BELGIUM

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1 OVERVIEW OF THE REGION

Characteristics of the Region

On 1st January 2013, 11,082,744 people lived on the 30,528 km² of Belgian land, which comprises 3 Regions:

- Brussels Capital, the city of Brussels and its surroundings, 161 km² in which 1,147,043 people live;
- the Flemish Region, the 13,522 km² Northern part of Belgium, in which 6,376,425 inhabitants live;
- Wallonia, the Southern part of Belgium, slightly larger than the Flemish region (16,844 km²), with a population of 3,559,276. This is the Region of Belgium that this paper will focus on.

Belgium is composed of many levels of authorities, from the European level down to local ones. The federal state is governed by a federal government, competent in all matters of national (or partly national, partly regional) interests like defence, international affairs, social security, energy supply, economy, etc.

Many decisions have been delegated to regional levels of governance. Each Regional government is in charge of energy and environment matters, as well as housing, energy used in buildings, employment, transports, agriculture, public works, economic policy, trade, etc.

Belgium is furthermore divided into communities, provinces and municipalities; each has some level of decision-making authority. For instance, municipalities tend to local management and urban planning.

With regards to the economy in Wallonia:

- GDP reached €24,248 per capita in 2013 (National GDP per capita reached €32,697) (source: http://www.iweps.be).
- In 2012, unemployment reached 11.5% of the active population (15 to 64 years old people) (Forem, 2013).

Energy demand and supply of the Region

According to the "Institute for Advice and Studies on the Sustainable Development" in its 2010 energy assessment of Wallonia (ICEDD, 2011), the "energy autonomy" of Wallonia in 2010 reached a peak of 7.2% (see *Figure 1*), hardly considered very good. However, the tendency seems to be towards greater autonomy, thanks to the development of renewable energy production in Wallonia (see further developments below).

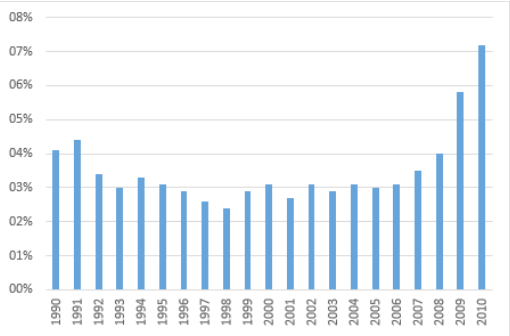


Figure 1 – Evolution of the Walloon energy autonomy (1990 – 2010) (ICEDD, 2011)

The numbers given hereunder come from the 2011 Walloon regional assessment (ICEDD, 2012).

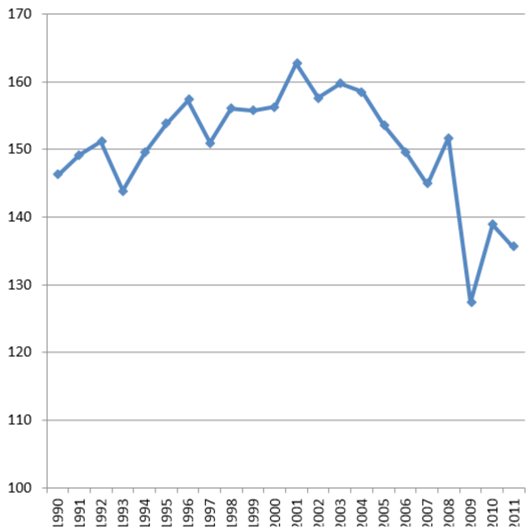


Figure 2 – Total energy consumption in Wallonia (1990 – 2011) (TWh) (ICEDD, 2012)

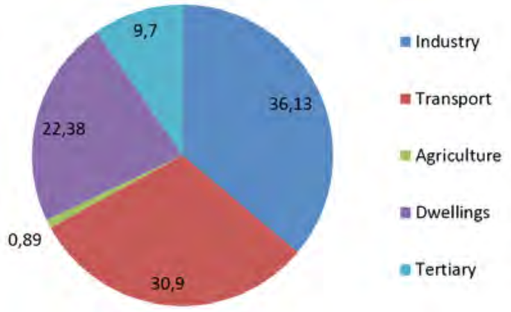


Figure 3 – Final energy consumption per sector in Wallonia in 2011 (%) (ICEDD, 2012)

The 2011 total final energy consumption is estimated at 135.4 TWh. When considering the sector repartition (*Figure 3*), the industry-related history of the Region is dominant (36.1%). As a consequence of the decline in industry there has been a sharp decrease in the total energy consumption from 2009 (visible on *Figures 2 and 4*) which can be explained by a disappointing steel industry, which has been through difficult times these past few years, which explains the Walloon achievement in meeting its Kyoto commitments. Since the beginning of the present century the transport sector (30.9%) has been outrunning the housing sector (22.4%) for second place, as visible in *Figure 4*.

The fuel repartition (*Figure 5*) is somewhat similar to most of western European countries, with a large part of the market shared by oil products (44.9%, including butane, propane and liquefied petroleum gas, or LPG), natural gas (22.2%) and electricity (17.8%).

