Building Market Brief The Netherlands

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Building Market Brief
The Netherlands

Climate Innovation Experience *Edition*

Building Market Brief
The Netherlands

Prelude

In light of the necessary global transformation towards a low-carbon economy, the building sector is facing dramatic changes and dire need for disruptive innovations in the years to come. These changes come with risks as well as opportunities. A solid and regional specific understanding is needed to minimize the first and maximize the second when designing, investing in or implementing low-carbon solutions.

Global greenhouse gas emissions from the building sector have globally more than doubled since 1970. In Europe buildings are responsible for 40% of the energy consumption and 36% of the emissions. As such, a low-carbon transformation of the building sector, (deep) refurbishment of the existing building stock and a revitalization of the sector are key components of the EU Roadmap 2050.

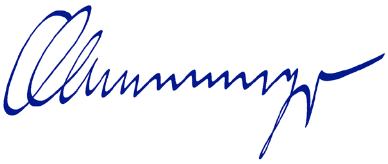
With this European perspective in mind, one of the major barriers curtailing large scale investments into low-carbon technologies in the building sector is the lack of cross-country comparable market data. Such an overview would enable inventors, low-carbon technology suppliers and other key stakeholder to exchange know-how and transfer solutions across borders. As the building sector is commonly described as one of the most fractured and regionally colored industries - with very specific habits, traditions and stakeholder setups - this is often impossible.

It is exactly this gap of understanding and data availability that the Building Market Brief series addresses. On a limited number of pages, the condensed essence of a countries' building sector and its spirit is summed up and quantified with indicators aligned across countries. The series of reports provides a reliable basis for low-carbon innovation, investments and adoption, by offering a pan-European market understanding and providing comparable insights of the sector. It aims at documenting a holistic understanding, taken from multiple perspectives, market experts, models and statistical data. This information contributes to enable optimization, integration and scaling. We endeavor a sustained, collective effort to channel investments and behavior in a manner necessary to realize this low-carbon future of the building sector.

Therefore, we would like to address low-carbon innovation suppliers and entrepreneurs that look for suiting markets for their ideas or inspiration for their developments, but also investors and policy makers who would benefit from a better pan-EU overview, allowing for benchmarking and cross-country experience exchange.

I am confident that the information and insights provided by the Building Market Brief series contribute to the transformation into a low-carbon economy as one of the key challenges of this century.

York Ostermeyer
Editor in chief



Acronyms list:

2DS:	2-Degrees Scenario
BSM:	Building Stock Model
CBS:	Central Agency for Statistics (Centraal Bureau voor de Statistiek)
CLO:	Compendium for the Environment (Compendium voor de Leefomgeving)
DH:	District Heating
EIA:	Energy Investment Allowance
EMF:	European Mortgage Federation
EPBD:	Energy Performance Building Directive
EPC:	Energy Performance Certificate
EU(28):	European Union
EUROSTAT:	European Statistical Office
GDP:	Gross Domestic Product
GHG:	Greenhouse Gases
HDD:	Heating Degree Days
INDC:	Intended Nationally Defined Contribution(s)
KWh:	Kilo Watt Hours
LCA:	Life Cycle Assessment
MDB:	Multi-Dwelling Building(s)
MEPS:	Minimum Energy Performance Standard
NEEAP:	National Energy Efficiency Action Plan
nZEB:	nearly Zero Energy Building(s)
R&D:	Research & Development
RES:	Renewable Energy Sources
RS:	Reference Scenario
SDB:	Single-Dwelling Building(s) also called Single-Family Houses
SME:	Small and medium-sized enterprises
t CO_2eq.:	Tonne CO_2 equivalent
TJ:	Terajoule
UN:	United Nations

How to use this report
How to read it and meta structure

This report is meant to provide an intuitive and reliable entry point for assessing the character of the construction sector in the addressed country. It is not necessarily meant to be read from the beginning to the end but rather to be used as an encyclopedia of facts and figures with links to complementary data sources if one wants to get more detailed information on a certain aspect. The structure of the report in independent subchapters enables the readers to start reading at any point depending on their needs and interests. Condensed information is provided from as many perspectives and sources as possible. This might lead to conflicting statements from different sources hopefully helping to communicate the complexity of the market rather than provide streamlined insights. This report is part of a series, one for each country. All reports follow a similar methodology, making all indicators listed comparable between countries. Even if not familiar with a certain indicator the knowledge on one market can therefore be used by the reader to put other markets into perspective. The structure of the reports also allows direct comparison. The readers will find the same indicator on the same page at roughly the same position in every report if it was available for the respective country.

This report is divided into three main chapters according to the methodology followed: **Chapter A**, a literature-based approach; **Chapter B**, a survey-based approach; and **Chapter C** a model-based approach. This structure is complemented by an executive summary and indicator factsheets in the beginning of each report.

Each of the chapters is divided into subsequent subchapters or sections addressing specific topic condensed in a 2-pager format. The main body of the text aims to highlight the most relevant information from the graphs and contextualize the data by explaining relevant frame conditions. For this purpose, the graphs and figure trends are listed side by side with absolute numbers in most cases. This aims to allow an easy perception of the development of a sector as well as to put trends into an absolute perspective, comparing relevance between countries. Specially highlighted numbers are also listed in the factsheet at the beginning of the report where they are sided with numbers form different fields to provide market characterization indicators.

The graphs in the report follow a color code. The color therefore indicates what kind of data is visualized in the graph, making the reading of the report as intuitive as possible.

The chapter's content is complemented by market expert comments and additional sources of information such as reports and data bases in the side bar of each page. The comments refer to opinions voiced by experts as a direct reaction to the report as well as in complementary workshops and interviews and are listed to provide a holistic view of the market as possible. Great care was taken to quote a wide array of opinions.

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Executive summary

Economic framework conditions

The Netherlands has a population of 16.9 million (2015), or roughly 3.3% of the EU population. The nominal GDP of the country in 2015 was 683.45 billion EUR, and it grew at an average annual growth rate of 2.31% from 2005-15. In the same period its GDP per capita increased from 33,462 EUR/capita (2005) to 40,439 EUR/capita (2015) and the disposable income per capita grew at an average annual growth rate of +1.49% (Section A). The Netherlands have a services oriented economy (78% of the Gross Value Added in 2015 is contributed by the tertiary sector, followed by industry & manufacturing (18.2%) and agriculture (1.6%). The construction sector of the NL accounts for over 6% of the Dutch GDP. In 2015 roughly 4.5% of the Dutch GDP, totalling € 30.5 billion, was spent on building construction expenditure. Since 2005 the total investments in building construction increased at an average annual rate of +1.3% per year (Section A5). The Netherlands are considered as an innovative country which is ranked 4th and grouped among “strong innovators” in the EU 28 countries (European Innovation Scoreboard 2017).

The monthly consumption expenditure per household grew +2.8% from 2005-15, while that spent on housing and energy grew by +22.8% in the same period, representing almost a quarter of the total expenditure (24%) in 2015.

The structure of the building sector in the Netherlands

The majority of Dutch building stock is in the residential sector (886 million m²) which constitutes about 62% of the total floor area which was about 1430 million m² in 2015. The share of non-residential buildings is 38% of the total area which is a relatively high share as compared to other countries.

About 80% of the residential floor area consists of single-dwelling buildings or also called single-family houses (stand-alone or in row houses). The residential floor area is also predominately privately owned (with a share of almost 70%) and 57% of the dwellings are owner-occupied. Not-for-profit (private, regulated) housing associations own about 30% of the residential floor area. (Sections A2 and A6).

The age distribution of the residential building stock shows a large share of medium-old buildings, with about 65% of the heated floor area built between 1945 and 2000, stemming from the need for rapid reconstruction after the Second World War and meeting growing demand entailed by high economic growth and income per capita. Another 19% of the FA was constructed before 1945. The absence and the still relatively low energy performance building regulations until the 1990s translates in a large share of very poorly insulated buildings. The first thermal regulation in the Netherlands was introduced in the 1980s. The building standards have continuously strengthened since 1990’s. In 1996 the energy performance regulations were introduced, with the energy performance coefficient decreasing from 1.4 (1996) to 0.4 (2015). The 2015 standard was further tightened and the Dutch National Plan for nearly zero-energy buildings ambitiously aims for all new buildings to be nearly zero-energy (25kWh/m²) and gas-free by 2021 (BENG standard). (Sections A4 and C1).

The effect of this regulatory development is reflected in the distribution of the specific carbon emissions per m² of floor area: In recent years, especially after 2000, the shares of medium (less than 20 kg CO_2/m²) and low carbon buildings (less than 20 kg CO_2/m²) have been visibly increased.

However, there still remains a significant number of buildings with GHG emissions that needs to be addressed (almost all buildings from before 2000 emit more than 10 kg/m², mainly due to their fossil heating systems and the quasi-absence of renewable energy sources in the Dutch building stock), as well as a share of buildings built in recent decades that do not meet the low-carbon threshold of 5 kg/m² (Section C1).

Policy framework and other demand side drivers

The Netherlands has made energy efficiency one of its main priorities, as set out in several national plans, including the Energy Agreement for Sustainable Growth (September 2013) and the third National Energy Efficiency Action Plan (NEEAP, 2014). The Agreement aims to achieve an average energy efficiency saving of 1.5% per year (adding up to a reduction of 100 PJ by 2020). After 2020, newly built buildings have to reach the Nearly Zero Energy Building (NZEB) standard. Moreover, increasing earth quakes in the area of the domestic gas field in the north of the country (Groningen) finally led to the decision to reduce the use of these gas fields and close them by 2030. This entails an increasing urgency to phase out domestic natural gas from the building stock. Possible solutions are the connection to district heating, more use of geothermal heating and high level isolations and the use of heat pumps.

In 2018 a new Climate Act will be introduced that requires the government to develop policies to realise a reduction of 95% CO_2 emissions in 2050. Also, a new Climate and Energy agreement involving all stakeholders, are developed to formulate concrete goals and policies. The aim is 49% CO_2 reduction is 2030.

These ambitious goals have translated into further plans and resolution for all sectors, including the building sector. For existing buildings, aims to increase the pace of energy renovation in the housing sector by targeting 50,000 major renovations per year in 2021 and then in a few years' time increasing to 200,000 per year, with the intention that all the stock adhere to the nearly zero energy standard by 2050 and fossil energy is phased out in the buildings' sector (Section A4) These policies are expected to be important drivers in an increasing demand for more efficient buildings and the shift from fossil fuels to renewable sources of energy.

Housing and derived energy demand and related carbon emissions are also driven by demographic developments, changing family and household structures, personal needs for more dwellings and floor space (Section A1). Considering these current trends and the fact of a housing supply shortage during the recent years, a net addition of 15% to the floor area by 2050 is expected. This increase is mainly driven an increase in the demand for floor area per person.

Demand side energy, carbon and market trends

Although population and floor area are expected to grow, final energy demand for heating, hot water, and ventilation (including ambient heat from water, ground and air) is expected to be 16% lower than present values in in 2050 under the current policy set up (what is called in this report the Reference Scenario1). With more stringent policies and regulations (the 2-Degrees Scenario2), the reduction would reach more than 30% by 2050 (Section C3)

The main responsible for this reduction are the building codes requirements for new construction and the ambitious plans that the Netherlands have set to comply with their climate goals, including an increase in the retrofit activity and a structural change toward RES. All of them fostered by financial instruments that are already in place and others that are expected to be implemented in the near future (Section A4 and C3).

The implementation of these plans will demand a shift towards more efficient building technologies and low emission heating system. Heat pumps and other renewable energy sources such as district heating, are expected to compensate the demand for fossil fuels that will be no longer attractive (also due to differentiated energy taxes) when retrofitting or building new. This results in a shift towards medium and low-carbon buildings, partly by 2030 (about 60% emit less than 20 $kgCO_2/m^2$ in the 2DS) and almost completely by 2050 in the 2DS where almost all buildings are below 10 $kgCO_2/m^2$ and about 60% are below 5 kg CO_2/m^2 (Section C4). This is triggered by policies dedicated to phasing out fossil energy from the heating sector, leading to a shift to district heating and electrically driven heat pumps, as well as the continued efforts in more and more cost-effective building retrofitting. An important prerequisite of this development is the decarbonisation of the Dutch electricity mix (Section C4).

According to calculations with the building stock model (BSM), the total market volume of the energy- and GHG-related building market amounts to about €19 billion per year in 2018 (Section C.5). A bit less than half of this market volume comes from energy sales (€10 billion per year), even though electricity sales for household appliances are not included. This volume is expected to increase in the medium and long term mainly from an increase in energy prices as well as a switch from cheap gas to higher priced electricity (rather than an increase in energy demand).

The building envelope and technology related market volume is expected to increase substantially in the short and the medium term in the 2DS (+14% and +41% respectively by 2021) from intensified activities to catch-up neglected retrofit from the past (Section C5).

In the long term, all market volumes show a decreasing trend. For energy sales, reduction of the energy demand in the building sector in both scenarios (due to more efficient buildings) cannot be offset by the shift to higher price energy carriers anymore.

The reduction on the envelope market volumes is mainly explained by the significant decrease on new construction, as the population of the Netherlands is projected to stagnate and shrink after 2030.

The supply side: construction sector and technology providers

The supply side in the Netherlands, particularly architects, engineers, planners and other stakeholders, consider that the envelope elements present the biggest opportunities for improving the energy performance. On the other hand, 'Ventilation' and 'The user' are perceived as hosting the lowest potential (Section B6).

The renovation of the existing housing building stock is a priority with a big part built before the oil crisis in the 1970s and in the 1980s, also to phase out gas supply in the heating sector. Yet increasing deep renovation rates from less than 1% per year to required levels of 2.5% to 3% represents a true challenge to retrofit sector, which currently mostly consists of small and medium sized companies. To respond to this situation the Dutch government is about to launch a concerted innovation program which goal is to advance industrial approaches to the retrofit case and to bring down costs considerably. Much is expected from standardisation, digitalisation, automation, prefabrication and in relation with this new production technologies, business models and organisation models in the building chain, possibly leading to changing roles for the actors.

The choice of which measures to implement and the motivations behind projects are highly dependent on the stakeholders' perspective (as well as other parameters such as circumstance and state of the building or dwelling).

From the perspective of provate owners, Energy-efficiency related projects are usually linked to energy saving goals or to the ambition to comply to the energy legislation (Section B5). From the perspective of supply-side stakeholder, the most effective drivers for low-carbon technologies are the desire to improve the internal comfort level and the perpective to reduce the energy bill (Section B7). Nevertheless, there are still some barriers to overcome as the lack of awareness and knowledge, limited budget, and in some cases the composition of the buldings (Section B7).

On the roles in different projects, it is usually the contractor who have the higher level of power and central role in communication in most projects. The customer would directly hire the construction company based on its competences trust and, in some occasions, even before having a project. Project developers also have a large role in private housing, as they often develops a whole neighborhood, in which both private houses and social houses are combined. The power of the architect has a tendency to decrease, being contacted when it is judge strictily necesary. (Section B4).

Conclusion and outlook

The climate policies adopted by the latest Dutch government have translated into stringent building codes and ambitious plans to retrofit the existing building stock, accompanied by financial instruments that together intend to drive a deep transformation of the built environment from here to 2050. The recent episodes of seismic problems related to domestic gas exploitation have helped to create more awareness on the matter.

The related reduction in the demand of fossil fuels suggests that the energy and technology providers should be prepared to diversify its activities and to carefully manage its infrastructure assets. Renewable gas or developing heat pump-related energy services might be elements of new business strategies (Section C3)

Other factors such as population growth, behavioural trends and changes in the family structure, will also shape the demand for residential building stock of the future in terms of volume and typologies.

This demands a building sector prepared to provide the necessary expertise and technologies to deliver a more energy-efficient and low-emission building sector, that can also ensure the comfort and health of its habitants.

A

Market overview

A

Aim

Chapter A intends to provide an overview of the country's building market, its frame conditions, trends and market mechanisms for the demand of low carbon products and solutions. It does this by providing a brief introduction of the country´s economy and society as well as a characterization of the building stock and influencing climate factors. Energy and climate goals of the country are also synthesized, which include grid mix, emission factors and implication of climate goals. This is followed by an overview of the current framework of standards and support measures. Investments and employment in the construction sector are finally depicted.

This chapter is based on an extensive literature study. The sources cover a wide range including European statistical data, the respective countries own statistical office, national and international public reports, scientific publications and market information such as prices and sales volumes. The main contribution is, therefore, collecting and summarizing this information, though readily available present in a fragmented manner. All data sources are clearly marked to allow the reader accessing more detailed information as needed. The complete list of sources can be found in the annex of the report.

A1 Introduction
The Netherland's economy and society

NOTE

Current Dutch population is 17.2 million.

The Netherlands is a small country with a population of 16.90 million (2015), or roughly 3.3% of the total EU population[1]. The nominal GDP of the country in 2015 was € 683.45 billion, and it has grown at an average annual rate of 2.31% from 2005 to 2015. The GDP per capita grew from 33,462 €/capita in 2005 to 40,439 €/capita by 2015, and the disposable income per capita grew at an average annual rate of 1.49% during the same period[2]. The population of Netherlands grew at an annual average rate of 0.36% from 2005 to 2015, and in the recent years, the population increase has been driven by a gain in net migration[3].

A1.1 – *Trends in Netherland's GDP, disposable incomes and population.*
Dutch GDP is expected to grow with strengthening domestic demand and exports. Due to the combined effect of a high mortality and a low birth rate, its population gain has been marginal and is fuelled by a net migration to the country.

Sources:
EUROSTAT

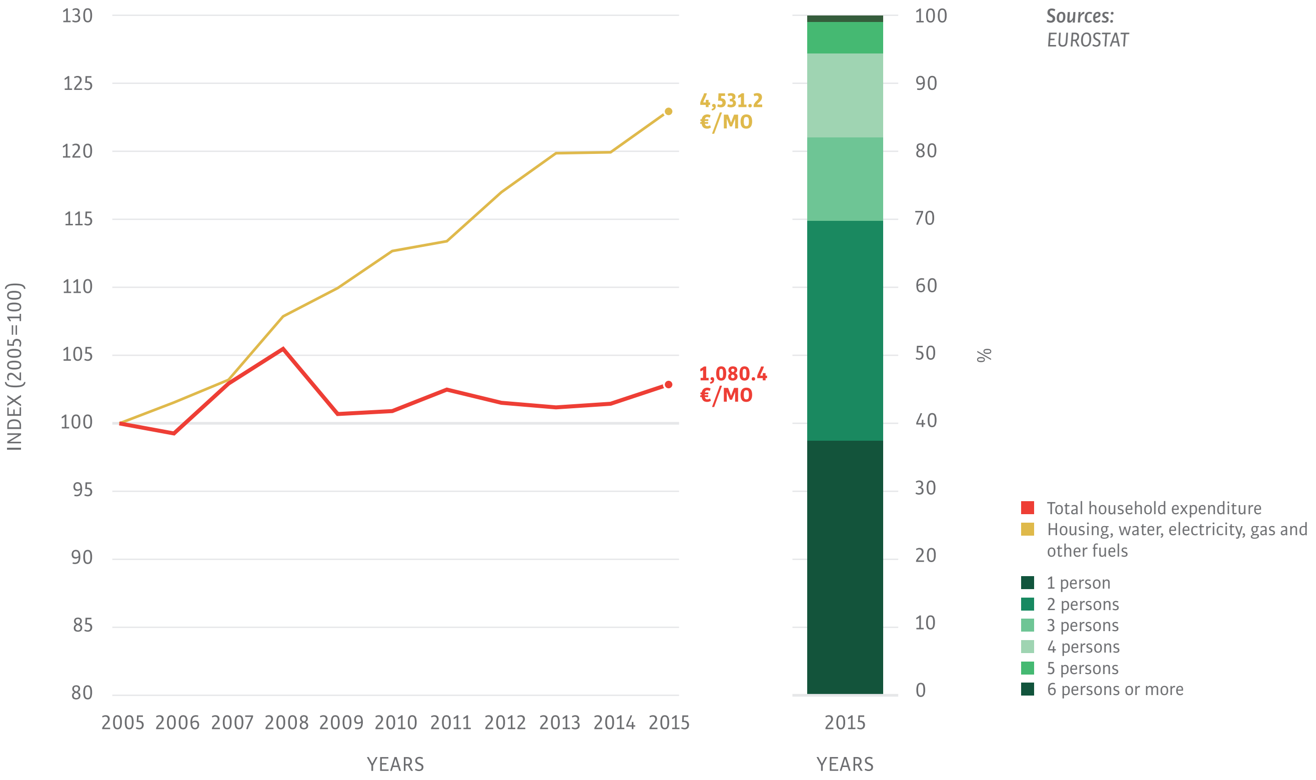
Notes:
GDP index depicted in the graph is in current €.

In 2015, the Netherlands began to limit gas extraction owing to its seismic effects, which also led to a cut in the GDP growth rate. This reduced natural gas production had a negative effect on the trade surplus[4], but nonetheless, the economy has expanded, and Dutch consumers continue to spend more due to the rise in disposable incomes. The services sector contributed 77.9% of the gross value added in 2015, while industry's share was 16%, manufacturing 12% and agriculture 1.9%[5]. The share in value added to the Dutch economy by SMEs is 62.7%, and almost all (99.8%) of Dutch enterprises are SMEs, which contribute 65.2% to total employment[6]. About 2% (in 2015) of the Dutch GDP is spent on R&D, marginally lower than the EU28 average of 2.03%[7], but the Netherlands was ranked 4th amongst the EU28 countries in the European Innovation Scoreboard 2017 and was grouped in the 'Innovation Leaders' category[8].

On the Global Cleantech Innovation Index 2017[9], the Netherlands saw a dip in its rankings, from 11th in 2014 to 15th in 2017. The country demonstrated robust systems that promote entrepreneurship, innovation, and an entrepreneurial culture across the nation but a weakness in the country's low renewable energy penetration relative to the country's overall energy consumption. Nonetheless, the Netherlands showed above average access to early-stage venture capital investments in cleantech start-ups, along with a good score for public R&D expenditure. Some 5.7% of total private equity investments (€ 209.29 million) in the year 2016 were made into Dutch energy and environment companies, up from 2.1% (€ 69.9 million) the previous year[10].

Monthly consumption expenditure per household grew by 2.8% from 2005 to 2015, whilst expenditure on housing and energy grew by 22.8% during the same period, representing an annual average increase of 0.30% and 2.08%, respectively. As a proportion of total consumption, housing and energy expenditure increased from 20.0% to 23.8%, whilst on an aggregate national level, total household consumption expenditure grew by 15.6% and expenditure on housing and energy by 38.1% from 2005 to 2015[11].

A1.2 – *Dutch households witnessed a gradual increase in 1 person households. In 2015, 69.6% of these households were 1 and 2 persons strong. The total household expenditure is roughly 53.1% of the GDP, while that on housing and fuel a 13.98% of the GDP. The slow growth in population and increase in single person households will lead to shift in consumption patterns and preferences overtime.*



From 2015 to 2015, the proportion of one-person households increased from 34.5% to 37.4%, with two-person households also showing a marginal increase, from 31.8% to 32.2%. One- and two-person households thus comprise 69.6% of total households, representing a change in family structure which will shape consumption patterns and the future demand for housing.

A2

Building stock
Building characteristics and influencing climate factors

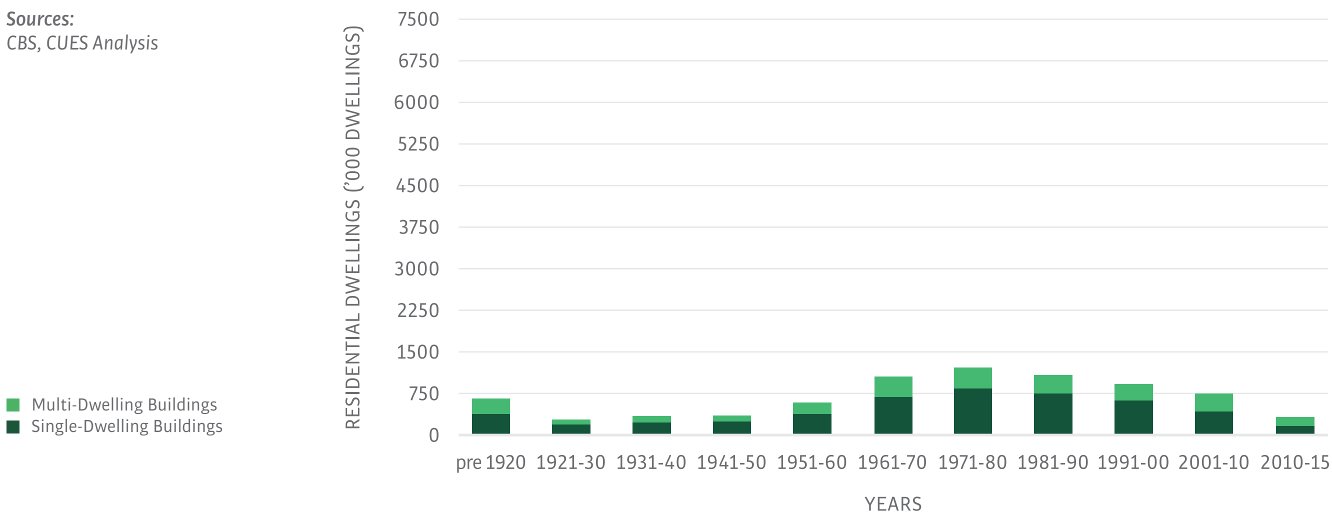
MARKET EXPERT COMMENT

Rather: too low to accommodate the growth in of population and of number of households.
- Arjen Meijer

Roughly 48% of Dutch residential dwelling stock was built before 1970, after which date the growth in the building stock has been waning[12]. The average living area per capita in the Netherlands in 2008 was 56 m²/capita[13]. Whilst both the population and the number of households have been increasing, the housing supply is largely stagnating, causing an annual housing shortage, which is more pronounced in the urban centres of the country[14].

