# GHGV Benefits Modelling

Table 1.5 in the Green Homes Grant Voucher (GHGV) Statistics contains benefit estimates for the scheme, including the energy savings and carbon emissions savings resulting from getting a measure installed. These are experimental statistics to provide an indication of the likely savings from the measures installed under the GHGV scheme. This document outlines the methodology used to estimate these benefits.

The figures are estimates based on modelled consumption values, therefore should not be used to evaluate the GHGV scheme. A benefits evaluation of the GHGV scheme, using real consumption data from meter readings, will be completed in due course.

## National Housing Model (NHM)

The benefits of each measure installed through the GHGV scheme, and subsequently monitored within the GHGV official statistics, will be estimated from the National Housing Model (NHM) commissioned by BEIS from the Centre for Sustainable Energy (CSE).

The NHM is a domestic energy-policy modelling and analytical tool covering the whole of Great Britain. It uses information from national housing surveys, including the English Housing Survey (EHS). It includes a detailed representation of the physical characteristics of Great Britain's housing stock and categorisations of the associated types of occupants. The NHM is a micro-simulation model that allows analysts to create policy scenarios and explore the potential impacts on domestic energy demand over time. Further information on the NHM is available at:

CSE NHM - https://www.cse.org.uk/projects/view/1233

GOV.UK NHM - https://data.gov.uk/dataset/957eadbe-43b6-4d8d-b931-8594cb346ecd/national-household-model

GOV.UK EHS - https://www.gov.uk/government/publications/english-housing-survey-quality-report

### SAP Calculation

The NHM estimates a property's level of fuel consumption required to maintain a specific heating regime. This heating regime is based on a set of standard assumptions of 21°C in living areas and 18°C elsewhere in the property. However, the user of the NHM can adjust these settings to test the effect of other heating regimes. These standard heating assumptions are used in the version of the NHM used for the GHGV experimental benefit statistics.

To estimate domestic energy demand, the NHM uses the housing stock dataset for information on properties physical characteristics, including building fabric, level of insulation and heating system. These housing stock characteristics are used with the standard heating assumptions to estimate a level of energy demand. This energy demand is combined with energy prices to calculate an annual fuel bill. This series of calculations results in the calculation of a SAP rating, which is an estimate of a building's energy efficiency and so can be used to assess and compare the energy and environmental performance of dwellings. [1]

SAP is part of a group of National Calculation Methods. It was originally produced to generate an energy label for a dwelling to enable occupants to compare the energy performance of different properties. It assumes a standard occupancy pattern and standard internal heating temperatures, to ensure the comparison is based on a property's performance rather than factors related to location or occupant behaviour. [2]

### NHM Version

The NHM is commonly used by BEIS policy teams to estimate the effects of policies on bill or carbon emissions savings. The NHM is periodically updated with data on government funded retrofit installations of measures and

[1] https://www.cse.org.uk/projects/view/1233

[2] https://www.sciencedirect.com/science/article/abs/pii/S0301421519301168?via%3Dihub

updating housing survey data, to ensure the NHM base housing stock reflects an up-to-date position. From the base stock, energy savings are calculated using the Standard Assessment Procedure (SAP) methodology. The NHM determines the associated energy saving from that measure installation and identifies the most efficient measures to install in each property.

The basis for the GHGV benefits estimation uses an NHM output generated for all measure types. For each measure type, the NHM output has theoretically installed the measure in all the possible households, where the household energy efficiency rating (EER) was increased. The exception to this was the installation of heat pumps, where the model installed them in as much of the housing stock as theoretically possible, to represent full decarbonisation of heating in the modelled housing stock. For some of these modelled heat pump installations, the measure might not be completely suitable. Further development work of the NHM is underway to better represent the potential of heat pumps in the housing stock.

## NHM In-use factors

The NHM output contains in-use factors to adjust for the difference between consumption and measure performance[3].

