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Potential for interactive EPCs for Scotland

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1 Executive summary

This project was commissioned to inform the Scottish Government on the potential for an interactive Energy Performance Certificate (EPC) in Scotland. It is proposed that interactivity could allow householders to better assess potential retrofit measures. This, in turn, may prompt households to undertake energy efficiency measures and switch to clean heat systems. This report will help inform whether it would be beneficial to incorporate data or functionality into the national EPC register to support potential EPC interactivity.

1.1 Key findings

Three levels of potential interactivity have been identified for the Scottish Government to consider implementing in relation to EPCs:

1. Simple interaction, where both (i) no new user data and (ii) no integration with a calculation engine are required. Users could choose between customised or simplified views of EPC data. Click-through links signposting to further information could also be included (e.g. about measures, funding, further advice services).
2. Medium interaction, where (i) no new user data is required, but (ii) integration with a calculation engine is required. Users could see updated calculations based on already-completed as well as potential retrofit measures. Fuel costs could be updated in line with recent trends.
3. Detailed interaction, where customised user behaviour and occupancy inputs could update outputs via integration with an enhanced calculation engine (medium interaction functions also included). Users could personalise a range of inputs for which default values are normally applied in an EPC calculation.

The EPC outputs likely to be most useful to households are costs: household energy running costs, running cost savings, and the capital cost of various retrofit measures. The extent to which these outputs may be customised varies, as does the complexity of implementation. For example, household energy running costs could be updated by simply considering the latest fuel prices. Or, it could be tailored by updating one or more of the following variables: fuel prices, occupancy, heating temperature set point, heating patterns, or the number of baths or showers taken per day.

However, customising more variables may not necessarily make the outputs more representative, since the reliability of obtaining some of those inputs may be quite low. At any level of customisation, it will be necessary to inform tool users that outputs are ultimately estimates. Actual energy use and costs will inevitably be influenced by annual climate severity, changing fuel prices, and changes in household circumstances.

There are a number of existing tools that already deliver energy advice to households. These have varying levels of interactivity and customisation. In response to user testing and feedback, many offer relatively limited customisation. Circumstantially, this supports the reasoning that a modest spectrum of customisation may be the limit to which users are prepared to use such tools.

Limited evidence was identified of a direct link between the provision of customised information and households being prompted to retrofit. However, various literature sources quoting both professionals and typical consumers call for interactivity and customisation of EPCs. There is also relatable evidence that the provision of tailored information to households can prompt behavioural change. Offering households some level of interactivity alongside a traditional 'static' EPC could therefore be beneficial. Unfortunately, no direct evidence was found to support whether simpler or more detailed interaction is more likely to prompt households to retrofit.

1.2 Considerations for implementation

If the Scottish Government is minded to pursue an interactive tool, there are various options. It may commission its own interactive tool, or alternatively, it may look to use or adapt an existing tool to deliver a similar service.

The Scottish Government will also need to consider how best to integrate net zero policy ambitions in the implementation of any tool outputs or recommendations.

Providing sufficient interaction/ customisation for end users to feel that outputs are relevant to them is likely to be most important. The ability to update information from a 'static' EPC to reflect changes that have already taken place will likely be key. Furthermore, the ability to toggle retrofit measures will give users a sense of choice and control.

While a relatively simple implementation may suit the majority of potential users, a minority of users may see particular benefit in tailoring a wider range of input variables. If 'detailed interactivity' were implemented (as defined above), then customised views/ functions for different user groups may help simplify the user experience.

Contents

2 Glossary / Abbreviations table

EER	Energy Efficiency Rating (from EPC certificates)
EIR	Environmental Impact Rating (from EPC certificates)
EPC	Energy Performance Certificate
GDOA	Green Deal Occupancy Assessment
PCDB	Product Characteristics Database
RdSAP	Reduced Data Standard Assessment Procedure. The Government tool for assessing the energy performance of existing homes for regulatory requirements.

3 Introduction

This project considers how an interactive Energy Performance Certificate (EPC) user interface may help to increase public uptake of energy efficiency and clean heating options in homes.

There could be an opportunity to integrate data that would support the development of an interactive EPC user interface when assessing the future needs of the national EPC register in Scotland. A system that enables the public to better assess energy efficiency and clean heat options may be expected to increase uptake of these measures. However, the Scottish Government needs to understand the likely benefits and limitations of such an interactive user interface before it makes decisions on changes to the EPC register.

4 Background and research scope

The focus of this report is on domestic EPCs. An EPC assessment combines findings from a physical survey of a building with standardised assumptions on how it is used. EPCs therefore provide an 'asset performance assessment' that allows homes to be compared to others elsewhere in the country. This is regardless of whether they are different sizes, specifications, or have different systems and/or use patterns. They are accompanied by a Recommendations Report. This provides examples of measures that may improve the efficiency of the home and make savings, intended to encourage homeowners to take action. Recommendations are presented in a set sequence that follows a fabric-first approach, with renewable energy sources considered last. EPCs are therefore an important source of information for homeowners and buyers to inform decision making.

However, the presentation of recommendations and savings means users are not aware of the impacts of implementing measures out of sequence. Also, EPCs do not provide information regarding potential options for switching to cleaner heat systems where properties are currently served by another fuel type. EPCs as therefore not necessarily aligned with the aims of the Scottish Government Heat in Buildings Strategy with regard to clean heat systems. Savings predictions reflect the standardised assumptions made in the

EPC calculation in relation to occupancy and heating patterns. This makes the EPC less helpful when a homeowner wants to understand the benefits and savings they may experience according to their own circumstances. Offering users a level of interactivity may allow benefits of different potential improvement measures to be expressed. This can lead to more tailored recommendations and thus may better support users to act on them. There could therefore be value in a traditional 'static' public EPC for regulatory compliance, and an interactive interface to provide customisation for homeowners.

The scope of the research was therefore to identify the data inputs and outputs that may be relevant to an interactive EPC and consider how data inputs may be sourced.

The focus was on interactivity that would allow homeowners to input contextual information about how they use their home; essentially customising aspects of the EPC calculation that would otherwise use standardised assumptions, e.g. occupancy, heating patterns and temperatures. It was assumed that data obtained from an original EPC building survey would not fundamentally be challenged, e.g. floor areas, construction types. However, it is acknowledged that homeowners may wish to update information where retrofit works had already taken place since the EPC was carried out. For example, when new insulation has been installed or when energy systems have been upgraded or changed. Note that implications of the General Data Protection Regulation (GDPR) on interactive EPCs were deemed beyond the scope of this study.

Further, we sought evidence to understand the benefits and limitations that an interactive EPC interface may provide, to demonstrate whether user interactivity has led to increased uptake of retrofit measures. Our research explored a number of existing tools that offer a level of interactivity with EPC-like outputs. These were primarily targeted at homeowners (i.e. covering domestic/ residential properties), although portfolio-level tools were also briefly considered. The research also involved a desk-based literature review.

5 Data inputs and outputs for potential EPC interactivity

5.1 EPC review

Domestic EPCs for Scotland are produced using the UK Government's Standard Assessment Procedure (SAP) implemented in approved software tools. For existing dwellings, it is recognised that detailed construction information is unlikely to be available. A 'reduced data' version of SAP (RdSAP) is therefore used, which makes assumptions about the construction based on age, etc. A selection of the inputs and outputs of the resulting calculation are held centrally in the Scottish Government's EPC Register. Note, however, that not all intermediary outputs from the RdSAP calculation steps are held on the Register.

5.1.1 EPC outputs

We reviewed the outputs reported on a current Scottish domestic EPC (as at 2024). Those that may be relevant to end users making decisions on energy efficiency and clean heat measures were identified, as noted below. Further metrics proposed in the Scottish

Government consultation on EPC reform were also considered for insight into potential future changes.

