Assessment of energy and business performance of innovative technologies in SMEs

Pieter Proot [a], *Ad* Breukel [b], *Jeroen* Lippens [c], *Hugo* de Moor [d], *Hilde* Breesch [e]

[a] KU Leuven, Building Physics and Sustainable Design, Department of Civil Engineering, Ghent Technology Campus, Ghent, Belgium, pieterproot@telenet.be

[b] Avans University of Applied Science, Research Group Smart Energy, 's-Hertogenbosch, Netherlands, awv.breukel@avans.nl

[c] KU Leuven, Building Physics and Sustainable Design, Department of Civil Engineering, Ghent Technology Campus, Ghent, Belgium, jeroen.lippens@kuleuven.be

[d] Avans University of Applied Science, Research Group Smart Energy, 's-Hertogenbosch, Netherlands, hhc.demoor@avans.nl

[e] KU Leuven, Building Physics and Sustainable Design, Department of Civil Engineering, Ghent Technology Campus, Ghent, Belgium, hilde.breesch@kuleuven.be

Abstract. A major target of the European Green Deal is to raise the 2030 greenhouse gas emission reduction target to 55% compared to 1990. This high ambition includes an increase of the energy performance of buildings and additional generation of renewable energy in all sectors. The tertiary sector, including small and medium sized enterprises (SMEs) such as butchers, small food and non-food shops, restaurants and pubs, is one of the sectors that can contribute to this goal. While large companies in this sector are regularly in the news with iconic projects, for many SME owners "sustainability" is not a key issue. Reasons are that 1) they are not aware of interesting technologies or business cases specific for their company, 2) they are focused on their own business operation and 3) do not always own the building. That is why the Flemish-Dutch TERTS project strives for a transition in energy use and production by 1) demonstrating cutting-edge (innovative) technologies (e.g. circular isolation materials, heat pumps etc.) in SMEs and 2) by guiding these SMEs. This study assesses the impact of different (innovative) technologies specific for the target group 'barber shops'. A reference building is made by analysing 60 existing barber shops in Flanders. The energy use of the barber shop including the systems is calculated according to DIN V 18599 using the Energieberater 18 599 3D PLUS. Subsequently, the cost-benefit of various measures is calculated and compared. This provides us with an approach that not only includes financial measures but also takes metrics into account for CO_2 reduction and comfort. Several technologies, which only have moderate financial benefits, reach acceptable overall satisfaction due to the inclusive metrics. This approach is based on modern business model developments and offer SMEs a more qualitative and inclusive way of the return of innovative technologies to support their investment decision making.

Keywords. Energy assessment, inclusive business case, energy transition/innovation, SMEs (tertiary sector)
DOI: https://doi.org/10.34641/clima.2022.266

1. Introduction

A major target of the European Green Deal in September 2020 is to raise the 2030 greenhouse gas emission reduction target to 55% compared to 1990 (1). This is a very high ambition and includes an increase of the energy performance of buildings and additional generation of renewable energy in all sectors. In Flanders only 7,2% of the final energy consumption was renewable in 2019 (2). Looking at the Netherlands, only 8,8% of the final energy consumption was renewable in 2019 (3). The tertiary sector with many small and medium sized enterprises (SMEs) such as butchers, barbers, small food and non-food shops, restaurants and pubs is one of the sectors that can contribute to this end as SMEs in this sector have significant CO_2-emissions and energy use (4). While large companies are regularly in the news with iconic sustainable projects, for many SME owners the Green Deal is not a key issue. Most of the owners of SMEs attach more importance to investments in their business operation than to invest in energy performance of buildings. Reasons for this include that 1) they are not aware of interesting technologies or business cases specific for their type of company 2) they are not interested in technologies that have presumably no relation with their core business and 3) they are not always the owners of the building.

Following actions are already taken by the governments to stimulate SMEs in this energy transition. The Flemish government will oblige SMEs to draw up a so-called 'energy balance', which mainly intends to gain insights into their energy consumption. SMEs will be required to implement measures that have a payback period shorter than three years. These measures are called the 'no-regret' measures and include roof and (cavity) wall insulation, relighting with LEDs etc. (5). In the Netherlands, if the energy use of SMEs exceeds 50.000 kWh for electricity or 25.000 m^3 for natural gas, SMEs are required to inform the authorities about their energy reduction investments with technologies with a pay-back period of less than five years. However, monitoring and verification of these measures is not yet deployed. Besides, more complex investments depend on the voluntarily attitude of the entrepreneurs with the assumption that investments (such as heat pumps) are cost effective within their technical lifetime. This is not always the case without subsidies (6).