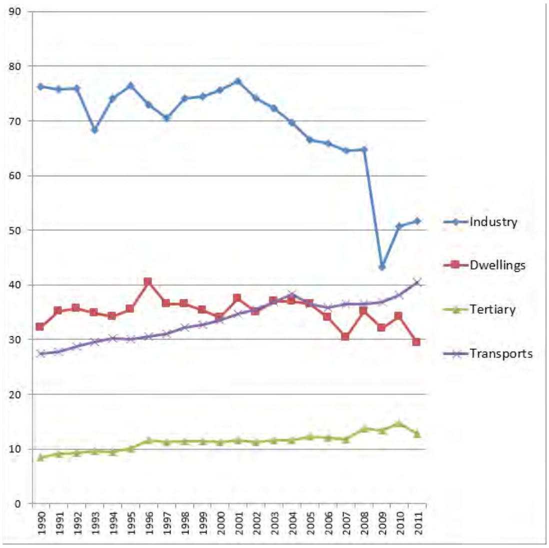


Figure 4 – Evolution of the total final energy consumption per sector in Wallonia (1990 – 2011) (TWh) (ICEDD, 2012)

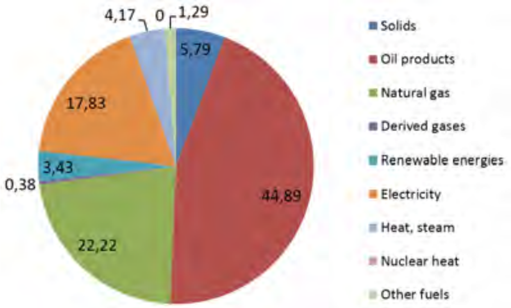


Figure 5 – Final energy consumption per fuel type in Wallonia in 2011 (%) (ICEDD, 2012)

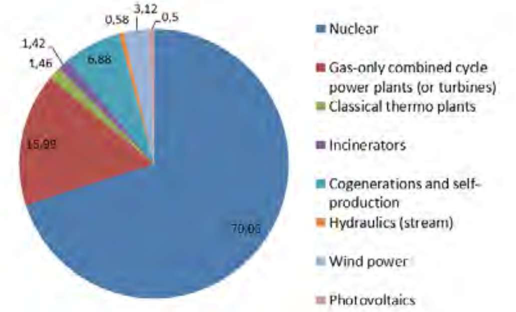


Figure 6 – Share of energy sources for electricity production in Wallonia in 2011 (%) (ICEDD, 2012)

The share of energy sources for electricity production (%) is shown in *Figure 6*. 70% is produced through nuclear processes.

The GHG emission factor for grid electricity that is used in the Walloon EPB calculations is 0.198 $kgCO_2eq$/MJ or 0.713 $kgCO_2eq$/kWhLHV (LHV = Lower Heating Value), characterising old charcoal power plants. However, other data could be considered (Energieplus, 2013):

- CWaPE (Walloon Commission for Energy): 0.456 $kgCO_2eq$/kWhLHV (but only combustion is considered here);
- Belgian production average factor: 0.29 $kgCO_2eq$/kWhLHV (summer off-peak hours: 0.264 $kgCO_2eq$/kWhLHV / winter peak hours: 0.335 $kgCO_2eq$/kWhLHV);
- France (Wallonia's main partner in electricity transactions) emissions factor, integrating the whole production cycle (extraction, transport, combustion and conditioning) (ADEME, 2013): 0.267 $kgCO_2eq$/kWhLHV[1].

In Wallonia, many companies are active in the production, operation, or maintenance of renewable energy specific components. By the end of 2012, there were 260 wind turbines on the Walloon territory, across 43 sites, generating 576 MW, providing 1,267 GWh (the equivalent electric consumption of 24% of the Walloon residential stock, around 362,000 households).

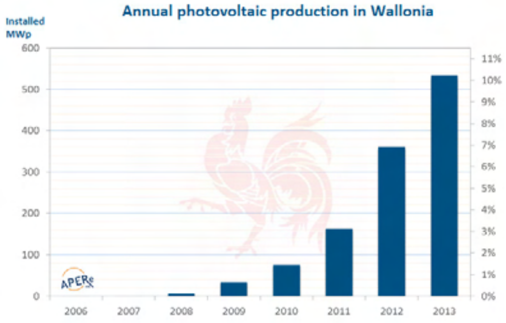


Figure 7 – Annual photovoltaic production in Wallonia (left scale: MWp installed; right scale: percentage of households' electrical consumption covered by photovoltaic installations).
Source: http://www.apere.org/index/node/134

For 2020, the Government plans to provide 1,180,000 households with 4,500 GWh of wind-produced electricity which would require the annual installation of 80 wind turbines, each with a 2.1 MW power at a cost a total of 2 billions Euros (source: Tweed cluster).

Solar energy is also a growing market for Walloon companies, including production or installation of panels or components, operation, maintenance and technological innovation. At the end of 2012, the total photovoltaic power installed in Wallonia reached 491 MWp (or 140 Wp per inhabitant), producing an estimated 6% of the Walloon residential electrical consumption (96,000 households – 337 GWh) (source: Tweed cluster).

Belgium is well known for its rainy weather and is covered in natural water streams, used to produce electricity from hydraulic installations. 106 sites were exploited by the end of 2012 (110 MW), producing an estimated 371 GWh of electricity, which is enough to supply 106,000 households. The very stable production is mainly located in Wallonia. 90 hydraulic power stations generate a total power of 109 MW for an estimated production of 367 GWh each year.

It is believed that, for Wallonia, biomass will be the renewable fuel that will most contribute to reach the 2020 objectives. In

2010, 5.5 TWh of energy used in Walloon households were produced by electric power plants using biomass (cogeneration or other), 0.2 TWh by biomethanisation, 1.5 TWh by domestic biomass fuels (pellets or wood fired boilers) and 1.9 TWh by biofuels. The total production represented 6.2% of the total final consumption.

There are 8 pellet producers in Wallonia, producing altogether 500,000 t/yr. It is far from sufficient in order to cover the total use, so that the major part is imported from Canada, East Europe, Germany and Austria (source: Tweed cluster).

2. CURRENT SITUATION: TARGETS RELATED TO ENERGY POLICY

The energy-related targets announced by the Walloon Government relate to three priorities:

- decrease consumption;
- develop renewable energies;
- make the energy market accessible and transparent.

Means of achieving these goals include:

- developing economic and financial tools, such as incentives, "green certificates" (the minimal guaranteed price at which a private "green" electricity producer can sell energy produced back to the grid) or collective agreements with low-energy industries and the tertiary sector;
- developing information tools, such as the Energy Performance Certificate (EPC) or advice services to the citizens;
- insuring the Energy Performance of Buildings regulations application;
- including energy management plans in environment permits;
- supporting flourishing sectors and investments in renewable sectors, to increase renewable energy sources.