A2.1 – ***Residential building space trends.***
The proportion of new built multi-family dwellings is gradually increasing since the past few decades.

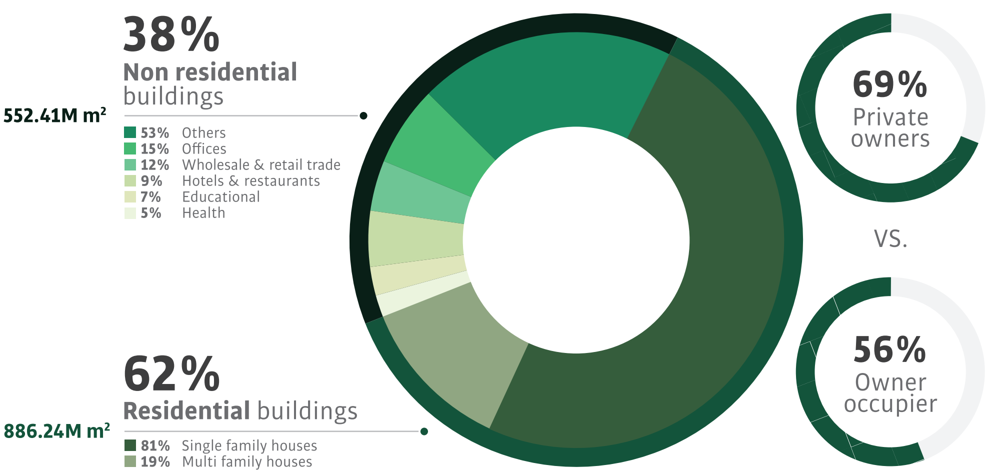
Sources:
CBS, CUES Analysis



In the Netherlands, the residential floor area accounts for about 62% of the total building area of 1,438 million m², whilst the non-residential stock is 38%. Furthermore, single-dwelling buildings (including row houses) account for 79% of the total residential building stock in the country[15].

A2.2 – ***Breakdown of the building stock.***

Sources:
CBS, EU Building Observatory

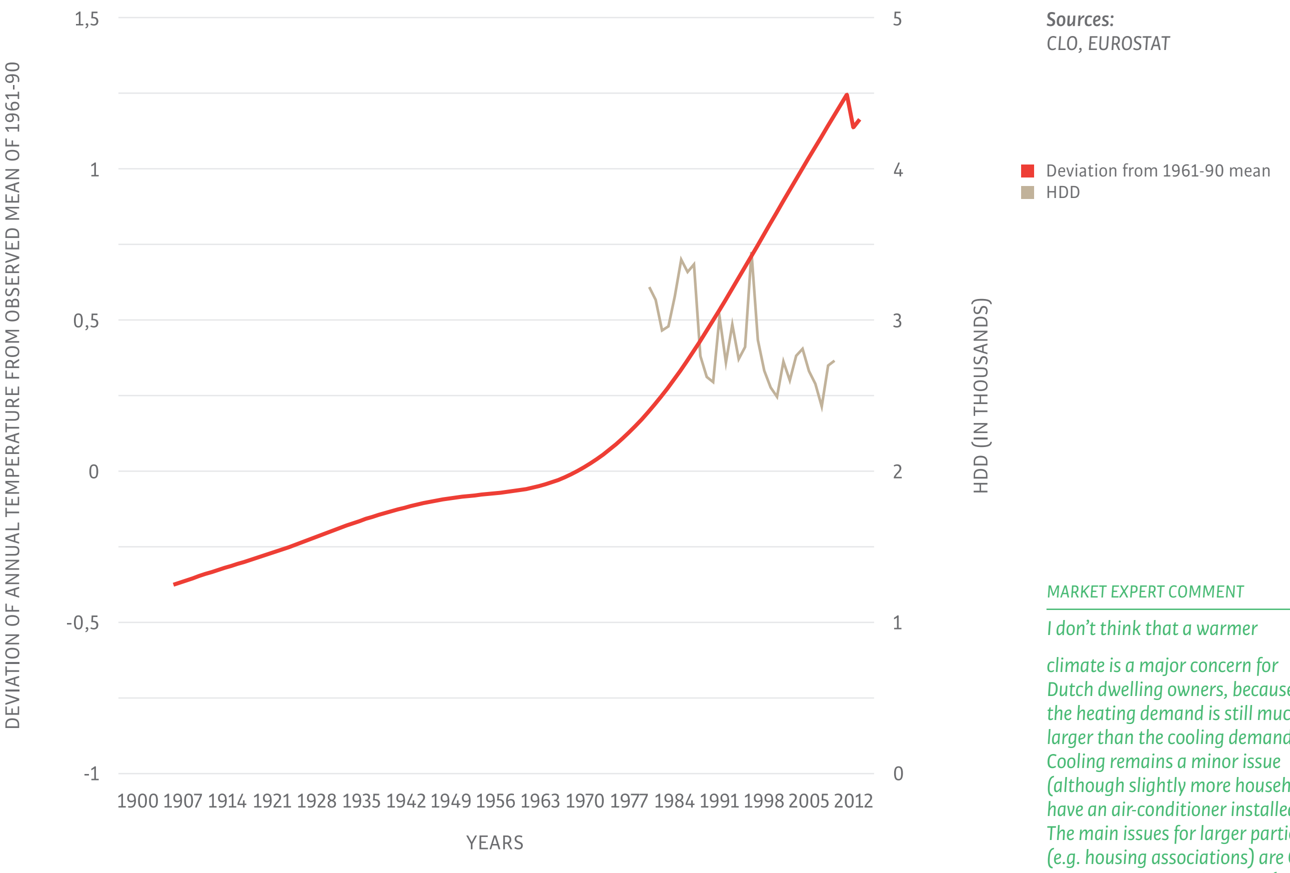


Roughly 69% of residential building stock is privately owned, with **56% being occupied by the owners in the Netherlands**. Around 13% of the residential dwellings are occupied by private tenants, and the remaining 30% are social housing dwellings. A marginal shift has also occurred from the owner-occupied to the rental market[16 17].

Apart from changing socio-economic and demographic factors, the future of Dutch building stock will also be shaped by the effects of climate change. A slow increase in the average mean temperatures has already been observed throughout the previous century and is expected to continue, resulting in a simultaneous reduction in the annual number of HDD's[18], which 1980 to 2009 decreased by 15.15%. The variation in temperatures over time will affect energy demand as well as the design load of future buildings,[19 20] and over time, a higher cooling load is expected to maintain a comparable level of thermal comfort [21].

A2.3– *A period of constant warming.*

Substantially reduced heating demand due to increasingly warmer mean temperatures.



Building stakeholders must therefore be alerted to the consequences of climate change and particularly to the importance of adapting their building to such changes whilst carrying out maintenance-related activities. Erratic changes in weather-related events call for a proactive design of policies and measures that make the building stock resilient to these environmental changes whilst optimising the demand for energy.

NOTE

(HDD) is an indicators to quantify the heat energy demand for a building. It is the number of degrees that a day's average temperature is below a base temperature, below which buildings need to be heated.

USEFUL READING:

~~**BPIE 2014. Renovation strategies**~~ **of selected EU countries. Buildings Performance Institute Europe, Brussels.**
www.bpie.eu

BPIE 2011. Europe's buildings under the microscope. Buildings Performance Institute Europe, Brussels.
www.bpie.eu

Sources:
CLO, EUROSTAT

MARKET EXPERT COMMENT

I don't think that a warmer

climate is a major concern for Dutch dwelling owners, because the heating demand is still much larger than the cooling demand. Cooling remains a minor issue (although slightly more households have an air-conditioner installed). The main issues for larger parties (e.g. housing associations) are CO_2 targets, energy label targets (at least for housing associations), energy costs and the new discussion about the decreasing natural gas production in the Netherlands. For private house owners, the energy costs and, to a lower extent, environmental awareness are the major drivers for energy saving measures.
- Arjen Meijer

A3 Energy, emissions, and climate goals
Introduction to the energy mix, emissions profiles, and the implications of climate goals

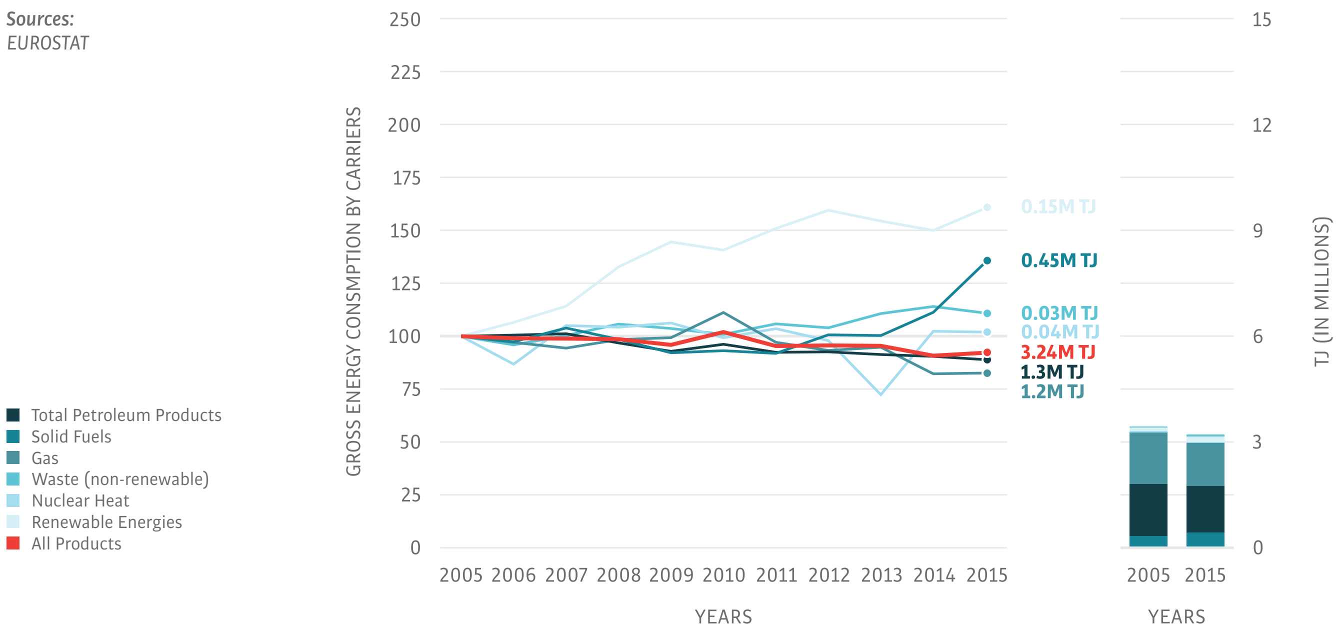
MARKET EXPERT COMMENT

In 2017 a new government coalition agreement increased the targets: 2030 – 49% reduction in CO_2 (ref. 1990); no more Dutch gas by 2030 due to earth quake problems.
- Henk Visscher

The Netherlands's economy relies highly on fossil fuels in its energy mix: in 2015, petroleum products accounted for 40.23% of gross inland energy consumption, followed by gas (37.62%) and solid fuels (14.11%). Gross inland energy consumption has, however, decreased at an average annual rate of 0.75% from 2005 to 2015,[22] and during the same period, the share of renewable energy in gross final energy consumption rose from 2.5% (2005) to 5.8% (2015)[23].

A3.1 – *A decade since 2005, the Dutch total gross inland energy consumption decreased by -7.79%.*
Netherland's climate goals, in line with that of EU, support 20% reduction in GHG comparing 1990 levels.

Sources:
EUROSTAT



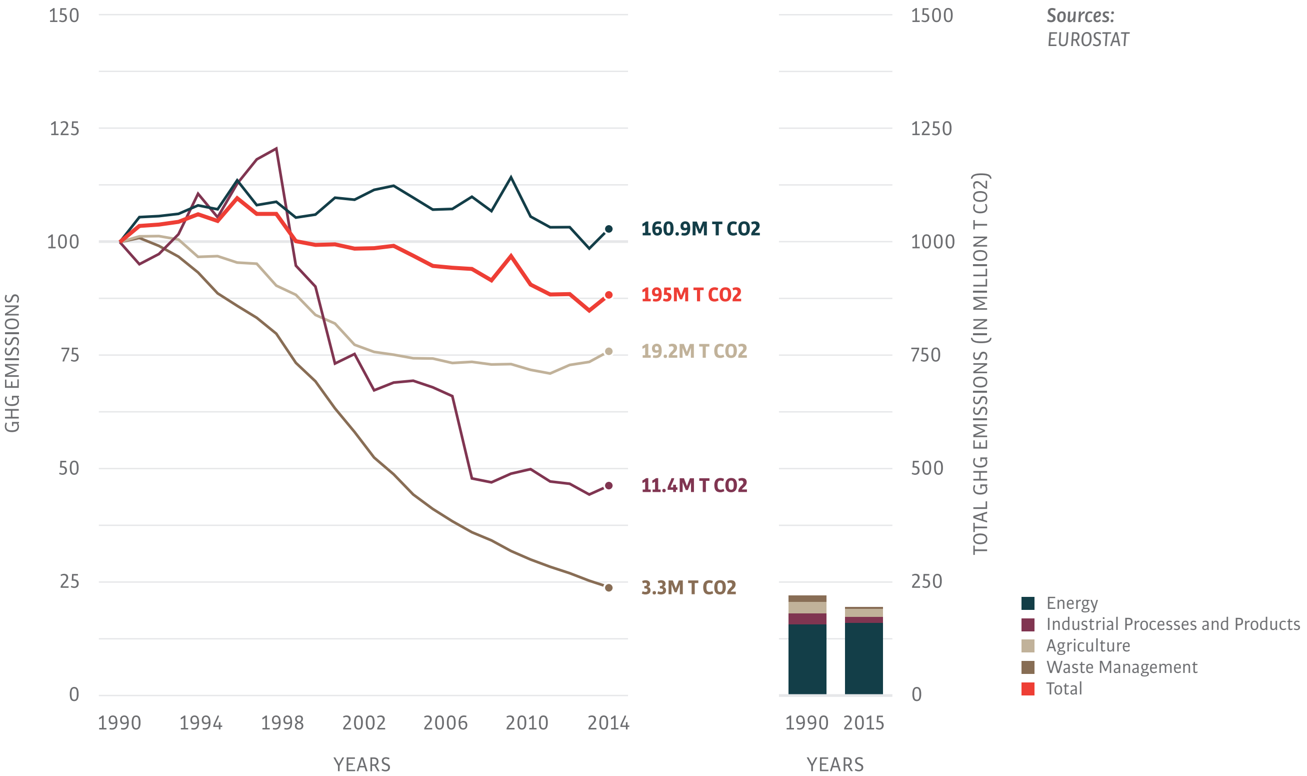
In 2015 in the Netherlands, 103,112 GWh of electrical energy was consumed, marginally lower than the 104,666 GWh consumed in 2005. In 2015, total residential consumption of electricity was 22% of gross consumption (2015)[24] and was heavily dominated by gas (71.3%), followed by electricity (20.4%)[25]. Fossil fuels occupy a major share of the electricity mix at 81.3% (mostly gas and coal), followed by renewable energy (12.4%) and nuclear (3.7%)[26]. The standard emissions factor for the electricity generated is 0.435 kg CO_2eq./kWh, whilst that with a LCA approach is 0.716 kg CO_2eq./kWh[27]. The average electricity price (including taxes) for medium-sized households in the Netherlands was around 0.1986 €/kWh_{electr}, whilst that for a mid-sized industry was 0.0722 €/kWh_{electr}[28].

Residential energy consumption stood at around 400,140 TJ in 2015, or 19.7% of total energy consumption[29], with space heating as the dominant usage of residential energy (63.1%), followed by lighting and appliances (17.8%) and water heating (16.7%). The fuel used for space heating is pre-dominantly gas (86.9%), which is also the major energy source in water heating (89.8%)[30]. The share of renewable energy in heating and cooling in the Netherlands was 5.5% in 2015, up from 2.4% in 2005[31]. The emissions factor as a result of heating ranges from 0.129 kg CO_2eq./kWh_{heat} to 0.031 kg CO_2eq./kWh_{heat} based on the heat source.[32].

Energy consumption by households and commercial institutions which is attributable to building-related emissions stood at 24.4 Mt CO_2 eq. in 2015 (over 12.5% of total emissions). Since 1990, building sector emissions fell by 17.79% at an average annual rate of -0.22%[33].

***A3.2** – Since 1990, total direct CO_2 emissions of the Netherlands decreased by 11.7% while building sector emissions reduced by 17.8%.*

Since 1990 till 2015, the Dutch total emissions remained in the range of 187-230 Mt. The emissions per capita in 2015 was 12.23 t CO_2eq/capita which is above the EU average of 8.75 t CO_2eq/capita.



Sources:
EUROSTAT

During the same period (1990–2015), the amount of residential building space to be heated increased along with the Dutch population (from 14.9 to 16.9 million). Despite this growth, the amount of overall emissions decreased due to the shift from coal-based power to gas, as well as energy efficiency measures.

The Netherlands achieved an 11.57% emission reduction from 2008–12, compared to 1990 levels, therefore exceeding its target of 6% for Kyoto Protocol Phase I. The government employs a variety of policies and instruments to address GHG emissions and energy issues. The Clean and Efficient Program (CEP Schoon en Zuinig Program, 2008), the Environmental Management Act (Wet milieubeheer), and the National Climate Policy Implementation Plan provide a framework for implementing climate and energy efficiency policies. The EU's 2020 targets include 14% of total energy being renewable and a 16% GHG emissions reduction by 2020, compared to 2005 levels[34]. Dutch climate commitments are based on the Climate Letter 2050 (Klimaatbrief 2050, 2011) and the Climate Agenda (2013). In accordance with EU directives, the country intends to reduce emissions by at least 40% by 2030 and 80–95% by 2050, compared to 1990 levels, goals which were also laid out in the EU's INDC to the UN.[35 36 37 38]

USEFUL READING:

INDC of EU and Member States.
www4.unfccc.int

A4 Policy framework
Building sector norms and a legal framework

USEFUL READING:

ING 2013. Saving Energy in the Netherlands. ING.
www.ing.nl

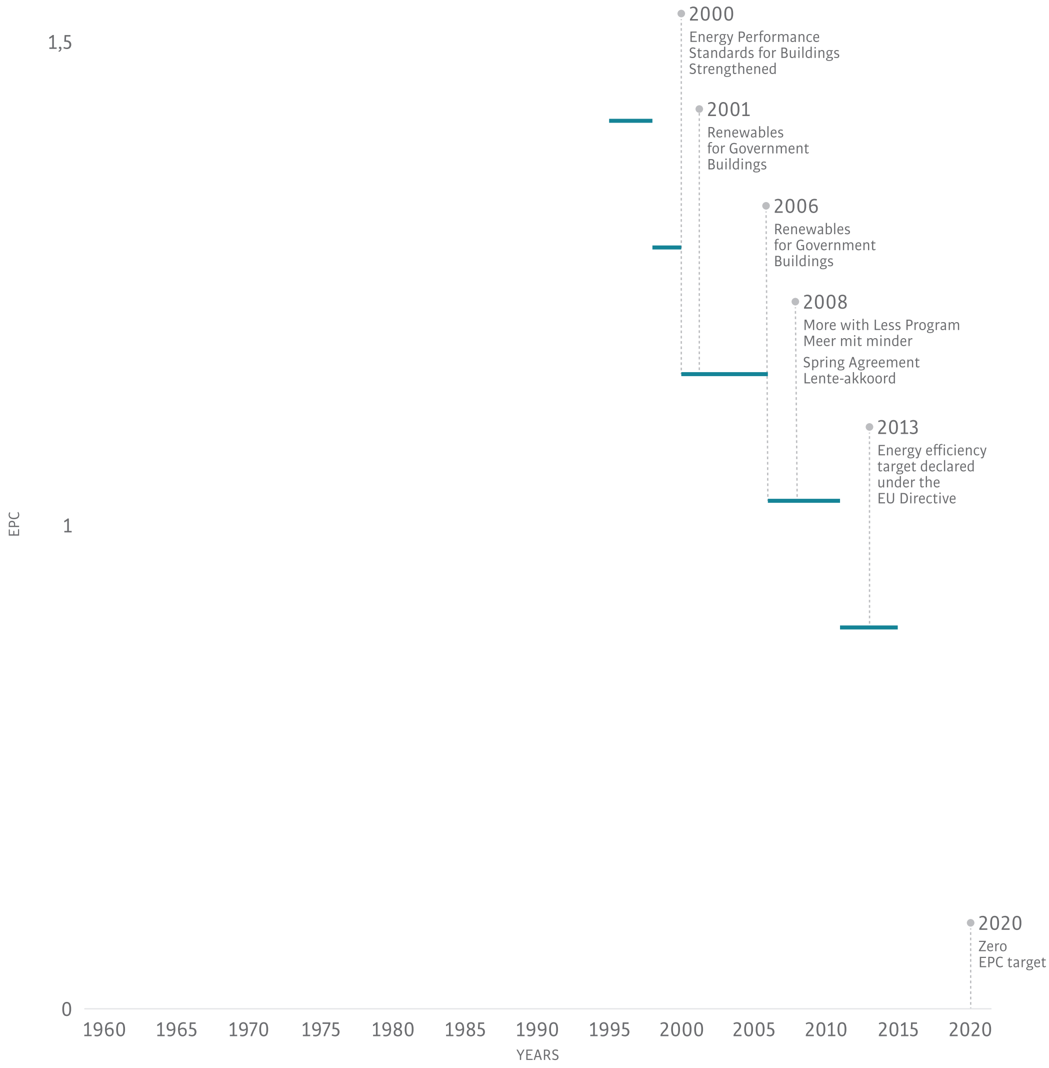
The energy efficiency policies in the Netherlands are coordinated by the Ministry of Economic Affairs in collaboration with other ministries and are set out in the Environmental Management Act (Wet milieubeheer) and the National Energy Efficiency Action Plan (NEEAP)[39]. Since 2008, the country has relied on its Clean and Efficient Program (Schoon en Zuinig) and the Energy Transition Framework, which based the domestic energy policy of the Netherlands on the EU's 20-20-20 targets and framework. The 2011 Energy Report outlined the Netherlands's ambition to become more sustainable in its energy usage and thus transition to a low-carbon economy by 2050.

On the basis of a coalition agreement (Building Bridges 2012), in 2013, the government along with other parties concluded an Energy Agreement (Energieakkoord) for sustainable growth, which aims to double energy efficiency savings to 1.5% per year (or 100 petajoule's) by 2020[40]. Building upon the Energy Agreement, the Climate Agenda of 2013 affirmed the country's commitment to reducing CO_2 emissions by at least 40% by 2030 and by between 80% and 95% by 2050[41]. To promote energy efficiency, the Netherlands uses energy taxation, which is levied on all electricity and natural gas consumption except the 'basic energy needs' of households[42].

A4.1 – *Progression of energy performance co-efficient (EPC) for new residential houses in the Netherlands.* *Building standards have increasingly become stringent over the past decades*

Sources:
CUES Analysis

Notes:
Lower EPC corresponds to higher energy efficiency in buildings. The EPC is separate for residential and non-residential buildings. In determining the EPC of new residential houses options related to the building envelop, space heating, hot water and ventilation, and renewable energy usage are considered.



The climate agenda has influenced policies in the building sector since the 1990s, with the Sustainable Building Action Plan (1995) targeting energy usage as one of its key areas. In December 2002, the parliament and council approved the European Energy Performance of Buildings Directive (EPBD)[43].