- Energy Efficiency Rating (EER) (also known as the 'SAP score'; Proposed to be called 'Energy Cost Rating' following EPC reform)
- Environmental Impact Rating (EIR)
- Primary energy indicator (kWh/m^2year)
- Running costs (£ for 3 years)
- Savings (from potential recommended measures) (£ for 3 years)
- Savings per recommended measure (£ for 3 years)
- Recommended measures capital cost (£)
- Emissions from the home ($kgCO_2/m^2$/year)
- Space heating demand (kWh/year)
- Water heating demand (kWh/year)
- Heat Retention Rating (proposed for EPC reform; expected to be similar to Space heating demand metric)
- Total energy use (proposed for EPC reform; expected to be similar to the calculation for primary energy indicator, but for delivered energy, i.e. without primary energy multiplier)

5.1.2 Dependent inputs

We then interrogated the underlying RdSAP calculation methodology[1] to identify the key inputs used to calculate the identified outputs. All outputs are derived from numerous inputs and calculation steps, with the exception of 'Recommended measures capital costs', which are simply quoted reference values. Inputs that offer the potential for contextual customisation relevant to particular occupant behaviour/use are noted below.

- Fuel prices and standing charges
- Capital costs for retrofit measures
- Number of occupants
- Number of baths or showers taken per day
- Living room comfort temperature set point
- Heating pattern on/off times (for a normal day and an alternative day, e.g. weekend)
- External temperature (from regional climate information)

5.1.3 Ease of implementation

We made a qualitative assessment of the ease with which the above EPC outputs may be customised via calculation. Extensive customisation of an RdSAP calculation using occupancy parameters was implemented in the Green Deal Occupancy Assessment (GDOA) tool[2]. Since

[1] As set out in the SAP Technical Appendix document RdSAP 2012 v9.94 (BRE, 2019)
[2] RdSAP 2012 version 9.92: Occupancy Assessment version Mar 2014. (BRE, 2014) This supported the Green Deal funding initiative (2012-2015) to ensure the cost of retrofit repayments would not exceed energy bill savings.

the GDOA tool functionality already exists[3], customisation of a number of contextual/ user inputs could be relatively easily facilitated in an RdSAP 2012 calculation. The following 'ease of implementation' ranking was therefore applied to the EPC outputs identified above:

- High ease: Where an output already held on the Scottish EPC register could be adapted via a straightforward side calculation (i.e. where no RdSAP calculation engine would be required to re-model the impact).
- Medium ease: Where the output could be updated by implementing aspects of the GDOA as part of a new RdSAP calculation, using data held on the EPC register.
- Low ease: Where customisation of metrics has not previously been implemented in an RdSAP calculation, and therefore more work would be required to implement.

Note: In assigning this 'ease' hierarchy, it is assumed that the data held in the non-public version of the Scottish EPC register aligns with the import requirements of an RdSAP 2012 calculation. This appears likely to be the case based on summary information provided by the Scottish Government for this study. However, this would need to be verified in order to validate the recommendations of this study.

Table 1 shows the qualitative 'ease of implementation' ranking for customised EPC outputs.

The table refers to the SAP Product Characteristics Database (PCDB). The PCDB holds reference data for mechanical systems, which is used in SAP and RdSAP calculations. It also holds fuel prices and estimates for the capital costs of measures that are used in RdSAP calculations. Fuel prices are updated in the PCDB every 6 months but they are fixed in an EPC at the time of its issue. Capital cost of measures are only updated when a new version of the RdSAP methodology is released.

Currently, the EPC register does not store fuel use totals from the RdSAP calculation, although it is an intermediary calculated value that underpins many subsequent metrics. It is understood that this data is absent from both the public and non-public versions of the register held by the Scottish Government. It follows that even relatively simple-seeming amendments to EPC outputs, e.g. updating fuel prices, would require an RdSAP calculation to be re-run. Two scenarios have been presented in Table 1 for 'Recommended measures capital cost'. Scenario A is assigned a 'high' ease of implementation, while Scenario B is assigned a 'low' ease of implementation. The measures costs applied to an EPC are generic and not tailored to the property (e.g. according to property dimensions, or similar). Scenario A assumes this is still the case but an alternative, updated source for measures costs could be referenced by an interactive tool. Customised retrofit measures costs were not a function that was implemented in the GDOA. Therefore, if such a customisation function were desired, this scenario would have a low ease of implementation.

[3] The GDOA tool underpins the UK Government Find Ways to Save Energy tool discussed in section 5.2.1.

EPC output	Ease of customisation ranking	Notes
Energy Efficiency Rating (EER) (Energy Cost Rating)	N/A	A regulatory metric fundamentally based on standardised assumptions for comparability. We therefore suggest that this metric should not be customised.
Environmental Impact Rating (EIR)	N/A	As with EER, a regulatory metric fundamentally based on standardised assumptions for comparability. We therefore suggest that this metric should not be customised.
Primary energy indicator	Medium	Calculation re-run with inputs customised.
Running costs	Medium	Calculation re-run with custom fuel prices, updated costs from PCDB and/or with other inputs customised.
Savings (from potential retrofit measures) (also 'per measure')	Medium	Calculation re-run with custom fuel prices, updated costs from PCDB and/or with other inputs customised.
Recommended measures capital cost	Scenario A: High Scenario B: Low	Scenario A: Values are not used in any output calculations. Updated typical/ generic values from an external source could therefore be presented to users relatively easily. Scenario B: Currently no function exists to 'customise' costs via an RdSAP calculation (e.g. according to property dimensions, or similar).
Emissions from the home	Medium	Calculation re-run with inputs customised.
Space heating demand	Medium	Calculation re-run with inputs customised.
Water heating demand	Medium	Calculation re-run with inputs customised.
Heat Retention Rating (proposed)	N/A	Proposed to be a regulatory metric fundamentally based on standard assumptions for comparability. We therefore suggest that this metric should not be customised.
Total energy use (proposed)	Medium	Calculation re-run with inputs customised.

Table 1: Ranking of current and proposed EPC outputs according to their anticipated ease of customisation

5.1.4 End user value of existing EPC outputs

The EPC outputs identified in 5.1.1 were qualitatively assessed for their likely importance to end users in retrofit decision making. Discussions were held with Retrofit Coordinators at the National Energy Foundation, who directly engage with households on energy retrofit. Their feedback is supported in various studies (including National Retrofit Hub (NRH), (2024), Which? (2024), Jones (2022), and Bančič, Vetršek and Podjed (2021)) that have examined which metrics different end users find or would find valuable when considering home upgrades. In Table 2, the EPC outputs have again been assigned a ranking, this time indicating their expected usefulness to end users. Notes provide supporting rationale for each ranking.

EPC output	Likely importance to end users	Notes
Energy Efficiency Rating (EER) (Energy Cost Rating)	Medium	As a relative metric intended to enable comparison between dwellings, it is somewhat conceptual for consumers. However, it does show a relative point on a sliding scale of 'good' and 'poor' energy efficiency performance.
Environmental Impact Rating (EIR)	Low	Most consumers do not have a tangible concept of carbon emissions, although the rating does show a relative point on a sliding scale of 'good' and 'poor' environmental performance.
Primary energy indicator	Low	Primary energy is likely to be an unfamiliar concept for most consumers. It does not correspond directly to people's actual energy bills despite incorporating 'kWh', which could cause confusion.
Running costs	High	Likely to be one of the most important, and tangible, indicators for consumers.
Savings (from recommended measures)	High	Likely to be one of the most important, and tangible, indicators for consumers.
Recommended measures capital cost	High	Consumers may not otherwise have an idea of relative costs of improvement measures prior to seeking their own quotes for work.
Emissions from the home	Low	Most consumers do not have a tangible concept of carbon emissions.
Space heating demand (Heat Retention Metric)	Medium	Allows users to see a breakdown of energy by end use (i.e. space heating). Some people may not readily relate to it being expressed in 'kWh'.

EPC output	Likely importance to end users	Notes
Water heating demand	Medium	Allows users to see a breakdown of energy by end use (i.e. water heating). Some people may not readily relate to it being expressed in 'kWh'.

Table 2: Ranking of EPC outputs according to their likely importance to end users in retrofit decision making

Simple cost-based metrics are more likely to be easily understood by consumers and are therefore more likely to contribute to retrofit decision making. This includes running costs and cost savings from potential retrofit measures. Energy assessors, consultants or other professionals in the sector may see value in the other metrics, but feedback suggests these are of less use to households. Furthermore, the concept of carbon emissions is identified in the above reference sources as not being tangible for most consumers, despite national policy striving for 'net zero'.

