant, as illustrated by the Total Equivalent Warming Impact (see figure below) which is a function of direct (leakage) and indirect (CO_2 production) impact on the greenhouse effect, expressed in kg CO_2/100years.

	Refrigerant	ODP	GWP	TEWI	Environmental impact	Energetic efficiency	safety	Supply of components
CFK	*R134a*	*0*	*1300*	*120702*	-	+	+	+
	R407C	*0*	*1610*	*120869*				
	R410A	*0*	*1890*	*121021*				
natural	*R290 propaan*	*0*	*3*	*120002*	+	+	-	-
	R600a isobutaan	*0*	*3*	*120002*				
	R744 (CO_2)	*0*	*1*	*120001*				

- Beside those European labels, several national or regional labels exist in countries where HP has a relevant market share. A short presentation of each one of those is given in section 2.3 of WP2 HP.

- For residential air conditioners with heating option, there is an energy efficiency label according to EU directive 2002/31/EG.

- The project group agreed that labeling the full HP system would require more than a product label. Specific requirements towards the concept, design, sizing, performance… of the installation should include:

- Training and certification of installers and drillers, as organized by the European Certified Installer initiative [10];
- fulfillment of the requirements of the Flemish code of good practice[11];
- inspection of the ground-collector during the installation phase;
- inspection of the whole installation during/after commissioning;
- Check of the system efficiency after 12 months operation.

- The most important specific requirements to set at each level of the market chain in order to improve HP quality as a whole were found to be:

- *Component* - compressor and his engine must be designed to reduce pressure drop of circulating mediums;

[10] EU-CERT.HP is a European training and certification initiative for heat pump installers managed by EHPA

[11] Code van goede praktijk voor de toepassing van warmtepompsstemen in de woningbouw (ANRE) http://www2.vlaanderen.be/economie/energiesparen/doc/code_warmtepompen.pdf

- *Product* - COP of the heat pump unit must fulfil Eco label requirements for each type;
- *System design* - heat release system must be low to very low temperature, the heat source must offer relatively high temperature;
- *System integration* - the heat capacity of the heat source must be sufficient;
- *Installation* - state of the art installation must ensure high SPF;
- *Operation* - system regulation must take the outside temperature into account;
- *Maintenance* - specific requirements for each type of HP (ex: for direct expansion system: annual check should be mandatory, given the higher coolant content)

- Appropriate training for installers is needed all over Europe and resulted (as from 2002) in a joint EU project with participation of the EHPA. The aim of this "European Certified Installer" is to develop and initiate training programs on each emerging markets, based on experience from the most developed countries. The project set up European curricula for training courses and would develop a European certification scheme. Partners from Austria, Germany, Italy, Ireland, UK, Sweden, France, Czech Republic and Slovenia are involved.

- EU-CERT.HP Project includes a training manual detailing the knowledge and requirements to become an EU Certified Heat Pump Installer, the facilities and equipment needed in an approved training centre, the practical learning experience and the setup of a Certification Committee to validate the qualification whilst ensuring consistency and quality of the courses and training. The Project was completed by December 2006. The Education Committee of EHPA is currently in charge of the European Heat Pump training and certification scheme.

An overview of national training initiative is given in the table below. More details on existing national training scheme are available in section 2.3 of WP2 Technological State of The Art Heat Pumps.

	Accredited certification scheme	Unofficial certification/licensing courses	Training offered by manufacturers
Austria	yes	no	yes
Czech Republic	no	no	yes
France	no	no	yes
Germany	no	no	yes
Ireland	no	no	yes
Slovenia	no	no	yes
Sweden	no	yes	yes
Switzerland	no	yes	yes
United Kingdom	no	no	yes

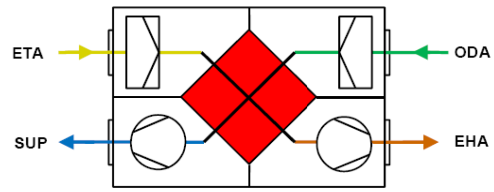
6.3.5 Ventilation with Heat Recovery

State of the Art VwHR technology

Ventilation system with heat recovery is an energy efficient technology decreasing the energy used to heat a building while maintaining a very good indoor air quality. VwHR is assimilated to a renewable energy technology, because the system recovers energy from the ambiance, energy which would be lost in absence of such system.

VwHR is a mature technology offering promising energy savings in buildings.

The heat of the air extracted by the ventilation system is usually recovered to pre-heat the fresh air supply, as illustrated in the figure below. Such heat recovery occurs in a passive way, with no additional energy source, except a small amount of electricity used by auxiliary devices (fans, control unit, etc).



Picture 1 – Unit with A/A HEx – Exhaust / Supply air – Heat Exchanger

The research showed that:

- VwHR is a relatively complex system including several components such as:
    - Air handling unit (AHU), incl. the heat exchanger, the fans, the filters, etc;
    - Piping (including noise suppression);
    - Air terminal devices for air supply and extraction;
    - Control system.
- A distinction is further made between:
    - Recuperative heat exchangers transferring heat in an continuous way (through heat exchangers, heat pipes, run around coils)
    - Regenerative heat exchangers where heat is alternatively stored and released using an intermediate heat storage capacity (e.g. rotary wheels, static regenerators)
- The most common types of exchangers used in residential dwellings are plate heat exchangers or rotary wheels.
- The various components of a VwHR are usually assembled on site by the installer.
- The main recent technological developments that improved the quality of VwHR are in the field of:
    - Design of the system to decrease the noise generation
    - Higher efficiency of the fans (more efficient DC motors are currently well generalized and AC are nearly no more available on the market)
    - Development of small AHU, adapted for low flow rates, for example for small houses or apartments
- Further major technological evolutions that should improve quality of VwHR are:
    - Design: greater availability of design tools
    - Commissioning: simplified methods (adapted for small scale) for flow measurement and flow adjustment
    - Product: availability of decentralized ventilation control systems
- The most effective technology combination expected to improve quality of the whole system considered is the integration of different RES technologies in one unit; eg VwHR, Solar thermal for DHW, Heat pump. The main advantage is that such a 'black box' can be factory made and the combination of RES can be optimised, and is no longer dependent of the installer. However, there will always be a need to adapt the performance (flow capacity, heat and DHW load) to each individual project.

Status of supply Chain and market

The research showed that:

- Ventilation with heat recovery has a higher market penetration in northern European countries given the lower winter temperature.

- System components are easily available throughout Europe.

- Further product evolutions are expected in the field of noise limitation, filtration, frost protection and control strategies.

- According to a Swedish survey, the main problems encountered in the maintenance of ventilation systems are:

▪ Inappropriate air flow rate (61%),
▪ Missing maintenance manuals (48%),
▪ Deposits in fans (40%), defects of fans (30%),
▪ Deposits in ducts (37%),
▪ Control and guidance equipment (27%),
▪ Deposits in filters (25%), defects of filters (20%),
▪ Defects of supply and exhaust devices (23%), deposits in supply air devices (22%).

In Belgium:

- VwHR is not largely used in residential buildings yet. However, it is currently developing thanks to EPB regulation and financial support schemes.

- Availability of component performance data should be improved (e.g. efficiency of exchangers, working curves of fans, etc).

- Several quality issues concerning design and installation of ventilation systems were reported in residential buildings, such as inadequate flow rate, high electric consumption, pressure drop, air leakages… Those are mainly due to the heterogeneity and lack of maturity of the market.

- Performance of the VwHR system in operation is often below expectation

- The most important quality requirements to set at each level of the market chain in order to improve quality of VwHR as a whole are:

▪ Component & Product: unified definition of component & product performance, availability of data
▪ System design : availability of design tools,
▪ System integration : control strategy and support products
▪ Installation : commissioning of the installation – flow rate setting and measuring
▪ Operation of the System: information to the end user

VwHR standards

The European normative framework for ventilation systems is well developed. For example, the draft standard prEN 13142 (Version CEN/TC 156, 17/06/2008) defines 10 categories of complete mechanical ventilation systems according to the way heat is recovered.

EU standards mainly cover product and system design requirements.

The research showed that common uniterm definition of AHU performance is definitely a must.

There is no single existing standard that can ensure quality improvement of VwHR on its own. The whole standard framework regarding ventilation is highly relevant to improve quality, from the basic design (flow rates, etc.) covered by NBN D 50-001, to the European standards related to the performances of individual components, for example the series NBN EN 13141.

VwHR Quality insurance and labeling

Several countries implemented VwHR quality schemes, such as:

▪ The voluntary HVI Certification of product performance In Canada
▪ The Dutch “Stichting HR Ventilatie” independent foundation in the Netherlands
▪ The National Council for Housing, Construction and Planning (“Boverket”) In Sweden.

6.3.6 Solar Domestic Hot Water Systems

State of the art of ST technology

SDHWS are designed to harness, store and deliver solar heat, they are protected against freeze; active systems use pump operation control and safety assembly. All types use some kind of heat-transfer fluid. Indirect systems in northern climate use a Propylene glycol solution that will freeze only at very low temperatures.

The scope of the solar thermal systems considered covers three main application domains:

- solar domestic hot water systems (SDHWS);
- solar domestic hot water systems with heating support (combi-systems);
- solar systems for (outdoors) swimming pools (mainly using unglazed plastic collectors);

The main types of Solar Water Heaters for single family-houses can be classified according to following characteristics:

- Thermosyphon vs. forced circulation systems (mostly used in northern countries)
- Open vs. closed systems (mostly used)
- Single-circuit (directly from the storage vessel to the collector) vs. twin-circuit (indirect, solar loop and SHW circuit) systems (mostly used)
- Filled vs. drain back systems (the collector drains completely when the collector pump is switched off); both kinds of systems are commonly used in Belgium.

The main component of a solar system is the **solar thermal collector** that usually operates within a 60-80°C temperature range. The most common types used in northern countries for SHW preparation are glazed flat plate collectors and alternatively evacuated tube collectors.

The second main component is the **thermal storage**. For SHW applications, heat is directly stored in a hot water tank or in a buffer tank (dead storage). The most popular tanks are made of steel with an inner glass, stone or epoxy lining to protect the steel from galvanic corrosion, and an anode rod to keep the oxygen away from the steel. Stone-lined tanks and stainless steel or copper tanks are commonly used also.

Indirect systems have **heat exchangers** enabling the energy transfer from the heat transfer fluid to the potable water. Heat exchangers can be either inside or outside the storage tank. Common heat exchanger designs for SDHWS are the tube-in-tube, shell-in-tube, coil-in-tank, wraparound-tube, wraparound-plate and side-arm designs.

The third main component is the **pump** of the solar loop. The most common pump or circulator used in solar systems is the "wet rotor" type in which the moving part (rotor), is surrounded by the heat transfer fluid, acting as a lubricant during pump operation.

Piping is another key component of a SDHWS, enabling the fluid transport throughout the system. Pipes & ducts must withstand high temperature. Most systems use copper piping. Copper, brass, and bronze should be the only materials used in active direct solar systems using potable water. The most appropriate pipe insulation is the closed cell flexible elastomeric foam type (rubber). Piping insulation outside the building must be protected from environmental and ultraviolet ray degradation.

Last but not least, in active SDHWS, the **control unit** acting as the "brain" of the system switches on the pump of the solar loop when enough solar energy is available to heat the storage. The most frequently used is the differential controller, working with two sensors, one at the (hot) collector outlet and the other at the (cold) storage tank inlet. When the temperature measured by the two sensors reach a preset difference of 4 to 15 K, the controller switch the pump on. More and more controllers are assembled with security valves, pressure, temperature gauges and flow meters into a so-called *solar station*, as illustrated.

A variety of valves, gauges and meters are usual parts of a SDHWS, used to:

- Expel and vent air from the system (air vents)
- Safely limit excessive temperatures and pressures (pressure relief and temperature-pressure relief valves)
- Prevent vacuum locks during drainage (vacuum breakers)
- Isolate parts of the system (isolation valves)
- Prevent Thermosyphon heat losses and maintain flow direction (check valves – mechanical and motorized)
- Provide freeze protection (freeze-prevention valve)
- Monitor the system (pressure gauges, temperature gauges and flow meters)
- Enable the user to check if the pump is operating and at what flow rate (flow meters)

The research showed that:

- In Belgium, solar collectors for domestic applications are usually mounted on sloped roofs or on metal structures on flat roofs. As the market grows, more and more fully integrated flat plate glazed collectors are installed on residential houses.

- The main recent technological developments improving the overall quality of SDHWS on the Belgian market are:

- the evolution of common control strategy for stoves (the on/off-control resulting in unnecessary high emissions) to a more advanced control system varying the heating rate from maximum to minimum in order to keep a constant room temperature reducing the number of start and stop and their associated emissions
- Improved thermal stratification and component integration of storage tanks (auxiliary heating, pump group, expansion vessel, auxiliary components, monitoring…) in order to reduce installation cost and risks of failure

- The R&D topics in the field of solar thermal collector that are the most susceptible to improve the overall quality of the system were found to be:

- New heat transfer media, withstanding freezing and high operation temperatures stagnation-proof collectors
- Integration with conventional heat sources and /or into conventional HVAC systems
- New designs of concentrators for CPC tube, favouring roof mounting and low maintenance requirements

Some typical values of a SDHWS on the Belgian market are listed in the table below:

Coeff.	Désignation	Valeur	Optimum	Fréquent	Unité
CAPTEUR					
ά	Coefficient d'absorption de l'absorbeur	0 à 1	1	0,95	-
ὰ	Coefficient d'émission de l'absorbeur	0 à 1	0	0,03	-
œ	Taux de transmission du vitrage	0 à 1	1	0,92	-
kè	Facteur correctif fonction de l'inclinaison du capteur	0 à 1	1	0,95	
CAPTEUR PLAN					
ç	Rendement du capteur	0 à 100	100	50	%
ç0	Rendement optique du capteur solaire	0 à 100	100	80	%
U_m	Coefficient global des pertes thermiques	0 à 10	0	3,5	W/m² K
a_1 (pfs k_1)	Coefficient des pertes thermiques par conduction et convection	0 à 10	0	3,5	W/m² K
a_2 (pfs k_2)	Coefficient des pertes thermiques par rayonnement	0 à 1	0	0,01	W/m² K²
F'	Coefficient de transfert de chaleur entre l'absorbeur et le fluide	0 à 1	1	0,92	
	Température de stagnation en laboratoire	0 à 300	300	200	°C
	Rendement annuel du capteur obtenu en laboratoire	0 à 1000	1000	500	kWh/ m² sur 1 an

Coeff.	Désignation	Valeur	Optimum	Fréquent	Unité
CAPTEUR SOUS-VIDE					
ç	Rendement du capteur	0 à 100	100	60	%
ç0	Rendement optique du capteur solaire	0 à 100	100	75	%
U_m	Coefficient global des pertes thermiques	0 à 10	0	1,5	W/m²K
a_1 (pfs k_1)	Coefficient des pertes thermiques par conduction et convection	0 à 10	0	1,5	W/m²K
a_2 (pfs k_2)	Coefficient des pertes thermiques par rayonnement	0 à 1	0	0,005	W/m²K²
F'	Coefficient de transfert de chaleur entre l'absorbeur et le fluide	0 à 1	1	0,92	
	Rendement annuel du capteur obtenu en laboratoire	0 à 1000	1000	700	kWh/m² sur 1 an
BOILER					
	Déperditions thermiques fonction de la nature et épaisseur de l'isolant	0 à 10	0	2	°C/24h
		0 à 5	0	2	KWh sur 24h
REGULATION					
	Possibilité de réglage du Ät de démarrage				
COMPTEUR D'ENERGIE					
	Puissance instantanée récupérée				W
	Energie solaire récupérée				Wh
DIVERS					
G	Rayonnement solaire incident			1000	KWh/m² par an
	Rendement global de l'installation solaire	0 à 100	100	30-40	%

Status of supply Chain and market

The main market for Solar Thermal is the residential market with domestic hot water and space heating.

The total installed capacity (2007) of solar hot water systems worldwide was approximately 154 GWth. **China** is by far the largest solar thermal market worldwide re newly installed solar thermal capacity per year, with 70 GWth installed as of 2006.

The second biggest market in the world is **Germany** (34 % of EU market share), with a newly installed capacity of 658 MWth (940,000 m²) in 2007. The third biggest solar thermal market is held by **Turkey**, which is estimated between 350 and 700 MWth.

In Europe (2007), after years of very dynamic growth, the total market for glazed collectors in the 27 EU Member States and Switzerland decreased by 9% to 1,9 GWth of newly installed capacity (2,7 million m² of collector area). The total capacity in operation reached 15,4 GWth (22 million m²). The European Commission issued a proposal for a European Directive to promote renewable energies, covering heating and cooling RES.

Process heat is a market segment that seems to be boosted as there is a huge demand for heat below 250 °C in industry, which can be reached with solar thermal collectors. Task 33 of the IEA estimated the potential of solar process heat in the EU at 100 GWth, which corresponds to 140 million m² of collector area.

In the **United States**, **Canada and Australia**, heating swimming pools is the dominant application of solar hot water, with an installed capacity of 18 GWth as of 2005.

The research showed that:

- The solar thermal market development is strongly influenced by the usual heating equipment market.

- The ups-and-downs encountered by the industry over the years on several markets are partly due to a stop-and-go of some public support schemes. Financial incentives are put in place and then reduced or removed after some years. Another explaining factor is that consumers are overwhelmed with too many technologies likely to reduce their energy demand, some competing against each other (e.g. solar PV taking market shares from Solar thermal).

In Belgium:

- In the Walloon region, nearly 13.000 m² were installed in 2006. End 2006, about 37.000 m² solar thermal collectors was installed in total (± 26 MWth). The average collector surface for SHW production is 4 - 7 m² and the average storage capacity lies between 200 and 500 litres.

- In the Brussels region, 2.500 m² of solar thermal collectors were installed at the end of 2006, (roughly 200 installations from which a dozen of medium to large size installations)

- In 2007 Flanders produced ± 28.000 MWh heat form the sun, corresponding roughly to the hot water used by 10.000 households. There was in total, 40.000 m² solar collectors installed in the Flemish region, end 2007.

- An official solar thermal installer training and accreditation program exist in the Walloon region (Soltherm training).

- A broad range of technically matured flat-plate and vacuum tube collectors are available.

- The distribution channel for SDHWS is quiet simple; the manufacturers sell their products to wholesalers who act as their agent, in regions, provinces or cities. The wholesalers sell on to dealers. The end-user buys the product from a (local) dealer, mainly installer. Installers purchase components or (preferably) standard kits from wholesalers.

- It is increasingly difficult for planners, installers and consumers to choose for the right product, especially as they are hardly distinguishable. Hence the choice is mostly based on the (lowest) price.

- Less than 5 Belgian manufacturers with local production capacity exist, all other suppliers are foreign players, retailers, etc. The main Belgian solar thermal collector production facility is ESE in Walloon. Roughly 30 Belgian companies assemble, supply and/or retail SDHWS and about six companies retail solar collector for swimming pools.

ST standards

Two main standards regard solar thermal collectors and factory made solar thermal systems respectively: EN 12975 and EN 12976. A pre standard ENV12973 does exist for custom built systems.

Beside some general requirements, those standards define procedures & guidelines to run several performance and quality tests.

EN12975 specifies requirements on durability (incl. mechanical strength), reliability and safety for liquid heating solar collectors; including provisions & procedures to follow and evaluate the conformity of a solar thermal collector, namely:

• Conduction of the required tests in a specified order by an appropriate testing laboratory,

• Continuous internal control by the manufacturer in the framework of an existing production control system (EN ISO 9000 series)

• Check by appropriate body if no production quality control system is used.

the Standard also defines security requirement for the materials and their properties (combustibility, toxicity, stability in high temperature, resistance to UV radiation, mechanical, thermal and chemical requirements, etc), design (water tightness, no leakages, cover stresses, absorber corrosion, etc) installation and weight of the collector, as well as collector identification material (drawings, data sheets, labeling, installer instruction manual).

EN12976 specifies requirements on durability, reliability and safety of Factory Made thermal solar heating systems; including provisions and procedures to evaluate conformity to these requirements as a 'product'. The installation of the system is not considered, but requirements are given for the documentation. The standard defines two test methods for thermal performance characterization by means of whole system testing.

The following criteria of solar thermal products are usually tested and therefore part of the quality requirements:

- Internal pressure resistance
- Mechanical load
- High temperature resistance
- Internal and external thermal shock resistance
- Exposure
- Rain proof
- Impact resistance
- Thermal performance

For **factory made systems** the following characteristics are tested additionally:

- Suitability for drinking water
- Freeze resistance over temperature protection
- Reverse flow protection
- Pressure resistance
- Safety equipment

It is important to notice that those European standards - registered as Belgian standards - are not really *product standards* but rather *standard test methods*. As most standards, they are of voluntary application, unless otherwise stated.

Specific pre standards do exist for solar tanks (storage) and control units, which might become CEN Technical Specifications and then later, full EN standards.

An extensive list of international codes and standards applicable to Solar Thermal components and system is given in WP2[12].

A Belgian equivalent of the Dutch label "Gaskeur Naverwaming Zonneboilers" or "Gaskeur NZ" certifying the compatibility of a water heating system with SDHWS might be useful to easily identify backup heaters with modulating power and inlet temperature based start-up.

[12] Technological State of The art, Supply Chain & Quality Standards of Solar Thermal Systems

ST Quality insurance and labeling

Early 2000 the Walloon energy minister put the first comprehensive solar thermal market development plan of Belgium in place, the so-called *Soltherm Action Plan*. The plan included a quality charter based on self declaration of SDHWS supplier and installers about basic commitments & services to the end user.

Two years later, the Region put in place a 28 hours + 4 hours exam Soltherm training and acknowledged a couple of training centres and trainers. In 2004, the Soltherm financial support scheme had boosted the market and attracted so many new players that the single voluntary quality charter was outdated.

The region decided to link the Soltherm training certification with the SDHWS incentive and the implementation of SDHWS on site inspections. The end-users had to use the service of a Soltherm Installer to get a regional subsidy. No particular action was required from the suppliers/manufacturers, except being able to prove the performance of their system or components upon request. In 2008, the Soltherm directory counted more than 1000 'Soltherm installers' and the training went up from 32 to 56 hours, including practical training.

