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Discussion Paper

# Updated method for disaggregating domestic natural gas consumption by end use using smart meter data

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# Abstract

The Netherlands is committed to making the built environment more sustainable. Reducing domestic natural gas consumption will play a major role in achieving that objective. To implement effective policies, more information is needed about the natural gas consumption by end use type. Before now, the total natural gas consumption was disaggregated into the consumption for heating, cooking and hot water using an outdated empirical formula. In this study, we present an updated method based on monthly gas meter readings derived from smart meter data.

The total gas consumption can be split into a season-independent part for cooking and hot water (the basic consumption) and a season-dependent part for heating (the supplementary consumption). The new method was tested using smart meter data for the 2022 and 2023 reporting years and preliminary figures for 2024. The study demonstrates that the basic consumption of homes is primarily determined by the number of occupants, while the supplementary consumption primarily depends on the floor area and energy label. These trends can be used to predict the natural gas consumption of homes without smart gas meters. The method can also be used to analyse year-on-year changes in natural gas consumption by end use type.

This study shows that between 25 and 29 percent of the total natural gas consumption of homes consists of the basic consumption. The supplementary consumption accounts for the rest. This study also provides an indication that the sharp decline in natural gas consumption in homes between 2022 and 2023 was due to a decline in both the basic consumption and the supplementary consumption. The basic consumption declined more in relative terms (-19 percent) than the supplementary consumption (-6 percent). To assess the relatively large decline in the basic consumption, several variants of the method of disaggregating the total consumption into the basic consumption and supplementary consumption were studied. A comparable relative decline in the basic consumption was found for all variants. In absolute terms, there is however an uncertainty of around 13 percent for the basic consumption and 4 percent for the supplementary consumption.

The uncertainties for the basic consumption and supplementary consumption can be reduced in the future by using smart meter data with a higher frequency than monthly readings, for example readings for every day, hour or quarter of an hour.

Keywords: natural gas, disaggregation, end use, smart meter

# Contents

# 1 Introduction

The Netherlands has set ambitious targets to make the built environment more sustainable. Making homes less dependent on natural gas will make a major contribution to that objective. Natural gas is primarily used in homes for heating, and to a lesser extent for cooking and hot water. It is uncertain exactly how much natural gas is used for heating and how much for cooking and hot water. This is because, until recently, Statistics Netherlands (CBS) only had access to data for the total annual natural gas consumption per home. The consumption for each end use is not metered separately. Natural gas consumption is currently disaggregated by end use type using an empirical formula. This formula was developed in 2014 following a study that included a sample survey of homes (Tigchelaar 2013). However, due to recent developments in the energy transition, including incentives to make homes more sustainable and the 2022 energy crisis, it is reasonable to assume that this formula is no longer accurate. This means the current method of disaggregating the natural gas consumption by end use type is inadequate.

Since 2024, a new data source has been available: data for the monthly natural gas consumption per home from smart meters. Around 5.7 million homes now have a smart gas meter. That is over 80 percent of all gas-heated homes. The monthly gas consumption can be used to analyse the typical seasonal gas consumption pattern: high consumption in the winter and low consumption in the summer (CBS 2024). It is expected that gas is primarily used for heating in the winter months, and that the gas consumption for cooking and hot water will remain almost constant throughout the year. The monthly gas consumption can be disaggregated into the season-independent basic consumption and the season-dependent supplementary consumption. By developing a model for gas consumption at the micro level, it is possible to separate the basic consumption from the supplementary consumption. This allows us to estimate how much natural gas is used for heating and how much is used for cooking and hot water in each home. This model can improve our understanding of how much natural gas is consumed by each end use. This will allow more effective sustainability policies to be introduced in the future.

# 2 Model

## 2.1 Population of homes

Since 2024, CBS has had access to monthly meter readings from smart meters going back to 2022. Around 5.7 million homes now have a smart gas meter. Homes for which no monthly data is available and homes with negative consumption figures were filtered out of this group. Homes for which more than 50 percent of the total gas consumption arose in a single month were also excluded, as the model cannot process these accurately. Finally, only homes with an individual gas connection were selected. The population used for this study consists of the remaining homes – around 5.0 million – for which valid gas consumption figures could be determined for all 12 months of each year. This amounts to around 75 percent of the total population of gas-heated homes.

## 2.2 Average natural gas consumption per degree day

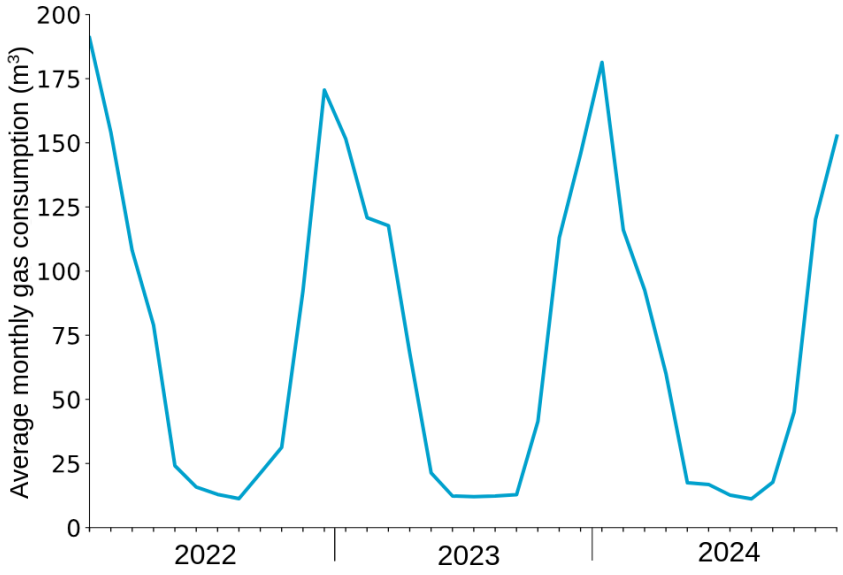



**Figure 2.1 Average gas consumption per month in $m^3$ between January 2022 and December 2024 of gas-heated homes.**

Figure 2.1 shows the average gas consumption per month from January 2022 to December 2024. A seasonal pattern can be seen in the graph: the gas consumption in the winter months is considerably higher than in the summer months.
The number of degree days is a quantitative measure that can be used to assess the effect of the weather on the energy consumption in a particular month. For each day that the average daytime temperature is less than 18°C, the number of degree days is equal to the difference between 18°C and the average daytime temperature. This can be expressed using the following formula:

$$\text{degree days} = \max(0, 18°\text{C} - T),$$

where $T$ is the average daytime temperature in degrees Celsius. A cold month such as January typically has around 500 degree days, while a warm August will typically only have around 20 degree days. In 2022, the Netherlands Environmental Assessment Agency (PBL) introduced an

updated version of the degree day. In addition to the average daytime temperature, the new version also takes account of solar radiation, wind speed and the temperature on the previous days (Volkers et al. 2022). This updated degree day is largely based on a method (profile methodology) used by energy suppliers to measure the consumption of connections that are not continually metered. On calm, sunny days, less energy will be used for heating than on cloudy, windy days. The updated formula is:

$$\text{degree days}^* = \max\left(0, 18^\circ\text{C} - T_d^*\right) \tag{1}$$

$$T_d^* = 0.65\left(T_d - \sqrt{W_d}\right) + 0.35\left(T_{d-1} - \sqrt{W_{d-1}}\right) + \frac{1}{480}Q_d.$$