5.2 Review of existing interactive home energy advice tools

Numerous tools are available, beyond a traditional RdSAP calculation, that offer EPC-type outputs to users with a level of interactivity/customisation. A selection of these tools were reviewed for this study to consider the possible forms a Scottish EPC user interface could take. Tools were identified using web searches and the knowledge of the research team. Criteria for inclusion included:

- A domestic/ housing focus
- An aspect of interactivity/customisation
- Outputs similar in nature to those on an EPC (e.g. energy use, cost, retrofit recommendations)

Six tools were then selected for more detailed investigation. Selection criteria included:

- Sufficient information available so they could be assessed for this research
- Tools offering differing levels of interactivity/customisation
- Limiting duplication of tools created by a single organisation, unless they offered something distinctly different from one another
- Inclusion of a commercial/ portfolio assessment tool

We assessed outputs provided by each tool and the customisable inputs they request from users. These are summarised in Table 5 and Table 6 respectively, in Appendix A, alongside the outputs and inputs discussed earlier for EPCs. For the latter, the potential inputs are those of the RdSAP Green Deal Occupancy Assessment, which is taken as a baseline for calculation customisation potential.

It is apparent that many consumer-facing tools are based on a limited number of calculation engines. The Energy Saving Trust (EST) engine and the Parity Projects/ Core Logic engine

appear to be popular options underpinning branded tools. These front-end tools may offer slight variations in presentation or user functionality, but they draw on the same foundational data and calculation approach. All tools rely on an underlying RdSAP calculation engine to generate outputs. However, they do not offer the full functionality of RdSAP to be customised, instead utilising many assumptions and generalisations. Most tools use at least some EPC data (from the EPC register) to pre-populate information for calculations.

Tools typically offer one or more of the following levels of interactivity/customisation:

- Ability to toggle potential retrofit measures on or off and assess impacts/ benefits
- Ability to make simple updates to property data (compared to that held on EPC), e.g. if insulation or new windows have been installed. Some also ask if there is space to facilitate renewable energy systems
- Ability to provide basic contextual or occupancy information (some tools will typically progress with assumptions if users do not wish to provide customised information e.g., number of occupants, typical living room set point temperature, when people are typically at home)
- Ability to provide more detailed contextual or occupancy information (again, some tools will typically progress with assumptions if users do not wish to provide customise information e.g., number of baths and showers taken per week, actual energy use totals from bills)

Many tools also offer further interactivity that does not relate to the calculations process but provides users with additional information. Examples include click-through links providing:

- Specific information about retrofit measures
- Information about potential funding or finance options
- Links to trusted trades or advisory services (e.g., TrustMark, one-stop-shops)
- Links to professional whole house retrofit plan or Retrofit Coordination services

It was noted in discussions with NEF that consumers often feedback that they are not confident translating a retrofit plan into action. There is apparently often distrust of trades/ contractors. Qualitative information such as that above may help households build confidence to take plans forward.

None of the consumer-facing tools reviewed allows for customisation to the same extent as the GDOA tool. The EST/ Home Energy Scotland tool provided the widest range of user customisation options. From discussions with a selection of tool owners, their user testing and feedback has identified a need for relative simplicity. It is assumed that this reasoning has also been applied to other tools, as they often offer similar functionality.

All the reviewed tools focus on the outputs expected to be of most value to consumers, as noted in section 5.1.4. These include running costs, cost savings from measures and the expected capital cost of retrofit measures. Most tools also report associated carbon emissions. However, despite this alignment in key outputs, the extent to which inputs can be customised varies across tools. It may be expected that outputs based on more extensive customisation will be more representative of a user's actual circumstances. It is relatively

unlikely that users will have an appreciation of this though, since they may only ever interact with one tool. All tools evidently have their place in the market, though it is very difficult to accurately assess their respective 'success' (i.e. the extent to which they encourage homeowners to undertake retrofit). Some commentary is offered in relation to specific tools below.

A consistent aspect of functionality offered across all tools is the ability to update whether some building elements have already been enhanced. They all also offer the option to select different potential retrofit measures to form a tailored retrofit plan. It should be noted however, that these outputs are not equivalent to a 'whole house retrofit plan' as defined by the PAS 2035 framework (BSI, 2023). These aspects of interactivity can help consumers consider the impacts of certain retrofit options and thus they can provide a useful step beyond a traditional 'static' EPC. It may be inferred that these are the aspects of most value to consumers, and there is perhaps less focus on perceived 'accuracy' of further customisation. Some aspects of the reviewed tools are discussed in more detail below.

5.2.1 UK Government 'Find ways to save energy' tool

This tool is owned by the Department for Energy Security and Net Zero (DESNZ). It uses an RdSAP engine hosted by BRE that implements selected parts of the GDOA. It includes default assumptions being made for parts of the GDOA that users are not asked to customise. DESNZ have indicated in discussions that user testing and consumer feedback has shaped the current functionality of the tool. For example, an earlier release of the tool included more customisation questions. However, these were removed as they led to high levels of user 'drop out' associated with those questions (i.e. users exited the online tool without completing beyond certain questions). Additional feedback suggests that a minority of users (estimated ~10%) would like more detail than the tool currently offers. DESNZ are exploring options for potential future updates.

5.2.2 EST engine backed tools

Three different tools were reviewed that utilise EST's calculation engine:

- Home energy check (branded as Home Energy Scotland)
- Go renewable tool, developed with the Microgeneration Certification Scheme (MCS)
- The Snugg Plan Builder (an example with a custom branded front end)

Each offers slightly different functionality and very different user interfaces. For example, the Home Energy Scotland tool does not directly link with the EPC register. However, users are encouraged to obtain their EPC information (from the register if not readily available) to aid answering questions. The Go renewable tool, as the name suggests, focusses on advising on renewable energy systems. It also gives recommendations on basic fabric efficiency measures that should ideally be carried out in conjunction with certain renewables.

Go Renewable and the Snugg Plan Builder each introduce some novel output metrics. Go Renewable offers a 'heating system running cost metric', which allows different heating system options to be directly compared. The Snugg tool features a metric on the potential income from a PV system (based on the Smart Export Guarantee). It also estimates a potential increase in property value increase resulting from installing retrofit measures. 'Savings' metrics may not motivate landlords or people that do not expect to stay in a home

that long. However, metrics linked to property value may be an alternative motivator for such users.

5.2.3 Parity Project/ Core Logic 'EcoRefurb' tool

EcoRefurb is part of the Core Logic 'Plan Builder' suite of tools. It is an example of a branded front-end tool that uses the underlying Core Logic engine. According to the developers, user testing shaped the development of both inputs and outputs within the tool. One key aspect they identified as important was the provision more customised measure recommendation costs for users. Very few users apparently fed back that they would like to get into more detail in the initial assessment. More detail may be customised in the Plan Builder tool Core Logic provide to Retrofit Coordinators (similar to that in the GDOA) however, this was not reviewed during this study.

5.2.4 IRT 'DREam' stock assessment tool

Stock-level assessment tools were also considered during this study, although it is acknowledged that householders are not their target end users. The IRT tool is one such example intended for housing providers[4] (e.g. social landlords) to assess potential retrofit options at a stock level. Customisation typically focuses on filling data gaps where individual property surveys or EPCs have not been conducted. They also allow updated information to be input, based on maintenance records for example, to provide updated energy data for properties. A key feature of the DREam tool is that it integrates a map function and can overlay areas by index of multiple deprivation for example. It also provides comparisons of funding options that may support housing providers to deliver area based retrofit schemes. Understandably, occupancy-based customisation is not a focus of tools such as this. However, the property information updating and measures toggling functions are evidently important interactive outputs for the tool's target audience.

[4] Note that others including EST, Core Logic and BRE also provide tools for this market.

5.3 Discussion: Levels of interactivity

Three broad levels of interactivity (simple, medium and detailed) are identified here for potential application to the existing EPC, for consideration by the Scottish Government. These levels reflect the functionality of the calculation tools that underpin an EPC and the capabilities of other existing interactive 'energy advice' tools that have been reviewed. This also assumes that data from the non-public version of the Scottish EPC register is sufficient to recreate a new RdSAP 2012 calculation for a dwelling.