Since then, on site inspections were removed from the agreement renewal procedure for cost reasons and the gap between *good* and *bad* Soltherm installers increased.

In Flanders, the basic requirement in order to get DSO incentives for SDHWS was for solar equipment suppliers and manufacturers to be member of or to fulfil the Belsolar Quality system put in place in 2006. No particular action was required from the installer apart of legal requirements. In Brussels, no particular quality requirement from installer or supplier is linked to the energy subsidy for households installing a SDHWS.

This kind of situation, in line with other RETs incentive schemes, brings market distortions and confusion. Moreover, it reinforces the feeling among installers and suppliers that they just *need a paper* (training certificate, membership card...) to be eligible for subsidy. They do not understand that a strong requirement in one region might not be considered desirable in other ones.

A European harmonized certification procedure was put in place for solar thermal collectors and factory made systems. The "Specific CEN KEYMARK Scheme Rules for Solar Thermal Products" was designed together with manufacturers, testing laboratories, certification bodies as well as ESTIF. This certification scheme specifies that manufacturers have their products been tested and surveyed according to common European quality criteria by neutral, independent and competent bodies and that respective standards are fulfilled by a collector (according to EN 12975) or a factory made system (acc. to EN 12976).

Only those solar thermal products which were successfully tested by a testing laboratory approved by the CEN Certification Board and DIN CERTCO are certified with the KEYMARK. After a positive result of the assessment DIN CERTCO issues a certificate that is unlimited valid, provided that the surveillance (annual inspection of the factory and physical inspection of the product at least every 2 years) shows that the preconditions are fulfilled

An overview of existing quality scheme of SDHWS is summarized in the table below. Detailed explanation is available in WP2 report.

	Country / launching date	Originator	Principle Approach	Content generic/ specific	Target group	Covered elements	Other technologies covered
BELSOLAR Quality Charter	Belgium launched 2000 for ST	Sector associations Belsia, BELSOLAR & Walloon gov.	self-commitment, initial evaluation, no site visits, focus on small systems	specific	system integrators (suppliers)	Commercial, contractual, technical aspects, documentation, commissioning, training	
QUEST Quality Charter	Belgium (Flanders) launched 7/2008	Applied research and sector associations (BELSOLAR, BelPV), VEA	self-commitment, initial and repeated evaluation including site visits, focus on small systems	specific	Suppliers & installers of SDHWS system	Commercial & contractual aspects, technical aspects, documentation, commissioning	Solar PV, small wind turbines, heat pumps, ventilation, biomass conversion, low-energy buildings
Soltherm	Belgium (Walloon) launched 1/2000	DGTRE & sector associations (APERe, Institut Wallon,…)	Self-commitment initial evaluation, no site visits, focus on small systems	Specific	Suppliers & installers of SDHWS system	Commercial, contractual, technical aspects, documentation, commissioning, training	
QualiSol	France /1999	SER, other sector associations	self-commitment plus references or training	generic	installers	Commercial & contractual aspects, technical aspects, documentation, commissioning, training	Solar PV (QualiPV) Biomass heating systems (wood-based)
RAL	Germany 4/2005	DGS (ISES Germany, user oriented)	self-commitment, initial and repeated evaluation including site visits	specific	Different sub-labels for component manufacturers, system designers, installers & operators	Commercial & contractual aspects, technical aspects, documentation, commissioning	Solar PV Within the RAL framework many other quality systems are bundled
Micro generation Certification Scheme (MCS)	2/2008, replace the Clear Skies and PV programme	Government, BERR	initial and repeated evaluation, site visits	specific	sub-labels for component manufacturers installers	Technical aspects, documentation, commissioning,	Solar PV, Micro Wind, Heat Pumps, other technologies …

6.3.7 Solar PV

State of the Art of PV technology

The research showed that:

- Photovoltaic (PV) systems are characterized by a large number of parameters. The most important are listed in the table below. Due to the modular set-up of a PV system, most options are applicable to different system types. Nevertheless, a few options are dominating the current PV market.

Application type			
grid-connected	stand-alone rural	stand-alone industrial	consumer applications
Energy storage			
	batteries	mechanical storage	hybrid concepts
Installation type			
building-integrated	mounted on the building shape	free-standing	tracking systems
Protection concept			
double insulation	extra-low voltage	grounded live conductor	
DC topology			
central bus bar	multi-string topologies	string-oriented topology	module-based topology
AC connection			
single phase	three phases		
Mains monitoring			
automatic disconnection	External monitoring system	Manual disconnection	

- The main feature of grid-connected PV as compared to other RETS is the absence of need for energy storage. Grid-connected PV systems always generate the maximal available power.

- Re stand-alone systems, the only electrical storage devices commercially available today for PV are batteries.

<u>Installation Type</u>

- Building-integrated photovoltaic (BIPV) systems are truly integrated into the building shape. From the technical point of view this means that they replace another building element by taking over its constructive function.

- In Belgium, most PV modules are mounted on the shape of the building, typically on sloped roofs. Hence, the PV generator does not make part of the building. For ordinary roof-mounted installations, the generator is mounted on hooks several centimetres above the tiles.

- On flat roofs and on the ground, PV modules are mostly mounted on metal or plastic structures. These should be mounted to the roof or ground or fixed with ballast.

- Sun-tracking systems are mostly free standing systems. They follow the position of the sun or they position the PV generator in a way that the power generation at every moment is maximal.

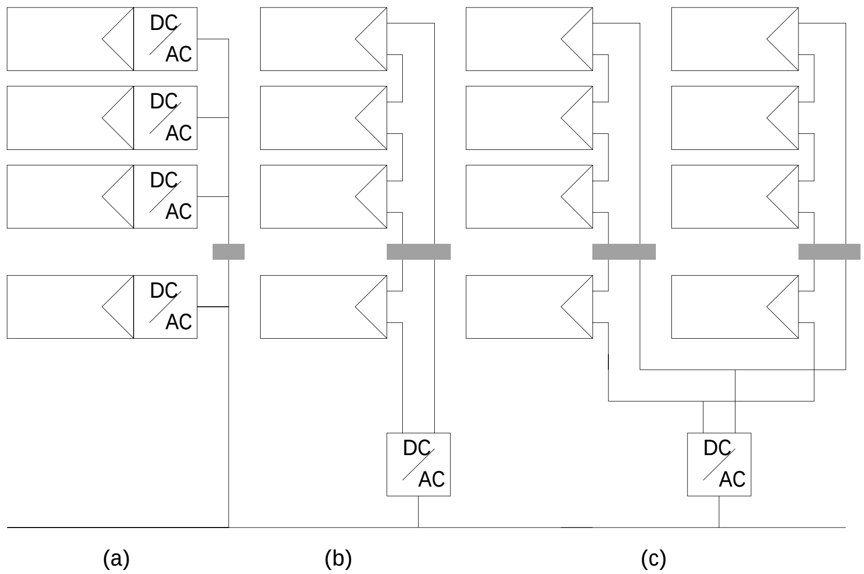
- The type of installation has a significant impact on the PV module temperature due to the different extent of free convection on the modules back side. Especially on hot days after periods of high solar irradiance, the temperature of a non-ventilated, roof-integrated module is approximately 20 °C higher than that of a free-standing system. For crystalline PV modules this would cause a 5.4% reduction in energy yield as compared to the free-standing system. Moreover, the thermal load of the building might increase when BIPV modules are badly ventilated.

- Several concepts exist for the protection from electric shocks, in accordance with the protection class of the applied electrical material. For grid-connected PV in Europe, a double insulation concept is usually applied in accordance with protection class II. PV modules and the entire DC circuit should comply with class II and no live DC conductors are grounded.

DC Topology

The prevalent DC circuit topologies mainly differ to the extent that PV modules are connected in series and strings are connected in parallel in order to feed the power conditioner. For grid-connected systems the power conditioner is the inverter.

Historically, three topologies for the DC connection of PV arrays were designed; namely, the central bus bar topology, the string-oriented topology and the module-based topology (see Figure below). Recently, multi-string topologies become increasingly applied especially for small-to medium-sized systems.



Different DC topologies; (a) module-based, (b) string-oriented, (c) central bus bar

AC Connection

- The AC connection is carried out either on one phase or on three phases. Belgian Synergrid requires the gird-connection to be carried out in three phases for generators of more than 10 kW.

Mains Monitoring

- Grid-connected PV systems require a mains monitoring system (usually integrated into the inverter for small systems). The system has to disconnect in case of abnormal voltage or frequency and in case of a loss of mains. In Belgium the disconnection must be automatic for single-phase PV systems up to 5 kW. For systems up to 10 kW the system can be automatic. Above 10 kW, a lockable safety disconnector is required that is permanently accessible to the distribution system operator

System Components (main components)

Photovoltaic Module

The smallest entity within a PV system is the solar cell. A number of different solar-cell technologies are currently applied or under development. The largest share of solar cells today is (by far) made of crystalline silicon, other cell technologies have recently gained significant market share. This applies mainly to thin film technologies like amorphous silicon, copper indium selenide (CIS) cells and cadmium telluride (CdTe) cells.

The power at STC is referred to as peak power and indicated by the index *p*. The point at the current-voltage curve of a PV cell or module where the generated power reaches its maximum is called the maximum power point (MPP).

In order to make PV easy to handle, solar cells are assembled into PV modules. Standard crystalline PV modules today mostly range between 150 and 220 Wp.

Inside the module, the cells are connected in series and parallel by means of copper strips in order to achieve practically applicable voltage and current.

Mechanical and optical properties are ensured by the physical structure, chosen for the particular module. Additionally, the module structure protects the cells and conductors from humidity.

Inverter

Inverters for DC-AC conversion are usually self-commutated inverters with pulse-width modulation. Inverters designed for grid connection usually operate as a current source. While voltage and frequency are determined by the grid, they inject a maximum current into the grid, depending on the MPP power available.

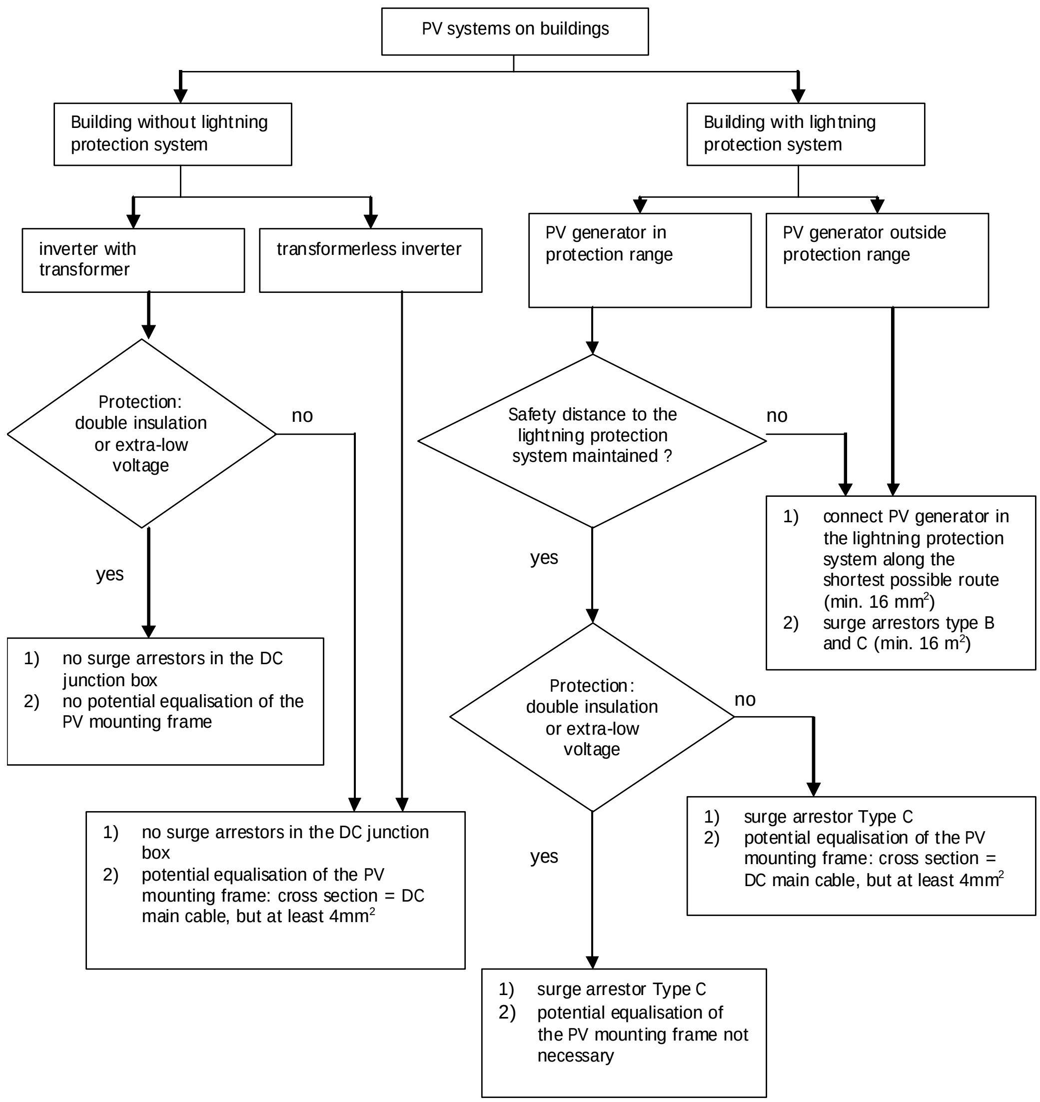
The Belgian distribution system operators evaluate the grid compliance of a PV inverter according to the Synergrid code C10/11

Since the efficiency is not constant over the full power range, in order to characterize the long-term efficiency of PV inverters in the field, the European efficiency η EU has been introduced. The European efficiency is an average efficiency for different operating points, weighted according to their long-term frequency of occurrence. The most efficient inverters available in the range below 10 kVA have a maximum efficiency of 98% with a European efficiency of 97,7%.

Specific Balance-of-system Aspects

Lighting Protection and Earthing

There is no specific standard for lightning protection and earthing of PV systems. For PV systems on buildings the flow chart hereunder is considered as a common good practice.



Status of supply Chain and market

International photovoltaic production has known a steady increase (average growth rates > 35%) since more than 15 years, reaching production volume of over 3700 MWp of PV modules in 2007. Grid-connected PV systems are the most strongly growing market segment of PV world-wide. Although EU markets determine to a large extend the current evolution, PV production is an international business with Europe, Japan and China each covering 25% of the worldwide production.

The top 3 cell manufacturers are Q-cells (Germany), Sharp (Japan) and Suntech (China), each producing about 10% of the total volume. Other major manufacturers are Kyocera (Japan), First Solar (US – CdTe technology), Motech (Taiwan) and Sanyo (Japan).

The total installed capacity in 2006 in the IEA countries participating in the IEA's PVPS program was 5695 MWp. Germany (51%) and Japan (30%) taking a major part of this capacity. Germany knew continuous growth of its installed capacity since 2000 at rates above 50% due to its stable and successful feed-in tariffs mechanism.

Beside those traditional PV markets, several other countries put in place stable support mechanisms for photovoltaic electricity production. Since 2006, the Spanish market is developing fast with large investments in multi-MW free field installations. In France, a feed-in tariff that differentiates strongly on building integration was put in place in 2007. Since 2008, Italy joined the fast developing PV markets with a favourable support mechanism. Other countries following this trend are Greece, the Czech Republic, South-Korea, Turkey and some states of the USA.

In Belgium:

The photovoltaic cell production facility of Photovoltech[13] in Tienen will have a capacity of 140 MWp by 2009. The company produces high-efficiency crystalline silicon PV cells based on registered IMEC technology.

Furthermore two companies (Issol and Soltech) are manufacturing PV modules, mainly for building integration.

Besides in cell and module production, several other companies have an important activity in the photovoltaic sector: Umicore (source material), ICOS (inspection systems), Enfinity, Dexia (project development and financing), Tractebel, 3E (engineering).

Installed Capacity

From 1998 until 2005, PV market development was determined by the investment subsidy scheme for small scale (< 3 kWp) PV systems in Flanders. End 2005, this resulted in an installed capacity of about 2 MWp distributed over about 800 residential systems in Flanders only.

In 2006 the Flemish regulatory framework was adapted. The PV support scheme was integrated into the green certificate mechanism. From 2006 onwards the DSO has been obliged to buy green certificates for electricity from PV at a minimum price of 450 €/MWh. Consequently, the market has extended rapidly towards larger systems resulting in a cumulative installed capacity of 4 MWp in 2006 and 14 MWp in 2007 of which 50% systems with a size larger than 10 kWp.

The different systems for issuing and pricing of tradable green certificates guarantee a high value for PV electricity. In Flanders this has led to a strong growth of the installed PV capacity in 2006 and 2007, followed by a significant growth of grid-connected PV in Brussels and Wallonia which have adopted support mechanisms allowing the economically viable exploitation of PV systems. In 2007, about 128 kWp of PV systems were installed in the Walloon region; both mechanisms favour smaller installation by reduction of the relative amount of certificate for larger systems.

PV standards

PV standards exist on component level and on installation level. Installation Standards are limited to safety issues. Issues related to system performance, reliability and lifetime do not exist. No international standards are expected to be developed in the coming years. However, the state of the art is defined by the available technical reference literature. Training and knowledge dissemination in line with international good practice is key to that respect.

A list of applicable codes, standards and regulations is available in section 3.1of WP2 PV State of the art of technology.

Since PV is a relatively young technology, many technical practices were not consolidated yet nor implemented into international standards. Nevertheless, there is a consensus about what is to be considered as *good practice* in many aspects, especially in the EU countries, sharing a similar approach to electrical safety and quality. The following works can be considered as reference guides for good practice in installing PV:

- Planning and Installing Photovoltaic Systems, James & James / Earthscan, London 2005
- F. Antony, C. Dürschner, K.-H. Remmers. Le photovoltaïque pour tous. Observ'ER, Paris, 2006.

[13] joint-venture between Total, Suez and the Interuniversity Microelectronics Centre IMEC

PV Quality insurance and labeling

There are different national and international PV quality initiatives at system level. Most of them were initiated by national organizations representing the PV component industry, suppliers or customers. The existing systems differ in ambition level and approach.

Many of these quality systems rely on quality of materials, installation and information by means of simple technical criteria, co-operation with associations of installers and effective control mechanisms. Many of the systems listed in the table below are still in an early stage. Therefore, important lessons can be learned for further development and implementation of a quality scheme in Belgium and other emerging PV markets.

In the long run, European best-practice guidelines for small-scale photovoltaic installations should be pursued. These guidelines might be used as reference publications for the training and certification of installers as proposed by the EC new RES directive. Two well known quality system are briefly described here, more details are available in section 3.2 (international survey) of WP2 PV State of the art of technology.

RAL-Güteschutz:

The RAL quality label for solar energy was initiated by DGS. The quality system is coordinated by the association *Gütegemeinschaft Solarenergieanlagen* which also issues the label to its member organisations.

Different criteria exist for different segments of the PV supply chain. Four distinctive labels are available (for component manufacturers, system designers, system installers and system operators).

Member companies can use the RAL Quality label in their communication. They commit themselves to include the underlying quality provisions into their contractual provisions. The RAL Quality referential for solar energy contains provisions for quality insurance on the different levels and for initial and regular verification done by independent experts. Candidate members are initially evaluated and afterwards two times per year. The experts can spontaneously schedule company visits or visits of existing installations.

PV-GAP

The Global Approval Program for Photovoltaics (PV-GAP) was launched as an international organisation in 1996 and created an international quality benchmark for photovoltaic products based on product certification according to IEC standards. Quality testing has to be done by certified laboratories and certification happens according to the IECEE. PV-GAP published a Reference Manual, a Manufacturing Quality Process Manual for PV Components and Systems and a PV Manufacturers Quality Control Training Manual.

PV GAP issues a so-called Quality Mark for PV system components and a Quality Seal for PV systems. In practice, six PV module manufacturers carry the PV GAP Quality Mark which is mainly required by the World Bank when tendering for rural electrification projects.

Although, PV-GAP in principle aims at components as well as stand-alone and grid-connected systems, the scheme is not relevant for the PV installation practice in Europe.

	Country / launching date	Originator	Principle Approach	Content generic / specific	Target group	Covered elements	Other technolgies covered	Homepage
BELSOLAR Quality Charter	Belgium launched 2000 for ST, 2005 for PV until 2007	Sector associations Belsia, BELSOLAR	self-commitment, initial evaluation, no site visits, focus on small systems	specific	system integrators (no pure installers)	Commercial & contractual aspects, technical aspects, documentation, commissioning, training	Solar hot water	www.belsolar.be
QUEST Label	Belgium (Flanders) launched 7/2008	Applied research and sector associations (BELSOLAR, BelPV)	self-commitment, initial and repeated evaluation including site visits, focus on small systems	specific	parties offering PV system to the end customer	Commercial & contractual aspects, technical aspects, documentation, commissioning	Solar hot water small wind turbines heat pumps ventilation with heat recovery biomass conversion	www.questforquality.be
PVQual	Belgium (Wallonnie) launched 6/2008	Sector association RBF	self-commitment	generic	installers	Commercial & contractual aspects, technical aspects, training	NA	www.energyplatform.eu
QualiPV	France 10/2007	SER, other sector associations	self-commitment plus references or training	generic	installers	Commercial & contractual aspects, technical aspects, documentation, commissioning, training	Solar hot water Biomass heating systems (wood-based)	www.qualit-enr.org
RAL Güteschutz Germany	4/2005	DGS (ISES Germany, user oriented)	self-commitment, initial and repeated evaluation including site visits	specific	Different sub-labels for component manufacturers system designers installers system operators	Commercial & contractual aspects, technical aspects, documentation, commissioning	Solar hot water Within the RAL framework many other quality systems are bundled	www.gueteschutz-solar.de www.ral.de
Photovoltaik-Anlagenpass Germany	5/2008	BSW-Solar, ZVEH	self commitment	specific	installers	technical aspects, documentation, commissioning	no	www.photovoltaik-anlagenpass.de
Microgeneration Certification Scheme (MCS), UK	2/2008, replacing the Clear Skies and PV programme schemes	Government, BERR	initial and repeated evaluation, site visits	specific	Different sub-labels for component manufacturers installers	Technical aspects, documentation, commissioning,	Solar Heating Collectors Micro Wind Heat Pumps other technologies in preparation	www.greenbooklive.com
PV-GAP World-wide	1996	IEC, World Bank, industry	independent evaluation; in practice applied to off-grid systems	specific	component and system manufacturers	technical aspects	no	www.pvgap.org

6.3.8 Small Wind Turbines

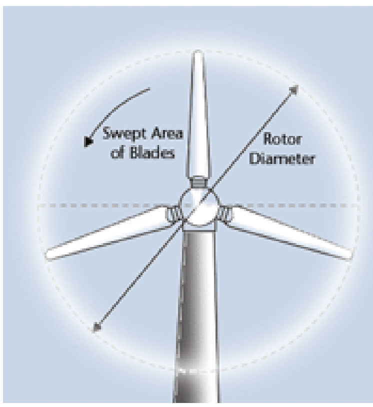
State of the Art SWT technology

According to the SWIIS, SWT have a power capacity of maximum 100kW. Those having a maximum capacity of less than 1 kW, (predominant sizes of about 100 W) are called 'microturbine'.