Here $T_d$ is the average daytime temperature and $T_{d-1}$ is the average daytime temperature on the previous day in degrees Celsius, $W_d$ is the average wind speed in $m/s$, $W_{d-1}$ is the average wind speed in $m/s$ on the previous day and $Q_d$ is the average solar radiation in $J/cm^2$. This adjustment results in a number of degree days that is slightly lower in the winter months in particular than if only the average daytime temperature is taken into account. The effect on the number of degree days in the summer months is small.
For this study, the number of degree days per month was determined using the formula 1, in which the daytime temperature is determined using data from the Royal Netherlands Meteorological Institute (KNMI) (KNMI 2025) for the weather station closest to the home.

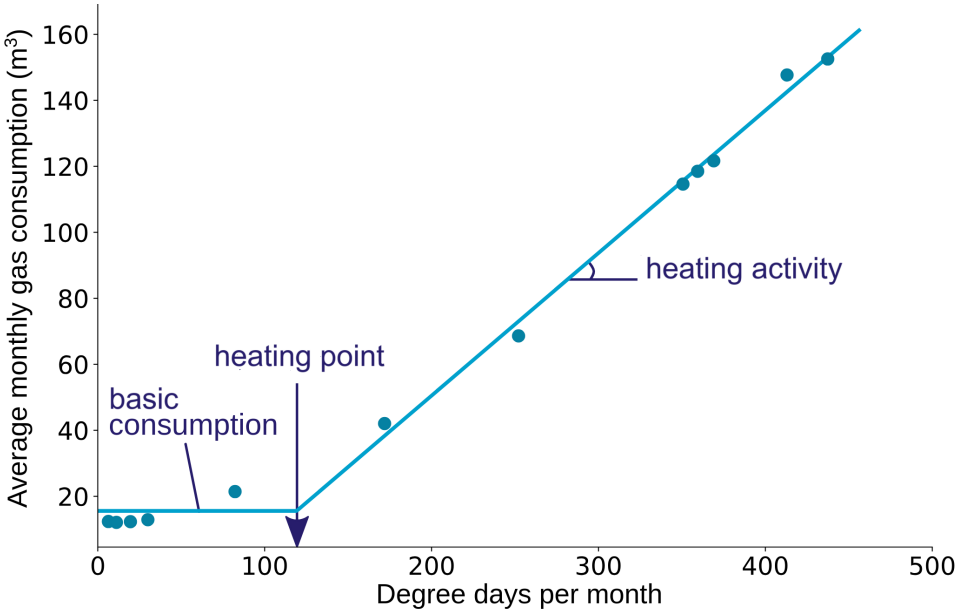



**Figure 2.2 Average monthly gas consumption in $m^3$ in 2023 against the number of degree days per month for gas-heated homes.**

Figure 2.2 shows the average monthly gas consumption in 2023, but now against the number of degree days per month. The data points below (to the left of) 100 degree days are for the months of May to September and the data points above (to the right of) 300 degree days are for the months of January, February, November and December. The graph shows that the natural gas consumption in the summer months is almost constant, despite the differences in the number of degree days. In the winter months, the natural gas consumption is much more dependent on the number of degree days per month.

The simplest interpretation of this trend is that households only use natural gas for cooking and

hot water in the summer months. In the colder months, natural gas is also used for heating. We model the monthly gas consumption based on two components: the season-independent *basic consumption* and the season-dependent *supplementary consumption*, which increases linearly with the number of degree days from a certain number of degree days per month (Volkers et al. 2022; CBS 2024). We call this point the *heating point*.

## 2.3 Modelling assumptions

Figure 2.3 shows the disaggregation of the total consumption into the basic consumption and supplementary consumption for homes with a smart natural gas meter. The total monthly gas consumption is disaggregated into the fixed basic consumption (light red bar) and the variable supplementary consumption (dark red bar). The basic consumption is defined as the average gas consumption in the months from May to September. The consumption above the basic consumption is the supplementary consumption.

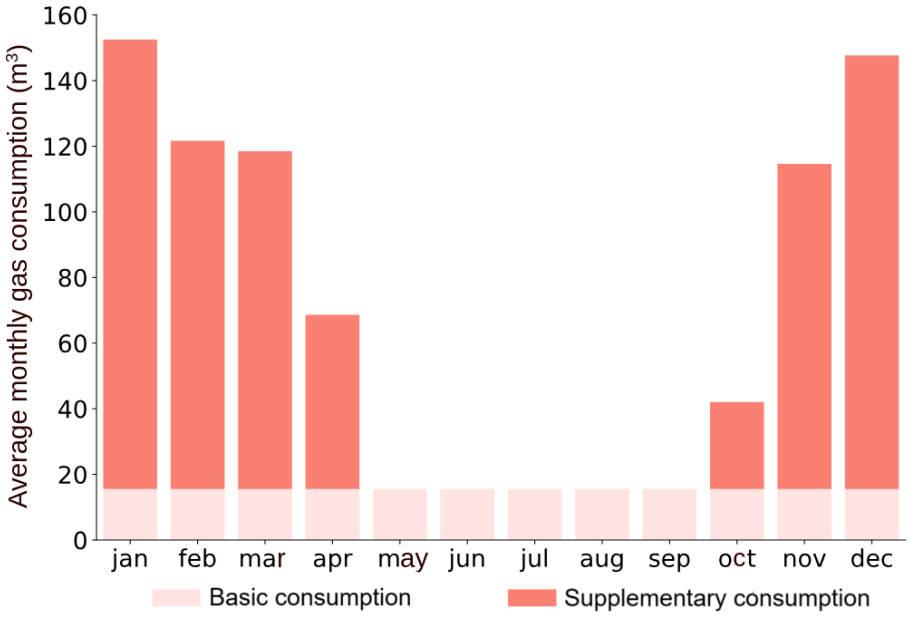



**Figure 2.3 Average monthly gas consumption in $m^3$ for homes with a smart meter in 2023. The bar charts show how the total consumption is disaggregated into the basic consumption and supplementary consumption. The light red bar shows the season-independent basic consumption. The dark red bar shows the season-dependent supplementary consumption.**

A model was developed based on the observation that the total gas consumption consists of season-independent and season-dependent parts. This model assumes that homes do not use natural gas for heating in the months with fewer degree days than the heating point. The gas consumed in those months is assumed to be used exclusively for cooking and hot water. The growth in gas consumption in the months with more degree days than the heating point is assumed to be entirely due to heating. By determining the basic consumption per home, we can achieve the desired disaggregation.