As stated in the "Walloon Action Plan on Renewable Energies for 2020" developed by EDORA[2], the potential renewable energy consumption in 2020 could reach 11,232 GWh/yr for the electricity consumption (14,252 GWh/yr if offshore wind power production is considered), 14,207 GWh/yr for heating consumption and 3,210 GWh/yr for transportations, representing 18 to 20% of the total energy consumption, depending on the scenario considered (moderate or low energy demand) (EDORA, 2010).

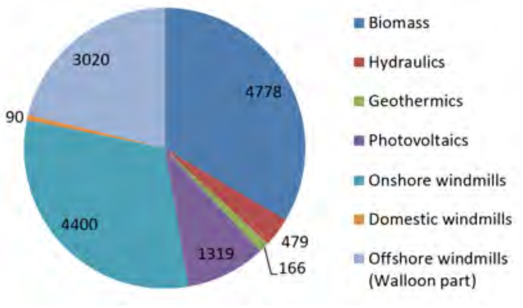


Figure 8 – Potential renewable energy sources capacity for Wallonia in 2020 (GWh) for a total of 14,252 GWh

Wallonia emitted 42,707 ktCO_2eq of GHG in 2010 (IWEPS[3], 2013), less than 80% of the 1990 emissions (54,707 ktCO_2eq) as illustrated in *Figure 9*.

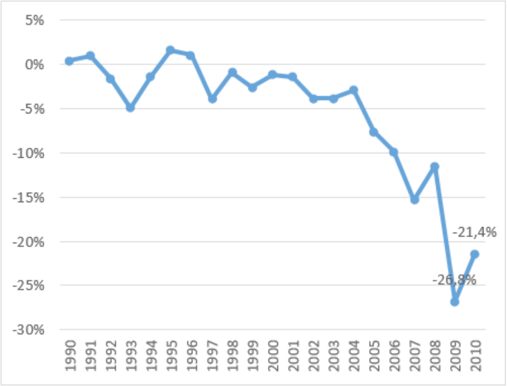


Figure 9 – GHG emissions in Wallonia between 1990 and 2010 (IWEPS, 2013)

The main reasons given for this reduction are:

- The closing of industrial plants, mainly in the steel sector;
- the increased use of natural gas and wood as fuels, in every sector;
- the improvement of processes energy efficiency;
- the decline of the agricultural sector;
- the recovery and valorisation of methane in waste treatment centres;
- the economic and energetic crisis of 2009 which led to more careful consumption. proved by the 2010 progressive rebound.

The repartition by sector is as follows (*Figure 10*)

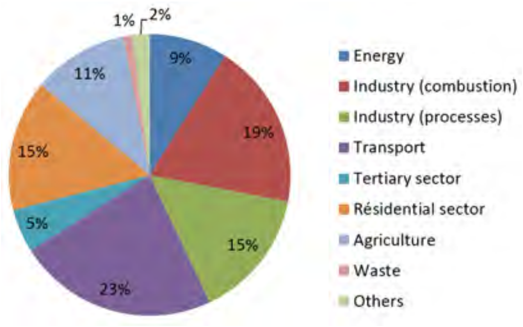


Figure 10 – Repartition of the 2010 Walloon CO_2 emissions per sector (AirClimat[4], 2012)

The Walloon Government is investigating the different scenarios provided by the European "Energy Roadmap 2050" (Europe, 2012), whilst keeping in mind the 2003 law and planning the end of nuclear production of energy (the current agenda foresees the progressive closing of the nuclear reactors between 2015 and 2025).

Wallonia has already decreased its GHG emissions by 21% between 1990 and 2011, reaching therefore its Kyoto objectives. It is believed (IWEPS, 2013) that in short term, the GHG emissions in Wallonia should reduce slightly and, with small adjustments, it would then be possible to reach a 30% decrease by 2020. In order to reach the 2050 objectives however, it will be essential to accelerate this tendency in order to reach a 4.5% annual decrease rate.

Here is a table summarising the Walloon objectives related to the CO_2 emissions, published in April 2013 by the Walloon Minister in charge of energy:

	1990	2010	2020	2050	
				worst	best
ktCO2eq	54707	42707	38295	10741	2735
%	100	78,06	70	19,63	5

Figure 11 – CO_2 emissions targets for 2020 and 2050, in Wallonia

It will be essential to target sectors that have been growing alarmingly in the past two decades: the tertiary sector (46% growth of emissions between 1990 and 2010), the transport sector (+43%) and the residential sector, which has not seen a large increase, but will not decrease as much as needed unless solid regulation for existing buildings is established. Hopefully, the new European "energy efficiency" and "renovation" Directives that are under transposal procedures will allow improvement in that sector.

Energy Performance of Buildings (EPB)
Several actions have been undertaken in Wallonia in order to make energy performance evolve through the years together with public awareness.

Wallonia was the first Belgian Region to adopt a thermal regulation for buildings in 1984, which was implemented in 1985.

Following the first EPBD Directive (2002-91-CE), a temporary (and simplified) calculation sheet has been available that allows architects, on a voluntary basis, to undertake an early evaluation of their clients' house performances, in exchange for advice and subsidies. Up to then, no calculation method took so many essential parameters of the overall performance into account in any Belgian regulation, enabling builders to consider insulation, air tightness, ventilation, solar gains, internal gains and systems efficiencies. This action ("Build with energy… naturally", funded in 2004 by the Walloon Region) stopped in 2012, when the EPB Directive was completely implemented.

In order to respect European targets, Wallonia is currently setting up a roadmap towards 2020 new "near zero energy buildings". One of the goals of the 2010/31/CE Directive was to link optimum energy performance levels with costs parameters and future energy requirements for new buildings. As a result, a "cost-optimum" study has been led in order to link optimum energy and cost performances for different buildings, and to check that the difference between Walloon EPB requirements and cost optimum is not greater than 15%. A similar study, targeting existing buildings, is also being carried out.