Simple interaction

This is characterised as interaction that requires no new user data to be input and no calculation engine. Examples of potential functionality could include:

- The ability to provide switchable, customised or simplified views for data for different types of user via an online interface. For example, more detailed EPC information could be accessible by professionals, while only key outputs may be required by households, with options to switch between views.
- Click-through links signposting users to further information – such as details about measures or funding, links to trusted tradespeople or advisory services, etc.

Medium interaction

At this level, no new data inputs are required from users, but an RdSAP calculation engine would be needed to support provision of increased interactivity. Examples of potential functionality could include:

- Allowing users to select their own potential retrofit measures, providing tailored cost savings for different retrofit approaches or combinations of measures (rather than a fixed sequence as per the current EPC methodology).
- Enabling potential updates to property information where retrofit measures have already been installed.
- Incorporating updated fuel costs sourced from the latest version of the PCDB.

Detailed interaction

Here it is assumed that a calculation engine is capable of incorporating customised user inputs to inform updated outputs. (All of the medium interaction functions above should also be possible at this level.) Examples of potential customisation could include updating with:

- Actual household fuel costs and standing charges.
- Actual number of occupants.
- Actual living room temperature set points, heating schedules.
- Actual number of baths or showers taken per day by household.

Section 6 discusses the ease with which data inputs may be sourced. It highlights that there may be a sliding scale of complexity of customisation at the 'detailed' level.

5.4 Implications related to RdSAP 10 and the Home Energy Model (HEM)

Data currently held on the Scottish EPC Register will have been created using the RdSAP 2012 software version. Reusing this data to re-run a new RdSAP calculation will therefore be more straightforward with an RdSAP 2012 engine. This is subject to confirmation that data held in the non-public version of the register is an appropriate format.

An updated version of the software, RdSAP 10, is currently in development. The 'full' version of SAP 10 has been in use since 2022 for newly built homes. It introduces several updates, related to heat pumps and introduces battery storage into calculations.

Translation of existing EPC Register data (created under RdSAP 2012) for use with a newer SAP engine such as the proposed RdSAP 10 would be more complex. Additional assumptions would need to be added alongside the original data from the EPC register. Furthermore, there is also no GDOA implementation in RdSAP 10 (i.e. customisation of occupancy parameters), so a further exercise would be required to replicate this functionality. However, moving to an RdSAP 10 engine would bring any new tool in line with the most current calculations, based on updated research.

The Home Energy Model (HEM) is a new calculation methodology that will eventually replace SAP and RdSAP. A key change in this approach is that calculations will be performed with much finer time resolution. While existing SAP and RdSAP calculations consider a monthly timestep, HEM utilises a 30-minute resolution. This is expected to better-represent heating demands, energy storage and demand flexibility potential for example.

HEM is based on a fundamentally different underpinning architecture compared to SAP. It will use 'wrappers' to assess different use cases, with each wrapper defining inputs and outputs that are processed by the core HEM model. One such wrapper will support the Future Homes Standard (FHS). In this context, key changes to modelling assumptions are expected compared to SAP. For example, assumptions about occupancy being linked to floor area (as in SAP) to being based on the number of bedrooms in a property. These changes reflect evolving consumer behaviours and systems operation patterns, highlighting further divergence from the assumptions used in SAP 10.

HEM will undoubtedly offer additional functionality compared to SAP, along with the ability to assess certain technologies more effectively due to its increased granularity. Some innovators, such as City Science and Furbnow, are already attempting to link existing home energy assessments to HEM. Both have undertaken projects in this space with the support of Innovate UK. However, during presentations at the Innovate UK 'Net Zero Heat Open Day' both organisations reported that additional input data, gathered from surveys and/or monitoring, is needed to achieve this (UKRI, 2024). That being the case, it seems unlikely that data from the existing EPC register could readily be aligned with HEM. Exploring the effort likely required in achieving this was beyond the scope of this study.

6 Data collection/ input methods and limitations

6.1 Review of potential data sources

A number of potentially customisable data inputs were identified in section 5.1.2.[5] This section explores ways such data may be sourced and/ or physically input into a tool (e.g., automated versus manual methods). While several theoretical options have been explored, the likelihood of some such information being available/ usable short term is low.

Table 7 in Appendix A gives an overview of relevant data input options that were identified during this study. Each input method was qualitatively assessed, based on the research team's judgement, on a 'high, medium, or low' scale against the following parameters:

- The ease of data input for the user
- Likely reliability of the information
- Likelihood of an information source to be available in the short-to-medium term

The rankings were assigned a score (High = 3, Medium = 2, Low = 1). These were summed to provide an overall current 'readiness' metric (scored out of 9).

6.1.1 Manual data entry approaches

Manual approaches rely on households obtaining data from existing sources (such as energy bills) or simply recalling their comfort/ heating preferences (e.g. temperature set points and heating patterns). Users will also readily know how many occupants are typically in the house.

The current readiness score of some manual inputs reflects the potential risk of reduced reliability when households need to consider typical conditions over a whole year. For example, if users never adjust temperature set points on their thermostats, reliability of temperature inputs may be high. This may also be the case if they never adjust programmed heating patterns. However, users are unlikely to take account of incidental day-to-day or seasonal adjustments made outside the normal programming. It is also unlikely that households would consistently track their average number of baths and showers per day for a whole year. A best estimate based on typical patterns seems far more likely. Reliability of some inputs may therefore be low when it depends on household recollection rather than on actual recorded data.

6.1.2 Automated data entry approaches

Automated methods range from updating information from the PCDB through to potentially obtaining data from internet of things smart devices. Fuel prices and standing charges could be taken from the most recent version of the PCDB. There are artificial intelligence (AI) tools

[5] Note that much innovation and research is underway into obtaining 'real' data for fabric performance metrics for use in SAP. For example, there are projects funded by Innovate UK exploring monitoring solutions, U-value measurement and automated thermography for fabric elements. However, inputs relating to building fabric performance and dimensioning were beyond the scope for this study.

that exist (generally intended for businesses) that can extract information from digital energy bills. However, for individual households, such tools are unlikely to be warranted since the information could manually be obtained relatively easily. Smart sensors include motion detectors (inferring occupancy), shower sensors, thermostats and programmers. All of these devices may theoretically be able to track and log conditions and output household data.

Note that there is currently no function or API (Application Programming Interface) to import external data sources into an RdSAP calculation. SAP calculations call on data held in the PCDB, but this database is updated periodically and not accessed 'live'. The automated transfer of data is therefore an aspect that would need to be developed, if such functionality were desired. Subsequently, any proprietary sources of data (e.g. from consumer apps) would need to be collated and formatted accordingly to feed into SAP. It is assumed that users would be unlikely to manually process such data themselves if it were not automatically formatted and exported.

Automated methods therefore tend to score less highly than equivalent manual methods in the combined readiness metric. They score highly with respect to the ease of data input for the user and many provide inherently reliable data. However, they score low on the short-term likelihood for such automated functionality to be available. Fuel prices updated automatically from the PCDB are assumed to be less reliable than actual data from household bills due to averaging. However, the relative ease of implementing such an update still gives a high overall readiness score (8 out of 9).

6.1.3 Discussion of external temperature data

The RdSAP calculation utilises climate data broken down into 21 UK regions. These include assumptions for monthly average external temperatures. It is possible that some users may question whether the granularity of these climate zones is representative of their local conditions. However, it is quite likely that most users would not have the necessary awareness to challenge the relative accuracy of the climate data used.

Monthly temperature data is available from the MET office (the source of the current RdSAP climate data) at a resolution of 2km. This is a far higher resolution than the 21 UK regions. The format is essentially the same as is used in an RdSAP calculation. However, it would require reasonable effort (and signposting) for users to obtain this data manually and enter it into a user interface. As discussed above for automated methods, there is currently no function for new data to be imported into RdSAP. This would need to be specifically developed to automate the input of new, more granular external temperature data.