Those descriptions are based on IEC 61400 standard defining small wind turbine (SWT) as *a system of 200 m² rotor swept area or less that converts kinetic energy in the wind into electrical energy*. SWT can be categorised according to the following criteria:

- vertical axis wind turbines (VAWT) vs. horizontal axis wind turbines (HAWT)
- building-integrated vs. free standing SWT
- stand-alone SWT vs. grid-connected turbines

The scope of this research project is limited to 2,5 kW BUWT and 10 kW UWT, corresponding to approximately 40 m² of swept area or a diameter of approximately 7m for HAWT.



The research showed that:

-Vertical axis wind turbines (VAWT) are usually better suited for changing wind direction and turbulence than the HAWT. This type of turbine doesn't need to be positioned into the wind direction, but their overall efficiency is usually lower than the one of HAWT. VAWT is therefore also better suited for the built environment as it is less sensitive to changes in wind direction that are common in the built environment.

The Table below gives an overview of some advantages and disadvantages of both types.

	HAWTs	**Lift VAWTs**	**Drag VAWTs**
Advantages	1. Efficient	1. Quite efficient	1. Proven product
	2. Proven product	2. Wind direction immaterial	2. Silent
	3. Widely used	3. Less sensitive to turbulence than HAWT	3. Reliable & robust
	4. Most economic	4. Fewer vibrations	4. Wind direction immaterial
	5. Many products available		5. Can benefit from turbulent flows
			6. Fewer vibrations
Disadvantages	1. Does not cope well with frequent changing wind direction	1. Not yet proven	1. Not efficient
	2. Does not cope well with buffeting	2. More sensitive to turbulence than drag VAWT	2. Comparatively uneconomic

- Free-standing small wind turbines are not physically connected to a building, but mostly put on top of high poles. While building-mounted wind turbines are physically linked to the building. The building is then used as a tower on which the turbine is placed. Important criteria to allow BMWT is the structural integrity of the building. The structure must be able to support the turbine's weight, as well as the loads and vibrations due to normal operation.

- Building Augmented Wind Turbines (BAWTs) are a special kind of BMWT, mounted on a building in such a way that flow concentrations around the building are used to get a higher AMWS and turbine efficiency. An advanced type of BAWT is the one where the building itself is designed specifically to augment the flow through the turbine, as small changes to a building design can lead to substantial efficiency gains.

- A first group of stand-alone turbines are found in battery charging applications. These are among the most common applications of SWT, found on boats, caravans, rural farms… The wind turbines designed for these applications have a typical output voltage of 12 or 24 Volts.

- Another group of stand-alone turbines are those that provide power to households not connected to the electricity grid. Hybrid systems are often part of this group.

- A third group of stand-alone turbines are those directly connected to the load. They are mostly used for water heating purposes. In this case the load, the heater, is directly coupled to the wind turbine power output.

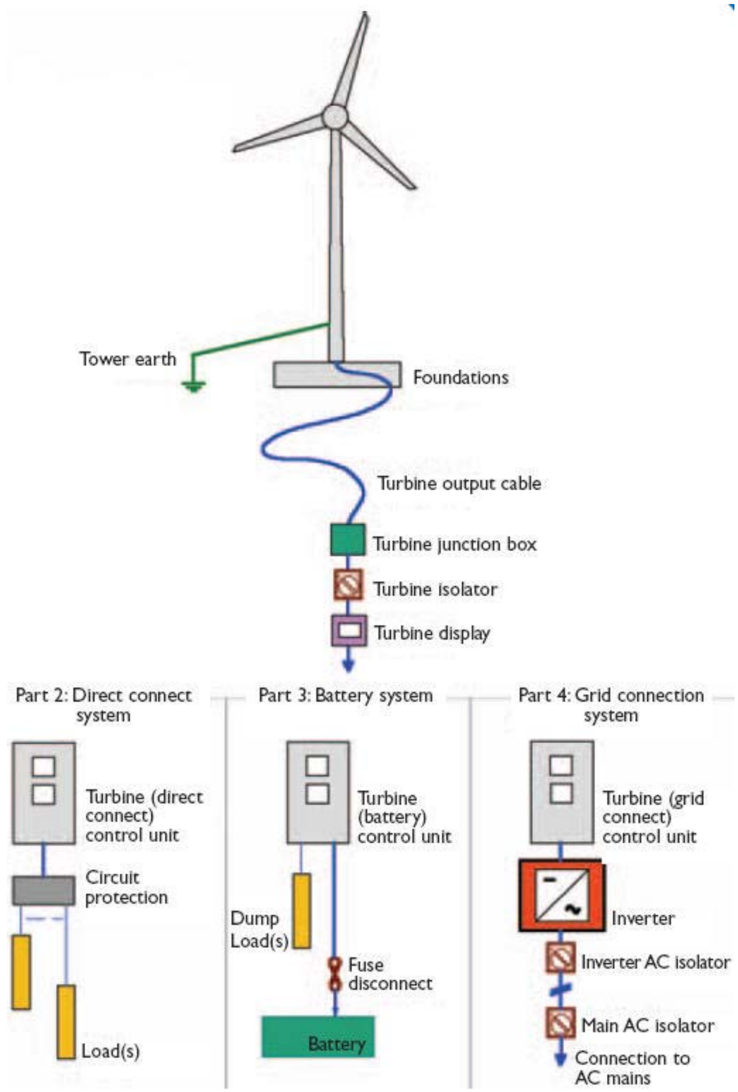
- Grid-connected turbines are usually not designed to take on the full energy consumption of the user, but rather to lower the electricity bill. The output of the wind turbine is directly connected to the existing mains. This means that the output has to be AC voltage of 50Hz and 230V in Europe.

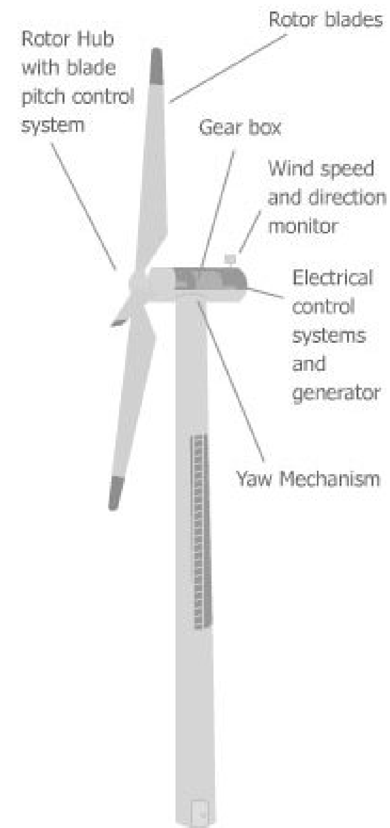
- The connection to the mains has to be approved and security systems must be installed, a.o. to ensure the disconnection in case of a blackout or scheduled maintenance of the grid.
The upper limit of UWT considered in this project is 10 kW, which is the maximum power that can be connected to the grid using a compensating meter in Flanders.

- System components can be divided into main components (as shown in Figure below) and specific balance of system components. The latter is largely common to PV technology.

- Main components are the whole of the turbine itself and the connection to the grid, the load or the batteries. The turbine can be further split up into the aerofoils, the nacelle and the tower (in case of a common HAWT)

- Most SWT generators nowadays are permanent magnet generators (PMG) that might be controlled by a turbine control unit that might incorporate a rectifier for the 3-phase AC power output from the generator.





The remaining parts of the turbine are the rotor blades. A 10 kW HAWT shows at least 2 rotor blades, (the more the blades, the slower the turbine rotates). In a wind turbine based on the lift principle, the blades are shaped like aerofoils.

- There is no specific standard for lighting protection for urban wind turbines; the same considerations apply than for PV installations (see 6.4.3). However a free-standing SWT or a BMSWT rising above the building or the surrounding obstacles might require some lightning protection. Some turbines are fitted with an integrated full protection of their electrical circuits.

- Re Free-standing SWTs, the tower construction and eventual guying wires should be earthed.

- A relatively new development in power control of SWT is the implementation of maximum power point tracking (MPPT): an electronic sensor checks the turbine speed and changes the load applied to the generator, at any time between the cut-in and rated level; altering the turbine speed to optimise its efficiency and bringing higher efficiencies at low wind speeds, which can be particularly relevant for stand alone systems.

Status of supply Chain and market

More and more small-sized wind turbine systems with a power rating less than 100 kW per unit are coming on the market. They are considered as renewable generator units to be mounted in the vicinity of buildings or on building roofs, offering an alternative for e.g. Photovoltaics, or combined with PV into hybrid systems.

The scope of the research is limited to the market segment of the residential "urban" applications where SWT are usually grid-connected systems. The building is preferably used as support structure although free-standing turbines in large gardens might be an option.

The vertical-axis and cross-flow turbines are particularly appreciated because of their simplicity (no yaw system) and compatibility with turbulent flows. In larger buildings, several turbines are installed on rooftops.

The research showed that:

- The market for small wind turbines, more specifically UWT, can be defined as *emerging* or *growing* rather than *stable* or *mature*, compared with other technologies such as solar thermal or heat pumps. It is a niche market with a very large number of manufacturers and a variety of technologies.

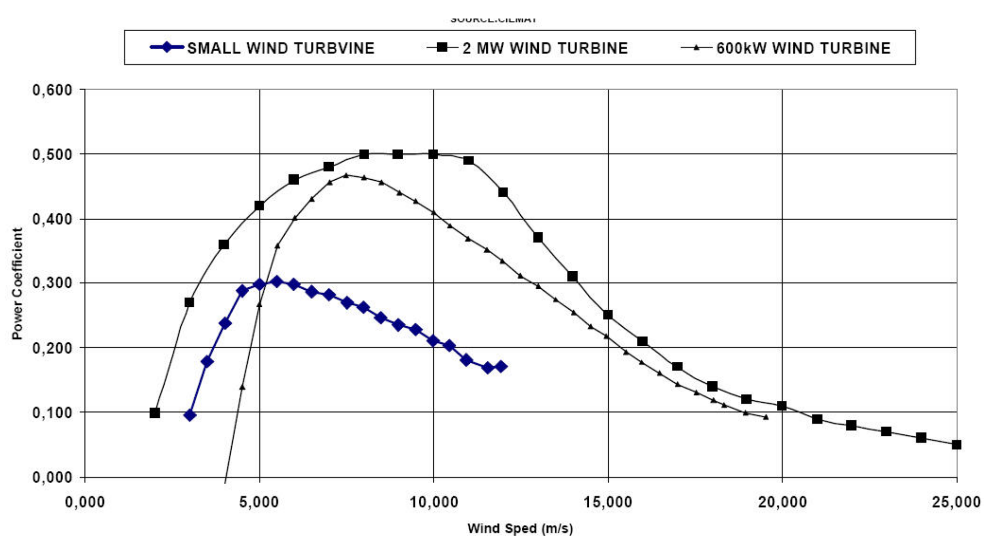
- Several catalogs of commercially available small wind turbines exist; they are listed in the WP2 report[14]. Moreover, many SWT manufacturers offer the possibility to buy their products on-line and ship internationally.

- Wind energy associations usually represent the SWT industry but since it's only a small fraction of overall wind energy business, the attention dedicated to this market segment is rather little with the noticeable exceptions of BWEA and AWEA which have special sections of their website dedicated to small wind.

- The residential turbine market segment recently shown rapid growth: a 1 to 10 kW turbine (mostly in the 1-3 kW range) for installations close to dwellings, used to lower the electricity bill.

- The smallest market segment is devoted to the larger turbines that still meet the IEC definition of SWT: turbines with a rated power of 10 to 50 kW for application in either stand-alone or grid-connected application, for tertiary-sector installations or small industrial facilities.

- There are very big differences between SWT technologies in terms of quality, technological characteristics and price. SWTs cover the complete scope from rickety DIY[15] home-built turbines to fully-certified tried-and-tested products. In comparison with large wind turbines the performance of small wind turbines tends to be rather disappointing as shown in the figure below and only a small number of models have a design certification and calculations.



Power Coefficient Comparison Small vs. Large Wind Turbines

- Moreover, the power curve given by the manufacturer is often not certified by an independent third party.

- Technical features vary enormously even among SWT with the same power ratings. E.g. for turbines with a nominal power of 6 kW, rotor diameters varied up to 60%

[14] WP2: SWT – State of the technology, the supply chain & the quality systems

[15] DIY does not necessarily mean the design is unreliable or faulty

- Most studies point out important market barriers that prevent a widespread application of urban turbines. Some of these barriers are inherent to the technology and will have to be dealt with by maturing technology. Others are caused by the installation and authorization procedures. Last but not least, the financial return of urban turbines is rather low compared to other technologies such as PV that generally benefit from much higher incentives.

- The purchase price of a SWT remains the single largest factor affecting market growth, domestically and abroad. This price depends on production volumes and cost of raw materials such as copper and steel. For UWT as for many other RETs, the specific cost decreases as rated power increases, making the smaller turbines relatively more expensive

- The lack of clear legal framework and financial incentives is also detaining market growth which is largely depending on local state and federal policies, particularly rebate programs and property tax exemptions as well as other incentives such as standardized interconnection policies, annualized net metering, local zoning status and authorization procedures.

- Uncertainty re the expected energy production also deters potential owners of UWT. Specific environmental conditions as turbulence and possible airflow obstructions make the annual energy yield difficult to predict.

SWT Standard, Quality insurance and labelling

An overview of international codes and standards applicable to SWT is given in the table below

Reference	**Title**	**Description**
IEC 61400-2	Design requirements for small wind turbines	Deals with safety philosophy, quality assurance and engineering integrity and specifies requirements for the
IEC 61400 series	Wind Turbine Generator Systems	
IEC 61400-1	Safety and design requirements	Provide an appropriate level of protection against damage from all hazards during the planned lifetime. IEC 61400-2
IEC 61400-11	Noise measurement	Presents measurement procedures that enable noise emissions of a wind turbine to be characterized.
IEC 61400-12-1	Power performance measurements of electricity	
IEC 61400-13	Measurement of mechanical loads	Mainly focussed on large (>40m^2) HAWTs, however described methods might be applicable to other wind Describes a methodology and corresponding techniques for the experimental determination of the mechanical
IEC 61400-21	Power Quality	Measurement and assessment of power quality characteristics of grid connected wind turbines.
IEC 61400-22	Wind turbine certification	
IEC 61400-23	Full-scale structural testing of rotor blades	To demonstrate to a reasonable level of certainty that a blade type when manufactured according to a certain set
IEC 60034-1	Rotating electrical machines: rating and performance	Applicable to all rotating electrical machines except those covered by other IEC standards.
IEC 60204-1	Safety and machinery - electrical equipment of	Applies to the application of electrical, electronic and programmable electronic equipment and systems to
IEC 60364-5-54	Low voltage electrical installations: Selection and	Earthing arrangements, protective conductors and protective bonding conductors in order to satisfy the safety
ISO 2394	General principles on reliability for structures	Intended to serve as a basis for commitees responsible for preparing standards or codes of practice for structures
CE Marking		CE mark confirms conformity with the applicable European directives, mainly low-voltage directive and EMC

An overview of Belgian national and regional codes and standards that are also applicable to SWT is given in the table below:

Reference	**Titel**	**Summary**
AREI	Algemeen reglement op de elektrische installaties	Belgian code for electrical installations. PV systems need to be fully conform to this code, AREI also contains a specification of the safety interface for small PV installation (mains monitoring)
Technical requirements Synergrid C10/11	Technische aansluitingsvoorschriften voor gedecentraliseerde productie-installaties die in parallel werken met het distributienet	Specification of the grid connection and especially of the safety interface., issued by the Belgian association of power system operators (Synergrid)
Flemish region	Technisch Reglement: Distributie Elektriciteit, Vlaams Gewest, Vlaamse Reguleringsinstantie voor de Elektriciteits- en Gasmarkt (VREG)	Technical grid code for the distribution system, applicable in the Flemish Region, includes specifications for metering
Walloon Region	16 OCTOBRE 2003. - Arrêté du Gouvernement wallon relatif au règlement technique pour la gestion des réseaux de distribution d'électricité en Région wallonne et l'accès à ceux-ci	Technical grid code for the distribution system, applicable in theWalloon Region
Walloon Region	1er JUIN 2004. — Arrêté ministériel déterminant les procédures et le Code de comptage applicable en matière de mesures de quantité d'énergie	Metering code applicable in the Walloon Region
Brussels Capital Region	Technisch reglement voor het beheer van het elektriciteitsdistributienet in het Brussels Hoofdstedelijk Gewest en de toegang ertoe (voorlopig: ontwerpversie door Sibelga)	Technical grid code for the distribution system, applicable in Brussels Region

The research showed that:

- The UK and the US have relatively high experience with SWT standards and guidelines; otherwise the normative framework is usually underdeveloped, compared with other RETs.

- Essential safety checks, product standards, certification and installers' accreditation are missing. Some are planned (in the UK for example) but are still far from completion despite popularity of this RET at the municipal level in Member States as the UK, The Netherlands, France...

- The normative process needs to be accelerated in all countries to avoid the risk of poor quality products and installations ruining the market and consumer's confidence.

- The SWT industry recommends customer property sizes of 2000 m² or more for turbines up to approximately 3 kW and 4000 m² or more for wind turbines above this size. Those requirements are mostly based on minimizing neighbours objecting wind turbines and seem to be very strict.

- In **the UK**, BWEA issued a performance and safety standard for manufacturers of SWTs supplying the British marketplace providing an evaluation method of wind turbines safety, reliability, power performance and acoustic features. This guarantees the British customer that the turbine is designed to withstand the structural loads imposed by the wind, that it's been tested in a full range of wind speeds and that it meets overall performance requirements. The standard also makes it easier to compare the noise level of several wind turbines by providing a method to measure noise output. The BWEA/AWEA standards address minimum requirements referring to the quality of wind turbines systems as a whole, from the manufacturer side, as they leave the factory, provided they are operated under appropriate conditions and mounted properly. The main missing requirements of those standards concern the maximum allowable turbulence intensity, as well as the amplitude and frequencies of oscillation of systems. BWEA also published some good practice guides, notably the *Briefing Sheet Small Wind Energy Systems* in 2006.

- The BERR *Microgeneration installation standard* adds up other requirements re SWT installation by setting up an installer certification scheme and an installation standard. A fund was also constituted by the BRE Trust and is granted to installations following those standards.

- In **the Netherlands**, the minimum requirement to install a SWT is a building permit, sometimes completed by an environmental permit. Unfortunately, legal base to issue those permits for SWT is incomplete (unofficial industry association set up various round-table discussions in the past, focusing on the viability and legislative framework of UWT).

- No environmental permit is necessary (and in practices no building permit either) for HAWT with a rotor diameter of less than 2m. For rotor surfaces smaller than 40 m² the calculations required to be granted an environmental permit are quite simple.

- The Netcode states some overall requirements for BMWT or UWT installed near buildings, to be connected to the grid (metering of the produced electricity if the installed power > 5 kVA...). It specifies safety measures to apply for SWT that are connected in parallel with the grid.

- The "Regeling groencertificaten Elektriciteitswet" deals with the registration of green electricity delivered to the grid.

- The Wineur[16] project led to a Small Wind turbine Guide providing guidelines for SWT in a built environment. Some issues are considered when planning UWTs, including rules of thumb regarding the location choice.

In Belgium:

- There is no legal framework for UWT; the authorization procedure is dealt with on a municipal level. No specific feed-in tariffs exist for SWT, except that, in some regions, units below 10 kW can benefit from the so called compensation principle. In Flanders for example, an upper limit to DER integration considered as "urban" was found to be the limit for which the electric meter can run backwards to compensate the electricity bought form the grid, otherwise a separate meter is required to measure the green electricity produced.

- The green certificate schemes apply to SWT without any minimum rated power required

- Several wholesalers supply SWT, such as Earth Wind and Solar Energy, Aqua Solar...

- There is very little experience so far with UWT installations and thus very few skilled installers on the market

[16] Final Brochure Wineur project - http://www.urban-wind.org

6.4 TECHNOLOGICAL ROADMAPS (WP3)

6.4.1 Foreword -General considerations

This is the core of the research, aiming to define common ambition level for quality issues related to building integration, HVAC integration and electro technical (grid) integration, using a broad set of technical & normative quality requirements by technology.

A common basis for quality requirements of several RETs looked essential to the Network in order to set up and organize further implementation of a microgeneration quality scheme throughout Belgium.

Many of the quality systems reviewed in other countries rely on quality of materials, installation and information by means of simple technical criteria, co-operation with associations of installers and effective control mechanisms. Most of them are still in early stage of implementation.

The British Microgeneration Certification Scheme (MCS) for example has been developed as entirely voluntary. However, to effectively regulate the market and successfully achieve the goal of ensuring systems and installations quality, initiatives have been put in place to make it attractive. The main advantage of using both products and installers certified under MCS is that the MCS underpins the BERR grant scheme[17]. Moreover, it is also meant to underpin other future national and local government initiatives.

The first phase of this project resulted in setting up a range of technical requirements for each technology, organized in roadmaps. The idea behind roadmaps is to locate each block of quality requirements in a timeframe of five years in order to:

- Give the RE sector enough time and market perspective to organize itself in terms of product & service management system, product testing, installer certification etc;
- Initiate a collective dynamic process of quality improvement stimulating technological & market development as well as energy policy in the building sector.