The Energy Performance Certificate (EPC), to include energy performance as a choice during the search for an existing dwelling, has been mandatory in Wallonia since 2010.

Finally the three Belgian Regions recently came to an agreement to implement together a unique Belgian environmental performance assessment referential for the certification of sustainable buildings ’Ref-b’, based on BATEX (see below), BREEAM (British certification system of sustainable buildings) and VALIDEO (a previous Belgian certification system for tertiary buildings created by the “Technical Control Bureau for Construction” (SECO) together with the Belgian Building Research Institute). ‘Ref-b’ certification method is currently at the end of the testing procedures, and awaits an official management structure before being released.

BATEX (for “BATiments EXemplaires” or “Exemplary Buildings”) is a subsidy system created in 2007 in the Brussels’ Region in order to develop and promote the exemplary renovation or construction of buildings, targeting both energy and environmental efficiency. In 2012, a “BATEX” action also began in Wallonia, with 23 residential projects including 49 dwellings granted 100 €/m^2 subsidy, and another action is set for 2013 – 2014.

Drivers and barriers

Subsidies can help raise community awareness on energy performance potential, along with other financial tools, which can be positive and popular (grants) or negative and unpopular (taxes). Wallonia provides subsidies in order to obtain energetic information by general audit, air tightness test, etc. or improve residential buildings’ energy performance through insulation, installation of highly efficient systems such as ventilation with heat recovery, condensing boilers, heat pumps or thermal solar panels for example. These incentives can be granted separately when needed, or be part of a new procedure such as ’Ecopacks’, where citizens can ask for a loan (0% interest rate, max. €30,000 for energy efficiency works + €30,000 for corollary works) for an efficient renovation of their dwelling. The capital to be reimbursed is equal to the loan, minus the incentives.

The industrial sector also has financial industry-wide agreements with the Wallonia Region since the 90’s, which includes the voluntary reduction of their energy consumption and GHG emissions. In this “win-win” situation, the Walloon Region obtains energy performance engagements (which results can be attained by any measure the industry sees fit), and the industries benefit by financial and administrative advantages from the Region.
In order to raise professional sector awareness, several continued training programs are available in Wallonia. For instance, the public institute for part-time professional training (IFAPME) organises continuous training sessions in various thematic seminars, such as EPB, for self-employed workers and workers from “small and medium-sized firms” with less than 50 employees. The Belgian Building Research Institute is also providing training and skills development sessions and evening sessions, as well as technical advice on construction sites, performance agreements and a wide variety of well informative publications on the subject.

3. CASE STUDY: SMART INCENTIVES FOR SMART ENVIRONMENT-FRIENDLY BUILDING SOLUTIONS

For several years, public awareness has been raised (willingly or not) towards both energy and environmental performance of dwellings. When building or renovating, how can smart choices be made, considering the plethora of available and rapidly evolving solutions? How can the energy administration influence the choice, towards smarter solutions, when the energy requirements and the financial parameters are also evolving fast?

Objectives and methods

A study was conducted in Wallonia, with a double objective:

- evaluate the pertinence of environmental performance requirements in the call for architectural projects (therefore going further than the regional energy regulations);
- assess the importance of a smart subsidy policy in the development of environment friendly building solutions;

This raised several questions: what could be the reasonable limits, when going beyond the regional regulations, as far as environment and energy are concerned? Is it possible to point out one unique solution that would be the best compromise on several levels (performance, costs, techniques and environment)? Can all these requirements be summarised in only one CO_2 criterion? And, most importantly, is the subsidy policy (federal, regional, municipal) adapted to the overall environmental performance target?

The house for the study (see *Figure 12*) was selected to be statistically representative of the newly built Walloon housing stock on several parameters: an isolated rural house, with an average heated floor area (Ach= 178 m² here), protected volume (Vp= 551 m³ here), thermal loss envelope area (AT= 408 m² here), compactness (C= Vp/AT = 1.35 m here), proportion of windows, orientations, etc.

Recent studies show that this kind of private housing estate represents around 13% of the houses built before 1991 (Monfils, 2013). According to 2012 national statistics (statbel, 2013), around 35% of the 2012 Walloon dwellings were four-façade single-family houses. These two numbers alone enlighten the new building tendencies to detached houses.

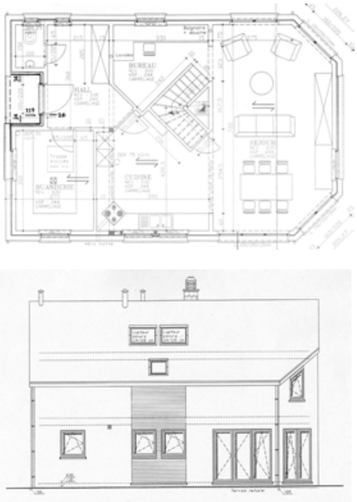
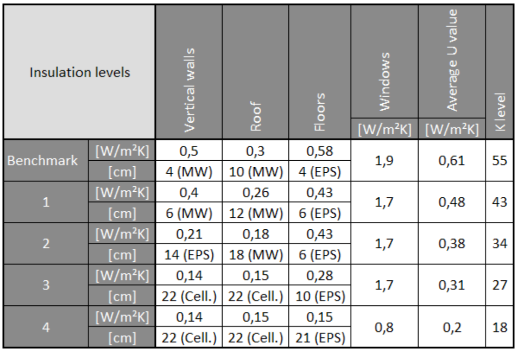


Figure 12 – Ground floor plan and South façade of the representative one-family house

In order to define the best solution(s), performances had to be assessed for different versions of this house, each with a different, but technically relevant, combination of insulation levels, air tightness performance, ventilation systems, energy vector, heating systems, domestic hot water systems and eventual renewable energy production systems. The different versions were then assessed on energy, environmental and financial performance levels and compared with a benchmark, the "basic" case.