MARKET EXPERT COMMENT

This is a key element in the Dutch building regulations. It is the main driver for application of insulation, and of energy efficient heating and ventilation in newly built houses. The EPC is introduced in 1995 as a result of the Nationale Milieubeleidsplan 2 (NMP 2).
- Arjen Meijer

In July 2018 the new Climate and Energy Agreement will be presenting with lots of new policies and financial measures. One of it will be a object based Mortgage system.
- Henk Visscher

Building Standards

Building standards have become increasingly stringent since the 1990s, with the energy performance coefficient decreasing from 1.4 in 1996 to 0.4 in 2015[44]. Recently, the building codes for newly built houses were strengthened by 25% in 2011 and 50% in 2015 (compared to 2007 levels). The 2015 standard was further tightened to aim for a 50% reduction in energy usage in new buildings (compared to 2007 levels). The Dutch National Plan for achieving nearly zero-energy buildings ambitiously aims for all new buildings to be nearly zero-energy (25kWh/m^2) and gas-free by 2021. Further, it ordains that all public government buildings with areas greater than 500 m^2 will receive an energy label from 2013 onwards and greater than 250 m^2 from 2015 onwards. Those houses which have Energy Performance Certificates can avail themselves of funding for renovation, and all homeowners were to be assigned with a label in 2015[45].

Financial Support Measures

A variety of voluntary agreements and measures stimulate energy efficiency investments in Dutch buildings, for example, the More with Less Covenant (Meer met Minder) and the Voluntary Energy Saving Agreement for the Rental Sector (Covenant Energiebesparing Huursector). According to these measures, corporate-owned residential buildings should achieve an average of energy label of B and those owned by private landlords a minimum of label of C by 2020. The government agreed to provide some € 400 million in financial support between 2014 and 2017 (i.e., about 100 million/year, which is less than 5% of the annual building market volume, see Chap. C).to enable owners to achieve these labels. Under the Energy Leap Program (Energiesprong), which enables the construction of Energy Neutral Areas (Gebieden Energie Neutraal) and buildings, a range of demonstration projects have been launched. The Energy Agreement foresees the creation of a revolving fund for energy efficiency of € 600 million to promote energy conservation in the residential housing. In addition, public subsidies for renovation can be accessed through the Green Fund Scheme, the Energy Investment Allowance (EIA), the Energy Savings Credit Guarantee, and the Green Projects Scheme or the National Mortgage Guarantee[46] [47].

USEFUL READING:

Thomas, S. et al. Energy Efficiency Policies in Europe. Energiesprong (Energy Leap) in The Netherlands. Energy Efficiency Watch.
www.energy-efficiency-watch.org

A5

Investment and employment
Construction costs and jobs in the building sector

USEFUL READING:

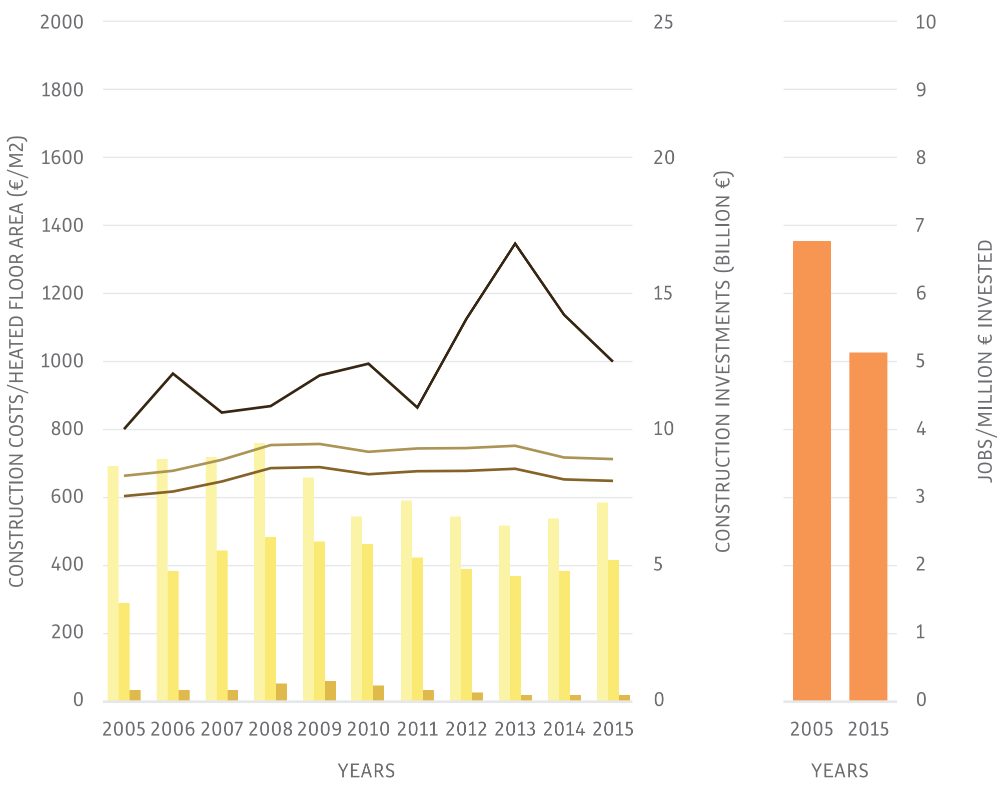
Investment in office property in the Netherlands: A European perspective. IVBN & JLL.
www.bouwinvest.nl

Colliers International 2017. The Dutch real estate market. Update august 2017. Colliers International.
www.colliers.com

The construction sector accounts for over 6% of the Netherlands's GDP. In 2015 roughly 4.5% of the Dutch GDP, totalling € 30.5 billion, was spent on building construction. Of this, some 65.8% was spent on the construction of new buildings, whilst the remaining went into repair and maintenance related work. Since 2005, total investment in building construction increased at an average annual rate of 1.3%. Aside from its apparent economic significance, the building construction sector has an employment impact too. In 2015, for every million € thus invested, around 5.1 jobs were created that could be directly linked to construction of buildings[48, 49].

A5.1 – *Total construction investments by type of development (EUR bil.) , along with jobs attributed to construction related investment.*
The total employment contribution by construction and ancillary sectors linked to it was 7.5% in 2015.

Sources:
CBS, CUES Analysis



Investment in building construction is driven by an increase in population, average net floor area per person and a trend toward smaller households. Since 2005, the proportion of building investment in single- and multi-dwelling buildings has varied, but gradual increase can be observed in the proportion of money invested in multi- dwelling buildings. In 2015, 58% of construction costs could be attributed to single-dwelling building development and the remainder to multi-dwelling[50]. Investment increased at an average annual growth rate of 4.3% in multi- dwelling buildings from 2005 to 2015. In terms of building constructions costs on a per-heated-floor-area basis, office construction costs are the highest amongst all the categories.

MARKET EXPERT COMMENT

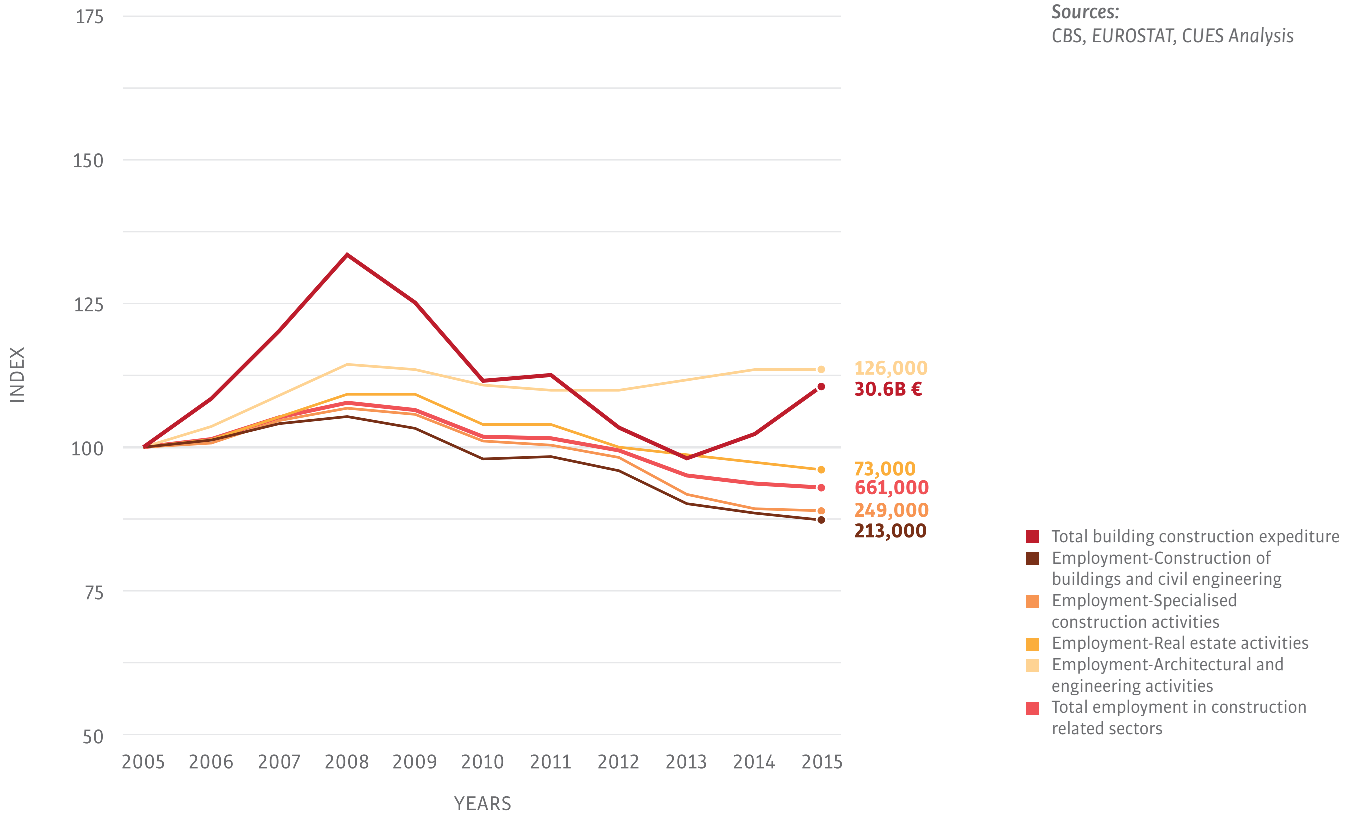
As per the Coalition Government Agreement in the next 3 years they wish to achieve renovation of 50.000 dwellings per year, followed by 200.000/300.000 per year.
- Henk Visscher

The Netherlands has 7.6 million residential dwellings, many of which require refurbishment for the country to meet its energy efficiency targets, but the current rates of deep renovation are too low to facilitate meeting of the goals. Most scenario analyses and roadmap reports on energy renovations and savings usually calculate high energy renovation rates of 2.5–3% for the near future to achieve the goals[51].

Of the 8.8 million total employment in Netherlands in 2015, roughly 7.5% of employment was attributed directly to the construction sector (including building construction) or sectors which are linked to main construction activity, including professional services such as architecture or building engineering and specialised construction activities such as refurbishment. In 2015, for all enterprise sizes, the hourly labour costs were € 33.8 in construction, € 39 in real estate activities, and € 43.6 in professional, scientific, and technical activities (which includes architecture and engineering services)[52]. The cost of labour and materials in construction was roughly divided at a 50:50 ratio for new buildings and 60:40 for renovation. In 2015, 65% of the Dutch population was of a working age (15–64),[53] and sectors such as public administration, health care, trade, transport, hotels and catering employed roughly 52% of the employed population[54].

A5.2 – *Index of employment and investment (2005=100)*

Increase in total construction investments, is paralleled by a similar trend in total employment related to construction.



Sources:
CBS, EUROSTAT, CUES Analysis

Gradual growth was witnessed in employment in the construction sector and the ancillary sectors which depend directly or indirectly on construction activity, including architectural and engineering services and real estate activities. Between 2005 and 2015, whilst total construction expenditure jumped by 10.8%, total employment in construction and its ancillary sectors declined by 7%. Of this, employment in architectural and engineering activities (a 13.5% increase since 2005), witnessed the most pronounced change.

The building construction sector is impacted by changing trends in business, lifestyle, and demographics. To transition the existing stock toward a low-carbon path would require not only specialised skills but also targeted investments.

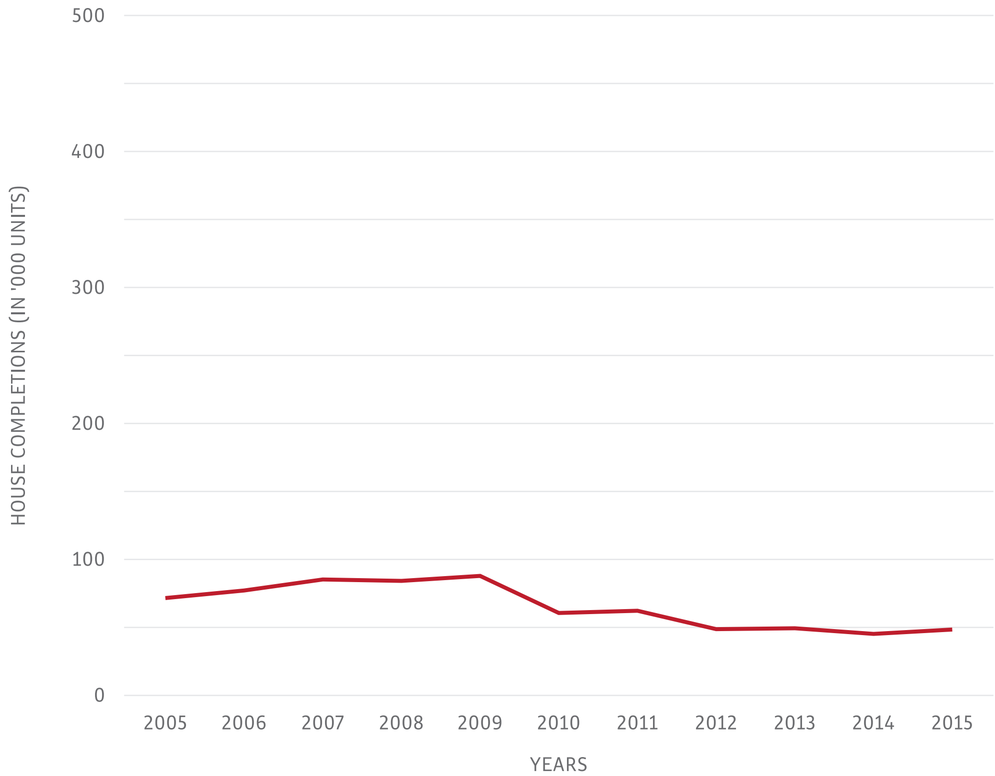
A6 Demand, supply, and affordability
Housing market conditions

The Dutch housing market consists of approximately 7.6 million dwellings, of which 57% are owner-occupied and the remainder rented. Only 10% of rental homes are part of the non-regulated rented sector, whilst the remainder are regulated. Housing associations own the largest share of rental homes (around 2.4 million), 94% of which belong to the regulated rented sector, whilst investors (institutional and private) own approximately 18% of all rental homes.

The economic crisis that struck from 2009 to 2013, combined with policy changes and stricter lending criteria, have had a strong impact on housing construction. In 2013, the number of building permits issued was 70% lower than in 2008. In the years preceding the financial crisis, around 80,000 homes were built annually, but this fell sharply after 2008. In 2010, construction declined to less than 60,000 units, and only around 50,000 were constructed annually in 2012 and 2013.

A6.1 – *House completions in The Netherlands ('000 units)*

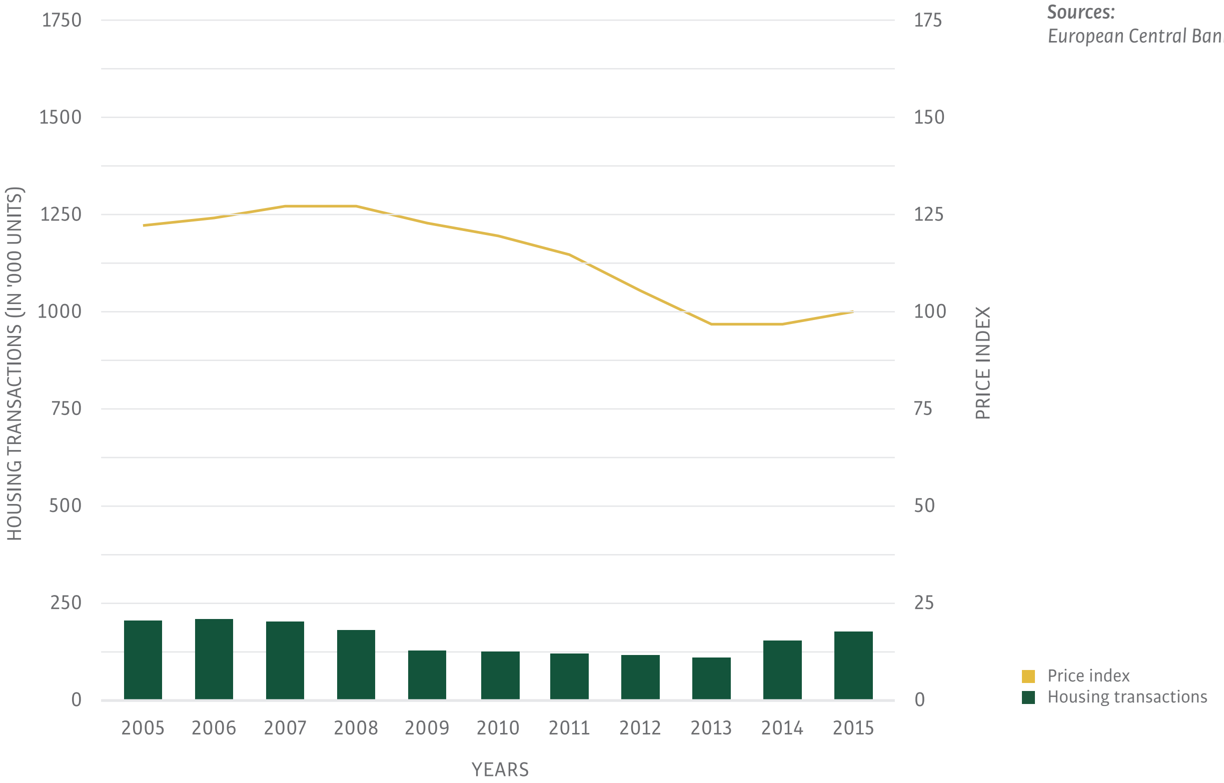
Sources:
European Central Bank



Since 2013, the number of permits issued has recovered, but it is still tens of thousands less than the 2000–08 average. In 2014, the Dutch housing market witnessed the first cautious signs of recovery, which continued vigorously in 2015, fuelled by low interest rates and increased consumer confidence and finally marking the end to the housing market crisis which began in 2008. Housing prices and transactions have grown considerably, particularly in the Randstad conurbation (Amsterdam, Rotterdam, the Hague, and Utrecht), and in 2018, the government agreed that in the next 10 years, a projected 75,000 new dwellings will have to be built annually.

The average price of an owner-occupied home declined by roughly 20% from 2008 to 2013 (excluding inflation). In 2013, both the number of transactions and the average sales price hit their lowest points. Since then, the number of homes sold, and their prices, have been on the rise. More than 170,000 homes were sold in 2015, at which point prices once more began to climb. By 2018, the levels apparent before the crises had once already again been reached.

***A6.2** – Number of transactions and housing price variations in The Netherlands*



Sources:
European Central Bank, EUROSTAT

The Netherlands is currently experiencing a housing shortage. Property websites pointed to around 150,000 available houses and apartments for sale in early 2017, compared to around 240,000 four years previously. Market estimates suggest that housing demand exceeded supply by 130,000 homes annually in recent years, a shortfall that is expected to persist in the near term. This shortage is most apparent in Amsterdam, where, against a backdrop of double-digit price rises, the number of sales declined in 2016 (down 2%), in contrast to solid transaction growth in other major cities.

Structural developments in the housing market are also a driver of recent price growth. The Netherlands has one of the largest social housing sectors in the EU (accounting for 30% of all households), but to encourage market-based rents government is gradually scaling back subsidies. This has led households to seek private accommodation and increased demand for rental properties.

The pre-crisis housing boom was driven by generous tax incentives for homeowners, loose borrowing criteria and lax regulatory oversight. Over recent years policymakers have encouraged prudent lending, gradually reducing the maximum loan-to-value ratio on new mortgages and mortgage interest deductibility. Nevertheless, the policy environment remains heavily weighted toward encouraging mortgage indebtedness with the household debt/disposable income ratio at 252% in 2015, compared with a euro zone average of 105%.Limited research has been conducted on the effects of energy efficiency on Dutch residential property values. Research conducted in 2011,55 however, demonstrated that there was a premium on rents or sale value for homes that were more efficient. After controlling for other factors affecting quality, the study found a 3.6% premium for A, B, and C rated homes compared to other properties in the Netherlands.

USEFUL READING:

Brounen, D. 2017. Lagere verkoopprijs door ongunstig energielabel woning. TIAS, NL.
www.tias.edu

AEDES 2016. COELO: Verhuurdersheffing rem op aantal sociale huurwoningen. AEDES.
www.aedes.nl

A7 The retrofit challenge
Status of building refurbishment

MARKET EXPERT COMMENTS

It is not regulated, but a communicative instrument. The labels only give insight in the performance of the building, without any mandatory implications to improve a building.
- Henk Visscher

In 2015, the government determined an estimated energy label (voorlopig energielabel) for houses with no energy label and made these available to the house owners. For the sale of a house, a definitive energy label is required. e.g. https://www.energielabel.nl/woningen/.
- Arjen Meijer

NOTE

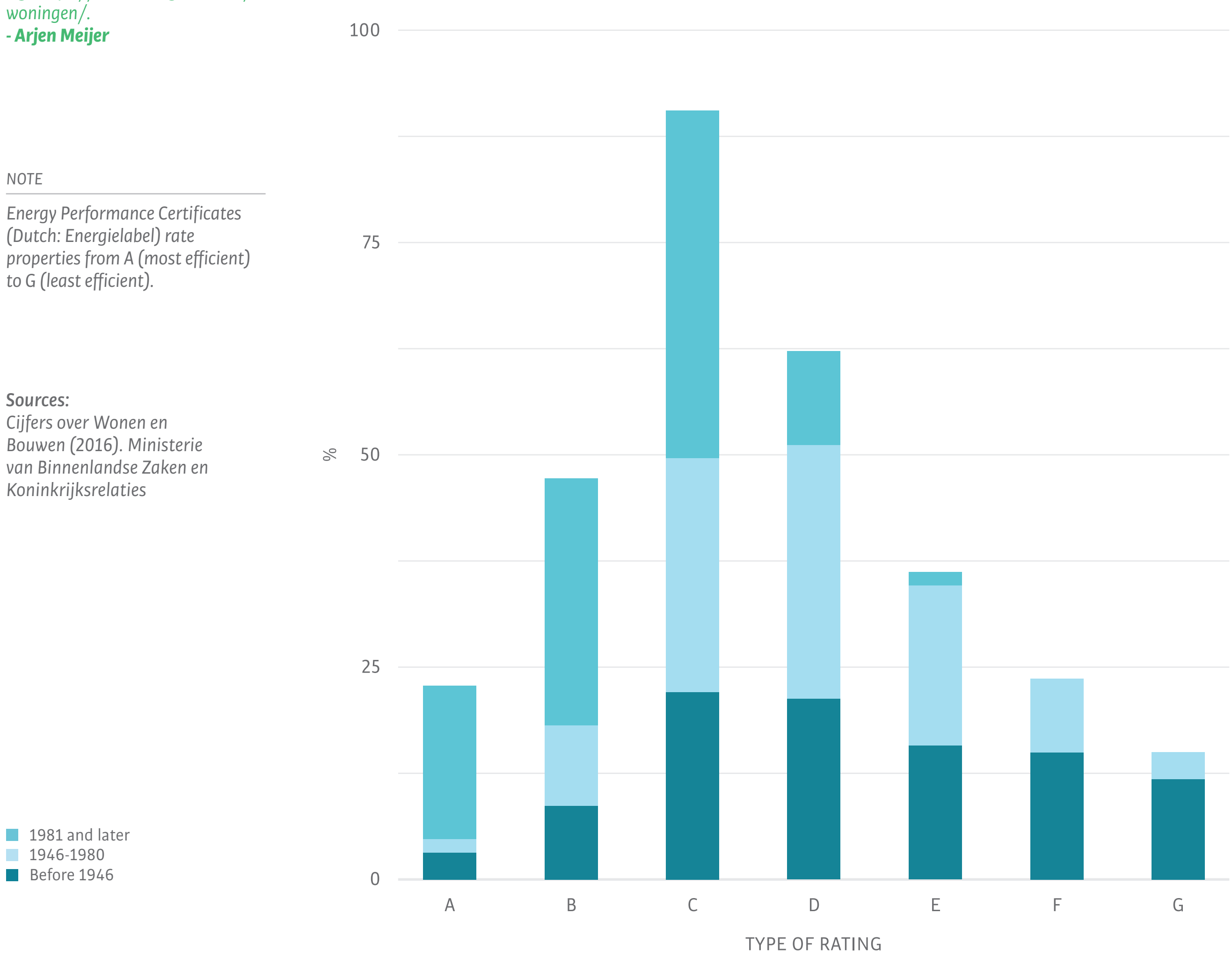
Energy Performance Certificates (Dutch: Energielabel) rate properties from A (most efficient) to G (least efficient).