Something of potential interest to users and the Scottish Government is that the MET Office also provide 'future climate scenario' data sets. If incorporated into an RdSAP calculation, it would be possible to see the impact of changing climate conditions on key outputs and recommendations. Granularity varies depending on the type of climate predictions offered. For example, monthly average temperature predictions against the highest emission scenario (RCP8.5) are projected at a 12km scale. Import of such data to RdSAP would face the same challenges as other updated MET Office data noted above.

6.2 Varying interactivity options for outputs

Table 3 shows the outputs assessed as being of highest importance to consumers[6] alongside the relevant potentially customisable inputs. 'Emissions from the home' is also included, since the policy focus of retrofit is ultimately on achieving net zero emissions. Both a 'medium interaction' and 'detailed interaction' version (as per section 5.3) is included where such options exist. Note the medium interaction would require a SAP calculation engine but no new user input, instead using updated information from the PCDB or elsewhere. The highest 'readiness' levels determined for each of the data inputs is presented in the table.

EPC output	Fuel prices	Fuel standing charge	Capital cost of retrofit measure	Number of occupants	Main temp set point	Heating pattern timings	Partially heated rooms	Number of baths & showers per day	External temp
Running costs (medium interaction)	8	8							
Running cost (detailed interaction)	9	9		9	7	7	7	6	7
Running cost savings (medium interaction)	8								
Running cost savings (detailed interaction)	9			9	7	7	7	6	7
Measures capital cost (medium or detailed)			7						
Emissions from the home (detailed interaction)				9	7	7	7	6	7

Table 3: Highest 'readiness level' of data inputs that may be customised for EPC outputs (at varying levels of interaction)

While some outputs in Table 3 have several potentially customisable inputs, not all may necessarily be customised. The example tools reviewed in section 5.2 implement different customisable inputs yet deliver essentially equivalent outputs. The inputs therefore represent a sliding scale of potential customisation.

Users may find it quite easy to customise one or two inputs with a high-scoring readiness indicator. Meanwhile, a more bespoke version of the same outputs may be possible, but the ease with which the data may be reliably obtained may be lower. This creates a potential risk of dubious accuracy; an output may seem to be accurate since it is based on multiple user customised variables. However, those variable values themselves may be inaccurate or

[6] Virtually all outputs were identified as having the same ease of customisation in section 5.1.3. Therefore, outputs with highest perceived importance to consumers have instead been selected as the focus here.

unreliable, thus reducing the overall representativeness of the output. A sensitivity analysis on this phenomenon is unfortunately beyond the scope of this present study.

Absolute accuracy may not in fact be so relevant for an interactive tool intended to aid retrofit decision making. Pre- and post- retrofit energy performance of homes is relative; after all, many variables out of a user's control influence energy consumption and cost over a given year. (e.g. external climate, energy price changes, varying household needs.) Providing sufficient interaction/ customisation for end users to feel that outputs are relevant to them is likely to be most important. The ability to update information from a 'static' EPC to reflect changes that have already taken place will likely be key. The ability to toggle retrofit measures selection will give users a sense of choice and control. Other input variables may be of more or less interest to users depending on how far they feel their behaviours are from 'typical'. Households that align with these national trends may see little variation in customised calculations compared to default calculations. It is only when household characteristics are quite different from national trends that it may make notable differences to retrofit recommendations.

7 Evidence of intended outcomes

We looked for evidence that directly linked the use of interactive tools to the initiation of retrofit measures. Information was also sought on whether different types of interaction or customisation were more likely to prompt household decision making. A desk-based evidence review sought information from academic articles and grey literature. A selection of search terms were initially used, as detailed in Appendix B. These were expanded upon as other terms and concepts were identified in the reviewed sources.

In addition, advisors from NEF provided general feedback based on their experiences of directly supporting consumers with retrofit projects and administering grants.

Feedback related to the use of existing interactive energy advice tools, such as those discussed earlier, was also explored. This was primarily via online sources, though interviews were conducted with tool developers where possible. DESNZ (as owners of the UK Government 'Find ways to save energy' tool) and Core Logic (EcoRefurb tool) provided direct feedback on their respective tools.

The evidence review was widened to 'relatable activities' when it became clear that limited information was available on interactive tools and retrofit. Relatable activities were defined as those in which the provision of some form of customised information prompted behavioural change. The scope was limited to households and housing, and to at least energy-related behaviours, if not retrofit specifically. This broader search was not exhaustive but was intended to provide indicative context relevant to the primary concept.

7.1 Review of literature

Many sources suggest there is a need for interactivity and customisation of EPCs, with inference that this could promote the uptake of retrofit measures. However, no evidence was identified in the literature review to confirm that interactive tools would, or have directly, prompted retrofit actions. Nor did the literature review indicate what level of interaction or customisation might be more likely to prompt households to undertake retrofit.

Several EU research projects have explored ways that EPCs could be improved to better-serve various end uses (e.g. U-CERT, D2EPC, X-Tendo, CHRONICLE, EDYCE, Smart living EPC). U-CERT produced an extensive series of recommendations for EPCs (Bančič, Vetršek, and Podjed, 2021). This followed interviews and focus groups with different types of potential EPC users across 11 participating EU countries. Some recommendations related to improved granularity of calculations and reducing the 'performance gap' by using dynamic simulation and the use of measured data. However, many specifically focus on helping users better understanding energy use and prompting retrofit action. Several of these are also recognised in other sources (discussed below).

Example recommendations include:

- Focus on cost-based metrics, as these are most tangible for users
- Offer interactivity to make the information relevant to a user's own circumstances and context
- Provide different views tailored to the needs and knowledge levels of various users:
    - (a) non-professional users, for buying and selling properties, for energy management, and for retrofit recommendations.
    - (b) Professionals and more advanced users with more detail and technically specific data.
    - Digitalisation offers the potential for a 'modular' approach from basic to expert with options according to user interests
- Explain the context of assumptions, so users understand if their patterns are likely to be different to what is assumed

Various studies have investigated the extent to which current static EPCs motivate users to retrofit. A recent study by Which? (2024) indicated that EPCs are rarely used to inform renovation decisions. Users instead rely on advice from builders or their intuition. The study suggests that the current format of EPCs does not effectively encourage homeowners carry out energy efficient home improvements, nor does it meaningfully guide their choice of measures.

The D2EPC research study found that less than 5% of end users were motivated to retrofit because of their EPC (Panteli and Duri, 2021). At least half of those surveyed were also not convinced that their EPC accurately represented their building's energy efficiency. A Barclays/ Ipsos survey (Barclays, 2023) suggests that over half of homeowners do not feel confident making homes more energy efficient. A further study (Hiscox, 2018) indicates that a third of those surveyed renovated to keep up with current trends rather than for functional reasons.

The U-CERT and Which? studies indicate there is a need to update an EPC so they can still be relevant if some changes/ improvements are made. Otherwise they are readily obsolete (Bančič, Vetršek, and Podjed, 2021; Which?, 2024). The Which? study also states that EPC recommendations are too rigid, presented in a specific order rather than tailored to household priorities and budgets. This need for greater flexibility was echoed in discussions with Retrofit Coordinators at NEF who work directly with consumers. They observe that many households are favouring less disruptive, less risky technologies, rather than deep energy efficiency retrofit measures. App-linked technologies also gaining popularity, raising people's interest in things like heat pumps, PV and battery storage.

This supports a case for savings forecasting across a flexible sequence of measures, rather than the pre-defined order used in EPCs. However, NEF note the importance of linked guidance (i.e. simple interactivity) on risks and implications of implementing measures outside a validated sequence. They advocate the role of Retrofit Coordinators in developing whole house retrofit plans to help households avoid unintended consequences. The U-CERT recommendations similarly stress the value of contextual information and guidance alongside an EPC (Bančič, Vetršek, and Podjed, 2021).

The majority of reviewed literature generally supported the concept of interactivity for EPCs. However, in the experience of innovators 'Furbnow' (UKRI, 2024), some users were not confident in entering property data in EPC tools. For this study, we recognise that there is a risk that too much complexity could deter users. Simpler interactivity may therefore be preferable.

7.1.1 Review of relatable activities

The literature review was widened to 'relatable activities' based on the research team's experiences in the energy and retrofit sector. This included exploring links between interactive outputs and intended behavioural change on retrofit plans, smart meters and green finance (for retrofit). Reviewing these relatable activities provided some evidence that customised and/ or interactive information can prompt intended behavioural change among households.