The Flemish-Dutch Interreg TERTS project (7) focusses on this topic and aims for a transition of energy use by 1) demonstrating cutting-edge innovative energy technologies supported by subsidies and 2) guiding these SMEs. To make the sector more aware of the potential of innovative technologies, demonstration projects are established in Flanders and in the Netherlands. Moreover, the innovative technologies are listed in guidelines for each target group of SMEs. These innovative technologies include circular insulation materials (e.g. glass foam granulate), vacuum glazing, different HVAC-systems (e.g. heat pumps, cooling systems with heat recovery etc.), controllable (LED) lighting and collective energy management systems. The present study focuses on barber shops, which falls into the category of non-food shops.

The objective of this study consists of 1) the identification of the most cost-effective technologies to improve energy performance of SME buildings, represented by barber shops and 2) estimation of the returns of (innovative) technologies towards ecological and non-financial matters. First, the method to determine the reference building is presented, followed by the description of the energy calculations and the cost-benefit analysis. Here, the focus will lie on possible 'no-regret' measures and the implementation of technologies introduced by the TERTS project. Subsequently, this study also takes into account the importance of the society values toward ecological and non-financial matters, such as (thermal) comfort experiences of clients. Price models such as "true price" already take this into account (8). New business model approaches address the rewards of ecological and social values next to the traditional business case (9). These values offer SMEs a more qualitative way of the returns of renewable technologies that may support their renewable investment decision making.

2. Research method

2.1 Reference building

First, a reference building model of a barber shop is determined. In this case, the reference building model aims to represent each individual building within the analysed category 'barber shop'. The geometry and building envelop are based on an analysis of 60 existing barber shops located in the metropolitan area of Bruges (Flanders, Belgium) and the city of Gistel (Flanders, Belgium), which represents the more rural areas. Barber shops are usually located on the ground floor of a residential building. Since this trend is also noticeable in the sample, the building characteristics are based on the TABULA database for dwellings (10). By using this database, an estimation of the U-value of the building envelope is made based on the year of construction. The properties of domestic hot water and heating systems are also determined from this database.

2.2 Calculation final energy use

The energy use of the barber shop including the systems is calculated according to DIN V 18599 (11) using the Energieberater 18 599 3D PLUS software (12). As no specific electrical appliances (such as hairdryers) can be simulated in the Energieberater, the electricity consumption of this equipment is estimated based on a site visit of a (small) barber shop and combined with the energy use as output from the simulation model. Climate file of Düsseldorf (Germany), comparable to Uccle (Belgium) is used for calculating the final energy use.

2.3 Financial cost-benefit analysis

The Energieberater offers changes in energy use (in kWh and m^3) as a result of investment in (innovative) technologies. It also includes measurements of changes in energy costs, in CO_2 emission and offers the payback period of the investment. A cost-benefit model has been developed for the TERTS project that uses the energy quantities of the Energieberater as input for subsequent cost-benefit calculations. This model applies the Net Present Value (NPV) approach that sums the future cash flows from an investment while taking the life time of this investment into account. This economic approach is based on the assumption that money loses value over time because it could have been invested elsewhere. The benefits in the model are the decreased use of fossil energy (in kWh or m^3) during their lifetime as calculated by the Energieberater and based on average energy prices in Flanders. The costs are the total sum in investments and add annual costs such as maintenance and income tax. The present study includes the TERTS subsidy (50% of investment costs) and possible other subsidies from the government. This data makes it possible to compute the Return-on-Investment (ROI) as the quotient of summated cashflows minus the investment divided by the investment. The Internal rate of return (IRR), which is the discount rate where the benefits are zero, and the pay-back period are also determined.