By identifying two parameters (basic consumption and heating activity), a similar line per home is found as in figure 2.2. To filter out unreliable fits, the *mean squared error* and *coefficient of determination* were determined for each home. The homes with the worst scores (10 percent)

were filtered out. These include, for example, homes that were unoccupied for long periods of the year, that were extensively renovated or where there was another major change in the factors that determine the gas consumption during the year.

## 2.4 Model parameters

The model has three parameters, which are used to disaggregate the total monthly natural gas consumption by end use type. The basic consumption is the season-independent part of the total consumption. The free parameters are the heating point and the gradient of the linear increase in the supplementary consumption in response to the increasing number of degree days per month (which we call the *heating activity*).

The **basic consumption** of each home is determined using the average gas consumption in the months in which the number of degree days was lower than the heating point. To correct for the effect of holidays, when households consume less or no natural gas, the basic consumption is determined by taking the average of all months under the heating point, except for the two months with the lowest gas consumption. This means the months in which people are at home less are not included in the basic consumption calculation.

Because there are only 12 data points per household in a year (1 per month), it is not possible to accurately determine the heating point at the micro level. Instead, a **single heating point** is determined for the entire population of homes for each reporting year. The basic consumption is defined as the average gas consumption in the months from May to September. The heating point and heating activity are subsequently optimised as free parameters based on the method of least squares. The resulting heating point is then used for all homes in the model.

The **heating activity** is optimised at the micro level based on the method of least squares using the data points for which the number of degree days per month is higher than the heating point.

# 3 Results

To allow the total gas consumption to be disaggregated into the consumption for heating, cooking and hot water at the micro level, the three model parameters are determined for each home as described in section 2. We begin by disaggregating the total gas consumption into the consumption for heating and the consumption for cooking and hot water. In the final subsection of this section, we attempt to separate the gas consumption for cooking and hot water.

Homes with a smart natural gas meter can be divided into three main groups: homes with a connection to a district heating grid, homes with a (hybrid) heat pump and gas-heated homes. We first focus on the gas-heated homes(95 percent of the total). We discuss the disaggregation of the total consumption into the basic consumption and supplementary consumption in greater detail, and also the effect of properties such as the type of home and number of occupants on the resulting values. This is followed by a discussion of homes with a hybrid heat pump. The results for these components are for 2023. We conclude by examining the overall differences between the years 2022 to 2024.

## 3.1 Gas-heated homes

As described above, the heating point was determined for all 5.0 million homes. The heating point for 2023 is 125 degree days per month. This allows the gas consumption for each home to be split into the basic consumption and heating activity. Figure 3.1 shows this disaggregation into the monthly basic consumption and heating activity.

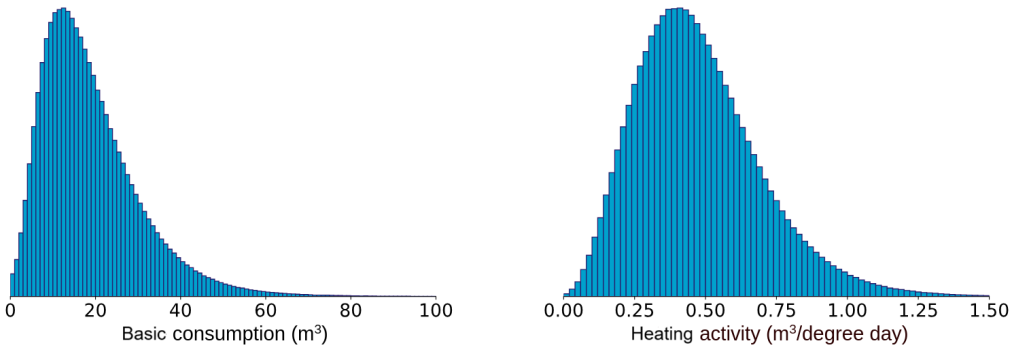



**Figure 3.1 Disaggregation into monthly basis consumption in $m^3$ and heating activity in $m^3$/degree day for homes with a smart meter in 2023.**

The graph shows that there is variation in both the basic consumption and heating activity. In the next subsection, we consider the effects of certain properties of homes on gas consumption.

## 3.2 Home properties

### 3.2.1 Home type

CBS is aware of whether homes are apartments, terraced houses, corner houses, semi-detached houses or detached houses. Figure 3.2 shows the monthly basic consumption and the heating activity broken down by home type.

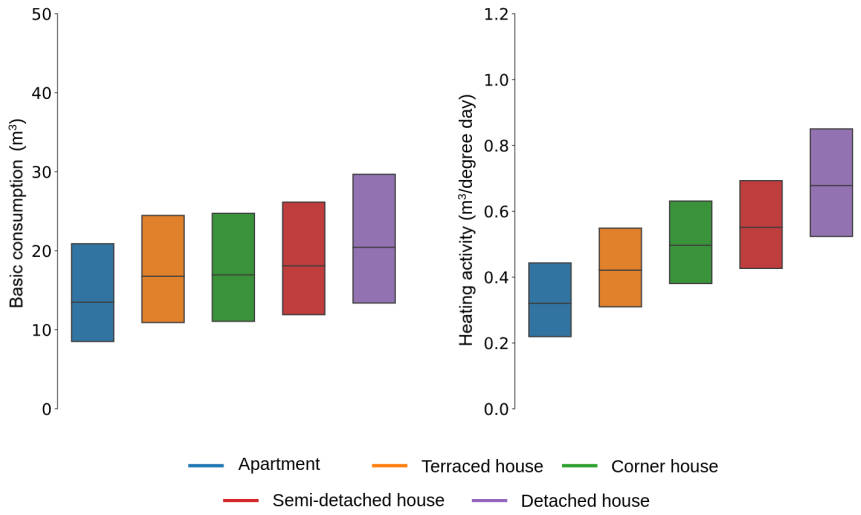



**Figure 3.2 Monthly basic consumption in $m^3$, in the left graph, and heating activity in $m^3$/degree day, in the right graph, for gas-heated homes with a smart meter in 2023, broken down by home type. The black line in the centre of each box shows the median. The upper and lower boundaries of the boxes show the 25th and 75th percentiles.**

Figure 3.2 shows that there is a great deal of overlap in the basic consumption of different home types. This is because the basic consumption – which consists of the gas consumption for cooking and hot water – is not directly dependent on the home type. However, we see that the median is slightly lower for apartments and slightly higher for detached houses than for other home types.