**Table 1: NHM in-use factors**

| Measure | In use factor |
|---|---|
| Loft Insulation | 0.65 |
| Cavity Wall Insulation | 0.65 |
| External Solid Wall Insulation | 0.67 |
| Floor Insulation | 0.85 |
| Draught Proofing | 0.85 |
| Double Glazing | 0.85 |
| Hot Water Cylinder Insulation | 0.85 |
| Hot Water Cylinder Thermostat | 0.9 |
| Air Source Heat Pump | 0.75 |
| Ground Source Heat Pump | 0.9 |
| Solar Thermal | 1 |

## Comfort Factor

A comfort factor of 15% is applied to reduce the modelled savings. Evidence suggests that once energy saving measures are installed in a home, the occupants tend to heat their home more due to decreased costs. This means that not all the modelled energy savings are realised.[4]

# Energy Savings Matrix

Splitting the modelled savings by property characteristics allows the model to accurately tailor the savings to the properties installed on the GHGV scheme. A matrix of measure type and property archetype is calculated from the NHM output. Consumption and consumption savings vary by property, for example on average detached properties will require higher consumption to heat than terraced houses, as in a detached property there are more external walls from which heat can leak. Every value in the matrix corresponds to a GHGV measure and archetype combination and has an associated average consumption saving.

The archetypes chosen are Property Type, Number of Bedrooms, On/Off Gas Grid. These were chosen to target three characteristics - type, size, and heating source. We also considered those that can be retrieved for the GHGV scheme data, and their correlation to the energy savings.

[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48407/5505-how-the-green-deal-will-reflect-the-insitu-perfor.pdf
[4] https://www.sciencedirect.com/science/article/pii/S0301421515001706

# Conversion Factors

To convert energy savings (kWh/yr) to bill savings (£/yr) and carbon emissions savings (kgCO2e/yr), conversion factors for each fuel are used.

## Energy Prices

To convert the energy saving to a bill saving, the 2020 domestic energy price is used based on the Quarterly Energy Price (QEP) publication and the Treasury's Green Book.

### Table 2: Energy Retail Cost Factors

| 2020 prices | Gas | Electricity | Bulk LPG | Bottle LPG | Oil (Burning Oil) | Coal | Biomass |
|---|---|---|---|---|---|---|---|
| Energy retail costs (£/kWh) | 0.034 | 0.174 | 0.069 | 0.069 | 0.042 | 0.066 | 0.053 |

Sources:

- Gas and Electricity - https://www.gov.uk/government/statistics/quarterly-energy-prices-december-2020
- Oil and Coal - https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal
- LPG and Biomass - Clean Heat Team and assumed to be constant.

## Carbon intensities

To convert the energy saving to a carbon emission saving, the Treasury Green Book Emission Factors, and projections, are used, along with the Greenhouse Gas Inventory (GHGI) conversion factors. The conversion factors are those from 2020 for final energy demand. A conversion factor is applied to energy saving based on the fuel type used in the modelled property.

### Table 3: Carbon Intensity Factors for 2020

| 2020 conversion factors | Gas | Electricity | Bulk LPG | Bottled LPG | Oil (Burning Oil) | Coal | Biomass |
|---|---|---|---|---|---|---|---|
| Carbon intensities (kgCO2e/kWh) | 0.184 | 0.296 | 0.214 | 0.214 | 0.247 | 0.345 | 0.015 |

For gas, the Green House Gas (GHG) emissions factor for natural gas is used.
For electricity, the long-run marginal consumption-based emission factor is used.
Bulk LPG and Bottled LPG are assumed to have the same emission factors, with the LPG GHG emission factor used.
For coal, the domestic steam coal GHG emission factor is used.
For biomass, the GHGI conversion factors for 2020 are used. It is assumed that biomass used domestically is either wood logs, wood chips or wood pellets, which all have the same conversion factor.
Source:

- https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal
- https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020

# Assumptions

## Measure Alignment

The measures offered on the GHGV scheme do not directly align to those contained within the NHM. Some assumptions for the missing measures are made. For example, the GHGV scheme offers types of roof and loft insulation (pitched roof, flat roof, room-in-roof etc), so within the NHM it is assumed that all are equivalent to loft insulation. Other notable assumptions are:

- Internal and External Solid Wall Insulation are assumed to be External Solid Wall Insulation.
- Energy Efficient Replacement Doors are assumed to be Draught Proofing.
- Solid and Suspended Floor Insulation are assumed to be Floor Insulation.