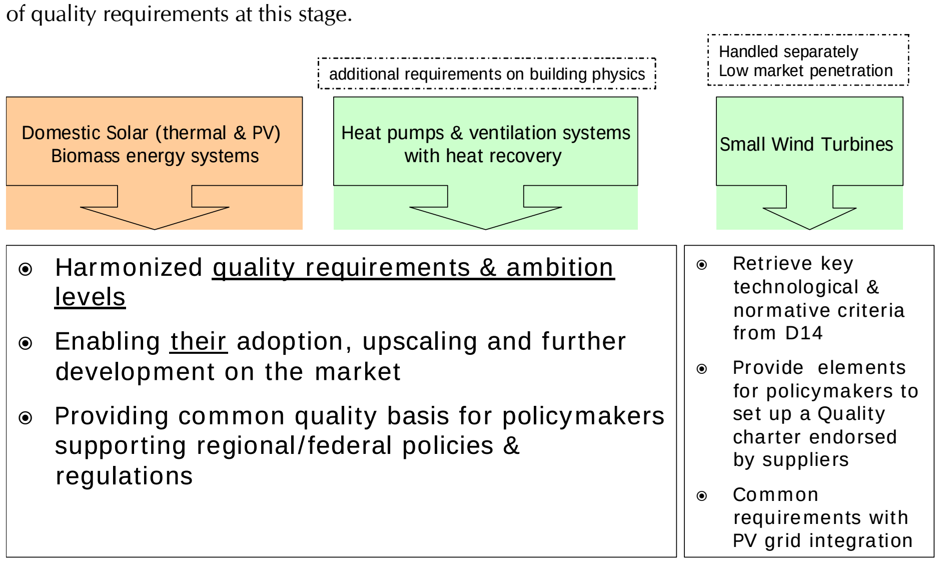
6.4.2 Integrated results of WP3

The quality scheme is respectively dealing with:

- Domestic applications of solar and biomass energy systems on the one hand
- Heat pumps & ventilation systems with heat recovery on the other hand

The design of HP and VwHR is so strongly influenced by the building physics that they deserve an ad hoc set of (additional) quality requirements regarding their integration in residential housing buildings.

Small Wind Turbines are handled separately as their market penetration is too low to implement a whole set of quality requirements at this stage.



Technical requirements improving the quality of RE products & installations have to be designed to achieve appropriate system performance, safety and operation control.

[17] the British governmental Low Carbon Buildings Programme

As the installation work of RETs plays a key role in overall system performance and operation, specific technical background is required from the installers. New skills acquired by training must be updated, regularly controlled and further certified by a third party.

The **QualiCert** initiative is of particular relevance to that respect. This consortium is leading concerted action among Member States and key stakeholders on training and certification of installers in order to develop and validate a manual of key success criteria for accreditation & certification systems. This is linked to article 14 of the EU RES DIR, obliging Member States to develop & mutually recognize accreditation & certification schemes for installers of small-scale renewable energy installations by December 2012.

Quality requirements should cover the following cross-technology areas:

- Components and system design
- Installation works, guarantee and after sale service
- Function control and monitoring of performance or guaranteed performance result
- Third party evaluation of a sample of systems in operation.

6.4.3 Electro technical (Grid) Integration of RETs

Context and scope

Historically, the electricity system in Belgium has been designed for centralized bulk generation, injecting power in the high voltage transmission system and being distributed to customers at medium and low voltage with unidirectional flows in radial distributed systems.

PV and SWT are connected to the power grid via DC-AC inverters to convert DC current to 50 Hz AC current.

The inverters are self-commutated inverters with pulse-width modulation with high power quality. Inverters designed for grid connection usually operate as a current source injecting a maximum current into the grid while voltage and frequency are determined by the grid.

The introduction of distributed generation connected at lower voltages causes bidirectional power flows and, consequently, voltage rises in the distribution system. The most common power quality problem in distribution systems is that of voltage sags. To protect the equipment, DG units will disconnect from the grid in function of the magnitude of the voltage deviation and the time span during which this lasts.

Grid integration of DG in Belgium is regulated by different parties and documents.

- The distribution network operators evaluate grid compliance of small generators according to the Synergrid C10/11 and local guidelines
- At regional level CWaPE; BRUGEL and VREG regulate via decrees
- The AREI/RGEI rules the automatic disconnection function of generators and good practice of electrical installations
- Other international standards are used for grid compliance

Among the technologies reviewed, only PV and SWT are concerned. Their integration to distribution and building electric systems must fulfil a whole range of technical requirements.

The research showed that:

- No current standards or good practice guides cover all grid integration aspects of PV and SWT (e.g. there is no straight forward standard on current harmonic restrictions for PV invertors).

- The few available international standards (IEC61400 series) re PV grid integration should be extended/applied to SWT, as their grid interface is almost similar.

- For DG to have a positive impact on the emission level of the electricity production system, units must be installed by consumers in their hundreds of thousands. This requires a new highly decentralised approach to energy planning and policy. In addition, a new understanding of the likely interaction between DG technology and its multitude of potential end users (the general public) must be developed. Hence, **a transition of passive to active grid operation is essential** to facilitate the integration of DG, i.e.:

- LTC settings need to consider the power generation in the distribution system as well;
- DG should be required to its power output in case of unacceptable voltage rise or feeder/transformer congestion instead of disconnecting. The increased potential DG connections and/or ancillary service remunerations need to outweigh the avoided opportunity cost due to the curtailment;
- A mix of DG sources together with spatial layout would result in smoothing of the total injected power.

- The often stated concern that renewable electricity generation would result in unmanageable fluctuation of injected power is not established. More, spatial distribution of PV installations throughout the distribution network would result in a smoothing of the cloud-induced power injection variation due to clouds.

Hence, two ambition levels are distinguished for common quality requirement re grid integration of PV & SWT:

Element of Value Chain	Ambition Level 1	Ambition Level 2
Component – Inverter	Compliance with existing codes and standards	
System		Active grid support from DG ⇨ driven by R&D, pulled by DSO
Installation	Good practice + AREI/RGIE Conformity	

Ambition level 1

The first ambition level aims at compliance of the grid connected installation with existing grid codes and standards specifically considering decentralized energy production.

Those broadly rely on IEC/CENELEC standards that are published by the regulators and implemented by DSO based on the Synergrid code. Conformity of the installation of the unit itself with the AREI has to be guaranteed.

Current requirements re safety, power quality and building electric system protection related to grid integration of DG are described in Deliverable 9[18] .

The research showed that:

- To date, the first ambition level is commonly reached by PV systems and SWT (grid connection procedures are available to all stakeholders).

- Many PV experts worry about the fact that many PV installers are apparently not aware of some safety aspects re PV integration, e.g. in grounding. For the time being, there is no mandatory course or certification for PV installers and no widely spread 'installers guide' explaining the practical aspects of proper PV installation in Belgium.

Ambition level 2

The second ambition level aims at a transition from passive grid operation, based on a 'fit and forget' policy for distributed generation, to an active grid operation with a 'fit and rely upon' DG paradigm.

Most DER in use nowadays are still operating under passive grid. To facilitate the integration of DER units within an efficient and active grid management, new control strategies are needed. The 4 most straightforward active grid management strategies (*Curtailment of power generation; Reactive power control*; *coordinated voltage control by OLTC transformers*; *Voltage regulators*) are briefly described in D9.

Several DER hierarchies may be established when ancillary services of small units are used. Most experimental research is ongoing in the fields of *Virtual Power Plants* and *Micro grids*. The first aims at aggregating the operation of a number of small units across the grid. The latter uses local control in a specific grid subsystem which can disconnect from the main grid in case of emergency. Both are shortly addressed in annex of D9.

The research showed that:

- With passive operation of DG, these units are regarded as uncontrollable 'negative' loads. Grid operation and planning in a business-as-usual approach result in a suboptimal integration of DG. Bottlenecks on the distribution system are reached much faster than with an active approach.

- With active operation, the DG units are allowed to actively support grids and to provide ancillary services. This may result in higher DG penetration and provide an additional remuneration for the DG owner and a cost-effective alternative for grid operators re grid investments.

- Active grid support from DG is currently widely investigated by the academic world but there are few demonstration projects proving their value for the regulators to provide correct incentives to producers and grid operators

- There are no good practice guides available yet re active grid support, no specific quality standards.

---

[18] reference document : Technical quality requirements re electro technical integration of small wind turbines and photovoltaic systems into the grid

- EU directives 2003/54/EC imposing common rules for the internal market in electricity and 2001/77/EC on the promotion of the electricity produced from RES prompt to use all potential benefits of DG units in grid operation as well as asset management. The direct incentives need to be included in regulatory policies. In Belgium the federal regulator CREG needs to approve the tariff schemes proposed by the DSOs on a yearly base. A cost driven mechanism is used in which fair revenue is attributed based on acceptable costs. Drawbacks of this system are that there is little incentive for innovation due to the constant 'fear' that specific costs aspects will not be approved. However, a **worldwide transition can be observed towards price cap mechanisms in which the emphasis lies with performance characteristics of DSO operation by setting cost tariff objectives**. The DSO's profit depends on its capability to lower its own investment and operation costs while guaranteeing grid operation requirements.

A common belief is that this shift towards performance based regulation should facilitate DSO's interest in innovative techniques, e.g. ancillary services of small DG units.

6.4.4 RETs integration in HVAC systems

Context and scope

Integrating RETs - especially BES, ST and HP - into residential buildings entails several interactions with the Heating, Ventilation and Air Conditioning system and with the sanitary hot water production.

The main issues at stake, the existing standards & regulations and common quality requirements are extensively described in D10[19]. A distinction is made between requirements for HVAC integration which are already covered by standards, regulations or good practice and those that are not.

PV systems and UWT are not part of the scope since they usually do not interact with the HVAC system of a residential house.

RET interaction with cooling system is not part of the research since artificial cooling can usually be avoided in residential housing and is not energy efficient compared to other measures (solar protections…).

Interaction of a given RET with the relevant HVAC domain is marked by 'x' in the table below.

HVAC Domain	SDHWS	Heat pumps	Biomass	Ventilation
Heating system		x	x	x
Hot water system	x	-20	x	
Ventilation systems		x	x	-(21)
Cooling22		(x)		(x)
Regulation and control	X	x	x	x

RET integration in the heating system - Highlights

<u>**BES** - Integration in central heating system</u>

- Biomass heating boiler can easily be integrated into an existing central heating network and does not require any backup heating system.
- The use of a heat storage tank is recommended for efficiency and maintenance purposes.
- Heating elements must be properly designed, the optimal size of the radiators depends on two main factors:
    - The reference temperature

[19] reference document : Technical quality requirements re HVAC integration of RETs

20 Combined Heat pump /boiler systems are not part of the scope of this document

21 If the technology reviewed equals the HVAC domain, it is not covered here (see 6.4.8 for Quality requirements of VwHR

22 Artificial cooling can mostly be avoided in residential applications. Therefore, interactions of RETs with cooling are not covered here

  - The heat loss of the room/building

<u>**BES** integration in pre-existing heating system</u>

- A fossil fuelled boiler (P-marked), can be converted into a pellet boiler by replacing the oil burner with an appropriate pellet burner, according to NBN EN 15270
- Special attention must be given to the chimney to ensure sufficient draft (minimum -10 Pa) for the safe discharge of combustion products to the atmosphere.
- Appropriate pellet fuel storage and supply system is required

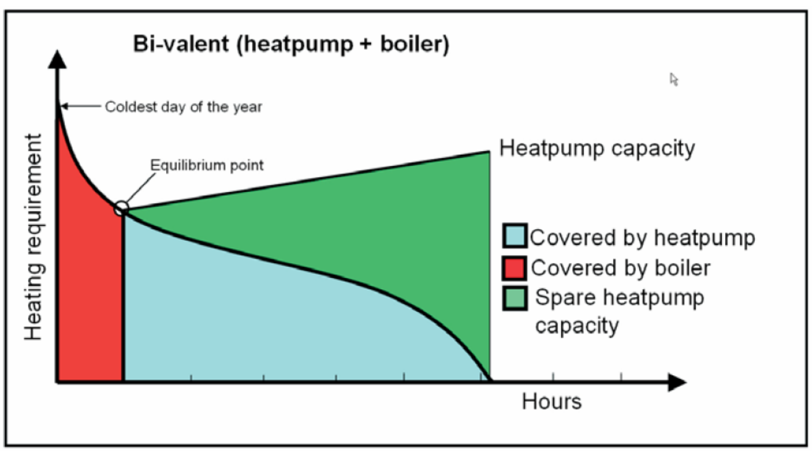
<u>**HP** - Heat Pump unit design</u>:

- a low temperature heating emission system is essential
- Conventional heating boilers were previously oversized. Oversizing a HP unit has a negative effect on its SPF.
- The power of a heating system has to be calculated according to the Heat loss calculation standard NBN B 62-003. Although, most HP installers do not calculate the heat losses of a building but do apply ratios which often result in oversized heating units

<u>Specific Requirements towards HP integration in the heating system</u>

The HP unit usually replaces the conventional heating boiler; no backup system is required; the only auxiliary source is electricity.

- Requirements of the 'Code van goede praktijk voor de toepassing van warmtepompsystemen in de woningbouw' should systematically be followed;
- In case of existing dwellings retrofit, the old heating elements might be preserved if they are dimensioned for low temperature;
- Temperature of the heat release system should be kept as low as possible by using a low temperature heating system.
- For thermal power < 10 kW, some HP-unit should be designed at 60% of the heat-losses (Beta-factor = 0,6), the HP will then deliver 94% of the heat needed on a yearly base. A back-up heating will be necessary for the remaining 6%
- For larger units (>10kW) it becomes efficient to set up two compressors in parallel, so the HP is able to run at two power-levels
- For air/water heat pumps :
  - the outside unit requires regular maintenance; otherwise the noise level might get higher after some years and become a nuisance for the neighbourhood;
  - The location of the outside units (usually a terrace or an outside wall) should be chosen carefully to limit visual disturbance;
  - Existing condensing boiler might be kept in place next to the air/water HP, so that when the maximum power of the HP goes down along with the outside temperature, the condensing boiler can take over or supply the heating need of the building, as illustrated in the figure below.



- Dimensioning a vertical or groundwater heat exchanger must be done by specialised drillers. For the latter, the water flow has to be defined by the driller to avoid chilled water being pumped up again.

- For an air/refrigerant heat exchanger, if the air evaporator is part of the unit, the installer should simply buy the unit with the appropriate nominal power. If the evaporator is not part of the unit, the installer must be a cooling specialist able to choose the appropriate evaporator type and power.

VwHR - Integration in the heating system

Ventilation systems with heat recovery are usually independent from the heating system of the building. However, the following issues have to be considered:

- VwHR affects the overall heating load of the building through ventilation losses: cold outdoor air is brought into the building and must be heated to reach the comfort temperature;
- Calculation of the heating load is affected by the design flow rate of ventilation although with a heat recovery device, ventilation losses are drastically reduced since the outdoor air is pre-heated in the heat exchanger, while crossing the heat from the exhaust air; lowering the additional power of the heating system.

Specific requirements for combustion appliances:

- The use of closed combustion devices (instead of open ones) is a prerequisite to the use of VwHR.

Combined Heating and ventilation systems

In very low energy buildings, space (air) heating is sometimes linked to the ventilation system in order to avoid the installation of a separate heating system. This combination should be limited as much as possible since a heating system usually available in conventional buildings is by far more efficient than post-heat of the supply air.

In very low energy building and passive buildings, the post-heat of the supply air to ensure the space heating should also be avoided since:

- Ventilation and space heating have specific needs and objectives and the combination of both functions is difficult to regulate properly (heating power depends on outdoor temperature while ventilation flow rate depends on indoor air quality);
- Only dry spaces can be heated (where air is supplied).
- The heat supplied by air is limited, such system requires a drastic reduction of the heating needs of the building (insulation, air-tightness, passive windows, etc).

If ventilation is combined with air post-heating, the following recommendations apply:

- The temperature difference should be limited to 30°C, (max. supply air temperature of ± 50°C);
- Centralized post-heating should be avoided because the same temperature is then supplied everywhere;
- Electric heating should be avoided because its higher primary energy use;
- If space heating is linked to domestic hot water heating through a SDHWS, special attention is required to avoid Legionella proliferation through ducts and storage.

RET integration in the sanitary hot water production system - Highlights

BES - Biomass domestic hot water system

Hot water storage tank for a pellet boiler can provide hot water for the radiator network as well as for sanitary purposes. Appropriate size of the hot water tank is of primary importance to the overall system efficiency.

NBN EN-303-5 provides a basic formula to calculate storage tank size for a pellet boiler.

According to the Scandinavian Swan-mark quality label, the storage vessel must be at least 15 times the volume of the firebox.

SDHWS - Solar Domestic Hot Water System

Every SDHWS needs a backup heater (external or included) and corresponding control, linked with existing or new external components.

Sizing and connection of the hot water storage tank

Combining the solar tank with an existing hot water storage tank should be avoided. The installation of a multi-energy solar storage of appropriate volume is required to provide an integrated backup heater solution and to avoid additional heat losses & components, oversized storage volume and suboptimal use of available solar energy during non drawing periods.

Sizing the SDHWS in relation to the backup heater

The SDHWS must be sized to cover all the hot water needs during sunny summer days, in order to reduce the number of start-ups of the backup boiler (direct flow system through gas fired water heaters or storage boilers are concerned).

Direct hot water stream through backup heaters

If pre-heated water directly flows through backup heaters (mostly gas fired, but sometimes also electric water heating, it may damage the water heating system and/or result in too hot water at the drawing point, (safety issue). If a temperature sensor is mounted at the outlet of the backup heater (which is often the case in ordinary direct heaters with modulating power, it will not prevent a boiler start-up flown by pre-heated water but will only shut down when the temperature at the outlet reaches the heater's setpoint.

A backup heater flown by pre-heated sanitary water requires a temperature sensor at the water inlet to avoid unnecessary start up (if the solar hot water temperature reached the set point) and a modulating power to prevent getting too hot water at the drawing point.

Position and regulation of the temperature mixing valve

Every SDHWS needs a hot and cold water mixing unit to prevent water coming into the distribution system at temperatures above 60°C.

For direct stream of sanitary hot water through the backup heater:

- The mixing valve has to be mounted between the storage tank and the backup heater and its temperature set point needs to be at least 5K higher than the one of the backup heater, and not higher than 65°C.

For backup heater inside an auxiliary storage tank:

- The mixing valve with a set point of maximum 60°C should be installed after the backup storage tank and the compatibility of the auxiliary storage tank with temperatures up to 80 or 90°C should be guaranteed.

Integration of a SDHWS in a distribution network with circulation loop

The down comer tube of the recirculation loop should be connected to the solar tank in order to cover (part of) the distribution losses with solar thermal energy. The storage tank must have a connection for the recirculation pipe.

RET integration in the ventilation system - Highlights

HP - Integration in the ventilation system

The design of the thermal power of a heat pump is fairly critical with respect to thermal comfort.

Hence, it is required to size the power of the heat pump considering the real ventilation flow, as the share of the ventilation losses in the total heat loss increases with higher insulation levels (see table below).

[Watt]	K76	K45	K40	K35	K30	K25
Q transmission	11000	6500	6100	5800	5400	5000
Q ventilation	3000	3000	3000	3000	3000	3000
Total	14000	9500	9100	8800	8400	8000
% of ventilation	**21%**	**32%**	**33%**	**34%**	**36%**	**38%**

BES - Integration in the ventilation system

In case of open combustion devices (combustion air out of boiler room)

The boiler room equipped with a biomass burner requires appropriate openings for fresh air supply compared with its thermal output, for combustion and safety reasons.

- A permanent (not including an closing device) air inlet with a total free area of at least 550 mm² per kW of the rated output above 5 kW is required with a minimum of 6500 mm²;
- If a flue draft stabilizer is used, the total air inlet free area should be increased by 300 mm² for each kW of the rated output.

See also the integration of VwHR in the heating systems, hereabove.

In case of closed combustion devices (combustion air taken directly from outside)

There is no need for permanent supply of combustion air, however some basic ventilation of the boiler room is needed (mostly 25 m³/h)

Regulation and control - Highlights

BES - Regulation

Operating a BES requires additional sensors and controls; depending on the desired comfort and auto-control of the boiler operation.

- The use of a pressurized sensor data reading allows an accurate combustion control at the point of maximum efficiency, regardless of changes in chimney conditions, level of residues present in the system and other parameters affecting efficiency;
- For the highest accuracy in combustion efficiency control, the system requires Oxygen measurement from the lambda probe. This should be required in every domestic application of a pellet boiler.

A suitable hysteresis has to be designed to switch the boiler on and off depending on the temperature in the hot water storage tank. Hence, a temperature sensor is required in the hot water storage tank.

Other regulation control components required are:

- Programmable room thermostat
- Cylinder thermostat
- Pipe thermostat to prevent overheating in the system and very low temperature
- Thermostat radiator valve to allow lower temperature in non occupied rooms
- Boiler interlock to control boiler firing in case of no demand and to reduce heat losses due to unnecessary heating fluid circulation
- Zone controls to allow different temperature in different zones at different time
- Stop Function of the burner operation if the storage tank temperature exceeds either 105 °C or any lower value specified by the manufacturer.

HP - Regulation

In most cases, the use of a (very) low-temperature heat-release system (like floor heating) is required to ensure efficient operation of the heat pump, as the COP of a HP decreases when the difference between source-temperature and release temperature increases. For the same reason, temperature of the heat-source should be as high as possible (in the winter the ground temperature is kept around 10°C, while outside-air temperature drops down (sometimes below 0°C), this explains why ground-sourced HP systems usually perform better when it’s colder than 10°C outside.

Regulation unit should take outside temperature into account (using outside temperature sensor to do so) in order to keep heating curves as low as possible. (Very) Low Temperature Heating Systems usually include feed forward control and appropriate preset regulation options. Ad hoc information of the end user is also important to ensure good regulation of the system.

The temperature difference over the heat release system should be as small as possible. The flow through the pipes should be designed to get a delta T of about 5K. Usual Delta T of around 20K with release systems at full power is too high for a HP and would raise the condensation temperature.

VwHR - Regulation

In most cases, the heating and the ventilation systems are independent. It is recommended to avoid combination of both systems (see above).