Figure 3.2 also shows that the heating activity is in fact highly dependent on the home type. Detached houses consume considerably more natural gas per degree day than apartments, for example. This difference can be explained by various factors. Firstly, apartments are generally considerably smaller than detached houses, for example [1)]. This means a smaller area needs to be heated. Apartments also share walls with adjacent homes. This means some of the heat comes indirectly from the neighbours, which means occupants do not need to heat as much.

To study these factors, the heating activity per square metre of floor area of was determined. Figure 3.3 shows the results of this calculation, which demonstrate that the heating activity is now almost the same for all home types. The heating activity is thus primarily dependent on the floor area.

1) Apartments have an average floor area of 76 $m^2$ and detached houses have an average floor area of 178 $m^2$.

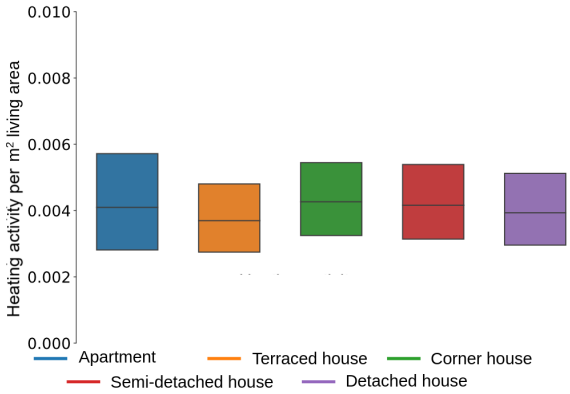



**Figure 3.3 Heating activity in $m^3$/degree day corrected for floor area in $m^2$ for gas-heated homes with a smart meter in 2023, broken down by home type. The black line in the centre of each box shows the median. The upper and lower boundaries of the boxes show the 25th and 75th percentiles.**

### 3.2.2 Number of occupants

Figure 3.4 shows the monthly basic consumption and heating activity, broken down by the number of occupants and also by floor area for the heating activity. All homes with more than four occupants are combined, as there are relatively few such homes and they display the same behaviour. In contrast to the home type, the basic consumption is highly dependent on the number of occupants: the more people live in a home, the higher the basic consumption. This is to be expected, given that the gas consumption for hot water primarily depends on the number of occupants. A single-person household consumes considerably less natural gas for hot water than a four-person household. This also explains the fact that apartments have a slightly lower basic consumption and detached houses have a slightly higher basic consumption (Figure 3.2). An average of 1.7 persons live in apartments and an average of 2.8 persons in detached houses.

In contrast, the right graph in Figure 3.4 shows that the heating activity is much less dependent on the number of occupants. In this graph, the homes are further broken down into three groups based on floor area: smaller than 100 $m^2$, 100-150 $m^2$ and larger than 150 $m^2$. The heating activity is largely the same for all three groups. It can also be seen that the heating activity is strongly dependent on the floor area, as we have already seen.

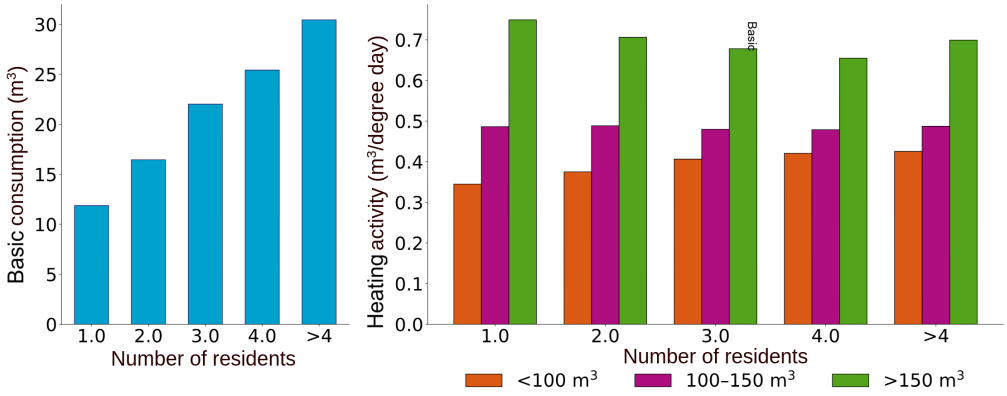



**Figure 3.4 The left bar chart shows the average basic consumption in $m^3$ for gas-heated homes with a smart meter in 2023, broken down by number of occupants. The right bar chart shows the average heating activity in $m^3$/degree day. The heating activity is also broken down by floor area. All households with more than four occupants are combined under '>4'.**

### 3.2.3 Energy label

The final property to be studied is the differences between homes with different energy labels. The energy label indicates how sustainable and energy efficient a home is. Homes with a G label are the least energy efficient, while homes with an A label or better are the most energy efficient. Not all homes have an energy label and registered energy labels may be out of date. The analysis was therefore limited to homes with an energy label that is no more than five years old. Data for a total of around 2.2 million homes were analysed. Figure 3.5 shows the basic consumption and heating activity for each energy label. All households with energy label A or better are combined under '>A' and all households with energy label E or worse are combined under '>E', because these groups show the same behaviour and are relatively uncommon.

The left bar chart shows that the basic consumption is largely independent of the energy label. However, energy efficient homes can be expected to consume less natural gas for heating. These homes are often better insulated or have a more efficient heating system. This effect can indeed be seen in the right bar chart in Figure 3.5.

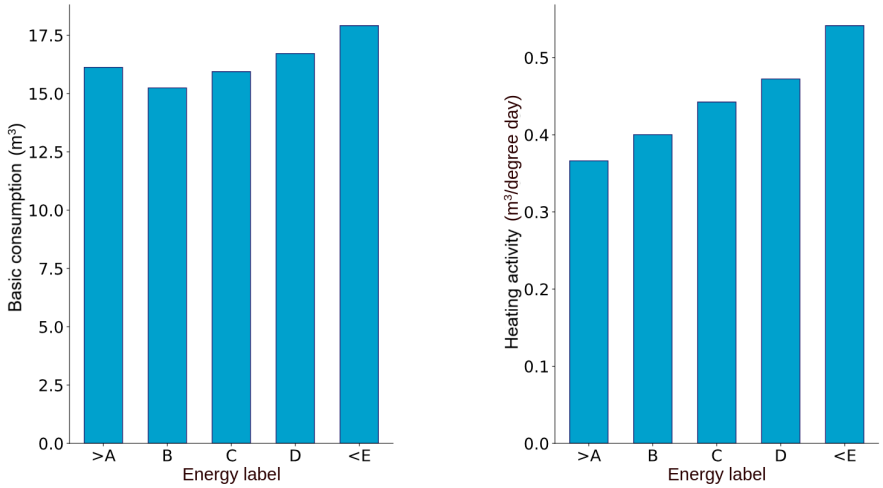



**Figure 3.5 The left bar chart shows the average basic consumption for gas-heated homes with a smart meter, broken down by energy label. The right bar chart shows the average heating activity. All households with energy label A to A++++ are combined under '>A' and all households with energy label E, F or G are combined under '<E'.**

## 3.3 Hybrid heat pumps

As mentioned above, the homes in this study can be divided into three groups: homes connected to a district heating grid, homes with a (hybrid) heat pump and gas-heated homes. So far, we have focused on the largest group: gas-heated homes. In this section, we focus on the differences between those homes and homes with a hybrid heat pump.