Five different levels of insulation, identifiable by the K indicator (translating the overall level of thermal insulation, depending also on the compactness of the building; the lower the K-level, the better insulated the building) were tested. The benchmarking level (K55) just respected the energy regulation of 2007, when the study was first conducted. The actual maximum K-level is set at 35. The highest level (K18) reaches "passive" standard (0.15 W/m²K for opaque walls, and 0.8 W/m²K for windows).



Insulation levels		Vertical walls	Roof	Floors	Windows [W/m²K]	Average U value [W/m²K]	K level
Benchmark	[W/m²K]	0,5	0,3	0,58	1,9	0,61	55
	[cm]	4 (MW)	10 (MW)	4 (EPS)			
1	[W/m²K]	0,4	0,26	0,43	1,7	0,48	43
	[cm]	6 (MW)	12 (MW)	6 (EPS)			
2	[W/m²K]	0,21	0,18	0,43	1,7	0,38	34
	[cm]	14 (EPS)	18 (MW)	6 (EPS)			
3	[W/m²K]	0,14	0,15	0,28	1,7	0,31	27
	[cm]	22 (Cell.)	22 (Cell.)	10 (EPS)			
4	[W/m²K]	0,14	0,15	0,15	0,8	0,2	18
	[cm]	22 (Cell.)	22 (Cell.)	21 (EPS)			

Figure 13 – Insulation levels considered (MW = mineral wool; EPS = expanded polystyrene; Cell. = cellulose wool)

Three different values for the *air tightness* (v50, the air leak-flow per m² of thermal loss surface, with a 50 Pa of pressure difference between inside and outside) were considered: 12 m³/h.m² (regulatory by-default value), 4 m³/h.m² (level 1) and 0.8 m³/h.m² ("passive" level 2).

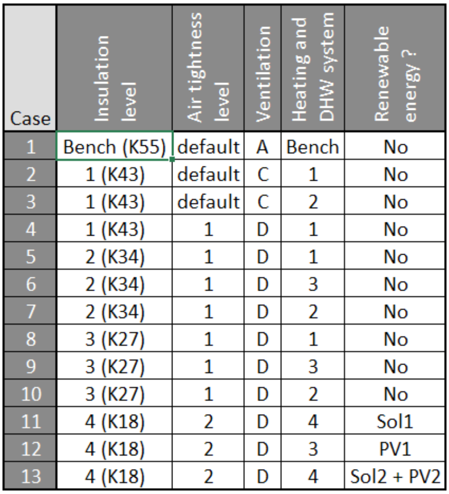
The three main types of ventilation systems have been selected: a completely natural ventilation system ("A", for the benchmark case only), a semi-mechanical "single flux" system ("C", with exhaust fans) and a complete mechanical "double flux" system ("D", with supply and exhaust fans, and a heat recovery unit).

Natural gas, often unavailable in isolated areas dictated the choice of *heating and domestic hot water (DHW) production systems,* as follows:

- benchmark case: low temperature oil-fired boiler.
- system 1: condensing oil-fired boiler.
- system 2: wood-fired (pellets) boiler.
- system 3: ground-water heat pump.
- system 4: for "passive" housing only, a pellet-fired stove for heat production, coupled with an electric boiler for DHW production.

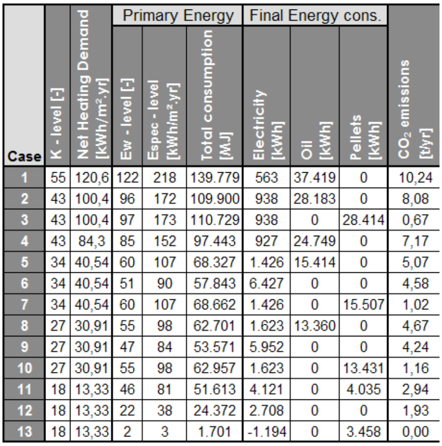
In 3 cases, we have added *renewable energy* production systems: South oriented thermal solar panels to help heating DHW (Sol1: 4 m²; Sol2: 6 m²) and/or South oriented photovoltaic panels for electricity production (PV1: 2.1 kWp; PV2: 4.2 kWp).

Figure 14 summarises the parameters combination for the 13 studied cases, with energetic results presented in *Figure 15*, as given by the Walloon EPB regulation calculation method. The Ew level [-] translates the level of performance, where the primary energy consumed by the building (as built) is compared with the primary energy consumed by a same building equipped with standard systems (the current target is Ew= 80, meaning that the actual building's performance has to be at least 20% better than the standard building's). The Espec level [kWh/m².yr] gives information on the specific primary energy consumption by square meter of heated floor area (the maximum is currently set at 130 kWh/m².yr).



Case	Insulation level	Air tightness level	Ventilation	Heating and DHW system	Renewable energy ?
1	Bench (K55)	default	A	Bench	No
2	1 (K43)	default	C	1	No
3	1 (K43)	default	C	2	No
4	1 (K43)	1	D	1	No
5	2 (K34)	1	D	1	No
6	2 (K34)	1	D	3	No
7	2 (K34)	1	D	2	No
8	3 (K27)	1	D	1	No
9	3 (K27)	1	D	3	No
10	3 (K27)	1	D	2	No
11	4 (K18)	2	D	4	Sol1
12	4 (K18)	2	D	3	PV1
13	4 (K18)	2	D	4	Sol2 + PV2

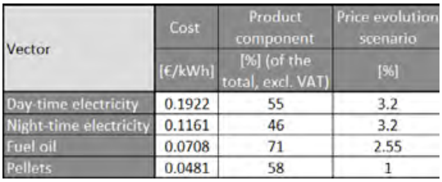
Figure 14 – Parameters combination for simulated cases