Sources:
Cijfers over Wonen en Bouwen (2016). Ministerie van Binnenlandse Zaken en Koninkrijksrelaties

Households in the Netherlands account for approximately 18% of the country's total carbon emissions[56]. The Dutch government has been taking energy-efficiency measures since 1975, mainly through building decrees. Despite the regulations and directives, a greater focus has been placed on newly built dwellings, achieving nearly zero-energy standards, than on energy renovations of building stocks.

Since the EPBD was implemented in the Netherlands in 2008, the energy performance of the existing housing stock is being regulated through EPCs. Currently, around 2.9 million dwellings have an EPC, the majority belonging to the rental sector, and the average EPC rating in 2015 was a C[57].

A7.1 – *Energy rating of dwellings by year of construction (2015)*



TThe Netherlands has made energy efficiency one of its main priorities, as established in several national plans, including the Energy Agreement for Sustainable Growth (September 2013) and the third National Energy Efficiency Action Plan (NEEAP, 2014). The Energy Agreement aims to achieve an average energy efficiency savings of 1.5% per year, adding up to a reduction of 100 PJ by 2020, after which time newly constructed buildings must reach the Nearly Zero Energy Building (NZEB) standard.

To realise these objectives, the government signed voluntary agreements with key players within the Dutch housing, energy, and construction sectors to improve the annual energy performance of at least 300,000 existing residential and other buildings by at least two EPC ratings. The parties to the Voluntary Energy Saving Agreement for the Rented Sector [Convenant Energiebesparing Huursector] committed themselves to the agreed objectives of ensuring an average EPC rating of B for housing corporations and a minimum EPC rating of C for 80% for private landlords by 2020. Housing corporations are non-profit organisations and own about 2.4 million rental homes, representing 31% of the housing stock. The government has made available € 400 million of funding between 2014 and 2017 for investment in energy-saving measures in the subsidised rented housing sector in order to contribute to achieving the objectives of the Voluntary Agreement.

On the regulatory front, the Dutch government has made changes to the valuation system for residential buildings, whereby the maximum rent that a landlord can charge for a property is linked to its EPC rating. From July 2011, the changes applied to dwellings that already had an EPC and those that must have had an EPC under the regulations and were extended to all rental homes from January 2014.

In recent years, the Netherlands has successfully tested innovative financial models to enable large-scale retrofitting. One of these programmes, Stroomversnelling[58] (Acceleration), is a deal between housing corporations and builders that will enable dwellings to be renovated to a ‘zero-on-the-meter’ (nul op de meter) standard by 2020. The essence of the concept is the idea of using the energy bill to finance the renovation of housing into zero-energy homes. Building companies provide landlords with guarantees that the home will have no energy costs after renovation. The first deal was signed in June 2013 between four builders and six housing corporations for the renovation of 11,000 homes, a number later extended to 100,000 homes. More recently, around 800,000 dwellings are being tackled through a similar programme in the province of Noord-Brabant.

Another market development programme is Energiesprong[59] (Energy Leap), launched in 2010 with a € 50 million government funded budget to develop attractive and viable net-zero energy retrofit solutions. The key to the success of this measure is that it appeals to both industry and tenants. For tenants, the retrofits are affordable and quick to implement, and their long-term performance is guaranteed. For builders, the scheme provides economies of scale and guaranteed income, as they are paid for through savings on energy bills. Energiesprong has successfully delivered nearly-zero energy retrofits to over 2,000 new and existing homes so far and has agreed a deal to retrofit 111,000 Dutch homes by 2020. The success of this model has led to it being exported internationally into markets such as the UK and France.

MARKET EXPERT COMMENTS

This was the plan, in practice I estimate that a little more than 1000 (renovated) dwellings have been realised so far. The investments (for renovations) so far are still too high: 70/80,000 EUR per dwelling. With a 30,000 EUR aid it would become affordable.
- Henk Visscher

Stroomversnelling and Energiesprong is more or less the same. Energiesprong was a large innovation programme from which the Stroomversnelling emerged. The net zero home concept, the planned numbers and the realised houses are all the same.
- Henk Visscher

B

Market mechanisms, barriers and drivers

B

Aim

The chapter 'Market Mechanisms, Barriers and Drivers' provides stakeholders' perspective on residential building projects in Germany. The aim of this chapter is to support the conception of business strategies and policy measures to foster energy efficiency and low carbon solutions.

Based on a survey covering the whole value chain and a series of experts' interviews, this chapter aims to capture the stakeholders' perspective on low carbon building concepts and solutions, covering both the construction of new buildings and the retrofit of existing ones. Special attention is put on those aspects considered as most critical for in the uptake of respective technologies, particularly the decision-making process.

Methodology

The data gathered in this chapter was obtained via an online survey and in-depth market expert interviews.

The data from the online survey were collected from June 2018 to September 2018 and covered stakeholders along the complete value chain of the building. Stakeholders from a stratified sample of a total of 21 groups were approached, providing a differentiated view of the market. The study is centred around concrete past projects of the respondents. The survey results are used to quantify findings when a statistically relevant response rate is available.

The content and topic of the survey is based on exploratory interviews and findings from a literature review study. Sources used are listed in the reference section of this report. Questions and answer options were tested in a pilot phase. Every survey question offered a pre-selection of choices as well as 'other' and 'I don't know / can't judge' options.

The in-depth experts' interviews to market experts were conducted between August and September 2018. The experts were selected to cover the complete value chain of the construction sector in the respective country (i.e. planning, technology and material suppliers, construction and installation, use, end of life and overarching), as well as projects types (new built and refurbishment) and project scales (small and large typologies of buildings), where applicable. The results from these interviews are presented and clearly marked after the survey results, to complement this information. These statements may, in rare occasions, conflict the results from the survey.

The level of agreement among the interviewees on the statements in the main text is ranked in the following stages:

- **Very high**: virtually all experts that feel confident to comment on the statement agree.
- **High**: nearly all experts agree at least to a certain degree.
- **Medium**: there is a trend among the experts to back up the statement, but a notable number are not convinced, though they don't disagree.
- **Low**: some experts emphasize the statement but there is no consensus among the experts, some experts might even disagree

B1 Value chain & life cycle of the building
Defining the scope and rationale

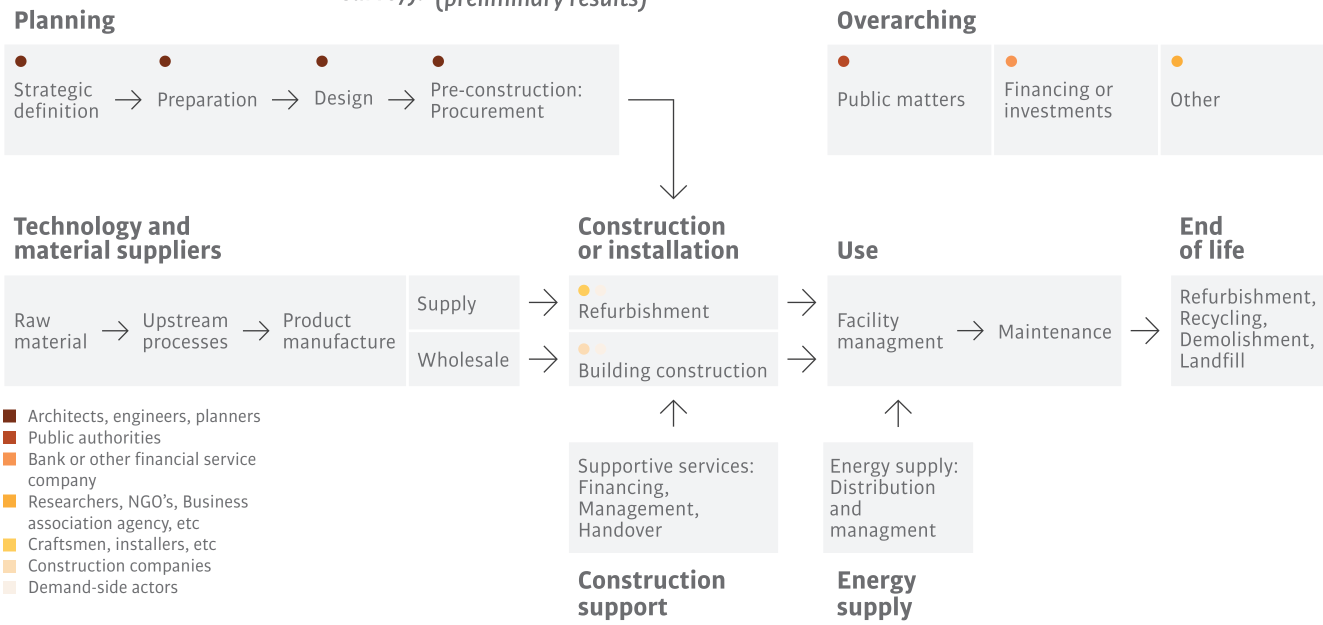
USEFUL LINKS:

www.ec.europa.eu

The value chain refers to all stakeholders from the raw material, material and technology production, installation usage and deconstruction professions. To provide a comprehensive understanding of stakeholders' view, this study covers groups along the whole building value chain in The Netherlands, entailing more than 20 stakeholder groups. To properly contextualize the market structure the exact number and size of enterprises is listed below for the main stakeholder groups.

Figure B1.1.1 visualizes the structure and main phases in the building value chain that were used as basis for the survey and structure of the following subchapters. From the table B1.1.2 below it becomes apparent the majority of companies and also of the professionals of the main sectors of the building value chain in The Netherlands are small and medium sized companies up to 50 employees. Only in the main sector of (new) building construction larger companies prevail.

*B1.1.1 – **Dutch** characterization of the residential building value chain (the "universe" of the survey). (preliminary results)*



Sources:
NACE Rev. 2, Eurostat

(preliminary results)

*B1.1.2 – Number of enterprises and employees for planning and construction activities in **The Netherlands**.*

		Total	0 to 9	10 to 19	20 to 49	50 to 249	250 or +
Number of enterprises	**Construction of buildings**	**66,526**	**65,115**	**744**	**432**	**214**	**21**
	Development of building projects	4,482	4,417	40	18	7	-
	Construction of residential and non-residential buildings	62,044	60,698	704	414	207	21
	Specialised construction activities	**86,323**	**83,277**	**1,708**	**925**	**365**	**48**
	Demolition and site preparation	5,683	5,370	161	109	42	1
	Electrical, plumbing and other construction installation activities	19,712	18,115	846	483	225	43
	Building completion and finishing	45,077	44,455	406	170	46	-
	Other specialised construction activities	15,851	15,337	295	163	52	4
Number of employees	**Construction of buildings**	**78,007**	**20,267**	**10,463**	**14,205**	**20,398**	**12,675**
	Development of building projects	5,235	2,949	-	738	900	-
	Construction of residential and non-residential buildings	72,771	17,318	-	13,467	19,497	-
	Specialised construction activities	**168,864**	**38,459**	**23,989**	**29,126**	**35,732**	**41,559**
	Demolition and site preparation	12,598	2,763	-	3,352	3,845	-
	Electrical, plumbing and other construction installation activities	105,209	15,775	12,016	15,631	22,716	39,070
	Building completion and finishing	27,825	13,154	-	5,131	3,965	-
	Other specialised construction activities	23,232	6,766	-	5,012	5,205	-

The building life cycle refers to the prospect of a building over the course of its entire life - encompassing the design, construction, operation, maintenance, modification and eventual demolition and waste treatment. To characterize what measures have taken place during the complete building's cycle in The Netherlands, the building typologies are differentiated between small (one family home, row houses, small multi-dwelling building, etc.) and large projects (large multi-dwelling buildings) and types of projects are differentiated between new building activities, light modification of an existing building (overhaul, partial retrofit, refurbishment) and in-depth modifications of an existing building (deep comprehensive retrofit).

USEFUL READING:

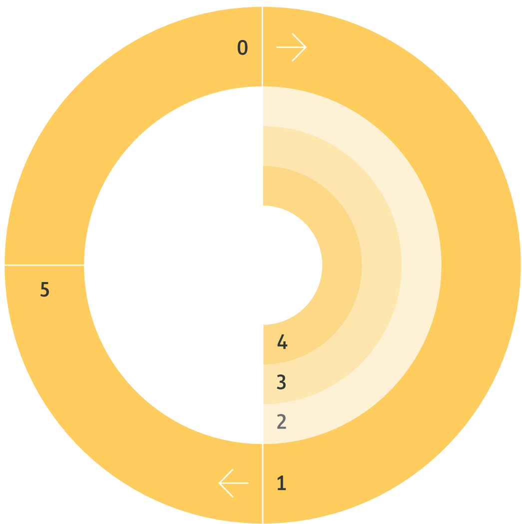
https://www.eib.nl/pdf/Monitor_Bouwketen_voorjaar_2018.pdf

https://www.eib.nl/pdf/EIB%20rapport%20GA%20en%20afbouw_web.pdf

https://www.eib.nl/pdf/Gespecialiseerde%20restauratiebedrijven%20in%20beeld.pdf

Figure B1.2 depicts the buildings life cycle, starting with planning/ construction phase (0), followed by a usage/ maintenance phase (1), continued by repair (2), interrupted by different intensities of light (3) and deep refurbishment (4), and eventually ending with deconstruction (5).

B1.2** – Type of projects over the life cycle of the building.* ***(The Netherlands) *(preliminary results)*



Phase 0
Construction

Phase 1
Usage and maintenance

Phase 2
Repairs

Phase 3
Light/partial refurbishment

Phase 4
Deep/comprenhensive refurbishment

Phase 5
Deconstruction

The statements and findings of this chapter are accordingly aggregated into the following project types a) to f):

	SMALL BUILDING	LARGE BUILDING
Construction of a new building	a)	b)
Overhaul or partial retrofit or refurbishment project	c)	d)
Comprehensive retrofit project	e)	f)

All questions in the survey are related to a concrete project that the respondent or interviewee worked on. This is to ensure receive concrete and specific answers.

There is a **high** level of agreement that, unlike other markets such as Germany or Switzerland, craftsmen in The Netherlands do not need a mandatory professional education or certification. This is due to a past policy, where it was decided to remove restrictions on professions. Anyone can do any task, with some exceptions such as a notary, architects, medicine, in which specialized education and certification is indeed mandatory. In the case of architects, you only become an architect after having coursed the complete architectural program and having undergone through two years of practice

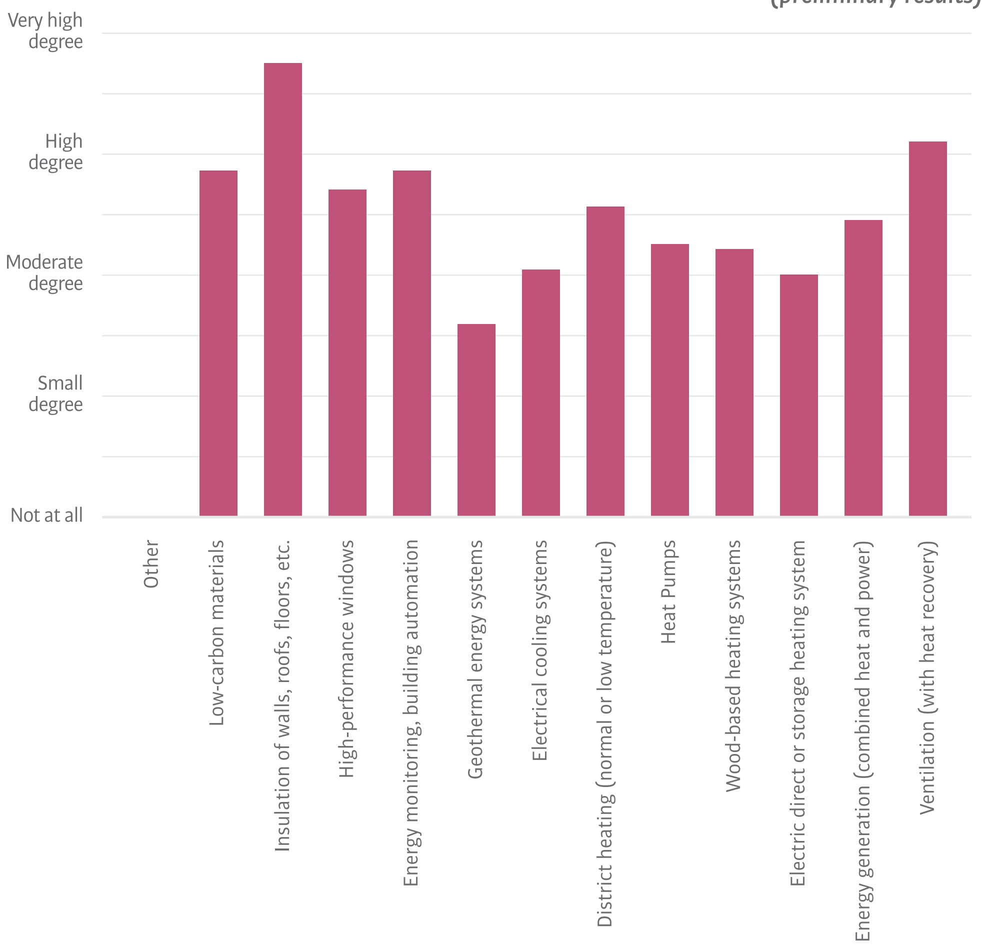
B2 Technology competences
Familiarity with technology groups

Competences related to implementation of technologies differ significantly in different markets. It is important to identify the level of knowledge towards different solutions a market has in order to design education programs when necessary. Hence, the following section assesses the level of competence and familiarity of stakeholders involved in planning and construction projects to different energy efficiency and low carbon technology groups in The Netherlands.

Survey respondents from the groups of planners, constructors and facility managers/maintenance were asked ***'How familiar are you with the following technologies?'*** They were then provided with a pre-selected list of technologies and the options ***'worked with it once; worked with it several times, part of day to day business, no experience'*** on all technologies. Answering was not mandatory. The respondents could also add technologies they felt highly relevant in a free entry field. The final responses are listed in figure B2.1, indicating the average familiarity of respondents with the listed technologies. Interviewees were asked the same question and given the opportunity to contextualize and comment.

As can be seen in the bar graph B2.1, 'Insulation of walls, roofs, floors, etc. " has the highest level of familiarity among the respondents in The Netherlands. However, the technology with the least level of familiarity among the respondents is 'Geothermal energy systems'. This is closely followed by 'Electrical cooling systems'.

B2.1 *– Familiarity level with low carbon and energy efficiency technologies in* ***The Netherlands****.*
(preliminary results)



There is a **medium** level of agreement among the interviewees that when it comes to energy efficiency and/or low-carbon technologies, in general terms, construction companies in The Netherlands can be classified into two main types; 'front-runners' and 'business-as-usual'.

'Front runners' reckon the decarbonization challenge ahead and do as much as possible to learn and adapt themselves to enable this transformation. The way in which these companies update themselves is by exchanges in workshops, expert groups or specialized platforms. 'Business-as-usual companies', on the other hand, are moving slower or not-at-all in trying to pick-up on energy efficiency and/or low-carbon solutions. These companies or stakeholders prefer to continue their exercise using the same techniques and know-how that they have used in the past.

There is a **high** level of agreement that another way in which Dutch construction companies gather expertise and information on energy efficiency solutions is through 'umbrella organizations'. For instance, installation companies have policies to competencies of their members.

There is a **high** level of agreement that there is a human capital agenda on a national level to also fulfil the agenda and carbon challenges. Therefore, there is a general concern on how to implement this on the ground. This is high-level policy, but they connect with the middle, high and craftsmen's mainly through the aforementioned 'umbrella organizations'.

There is a **medium** to **high** level of agreement that for PV panels there are specialized companies only focusing on the calculation, planning and installation of this technology.

Otherwise, there is a **high** agreement that in The Netherlands there is a systemic perspective of building technologies, stakeholders don't focus on a single technology but on the conception of them as a system. Thus, for other technologies, installation companies have a wide spectrum of know-how and are usually capable of implementing them in site.

There is a **high** level of agreement that, for new building, engineering companies have a great power and say. When it comes to renovations, private home owners mostly involve building or installation companies directly. For professional parties such as housing associations, the contractor or building owner is often involved with an engineering company on establishing the framework conditions on what should be developed. In some occasions they even work together until the end of the renovation project.

A general difference between the Dutch and the German market for instance, is that in the German market technologies are heavily regulated which results in engineers and craftsmen having to be specialized in specific technologies. This is not the case of The Netherlands.

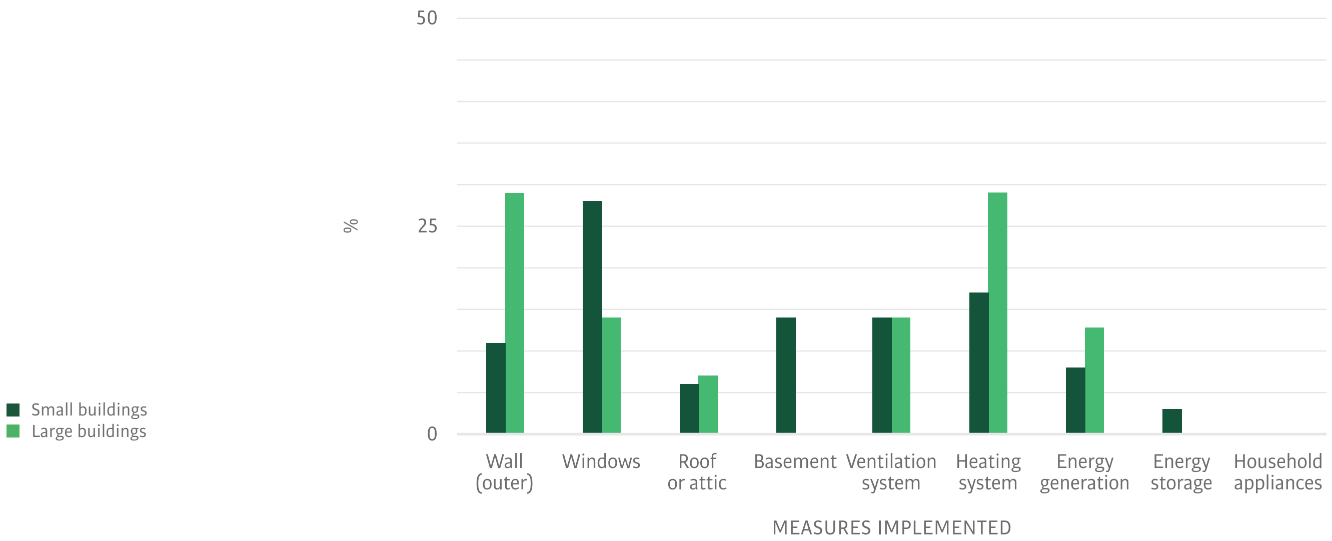
B3 State of play
Measures implemented in the building stock

In most European countries, the state of the building stock is mostly unknown due to limited monitoring of past and present retrofit measures. This section characterizes the measures that have been implemented in the residential buildings in The Netherlands for the different project types. The results in B3.1 and B3.2 are based on the survey results. These have been complimented by insights from in-depth stakeholder interviews.

To gather this information, survey respondents were asked ***'What measures were implemented in your latest project?'*** The respondent was provided with a table with 9 different elements covering all building components which they had to choose from. Then had to indicate what was the type of measure. The answer options were: 'Maintenance (including repair)', 'Upgrade of existing elements or systems (incl. insulation and control)' and 'New element or systems'. Additionally, to these answer options, they were provided the option of ***'I don't know'*** and ***'Other'***. Interviewees were asked the same question and given the opportunity to contextualize and comment.

The type of measure can vary substantially depending on the size of the building in overhaul or partial retrofit in The Netherlands. In small buildings, 'Windows' (28%) are the most often implemented measures (figure B3.1). Whereas in large buildings, it is 'Wall (outer)' (29%) along with 'Heating systems' (29%). When it comes to the least frequent implemented measures it is 'household appliances' in both cases (0%).

***B3.1** – Measures implemented in (c) overhaul or partial retrofit or refurbishment project in small building and (d) overhaul or partial retrofit or refurbishment project in large buildings in **The Netherlands**. (preliminary results)*



In order to contextualize the results from what measures are implemented in terms of overhaul, partial retrofit or refurbishment projects in residential buildings in The Netherlands, we need to distinguish between private owners and housing associations. This is due to the clear distinction between the approaches and measures undertaken by each one.