A heat pump uses ambient heat from the soil or outside air to heat the home. It also consumes electricity. The heat pump may also provide only part of the required heating, with the rest coming from a natural gas fired central heating boiler. In this case, we refer to a hybrid heat pump. When the outside temperature is low, the central heating boiler turns on and heats the home together with the heat pump.

Recorded ISDE subsidy applications [2)] and energy labels allow some heat pump systems to be identified at address level. Because homes in which a heat pump was installed during the reporting year may give anomalous results, the survey population was selected by including only homes with a registered heat pump on 1 January of the reporting year. In 2023, there were 48 thousand homes with a registered heat pump on 1 January, a smart natural gas meter and a natural gas consumption higher than 225 $m^3$. The threshold of 225 $m^3$ was used to select homes that, in addition to an electric heat pump, probably also use natural gas for heating.

Figure 3.6 shows the average monthly gas consumption against the number of degree days per

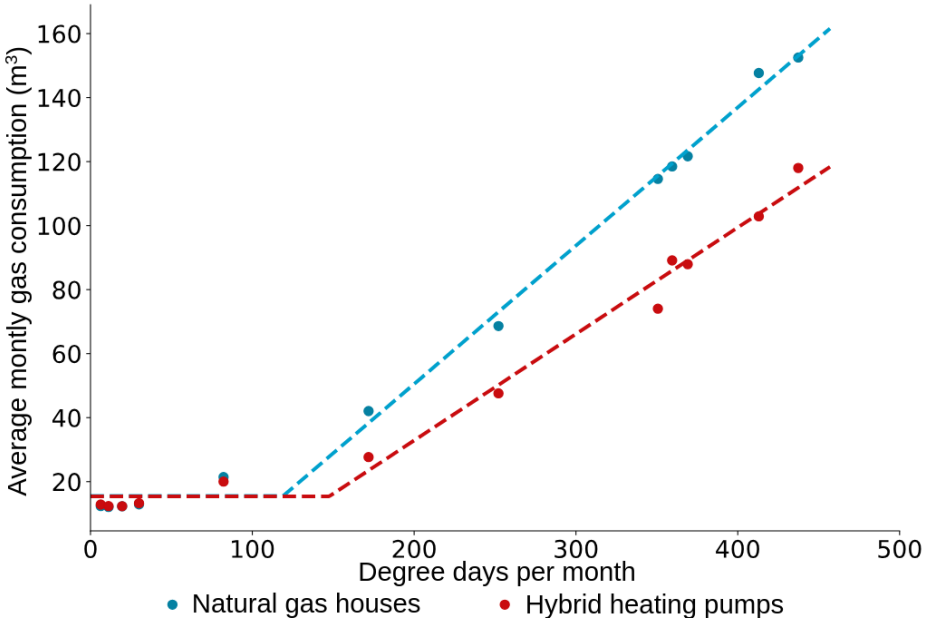



**Figure 3.6 Average monthly gas consumption in $m^3$ against the number of degree days per month in 2023 for homes with a smart meter. The blue dots indicate gas-heated homes. The red dots indicate homes with hybrid heat pumps.**

month for gas-heated homes (blue) and homes with a hybrid heat pump (red). Several differences can be observed: firstly, the gas consumption in the summer months is almost identical for both groups. This means there is little difference between the average basic

2) Households that wish to make their (existing) home sustainable are eligible for the *Sustainable energy and energy saving investment subsidy* (RVO 2025).

consumption of the two groups. One notable difference is that the heating point is considerably higher for homes with a hybrid heat pump than for gas-heated homes. The heating point for gas-heated homes is around 125 degree days per month, while the heating point for homes with a hybrid heat pump is 150 degree days per month. This reflects the way hybrid heat pumps operate, as the central heating boiler only turns on once the outside temperature is colder and the heat pump is unable to supply sufficient heat. Finally, it is notable that the gas consumption per degree day after the heating point is lower for homes with a hybrid heat pump than for gas-heated homes. A possible explanation is that homes with a hybrid heat pump are more energy efficient than gas-heated homes [3)].

No significant differences were found between homes with a hybrid heat pump and gas-heated homes when the effect of home properties on gas consumption was considered. The group of homes with a hybrid heat pump shows the same qualitative trends as shown in subsection 3.2.

## 3.4 Annual consumption figures

Using the model described in this paper, it is possible to disaggregate the gas consumption per home into the consumption for heating and the consumption for cooking and hot water. This is shown for the 2022, 2023 and 2024 reporting years in Figure 3.7. The heating points for 2022, 2023 and 2024 are 118, 125 and 121 degree days respectively. With 2621, 2610 and 2598 degree days in De Bilt (headquarters of the Royal Netherlands Meteorological Institute) in these years (calculated according to (Volkers et al. 2022))), 2022, 2023 and 2024 had similar weather.
The left graph shows the average annual basic consumption. The right graph shows the average supplementary consumption. The average gas consumption declined sharply – by around 10 percent – between 2022 and 2023. The average basic consumption and supplementary consumption both declined. This decline is consistent with previously published figures (CBS 2025a). This trend may be explained by the high energy prices in late 2022 and 2023 (CBS 2025b), which led many homes to reduce their gas consumption. A relatively small increase in the total gas consumption of 3 percent can be seen between 2023 and 2024. The basic consumption increased by 8 percent and the supplementary consumption remained almost the same. Despite the subsequent decline in energy prices in 2024 (CBS 2025b), there is no clear indication that households started consuming more natural gas. It is notable that the decline in natural gas consumption between 2022 and 2023 was primarily due to a decline in the basic consumption. The left graph in Figure 3.7 shows that the basic consumption declined by almost 20 percent. The supplementary consumption fell by much less – just 6 percent. Because the gas consumption for cooking is much less than the gas consumption for hot water (Eurostat 2025), it is reasonable to assume that households primarily reduced their gas consumption for hot water. The water consumption during the same period also declined by around 5 percent (CBS 2025c). It is unknown which specific end uses contributed to the decline in water consumption (CBS 2022), which means definite conclusions cannot yet be drawn about the possible decline in the consumption of hot water.