Case	K - level [-]	Net Heating Demand [kWh/m².yr]	Primary Energy			Final Energy cons.			CO₂ emissions [t/yr]
			Ew - level [-]	Espec - level [kWh/m².yr]	Total consumption [MJ]	Electricity [kWh]	Oil [kWh]	Pellets [kWh]	
1	55	120,6	122	218	139.779	563	37.419	0	10,24
2	43	100,4	96	172	109.900	938	28.183	0	8,08
3	43	100,4	97	173	110.729	938	0	28.414	0,67
4	43	84,3	85	152	97.443	927	24.749	0	7,17
5	34	40,54	60	107	68.327	1.426	15.414	0	5,07
6	34	40,54	51	90	57.843	6.427	0	0	4,58
7	34	40,54	60	107	68.662	1.426	0	15.507	1,02
8	27	30,91	55	98	62.701	1.623	13.360	0	4,67
9	27	30,91	47	84	53.571	5.952	0	0	4,24
10	27	30,91	55	98	62.957	1.623	0	13.431	1,16
11	18	13,33	46	81	51.613	4.121	0	4.035	2,94
12	18	13,33	22	38	24.372	2.708	0	0	1,93
13	18	13,33	2	3	1.701	-1.194	0	3.458	0,00

Figure 15 – Energy and environmental performance results for each modelled case

The focus has now to be put on investments, incentives and costs. Energy costs are calculated with estimated consumptions and recent energy prices:

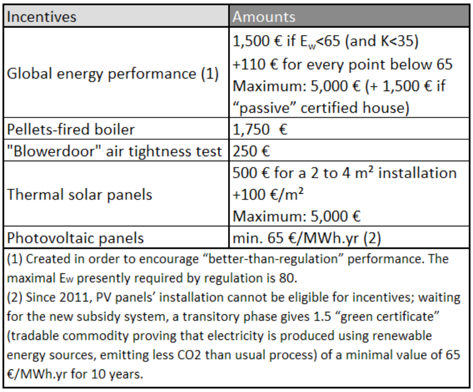


Vector	Cost [€/kWh]	Product component [%] (of the total, excl. VAT)	Price evolution scenario [%]
Day-time electricity	0.1922	55	3.2
Night-time electricity	0.1161	46	3.2
Fuel oil	0.0708	71	2.55
Pellets	0.0481	58	1

Figure 16 – Energy prices evolution

The “overinvestment” exceeding the threshold investment required to build the benchmark house will be taken into account (*Figure 18*): additional insulation, extra cost of higher air tightness performance, ventilation system upgrade cost, alternative heating and domestic hot water production system(s) costs, and eventual renewable energy production systems.

Financial incentives are obviously a big part of making performance choices. The actual financial incentive that exists when a building is built or renovated can contribute in choosing a solution instead of another one.



Incentives	Amounts
Global energy performance (1)	1,500 € if E_w<65 (and K<35) +110 € for every point below 65 Maximum: 5,000 € (+ 1,500 € if “passive” certified house)
Pellets-fired boiler	1,750 €
"Blowerdoor" air tightness test	250 €
Thermal solar panels	500 € for a 2 to 4 m² installation +100 €/m² Maximum: 5,000 €
Photovoltaic panels	min. 65 €/MWh.yr (2)

(1) Created in order to encourage “better-than-regulation” performance. The maximal Ew presently required by regulation is 80.
(2) Since 2011, PV panels’ installation cannot be eligible for incentives; waiting for the new subsidy system, a transitory phase gives 1.5 “green certificate” (tradable commodity proving that electricity is produced using renewable energy sources, emitting less CO2 than usual process) of a minimal value of 65 €/MWh.yr for 10 years.

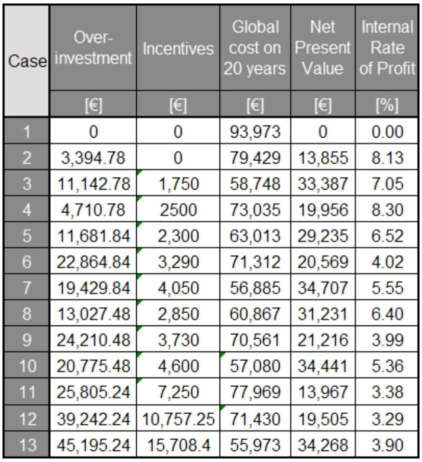
Figure 17 – Considered incentives

The parameters of the economic study for the different cases are presented below:

- use (and loan) duration: 20 years;
- rate of inflation: 1.5%;
- interest rate for mortgage loan: 3.7%;
- VAT for pellets: 6%;
- VAT for any other energy fuel: 21%;
- discount rate: 3.5%.

The first step of the economic study is to define energy prices during those 20 years, and to calculate corresponding energy bills which can be compared to the benchmarking bills. Then, the ‘Net Present Value’ (NPV) calculation method is used in order to evaluate whether the savings were worth the initial investments, taking incentives and energy bills into account. When the NPV is positive, the investment is profitable, which is validated by the calculation of the internal rate of profit (IRP, the discounting rate for which NPV is null). When the IRP is lower than the discounting rate (which is fixed at 3.5% here), the investment is not profitable (more funds would be raised in the bank, with a 3.5% interest rate).

NPV and IRP results are given hereunder for each project option over a 20 year period:



Case	Over-investment	Incentives	Global cost on 20 years	Net Present Value	Internal Rate of Profit
	[€]	[€]	[€]	[€]	[%]
1	0	0	93,973	0	0.00
2	3,394.78	0	79,429	13,855	8.13
3	11,142.78	1,750	58,748	33,387	7.05
4	4,710.78	2500	73,035	19,956	8.30
5	11,681.84	2,300	63,013	29,235	6.52
6	22,864.84	3,290	71,312	20,569	4.02
7	19,429.84	4,050	56,885	34,707	5.55
8	13,027.48	2,850	60,867	31,231	6.40
9	24,210.48	3,730	70,561	21,216	3.99
10	20,775.48	4,600	57,080	34,441	5.36
11	25,805.24	7,250	77,969	13,967	3.38
12	39,242.24	10,757.25	71,430	19,505	3.29
13	45,195.24	15,708.4	55,973	34,268	3.90

Figure 18 – Financial results for each project option, incentives included

Results

In the following graphs (*Figures 19 to 21*), each dot is referring to a case study, listed in the tables above. The green dotted lines represent the current new buildings energy requirements: Ew,max= 80 and Espec,max= 130 kWh/m².yr.