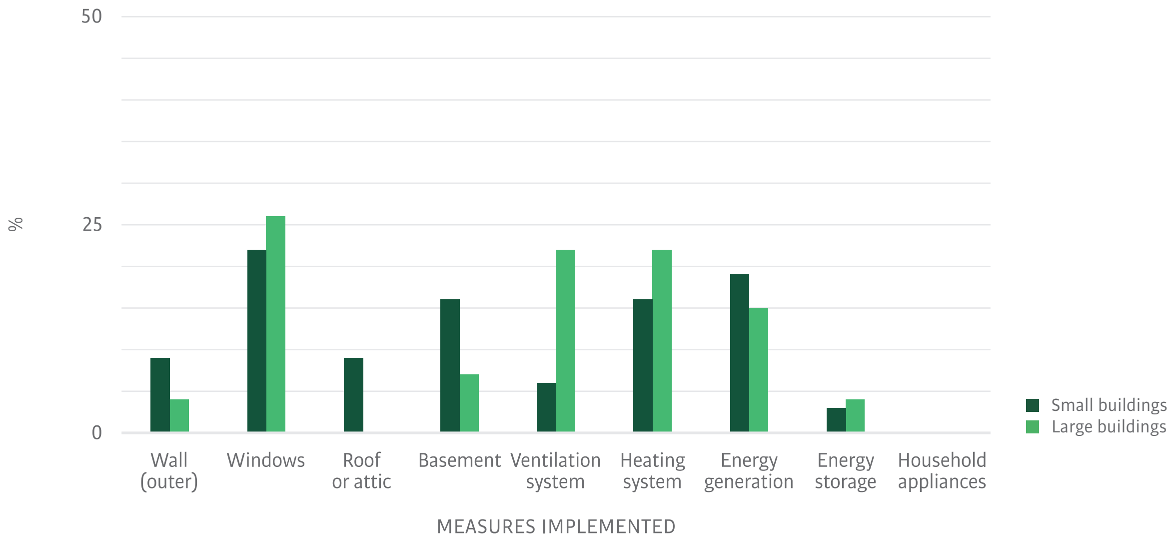
As for private home-owners, there is a **high** agreement among stakeholders that Photovoltaic (PV) panels are very often applied, especially in single-dwelling-buildings (SDB) or, also called 'single-family building'. This is closely followed by roof-related measures, such as insulating the roof.

There is a **medium** to **high** agreement that replacing or exchanging of windows and/or glazing for a more efficient one is very common measure among home-owners in the Netherlands, with the main purpose to increase of internal comfort.

There is a **high** agreement that the replacement of the heating system does mostly take place at end of service life and that the exchange of heating systems specially if it implies a change into another energy carrier, is seldom.

Again, in comprehensive retrofit projects, measures can vary substantially between small or large buildings. As can be depicted in figure 3.2, the most often implemented measure both in small and large buildings is 'Windows' (22% and 26% respectively). Again, in small and large projects 'Household appliances' (0%) are seldomly identified as common measures. Closely followed by 'Energy storage' (3% and 4%).

***B3.2** – Measures implemented in (e) comprehensive retrofit project in small building, (f) comprehensive retrofit projects of large building in **The Netherlands**. (preliminary results)*



As in 'Overhaul, partial retrofit or refurbishment projects', results of 'comprehensive retrofit' need to classified according to private owners and housing associations, due to the clear distinction between each one of them in terms of approaches and measures.

As for private home-owners, o there is a **medium** to **high** agreement that for single-dwelling-building (SDB) or, also called 'single-family building', deep refurbishment projects usually take place when there is a change of ownership. The usual measures are: ventilation systems, windows, heating systems (normally replacements and seldom to another type of heating).

There is a **medium** to high agreement that for multi-dwelling-building (MDB), also sometimes called 'multi-family buildings' , there is often a more systematic approach. Most of the renovations still start with maintenance and then be combined with more comprehensive concepts, entailing more building components. These concepts are, in most cases, driven by comfort ambitions.

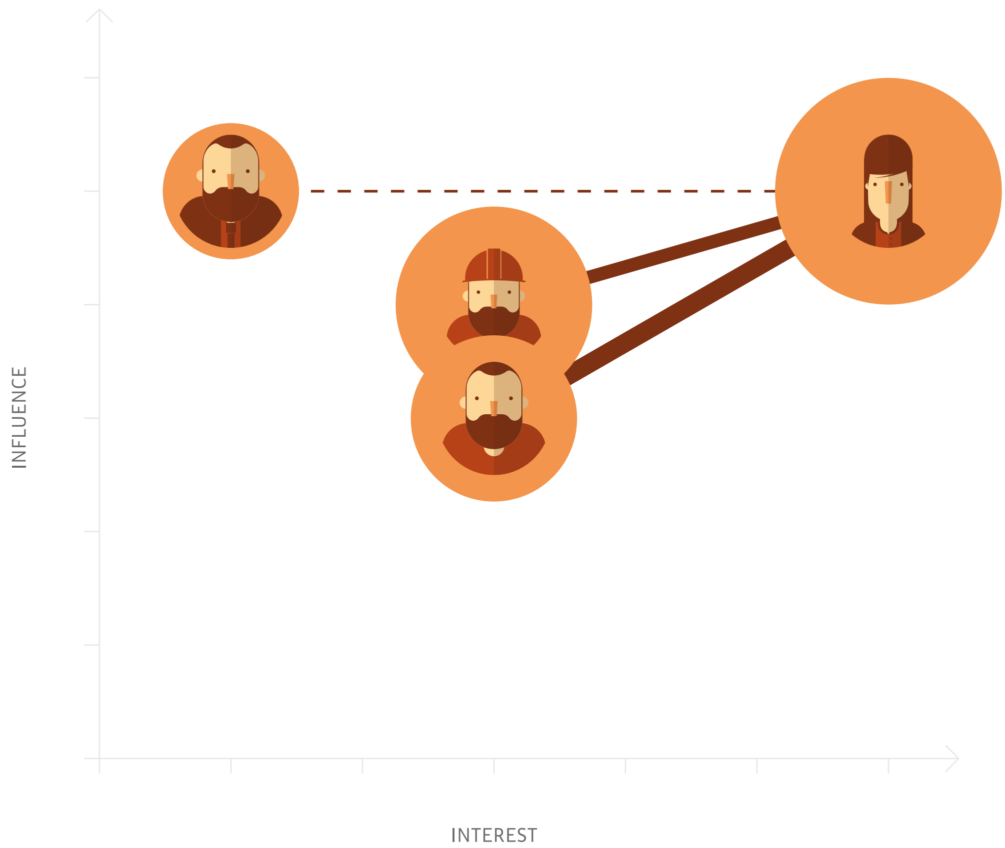
B4 Deep-dive into stakeholder's interaction
The technology selection

The stakeholder setup in the building sector is considered to be complex and fragmented. Furthermore, it varies across project types, phases or even decisions. This section assesses the level of power and interaction of the stakeholders involved in the technology selection for residential building projects in The Netherlands.

Referred to their latest project, survey respondents were asked ***'What was your level of interest in the energy-efficiency and low-carbon strategy in your project?'***. And ***'How much did you communicate with the stakeholders about the energy-efficiency or low-carbon strategy in your project?'*** Followed by ***'What was the level of influence of the following stakeholders in the energy-efficiency and low-carbon strategy in your project?'*** This was complimented by ***'What was your level of interest in the technology selection in your project?'*** And, ***'How much did you communicate with the following stakeholders about the technology selection in your project?'***. Finally, ***'What was the level of influence of the following stakeholders on the technology selection in your last project?'***. In doing so, respondents were provided with a scale 0-5. Results are illustrated in figure B4.1 below. Interviewees were asked the same question and given the opportunity to contextualize and comment.

For the decision on what technology will be implemented in the project, 'consultants' in The Netherlands are perceived to have the highest level of influence as well as interest. 'Public authorities' have a high level of influence but perceived to have a lower interest. Main communication streams are between the consultant and the 'home owners' this might indicate that they might have an important say in what the consultant is deciding.

B4.1 – *Stakeholder interaction regarding the technology selection in* ***The Netherlands****.* *(preliminary results)*



For the stakeholder interaction regarding the technology selection in new construction in The Netherlands, there is a high level of agreement that:

The power role of the architect in The Netherlands is lower than in other markets, such as Belgium.

Project developers also have a large role in building private housing. Basically, a project developer often develops a whole neighborhood, in which both private houses and social houses can be combined.

The contractor has the most powerful role in most projects as they have a high level of power and central role in communication, though this can vary depending on the specific project and building typology.

There is a **medium** level of agreement that for large new buildings developed by housing associations, the housing association would first hire the construction company, based on its competences and trust. In some occasions, before even having a project. This is a remarkable trait of the Dutch construction market that would be unthinkable in other European markets such as Germany, France or Switzerland. In which this kind of relationship would built with the architectural office and not with the construction company.

For 'Overhaul, partial retrofit or refurbishment projects', there is a **high** level of agreement that architects are, in most instances, not involved in the project unless a critical in-depth problem appears. This is highlighted by the fact that there is no regulation in terms of the education and certifications in the construction market in the Netherlands.

There is a **high** level of agreement that not including an architect nor developing a plan for these projects brings a potential risk of lock-in effects due to the lack of comprehensive/ systemic understanding of the building and its potential to low carbon measures.

There is a **medium** level of agreement that new technologies such as heat pumps are not so often implemented in these projects as they are perceived as involving to high costs.

There is a **high** level of agreement that private owners are gathering more and more in-formation regarding building projects. There is an increasing trend for the development of social media platforms regarding low carbon solutions.

In The Netherlands, it is considered a 'comprehensive retrofit' project when either more than 25% of the surface skin is renewed, changed and/or enlarged or the 'dormer' is completely new or renew. In both of these instances, new buildings standards should be applied to the building.

There is a **medium** to **high** agreement that in deep-retrofit it should be the architect that takes the lead. However, there are not that many architects specialized in deep-retrofits nor especialized education on this, which is quite noteworthy given that is key to fulfil the na-tio-nal energy performance goals.

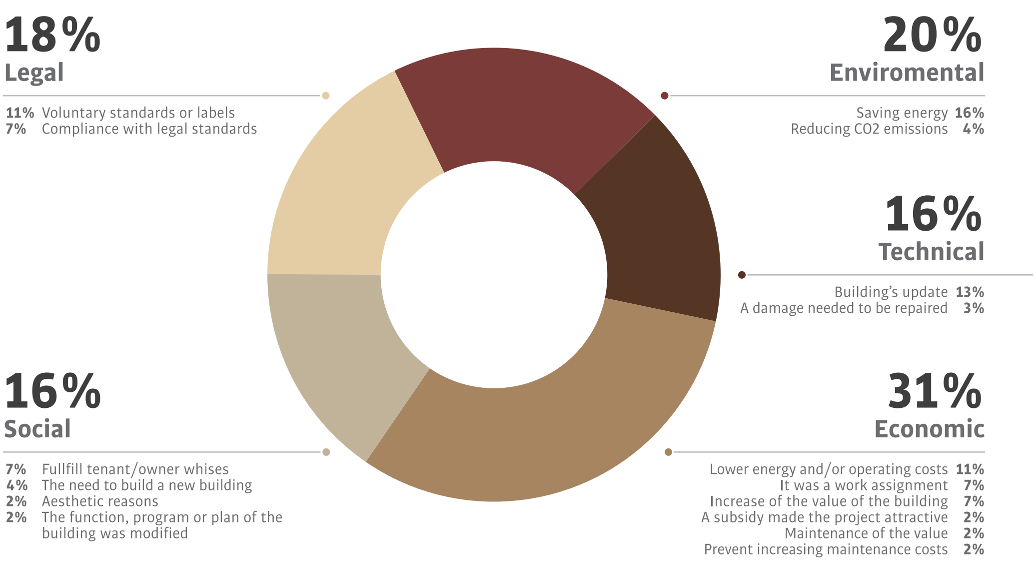
B5 Motivations and barriers behind projects
The demand-side's perspective

Motivations behind projects differ significantly depending on the project type, the building typology or the demand-side's perspective. The following section describes stakeholders' motivations behind projects in The Netherlands, as well as hindering factors in pursuing 'higher' performing buildings, meaning, even more performance energy-efficient or low-carbon technologies or solutions.

Survey respondents were asked ***'What were the main motivations for your project?'*** They were then provided with a pre-selected list of arguments structured into environmental, technical, economic, social and legal clusters as well as the option to select ***'Other'***, and ***'I don't know'***. This question allowed participants to choose more than one answer option. Thus, the percentage of answers is calculated on the basis of the total number of options selected. The final responses have been classified according to the 'professional organizations' (POs) perspective. Main motivations have been listed in figure B5.1, indicating in each case the % of responses that were selected for that answer. Interviewees were asked the same question and given the opportunity to contextualize and comment.

As can be depicted from B5.1, main motivations for owners is 'Saving energy' (16%), followed by 'Building's update or future-proof' (13%). One of the least identified motivations are aspects such as 'A change of tenants / residents offered the opportunity to do the work now' or 'Social peer pressure' (both, 0%).

__B5.1__ – Main motivations behind projects in __The Netherlands__. The PO's perspective. (preliminary results)



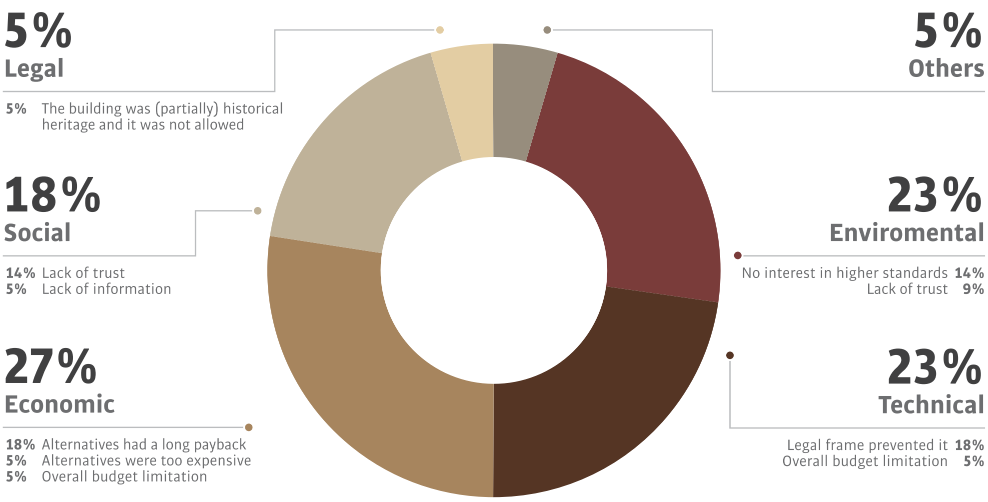
For private owners, there is a **medium** level of agreement that the main motivation behind projects are 'natural moments to do something', meaning when is the right time to implement a certain measure. In the case of technical aspects and 'comfort' in the case of upgrades or replacements. Energy-efficiency related projects are usually linked to energy saving goals or to the ambition to comply to the energy legislation. There is an increasing awareness to transition away from natural gas. This is somewhat different to markets such as Switzerland, where 'comfort' is identified as one of the greatest arguments, or Germany, where economic arguments such as return of investment have been historically strongly pursued.

There is a **medium** level of agreement that for housing associations, the main motivations are to ensure good housing standards. This can be partially attributed to the fact that there is a strong demand for housing in The Netherland due to a shortage in stock. Thus, housing associations have a social responsibility (as highlighted by policies) to ensure good housing conditions and standards. As a matter of fact, housing associations are typically rated and have their own benchmark systems.

To identify what were the main barriers to not pursue higher performing technologies, survey respondents were asked ***'What were the hindering factors for not implementing (even) more energy-efficient or low-carbon technologies in your project?'*** They were then provided with a pre-selected list of arguments structured into environmental, technical, economic, social and legal clusters as well as the option to select ***'Other'***, and ***'I don't know'*** The final responses have been classified according to professional organizations. Main barriers for not pursuing (even) more energy-efficient and/or low carbon technologies have been listed in figure5.2. In each case it is indicated the % of responses that were selected for that answer. Interviewees were asked the same question and given the opportunity to contextualize and comment.

Graph B5.2 indicates economic and environmental aspects are perceived to be the main barriers for not implementing 'higher' performing solutions for professional organizations in The Netherlands, being 'The technology chosen was the best available technology' the most often identified answer. As the lowest hurdle respondents identified matters such as 'Noise / disturbance that the implementation would have caused'.

***B5.2** – Main barrier for not implementing (even) more energy-efficient or low-carbon technologies in residential building projects in **The Netherlands**. The PO's perspective. (preliminary results)*



There is a **low** to **medium** level of agreement that in the case of housing associations, this might be linked to economic reasons. In the Netherlands, housing associations normally operate on a closed budget, in many instances a multiyear investment planning. Thus, they would be able to do it but are currently not forced to.

B6 Promising approaches to reach carbon ambitions

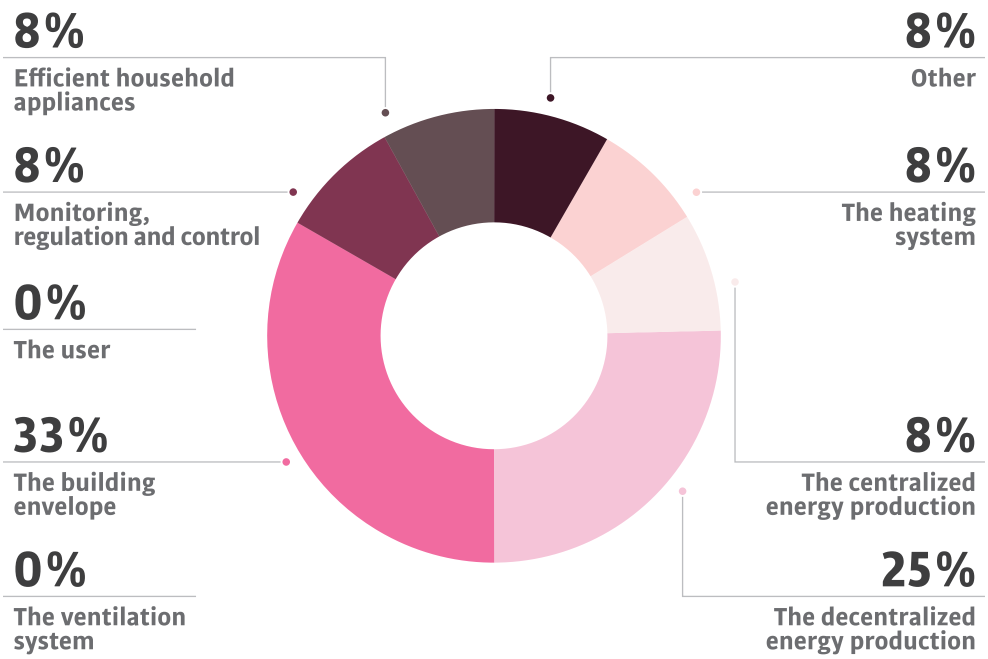
General potential in new and existing buildings

Buildings are complex systems formed by an extensive range of elements and components. The carbon performance of a building is highly dependent on the nature and conception of these components. This section identifies what building concepts do market actors see as most favourable to reduce carbon emissions and achieve climate-protection goals in The Netherlands. Results are presented for new built and refurbishment projects.

Survey respondents were asked ***'What technology or approach has the highest potential to contribute to reach ambitious climate-protection goals in The Netherlands.'*** They were then provided with a preselection of 8 aspects as well as ***'Other', 'I don't know' and 'none' for both new buildings and refurbishment***. This question allowed participants to choose more than one answer option. Thus, percentage of answers was calculated on the basis of the total number of options selected. Interviewees were asked the same question and given the opportunity to contextualize and comment.

'The building envelope' (33%) is perceived to have the highest potential to achieve climate goals in new buildings in The Netherlands. Closely followed by 'decentralized energy production' (25%). On the other hand, 'Ventilation' and 'The user' are perceived as hosting the lowest potential, both with 0% of the responses.

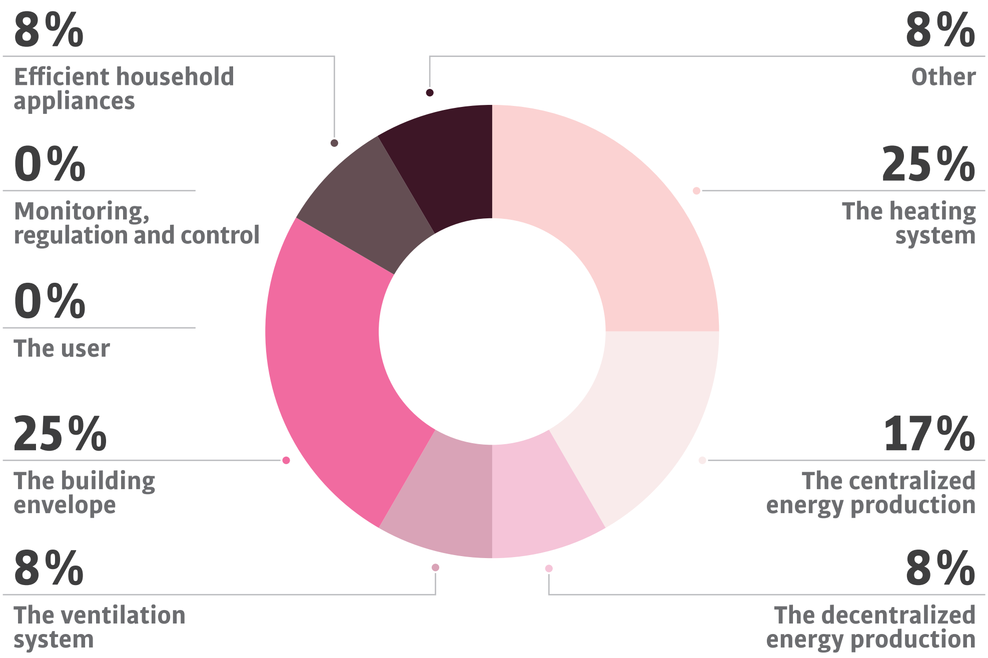
B6.1 *– Technologies perceived to have the highest potential to contribute to reach to climate-protection goals in **The Netherlands** for new buildings. (preliminary results)*



There is a **medium** level of agreement among market experts that both for private owners and housing associations, the building envelope and decentralized energy production have the highest potential to fulfil climate-protection goals.

When it comes to refurbishment projects, 'The heating system' and 'The building envelope' (both 25%) are considered as the measures with the highest potential to contribute to climate-protection goals. Conversely, 'The user' and 'Monitoring, regulation and controls' are found with the lowest potential (both 0%).

B6.2 – Technologies perceived to have the highest potential to contribute to reach to climate-protection goals in ***The Netherlands*** *in refurbishment projects. (preliminary results)*



Regarding the private owners, there is a **medium** to **high** level of agreement that in the past the technologies conceived as the most promising approach to fulfil climate protection goals were exchanging glazing, from single to double glazing. However, at some point it was noticed that this action would not be sufficient to reach carbon targets, nor lowering energy bills nor even increasing the level of comfort. So many POs started including insulation and PV panels as part of their actions. As a matter of fact, in order to achieve EPC standards, the most common measure among POs is to include PV panels. However, EPC standards are only mandatory for new houses. PV panels for refurbishment are seen as a way to save energy and to save costs, meaning related to payback time.

When it comes to housing associations, there is a **medium** level of agreement that currently the building envelope and the heating systems are the measures with the highest potential.

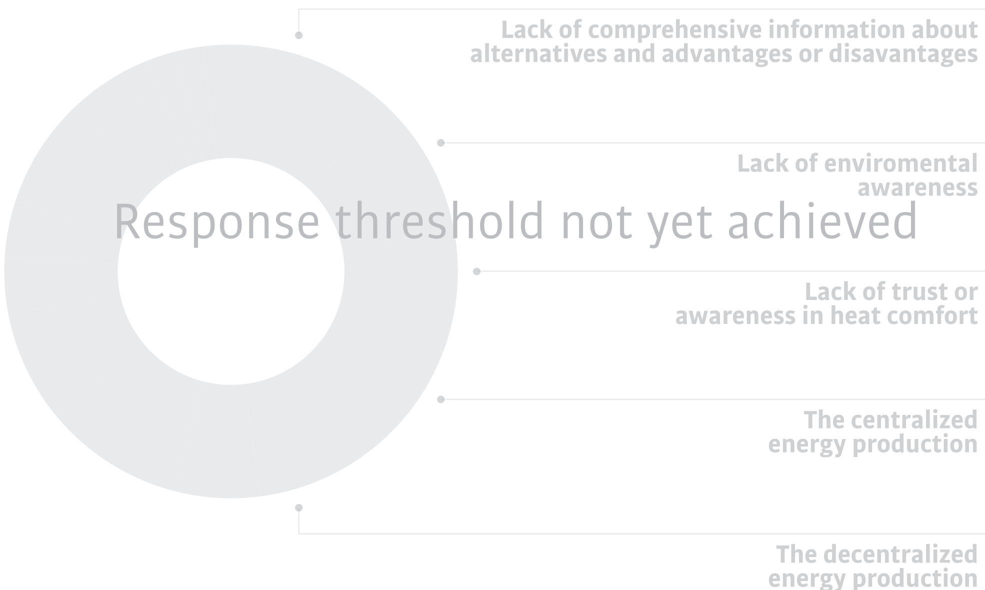
On an expert level discussion, there is a **medium** to **high** level of agreement that the residential building stock will not move completely away from natural gas but at least will change the type of gas (e.g. biogas). However, the political will to move out of natural gas has created a thought of process on what would be the next solution to solve this matter. Whatever the outcome, the building owner is dependent on this resolution in order to know what measures should be implemented in its dwelling, building or portfolio, to be able to fulfil future policy and building standards.