If the heating and ventilation systems are linked and the supply air for space heating is post-heated by the VwHR:

- The flow rate for the supply air can only be reduced according to the ventilation need (relative humidity, CO_2 level, occupancy…).
- The flow rates can never be reduced below the minimum system design flow rate, according to heating regulation.

The flow rate can be increased above the minimum system design flow rate for heating reasons, but this is always responsible for an increase of the ventilation losses and of the energy consumption for heating and/or electric power for fans (even with heat recovery systems).

SDHWS regulation

In order to avoid on-off cycling of the backup boiler linked to a SDHWS, the hysteresis on the temperature set point has to be high enough.

Temperature set point, hysteresis and sensor position are linked and both have an influence on energy use and hot water use comfort.

To ensure a fair balance between safety and energy conservation:

- Sensor shall be mounted in the middle of the upper part of the storage volume available for the backup heating;

- temperature set point should be ± 60°C;
- A hysteresis of 10 to 15K should ensure a temperature of at least 50°C or 45°C in the upper half of the storage tank, available for backup heating.

If a solar combi-boiler is used for space heating and hot water production, priority should be given to the hot water demand which is much more sensible to short production stops than space heating. Old backup heaters should be shut off during non heating periods.

6.4.5 Building Integration of RETs

Context and scope

The key building pre-requirements and installation requirements towards high quality integration of RETs into a single family house were analyzed. This part of the research aims at answering the following questions:

- How does the building affect the overall operation of a given RET?
- What is required from the building to ensure an efficient working of a RET?
- How does the installation of a given technology affect the overall quality (performance, structure...) of the building?
- Which system / installation requirements do ensure optimal performance of the building?

Main interactions between RETs and building / installation requirements are summarized in the table below:

	Renewable energy technologies					
	1	2	3	4	5	6
	ST	PV	Wind	Biomass	HP	Ventilation
Building pre-requirements						
Envelope airtightness				x	x	x
Envelope insulation				x	x	
Space required	x	x	x	x	x	x
Building orientation and position	x	x	x			
Building structure/stability	x	x	x			
Installation requirements towards building integration						
Building envelope						
Water tightness of the building envelope	x	x	x	x		x
Air tightness of building envelope	x	x	x	x	x	x
Insulation layer of the building envelope	x	x	x	x	x	x
Acoustical comfort						
Limitation of noise		x	x	x	x	x
Indoor air quality						
Exhaust of used air close to opening				x		x
Safety						
Fire safety	x			x		
Electrical safety		x				
Mechanical safety						
Lightning protection	x	x	x			

Space required within and outside the building

RETs require a certain amount of space (varying according to the size or power of the equipment) around or within the building for technical equipment (fans, panels, boiler, stove ...) or for ducting (air ducts, water ducts, chimneys, etc) or storage (biomass/pellets, water vessel). Some of these spaces should be easily accessible for maintenance.

BES

The two main space requirements concern the boiler itself (function of its output range) and the pellet fuel storage (function of thermal output required). The fuel storage place should be designed to ensure one year autonomy and easy access to refill. A pellet storage room should be rectangular, and not wider than 2m. 2m × 3m × 3.2m proved to be a reliable dimension.

HP

Variable space is required for the evaporator according to its type (H/V ground collector, air collector) and for the heating unit.

Four types of Heat sources were investigated: vertical ground heat exchanger; horizontal ground heat exchanger; groundwater; outside air. It is of utmost importance that the heat-source is not undersized, to avoid possible freezing of the soil around the ground-heat-exchanger or thermal exhaustion of the underground. On the other hand, oversizing the heat-source might have a positive effect on the COP and the SPF (but means also a higher cost of heat source related components)

No chimney is required and the technical room does not require ventilation openings either. The storage vessel requires dedicated space and specific attention towards potential adverse effect of weight overload on the building structure.

The building requires increased insulation level in order to be heated by low temperature emitters.

VwHR

The space required concerns mainly the AHU and the air distribution ductwork. The AHU should be preferably installed in a separated technical room for acoustical reasons. The AHU must be easily accessible for maintenance. The size of the AHU varies greatly from one device to another and also depends (to some extent) of the maximum capacity of the unit.

For air distribution, the ductwork is composed of at least one duct toward each dry space and one duct from each wet space. For acoustic reasons, the ducts should be dimensioned in order to limit the inner air speed to ± 2 m/s.

SDHWS

The roof slope shouldn't be shadowed, it should be free of obstacles and south oriented, with a tilt angle between 35 and 45°. A flat roof requires at least 2,7 times the surface of the solar collector surface; i.e. 3 to 6 m² of solar thermal flat plate glazed collectors requires 10 to 20 m² flat roof (free of shadow and obstacles). This collector surface is appropriate for the hot water production of a single family house.

The primary circuit (solar loop) is made of two ducts connecting the collectors with the storage tank. These ducts need to be insulated (10 to 15cm equivalent diameter required) and require appropriate space between the roof and the storage room. If new ducts need to be foreseen between the storage tank and the hot water tap points in the building, enough space has to be foreseen, esp. for the insulation of the hot water ducts.

Additional space for the storage tank is required, with a minimum room height of 2 meters. The solar tank is ideally located close to the main hot water tap points, close to the solar collectors and at minimum distance of any back-up heater.

PV

The roof slope should not be shadowed, it should be free of obstacles and south oriented.

A flat roof requires at least 2,7 times the surface (free of shadow and obstacles) of the PV solar panels.

Some space is required for the inverter (typical size 40 x 60 x 20 cm) which is preferably located inside the building. Some wires & cables need to be laid between the PV array, the inverter and the main electrical switchboard. Those are not obtrusive.

SWT

The installation of an urban wind turbine on a building requires space and allowed height above the rooftop.

The protection of the building structure against vibrations of the wind turbine is an essential requirement and should be covered by ten-year-guarantee.

NB: DER like PV and SWT require little or no additional space inside the building. On the other hand, both technologies need some free space on the building roof.
Appropriate roof area, orientation and structure are essential requirements to ensure connection safety, weight distribution and local electricity production.

Building shape, orientation and environment

Those requirements are very important for PV, ST and SWT. Nonetheless, the building orientation can affect the heating and cooling load of the building and the associated size of heating devices such as HP or BES.

ST / PV

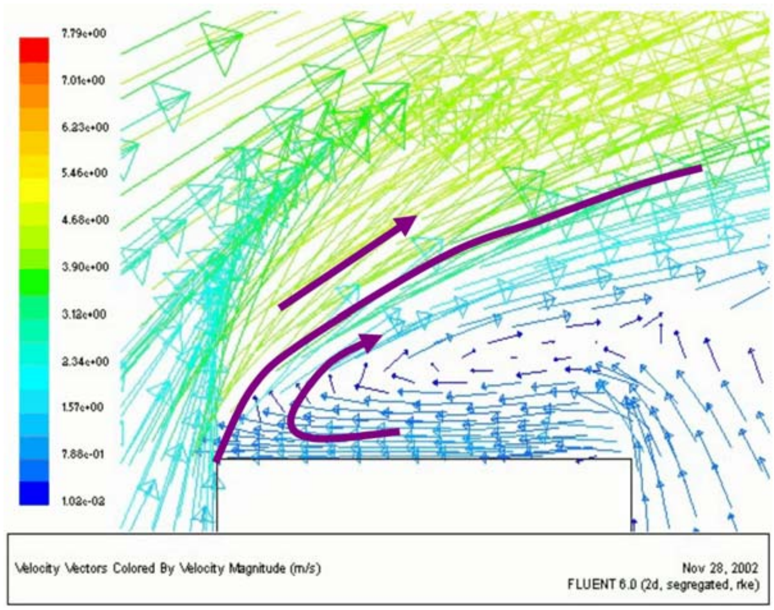
The roof orientation is critical for the output of the solar collector. Collectors shall be oriented south +/- 90° with an optimal tilt angle of 35°. The absence of shadow on the collector area is required.

SWT

The building orientation has to match the prevailing wind direction.

The shape and orientation of a building have a negative impact on the output of the wind turbine if they block the wind or if they entail a very turbulent air flow over the building. A positive effect is also possible where concentration effects are found (mostly influenced by the wind direction) as illustrated in the figure below.

Potential sites for SWT should be evaluated on a case by case basis to reach an acceptable prediction level of the annual energy output, because of the many local factors influencing the output.



Obstacles around the building esp. on the side of the prevailing wind direction have a negative effect on the annual energy output of the turbine. Existent and future obstacles that might arise during the operation lifetime of the device must be taken into account in the calculation of the expected annual energy output of the turbine.

Building structure and stability

BES

The mechanical stability of the constructional hearth should be able to hold the weight of the boiler.

The surrounding walls of the pellet storage room must be able to withstand the loads imposed by the pellets (bulk density 650 kg/m³).

ST / PV

There is no additional requirement if the collector is integrated and replaces conventional roof structure as tiles.

The roof structure may require reinforcement if the collector is super-imposed. If the collector is not parallel to the roof surface, dynamic effect of the wind force must be taken into account to check the strength of the load bearing structure. On a flat roof, additional ballast (increasing the static load) might be required to prevent the solar collector from being blown away.

For **SDHWS**, the building must be also support the weight of the storage solar tank (100 to 600 kg) on its particular location.

SWT

The building is required to offer enough structural strength to support the turbine's weight and to withstand the vibrations an UWT in operation might entail.

The level of vibrations should be specified by the SWT manufacturer as stated in IEC 61400-2. Dynamic tests should be carried out in order to verify that no unwanted vibrations arise within the operational wind speed range of the wind turbine. These vibrations should be measured in critical parts of the wind turbine and of the support structure.

Heating and cooling loads

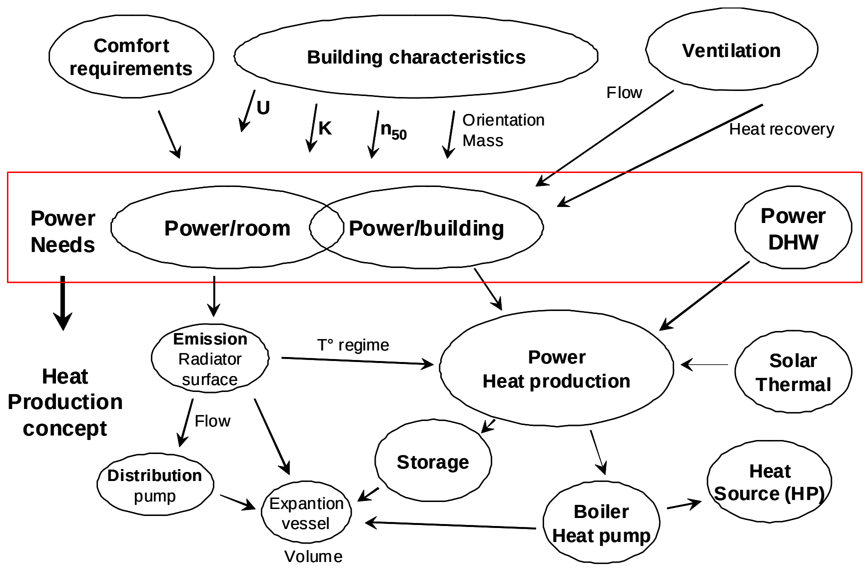
Building characteristics such as insulation, air tightness, structural mass… affect the heating/cooling load and hence the:

- nominal power of heating and cooling devices;
- surface specific heating/cooling load of each room;
- Temperature regime of the heating system.

A difference is made between the global building performance, such as the building insulation level or the global air tightness (n_{50}) on the one hand, influencing the global power, and the unequal distribution of insulation or leaks on the other hand, affecting the local surface load.

In some cases, local surface load values requires strict application to enable the use of a given technology (ex HP), whereas global requirements might be lower.

The figure below gives an overview of the impact of the heating load on the design of heating systems:



Envelope insulation

The insulation of the building envelope influences the heating load of the building and therefore the nominal power of heating systems such as HP and BES. Specific insulation requirements for the building envelope may apply to enable the installation of given technologies such as HP.

NB: legal requirement for the global insulation level of residential buildings (according to EPB regulation) are different in Brussels (K40) than in Flanders and Wallonia (K45).

K45 is a minimum requirement to enable low temperature heating linked to a heat pump.

Air tightness of the envelope

The air tightness of the building is not strictly required to enable VwHR, however, improving the air tightness of a building might be more profitable than installing a VwHR (compared to other ventilation systems).

Two options allow the limitation of ventilation induced in- or exfiltration:

- Improving the air tightness of the envelope;
- Increasing the transfer openings capacity.

Cooling capacity of roof-mounted PV panels

PV panels must be ventilated on both sides since their power output decreases with a Temperature increase.

- Natural convection allows the cooling of superimposed PV panels;
- For BIPV, sufficient ventilation at the inner side of the panel is required.

Installation requirements towards building integration

The installation of RETs in a residential building might have an impact on the building envelope, it goes mainly over:

- Solar panel integration or SWT securing/lashing on the building roof;
- Perforation for connections (electrical, water ducts, air ducts…) through the building envelope.

However, RETs integration cannot compromise the primary functions of the building envelope which are:

- Water tightness and protection against rain and ground water;
- Air tightness of the building and thermal insulation of the envelope to ensure high energy performance.

The table below gives an overview of the interactions between RETs and the building envelope:

RET	**Component**	**Water tightness**	**Air tightness**	**Insulation**
Ventilation	Air inlet Air exhaust	Roof or wall	Perforation	Risk of thermal bridge
Wind	Turbine fixation	Roof		Risk of thermal bridge
	Electrical connection		Perforation	
PV	Panel fixation	Roof		
	Electrical connection		Perforation	
ST	Panel fixation	Roof		
	Water ducts		Perforation	
Biomass	Chimney	Roof	Perforation	Risk of thermal bridge
	Air intake		Perforation	
HP	Water ducts (heat source: air or ground)	Wall	Perforation	
	Air ducts (heat source: air)		Perforation	

Water tightness of the building envelope

Components such as solar panels, wind turbine installed on a roof shall be considered as other usual obstacles (window, chimney...) on a roof or as roof covering, and as such submitted to the same roof-specific technical information notes as NIT 202; 215; 219 or 225 from BBRI.

Ducts and pipe penetration through a façade should foresee a slight slope of the hole towards the outside to avoid water penetration: a 2° slope of the connection tubes is required to avoid water-drops gliding inside the building.

Air tightness of the building envelope

Ait tightness is usually assured by an air barrier at the inner side of the envelope (such as plastic foil in wood constructions). Each penetration of ducts in this air barrier should be sealed properly.

Sealing material or prefabricated sleeves can be used to seal a connection through a plastic foil. Several size and shapes of sleeves are available. To seal a connection through a coated wall, PU foam or silicon rubber is allowed.

Insulation of the Building envelope

In most cases, the interactions of RETs with the insulation layer of a building are limited and simple requirements ensure an optimal protection of the insulation layer.

The insulation can be damaged by the penetration of ducts and pipes. It is therefore important to minimise the size of the perforations. If the insulation layer is elastic, the diameter of the hole should be smaller than the one of the duct.

In some cases, the installation of RETs might increase the risk of thermal bridge through the building envelope (fixation of a wind turbine, set up of a chimney for BES...).

Acoustical comfort

The NBN S01-400 standard gives the requirements to limit the noise level inside dwellings, and the noise limitation requirements from installation such as VwHR.

BES

Bedrooms should not be arranged directly above the boiler room since sound transmitting chimneys should not pass through those rooms.

In new buildings, boiler room and storage room should be separated from the walls and concrete floor by elastic absorbing materials.

Each contact point between mechanical parts and walls or floor materials should be acoustically insulated or isolated with vibration dampers in order not to spread vibration of the mechanical parts.

Each sound reduction elements specified by the manufacturer (such as isolation mats) must be properly installed.

The lack of binding standards means that it is often only possible to control and assess the sound emission of BES compared to reference installations.

HP

The compressor of a HP-unit makes noise. If groundwater is used as a source, the circulation pump can make some noise. Hence, those components need to be in a technical room. If outside air is used as a source, the outside-unit includes the compressor and a ventilator, which make noise outside the building

ST

The only source of noise of a SDHWS is the circulation pump. In drain back systems, temporary noise might occur when the fluid is drained in the drain back vessel. Volumetric pumps generating more vibrations and noise are required to be installed at distance from living areas or bedrooms. Pumps are usually mounted close to the storage tank, outside the comfort zones of the building.

PV

PV is a silent technology as it requires no moving parts. The inverter might induce some (hum or buzzing) noise due to the power electronics and should therefore not be mounted close to bedrooms.

SWT

An urban wind turbine consists of rotating parts inducing some noise. The noise level is generally low and the impact on the acoustic comfort inside the building is considered negligible.

IEC 61400-11 characterizes noise emissions of a wind turbine through appropriate measurement procedures. The inverter can be mounted in any room since the noise it produces is negligible.

Visual impact

Solar collectors (**ST / PV**)

As visible components of a building, mounting solar collectors require appropriate building integration (alignment, good craftsmanship, professional finishing).

SWT

The installation of a rotating turbine on the top of a building can cause some visual disturbance.

It is required to evaluate the shadow effect of a SWT on the visual comfort inside and outside the building or inside other buildings.

Sun reflections on the blades of the turbine might cause some visual disturbance. Therefore, rotating parts should be dark coloured in order to limit the reflection power of the blades.

Indoor Air quality

The indoor air quality can be affected by some devices, mainly VwHR and BES.

The air exhausts rejecting polluted air (flue or exhaust air from ventilation) must be distant from other openings such as windows, doors or air inlet for ventilation. Two standards (NBN B 61-002 and NBN EN 13779) using the same approach based on dilution factor calculations specify the requirements about the distance between air exhaust (ventilation exhaust, chimney) and opening in the building envelope such as a window.

In absence of other requirements, the exhaust openings for flues from biomass should be considered in the same way as conventional fuel heating devices. Some general rules can be drawn for the position of air exhausts:

- place air exhaust as far as possible from other openings;
- place air exhaust as high as possible compared to other openings.

The correct installation of the chimney is very important to ensure good indoor air quality.

Correct size, design and positioning of the chimney is essential to achieve desired natural draught which perform a dual function by removing exhaust gases from the boiler on the one hand and sucking combustion air into the boiler on the other hand.

Stainless steel twin-walled insulated flue pipes are required. A draught stabiliser should be fitted as standard to the short section of flue pipe that is connected to the boiler. The flue gas can exit the boiler room through the roof or through the wall by using a bend on the flue pipe.

In order to avoid down draught, the chimney or flue must end at least 600mm higher than the highest point of the roof, tree or building up to a distance of 9 m. The outlet of a chimney or flue pipe should leave at least 1 m above the top of any opening skylight, opening window or wall ventilator up to a distance of 2,3 m.

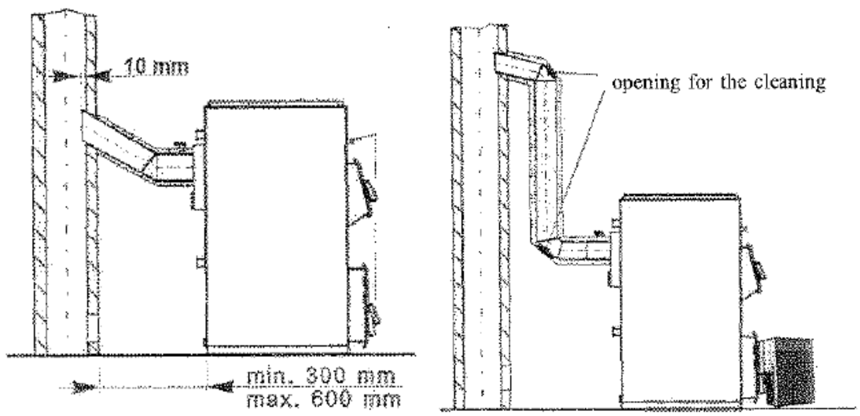
Insulation thickness should at least be 30 mm for chimneys mounted inside the building and 50 mm for chimneys mounted on an outside wall.

Temperature of the exhaust gases should at least be 30° C higher than the condensation temperature of the combustion gases.

Minimum distance between the boiler and the chimney should be 300- 600 mm (NBN-B61-002).

The waste gases pipe must form an angle of 30° to 45° with the horizontal.

The waste gases pipe should exceed the chimney wall from 10 mm to avoid condensates from the chimney entering boiler. Waste gases pipes exceeding 0.5 m require thermal insulation of at least 30-50 mm mineral wool.



Combined HP and ventilation systems

When air is used as heat source for HP and ventilation is used in the same building, the air inlet for ventilation should be positioned as far as possible from the evaporator of the HP. Indeed, the air is cooled down by the HP evaporator and should therefore not be uses as supply air for ventilation. Moreover, the quality of this air cannot be guaranteed.

Fire Safety

BES

Fire safety against "burn-back" is required.

- A pellet boiler without integral fuel hoppers shall incorporate two independent safety systems in addition to the connection between the burner and the fuel store.
- Burners or boilers with an integral fuel hopper shall be fitted with three independent safety systems. If the fuel hopper contains more than 40 dm^3, one of the safety systems shall be a water spray system that responds to temperature rise.

The temperature in any integral fuel storage container shall not exceed the ambient temperature by more than 65 K as per EN 14785:2006 (E).

The appliance shall include a protection against overheating of the water boiler, which turns off the burner if the temperature of the boiler water exceeds 105°C or any other value specified by the manufacturer as per EN 14785:2006 (E).

No electrical installations can be mounted inside the pellet storage room.

ST/PV/SWT

Mechanical Safety

A common requirement for all RETs is the proper fixation of each component on the building structure (solar collector, air ducts HP-unit, boiler, storage vessel...)

Special attention is required to ensure mechanical safety of wind turbines since they include moving blades which might seriously damage the building and its nearby environment (incl. people) in case of breakdown. UWT require a protection against high wind speeds or must be built to withstand very high wind speed. The maximum wind speed the turbine can withstand must be specified and guaranteed by the manufacturer. The research showed that since UWT are exposed to very turbulent wind flow, they are mostly built with extra sturdy so that breakdown cannot happen in usual operation.

Electrical Safety

Each RET component made of conducting material must be connected to the earth (as for metal air ducts and cases).

Lightning protection might be required for components mounted on building roofs, such as solar collectors, wind turbines or their supporting structures.