3) Around 50 percent of homes with a hybrid heat pump have energy label A or higher, but only 20 percent of gas-heated homes have energy label A or higher.

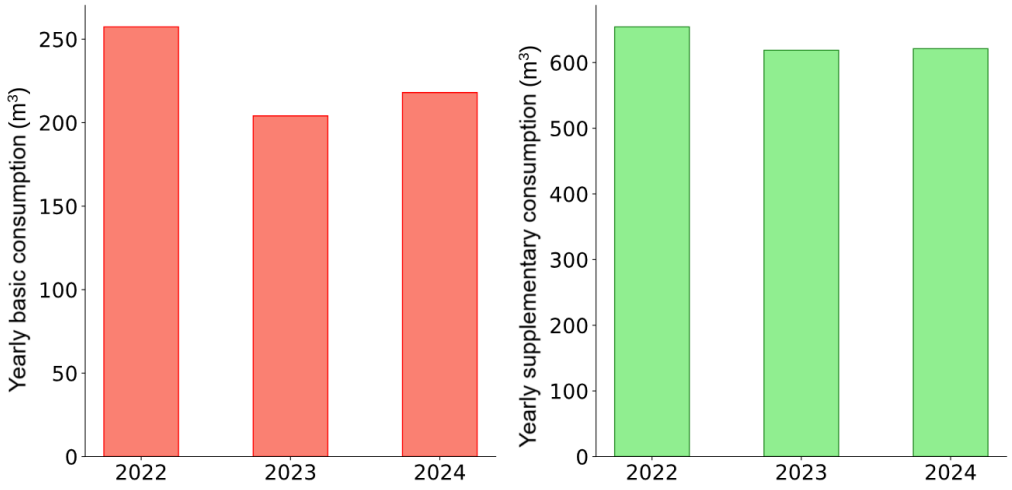



**Figure 3.7 The left bar chart shows the average annual basic consumption in $m^3$ of homes with a smart meter in the Netherlands between 2022 and 2024. The right bar chart shows the average annual supplementary consumption in $m^3$ of homes with a smart meter in the Netherlands between 2022 and 2024. The total number of degree days was 2621 in 2022, 2610 in 2023 and 2598 in 2024.**

An important new application of the updated method is that an estimate can be made of the basic consumption and heating activity of homes without a smart meter. Only the annual natural gas consumption on a year-on-year basis of these homes is known. The estimates of the basic and supplementary consumption, $G^{\text{basic}}$ en $G^{\text{suppl.}}$, can be calculated from the total annual consumption per home $G^{\text{tot}}$ as

$$G^{\text{tot}} = G^{\text{basic}} + G^{\text{suppl.}}, \tag{2}$$

where

$$G^{\text{basic}} = G^{\text{basic}}_{\text{sm, occ. class}} \tag{3}$$

and $G^{\text{basic}}_{\text{sm, occ. class}}$ is the basic consumption of homes with a smart meter in the same occupancy class as shown in Figure 3.4. Based on these estimates, the gas consumption can be disaggregated into the basic consumption and supplementary consumption for all homes in the Netherlands, including homes without a smart meter.

Only the total natural gas consumption on a year-on-year basis is known for homes without a smart meter. Based on the number of occupants, we can also estimate the basic consumption for these homes using the values in Figure 3.4. The remaining part of the annual consumption is the supplementary consumption. If we combine these disaggregated values with those derived from the monthly data, it is possible to estimate the total disaggregated gas consumption in the Netherlands. This is shown in Figure 3.8.

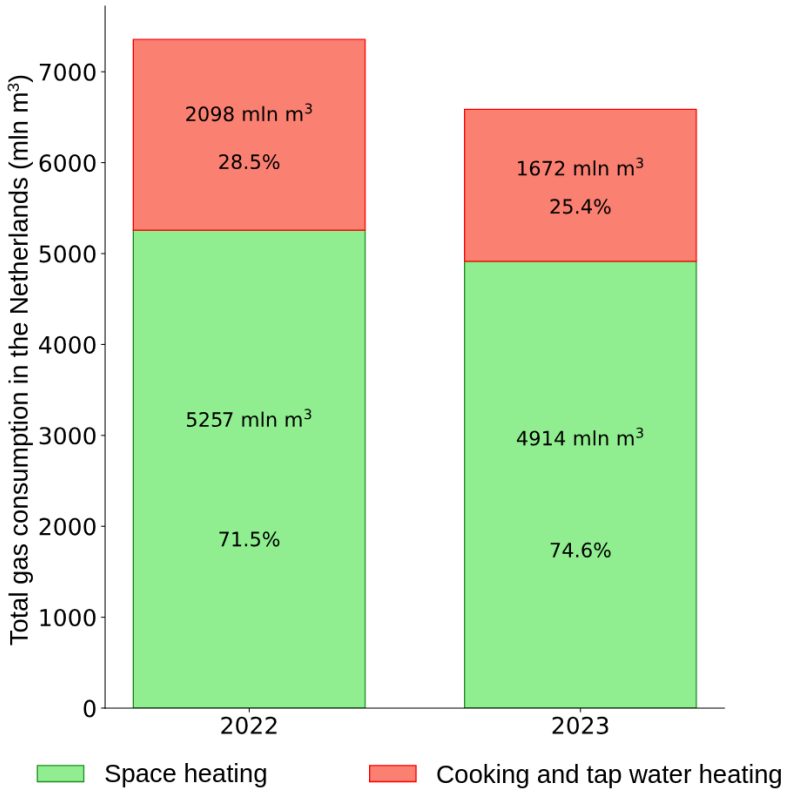



**Figure 3.8 Estimated total gas consumption in the Netherlands in 2022 and 2023 in million $m^3$. The green bar shows the share of the total for heating. The red bar shows the share for cooking and hot water.**

## 3.5 Disaggregation of gas consumption for cooking and hot water

The model presented here disaggregates the total gas consumption per home into the basic consumption for cooking and hot water and the supplementary consumption for heating. Further disaggregation of the basic consumption into components for cooking and hot water is complex with the available data, as a seasonal dependency cannot be used.

To produce an initial estimate of the typical gas consumption for cooking, we can consider homes that only use natural gas for cooking. The group of homes with a connection to a district heating grid [4)] as the main heat source that do not use natural gas for hot water is a good population for this analysis. In some cases, the energy label registration can be used to identify whether homes do not use natural gas for hot water. These homes often have a solar boiler or electric boiler for hot water. However, this combination is relatively uncommon. There were 300 homes with smart meters that met these criteria in 2023. The typical natural gas consumption for cooking of this population is 1.67 $m^3$ per month.