B7 Drivers & barriers to reach carbon ambitions
Towards promising approaches

Many barriers hinder the uptake of energy efficient and low carbon solutions. These barriers are context specific and, therefore, vary considerably depending on the country, building type, stakeholder group and even on the specific technology. The following section describes stakeholders' perceived drivers and barriers to the technology that had been found in previous section B6 as hosting the highest potential (in refurbishment projects) in The Netherlands.

Survey respondents were asked to state for which specific technologies they are experts in. For one of those they were questioned on ***'What is the biggest barrier for the upscaling of this technology in The Netherlands.'*** Interviewees were asked the same question and given the opportunity to contextualize and comment.

B7.1 *– Perceived barriers to insulation in* ***The Netherlands****. (preliminary results)*



There is a **high** level of agreement between market experts that the main barriers for insulation in the Netherlands are:

- Existing building composition: in the case of refurbishment, not all building typologies are perfectly compatible with adding insulation (e.g. brick facades, which are quite common for SDB in The Netherlands).

- Awareness: the level of consciousness about the need to implement energy efficiency measures in residential buildings is not yet high enough in many instances.

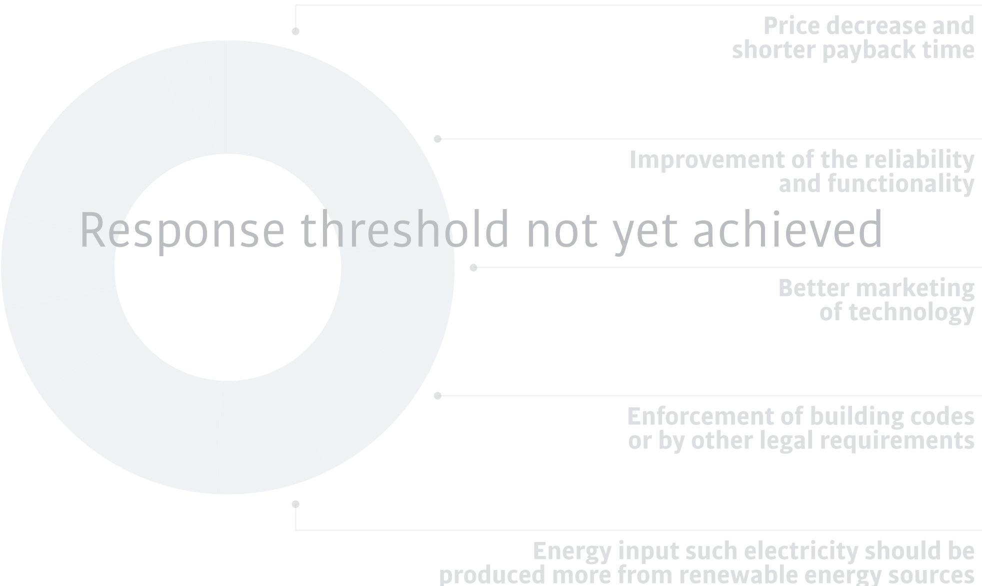
- Lack of knowledge: many stakeholders are not properly informed on what benefits and processes to follow to implement it.

As for deep renovation projects, interviewees have a **high** level of agreement that the main barrier for the private sector is that there are not enough interested parties (supplies) to pull this mechanisms through nor that there is enough profit in an individual house.

Drivers to low carbon solutions, the same as barriers, differ significantly depending on the building type, stakeholder group and even on the technology. Identifying stakeholders' market specific drivers and motivations is crucial in order to trace effective marketing campaigns and policy instruments to foster their uptake of low carbon energy solutions. The following section describes stakeholder perceived drivers to the technology that had been found in previous section B6 as hosting the highest potential (in refurbishment projects) in The Netherlands.

Survey respondents were asked what were ***'the most promising approach to support the market uptake of low carbon technologies.'*** Interviewees were asked the same question and given the opportunity to contextualize and comment.

***B7.2** – Perceived drivers to insulation in **The Netherlands**. (preliminary results)*



There is a **high** level of agreement between market experts that the main drivers for insulation in The Netherlands are:

- Comfort level: increase of the internal comfort level (i.e. improved thermal comfort, reduced moisture, etc.)
- Energy saving: Possibility to reduce energy bills.
- Cost-effectives: Economical arguments are also found to be a driver although not a main concern in overall.
- In the case of adding insulation in the attic: having a new room can become an important driver, especially for private-home owners.

As for DEEP RENOVATION, there is a **high** level of agreement between market experts that the main drivers are:

- Energy saving: the potential to reduce energy bills (e.g. zero energy bill)
- Comfort: increase of the internal comfort level (i.e. improved thermal comfort, reduced moisture, etc.)
- Upcoming policies: be updated in case new policies are implemented

Market volumes and economics

Aim

The chapter 'Market Volumes and Policy Scenarios' provides data on the current state of the building stock's greenhouse gas (GHG) emissions as well as annual market volumes in the short, medium and long term for two scenarios.

The first section of this chapter presents structural and GHG related data on the building stock (section C.1). The data on the building stock is collected from statistical sources, standards and norms. Market experts via interviews complement this information. A synthetic building inventory of 10,000 representative buildings has been generated based on the data collected. To set up this inventory, the building stock model (BSM) integrates a parametric variation approach.

At its core, this chapter describes the market volumes for a Reference Scenario (RS) and a 2 Degrees Scenario (2DS). The RS reflects current and decided energy and climate policy instruments and some moderate reinforcements that could be expected (similarly to the EU Reference Scenario). Both European and national policies are taken into account. The 2DS is designed to achieve ambitious climate-change mitigation goals. The < 2ºC goal of the Paris Agreement of 2015 serves as a guideline. National peculiarities and implementation approaches that may typically be expected are reflected in the scenario definition (section C.2).

In both scenarios, the effect of an increase in energy efficiency and in the share of renewable energy sources (RESs) have been considered. The resulting market volumes for the various technology groups are listed. The aim is to provide realistic market volumes estimates for different market segments.

All data sources are clearly marked to allow the reader to access more detailed information as needed. The complete list of sources can be found in the annex to this report. Key sources are listed as links in the side bar.

C

C1

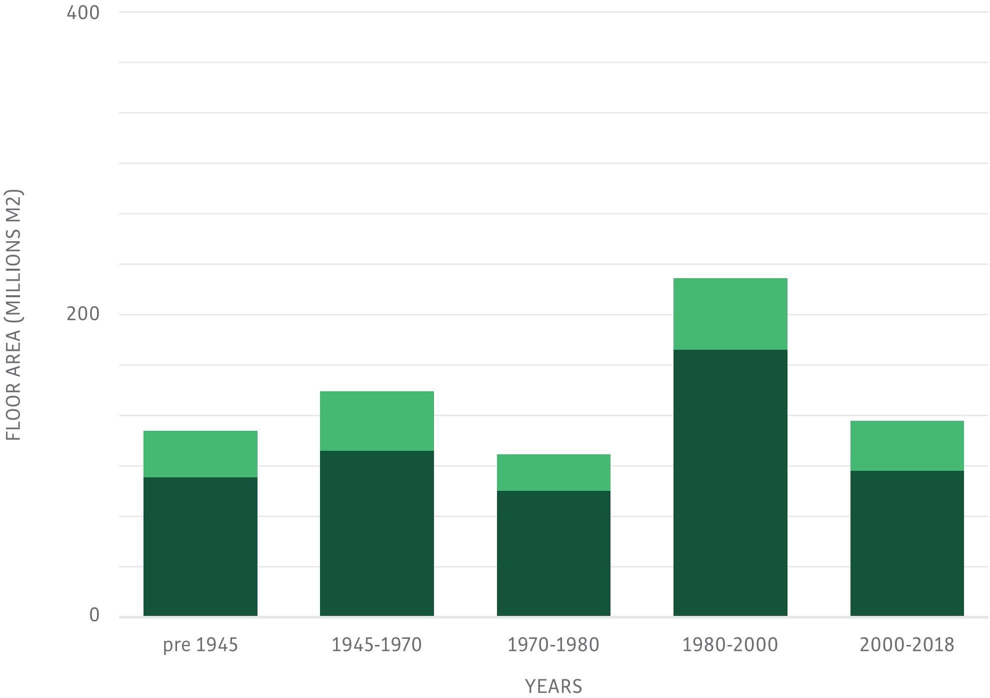
Status quo of the building stock
Structure and greenhouse gas emission intensity

The residential building stock of the Netherlands currently encompasses around 7.7 million dwellings. About 65% are located in multi-dwelling buildings (MDBs) and 35% in single-dwelling buildings (SDBs), including row houses. The Dutch row house is characteristic for the residential building stock of the Netherlands and it is therefore unsurprising that about 75% of the 843 million m² of the floor area is located in SDBs including row houses as well as detached and semi-detached houses and only about 25% in MDBs.

The age distribution (see Figure C.1.1.) still illustrates a large share of old buildings with almost 40% of the heated floor area having been built before 1970. A large proportion of the buildings stem from the construction boom of the 1970s and 80s when about 30% of the current buildings were added to the stock within just two decades. Since then, construction activity has decreased resulting in an add-on of 20% of the stock over the period of 20 years.

C1.1 – *Age distribution of the Dutch building stock, differentiating between single-dwelling buildings (SDB), includding row houses, and multi-dwelling buildings (MDB).*

Sources:
TEP Energy & Chalmers University, BSM.



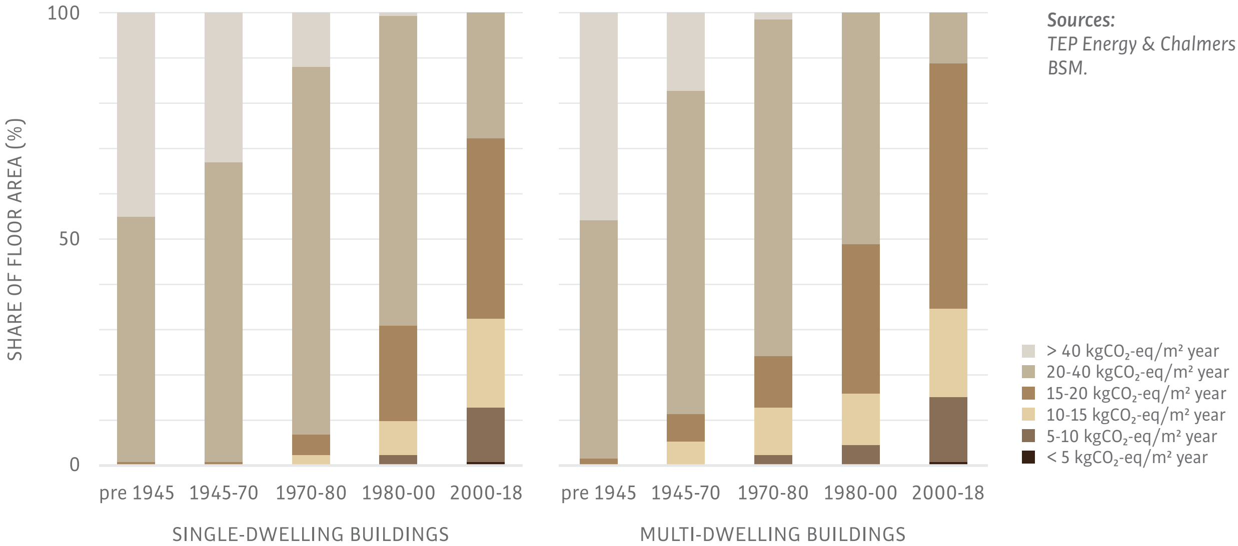
Notes:
GHG intensity: GHG emissions from final energy consumption for heating, hot water, ventilation and cooling from a life-cycle perspective. For example, 10 kg CO_2-eq per m² is equivalent to 45 kWh per m² in a gas-supplied building. GHG emissions embodied in the construction of the building are not included.

Figure C.1.2 illustrates the carbon efficiency of the stock in terms of its GHG intensity. The effect of the building code towards more energy efficient new buildings can be seen clearly. In recent years, especially after 2000, the shares of low carbon buildings have been visibly increased. Also, MDBs tend to have slightly lower CO_2 emissions per floor area as compared to SDBs. Indeed they have a larger share of buildings with less than 20 kgCO_2-eq per m², which is largely an effect of their more compact form.

Figure C.1.3 illustrates the distribution of final energy demand of the Dutch housing stock, which, like Figure C.1.2, reveals a clear trend towards new, more energy-efficient buildings. Some effects of the renovation efforts are, however, visible in the percentage of buildings built before 1980 with an energy demand of less than 100 kWh/m² year.

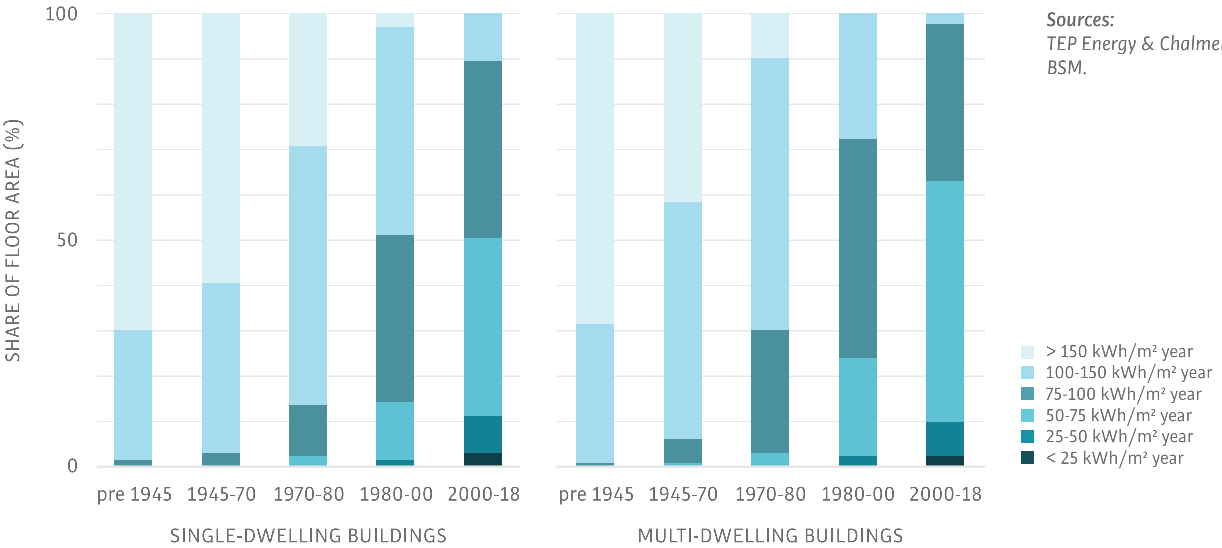
The effects of Dutch renovation programmes are observable in both the single-dwelling and multi-dwelling building stock, since there are small percentages of low-carbon buildings in the buildings from older construction periods. So far, however, the applied refurbishment measures have often only targeted single components (e.g., attic insulation, window replacement) instead of a comprehensive retrofit, leading to only marginal improvements in the efficiency of the building. Moreover, the majority of houses are heated by natural gas, which is a fossil fuel. As a result, there is still a significant number of buildings with high GHG emissions that need to be addressed, as well as a percentage of buildings built in recent decades that do not meet the targets of a nearly zero-energy building.

***C1.2** – GHG-intensity of the Dutch building stock in 2018 according to building age and building type.*



Sources:
TEP Energy & Chalmers University, BSM.

***C1.3** – Specific final energy demand distribution of the Dutch building stock in 2018 according to building age and building type.*



Sources:
TEP Energy & Chalmers University, BSM.

C2 Policy scenarios *To shape carbon emissions*

Notes:
The Reference Scenario (RS) represents an upper bound of future carbon emissions. It consists on current and decided energy and climate policy goals and instruments and some moderate re-enforcements.

The 2-Degree Scenario (2DS) is designed to achieve ambitious climate change mitigation goals. The <2ºC goal of the Paris Agreement of 2015 serves as a guideline. National peculiarities and implementation approaches that typically could be expected for the Netherlands are part of this scenario.

At present, the Netherlands has already implemented some policy instruments to foster energy-efficiency and the use of RESs and to curb CO_2-emissions (see section A.3). The targets of these polices are outlined in the Energy Agreement of 20131 to reduce CO_2 emissions by 80% to 95% by 2050 (compared to 1990) and to reinforce action on climate mitigation and adaptation.

The development of the market volumes very much depends on these economic and policy framework conditions and how they will develop. To reflect uncertainties in these framework conditions (arising for instance from decisions about policy instruments that are yet to be taken), two scenarios have been defined. Market volumes are then calculated for these two scenarios to constrain uncertainties. To ease comparison across the two scenarios, other drivers such as population growth or energy price are kept the same in both scenarios (see section C.3)

— Current and decided energy and climate policy goals and instruments are part of the RS. On the European scale, these are the Renewable Energy Directive2, the Energy Efficiency Directive3, the Directive on Energy Performance of Buildings4, and the Ecodesign Directive5. On the national scale, this is mainly the Energy Agreement of 20131.

— The 2DS is designed to achieve ambitious climate change mitigation goals. To reach the <2ºC goal of the Paris Agreement of 2015 some further reaching measures are needed to cut direct CO_2-emissions (almost) completely from the buildings sector. To this end, a new Climate and Energy Agreement is expected to be published by the end of 20186. Key polices to be expected are an almost complete phase-out of the gas supply by 2050 and a ban of gas in the case of new buildings is reasonable to assume, also as a response to the seismic issues the Netherlands faces with its domestic gas fields7. To facilitate this transition off gas, an adjustment of energy taxes to reduce electricity prices and increase gas prices is expected. In terms of existing buildings tangible instruments are part of the 2DS, e.g. a further upscaling of the large-scale renovation programme (currently planned from 50,000 to 250,000 dwellings per year).

To achieve the aforementioned ambitious climate-change mitigation goals, concrete tangible policy instruments need to be implemented. Concrete and specific assumptions are made to substantiate input for the BSM calculation and to underpin results regarding the short-, mid-, and long-term (2021, 2030, and 2050 respectively) development of different market segments.

— Building codes that are already ambitious in the RS shall be tightened in the 2DS. Nearly Zero Energy Buildings (nZEB) and a ban of fossil-fuel energy in the case of new buildings are part of this scenario.

— As heat pumps will play a major role due to the phase-out of gas supply in the housing sector, mandatory energy-efficiency standards (MEPS) will be introduced in the 2DS in order to assure an efficient use of electricity consumption from RESs including self-produced solar energy (which is incentivised by feed-in tariffs). Moreover, a targeted innovation programme should drastically reduce costs of building retrofitting, heat pump installation and other RESs.

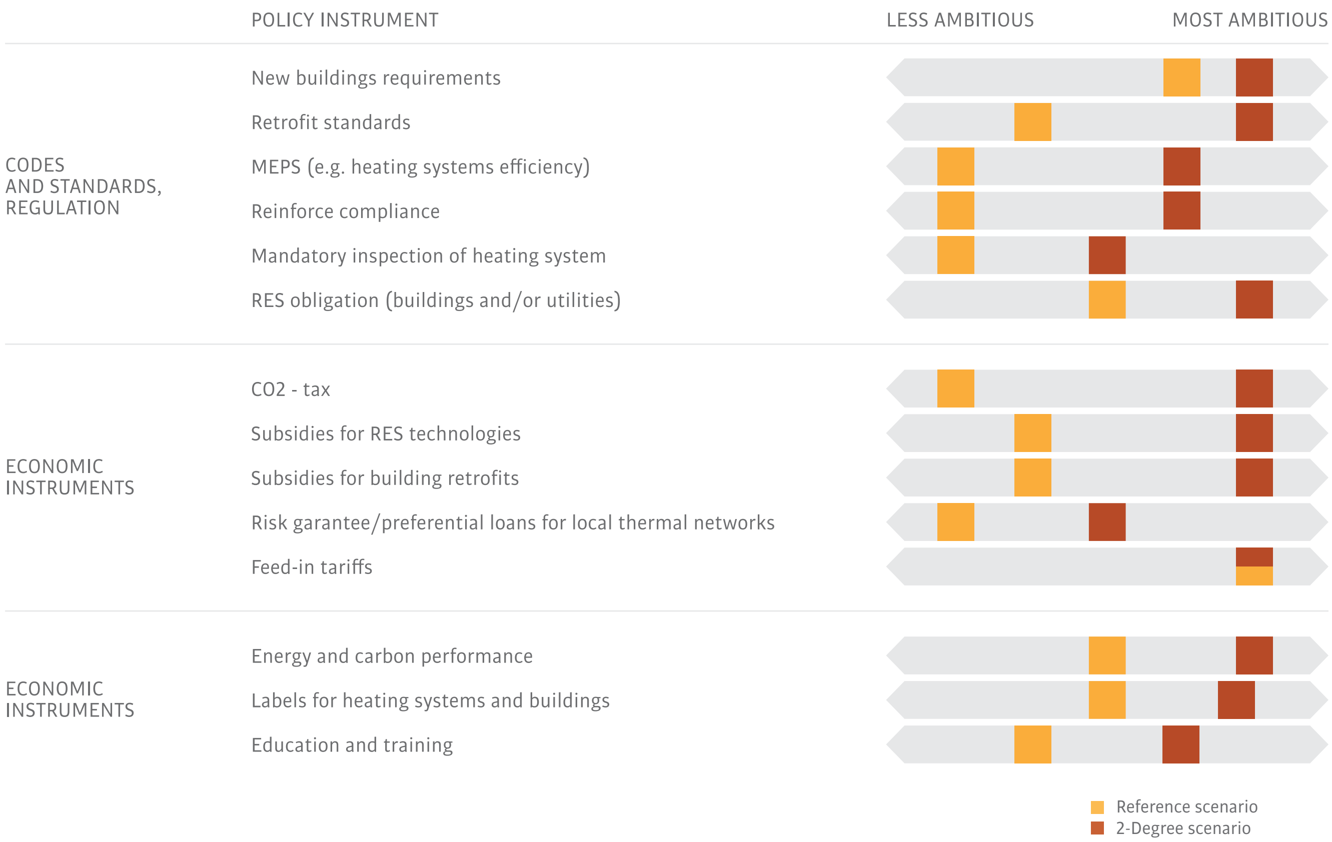
— In the 2DS, an extra effort will be undertaken to reinforce compliance with codes and standards and to secure the efficient operation of building technologies, particularly heating and hot water systems

- In order to foster the diffusion of low-carbon and efficient technologies and retrofitting measures, the existing energy levy will be adjusted and increased for conversion into a CO_2-tax in the case of the 2DS. Tax revenues will be utilized to scale-up the existing retrofitting subsidy programme as well as low-interest loans and building-bound loans/mortgages.
- Based on urban energy planning, the gas grid will be partly replaced by up-to-date district heating networks in order to supply high-density areas and districts with energy from RES such as geothermal heat, residual heat, etc.).
- These policy instruments are complemented and underpinned with coherent information measures (e.g. energy and performance labels and certificates) and an education programme that includes builders, installers and planners.

*The **building stock model** (BMS) simulates the dynamics of the building stock and the energy- and climate-related decisions of building owners and tenants. Decisions, e.g. regarding choice of heating system or whether to retrofit depend on:*

- *Technology prices and their energy performance,*
- *Energy prices (including taxes),*
- *Subsidies, tax exemptions and other financial incentives,*
- *Codes and standards, and*
- *Availability (e.g. of RESs and of energy infrastructure)*

C2.1 – *Scenario definition.*



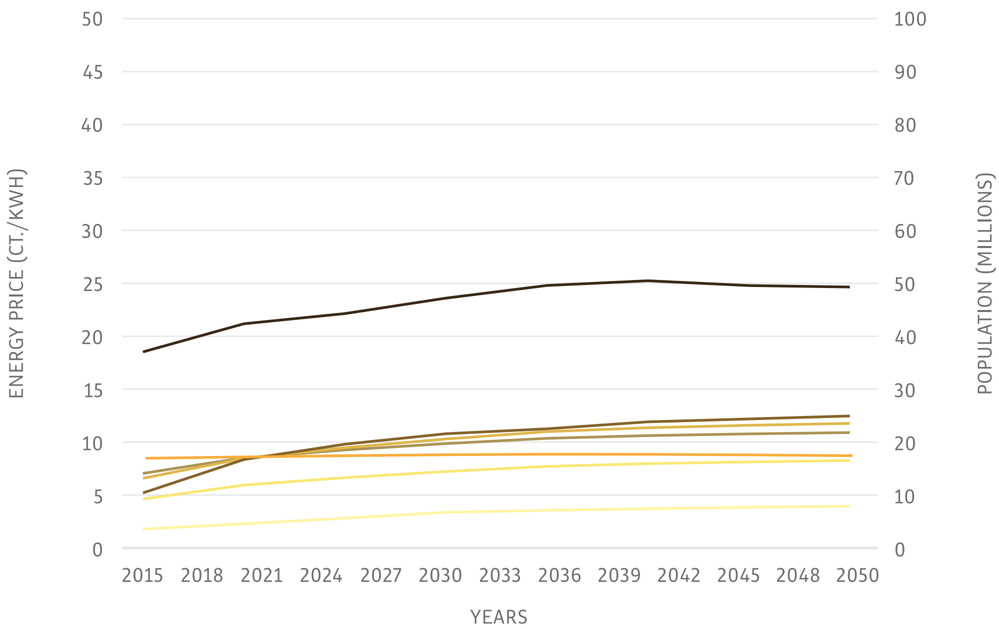
C3 **Development scenario**
Drivers and general implications

Notes:
The impact of these drivers is highlighted in sensitivity analyses available from the CUES Foundation.