7.1.1.1 Retrofit plans

Retrofit plans are bespoke reports intended to guide owners on how to retrofit their homes. These follow the principle of considering the individual context of a retrofit, (e.g. user influence), i.e. they include customised recommendations. Building Passport trials (including renovation plans) have been in place for a number of years in several countries and have also been the subject of previous ClimateXChange research (Small-Warner & Sinclair, 2022). Despite this, no quantitative evidence was found that their implementation increases retrofit uptake. Only circumstantial evidence of 'intent' from end users was given, suggesting likely future uptake of measures. In other words, it is not currently possible to directly link the implementation of renovation plans in Building Passports to a measurable increase in retrofit.

In the iBroad project trial, the majority of respondents agreed that a renovation roadmap enables and motivates them to undertake retrofit measures (Irish Green Building Council (IGBC), 2020). Similarly, 63% of experts surveyed for the follow-up iBroad2EPC project believed that tool would motivate homeowners to renovate (Mellwig, Maiwald, and Pehnt, 2024).

It was observed that renovation plans implemented in EU countries generally follow national policy by prioritising energy efficiency recommendations before renewable energy measures (Enefirst, no date). This is similar to the current approach taken in UK EPCs. As implemented, these plans do not necessarily provide the flexibility called for in many discussions of EPC reform. They are however, tailored to personal circumstances based on assessor expertise.

7.1.1.2 Smart meters

Smart meters serve multiple purposes. These include accurate billing, supporting the use of flexible tariffs, and improving visibility of the granularity of energy use at a local and national level. Alongside in-home displays, smart meters provide information that can help households to understand and potentially reduce their energy use.

A study for Smart Energy GB (Populus, 2019) found that consumers with smart meters report a higher number of energy saving activities than non-users. These activities increased over time with continued active smart meter use. There were also increased levels of behavioural change, such as buying more efficient appliances and implementing energy saving habits. Smart meters also enabled people to take part in flexibility and Time of Use activities to save money. These benefits are attributed to the in-home display showing energy use in near real time. This tailored, real-time information was reported to aid users in identifying energy usage and making more informed decisions to reduce usage.

These findings are supported by several other studies, some of which highlight the importance of displaying data in terms of cost to make it more relatable to users. (Darby *et al*, 2015, National Centre for Social Research (NatCen), 2022, Marshall Cross *et al*, 2019).

Detailed data (i.e., at appliance level information) was found to be most useful and persuasive for end users. For example, Scottish Power data analysis of interactive app users suggests a 5% energy saving compared to non-users. This is attributed to the more detailed breakdown of energy use, which raises awareness among householders and prompts action (Scottish Power, no date).

These findings support the concept that the provision of bespoke, time-relevant and cost-based data can encourage behavioural change. This may be likened to the customisation of an EPC providing up to date cost saving measures recommendations. Similar behavioural motivations may therefore be experienced as has been seen with smart meters.

7.1.1.3 Green finance mechanisms

Green finance (i.e., lending that supports environmentally-friendly activities) has been briefly explored as a behavioural incentive for retrofit. Data from Knight Frank for example supports the view that users value properties with higher EPC ratings (Knight, 2022). As such, retrofit measures that improve an EPC could increase property value. While this does not directly relate to interactivity, introducing interactivity or customised elements to EPCs that link recommendations to potential increases in property value could help promote behavioural change towards retrofit. This may be particularly motivating for landlords or individuals that do not expect to stay in a property long term, for whom typical 'savings'-based motivators may be of little interest. The Snugg/ EST tool mentioned in section 5.2.2 includes an assessment on post retrofit property value.

7.2 Review of existing tools

No direct evidence was found to indicate whether simpler versus more detailed interaction and customisation is more likely to prompt households to undertake retrofit. As discussed earlier, many of the existing advice tools reviewed for this study offer limited level of customisation features. Circumstantially, this supports the idea that a modest spectrum of interactivity and customisation may be sufficient to motivate consumers. It is noteworthy

that many consumer-targeted energy advice tools ultimately refer users to a professional service, where more detail can be explored. Such tools therefore appear to be primarily intended as a mechanism to motivate households onto the next step on a retrofit journey.

Direct feedback was obtained via interview by DESNZ regarding the UK Government's 'Find ways to save energy' tool. This is only an advice tool and is not formal linked to any retrofit delivery schemes. As such, DESNZ are unable to track a 'success rate' for how many users of the tool convert to actually implementing a retrofit.

Additional feedback was gathered by interview with product developers Core Logic regarding their EcoRefurb tool. Core Logic advise that it is a free online tool to give consumers an idea of the retrofit options that may be suitable for their home. Users are then encouraged to develop a more detailed Whole House Plan with a Retrofit Coordinator. The developer reports that around 50% of users that submit a plan via the free tool go on to obtain a Whole House Plan. They consider this a good uptake rate.

By the time that consumers engage with professionals, they are reportedly well-informed and have a clear idea of the improvements they wish to pursue. However, from this point, it can sometimes take a year or more for households to instigate measures. A similar observation was also shared by NEF, who noted that households may need to save up for works or may choose to align with wider home renovation activities.

8 Conclusions and recommendations

Our research finds that cost-based metrics are most tangible and motivating to end users. The following EPC outputs are likely to be the most worthwhile focus for any proposed interactivity or customisation:

- Running costs
- Running cost savings
- Retrofit measures capital costs

We identified three potential levels of interactivity (Table 4) for the Scottish Government to consider implementing in relation to EPCs.

Level of interaction	New user data required?	Integration with calculation engine required?	Example functionality provided
Simple	No	No	• Customised/ simplified views • Click-through signposting to further information
Medium	No	Yes	• Update with already-completed retrofit measures • Select own retrofit measures and sequence • Running costs updated by calling on updated cost information from the PCDB
Detailed	Yes	Yes	As per Medium interaction, plus: • Manual user inputs. (Automated inputs currently limited by a lack of import functionality into RdSAP) • More tailored versions of outputs by allowing more customisable inputs

Table 4: Potential levels of interactivity for EPCs

We did not find direct evidence to support whether simpler versus more detailed interaction or customisation is more likely to prompt households to retrofit. However, there appears to be significant demand from professionals and consumers for interactivity and customisation of EPCs. Additionally, there is relatable evidence from the use of smart meters, retrofit plans and from green lending that the provision of tailored information to households can prompt behavioural change. Offering households some level of interactivity alongside a traditional 'static' EPC could be beneficial.

All pf the tools reviewed in this study include the ability to update and toggle retrofit measures, addressing the call for increased flexibility in EPCs identified in the literature review. User testing and feedback from energy advice tool providers suggest that most existing tools offer a relatively limited degree of customisation. Circumstantially, this supports the notion that a modest level of customisation may represent the upper limit to what users are willing to engage with.

Many existing energy advice tools operate at the medium interaction level. There can be a sliding scale of complexity of customisation at the 'detailed' level. Importantly, greater customisation of inputs does not necessarily make the outputs more accurate, since confidence in various data inputs may be variable. The option to offer various customised or switchable views or functions for different users may help simplify an interactive EPC experience if necessary. For example, users could switch between 'simple' and 'medium' interaction views for users that do not wish to enter detailed personalised inputs.

At any level of customisation, it will be necessary to inform tool users that outputs are ultimately estimates. Actual energy use and costs will inevitably be influenced by a range of other factors e.g. annual climate severity, changing fuel prices, and changes in household circumstances, etc.

The implementation process may be more complicated depending on what version of SAP is targeted for use. RdSAP 2012 is the version used to create the EPCs currently on the register. Translation of existing EPC register data to use the newer RdSAP 10 engine would be more complex. It would also require some assumptions to be added alongside the original data from the EPC register. A move to align to RdSAP 10 would however bring the tool in line with a number of updated calculation assumptions. Moreover, the effort required to align with a HEM calculation has not been explored, though it is noted that the mechanics of HEM fundamentally differ from SAP. Considerable effort would be required by numerous parties to unlock the automated input of data i.e. an RdSAP tool provider (working on behalf of the Scottish Government) and proprietary software or app providers collecting user data.