Any RET connected to the grid has to comply with electrical safety rules and general rules for protection of electrical devices imposed by the AREI. The grid connection must be checked by an accredited body and the DSO must give a written permission to allow the connection of DER to the grid. There is however an exception to this rule for small generating units, in this case no permission needs to be asked, the DSO needs just to be notified in this case. This exception is only valid when the following conditions are met. For single phase connections the total power of the installation at the connection needs to be smaller than 5kVA, for three phase connections this is 10kVA with a maximum imbalance between the phases of 20A. The installation has to be equipped with an automatic disconnection mechanism. However, an evaluation period for these limits is running and they can be revised after the 31th of December 2009.

General and specific electrical protection requirements are listed in a reference document Synergrid C10/11.

Protection is required for decentralised generation. Devices must be able to automatically disconnect in case of power outage of the grid or if the voltage falls out of a certain range. Decoupling protection must be installed upstream or downstream of the dispersed generation transformer.

Protection required for low-voltage grid connection of a DER is summarized in the table below (freely translated from Synergrid C10/11, version 6/2006; see http://www.synergrid.be/index.cfm?PageID=16832#):

Distributed generation behind MV-branching

General case	∣∣ 10 kVA	Frequency	Voltage					Detection islanding
		47,5 / 51,5 Hz instantaneous	maximum ... 110 % instantaneous	upper minimum 50 .. 85 % 0 -> 1,5s	lower minimum 25 .. 50 % instantaneous	homopolaire U0 Delayed		Vector shift or df/dt
						see comm. 1		
	or =>	Automatic isolating system according to AREI art 235 c1) and d)						

comment 1) Optional for small power compared to the grid

Distributed generation behind LV-branching

General case	∣∣ 10 kVA and technically NOT capable of islanding operation	Frequency	Voltage					Detection islanding
		47,5 / 51,5 Hz instantaneous	maximum ... 110 % instantaneous	upper minimum 50 .. 85 % 0 -> 1,5s	lower minimum 25 .. 50 % instantaneous		3 phazes present (>10kW)	Vector shift or df/dt
	or			instantaneous				
	or	Automatic isolating system according to AREI art 235 c1) and d)						

Environmental safety

Any risk of toxic compound release into the environment must be avoided. This is mainly the case for RET using heat transfer fluid as HP and SDHWS. The fluid that might escape from any security valve must be collected in an appropriate vessel to avoid contamination of the groundwater.

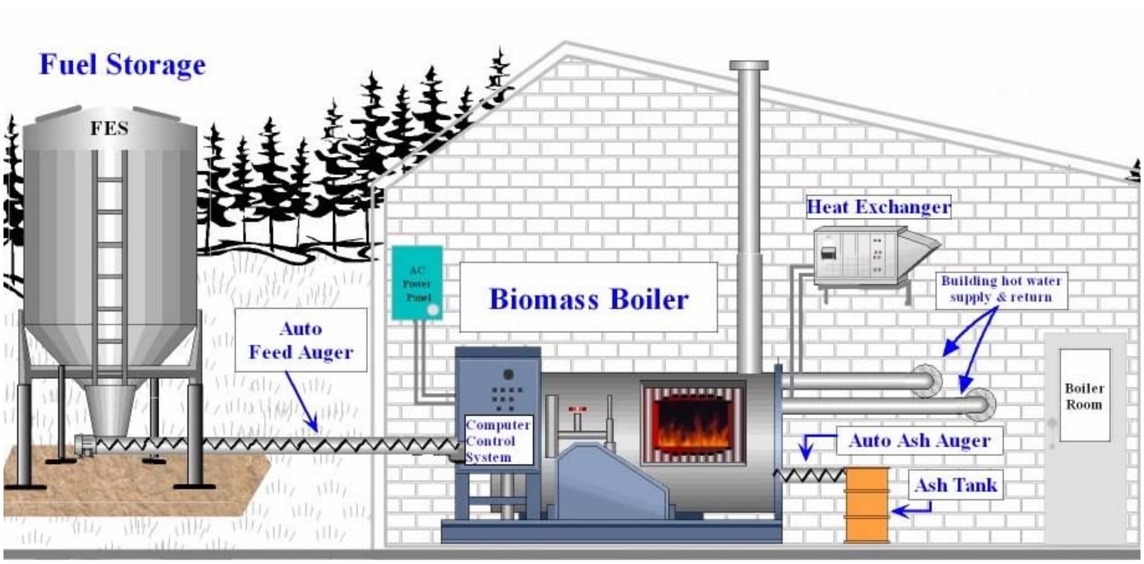
6.4.6 BES Roadmap

Two existing quality schemes were broadly used by the network as references to assess and ultimately define a full set of technical requirements related to BES quality components, system, design & operation:

- The Belgian Optimaz quality scheme for oil fuel boilers;
- The German Din*plus* quality requirements for biomass pellets.

Those technical requirements aiming at a safe, efficient and pollution free operation of the system (burner and boiler as one unit), were split up into six categories roughly depicted in the figure below:

- Fuel Supply System
- Combustion
- Heat Exchanger and Storage
- Exhaust venting system
- Safety
- Maintenance & miscellaneous



The research showed that:

- Quality marked biomass energy systems in Belgium should be restricted to complete systems:

- Of a thermal output capacity up to 70 kW
- Which burners can only be fuelled with wood pellets of recommended characteristics (i.e. DIN*plus* or prEN14961 or equivalent), to make sure that efficiency and emission level do not deteriorate with time.
- With Fully automated ignition, performance and combustion control[23] as well as cleaning of the heat exchanger, in order to avoid damage due to improper handling.
- Allowing standardized efficiency and emission level assessment.
- That can be certified according to EN 303-5.

- Normative requirements of marked BES should include compliance with:

- The Low-Voltage Directive (73/23/EEC), the EMC Directive (89/336/EEC) and the Machine Directive (89/392/EEC), as a prerequisite;
- The Royal Decree governing the nitrogen oxides (NOX) and carbon monoxide (CO) – Emission values of the gases from the central boilers and burners, with a nominal thermal capacity equal to or lower than 400 kW: K.B. of 8 January 2004 (Belgian Bulletin of Acts, Orders and Decrees of 30 January 2004);

[23] exclusion of systems with manually operating control devices (for example, adjusting-lever-controlled combustion air supply

- The EU directive 98/34/EG of the European Parliament and the Council of 22 June 1998: re information procedure in the field of standards and technical regulations;
- The EU directive 2002/91/EG of the European Parliament and the Council of 16 December 2002: re energy performance of buildings;
- NBN EN 303-2: Boilers- part 2: Boilers with aerator burners - special requirements for boilers with atomising burners.
- NBN EN 303-6: Boilers- part 6: Boilers with aerator burners - Specific requirements for the combination of domestic hot water boilers with aerator burners with a nominal heat input no greater than 70 kW (1st edition);
- NBN EN 12809: 2002/A1:2005/AC: 2007: Residential independent boilers fired by solid fuel - Nominal heat output up to 50 kW - Requirements and test methods;
- NBN EN 303-5:1999: Heating boilers. Heating boilers with forced draught burners. Heating boilers for solid fuels hand and automatically fired, nominal heat output of up to 300 kW. Terminology – requirements - testing and marking;
- NBN EN 14785:2006: Residential space heating appliances fired by wood pellets -Requirements and test methods;
- EN 50156: Electrical equipment of non-electric appliances for household and similar purposes- Safety requirements.

- The first proposed set of quality requirements for a Belgian - Optimaz kind of - BES label is summarized in the table below and should include :

Pellet Boiler		**Level*****		**Level****		**Level***	
		Nominal Load	Partial Load	Nominal Load	Partial Load	Nominal Load	Partial Load
Heat out put range		≤ 70 KW	30 % of nominal load	≤ 70 KW	30 % of nominal load	≤ 70 KW	30 % of nominal load
NO_x (mg m^{-3})		150	150	150	150	200	250
CO (mg m^{-3})		80	100	90	200	200	300
Dust (mg m^{-3})		20	SV	20	SV	50	75/SV
OGC (mg m^{-3})		5	5	5	5	25	40
Efficiency (%)		≥ 97	≥ 95	≥90	≥ 88	≥85	≥ 80
Noise (db)		≤ 50 Day	≤ 35 Night	≤ 50 Day	≤ 35Night	≤ 50 Day	≤ 35Night
Halogenated plastic component (g, maximum)		50		50		50	
Surface treatments	Heavy metal pigment	Not allowed	Not allowed			Not allowed	
	Organic solvents	Not allowed	Not allowed			Not allowed	
Packing (halogenated plastic)		Cl-plastic-Guideline		Cl-plastic-Guideline		Cl-plastic-Guideline	
Auxiliary power demand (% of heat output)		≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0	≤ 2.5	≤ 3.0
Heat Losses (% of heat output)		0.8	0.8	1.5	1.5	2.5	2.5
Surface temperature (°$C_{maximum}$)		35 at 20 ambiant temperature		35 at 20 armbant temperature		35 at 20 ambiant temperature	
Hot Water Tank		yes		yes		yes	
Laboratory testings		ISO 17025		ISO 17025		ISO 17025	
Recommendation for fuel		prEN 14961/ DINplus	prEN 14961 DINplus	prEN 14961 DINplus	prEN 14961 DINplus	prEN 14961 DINplus	prEN 14961 DINplus

Note: Limit values are defined for 13 volume % O_2 in the dry flue gas, 0°C at 1013 mbar. SV= Specify the values.

- Belgian pellets market is dominated by DINplus certified wood pellets for residential heating. Quality requirements of DINplus certification are very close to prEN-14961 Hence the quality requirements for pellet fuel used under a Belgian quality scheme should equal those of the DIN*plus* mark (See the following Table).

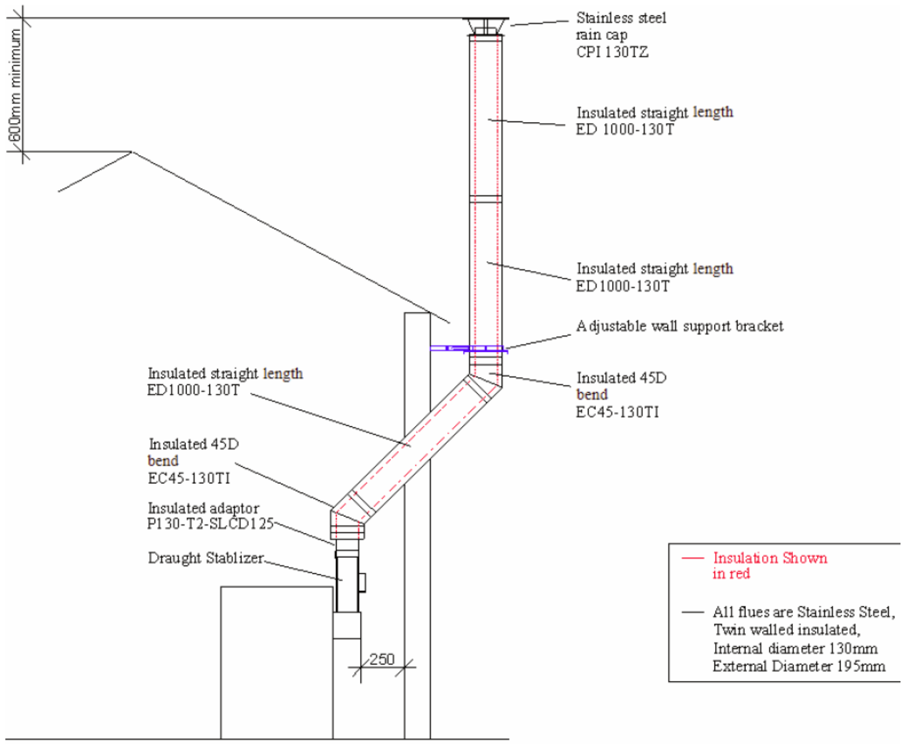
Parameter	DIN*plus*	DIN51731	Ö-Norm M-7135	Swan Label		SS 187120			Swiss Pellet
				G_1	G_2	C_1	C_2	C_3	
Diameter(mm)	4-10	4-10	4-10	≤ 6	≤ 8	≤ 25	≤ 25	≤ 25	5-7
Length (mm)	5×D[a]	≤ 50	5×D	5×D	5×D	4×D	5×D	6××D	< 50
Density (kg dm^{-3})	≥ 1.12	≥ 1-1.4	≥ 1.12	0.63 < x ≤ 0.7	0.7 < x ≤ 0.78	≥ 0.6[d]	≥ 0.5[d]	≥ 0.5[d]	≥ 1.15-1.4
Humidity (% wt)	≤ 10	≤ 12	≤ 10	< 9.0	< 9.0	≤ 10	≤ 12	≤ 12	≤ 10
Ash (% wt)	≤ 0.5	≤ 1.5	≤ 0.5	≤ 0.5	≤ 0.5	≤ 0.7	≤ 1.5	≤ 1.5	≤ 0.5
Heating value (MJ kg^{-1})	≥ 18	15.5-19.5	≥ 18	≥ 16.9	≥ 16.9	≥ 16.9	≥ 16.9	≥ 15.1	≥ 18
Sulphur content (% wt)	≤ 0.04	≤ 0.08	≤ 0.04	≤ 0.04	≤ 0.04	≤ 0.08	≤ 0.08	-	≤ 0.04
Nitrogen content (% wt)	≤ 0.30	≤ 0.3	≤ 0.3	≤ 0.3	≤ 0.3	-	-	-	≤ 0.03
Chlorine content (% wt)	≤ 0.02	≤ 0.03	≤ 0.02	≤ 0.02	≤ 0.02	≤ 0.02	≤ 0.02	-	≤ 0.04
Fine content (% wt)	≤ 2.3	-	≤ 2	≤ 2[b]	≤ 2[b]	≤ 0.8[b]	≤ 1.5[b]	≤ 1.5[b]	≤ 3.8
Mechanical durability (% wt)	≥ 97.5	-	≥ 97.5	≥ 97.5	≥ 97.5	-	-	-	-
Binding agent/additives (% wt)	< 2	-	< 2	-	-	TS	TS	TS	Not allowed
Ash melting behaviour °C	-	-	-	IT ≥ 1300[c] HT ≥ 1400[c]	-	-	-	-	-

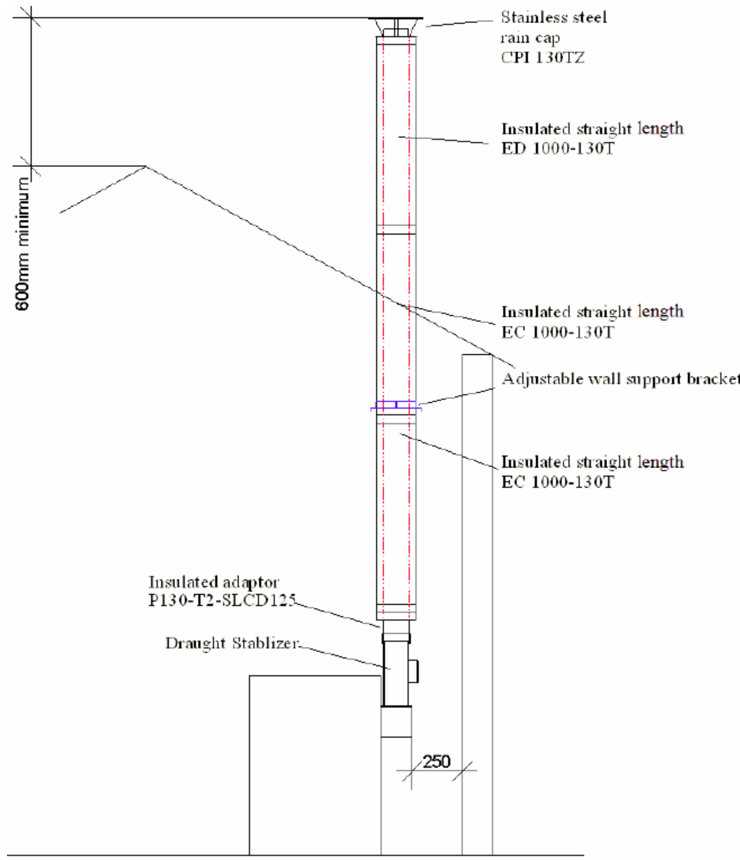
[a] No more that 20 % of the pellet may be longer that 7.5 x diameter. [b] Particle in weight % < 3.15 mm. [c] Initial temperature (IT) tested on ash produced at 550°C. G_1 and G_2 represent the respective pellet group as per Swan mark. C_1, C_2 and C_3 represent the respective pellet class as per Swedish regulations. TS- type and amount should be specified. In Belgium most of the suppliers get their certification by DIN*plus*.

- Installation instructions shall at least contain:
  - A written statement that each relevant national, local regulations and European Standards shall be fulfilled when installing the appliance.
  - Full assembly instructions for the appliance, especially if supplied in different parts.
  - Appliance model, number and/or type.
  - Nominal heat output in kilowatts or watts for each type of recommended fuel.
  - Reduced heat output in kilowatts or watts.
  - Water heating output in kilowatts or watts for the recommended fuel.
  - Requirements for the electrical power supply (auxiliary power demand).
  - Maximum operating water pressure in bar.
  - The weight of the appliance in kilograms.
  - Any necessary safety clearance distances from combustible materials and/or any other recommendations for protective measures of the building construction against the risk of fire.
  - Requirements for the supply of combustion air.
  - Need for any air inlet grid and specific requirement to avoid obstruction.
  - Minimum chimney draught requirements (in Pa) for safe operation at nominal heat output and reduced heat output.
  - Flue gas mass flow in grams per second at nominal heat output and reduced heat output where required by regulation or alternatively the nominal heat output, appliance efficiency and average CO2 concentration when operating at nominal heat output and reduced heat output.
  - Average flue gas temperature downstream of the flue spigot/socket in °C for nominal heat output and reduced heat output.
  - Recommendations re access to clean the appliance, the flue gas connector and the chimney flue.
  - Whether or not the appliance is suitable for installation in a shared flue.
  - Installation requirements re cut-off and damper devices, as well as all safety devices where applicable.
  - Water capacity of any boiler and instructions for fitting a drain-cock in the lowest part of the system (where applicable).

- Settings of the temperature sensor.
- Means to dissipate excess heat from the boiler (such as using a radiator ...)
- Installation and operation requirements of any control and safety equipment.

- State of the art chimney installation, through a wall or a roof should look like this:





- Operating instructions for the end user shall at least contain:

- A written statement that each relevant national, local regulations and European Standards shall be fulfilled when installing the appliance.
- A list of quality requirements for recommended pellet to achieve maximum efficiency with minimum emissions.
- Any modifications required to the appliance or the operation when using other fuels (e.g. diameter).
- Instruction for refuelling the pellet hopper.
- Instructions for the safe and efficient operation of the appliance, including the ignition procedure.
- A written interdiction to use the appliance as an incinerator or to burn any other fuel than pellets.
- Requirements re operation of any adjusting devices and controls.
- Requirements re operation for seasonal use and for adverse flue draught or weather conditions particularly in freezing situation
- Warning that the firebox must always be closed when the appliance is in operation.
- Requirements re operation of any thermal discharge control or other control or safety equipment, where applicable.
- Requirement of the regular cleaning of the appliance, flue gas connector and chimney flue
- Requirement to check for obstruction of ducts or inlet prior to lighting after a long shutdown period.
- Instructions to ensure appropriate provision for combustion air, ventilation air and safe removal of flue gases.
- Common troubleshooting and procedure for the safe shut down of the appliance in case of bad working (e.g. overheating, water supply shortage...)
- Warning against burn during system operation
- Instructions for any necessary safety clearances from combustible materials and protection against the risk of fire within and outside the radiation area.
- Written interdiction of any unauthorized modification to the appliance.

- Recommendation to use original replacement parts only, to keep the manufacturer warranty.
- Safety instructions in case of chimney fire.
- Efficiency values, CO and other emissions values.

NB: the existence of a natural draught in the boiler when connected to the flue (min. 10 Pa) should remain the responsibility of the end user and has to be checked by the installer during the commissioning, before ignition of the burner.

Request for regular cleaning of the boiler should remain the responsibility of the end user, as emptying the ash pan regularly.

6.4.7 HP Roadmap

The research showed that:

- The quality of a heat pump installation depends on three main factors:
  - the design of the system;
  - the practical execution of the installation;
  - the efficiency of the HP-unit.
- State of the Art installation of a HP involves several building crafts, as illustrated in the table below:

	Source	Conversion	Release
Designer	X	X	X
HP-manufacturer		X	
Installer	X [Air, horizontal ground collector]	X	X
Driller	X [Vertical ground collector, groundwater]		

- The EN 13313 European standard should be applied and mandatory to ensure high quality of the full process.
- To ensure a high quality design of the HP system, the following tools or guidelines should be used:
  - in general: the European Standard EN 15450: Heating systems in buildings – Design of heat pump heating systems. This includes the minimal SPF factors (Annex C) and the procedures for measurement of the SPF.
  - the feasibility test (Excel sheet on www.ideg.info/media/docs/CvGP-WP_v1-0.xls)
  - the code of good practice for application of HP systems in the housing sector
  - standard specifications sheet (www.ideg.info/media/docs/Bestek_wp.doc)
  - technical trainings provided by manufacturers for their installation designers.
- To ensure high quality of the practical execution of the installation work of a HP, the following requirements should apply:
  - a technical education standard for HP-installers according to the European Parliament and counsil. This can be similar to the existing EHPA course "EU Zertifizierter Wärmepumpeninstallateur". HP program should be implemented throughout the country; this should be a certifying process;
  - regular technical training offered by HP manufacturers to the HP-units installers (combined with the official training program, according to the EU Eco label for HP);
  - the code of good practice for application of HP systems in the housing sector should be followed
  - …
- To ensure the quality of the drilling operation if any:
  - The source should provide around ¾ of the heat released inside the house;
  - Drillers should follow appropriate training sessions dedicated to vertical ground heat exchanger characteristics based on documents such as VDI4640 which describes the design and installation aspects of vertical ground heat exchangers. Such training could resemble the DACH-label "Erdwärmesonden Bohrunternehmen".
- To guarantee the efficiency of the HP-unit:
  - Minimum COP values required by EU eco label (European Commission decision 2007/742/EC of 9th November 2007) should be mandatory, certified according to EN 14511 test methods. This is

the easiest quality requirement that can be implemented for each type of heat pump. It is already part of most of the regional subsidy schemes and usually based on EHPA values.