Drivers such as population growth and energy price developments are kept the same in both scenarios in order to increase the comparability. The population growth is based on the EU Reference Scenario8 and is shown in Figure C.3.1 along with the assumed energy price development. These drivers target different aspects: I.e. the population development mainly drives the new construction activity in the market, while energy price development is a key driver for the diffusion of low carbon technologies and retrofitting activities.

C3.1 – *Poulation growth and energy price development.*

Sources:
EU Reference Scenario, EUROSTAT, ENERGIFORSK, TEP and Chalmers.



Notes:
Ambient Heat is the heat extracted by the heat pump from the air, ground, or groundwater to heat the building.

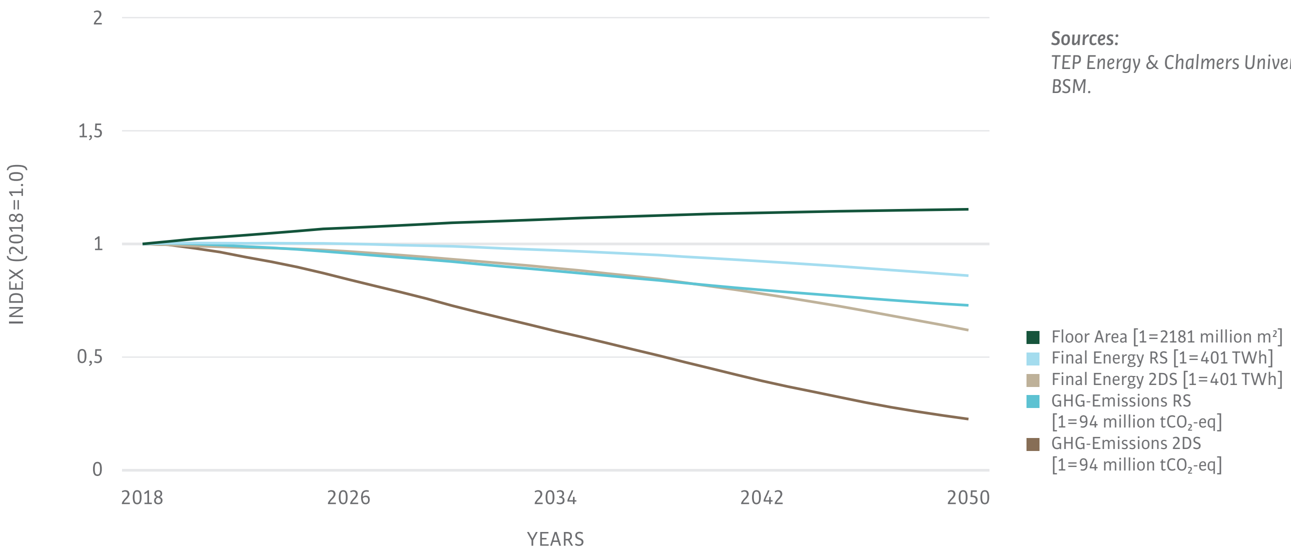
On the basis of the framework conditions outlined above, the main findings on final energy demand and GHG emissions are illustrated in Figure C.3.2 and can be summarized as follows:

— Although the population is set to grow by 4.5 % by 2035 (and slightly decreasing afterwards) and consequently the total floor area by 15%, final energy demand for heating, hot water, and ventilation decreases by 16% in the RS and by 30% in the 2DS. This is due to building code requirements for new buildings as well as retrofitting activities that take place in both scenarios. However, final energy demand in the 2DS, which includes RESs, is decreased more than in the RS. This is due to the effect of increased retrofitting activities and more stringent standards in the 2DS. In this scenario, retrofitting activities are fostered as a consequence of subsidies and an increasing CO_2 tax as well as a reduction of costs for retrofitting and renewable heating systems through targeted innovation programmes.

— Currently, gas is the dominant energy carrier in the Dutch housing sector (see Figure C.3.3). In the RS, demand has already decreased by 45%. Accordingly the gas sector should be prepared to diversify its activities and to carefully manage their infrastructure assets. Renewable gas, district heating or developing heat-pump-related energy services might be elements of new business strategies. Such shifts in the utilities' strategies are even more important as fossil gas is phased out almost completely in the 2DS.

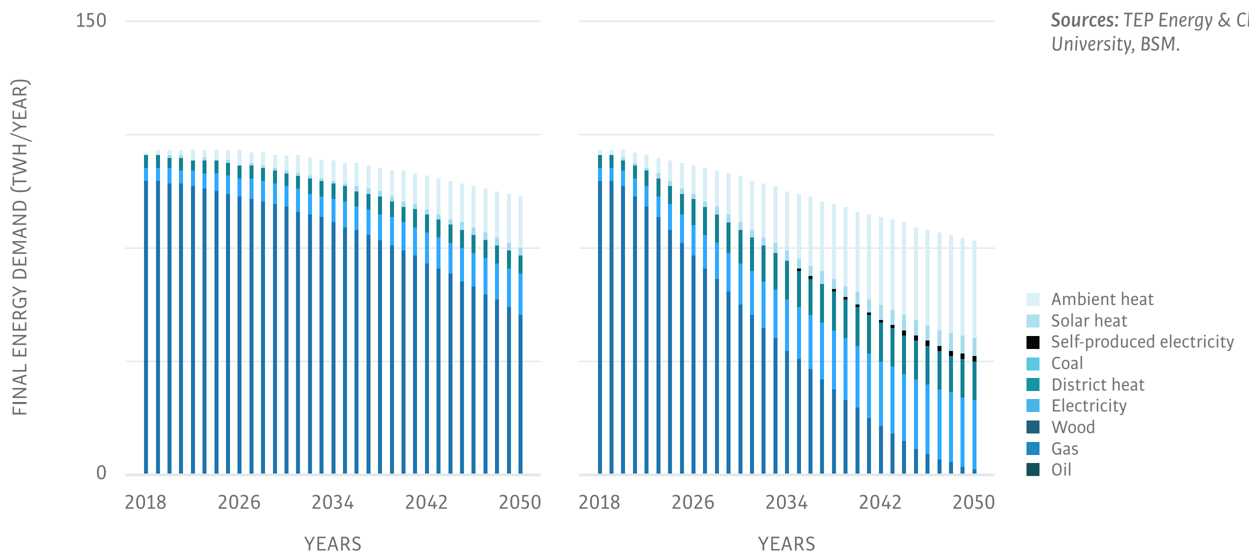
— Gas sales are partly compensated for by electricity sales. In the HVAC sector, electricity demand more than triples in the RS and is boosted by a factor of 5.5 in the 2DS, which means an increase of 8.8 TWh and 18.8 TWh respectively. Compared to the total electricity supply in the residential sector of 2016, this is equivalent to increases of 40% and 85% respectively.

***C3.2** – Development of floor area, energy, and GHG emissions according to the modelled Reference Scenario (RS) and 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

***C3.3** – Development of final energy demand for heating, hot water, and ventilation according to energy carriers in the Reference Scenario (left) and 2-Degrees Scenario (right).*



***Sources:** TEP Energy & Chalmers University, BSM.*

C4 Structural change of the building stock
Short-, mid-, and long-term development

Notes:
Partially refurbished means that a building has 1–2 building components that have been refurbished in an energy efficient manner since 2015.

Comprehensively refurbished means that a building has 3 or more building components that have been refurbished in an energy efficient manner since 2015.

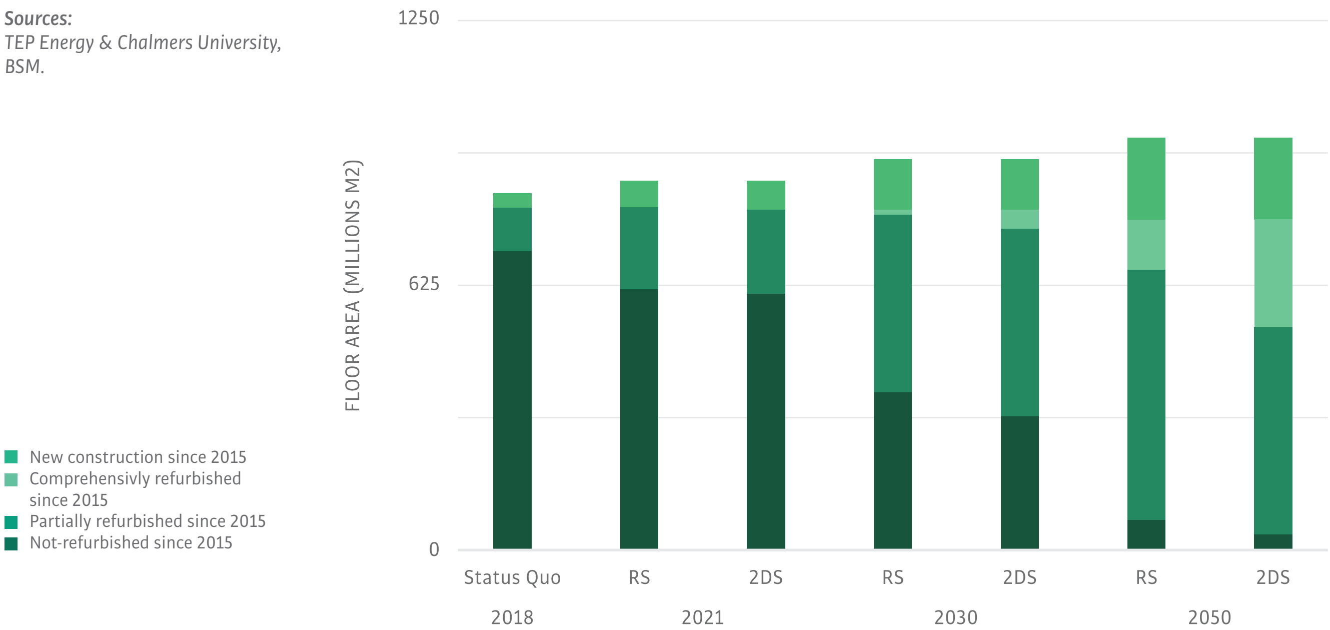
In both scenarios, the residential building stock of the Netherlands is still projected to grow by about 130 million m² of floor area to almost 972 million m² in 2050. The stock existing in 2018, however, is projected to decrease over this time period by almost 5% down to only 816 million m² by 2050 as a result of demolition. This still means a 15% net addition in floor area by 2050, with newly constructed buildings making up 20% of the stock in 2050. This increase in floor area is mainly driven by a growing population (+ 4.5%), and by an increasing demand for floor area per person. The latter is mainly explained by the decrease of the average number of persons per dwelling due to a trend towards smaller household sizes.

The refurbishment activities in the existing stock are an on-going process until 2050 (see Figure C.4.1), at which point both scenarios expect that most buildings will be at least partially refurbished. In the short term, the refurbishment rate is projected to remain almost the same under both scenarios. Refurbishments are carried out mainly as component-based retrofits resulting in similar percentages of partially refurbished buildings. In the medium term, the refurbishment activity should increase more in the 2DS compared to the RS, which is a consequence of subsidies, tax incentives, and an increasing CO_2 tax. This is reflected in the larger percentage of comprehensively refurbished buildings (5% of the stock) compared to the RS (1% of the stock). This trend continues in the long term until 2050, when a total of 33% of the current stock is comprehensively refurbished in the 2DS, while only 15% is completely refurbished in the RS.

Notes:
GHG intensity: GHG emissions from final energy consumption include those from electricity for heating, hot water, ventilation, and cooling from a life-cycle perspective. For example, 10 kg CO_2-eq per m² is equivalent to 45 kWh per m² in a gas-supplied building. GHG emissions embodied in the construction of the building are not included.

C4.1 – *Refurbishment and new construction activities relating to building stock according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*

Sources:
TEP Energy & Chalmers University, BSM.

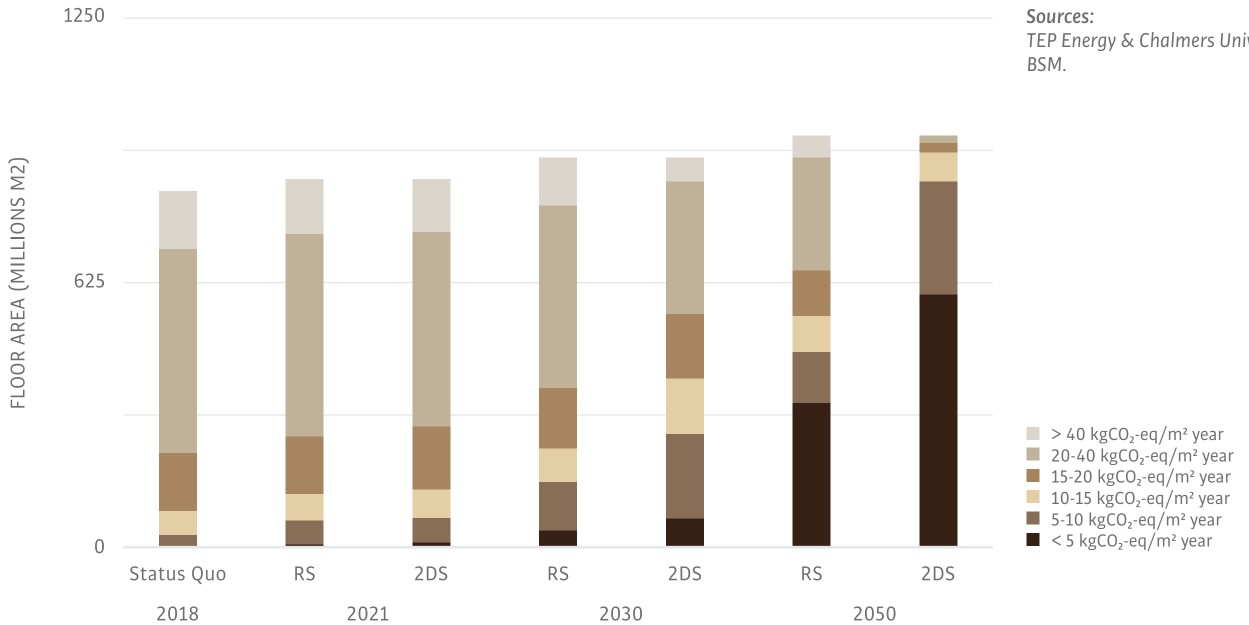


At present, most of the residential buildings in the Netherlands emit more than 20 kg CO_2-eq per m² (see Figure C.4.2). In the short term (until 2021), both scenarios anticipate only minimal changes in the GHG intensity of the building stock. Nevertheless, the percentage of buildings emitting less than 20 kg CO_2-eq per m² increases to over 30% of the stock in both scenarios. This increase stems mainly from new buildings added to the stock after 2018, which have a carbon intensity of less than 10 kg CO_2 per m².

In 2030, the majority of buildings still emit more than 20 kg CO_2 per m² in the RS (40% of the stock), because only a small percentage of the stock is refurbished comprehensively, and the majority of the buildings are still heated by fossil fuels. In the 2DS, however, the percentage of low-carbon buildings increases significantly compared to the RS due to more refurbishments and a faster changeover to renewable energy sources.

After 2030 there is a clear shift to low-carbon buildings, especially in the 2DS, resulting in the majority of the stock emitting less than 5kg CO_2 per m². This is triggered by policies dedicated to phasing out fossil energy from the heating sector, mainly driven by a shift to district heating and electrically driven heat pumps, as well as the continued efforts in building retrofitting. An important prerequisite of this development is the decarbonisation of the Dutch electricity mix based on the EU reference scenario.9 In the RS, the percentage of low-carbon buildings increases further, but the shift towards low-carbon buildings is less pronounced than in the 2DS. This is due to the fact that in this scenario, natural gas is still a dominant technology in the existing stock.

***C4.2** – Structural changes in the GHG intensity of building stock according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

C5 Structural change of the building market
Short-, mid-, and long-term development

Notes:
Construction activities not directly related to energy and GHG emissions (e.g. structural or interior work, kitchens and bathrooms) are not included.

-

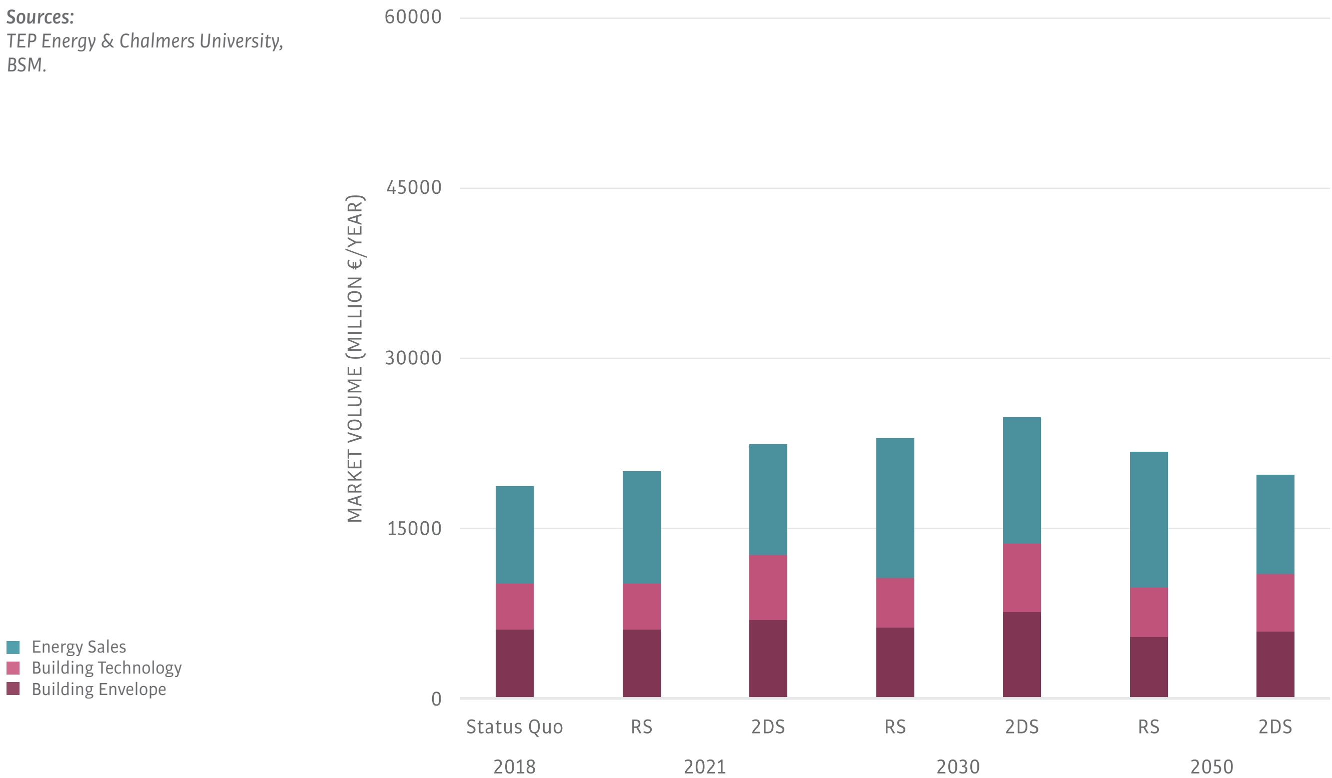
The market volumes presented in this and the next sections reflect the demand side. Possible shortages in capacity of the by the supply side to deliver (both in labour and material) are not explicitly taken into account.

In this and the following sections, the energy- and GHG related building market demand is assessed. This includes the building envelope market, the building technology market and related energy sales. Within this scope, the building envelope market encompasses all construction, retrofitting, refurbishment and maintenance activities on building envelope components (wall, roof, floor and windows). The building technology market includes heating, hot water and ventilation technologies. In the category of energy sales, all energy related to the building envelope and building technologies is included, whereas electricity sales from household appliances and CO_2-taxes are not. Hence, the entire value chain related to energy consumption and GHG emissions, including planning, installation, material and product sales, operation and maintenance, and the like is covered, for both existing buildings through refurbishment and the construction of new buildings. Note that construction activities not directly related to energy and GHG emissions (e.g. structural or interior work, kitchen and bathroom) are not included.

According to BSM calculations, the total market volume of the energy and GHG-related building market including energy sales amounts to €18.8 billion per year in 2018 (see Figure C.5.1). Almost half of this market volume comes from energy sales (€8.6 billion per year), even though electricity sales for household appliances are not included. The other half is split 60/40 between the building envelope (€6.1 billion per year) and building technology (€4.0 billion per year).

C5.1 – *Development of energy-relevant market volumes in the residential building market according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*

Sources:
TEP Energy & Chalmers University, BSM.



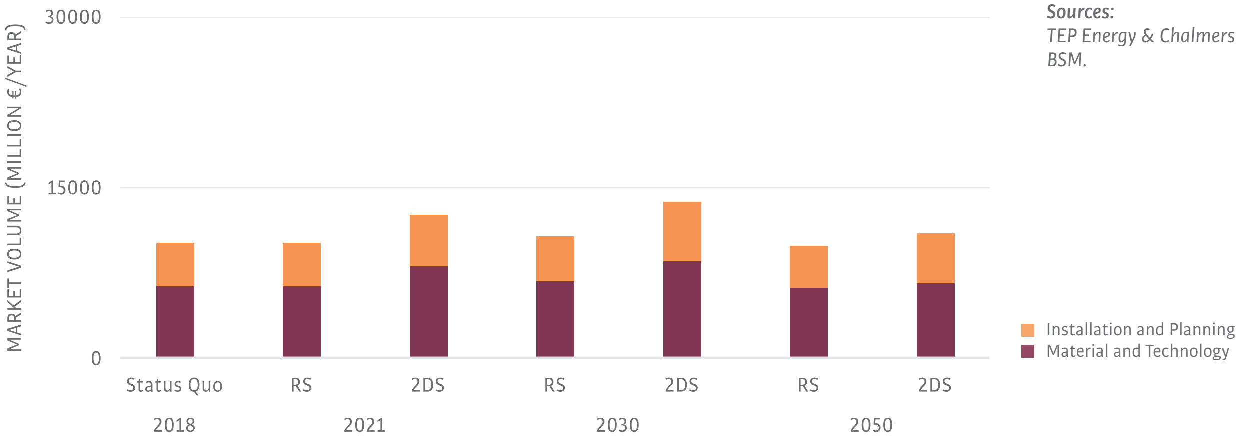
In the short term, the market volume increases in the RS. This comes from an increase in energy sales, mainly coming from an increase in energy prices, rather than an increase in energy consumption. In the 2DS, however, there is already a significant increase in the market volume from building envelope measures (+ 14%) and building technologies (+ 41%). This is mainly triggered by policies taking effect in 2020 targeting an increase in refurbishment as well as speeding up the phase out of fossil heating systems.

In the Reference and in 2-Degree scenarios, the total market volumes both increase until 2030. In the RS, the market volume for energy sales mainly increases. This is due to an increase in energy prices as well as a switch from cheap gas to higher priced electricity. In the 2DS the higher rate of refurbishment, and consequently a lower energy demand, results in a more or less constant energy sales volume as price and quantity effects level out. The market volume for building technologies continues to increase further (+54%) as the shift from gas to heat pumps and district heating is sped up.

In the long term until 2050, the overall market volumes decrease in both scenarios. The reduction of the energy demand in the building sector in both scenarios leads to a decreased market volume in energy sales, which cannot be offset by the shift to higher price energy carriers anymore. At this point, energy utilities should have shifted their business. The market volumes for building technologies and building envelope also decrease until 2050. While refurbishment activities are on-going until 2050, new construction decreases significantly as the population of the Netherlands is projected to stagnate and shrink after 2030.

The market volume is split about 35%–65% between installation, engineering and technical planning (€3.8 billion per year) and material and technology (€6.3 billion per year). The increase in the market volume in the short term and medium term in the 2DS mainly results from the material and technology category, for which the market volume increases to €8.1 billion per year (+27%) in 2021 and €8.6 billion per year in 2030 (+36%).