Following assumptions are made. Initial investment costs are gathered through surveys or are based on already performed research for the target group of butcher's shops (13). Current prices for electricity and natural gas are respectively 0.26 €/kWh and 0.05 €/kWh and subject to changes in the global energy market and due to tax changes (14).
Finally, the cost-benefit model has been checked by calculating the energy and cost effects independently from the Energieberater for two technologies without TERTS subsidy, namely the insulation of the cavity wall and heat pump for domestic hot water (DHW). Comparable outcomes in energy costs savings, CO_2 emission reduction and payback period have been found.

2.4 Non-financial benefits

Regular cost-benefits analyses often only apply financial parameters. The inclusion of ecological and social returns are needed to support a fundamental shift in business models of companies, in order to increase the level of sustainability (15). The Triple Layered Business Model Canvas offers possible metrics for sustainability-oriented business models, with attention to carbon reduction and the quality aspects for customer (9). This approach aligns with a contemporary idea of true prices that takes externalities, such as waste, into account in pricing.

Two parameters from this business model approach have been selected for the TERTS project to widen the regular cost-benefits calculations: 1) the decrease of CO_2 emission (in kg) and 2) the increase of non-financial returns such as comfort.

The CO_2 reduction is determined as 0,6 kg for each used kWh electricity and 1,9 kg for each used m^3 natural gas (16). Comfort is an important functional need that the physical environment of a company may offer to their clients (17). The comfort measurement method has been used as a starting point to address parameters that all refer to comfort and well-being. These parameters are: thermal comfort (air temperature, radiant temperature, drafts), air quality, lighting, acoustics, basic quality and appearance and supplements such as energy autonomy. These parameters will be individually assessed and then used as a basis for a joint comfort evaluation score (see an example in Tab. 1)

The expected ROI is based on the NPV calculation as described in section 2.3, the CO_2 decrease (in kg) is determined on the reduced amount of electricity & gas and the comfort points are the result of the expected improvement in comfort. The entrepreneurs related to the TERTS project will be interviewed about their expected satisfaction of these financial parameter (ROI), ecological (CO_2 emission reduction) and social returns (comfort evaluation). Next, these interview scores are summarized in one final satisfaction metric (maximum 5) based on the relative importance of the various return measures.

Tab. 1 offers an example of the ROI, CO_2 and comfort return data of investments in relighting technology followed by the satisfaction calculations.

Tab. 1– Satisfaction evaluation of relighting + control

Returns of innovative energy technology investment	Expected ROI	Expected CO2 reduction	Expected comfort increase	Overall investment satisfaction score
ROI (based on NPV calculation)	28,06%			
CO2 reduction as a result of less kWh electricity		991,2 kg		
CO2 reduction as a result of less m3 natural gas		-300,2kg		
Total CO2 reduction		691 kg		
Comfort increase (based on assessment of comfort parameters)			Positive	
Satisfaction with expectation (range 1-5)	3	5	3	
Relative importance of expectation	60%	10%	30%	
Satisfaction score (range 1-5)	1,8	0,5	0,9	3,2

During the present, first stage of the research, an estimation is made of the assessments of the entrepreneurs based on desk research and internal discussions. In the follow-up stage, the opinion of the SME entrepreneurs will be collected by means of interviews.

3. Reference building

3.1 Geometry and zoning

First, the building type (detached, semi-detached, terraced) is determined. Fig. 1 shows that a terraced building is the most common in the analysis of 60 existing barber shops. Second, boxplots are made of the width of the façade, floor area, building depth and window area. In Fig. 2 an example is shown of the façade width (6,8 m) and window area (5,94 m^2).

Results from the boxplots are used to design the reference model, most of the analysed barber shops are located on the ground floor of a residential building. For the present study, the residential part is not taken in consideration. The barber shop is divided into two different zones, namely zone 1 (barber shop) and zone 2 (storage + toilet). The properties of the zones are mentioned in Tab. 1. The floor plan and the 3D front view can be found on Fig. 3 and Fig. 4.