The *Figure 19* compares the Espec levels of each case with its CO_2 emissions. It shows that, beyond the obvious necessity to raise insulation levels in order to reach an optimal solution, the best results are awarded to models using a pellet-fired boiler for heating and DHW production. The 12th case is also part of these best solutions, thanks to the renewable energy production systems.

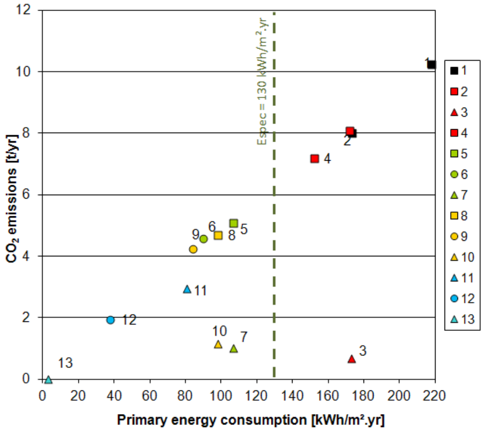


Figure 19 – Results comparison of the different

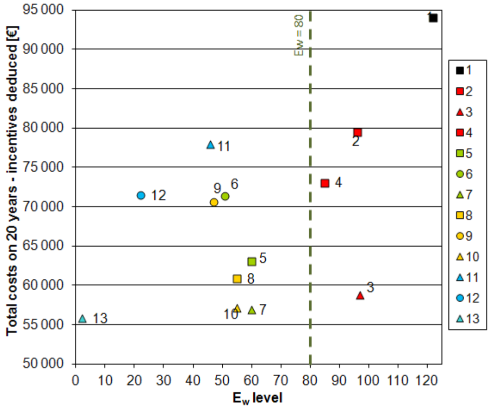


Figure 20 – Comparison of the financial (incentives included) and energy results of the different cases

The *Figure 20***,** comparing Ew levels and total costs on 20 years (incentives not included), shows that the cases that barely respect the insulation requirements (n°5 to 7) are not always the ones that cost the most after 20 years; an explanation could be found in lower overinvestment costs, in spite of the fact that energy bills are higher (and keep growing every year). Should this study be undertaken over a 30, 40 or 50 years span, global cost would have outgrown those of the more efficient – but more expensive – solutions.

Figures 21 and 22, comparing the Ew levels and NPV results for each cases, show that some solutions see their ranking drop when the financial incentives are not taken into account.

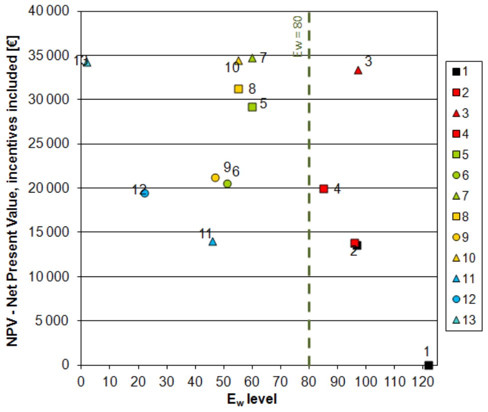


Figure 21 – Comparison of the results of the different cases: NPV (incentives included) vs energy (Ew level)

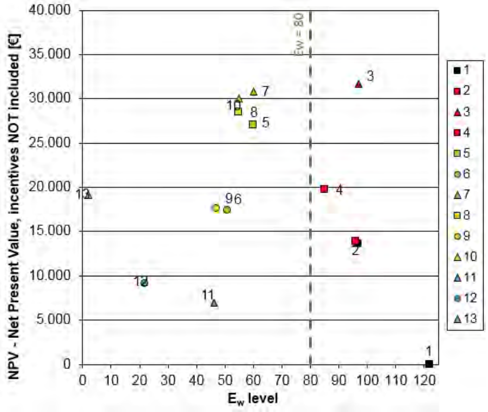


Figure 22 – Comparison of the results of the different cases: NPV (incentives NOT included) vs energy (Ew level)

For instance, the best incentives-included solution is the 13th, i.e. the highest efficient solution, which drops to the 6th best place when the financial grants are excluded, with lesser insulated models becoming more prominent (K43, K34 or K27 alike). The use of a pellet-fired boiler seems then to be the best solution, as a result of a combination of incentives, lower energy price evolution rate and lower VAT for pellets. On the other hand, heat pump solutions (n°6, 9, 12) were not identified as a strong solution as a result of higher investment costs, the absence of incentives and less advantageous use of electricity in the EPB calculations.

Financial incentives seem to allow highly efficient (but otherwise expensive) solutions, which allow the growth of sales, leading to ultimately lower prices and market opening for the product.

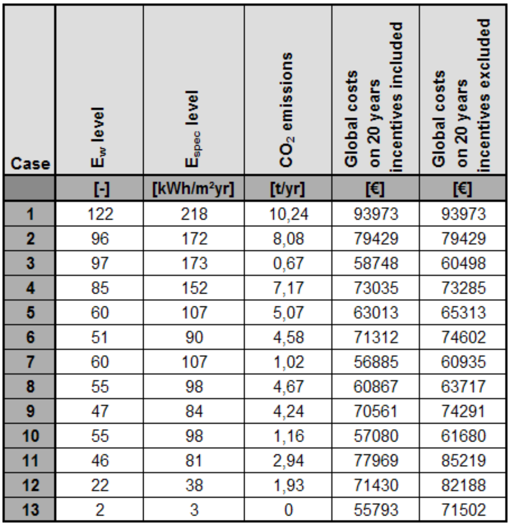
The influence of financial incentives is also visible in solar panel solutions: thermal solar panels receive less funding than photovoltaic panels. Consequently, solution number 11 (with 4 m² of thermal panels) is lower ranked than solution 12 (with 2,100 Wp of PV installations) or 13 (with 6 m² of thermal solar panels, but also 4,200 Wp of PV installations).