- Hybrid Heat Pump are assumed to have the savings equivalent to two-thirds of an Air Source Heat Pump. [5]

A table for the alignment of measure types is provided in Annex A.

For biomass boilers, there is no modelled data to base the savings on. Therefore, further investigation of this method type and a suitable proxy is being undertaken. Currently the savings are assumed to be zero. This has a marginal effect on the total GHGV published savings as the number of installed and to be installed biomass boilers is negligible.

## Property Type Alignment

To obtain property characteristics for properties on the GHGV scheme, the scheme data is matched to the National Energy Efficiency Data-Framework (NEED). To simplify the modelling, we have assumed some GHGV property types align to the same NHM property types. The least common property types have been grouped together, to ensure that the sample sizes of the combinations don't become too small.

**Table 4: Property Type Alignment between NEED-GHGV and NHM**

| NEED Property Type | NHM Property Type |
|---|---|
| Annexe | Bungalow |
| Bungalow | Bungalow |
| Caravan/Park Home | [6]Bungalow |
| Cluster house | Flat |
| Converted flat | Flat |
| Purpose built flat | Flat |
| Detached | Detached |
| Semi-detached | Semi-detached |
| End terrace | Semi-detached |
| Mid terrace | Mid Terrace |

## Property Heating Source Alignment

For the GHGV data, the property heating source is obtained from NEED. This dataset identifies whether a property is on or off the gas grid, based on the gas meter point data used to produce BEIS's sub-national gas consumption estimates and provides estimates of the number of properties within each local authority, Middle Layer Super Output Area (MSOA) and Lower Layer Super Output Area (LSOA) without a gas meter [7]. While these datasets give a strong indication of areas that have little or no connection to the gas network, there are some limitations:

- Domestic gas meters are identified where consumption is less than 73,200 kWh.
- Missing or incomplete address information results in some meters not being allocated to a local authority or LSOA.
- There is no differentiation between properties which do not have a gas meter, due to being in an area that is off gas grid, and those properties which are in an area on gas grid, but the property is not connected to it.

In England, for data for 2019/20 it is estimated that 14.0% of properties are off gas grid properties[8]. For the GHGV data, 86% of the properties with a net voucher issued (excluding expired vouchers) were on gas grid, while four per

[5] https://www.gov.uk/government/publications/hybrid-heat-pumps-study
[6] Paragraph 2.1.1 of Ofgem's carbon saving methodology suggests substituting Bungalow for measures installed in park homes. https://www.ofgem.gov.uk/system/files/docs/2018/07/eco3_deemed_scores_methodology_document_200718.pdf
[7] https://www.gov.uk/government/publications/regional-energy-data-guidance-note
[8] https://www.gov.uk/government/statistics/sub-national-electricity-and-gas-consumption-summary-report-2019

cent of GHGV properties with a net voucher issued had a 'Null' value for the gas grid flag, so were either not matched to the NEED database or the NEED gas grid flag was unknown.

To align the GHGV and NHM archetype for heating source, the GHGV property is identified as on or off gas grid. The equivalent NHM archetype is calculated from whether the main fuel in the NHM property is 'Mains Gas'. Those with 'Mains Gas' will align to GHGV properties on the gas grid and those without will align to off the gas grid. Heating source, particularly gas, is a key indicator to segment the modelled savings as the savings differ by measure and fuel type.

## Missing Characteristics

The model is designed that where a characteristic is missing from the scheme data (for example, the property type is unknown), the energy saving is imputed from the average NHM saving with respect to the remaining available characteristics.