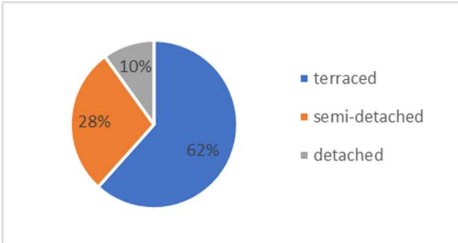

Fig. 1- Building type of studied buildings

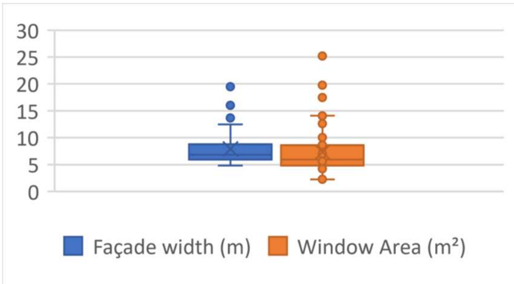

Fig. 2- Boxplots of façade width (m) and window area (m^2) of studied buildings

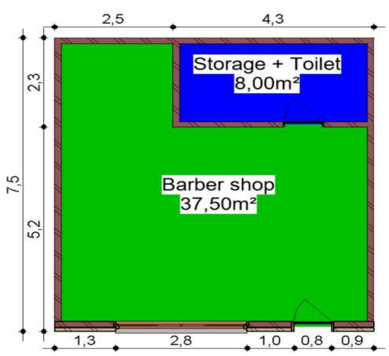

Fig. 3 - Floor plan of the reference building

Fig. 4 - 3D front view (NW) of the reference building

Tab. 1 – Zoning of reference building

Zone	Floor area (m^2)	Temperature (°C)	Illuminance (Lx)
Barbershop	37,5	21	500
Storage + Toilet	8	-	200

3.2 Building characteristics and use

Based on the analysis of 60 barber shops, the year of construction is determined. The construction year of the reference building is assumed to be between 1946 and 1970 as shown on Fig. 5.

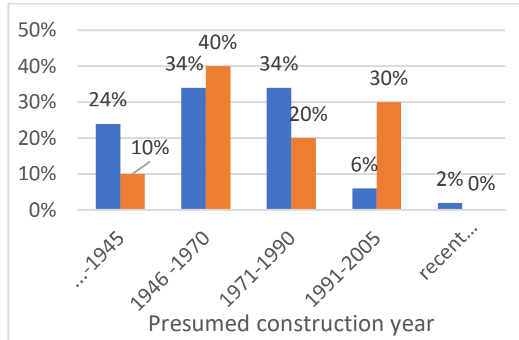

Fig. 5 - Analysis of presumed construction year (data in blue for Bruges and orange for Gistel)

After consulting the TABULA database, assumptions of the thermal transmittance U and building characteristics are mentioned in Tab. 2. For the air tightness (n_{50}) a value of 6 h^{-1} is assumed, based on previous research of the category 'butcher's shops' also no solar shading is assumed (13).

An occupancy of 250 days/year from 8 a.m. until 8 p.m. is assumed according to the Din V 18599. For the reference model, it is assumed that there are two people (fulltime) working in the barber shop.

Tab. 2 - Building characteristics and U-values

Component	Description	U (W/m^2K)
Façade	Non-insulated cavity wall	1,7
Ground floor	Non insulated	0,85
Window	Double glazing	3,5
Door	Double glazing	3,5

3.3 Systems

The barber shop includes a central heating system that is provided with a non-condensing gas boiler (from the year 2000), with radiators. The DHW is linked to the heating system with a consumption of 260 l/day (18). No ventilation system is provided in the reference simulation model. Fluorescent bulbs are provided in the barber shop (31,4 W/m^2) and technical room + toilet (32,4 W/m^2).

4. Results

4.1 Final energy use

The annual final energy use of the reference building, including heating, domestic hot water, lighting and other electrical equipment is listed in Tab. 3. The energy use of the electrical equipment is an estimation based on a site visit of a (small) barber shop with 2 employees and takes hairdryers, curlers and straighteners into consideration.

Tab. 3 - Final annual energy use of the reference building

Final energy use (kWh)		(kWh/m^2)
Total Gas:	11562	254,1
Heating	10789	237,1
DHW	3262	71,7
Total Electricity:	7540,5	165,7
Lighting	2918	64,1
Equipment	4622,5	101,6

4.2 Studied technologies

The following measures are studied regarding the building envelope:

- Insulation of the cavity wall (biofoam, d = 0.08m, λ = 0.034 W/mK)
- Insulation of floor (glass foam granulate, d = 0.15m, λ = 0.08 W/mK)
- Combination: cavity wall and floor
- Replacement of the glazing to vacuum glazing ($U_{glazing}$ = 0.7 W/m^2K)