Existing tools already deliver energy advice to households with varying degrees of interactivity and customisation. Therefore, rather than developing a new tool, the Scottish Government could consider whether a branded or adapted version of an existing tool may deliver a suitable service.

8.1 Opportunities and challenges of implementation

Interactive functionality has the potential to support the promotion of both energy efficiency measures and clean heating systems. There is clear scope to improve alignment with current Scottish Government policies on clean heat, particularly when compared to the limitations with existing EPCs. Currently, EPCs do not provide running cost or savings estimates for fuels types other than those currently used in the home. However, this functionality could potentially be introduced.

The Scottish Government will need to consider whether, and, how it wishes to support recommendations that involve the continued use of fossil-based systems. An interface could, in theory, be designed to present recommendations prioritised either for carbon savings or cost savings. Some of the tools reviewed for this study allow users to express their preference, which can subsequently influence the prioritisation of retrofit measures. The Scottish Government could choose to prioritise carbon savings in order to align with its 'net zero' policy. However, this may not align with the approach preferred by all households. Consideration of potential fuel poverty risks will also be needed.

Clean heat measures implemented in isolation from wider energy efficiency measures could lead to increased running costs for some users. However, the likelihood of this is reduced

where heat pumps are adopted and appropriately installed (EST, no date, National Energy Association (NEA), 2022). Any changes in running costs should be clearly reflected in tool outputs to support informed decision making. However, this would stray from the current approach to retrofit recommendations on an existing EPC. These are prioritised 'fabric-first', and only those that would provide running cost savings are included.

Providing flexibility in how retrofit measures are recommended on an interactive EPC would likely be welcomed by users. However, this flexibility also introduces risks if retrofit measures are actioned without due consideration of wider property factors. For example, improving insulation and airtightness without adequate ventilation can lead to moisture build-up, which poses health risks due to damp and mould, and in some cases, structural damage (May and Griffiths, 2015). To mitigate this, linked guidance would be advisable where users have unlimited flexibility when selecting retrofit options. This would help prevent unintended consequences.

It is noted that the Scottish Government's consultation for the Heat in Buildings Bill proposed a Heat and Energy Efficiency Technical Suitability Assessment (HEETSA) (Scottish Government, 2023). This is expected to offer a more tailored assessment of the suitability of retrofit than a standard EPC. If implemented, a HEETSA could play a role in reducing the risk of adverse outcomes from retrofit measures.

The provision of guidance and signposting (i.e., simple interactivity) may be a more user preferable and transparent alternative to policy-driven functionality. Users may lose trust in a tool if they feel the outputs are not aligned with their personal motivations. Conversely, they may value clear and candid advice, including information about potential risks, to support informed decision making.

Consideration may also need to be given to the skills and capacity of the retrofit delivery sector when designing an interactive tool. If the service proves very successful, an upturn in retrofit measures may be expected, which may outstrip local supply. Anonymously tracking the types of recommendations typically taken through to household retrofit plans could help identify potential capacity gaps within the delivery sector.

9 References

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10 Appendices

Appendix A : Supporting data

Outputs	Custom selection of retrofit measures for consideration	Energy Efficiency Rating (EER)/ Energy Cost Rating	Environmental Impact Rating (EIR)	Primary energy indicator	Running costs	Total running cost savings	Cost savings per retrofit measure	Recommended measures capital cost	Emissions from the home	Space heating demand/ Heat retention metric	Water heating demand	Total energy use	Heating system running costs	PV generation potential	Income from PV	Property value increase
EPC		X	X	X	X	X	X	X	X	X	X	X				
Find ways to save energy (UK Gov)	X					X	X	X								
Go Renewable (EST/MCS)	X					X	X	X	X				X	X		
Home Energy Check (EST)	X	X			X	X	X	X	X							
Snugg Plan Builder (EST)	X					X		X	X						X	X
EcoRefurb (CoreLogic)	X					X	X	X	X							
DREam (IRT)	X	X	X			X	X		X	X	X					

Table 5: Summary of outputs of existing interactive home energy advice tools, compared to EPCs

Inputs	Update property info, including completed retrofit measures	Number of occupants	Living room temperature set point	Heating pattern on/off times	Fuel prices & standing charges	Number of baths or showers taken per day	Any unheated or partially heated rooms	Types of appliances present	Fuel bill reconciliation function	Space around home for renewables
RdSAP GDOA	X	X	X	X	X	X	X	X	X	X
Find ways to save energy (UK Gov)	X	X	X	X						X
Go Renewables (EST/MCS)	X	X	X	X						
Home Energy Check (EST)	X	X	X	X		X			X	
Snugg Plan Builder (EST)	X	X	X							X
EcoRefurb (CoreLogic)	X									X
DREam (IRT)	X									

Table 6: Summary of customisable inputs of existing interactive home energy advice tools, compared with GDOA

Data input	Potential data collection/ input methods	Manual or automated?	Already on EPC register or PCDB? Y/N	Ease of data input for user HML	Likely reliability of data HML	Likelihood of availability (short-mid term) HML	Overall 'readiness' score	Notes
Fuel prices and standing charges	Actuals from recent fuel bills	Manual	No	High	High	High	9	Actual fuel price information should be easy for households to extract from energy bills.
Fuel prices and standing charges	PCDB updated prices (compared to original EPC)	Automated	Yes	High	Medium	High	8	Medium reliability as will be averages (updated 6 monthly) and not necessarily reflect local actuals.
Fuel prices and standing charges	Automated data extraction from fuel bills/ meters	Automated	No	High	High	Low	7	Current Optical Character Recognition (OCR)/ Artificial Intelligence (AI) tools exist to extract data from (pdf) energy bills. (Generally used by businesses with multiple sites/ fuels). Fuel prices theoretically available from smart meter data.
Capital costs	Actuals from user quotes	Manual	Yes	Low	High	Medium	6	Households could seek their own quotes for various works. However, the EPC does not calculate payback, so there is limited incentive for users to do this until they are relatively committed to pursuing the upgrade measure.
Capital costs	From a national average source	Automated	Yes	High	Medium	Medium	7	Industry/ government sourced data. Medium reliability, since it would give national averages and may not reflect local variations.
Number of occupants	Household knowledge	Manual	No	High	High	High	9	Based on household knowledge.

Data input	Potential data collection/ input methods	Manual or automated?	Already on EPC register or PCDB? Y/N	Ease of data input for user HML	Likely reliability of data HML	Likelihood of availability (short-mid term) HML	Overall 'readiness' score	Notes
Number of occupants	Sensor data, IoT	Automated	No	High	Low	Low	5	It is technically possible to infer occupancy from motion sensors. Reliability depends on type of sensors/ mode of operation. Such sensors are not common in homes. It is also likely to be unnecessarily complex for a householder-owned dwelling and too intrusive for a let property. There may be push-back from users for such sensors to be used in this way from a privacy perspective.
Number of baths or showers per day	Household tracking	Manual	No	Medium	Medium	Medium	6	Households are likely to estimate typical number of showers or baths, rather than actually log it (particularly if averaged over a year). Such data may therefore not be entirely accurate, but if (estimated) pattern differs from default assumptions, could be an improvement.
Number of baths or showers per day	Sensor data, IoT	Automated	No	High	Medium	Low	6	Shower sensors exist that extract data on number of showers and duration. However, not common technology in homes. (Note this does not cover baths, so an incomplete picture if a mix of showers and baths used in household, hence Medium ease.)