We now assume that the gas consumption for cooking of this population is representative of all other homes, that the volume of gas used for cooking is independent of the number of occupants and that all these homes cook with natural gas. This results in an overestimate of the share of the total consumed for cooking. However, the exact number of homes that cook with natural gas is unknown. By deducting the gas used for cooking from the identified basic

4) District heating is a heating system in which homes are heated by a network of heating pipes. These homes generally do not use natural gas for heating.

consumption, we can fully disaggregate the natural gas consumption by end use type. Figure 3.9 shows the average disaggregated values for heating, hot water and cooking in 2023. It is not possible to determine whether individual homes actually use natural gas for cooking at the micro level using the available data. Once data with a higher frequency become available [5)], or if there is more information about homes that are connected to district heating grids, it should hopefully be possible to do so and to generate a more accurate disaggregation.

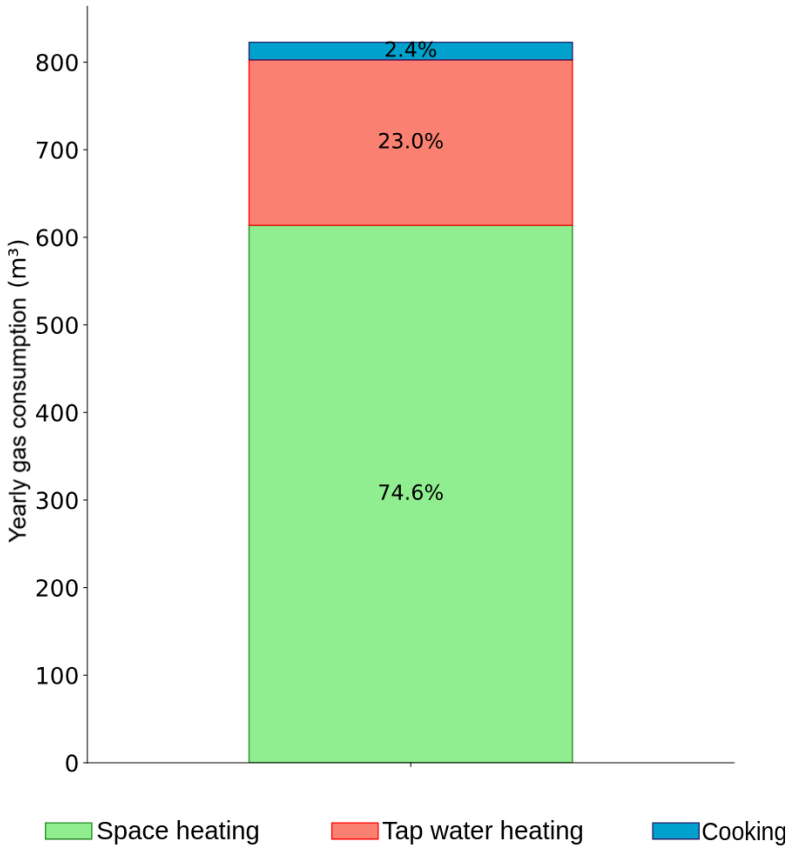



**Figure 3.9 Average annual gas consumption in $m^3$ if all homes cook with natural gas in 2023, broken down into consumption for heating, hot water and cooking.**

5) It is probably necessary to use data with a frequency of at least an hour to determine whether or not households use natural gas for cooking based on their gas consumption.

# 4 Discussion

In this section, we discuss the model in greater detail, including its strengths and weaknesses. The model is an updated version of a method developed in 2014, in which the total consumption is disaggregated by end use using an empirical formula (Tigchelaar 2013). This formula was developed based on a survey of 2840 homes. Given that significant measures have been implemented to make homes more sustainable since 2014, it is reasonable to assume that the results of this sample survey are no longer representative. In addition, a survey cannot directly ask respondents to report their natural gas consumption for specific end uses, as this is not metered in standard households. It is only possible to ask indirect questions, for example about the shower type and showering behaviour.

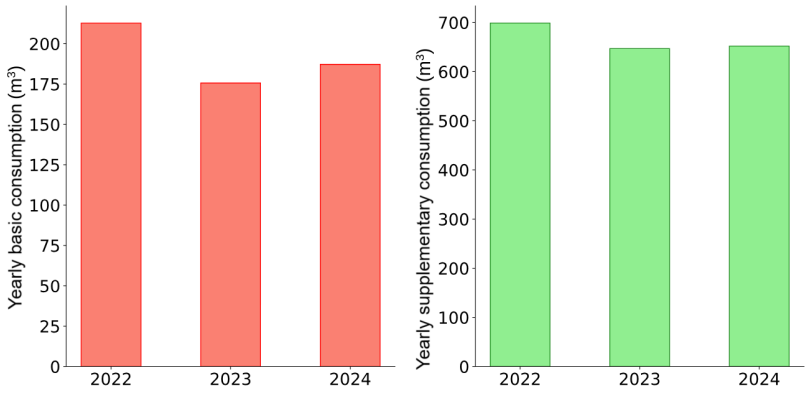
A major benefit of the new method is that it uses smart meter data from all six million homes, which allows a much more accurate picture of the gas consumption of those homes to be formed. This means a sample survey is no longer necessary, which has a positive effect on the accuracy and representativeness of the results.
The model is based on the assumption that the monthly gas consumption of homes can be disaggregated into the basic consumption and supplementary consumption. It also assumes that the basic consumption is season-independent. There are various reasons to believe that this approach is not entirely correct. For example, the lower tap water temperature in the winter months may affect the gas consumption for hot water. There may also be seasonal changes in behaviour that lead to differences between seasons in the consumption of hot water or gas for cooking.

One of the parameters we use in the model is the heating point. We determined the heating point for each year for the entire population to reduce the uncertainty in the model. The heating points for 2022, 2023 and 2024 are 118 degree days, 125 degree days and 121 degree days per month respectively. The increase in the heating point between 2022 and 2023 is particularly interesting. It shows that homes began heating at a lower temperature in 2023. This can be explained by the high energy prices (CBS 2025b) and the reductions in gas consumption made by homes at the time.