The impact of relighting with controllable LED and adding PV-panels (4,2 kWp, NW, slope of 40°) is also studied. Regarding the HVAC systems, the following systems are studied:

- Condensing boiler (27 kW, efficiency = 94%)
- Solar collector ($V_{storage\ tank}$ = 300l)
- Heat pump DHW (27 kW, COP = 3.3, $V_{storage\ tank}$ = 300l)

4.3 Financial cost-benefit analysis

- ***Building envelope***

First, different individual measures concerning the building envelope are studied. Tab. 4 shows the final energy use, the initial investment cost, the IRR, the ROI and (discounted) payback period compared to the existing situation (benchmark). TERTS subsidies (50% of investment cost) and additional (local government) subsidies are taken into consideration for this analyses.

It can be concluded that concerning the building envelope, insulating the cavity wall is the best solution to increase the energy performance of this reference building. The payback period is only 2 years, so this measure can be an example of a 'no-regret' measure, as mentioned in the introduction. Insulating the floor or replacing the glazing both have higher investment costs, which results in a longer payback period. The combination of insulating floor and the cavity wall offers a business case with 6 year payback period. Without taking the TERTS subsidy in consideration this payback period rises to 18 years.

Tab. 4 - Cost-benefit of individual measures concerning the building envelope

	benchmark (chapter 3.2)	Façade insulation (8 cm)	Floor insulation (15 cm)	Façade & Floor	Vacuum glazing
Heating (gas, kWh)	10789	8677	8973	6885	8523
DHW (gas, kWh)	3262	3303	3301	3372	3316
Lighting (elec, kWh)	2918	2198	2918	2918	2918
Equipment (elec, kWh)	4622	4622	4622	4622	4622
Investment (€)	-	300	1657	1957	2072
ROI (%)		319	30	73	15
IRR (%)	-	44	11	17	7
Payback period	-	2	11	6	18

- ***Systems and lighting***

Second, the effect of the measures regarding the systems and lighting are studied and illustrated in Tab. 5. Relighting with controllable LEDs causes a reduction of the final electricity use of 1670 kWh per year. The payback period, also due to the TERTS subsidy, of this measure is 8 years. Without the TERTS subsidy no payback period can be realised. Concerning the HVAC systems, a condensing boiler (heating + DHW) and a heat pump for DHW are not cost-effective for this case study. As for the heat pump DHW, the gas consumption decreases but a higher electricity consumption is measured. Due to the high electricity prices in Flanders, the benefits will not exceed the costs. Only the solar collector is concluded to be a cost-effective system. This technology is currently not included in the list of innovative technologies for the TERTS project. However, the present study shows that this renewable technology can offer a good solution with a TERTS subsidy.

To obtain a better business-case with the heat pump for DHW, a combination with renewable energy production is investigated. As an example, 14 solar panels (4,2 kWp) are placed (NW) on the pitched roof (slope: 40°). The results of this combination (without TERTS subsidy for the solar panels) can be found in Tab. 5 and shows that a better business-case is realised.

Tab. 5- Cost-benefit of individual and combined measures concerning systems and lighting

	Relighting + control	Condensing boiler heating +DHW	Solar collector	Heat pump DHW	Heat pump DHW + Solar panels
Heating (gas, kWh)	12668	7213	7402	8523	8523
DHW (gas, kWh)	3228	3638	104	3316	3316
Lighting (elec, kWh)	1248	2918	2918	2918	2918
Equipment (elec, kWh)	4623	4622	4622	5760	3181
Investment (€)	5000	3850	5000	2072	7700
ROI (%)	28	- 18	29	- 40	4
IRR (%)	11	1	13	<0	6
Payback period	8	-	8	-	14

4.4 Non-financial benefits

This section includes the non-financial benefits. Tab. 6 and Tab. 7 start with the ROI scores, and several self-evaluations from the perspective of the entrepreneur.