Data input	Potential data collection/ input methods	Manual or automated?	Already on EPC register or PCDB? Y/N	Ease of data input for user HML	Likely reliability of data HML	Likelihood of availability (short-mid term) HML	Overall 'readiness' score	Notes
External temperature	More localised weather file (for average monthly temp)	Manual	No	Medium	High	Medium	7	Data exists, format likely to be appropriate. Medium ease and likelihood for users to go to effort to obtain it and transpose it accurately.
External temperature	More localised weather file (for average monthly temp)	Automated	No	High	High	Low	7	Data exists, format likely to be appropriate. But would need to be linked to SAP (hence Low likelihood currently).
Main temperature set point	Household input (e.g. from programmed set points)	Manual	No	High	Medium	Medium	7	Ease to input a single average value, if one were available, would be high. If users vary their set points from time to time, the input may not be entirely reliable (medium). Users are unlikely to record historic set point information (so medium availability of information).
Main temperature set point	Extracted from home automation/ smart thermostat or similar	Automated	No	High	Medium	Low	6	Smart thermostats may log temperature setpoints. Not widespread in homes, and data not standardised. Would be based on real data, but may only be from a sample period that might not represent typical seasons.
Heating pattern/ on/off times, normal day and alternative day	Household input (e.g. from programmed set points)	Manual	No	High	Medium	Medium	7	Ease to input values, if patterns can be discerned, would be high. If users vary their heating patterns from time to time, the input may not be entirely reliable (medium). Users are unlikely to record historic patterns (so medium availability of information).

Data input	Potential data collection/ input methods	Manual or automated?	Already on EPC register or PCDB? Y/N	Ease of data input for user HML	Likely reliability of data HML	Likelihood of availability (short-mid term) HML	Overall 'readiness' score	Notes
Heating pattern/ on/off times, normal day and alternative day	Extracted from home automation/ smart thermostat or similar	Automated	No	High	Medium	Low	6	Data availability from sensors/ programmers varies. Not widespread in homes, and data not standardised. Would be based on real data, but may only be from a sample period that might not represent typical seasons.
Any non-heated or partial heated rooms	Household knowledge	Manual	No	High	Medium	Medium	7	Determining a typical profile if rooms are occasionally heated may be complex. Recollection of such instances over a typical year could be unreliable. Households unlikely to record this. However, if rooms are consistently unheated, it may be relatively easy to report.
Any non-heated or partial heated rooms	Extracted from home automation/ smart thermostat or similar	Automated	No	High	Medium	Low	6	Same issues as extracting heating patterns from sensors, plus would require a room-by-room assessment.

Table 7: Qualitative assessment matrix for data inputs

Appendix B : Methodology

10.1 Review of existing EPCs to identify data inputs and outputs for potential interactivity

An example of the current Scottish EPC format was reviewed. Outputs relevant to end users making decisions for energy efficiency and clean heat measures were identified. The Scottish Government consultation on EPC reform was also reviewed to give insight on future changes/ additional outputs.

The SAP calculation methodology used to create EPCs (RdSAP 2012 v9.94) was interrogated to extract the input data that could be customised to create the identified outputs. This focussed on metrics for which standardised assumptions are used by default in the calculation (e.g. occupancy). The Green Deal Occupancy Assessment, as set out in Appendix V of RdSAP 2012 v9.92, was referenced to help identify contextual parameters. The ease of implementation to make each output interactive was assessed qualitatively with developers in BRE's SAP team. This followed a 'high, medium, low' rating based on the following criteria:

- High ease: Where an output already held on the Scottish EPC register could be adapted via a straightforward calculation (i.e. no SAP calculation engine required).
- Medium ease: Where the output could be updated by implementing aspects of the GDOA as part of a new RdSAP calculation, using data held on the EPC register.
- Low ease: Where customisation of metrics has not previously been implemented in an RdSAP calculation, hence more work would be required to implement.

The likely importance/ value of each output, from an end user perspective, was qualitatively assessed, again on a 'high, medium, low' scale. This synthesised information from several sources:

- Information from literature sources (identified in subsequent tasks)
- Expertise of BRE staff that work in the retrofit sector
- Discussions with customer-facing practitioners from NEF

10.2 Review of existing consumer energy advice tools

Existing consumer-facing energy advice tools were identified using web searches and the knowledge of the research team. CXC had additionally cited the UK Government household energy tool and EST Renewables selector for consideration. Criteria for identifying tools included:

- A domestic/ housing focus
- An aspect of interactivity/ customisation
- Outputs similar in nature to those shown on EPCs (i.e. energy use, cost, recommendations)

A representative selection of tools were shortlisted for more detailed investigation. Criteria for shortlisting included:

- Limited duplication of tools created by a single organisation, unless they offered something distinctly different from one another (e.g. there are many tools created with the same underpinning architecture/ calculation engine by EST)
- Tools offering different levels of interactivity/ customisation
- Inclusion of a commercial/ portfolio assessment tool (e.g. for social landlords)
- Sufficient information available on tools to allow them to be tested and explored as part of the research

Interviews were held with DESNZ and Core Logic as product owners of the 'Find ways to save energy' and 'EcoRefurb' shortlisted tools, respectively.

Relevant EU research projects (into enhanced or dynamic EPCs) were also explored. However, since the resulting tools were generally intended for use by professionals supporting households, they were not comparable to the other user-centric tools explored. They were therefore not reported alongside the other existing tools but instead informed the wider evidence review on intended outcomes.

10.3 Assessment of data collection/ sourcing methods

Methods of data collection/ input were identified using web searches. This used key words on data input sources (taken from the task described above) linked to concepts of 'collection, data entry, data history, automation, smart'. Further methods were populated based on the research team's own experiences and expertise in data entry and surveying for SAP/ EPCs. Novel approaches being explored by Innovate UK projects were publicised during the 'Net Zero Heat Open Day'[7]. These were also reviewed for relevance.

Approaches were assigned as 'manual' versus 'automated' methods. It was also flagged if the data was already held on the EPC register or elsewhere linked to the creation of EPCs (e.g. the PCDB). The potential data sources/ collection methods were qualitatively appraised, based on the research team's judgement, on a 'high, medium, low' scale against the following parameters:

- The ease of data input for the user
- Likely reliability of the information
- Likelihood of an information source to be available short-mid term

Table 8 gives a practical illustration of the criteria for assigning the qualitative rating. The rankings were then assigned a score (High = 3, Medium = 2, Low = 1). These were summed to provide an overall current 'readiness' metric for each approach (scored out of 9).

[7] UKRI Innovate UK Net Zero Heat Open Day - Innovate UK Business Connect. Held online 03/10/24. Recordings available.

Assessment parameter	High ease assessment criteria	Medium ease assessment criteria	Low ease assessment criteria
Ease of data input for user	Either automated, so minimal effort for user, or based on a few input parameters users are likely to readily understand.	Some tracking of household behaviours required, or users will need to seek out relatively simple data.	Difficult to identify or extract data correctly, or laborious to obtain.
Likely reliability of information	Based on real, household-specific data.	Based on real data but averaged or normalised in some way, or some other risk of error being introduced.	Accuracy of automated determination likely to be low.
Likelihood of availability short-mid term	Data currently readily available. Manual or PCDB input into (SAP) tool.	Data source exists in appropriate format, but collation effort/ processing will be required, which is likely to deter users.	Data would need to be appropriately formatted from source, SAP tools not currently capable of accepting import.

Table 8: Example criteria for assigning 'high, medium, low' qualitative ratings to data collection/ sourcing methods.

10.4 Identifying evidence of intended outcomes

A desk-based evidence review sought information from academic articles and grey literature. A selection of search terms used are given in Table 9. These were expanded upon as other terms and concepts were identified in the reviewed sources. Feedback linked to the example energy advice tools identified in an earlier task was also sought. This was from online sources, though additional discussions were also held with tool developers where possible. DESNZ (as owners of the UK Government 'Find ways to save energy' tool) and Core Logic (EcoRefurb tool) provided direct feedback on their respective tools. Additionally, advisors from NEF provided general feedback from their experiences of directly supporting consumers with retrofit projects and from administering grants.

Research was widened to 'relatable activities' based on the research team's experiences in the energy and retrofit sector. The scope for this was limited to households and housing, and at least energy-related behaviours, if not retrofit. This included researching linkages between interactive outputs and intended behavioural change on smart meters, retrofit plans and green finance (for retrofit).

Energy Performance Certificate	Interactive	Building passport
EPC	User experience	(Retrofit/ Renovation) plan
Retrofit	Personal(ised)	Roadmap
(Retrofit) support	Dynamic	Behaviour change
Renovation	Customised	Consumer attitude
Smart meter	Success	Tailored advice

Table 9: Initial search terms used for evidence review (not exhaustive)

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