- The most relevant additional requirement to implement concerns minimum SPF-values for each type of heat pump, since SPF benchmarks the efficiency of the HP system in operation in real conditions[24].
- Energy efficiency label A or B (European directive 2002/31/EC of 22/01/2003) should be mandatory for air/air HP-units
- …

- A comprehensive quality scheme for HP units might articulate as illustrated in the table below, with level 1 corresponding to the current situation (too low to ensure min quality of HP installations); level 2 corresponding to a start level for high quality HP installation and services and level 3 being an objective for the coming 5 years.

	level 1	**level 2** = level 1 + …	**level 3** = level 2 + …
Component	**Minimum COP** **COP certified acc to EN14511**	European Eco-label	European Eco-label
Concept & Design	**Fulfilling the Code of good Practice for HP applications in the housing sector**	Mandatory training for HP **design** provided by the **manufacturer**. Yearly random inspection of one installation. Follow-up of complaints	EU Certified HP designer (mutually recognized training & examination). Minimum number of reference installations.
Installation	**Fulfilling the Code of good practice for HP applications in the housing sector'** **Using checklists** **Documentation**	Mandatory training for HP **installation** provided by the **manufacturer** to the **installer**. Installation instructions must be provided according to EU Eco-label. User manual must be provided according to EU Eco-label. 2 years warranty on installation work. Checklist for commissioning according to EU Eco-label. ID-plate with CE-label and COP values according to EN1451. Minimum 10% of yearly installation to be reported for random inspection. Follow-up of complaints.	**EU Certified HP Installer** (mutually recognized training & examination Retraining every 5 years. Minimum number of reference installations. given % of yearly installations to be reported for random inspections. After sale service has to be guaranteed during 10 years. SPF warranty (SLA contract). Checklist for commissioning according to EU Eco-label.
Maintenance & monitoring	**Maintenance manual stays with the installation**	One year standard monitoring of electricity use (HP-unit, pumps, electronics) Maintenance manual keeps track of electrical consumption and corresponding dates. Evaluation after the first year.	SPF warranty and monitoring. After sale service guaranteed if initial installer is no longer available: other certified HP-installer takes it over Every installation available for random inspection.

[24] An IWT project [070662] WP-direct is currently assessing the practicality of measuring SPF of a HP

6.4.8 VwHR Roadmap

The main function of a ventilation system is first to ensure a good indoor air quality by supplying appropriate volume of fresh (outdoor) air and by evacuating used air.

In the 3 Regions of Belgium, the installation of a ventilation system in new buildings is mandatory, as part of the regional regulations on the energy performance of building.

The research showed that:

- The products and components for ventilation systems are usually of good quality and easily available (see also the technological state of the art).

- The key point related to the quality is the design of the system, usually done by the installer which has to combine the different components to build the whole system.

- The maintenance is also an important aspect of the quality of ventilation systems, while the installation is relatively easy if based on a good design of the system.

- The quality of the ventilation systems is not only related to energy aspects but rather mainly to aspects related to the main function of the system (ventilate = ensure sufficient indoor air quality) and to the comfort of the end user (noise, drafts, etc.).

- The ventilation is largely covered by the standardization framework at Belgian and above all at European level.

- However, there is an important need for clearer definitions of the requirements (based partly on this standard framework), and their translation into practical solutions, especially for small scale systems.

- The quality requirements were developed first from an end user perspective (see the methodology) and then translated into specific requirements, related to the system components or to the steps of the design work. The main global requirements are summarized below.

- Most of the requirements for VwHR should be implemented at short term while only some of them are related to higher quality levels and should be implemented later.

Indoor air quality

To ensure good indoor air quality, the first requirement concerns the ventilation flow rates, as the evaluation of indoor air quality runs through the measurement of the air flow rates. Not only are the system design flow rates important for indoor air quality but also other parameters, such as:

- Air filtration;
- Air tightness, fouling and ease of cleaning of the ductwork;
- Avoiding component materials releasing odours or harmful substances;
- Avoiding conditions favourable to microbial growth (porous materials, exposition to high relative humidity);
- Avoiding fouling of the system during transportation, installation or other works (protection of the components and system; and/or cleaning of the system prior to commissioning).

Thermal & humidity comfort

The thermal comfort is influenced by human parameters such as activity, clothing... and by building parameters such as air temperature, air speed, mean radiation temperature and relative humidity.

A crucial comfort aspect of ventilation systems is the risk of draft, related to the air speed and air temperature (although the draft feeling can result from high asymmetry of the radiation temperature of the partitions, independently of the ventilation system).

To assure thermal comfort with a complete mechanical ventilation system, the key point is the right position of the air terminal devices (to avoid cold draft in the occupation zones). The air speed in the occupied zones should be limited to 0,1 – 0,2 m/s.

Compared to other ventilation systems, the VwHR offers the advantage that the supplied air is pre-heated thanks to heat recovery, limiting the temperature difference with the room.

Acoustical comfort

The acoustical comfort of the ventilation system is a very important issue because the occupants being usually sensitive to noise could be tempted to switch off the VwHR with dramatic consequences on the indoor air quality.

The main points for the acoustical comfort are:

- Choice and position of the air terminal devices,
- Limiting the air speed in the ductwork
- Choice of AHU producing low noise
- Use of silencers on each main duct connected to the AHU.

Energy recovery

The first point related to the energy performance is the heat recovery of VwHR. The research focused on heat recovery with air/air heat exchangers.

Not only is the efficiency of the heat exchanger relevant, but also several other aspects of the design of the ventilation system, such as:

- Flow balance
- Duct insulation
- Flow rate and control
- Air tightness of the ductwork
- Maintenance

Auxiliary electric consumption (Fan)

The second point of high relevance for the energy performance is the auxiliary electric consumption of VwHR. The fans are the main electric consumers in the system but the whole system influences the consumption of the fans. Moreover, there can be some auxiliary control equipment also requiring electricity.

The electric consumption of the fans is mainly related to:

- Type of fan
- Ductwork: pressure drop, air tightness, compactness of the net, etc.
- Choice of filter type and maintenance
- Regulation and control of the flows

The table below summarize the relation between the global and the specific requirements developed for VwHR.

	Global requirements					Responsibility				
	Indoor climate comfort			Energy Perf.						
	Indoor Air Quality	Thermal and humidity comfort	Acoustical comfort	Energy Recovery	Auxiliary Electric Consumption	Product Manufacturing	Basic design	Detailed design	Installation	Commissionning
Specific requirements										
Whole system										
Design flow rates	x			x	x		x	x		x
Flow balance and recirculation	x	x		x	x		x	x		x
Transfer capacity	x			x	x	x	x	x		
Effectiveness of ventilation	x	x	x				x	x		
Control strategy	x	x		x	x	x	x	x	x	x
Airtightness of Ductwork and AHU	x		x	x	x	x	x	x	x	
Cooking hood and tumble dryer	x			x			x			
Ventilation of other spaces	x			x	x		x			
Documentation: as built folder	x	x	x	x	x	x	x	x	x	x
Air transfer and air terminal devices	x	x				x	x	x		x
Noise										
Limitation of noise from the air terminal devices	x		x			x	x	x		x
Limitation of noise from the ductwork			x			x	x	x		
Limitation of noise from the AHU	x		x		x	x	x	x		
Limitation of noise transfer between spaces			x			x	x	x		
Ductwork										
Air velocity in ductwork			x		x		x	x		
Pressure drop in ductwork			x		x	x	x	x	x	x
Thermal insulation of ductwork	x			x		x	x	x	x	
Ease of ductwork cleaning	x			x		x	x	x		x
Cleanliness of ductwork	x			x		x	x		x	x
Documentation on the ductwork						x	x	x		
AHU										
Documentaton on the AHU						x		x		
Air filtration	x			x	x	x	x	x		
Internal Leakages	x			x	x	x		x		
Temperature efficiency		x		x		x	x	x		
Fan selection and regulation	x		x		x	x		x		
Fan electric consumption					x	x		x		
Ease of cleaning of the AHU	x					x	x			
Thermal Insulation of the AHU				x		x		x		
Air inlet/outlet										
Min distance for inlet and outlet	x						x	x		
Position of air inlet	x						x	x		
Protection of air inlet	x					x	x	x	x	
Ease of cleaning of air inlet/outlet	x					x	x	x		
Ground coupled heat-exchanger	x				x	x	x	x		

The global requirements, the specific requirements, as well as the roadmap for VwHR are further detailed in WP3[25].

[25] Technological Roadmap and Quality Reference of Ventilation with Heat Recovery in Residential Buildings

6.4.9 ST Roadmap

The Solar Thermal Roadmap identifies global and specific quality requirements corresponding to given standards, marks or regulations, at the level of:

- Manufacturer and supplier of factory build systems(or components thereof);
- SDHWS Installer;
- Installation set-up and performance.

Quality control should occur through several means, as:

- EU Accredited certification bodies (e.g. DINCERTCO) to licence the Solar keymark;
- BELAC Accredited Certification bodies (e.g. BCCA) to issue Technical Agreements;
- Accredited inspection agency (e.g. Buildling controllers as AIB-Vinçotte, SECO or SGS).

The table below summarizes this:

Stake-holder	**Quality requirements**	**Corresponding Standard / mark or regulation**	**Quality control**	**Observation**
Manu-facturer /supplier	Product / component	Solar Keymark collector / ATG level 2	Solar Keymark licence from Certification Bodies; Technical Agreement from associations accredited by Belgian Accreditation Body	Solar keymark collector broadly accepted by sector federations, National Technical Agreement still have good notoriety
	SDHW System	Solar Keymark System ATG level 3, 4		Solar keymark system not broadly accepted yet, expensive, practical difficulties as system components come form different factories
Installer	Installer	(EU) Certification of small scale renewable energy equipment installers / ATG level 5 or 6	Conformity with art.13 (Information and training) of EU RES DIR & annex 4 (Certification of installers) requirements	Solar Thermal Training schemes vary from Flanders to Walloon and are not in line with EU RES DIR yet, Belgium is still far from a "mutually recognition" of SDHWS installer certification
	Installation	Installation control (performance and set-up)	Inspection by accredited inspection agency or technical control body	Accredited inspection agency not trained yet to assess SDHWS set-up & performance dedicated monitoring of SDHWS not standard yet

6.4.10 PV Roadmap

Quality systems exist in different regions in Belgium and abroad. The quality systems differ in:

- Approach: self-commitment, independent evaluation, initial or regular control based on papers or installation controls ;
- Content: Technical and commercial; generic or specific references to a quality referential
- The target groups: component manufacturers, suppliers, installers,
- Technology: PV only, all solar energy, other small-scale RET.

While systems with self-commitment and generic content can be considered as an initial ambition level in quality assurance, a system with independent control, based on a specific referential can be recommended as a better (higher ambition level) approach.
The following commitment corresponding to initial & future ambition levels have been identified:

- Generic commitment according to relevant standards, regulations and good practice;
- Specific commitment according to relevant standards, regulations and good practice;
- Specific commitment providing higher quality than required by existing standards and regulations.

A generic commitment to follow relevant standards and good practice can be seen as a declaration of intentions. Since a generic commitment does not set priorities on different standards, it cannot be verified by third party evaluation.

In practice, aside on good will, the fulfilment of such a commitment will depend on the knowledge and capacity of the system integrator and installer. Therefore, training is an important element to increase the quality level linked to generic commitments.

A specific commitment to a set of standards and regulations and good practice requires supplier/installer to be aware of the specific requirements in their daily working practice. File evaluation is used to check such awareness level and detect flaws on specific items. In order to systematically verify that the quality level is maintained, regular site visits are needed to on site installations. Moreover, quality management on company level rather than on product level is suited to ensure a consistently high quality.

A specific commitment to higher quality level than required by regulations and standards would be achieved by additional commitments from the PV sector. This would also have to be maintained on company level and need regular verification by a third body. Industry may choose a higher quality standard in order to position itself in contrast to competitors who are hardly fulfilling existing standards.

Broadly speaking, the PV roadmap should go along the following directions:

- Content: from general commitment to specific technical requirements beyond existing standards and regulations;
- Control: from self commitment to independent third party evaluation and certification;
- Implementation: from product level quality insurance to certified quality of the company’s management process

Training, education and third body evaluation are essentials to enable the PV sector to reach those targets.

Specific requirements corresponding to initial and future ambition levels are summarized in the table below:

		Initial Ambition Level	Future (High) Ambition Level (Initial +…)
Supplier / installer	Offer and contract	Contract is based on a binding offer, including: • Estimated yield • estimated yield reductions due to suboptimal orientation or shadowing • Warranties • Detailed list of applied materials • Terms and delays for commissioning The price is subdivided per: • Modules • Inverter • Other material • Working hours and documentation • Options	
Manufacturer/ Importer	Component - Module	• Qualification according to IEC61215 or IEC61646 • Safety according to IEC61730 • Data sheet according to EN50380 • Specification of power tolerances	• Electrical specifications at low irradiance • Specification of flash test data • Independent verification of tolerances based on random samples • Material specification: glass and other materials
Manufacturer / Importer	Component – Inverter	• Comprehensive data sheet, including Pac, r, η values required for ηEuro at UDC,r • ηEuro at UDC,r • All efficiencies according to IEC 61683 • IP class • Indication of galvanic separation • CE declaration • EN 60146 conformity (Inverters) • Proof of grid-code compliance (Synergrid C10/11 by means of DIN VDE 0126-1) • Safety according to IEC 62093 and EN 50178 • Short manual for end user	• η values for 3 different DC voltages • Basic monitoring function indicating operation or failure mode (internal or external)
System integrator/ installer	DC cabling, connection boxes, connectors	• Double insulated cabling (ground and short circuit proof) • Temperature and UV resistance (outdoor) • Cable ducts according to AREI/RGIE • Suited IP class for connectors	• Bypass diodes replaceable
Installer	Component – Lighting protection & earthing	• Effective grounding and lightning protection	
System integrator / supplier	Mounting system	• Statics • Corrosion • Ventilation • Module mounting, • Proof of water tightness for roof-integrated systems	• Specification of static properties of the mounting system, possibly based on tables or sizing tools • The mounting system should contain cable ducts
System integrator	System	• Installation according to IEC 60364-7-712 • No string diodes • Proper sizing of conductors, switches, plugs… according to AREI/RGIE and good practice • Proper sizing of invertors with regard to PV arrays • Good practice in earthing and lightning protection	
	Installation	Installation by qualified staff: • Full qualification for electrical installations • Basic qualification for roofing works • All interactions with the roof according to good practice in roofing Technical documentation of the installation including: • Technical specifications of modules and inverters • Checklist from commissioning • Technical certification (technische keuring AC) • Technical Drawings • Short manual for end user	
	Maintenance	n.a.	• Maintenance guide

6.4.11 SWT Roadmap

The SWT roadmap is addressing quality issues progressively, as follows:

- Safety: SWT are meant to be installed in urban areas, and often marketed for individual home owners, which might lead to increased risks of damage and injuries. Safety requirements particularly concern HAWT since VAWT are designed to work in turbulent wind flows and at lower rotational speed. Their rotor diameter is designed in such a way that in case of a blade breaking, the ejection distance is limited.
- Comfort: Noise and landscape issues might jeopardize large wind turbines development. Noise is particularly critical to sitting small wind turbines, which are often installed in the close vicinity of dwellings. For building-mounted applications, another major issue is vibration.
- Reliability & profitability: Profitability of SWT is not driving the small wind industry, as profitability is closely linked to the urban wind resource, which is not well known while SWT market has been constantly growing. On the other hand, available and reliable power curves should be provided as they are crucial in the choice of a turbine, depending on the wind regime of a site.

Ambition levels must address those three issues as illustrated in the table below:

Quality issue	Criteria	Quality requirements
1.	Safety	Components / System quality Installation quality Appropriate location and laying out Working under designed conditions (turbulence…) Legislation requirements (distances) Structural compatibility turbine / building Service granted by manufacturers and installers
2.	Comfort	Components / System quality Installation quality Appropriate location and laying out No noise disturbance No vibration No visual disturbance Legal requirements (distances) Ease of use / maintenance
3.	Reliability & Profitability	Components/System quality Installation quality Appropriate location and laying out Working under design conditions (turbulence, etc.) Resource assessment Yield assessment Service granted by manufacturers and installers Development of appropriate legal framework

- Based on BWEA and BERR standards, the research showed that a sustainable roadmap for SWT quality development in Belgium might look like this:

Level		Initial ambition level	Future ambition level (intial+…)
Manu-facturer	System	BWEA standard requirements: - Electronics (IEC wind generator standard) - Strength (IEC 61400-2:2006), Safety and function (IEC 61400-2:2006) - Provisions for operation in high wind and to slow or stop the turbine in an emergency or for maintenance - Noise (IEC 61400-11:2003), Performance (IEC 61400-12-1)	- Compliance with requirements of IEC 61400-1:2005 (turbulence) - Testing of weight and natural frequency of systems AWEA standard requirement: - Compliance with requirements of IEC 61400-21 (power quality)
	Services	BWEA standard requirements: - Maintenance and component replacement provisions Energy Trust of Oregon: - Warranties on wind turbine, inverter and controller for 5 years	
Installer	Installation	BERR “Microgeneration installation standard”: - Distance to public, restriction of access, safe sitting - Tower suitability, foundations (BS8004 and 8110-1) - Guys, shackles and turnbuckles, output cables (BS7671) - Isolation, earthing, lightning protection, Labeling, Metering - Control and circuit protection (BS 7671), control, battery cables, selection, sizing and installation (BS 7671 and BS6133), control, inverters, isolator, cabling, current protection (G83/I, BS EN 60947-3, BS7671) - Extreme winds (suitable class of turbine for the site conditions), Structural (fixing method if on building)	- Resource evaluation similarly to the NOABL’s based method
	Maintenance	Energy Trust of Oregon : Installer’s warranty covering workmanship for 2 years.	

6.4.12 Opportunity analysis new technology

In order not to slow down the pace of technological innovation in the microgeneration sector, it is recommended to implement a flexible quality scheme relying on a broad set of (common) mandatory requirements which can be complemented or adjusted to the innovative character of the market. The section below presents some technical innovations that might be part of the project if its scope was to be broadened.

Combined BES/ST system

-new technological development that would be worth investigating are:

- Suitability of agro-pellets for residential heat generation, as:
  - multi-heat boilers (emerging on the Belgian market);
  - there is limited availability of wood biomass in Belgium
  - Huge agricultural residues are available for heat generation.
- BEST (Combined Biomass Solar Thermal Energy System)

The potential for combined biomass and solar heating systems for sanitary hot water and space heating is important. The technology is reliable and more and more systems are available on the EU market.

This hybrid system shows cross-effectiveness: during summer and spring, hot water need is less important and might be fully covered by the SDHWS working at full load. While during winter, solar collectors preheat the boiler water and pellet boiler completes the hot water demands by fulfilling the whole heating need of the residential area.

The energy performance of such a system is largely influenced by hydraulic setup and control.

If a pellet boiler is combined with a properly designed SDHWS, about 25-32% of pellet fuel may be saved in a moderately insulated single family house ($\approx$ 50 kW) located in Central Europe.

Such combination further limits the number of start-up and shut-down of the pellet boiler and the associated emission of pollutants and electricity use.

Specific requirement to achieve this is a 100% solar fraction of sanitary hot water needs during the summer period. During the winter season, the pellet heating boiler should function as the primary heat generation source.

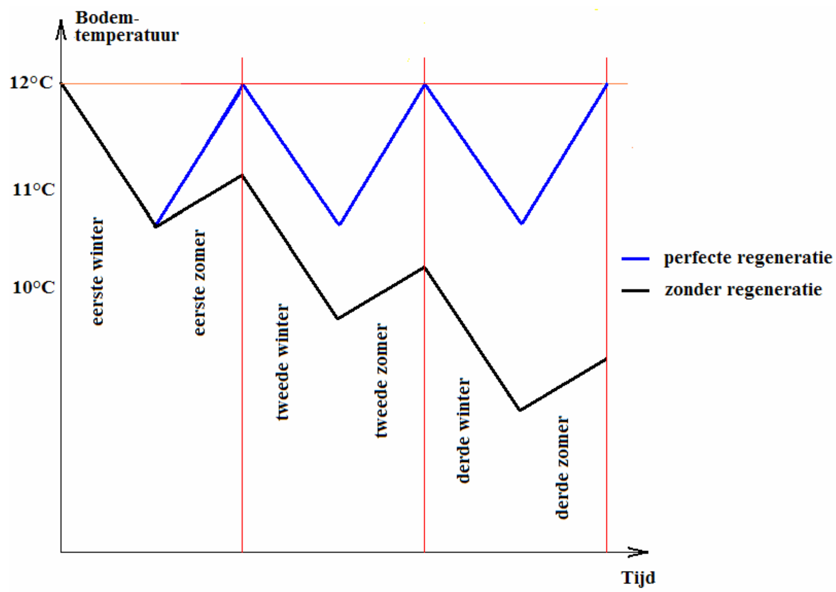
Combined HP – SDHWS

One of the most effective RET combination, improving the overall performance of the whole HP system is the combination and subsequent product integration of Heat Pumps and Solar panels:

- Geothermal HP + SDHWS: thermal solar collectors are used to regenerate the underground or to heat a storage vessel that can be used as a supplementary heat source (direct source for SHW or indirect source for the HP). A (low temperature) heat storage vessel (on the primary side) can be used to preheat the brine coming out of the ground heat exchanger before entering the evaporator (short time storage).

During the cold (heating) season, the underground temperature goes down. During the summer season the underground regenerates itself for a part. It's been observed that year after year, the temperature of the underground heat source was going lower and lower at the beginning of the heating season.

Combining the vertical ground heat exchangers of a HP unit with a solar hot water system may help the underground to regenerate. This artificial regeneration can totally restore (or even upgrade) the underground temperature (as shown by the diagram below), which would result in a higher SPF.



- Sanitary hot water production through HP is less efficient than space heating as the release-temperature is around 60°C. In this regard combination of HP with SDHWS is also advisable.

High temperatures can be reached with CO_2 as refrigerant; a high-pressure compressor is then needed (up to 120 bars)

- HP + PV system: photovoltaic solar panels can fully or partially cover the electricity consumption of electrically driven HP

Combined HP – VwHR

It would be worth analyzing Interactions of (reversible) heat pumps with ventilation systems.