## Lifetime Energy and Carbon Savings

In the statistics, two values for energy and carbon savings are provided – annual and lifetime. The lifetime saving for energy and carbon savings are provided as an indication of the multi-year benefits from the measure installations.

To estimate the energy and carbon lifetime savings, an average lifetime for each measure type was assumed (see Annex A). The measure type lifetime was based on an assumed value, which is based on the lifetimes published by Ofgem as part of the administration of ECO3, which are available here: https://www.ofgem.gov.uk/sites/default/files/2021-06/eco3_measures_table_v3.8_0.pdf .

To calculate the lifetime energy saving, the annual saving is multiplied by the measure type lifetime.

For the estimation of the lifetime carbon saving, the method reflects the projected decrease in the carbon emission factor for electricity. The annual carbon saving is calculated by multiplying the energy saving from each fuel type by the associated carbon emission factor for the fuel type. To estimate the lifetime carbon saving for all fuels except from electricity, the annual energy saving is multiplied by the carbon emission factor for the relevant fuel type and the measure type lifetime. For the estimation of the lifetime carbon saving associated with an energy saving from electricity, the carbon emission factor varies by future year, depending on the length of the measure lifetime. The future carbon emission factors for electricity are taken from the projections in the Green Book[9]. These are applied for the length of the assumed measure lifetime.

Lifetime savings are not provided for bill savings, due to the variability of energy prices over time.

While lifetime energy and carbon savings are provided for GHGV measures installed, these are not comparable to those lifetime savings estimated for the Energy Company Obligation (ECO). For ECO a different methodology is used to estimate savings, based on a scoring methodology administered by Ofgem.

[9] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

# Annex

## Annex A

| GHGV Measure Type | NHM Measure Type | Lifetime (years) |
|---|---|---|
| Air source Heat Pump | Air Source Heat Pump | 15 |
| Cavity Wall Insulation | Cavity Wall Insulation | 42 |
| Double/Triple glazing | Double Glazing | 20 |
| Energy Efficient Replacement Doors | Draught Proofing | 10 |
| Secondary Glazing | Double Glazing | 20 |
| Draught Proofing | Draught Proofing | 10 |
| Under-floor Insulation: Solid Floor | Floor Insulation | 42 |
| Under-floor Insulation: Suspended Floor | Floor Insulation | 42 |
| Ground Source Heat Pump | Ground Source Heat Pump | 20 |
| Hot Water Tank Insulation | HW Cylinder Insulation | 10 |
| Hot Water Tank Thermostats | Hot Water Tank Thermostats | 12 |
| Flat Roof Insulation | Loft Insulation | 42 |
| Loft Insulation | Loft Insulation | 42 |
| Park home insulation[10] | External Solid Wall Insulation | 36 |
| Pitched Roof Insulation | Loft Insulation | 42 |
| Room-in-roof Insulation | Loft Insulation | 42 |
| Solar Thermal | Solar Thermal | 20 |
| External Solid Wall Insulation | External Solid Wall Insulation | 36 |
| Internal Solid Wall Insulation | External Solid Wall Insulation | 36 |
| Heating Controls | Zone Controls | 12 |
| Hybrid Heat Pumps[11] | Air Source Heat Pump | 15 |
| Biomass Boiler | *To be determined* | *To be determined* |

[10] The GHGV has a specific Park Home Insulation measure, which is assumed to be the saving from External Solid Wall Insulation. Due to the nature of Park Home Insulations being specific to park home properties, the savings will be derived from the modelled savings for External Solid Wall Insulation on Bungalows. Paragraph 2.1.1 of Ofgem's carbon saving methodology suggests substituting Bungalow for measures installed in park homes.
https://www.ofgem.gov.uk/system/files/docs/2018/07/eco3_deemed_scores_methodology_document_200718.pdf

[11] Hybrid Heat Pump are assumed to have the savings equivalent to two-thirds of an Air Source Heat Pump.
https://www.gov.uk/government/publications/hybrid-heat-pumps-study