Given what has been said before, one can wonder why a clearer distinction between different insulation levels cannot be seen in the financial graphs. For instance, it is hard to point out a significant financial difference between solutions 3, 7 and 10, mainly differentiated by their insulation levels. The different ventilation systems and the grants available mainly explain the small gaps. This concludes that the current incentive system does not insist enough on the importance of insulation in the search of a better energy efficiency.

The conclusions drawn above regarding the financial incentive could be drawn from the NPV results. As far as the energy performance results are concerned, the obvious best solutions are options 11, 12 and 13, where the envelope performance is improved to the passive standard, and efficient systems are installed.

When considering the CO_2 emissions however, the best solutions are the ones using pellets for energy vectors (solutions 13, 3, 7, 10 and 11 are five of the top six), closely followed by the ones using electricity through heat pumps (solutions 12, 9 and 6 are the other three solutions of the top eight).

The overall aim of this study is to compare the energy and environmental performance results with economic and financial ones, to identify a "dominant" solution, if it exists. A dominant solution is hereby defined as a studied scenario (or combination of technical options) for which each performance result surpasses the same performance result for every other solutions. The following table (*Figure 23*) summarises the results obtained for each solution.



Case	E_w level	E_{spec} level	CO_2 emissions	Global costs on 20 years incentives included	Global costs on 20 years incentives excluded
	[-]	[kWh/m²yr]	[t/yr]	[€]	[€]
1	122	218	10,24	93973	93973
2	96	172	8,08	79429	79429
3	97	173	0,67	58748	60498
4	85	152	7,17	73035	73285
5	60	107	5,07	63013	65313
6	51	90	4,58	71312	74602
7	60	107	1,02	56885	60935
8	55	98	4,67	60867	63717
9	47	84	4,24	70561	74291
10	55	98	1,16	57080	61680
11	46	81	2,94	77969	85219
12	22	38	1,93	71430	82188
13	2	3	0	55793	71502

Figure 23 – Comparison of the results of the different cases: energy performance (Ew and Espec levels), CO_2 emissions and global costs (including or excluding incentives)

If financial incentives are included, global costs for 20 years follow more or less the energy performance results. As stated before, it is clear however that heat pumps are expensive and are not financially supported, whilst pellet users can still enjoy economic and financial advantages of this energy vector. Therefore, the dominant combination seems to be the 13th, the "near zero energy building", allying high energy and environmental performances, and best financial investment over 20 years. Excluding financial incentives, solutions using pellets-fired boilers (solutions 3, 7 and 10) become the best option.

When financial measures are excluded, results seem to shift from the energy performance: for example, best solution (number 13) drops to the 5th place when financial incentives are excluded. As a general rule, "technological" solutions are more sensitive to the incentives: though crucial for a global performance, insulation still seems "under-granted".

4. OUTCOMES AND CONCLUSIONS

This study was first conducted when the EPB calculation method was not implemented yet in Wallonia. Since then, the results of every study made in the EPB context are used in order to upgrade the method when needed. This study allowed the assessment of available technical combinations in order to reach regulatory energy requirements; these combinations have since been used in a "sensitivity study" in the "Build with energy… naturally" action (see above).

However, in these times of fast evolution of the building regulations and technical development, building sector stakeholders become concerned, because of the economical and financial consequences that tend to diminish young households' access to dwelling construction. Although smart energy solutions exist, they are not always obvious or affordable to private investors for retrofit or new build. This study aims at the smartest decision-making on a multi-criteria basis including energy, environment and economics, which is at the centre of the consultation initiated in Wallonia, including the financial actors (banks).

This study shows how financial parameters, such as VAT and policy incentives, can open markets to efficient technology, influence choices and, mostly, help make "good" decisions at a given time. Therefore, one great outcome has been and will still be its use in the "Near Zero Energy Buildings" and "Cost Optimum" studies foreseen by the European Directives, introducing cost and economic reality in the energy requirements. In that context, the economic calculation method and tool created here proved to be very useful.

This study shows that, at a given time, when considering long-time investments, environment can be a relevant criterion to seek the smartest solution. Actual financial incentive policies mainly target energy performance, but this study shows that, in order to reach environmental performance, smart development should focus on granting solutions that also allow the reduction of GHG emissions.

Dissemination of results

The study and its results could be widely used, at least to the whole Walloon Region, if adjustments were made for example, the availability of natural gas systems in urban areas could change the whole ranking. According to regional statistics (Statbel, 2013), there is an annual 0.7% construction rate of new residential buildings in Wallonia, the potential of a set of best choices in terms of energy performance, environment and finance can be seen. The results have been communicated to the regional energy Administration who became a stakeholder, and through building sector training.

The technologies and construction works considered here are quite common, so that this study would be easily transferable to other regions calculation methods, regulations and economic situations. Adaptation to other regional specific economic and financial policies on energy performance could influence the rankings.

FOOTNOTES

1. ADEME: French Environment and Energy Control Agency.
2. Alternative and Renewable Energy Federation.
3. Walloon Institute of Evaluation, Forecasting and Statistics.
4. Walloon Agency for Air and Climate.

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This publication is a section of the book
“Smart Energy Regions”
Published by The Welsh School of
Architecture, Cardiff University,
Bute Building, King Edward VII Avenue,
CARDIFF, CF10 3NB, UK.
Publication date: May, 2014; ISBN: 978-1-899895-14-4.

The COST Action TU1104 Smart Energy Regions brings together over 70 researchers from European institutions to investigate the drivers and barriers that may impact on the large scale implementation of low carbon technologies in the built environment. The book “Smart Energy Regions” is the outcome of the Working Group 1 of the Action and collects analysis and case studies from 26 European countries. For more information about the Action and COST please visit www.smart-er.eu and www.cost.eu.

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COST is supported by the EU

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This publication is supported by COST.