***C5.2** – Development of energy-relevant market volumes (excluding energy sales) for material and technology, and installation and planning according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

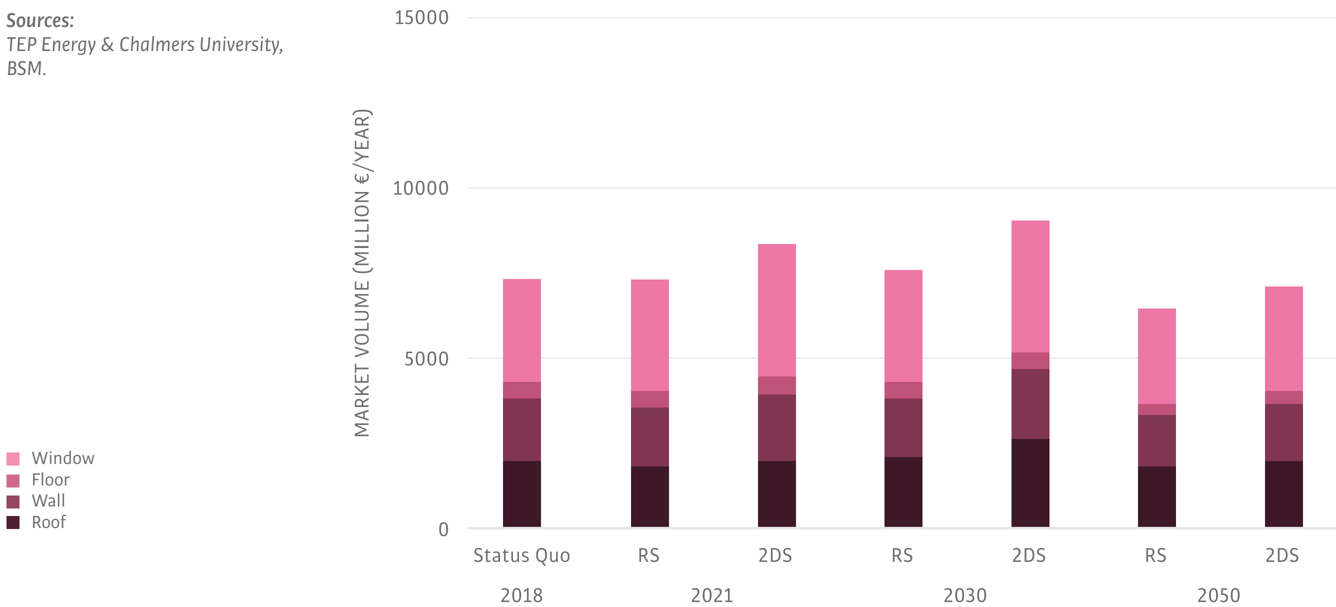
C6 Building envelope
Market volumes and development

The current annual market volume in the building envelope market amounts to €6.1 billion per year. The market volume is split between the different main building components (see Figure C.6.1). Window installation, replacement and refurbishment measures make up the largest share (€2.5 billion per year), closely followed by roof (€1.7 billion per year) and wall (€1.5 billion per year). Significantly lower are the shares of floor/basement ceiling insulations (€0.4 billion per year).

In 2018, about half of the building envelope market stems from the construction of new buildings (about 1% of floor area is added each year), and the other half from retrofitting existing buildings (an equivalent of about 1% of the building envelope is retrofitted energy efficiently, and an additional 1% is overhauled each year).

C6.1 – *Development of energy-relevant market volumes for various building components for both new construction and refurbishment according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*

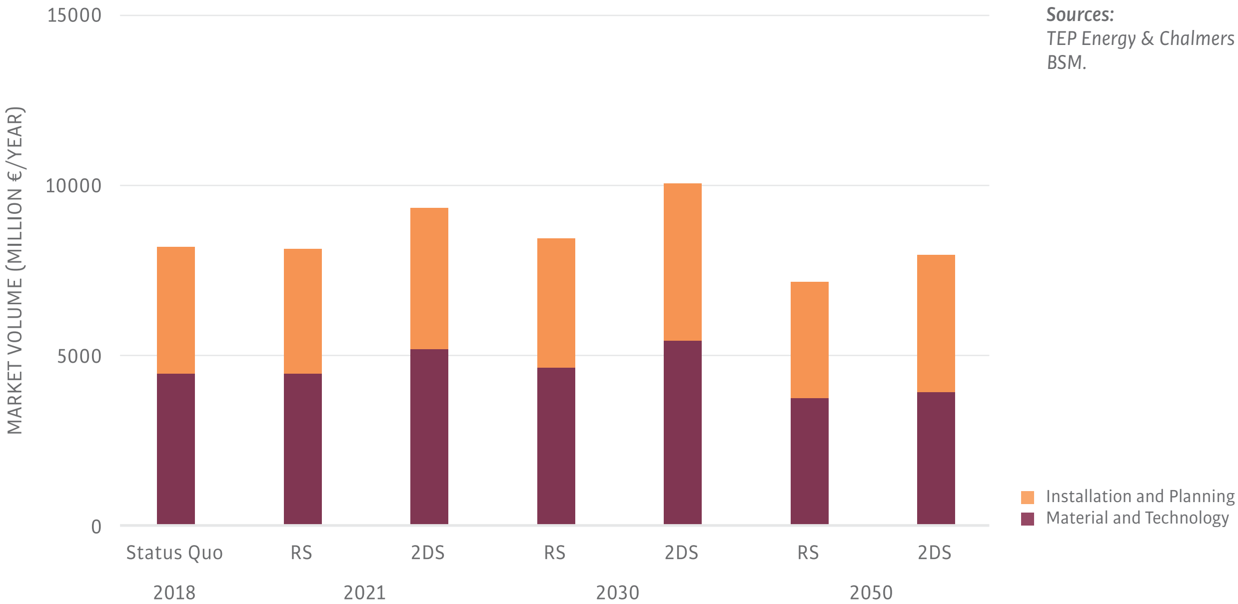
Sources:
TEP Energy & Chalmers University, BSM.



The envelope market volume only increases in the short term in the 2DS, as polices to increase the refurbishment rate and extend take hold. The market volume grows over all components but most significantly for windows, which increases to €3.3 billion per year (+30%). In contrast, the market volume remains constant in the RS. In both scenarios the new construction activity decreases, which is compensated by an increase in the refurbishment sector. This can be explained by the fact that a significant percentage of the building stock was constructed during the decade between 1970 and 1980, and based on the lifespan of the building elements for these buildings, they may need to undergo refurbishments in the short term.

In the medium term, the envelope market increases slightly in the RS and more significantly in the 2DS as decreasing new construction activity are compensated for by increases in the refurbishment activities. In the 2DS, increasing industrialization and automation reduces cost, leading to an increase in retrofit activity. The construction industry should therefore be prepared to shift their business towards more renovation.

***C6.2** – Development of energy-relevant market volume for material and technology and installation and planning for building envelope components according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

In the long run, that is, up to 2050, market volumes for both scenarios fall to 2018 as the market volume from new construction is decreased significantly. This can be explained by the development of the Dutch population that is projected to shrink after 2035. Until then, the construction industry should have shifted their business towards refurbishment

The envelope market volume is split about 45% to 65% between installation, engineering and technical planning (€3.3 billion per year) and material and technology (€2.8 billion per year) (see Figure C.6.2). The increase in market volume in the short term in the 2DS results more significantly from the material and technology category, for which the market volume increases to €3.9 billion per year (+16%), while the market for installation and planning increases to €3.1 billion per year (+11%). This results from an increase in the extent of refurbishment (e.g., through the application of thicker insulation and more efficient windows) rather than a significant increase in the rate of refurbishment.

In the medium term, the market remains increases in both scenario. However, in the 2DS, the market share of installation and planning increases more significantly than material and technology, resulting in a market volume of €3.5 billion per year (+25%) for the former and €4.1 billion per year (+22%) for the latter. This is a result of decreasing material and technology costs through innovation and automation and an increase in the refurbishment rate.

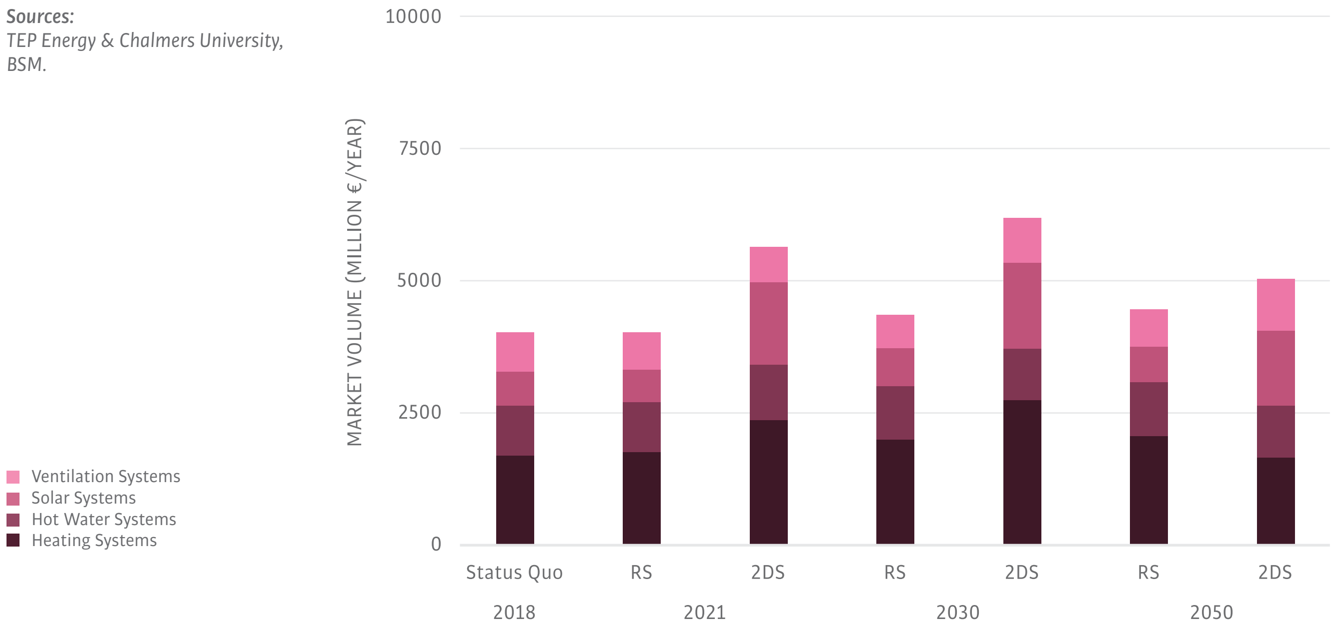
In the long run, decreasing market volume affects the material and technology market more significantly than it does installation and planning in both scenarios. In the RS it is decreased down to €2.6 billion per year (-16%) and in the 2DS down to €3.0 billion per year (-12%). In contrast, the installation and planning market remains above the 2018 level in the 2DS at €3.0 billion per year

C7 Building technologies
Market volumes and development

The current market volume of the Dutch residential building technologies market amounts to €4.0 billion per year. About two thirds of this market is made up of heating and hot water systems with €1.7 and €0.9 billion per year respectively (see Figure C.7.1). The remaining market volume is split into solar systems (both thermal solar collectors and photovoltaic systems) and ventilation systems with about €0.7 and €0.7 billion per year each.

***C7.1** – Development of energy-relevant market volume for various building technologies for both new construction and refurbishment according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*

Sources:
TEP Energy & Chalmers University, BSM.



In the short term, the market volume for building technologies remains more or less constant in the RS. It increases only in the 2DS (to €5.7 billion per year, i.e. by about 41%). The main driver of this increase is the phase out of gas and a replacement with heat pumps, district heating (still to a low extent in the short term as building up DH infrastructure needs time), and an increase of other renewable energy technologies. As a result, the market volume for heating systems and solar systems is increased to €2.4 billion and €1.6 billion respectively as the nZEB building regulations take effect.

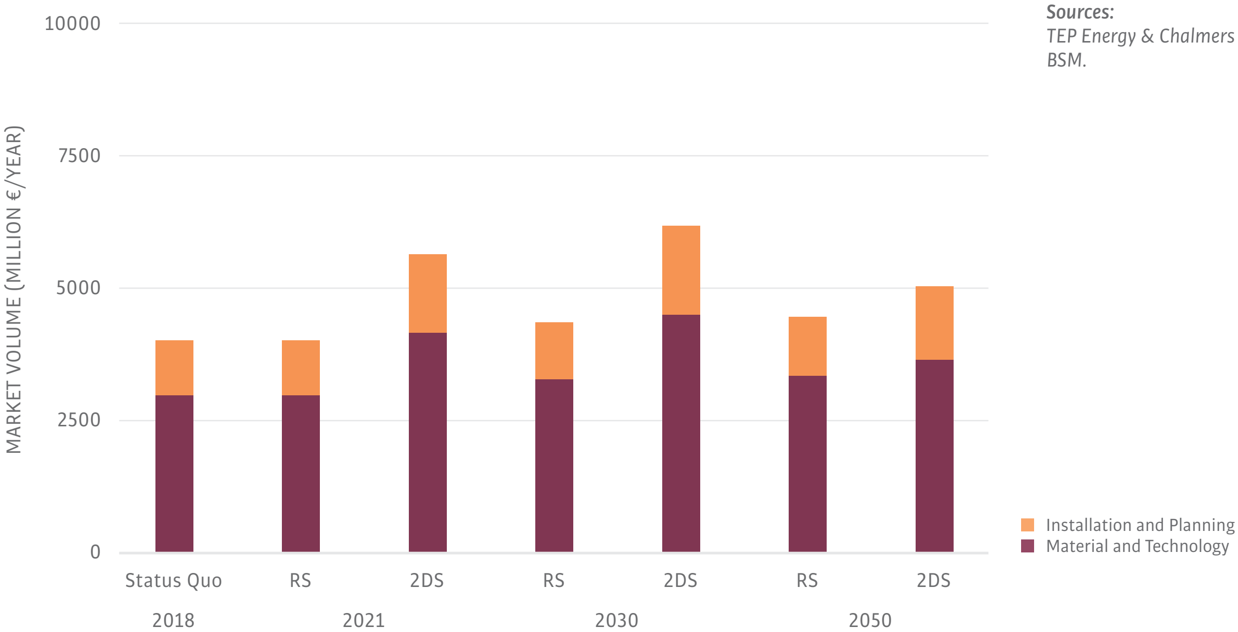
In the medium term until 2030, market volumes in the RS increase slightly and compensate for a decrease in new construction with an increase in replacement sales. The phase out of gas also affects the market volume in the RS, although it is slower in comparison to the 2DS. In the 2DS, the planned energy price adjustments lower the economic viability of gas systems and the tax reduction on electricity. The reduced cost of renewable heating systems through innovation programmes and subsidies help to finance the shift towards more expensive heating solutions such as heat pumps.

In the long run towards 2050, the market volumes decreases in the 2DS and remains constant in the RS. The missing market volume from new construction is compensated for by an increase in replacement sales and especially by increased sales of solar systems in the 2DS. In this scenario, the market share for heating systems is decreased in 2050 (-1%) and falls below the RS as cost reductions (especially for heat pumps) amplify the reduction from less new construction.

The building technologies market volume (see Figure C.7.2) is made up of about 25% installation and planning (€1.0 billion per year) and 75% material and technology (€3.0 billion per year). The slight decrease in the RS in 2021 affects installation and planning and material and technology proportionally. Similarly, also the increase in the 2DS is distributed almost proportionally between the two, where installation and planning increases to €1.5 billion per year (+44%) and material and technology to €4.2 billion per year (+40%). This is largely driven by the phaseing out of gas and the resulting increase in sales of more investment-intensive heat pumps.

***C7.2** – Development of energy-relevant market volumes for material and technology, and installation and planning for building technologies according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*

Sources:
TEP Energy & Chalmers University, BSM.



In the medium term, the market increases also in the RS, leading to an increase in installation and planning (+5%) and material and technology (+10%). In the 2DS, the market volume in both sectors increases further, up to €4.5 billion per year (+51%) for material and technology and €1.7 billion per year (+64%) for installation and planning. The larger increase in installation and planning is primarily a result of the higher planning effort in switching heating systems (e.g., due to the change from gas to heat pumps) as opposed to staying with the current systems.

In the long term, the market in the RS increases further, mostly in the material and technology sector (+13%). In the 2DS the market decreases again. In particular, the market for material and technology is decreased more significantly to €3.6 billion per year due to cost reductions as a result of innovation programmes on top of the decreasing new construction activity.

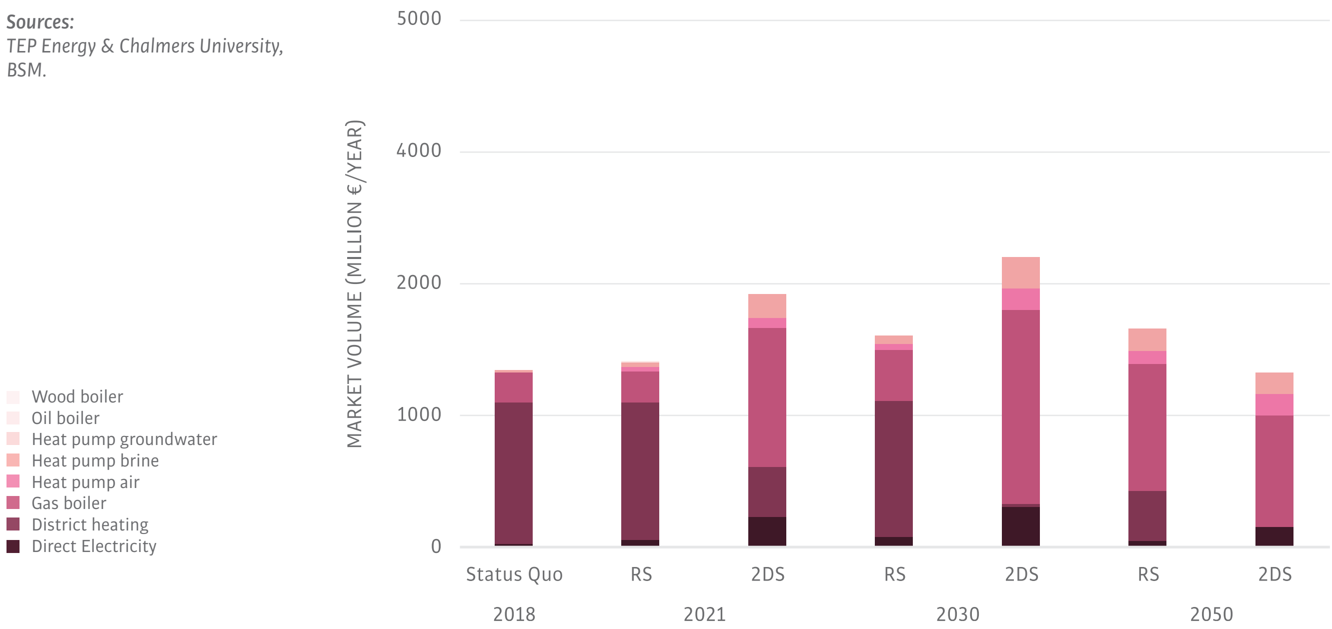
C8 A deep dive into heating systems
Market volumes and development

The current annual market volume for heating systems amounts to €1.7 billion per year, the majority of which comes from sales and installation of gas boilers with a market volume of about €1.4 billion per year. The second largest share comes from the sales and installation of air source heat pumps, which amounts to €0.2 billion per year. The rest of the market volume is made up from heating systems with lower market shares such as other types of heat pumps or district heating (see Figure C.8.1).

In the short term, market volumes remain more or less constant in the RS but increase significantly in the 2DS to €2.4 billion per year (+ 42%). Policies to phase out gas take effect and reduce the market volume for gas boilers to €0.4 billion per year. This is replaced by an increase mainly in the market volume of air source heat pumps and possibly hybrid systems (€1.3 billion per year) and district heating (€0.3 billion per year)

***C8.1** – Development of the market volumes of various heating system technologies (construction of new buildings and refurbishment of existing ones) according to the Refernce Scenario (RS) and the 2-Degrees Scenario (2DS).*

Sources:
TEP Energy & Chalmers University, BSM.



Notes:
Planned investment into innovation and optimization should drastically reduce costs of renewable heating systems. The new climate and energy agreement aims to do so by as much as 30-50%.

Until 2030, both scenarios show an increase in the heating systems market volumes. In the RS, gas boilers also begin to be phased out and their market volume decreases to €1.3 billion per year (-3%). Gas boilers are largely replaced by heat pumps and to a much smaller degree also by district heating.The 2DS shows an almost complete phase out of gas boilers and a continued increase of the market volume for heat pumps and district heating respectively.

Long-term developments until 2050 show decreasing market volume in the 2DS mainly due to decreasing new construction activities and an overall reduction of costs for renewable heating systems. Indeed, these systems will rapidly diffuse in the 2DS and make up the entire market in 2050. The market volume in the RS increases in the long term as the delayed phase out of gas picks up in this scenario. By this time, the market is dominated by air source heat pumps. However, cost reduction of these technologies has not progressed as far as in the 2DS.

In 2018, the heating system market (see Figure C.8.2) is made up of about 25% new construction (€0.4 billion per year) and 75% refurbishment (€1.3 billion per year). While the refurbishment sector is still dominated by gas boilers, which make up 96% of the market, heat pumps have the largest share in the new construction sector (76% across all types) and gas boilers only make up 21% of the market

In the short term, the percentage of heat pumps used in new construction increases in both scenarios, phasing out gas boilers completely in the 2DS already until 2021. In this scenario air-source heat pumps make up a market volume of €278 million per year (+6%), while in the RS the market volume decreases duet to the overall reduction in new construction. The replacement of gas in new construction is slower process in the RS, but also leading to a complete phasing out by 2030.

For existing stock, gas-fueled heating is still dominant in the short term and medium term in the RS, with only a slow increase in the market volume of heat pumps (€103 million per year in 2021 and €391 million per year in 2030). However, in the long run, especially air-source heat pumps replace gas as the dominant technology also in the refurbishment sector. In the 2DS, however, gas boilers are phased out already almost completely by 2030 and are primarily replaced by heat pumps and the extension of district heating in Dutch cities, resulting in market volumes of €1.1 billion per year for air-source heat pumps and €193 million per year for district heating in 2050.

***C8.2** – Development of energy-relevant market volumes for various heating system technologies according to the Refernce Scenario (RS) and the 2-Degrees Scenario (2DS) for the market segments new construction (left) and refurbishment (right).*

Sources:
TEP Energy & Chalmers University, BSM.

F2 Building inventory factsheet

Single-dwelling
BUILDING

Construction period: 1920 — 1945 — 1960 — 1980 — 1990 — 2000 — 2010

Details								
Cumulative floor area (million m²)	59.4	54.3	53.2	182.7	94.9	82.9	64	33.5
Heated floor area (m²)	119	116	109	117	118	129	137	134
Average number of floors (#)	2	2	2	2	2	2	2	2
Envelope surface area (m²)	216	209	200	205	203	225	244	242
Window wall ratio (%)	24%	24%	25%	29%	26%	25%	24%	24%
U-Value (W/m² a)								
Wall	1.21	1.2	1.09	0.78	0.41	0.27	0.22	0.2
Roof	1.02	1.02	0.83	0.53	0.35	0.21	0.17	0.15
Floor	1.65	1.65	1.51	1.38	0.51	0.22	0.13	0.13
Window	2.18	2.21	2.23	2.2	2.21	2.04	1.81	1.43
Heating Systems								
Oil boiler	0%	0%	0%	0%	0%	0%	0%	0%
Gas boiler	99%	99%	100%	97%	93%	92%	90%	89%
District heating	1%	1%	0%	2%	6%	6%	7%	6%
Heat pumps	1%	0%	0%	1%	1%	2%	3%	5%
Wood stove	0%	0%	0%	0%	0%	0%	0%	0%
Direct electricity	0%	0%	0%	0%	0%	0%	0%	0%
Coal boiler	0%	0%	0%	0%	0%	0%	0%	0%

Multi-dwelling
BUILDING

Construction period: 1920 — 1945 — 1960 — 1980 — 1990 — 2000 — 2010

Details								
Cumulative floor area (million m²)	20.3	18	20.5	54.7	21.5	25.1	22.8	10.7
Heated floor area (m²)	419	407	443	582	472	601	669	637
Average number of floors (#)	3	3	4	4	4	4	4	4
Envelope surface area (m²)	487	482	502	575	495	606	662	649
Window wall ratio (%)	31%	31%	33%	37%	31%	33%	34%	34%
U-Value (W/m² a)								
Wall	1.57	1.51	1.21	0.86	0.45	0.28	0.25	0.23
Roof	0.99	0.96	0.92	0.49	0.34	0.23	0.18	0.17
Floor	2.07	2.06	1.68	1.26	0.34	0.18	0.16	0.16
Window	2.19	2.23	2.19	2.2	2.19	2.03	1.78	1.42
Heating Systems								
Oil boiler	0%	0%	0%	0%	0%	0%	0%	0%
Gas boiler	97%	99%	93%	86%	86%	91%	88%	92%
District heating	3%	1%	7%	13%	14%	7%	10%	5%
Heat pumps	0%	0%	1%	1%	0%	3%	3%	3%
Wood stove	0%	0%	0%	0%	0%	0%	0%	0%
Direct electricity	0%	0%	0%	0%	0%	0%	0%	0%
Coal boiler	0%	0%	0%	0%	0%	0%	0%	0%

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