Tab. 6- Satisfaction points on financial – ecological – social returns concerning the building envelope investments

	Façade insulation (8 cm)	Floor insulation (15 cm)	Façade & Floor	Vacuum glazing
ROI (%)	319,6	30,83	73,6	15,77
ROI points	5	3	4	2
CO_2 decrease (kg)	336,3	288,8	615,6	359,1
CO_2 points	4	3	4	3
Comfort score	Positive	Positive	Positive	Positive
Comfort evaluation	3	3	3	4
Overall satisfaction score	4,3	3	3,7	2,7

Insulation technologies earn positive reviews, especially when it comes to insulating the façade. CO_2 reduction and comfort follow, and in the case of vacuum glazing, even add to the ROI evaluation. Overall, only the insulation gets a positive evaluation mainly based on high ROI.

Tab. 7 - Satisfaction points on financial – ecological – social returns concerning systems and lighting investments

	Relighting + control	Condensing boiler heating +DHW	Solar collector	Heat pump DHW	Heat pump DHW + Solar panels
ROI (%)	28,06	-18,23	29,31	-40,02	4,03
ROI points	3	1	3	1	2
CO_2 decrease (kg)	691	524,1	1083	295,7	1843
CO_2 points	5	3	4	2	4
Comfort score	Positive	Neutral	Neutral	Neutral	Neutral
Comfort evaluation	3	3	3	3	5
Overall satisfaction score	3,2	1,8	3,3	1,7	3,1

The lighting energy systems and solar collector have acceptable overall assessments, also because of the CO2 reduction, but the boiler and heat pump DHW do not have a good business case even with reasonable comfort points. However, adding a combination of PV (without TERTS subsidy) to the heat pump DHW (with TERTS subsidy) creates an acceptable satisfaction value for the previously unprofitable energy heat pump technology.

5. Conclusions, limitations and further research

5.1 Conclusions

The present study aims to identify the most cost-optimal technologies to improve the energy performance of the building and estimate the returns of (innovative) technologies towards ecological and non-financial matters. This study focusses on the category of barber shops, with domestic hot water and electricity use as the main energy consumers.

It can be concluded that in several cases (relighting, façade and floor insulation) the application of 50% TERTS subsidies is effective to elevate several innovative energy technologies without an acceptable business case to cost-effective technologies with an acceptable business case. Although the solar collector is not on the list of innovative TERTS technologies, the same conclusion applies for this technology. The positive impact is especially seen in the case of the combination of technologies (façade and floor insulation; PV and heat pump DHW), in which separate technologies do not have a proper business case but where the combination shows acceptable results.

Moreover, the inclusion of CO_2 decrease and increase of comfort measurements demonstrate an added value of these technologies in the eye of the entrepreneurs. These indicators provide a link between energy technologies with the core business of the SME. This is even true in the case of the floor insulation technology and the combination of solar panels + heat pump DHW, which have a long pay-back period but reach acceptable overall satisfaction levels.

5.2 Limitations and further research

This study argued that innovative energy technologies require subsidies to develop their economic potential and that they are not just commodities with a price tag, but also offer the entrepreneur an option to deliver sustainability, comfort and experience as unique selling points. There are three limitations concerning the conclusions.

First, this approach of inclusion requires more development and testing of the applied measurements, because the 1-5 scale of measurement for comparing the different benefits is less refined than traditional financial and ecological (LCA) measurement methods. Further research will focus on the measurement of comfort and experiences at SMEs (using Fanger's comfort equation to indicate how occupants assess the indoor climate) in order to reach a better comparison.

Second, several innovative technologies (such as façade insulation) are effective even without the TERTS subsidy. A recommendation to SME companies is to invest in one of this technologies as a no-regret measure.

Third, several other technologies (like heat pump, vacuum glazing) do not result in an acceptable business case even with a 50% subsidy. The positive ecological and comfort points are not sufficient to transform the business case in an overall satisfactory result. In order to support promising energy technologies without a proper business case for this tertiary sector, permanent governmental attention is suggested to develop appropriate support schemes for innovative energy technologies.

Next to that, further research will focus on different sales models (such as leasing constructions) as a solution to adopt such technologies. For these sales models, the concept of customer experiences will be included which is a fitting concept for the tertiary sector. Pine and Gilmore emphasize in "The Experience Economy" the focus shift for customers to pay for the experiences they receive instead of buying the product (19). This attention for experiences has led to a range of as-a-service leasing and performance contracts for sustainable technologies, which offers entrepreneurs the opportunity of using an innovative energy technology usage without the burden of high investments. This development, which has also been referred to as the concept of servitisation or Product Service Systems approach, offers a mix of products and services to fulfil customer demand with attention for environmentally and socio-ethically beneficial new solutions" (20).