As far as HP are concerned, recent technological development regarding the HP boiler should have precedence.

- The Heat Pump Boiler: Air/DHW

As ventilation became an obligation in new buildings in Belgium, it became possible to use the heat of the exhaust air to produce Domestic Hot Water with a heat pump boiler. This can be achieved with mechanical extraction-ventilation (C and D systems without heat exchanger). The expected short term market penetration of such combination is high.

- Air/air heat pump in D ventilation system (with heat recovery)

Low-energy houses with D ventilation system with heat recovery might be heated by using the hygienic ventilation system. Because of the low heating power, the temperature of the supply air will not be too high.

The expected short term market penetration of such combination is relatively high for passive and low-energy houses.

Mono-block air / water heat pump.

Air/water HP exists in split version but also in mono-block. The heat release system (water) can be connected straightforward to the outside unit. The expected market penetration of such product is high in the building renovation sector.

Combined HP – Condensing boilers

Air/water HP and condensing gas boiler are now sold as one-package combinations. The expected market penetration is low.

Heat Exchangers for HP

- CO_2 ground heat-exchanger

A closed pipe, partially filled with liquid CO_2 is inserted into the ground. The CO_2 is evaporating in its lower part and moves to the upper part. The evaporator of the HP is coiled around the upper end of the pipe where the CO_2 is condensing and falls down. No circulation pump is needed (as opposed to conventional vertical ground heat-exchanger). There is no risk of soil pollution since it uses no brine. The expected short term market penetration of such component is low. This due to the fact that this is a relatively new technology and there are only two importers in Belgium. Till present only a few (2-3) installations have been done. There is at this stage no longer term measurement available. This technology also doesn't allow natural cooling.

- Static air heat exchanger (DX or brine)

Two kind of static air heat exchanger do exist: the one with direct evaporation/expansion is in fact the source of an air-sourced heat pump without ventilator. While the one with circulating brine (indirect expansion) can be considered as the source for a brine/water heat pump. Both types have typical installation requirements and low market penetration expected in the short term.

Other Ventilation systems

Technological development and related quality requirements should not be limited to VwHR but have to include other ventilation systems, since:

- quality is an issue for other ventilation systems also;
- a common methodology can be applied to both system types;
- price competition of low quality ventilation systems would act against high quality standard of VwHR.

Solar Thermal R&D

- The development of medium temperature collectors gained much attention in the past years, as new product development and research programs[26] demonstrate.

- Reducing heat losses of storage tanks remains crucial; ESTTP considers the storage as the major technical bottleneck for further expansion of the solar thermal market. Thermo-chemical and phase change materials research is going on to find new media with high storage densities, able to store enough heat to cover the needs of a single house for a week or a even a month.

Hybrid SWT-PV system

A hybrid system combining grid-connected SWT with a PV installation might be much more efficient, since the power production of PV panels is usually complementary and lagged with the one of the wind turbine.

From SWT to Hydropower

The opportunity to define standards for small hydropower based on wind energy normative requirements remains an interesting field of research.

The opportunity of transferring knowledge on water turbulence around boats and their impact on propellers and the stability of boat structures to urban wind turbines could be of great interest and should be assessed as part of further R&D effort.

[26] Solar Heat for Industrial Processes, joint IEA research task by SHC Task 33, Solarpaces Task IV, ESTTP focus group 2…

6.4.13 Opportunity analysis of accreditation of Belgian test lab

A number of European standards only require a notified laboratory to perform tests, where no certification institute is required.

Each Belgian test laboratory notified by the Federal Public Service "Economy, SMEs, self-employed and Energy" and accredited by BELAC is accredited to run the respective test standards (in some other countries there is no such prerequisite).

An opportunity analysis of the accreditation of a Belgian test lab was conducted, using the ARGB as test case for future certification of BES according to EN-13240.

Within the framework of Q-direct, ARGB was able to perform the tests on a pellet boiler for the first time. This broadened their testing horizon.

The concerned tests might also be helpful for ARGB to get accreditation to perform EN-303-5 tests and certification in future.

ARGB is currently notified and, as such, accredited by BELAC for:

- EN 12809:2001/A1:2004/AC:2007 : Residential independent boilers fired by solid fuel - Nominal heat output up to 50 kW - Requirements and test methods
- EN 13229:2001/AC:2006 : Inset appliances including open fires fired by solid fuels - Requirements and test methods
- EN 13240:2001/A2:2004/AC:2007 : Room heaters fired by solid fuel - Requirements and test methods.

No other Belgian test institute is notified for these tests standards.

Other standards from the same CEN Technical Committee CEN/TC 295 "Residential solid fuel burning appliances" are:

- EN 15250:2007 : Slow heat release appliances fired by solid fuel - Requirements and test methods
- EN 12815:2001/A1:2004/AC:2007 : Residential cookers fired by solid fuel - Requirements and test methods

Neither ARGB nor any other Belgian test institute is notified to run tests according to those standards.

- EN 14785:2006: Residential space heating appliances fired by wood pellets - Requirements and test methods.

This standard is not a harmonized standard; as such a test institute cannot be notified to run test according to this standard.

7 GUIDELINES FOR POLICYMAKERS

7.1 COMMON GUIDELINES

7.1.1 Ambition level

- Regional authorities should avoid developing their own, limited, quality scheme but should rather gather efforts and experiences in order to set up and operate a shared Microgeneration Quality Scheme at federal scale. The logical ad hoc structure to formalize such a scheme might be the CONCERE[27] group.

- A quality scheme with independent third party control and certification, based on specific references documents is recommended for five out of the six RETs.

It should rely on different types of commitments, corresponding to initial & future ambition levels:

- Generic commitment according to relevant standards, regulations and good practice;
- Specific commitment according to relevant standards, regulations and good practice;
- Specific commitment providing higher quality than required by existing standards and regulations.

- Planning regulation should be tackled to avoid such scheme being blocked by local objections.

- SWT should be handled differently as it is not covered by the EU RES Directive[28] since it is not regarded as a building integrated technology. A Quality chart with self-commitment and generic content is considered to be an acceptable initial ambition level for quality insurance and market stimulation of SWT, given its very low market penetration.

7.1.2 Standards

- Few representatives from the Belgian RE sector and energy administration are actively participating in any related EU standardization committees. If the professional sector and policymakers do not want to apply standards that are entirely defined by counterparts or international competitors, more means should be allocated to an active participation of Belgian stakeholders in RE standardization committees (Brussels is a central place for that kind of meeting).

- Standards are generally of voluntary application, but are considered as code of good practice in case of legal conflict. Some standards are also referenced in regulations and are then obligatory, such as some safety standards or the standard for residential ventilation (NBN D 50-001) which is part of the EPB regulation. Such mention of standards in a regulation is however quite limited for RET.

Policymakers should turn relevant standards into *strongly advisable* or *mandatory* requirements, in order to ensure well defined quality level of the product installed. STS (Unified Technical Specifications) seem to be the appropriate tool to do so.

STS may be legally binding and might refer to other quality tools such as:

- Technical Agreement at Belgian(ATG) or European (ETA) level for component – product – system – management process or person;
- Good practice codes for RET installers or designers;
- European certification process of products (Keymark, Eco-label…) or Installers, based on mutually recognized training courses;
- Quality labelling of Installers (as long as it does not go against free market directive and fair competition).

[27] Groupe de concertation Etat-Régions pour l'énergie

[28] VwHR is not covered by the EU RES Directive neither

7.1.3 Quality label

A quality label expresses a prominent distinction of its bearer from its competitors; it is therefore a strong promotion tool that should:

- Only be granted within a scheme that guarantees independent third party verification or certification in line with internationally recognized best practice.
- Be granted to individual (installers) rather than products, since the Belgian market is too small to enforce a national quality label for RE products
- Be available to qualified installers or system integrators, irrespectively of their region/country of registration;
- Guarantee the same quality to the end users in both regions;
- Provide technical reference documents and application procedures in each official language.

A national quality label for RET installers should rely on quality requirements based on appropriate technical references, with particular emphasize on:

- Conformity of components and products with international standards;
- Guarantee of performance and availability of components used;
- Regular training and third party certification of installers;
- On site inspections of systems in operation and quality/performance control.

Granting efficient quality labels requires an independent verification of the quality level of the participating companies or individuals. Such verification should contain repeated evaluation schemes and site visits of recent installations, along with installer training to ensure state of the art installation of the system.

7.1.4 Installers Certification

In the EU RES directive, launched as part of the EC's Energy Package for 2020, training and certification of installers are mandatory. In anticipation of the implementation of Article 14 of the Directive on the promotion of the use of energy from renewable sources, the QualiCert consortium is developing and validating a manual of key success criteria for accreditation & certification systems. Those aspects need to be addressed in the National Renewable Energy Action Plans that Members States have to submit to the European Commission by June 2010.

It is therefore strongly advisable for Belgium to be involved in the QualiCert initiative (see 6.4.2) through federal as well as regional entities. To date, the only governmental bodies represented in the QualiCert consortium are ENEA, ADEME, KAPE, The Flemish VEA and Brussels Environment. Coordinators of QUEST and Q-Direct are already involved in QualiCert workshops, but it might be worth having a representative of the federal government in the consortium.

7.1.5 Test institutes & certifying bodies

The opportunity to develop competency in Belgium regarding RET standards testing should be further investigated.

For BES, further development opportunities are:

- ARGB for BES performance test: ARGB has appropriate facility to perform testing required for EN-303-5 certification of a pellet boiler and might get the appropriate accreditation soon.
- CRA-G has appropriate facility and is certified by IS-17025 to perform testing on biomass fuels.

For other RET, the opportunity to develop such testing facilities in Belgium should be further investigated. Test Laboratory that should be considered more particularly is Elyosis (climatic room for solar collectors (ST & PV).

7.1.6 R&D

Research about new heat storage media should be heavily promoted since it would benefit several technologies for which energy storage is key, such as BES, HP for SHW and ST.

More research is also needed in the field of ventilation, especially to define the ventilation requirements in term of performance and indoor air quality, for example:

  - Better understanding of the real ventilation needs (based on occupation, materials emissions, etc.)
  - Identifying and taking into account for the differences of performance between different ventilation systems, in term of indoor air quality

- o Defining additional requirements for demand ventilation systems, such as the minimum flow rate during absence, the type of sensors, etc.

7.1.7 Regulatory activities & Public support scheme

- More attention should be given within the mandatory EPB framework to 'as built' quality of any RET. This was already introduced to some extent but should be better used by system designers to lower E-levels along with their installations.

- Financial support schemes to RETs are nearly always regional ones[29], with no consideration for requirements made by other regions. Beside those schemes, some municipalities and provinces give additional incentives. On top of that, the federal government is giving tax credits to a range of energy efficiency investments, including most of the reviewed RETs. Last but not least, distributed energy resources (DER) (PV, SWT) benefit from Green Certificates that are calculated and issued following four different methods.

This mix of financial support in such a small market results in:

- Very high global support level (up to 90% and sometimes significant financial gains through GCS), turning some DER into attractive financial products;
- Plenty of RET suppliers and installers with variable levels of skills;
- Growing number of end users with variable ability to assess the quality of a product or a commercial offer;
- Heavy administrative procedures not ensuring minimal quality level of the installed system;
- Virtual impossibility to link regional subsidy to a voluntary, flexible and evolving quality scheme if the scheme's requirements have to be written down in laws or decrees
- …

- The federal tax credit mechanism seems to be the easiest way to make a voluntary quality scheme attractive for both installers and users; by making the fulfilment of the scheme's requirements a precondition to benefit from tax credit or itemized deduction.

Such link with a federal tax credit scheme should foresee:

- Continuous evolution of the quality scheme following technological innovations and market demand;
- independent third party accreditation of RET installers, according to article 4 of EU RES DIR;
- possible references of the scheme to sound normative tools, standards, technical specifications or labels

This opportunity will be further investigated in the second phase of the project, in particular the risk of such link being challenged by EU institutions or by foreign manufacturers, suppliers or installers.

- The impact on quality of the Walloon solar obligation for new and refurbished buildings should be further investigated as it is dramatically changing market dynamics, any building enterprise being forced to install solar thermal systems on several building types, according to EPB regulation. In the Flemish region, politicians also talk about obligations to install SDHWS.

7.2 TECHNOLOGY-SPECIFIC POLICY RECOMMENDATIONS

7.2.1 BES

- The *easiest* quality requirements for policymakers to implement in Belgium regards the system design, in order to fulfil quality requirements as defined in EN standards. Indeed, system design requirements could be the same all over Europe since common basic principles underlies this technology. As long as the system design meets EN standards, each system is supposed to be reliable and authorized all over the EU.

- An equivalent label to the existing Optimaz label for oil fired residential boilers - warranting an efficient and low emission operation at the boiler's place of use – might be an option for quality labelling of BES. Such quality label would be a plus, being stricter than the relevant EN Standards (EN 303-5), then promising better efficiency and lower emissions.

- The *most important* quality requirements for policymakers to implement in Belgium concerns the set up of minimum requirements for BES installers to be certified by an independent body, since a state of the art quality installation has a great effect upon the overall system efficiency and durability. Installation

[29] their requirements are usually based on those of the Region

requirements might be influenced by local architecture, climate, geography… Any training scheme should therefore include joint (EU) technological parts and specific/local parts prescribed by Belgian policymakers.

- Installer certification is also the most urgent quality requirements for policymakers to implement in Belgium since Belgian BES market is growing very fast (with 83.5 MW, residential heat generation from biomass was 18 times higher at the end of 2007 than in 2004 - 4.7 MW- in Wallonia), while it remains difficult to find skilled installers on this market.

- DINplus certified and/or prEN-14961 equivalent wood pellets could be recommended as standard pellet fuel to be used for residential heating purposes in Belgian situation, as DINplus certified pellets are the stringent, predominating pellet on the Belgian market, showing good reputation and characteristics close to pr-EN14961.

- Keeping harmonized/common EU standards seems important for the biomass industry as they limit the associated costs and expenses for authorisation procedures.

On the other hand, local circumstances may require much more severe standards, as would be required under common circumstances. Hence, harmonisation should preferably cover procedures and classes of requirements.

- The use of a Lambda probe is recommended for optimal regulation of residential pellet boiler in order to ensure the highest combustion efficiency and associated performance

- A binding standard should be written to specify acceptable / maximum sound emission level of BES at national level.

7.2.2 HP

- The European quality scheme for heat pumps might be implemented in both Regions (Flanders, Walloon and Brussels), as the EC launched:

  - A 'Certificate for Heat Pump Installer'
  - An Eco label for Heat Pump units and systems
  - An energy efficiency label for domestic air-conditioners (A… G)

- At least one of the Regions should become partner of EU-CERT.HP initiative and take the necessary steps to implement EU certifying training program for HP installers. The content might be based on the training courses initiated by the Austrian Heat Pump Association[30]

- Belgium representative(s) should be involved in the IEA Heat Pump Program (HPP), aiming at developing and disseminating information to achieve environmental and energy efficiency benefits through deployment of appropriate high-quality heat pump, refrigeration and air-conditioning technologies[31].

- Some reference documents currently only available in Dutch should be translated in French:

  - the feasibility test (Excel sheet on www.ideg.info/media/docs/CvGP-WP_v1-0.xls);
  - The code of good practice for HP applications in the housing sector;
  - standard specifications sheet & tender documents (www.ideg.info/media/docs/Bestek_wp.doc)

7.2.3 VwHR

-The most important requirements in order to improve the overall quality of VwHR are:

  - With regard to products: requirement that the components are tested according to harmonized European standards to make sure that comparable data are available to the market (eg a clear definition of AHU performance in the framework of EPB regulation)
  - With regard to the design of the ventilation systems: The available information, among other in the large standard framework related to ventilation, should be translated into more practical tools, especially adapted for small scale applications. The installers need some design tools to dimension the ductwork and select the components.
  - With regard to installation: standard methodology for commissioning should be available (e.g. for the setting and the measurement of the flow rates).
  - The quality of the installer trainings should be improved

Moreover, a long term strategy to improve the quality of ventilation systems could be drawn as following:

  - Ventilation basic requirements. This first part concerns the basic requirements for ventilation in terms of Indoor Air Quality. These requirements are currently expressed in terms of a minimum required design flow rates and are part of the EPB regulation (NBN D 50-001). However, the

[30] http://www.arsenal.ac.at/products/products_schulungen_wärmepumpen_en.html

[31] http://www.heatpumpcentre.org/default.asp

definition of these requirements in the regulation should be improved for several points such as: equivalence of the indoor air quality between the different authorized systems, additional requirements for demand ventilation systems, definition of the requirements in terms of performance rather than in a descriptive manner, balance between supply and extraction, interaction between ventilation and building envelope air tightness, etc. These improvements should be kept in mind for further development of the ventilation standards and regulation in Belgium.

- Performance of ventilation systems. This part concerns the performances of the ventilation systems in terms of acoustical comfort, thermal comfort, energy consumption, ease of maintenance, etc. There is a need of performance requirements as well as of technical solutions to be used by the installers for each step of its work (design, dimensioning, installation, commissioning, and maintenance). These technical solutions should be available for the installer as code of good practice or manuals.
- Quality assurance of the installers and/or installed systems. Finally, in order to assure the quality of the final installed systems, certification or control procedures should be implemented at least at the level of the installer, or even at the level of each installation.

7.2.4 ST

- The most important quality requirement to set at each level of the market chain in order to improve the overall quality of the SDHWS as a whole was found to be:

- Component: improvement of long term air-tightness of evacuated-tube collector. Pre-insulated pipes for the solar loop;
- Product: pre-designed solar tank including solar station, pipe fittings…
- System: generalisation of the solar keymark for the solar systems
- Installation: differentiated certification scheme for roof tilers and heating installers;
- Operation: use of integrated performance control device (recording calorimeter) for accurate monitoring and default detections;
- Maintenance: use of commissioning and maintenance check-list. Regular maintenance to prevent solar output reduction

- A minimum performance requirement for solar collectors under standard test conditions (as in the Blaue Angel quality label) might easily be enforced by policymakers. Such criteria might be additional to the solar keymark.

On the other hand, the end-user usually wants to have an idea of the average output of his/her own very system. This might be assessed in particular by CTSS[32] simulations, but cannot be enforced with a threshold value as minimum level quality requirement since the performance of a SDHWS in operation is strongly influenced by the day-to-day hot water consumption of the end-user.

- A working certification scheme for SDHWS installers is one of the most important requirements to implement by policymakers. Such scheme should:

- Work at individual level (as opposed to company level);
- Be based on expected background qualifications: distinct training and requirements for roof tilers than for heating engineers.

- A minimum monitoring function of the operation and overall performance of domestic systems is urgently required in order to enable the end user to check the proper operation and expected output of his SDHWS.

- At regional level, there is a need:

- To fit quality requirements associated with the Walloon Soltherm subsidy to current market situation and further technical evolution (combi systems, combined BES/SDHWS, combined HPST for building heating and SHW...)
- To extend quality requirements for SDHWS and related certifying training scheme to other regions and further harmonize criteria between both regions.

7.2.5 PV

- If regional and national authorities want to support the international role of the Belgian PV industry, a support for participation in international standardisation activities may be considered, in consultation with the PV sector.

[32] Component Testing and System Simulation (approved methodology)

- European, regional and federal Policy should strive for a harmonisation of requirements for electrical safety and PV grid connection. This should cover the required safety and control functions but not necessarily fix the required set points for such functions. Regarding those specific set points, an agreement at federal policy level should be pursued.

- As for grid connection, Distribution System Operators in different regions still interpret the existing regulations differently. As a consequence, different rules for grid connection apply according to the region.

- In the long run, harmonisation of standards is needed to reduce costs and expenses for authorising procedures. On the other hand, local circumstances may require much more severe technical requirements. Therefore, harmonisation of standard should cover procedures and classes of requirement rather than specific values.

- State of the art technical reference guides for quality PV exist in Belgium, as well as quality label or charts [PVqual, QUEST…]. Those are not universally applied or controlled. System integrators experienced a lack of practical skills among installers rather than a lack of good practice references. Therefore, policymakers should:

- Fully support ongoing initiatives to improve quality references and implement Belgian quality scheme and related quality controls. This should better happen in a coordinated way between regions, for the sake of the market.
- Make training of PV engineers and installers a priority. In each Region. Certifying training programmes based on international good practice manuals should be available for active professionals, students of professional education and of higher education.

7.2.6 SWT

- Regional Policy makers should set up a clear legal framework on the mounting of SWT in urban zones (see 6.3.8); the authorization procedure is of particular relevance in that regard.

- Financial incentives as multiplier factor for SWT green certificates and tax credit should be considered for "mature" product, based on the following criteria:

- Turbine design in compliance with the IEC 61400-2 standard
- Third party certified power curve
- Proven track record if several tens of units in operation for several years
- Cost Price in the 2500-3000 €/kW range

While some products meet all those criteria, the vast majority of available urban turbines don't. Especially the first and second criteria should be met, since they are the ones that assure the investment eventually pays off.

- BMWT manufacturers should be required to provide the information needed for a structural analysis of the building.

7.2.7 Grid integration PV / SWT

- In accordance with the grid code of the regulators, each PV system must be inspected by an accredited body to certify its conformity with the AREI.

- Grid connection must also be checked by a third party accredited by the DSO, as the use of PV panels for example entails a substantial modification of the electricity installation.

- There are no specific AREI rules re protection of electrical devices in case of decentralized production. PV-specific guidelines for the installation practice are standardized in IEC 60364-7-712. For the overall electrical installation including the PV part, the general AREI rules apply. It is strongly recommended to check the installed wiring and protection fuses/switches during commissioning of the installation.
- The opportunity to combine the existing compliance/security control by an accredited body with a standardized quality installation inspection by the same party should be explored.

- Firm measures to reform the grid distribution system are highly necessary so it can accept feeds from a large number of tiny generators, such as:

- Field demonstration should be organized in the short/medium term (4 years and beyond)
- Good practice guides and standards should be put into place in the medium term

- A nationwide geographical information system including data on local topography, building topology, morphology, orientation, height, wall construction and roof-type should be designed. Developing such a database would largely benefit solar PV, Solar Thermal and Urban Wind (building-mounted).