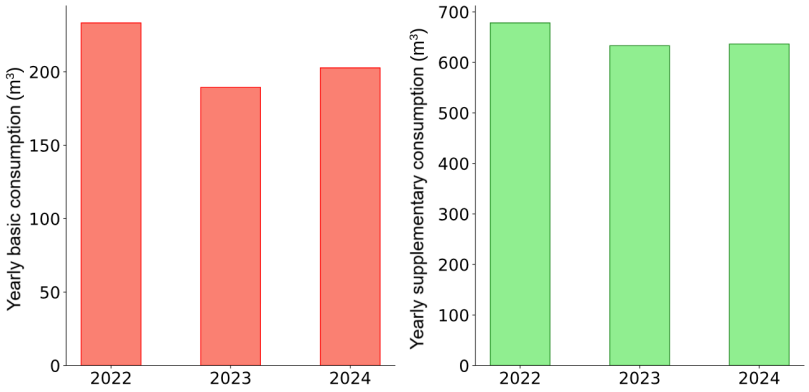
## 4.1 Model dependency of the basic consumption

The decline in the total gas consumption between 2022 and 2023 in subsection 3.4 is primarily explained by the decline in the basic consumption. One way of verifying whether this trend is realistic is to vary the method of determining the basic consumption. In the current model, the basic consumption is determined by taking the average gas consumption of all months with a number of degree days below the heating point. Because households are often on holiday in those months and thus consume less natural gas, the two months with the lowest gas consumption are disregarded. To verify whether the observed trend is due to the model or reflects a change in reality, we introduced three variations of this method. For each variant, we examined the changes in the annual basic consumption and supplementary consumption. We determined the basic consumption in three ways:

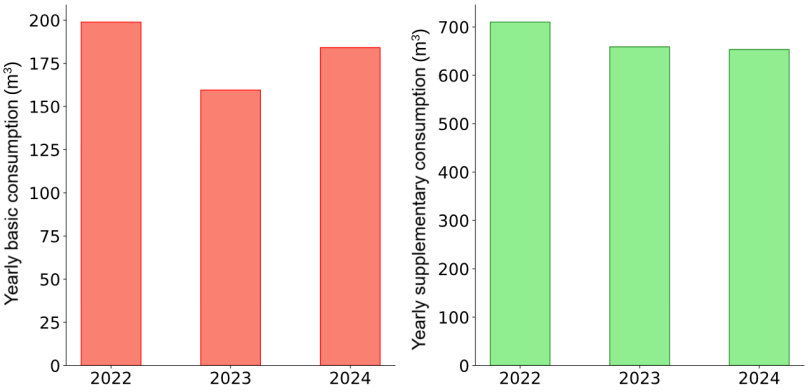
1. the average gas consumption for all months with fewer degree days than the heating point
2. the average gas consumption for all months with fewer degree days than the heating point, except for the month with the lowest gas consumption
3. the average gas consumption for all months with fewer degree days than the heating point, except for the months with the lowest and highest gas consumption.




**(a) The basic consumption is the average gas consumption for all months with fewer degree days than the heating point.**




**(b) The basic consumption is the average gas consumption for all months with fewer degree days than the heating point, except for the month with the lowest gas consumption.**




**(c) The basic consumption is the average gas consumption for all months with fewer degree days than the heating point, except for the months with the lowest and highest gas consumption.**

**Figure 4.1 The left bar charts show the average yearly basic consumption in $m^3$ of homes in the Netherlands with a smart meter between 2022 and 2024. The right bar charts show the average yearly supplementary consumption in $m^3$ between 2022 and 2024. In each of the three figures the basic consumption has been determined in another way.**

Figure 4.1 first shows that there was a decline in the basic consumption and supplementary consumption between 2022 and 2023, regardless of the method used to determine the basic consumption. The decline in the basic consumption was higher than the decline in the supplementary consumption, which is consistent with the results in Figure 3.7. The percentage change in the basic consumption and supplementary consumption between 2022 and 2023 is robust [6], regardless of the method used to determine the basic consumption. In absolute terms, we estimate that the uncertainty for the basic consumption is around 13 percent and around 4 percent for the supplementary consumption [7].

This uncertainty shows the shortcomings of the model presented here: the results are highly dependent on the method used to determine the basic consumption. Because the basic consumption is highly dependent on the chosen calculation method, it is important to be able to disaggregate the basic consumption more accurately. This may be possible using high-frequency (daily or hourly) smart meter data for the natural gas consumption. This would allow a more specific analysis to be made of warm days on which no gas is consumed for heating. Anomalous values arising due to holidays or homes being empty could also be filtered out more effectively.

[6] The decline in the basic consumption between 2022 and 2023 is 18 percent if method 1 is used, 19 percent if method 2 is used and 19 percent if method 3 is used. The decline in the basic consumption between 2022 and 2023 is 8 percent if method 1 is used, 6 percent if method 2 is used and 8 percent if method 3 is used.

[7] The uncertainty was determined based on the coefficient of variation: $C_v = \frac{\sigma}{\mu}$ where $\sigma$ is the standard deviation and $\mu$ is the average of the four data points from the four methods.

# 5 Conclusions

Reducing the consumption of natural gas by homes will make a major contribution to making the built environment more sustainable. This objective can be achieved more easily if a better picture of the natural gas consumption by end use type can be generated. Before now, this disaggregation into the consumption for heating, cooking and hot water was carried out using an outdated empirical formula.
This study provides a new method of disaggregating the total gas consumption by end use type using monthly gas meter readings from homes with smart meters. The monthly smart meter data show that the gas consumption of homes is highly season-dependent, with a peak in the cold winter months. The gas consumption can be split into a season-independent part for cooking and hot water (the basic consumption) and a season-dependent part for heating (the supplementary consumption). The supplementary consumption is modelled as a linear increase on top of the basic consumption as a function of the number of degree days. We call this increase per degree day the heating activity. By modelling the monthly gas consumption per home as a function of the number of degree days, the basic consumption can be separated from the supplementary consumption at the micro level.

The basic consumption is primarily determined by the number of occupants in the home. The heating activity is primarily dependent on the floor area and energy label. Homes with a hybrid heat pump also typically have a lower supplementary consumption than gas-heated homes. The number of degree days from which they turn on the heating is also higher than for gas-heated homes, because hybrid heat pumps heat using electricity at first. The natural gas boiler is only activated at low temperatures. This study also shows that there was a decline in the total natural gas consumption in the Netherlands between 2022 and 2023. This decline was primarily due to a reduction in the basic consumption (19 percent decline) and to a lesser extent a reduction in the supplementary consumption (6 percent decline). It is notable that the basic consumption, the smaller of the two, declined most in relative terms. Despite the expectation that there was a major decline in the basic consumption between 2022 and 2023, the absolute decline is still uncertain. In fact, a slight increase in gas consumption can be observed between 2023 and 2024.

The results of this study can be used to carry out a better disaggregation of natural gas consumption by end use in the future. This will also allow the monthly gas consumption of homes without a smart meter to be estimated. Because the total natural gas consumption can be disaggregated at the level of individual homes, it is also possible to use these data to publish new analyses, for example by region, year of construction or home type. The old method only provided figures for the Netherlands as a whole. One of the most challenging aspects to be addressed is the further disaggregation of the basic consumption into the consumption for cooking and hot water. This may be possible once more information is available about homes that are connected to district heating grids. The calculation of the basic consumption, and thus also the final disaggregation, can be improved once gas meter readings from homes with a higher frequency become available.

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