Finally, a comparison of the findings of this study specific for barber shops with the results of other target groups (bakeries; butchers) will be made in order to generalize the conclusions to the SME sector of Flanders and the Netherlands as a whole.

Acknowledgements

TERTS is financed within the Interreg V Flanders-Netherlands program, the cross-border cooperation program with financial support from the European Regional Development Fund. The project also received funding from local actors.

Data access statement

The datasets generated during and analysed during the current study are not available but the authors will make every reasonable effort to publish them in near future.

References

1. European Commission. Green Paper - A 2030 framework for climate and energy policies. COM(2013) 169 Final [Internet]. 2013;1–16. Available from: http://ec.europa.eu/clima/policies/strategies/2030/documentation_en.htm
2. Hernieuwbare energie - Statistiek Vlaanderen [Internet]. Available from: https://www.statistiekvlaanderen.be/nl/hernieuwbare-energie#aandeel_zon-_en_windenergie_in_groene_stroomproductie_groeit
3. CBS. 11 Procent Energieverbruik in 2020 Afkomstig Uit Hernieuwbare Bronnen [Internet]. Cbs. 2021. Available from: https://www.cbs.nl/nl-nl/nieuws/2021/22/11-procent-energieverbruik-in-2020-afkomstig-uit-hernieuwbare-bronnen
4. Relatieve evolutie broeikasgasemissie per sector sinds 1990 (Vlaanderen, 1990-2018) — Milieurapport Vlaanderen (MIRA) [Internet]. Available from: https://www.milieurapport.be/milieuthemas/klimaatverandering/broeikasgassen/emissies-broeikasgassen-per-sector/relatieve-evolutie-bkg-sector
5. Flemish Government. Versterkte wetgeving voor niet energie-intensieve ondernemingen [Internet]. 2021 [cited 2022 Jan 12]. Available from: https://beslissingenvlaamseregering.vlaanderen.be/document-view/60B871BF364ED9000800064E
6. Planbureau voor de Leefomgeving. Klimaat- en Energieverkenning 2020. 2020;184.

7. TERTS. Transition in Energy via direction Role in the Tertiary Sector [Internet]. Available from: https://www.terts.org/
8. Eidelwein F, Collatto DC, Rodrigues LH, Lacerda DP, Piran FS. Internalization of environmental externalities: Development of a method for elaborating the statement of economic and environmental results. J Clean Prod. 2018;170:1316–27.
9. Joyce A, Paquin RL. The triple layered business model canvas: A tool to design more sustainable business models. J Clean Prod. 2016;135:1474–86.
10. TABULA WebTool [Internet]. Available from: https://webtool.building-typology.eu/#bm
11. DIN. DIN V 15899: energy efficiency of buildings. 2018.
12. Dimitroulopoulou C. Ventilation in European dwellings: A review. Build Environ. 2012;47(1):109–25.
13. Lippens J, Lokere S, Barbary W, Breesch H. Evaluation of the energy performance and cost-benefit of innovative technologies in butcher's shops. E3S Web Conf. 2021;246:1–6.
14. Evolutie energieprijzen en distributienettarieven | VREG.
15. Bocken NMP, Short SW, Rana P, Evans S. A literature and practice review to develop sustainable business model archetypes. J Clean Prod. 2014;65:42–56.
16. CO2-Calculator - CO2- en klimaatneutraal ondernemen voor energiebewuste MKB-bedrijven [Internet]. Available from: https://www.klimaatplein.com/gratis-co2-calculator/
17. Kastelein J-P. Space meets knowledge. impact Work Des knowlegde Shar. 2014;319.
18. Din V 18599. 2013. p. 11–3.
19. Pine BJ, Gilmore. JH. The Experience Economy | Semantic Scholar [Internet]. Available from: https://www.semanticscholar.org/paper/The-Experience-Economy-Pine-Gilmore/87ece758df9f27fd5d742c0f7405366bc830ad00
20. Reim W, Parida V, Örtqvist D. Product-Service Systems (PSS) business models and tactics - A systematic literature review. J Clean Prod. 2015;97:61–75.