

Reducing uncertainty in the market for (low carbon) refurbishment: a web-tool that brings together home-owners, housing providers, manufacturers, installers and policy makers

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Abstract

Rising fuel prices, an obligation to alleviate fuel poverty, and challenging CO₂ targets are increasingly important factors defining the refurbishment needs of the UK's ageing housing stock.

With the availability of microgeneration technologies and more conventional energy conservation products, householders face myriad refurbishment options. Yet it is frequently unclear which measures are appropriate for each household, with the suppliers often overselling the performance of their products, whilst implicitly or explicitly offering scepticism over different technologies. Since the performance of products varies markedly across different houses, the information they give is not necessarily untrue. However, the uncertainty presents a barrier to the uptake of the most effective low-carbon refurbishment measures in homes.

To fill this information gap, the T-ZERO tool has been developed. Utilising a building energy model based engine with over 100,000 modelled buildings, the tool enables users to define their home, then provides them with tailored optimal 'packages' that offer the best performance, measured across eight different parameters. Once the user has selected their preferred package, they are linked to local suppliers of the measures contained within it, with the ability to request a quote within the tool.

This paper explores how householders can use this tool to inform and implement their refurbishment plans and share their

experiences with others; how housing providers can use it to inform strategic asset management decisions regarding upgrades, procurement, poverty alleviation and environmental goals; and how policy makers can use it to address decisions concerning the extent and nature of support for measures.

Introduction

Existing housing in the UK is responsible for over a quarter of all CO₂ emissions (DEFRA, 2008). At current demolition rates it will take 1,000 years to replace all of the houses in the UK, meaning that 70-80% of the 2050 housing stock has already been built - an estimated 21.8 million homes. Some studies have proposed increasing demolition rates to remove the worst housing, replacing these with efficient new build (ECI, 2005). However, demolition can lead to resource depletion, reducing landfill capacity, requiring land, and a huge expansion in the size of the construction industries. Refurbishment should be encouraged wherever possible.

Interest in low carbon refurbishment is increasing. Increasing energy costs, a rise in environmental awareness, and the recent slump in the housing market are all encouraging householders to refurbish their existing properties to reduce their energy demand, CO₂ emissions, and improve the comfort of their homes. Policies are helping drive this change, specifically targeting the most vulnerable in society. However, many who are outside this group are not benefiting through policy incentives, and they suffer from the large amount of uncertainty when it comes to low carbon refurbishment. Whilst there is a level of understanding relating to the order in which types of measures should be installed (generally insulation followed by heating systems, then renewable technologies), there are real

Table 1. Base Build Options

Build Form	Wall Type	Bedroom Number
Top Floor Flat	Cavity Wall	1,2, or 3 if Build Form is Flat
Mid Floor Flat	Solid Wall	2,3 or 4 if Semi, Terrace or Bungalow
Bottom Floor Flat	Non-Traditional Wall	2,3,4 or 5 if Detached
Semi-Detached		
Detached		
Terrace		
End Terrace		
Attached Bungalow		
Detached Bungalow		

Table 2. Measure Options

Loft Insulation	Wall Insulation	CFLs	Heating System	
25mm/None 100mm 270mm	Cavity Wall Insulation External Wall Insulation Internal Wall Insulation Insulating Render Flexible Insulated Lining	None 50% CFLs CFLs	Old Gas Boiler Old Gas Combi Old Oil Boiler Old Oil Combi Electric Storage Open Coal Fire	Gas Combi-Condensing Boiler Oil Condensing Boiler Oil Combi-Condensing Boiler Biomass Boiler Air Source Heat Pump Ground Source Heat Pump
Glazing	Draught Proofing	Renewables	Electric Underfloor Heating Gas Condensing Boiler	Secondary Heating
Single Glazing 6mm Double Glazing 16mm Double Glazing	None Draught Proofing	Solar Hot Water Photovoltaics Micro Wind Turbine		Log Stove

uncertainties when it comes to choosing which measures to adopt within each group. There is a lack of independent advice on the relative performance of measures, an estimation of how much they cost, guidance on problems with installation and planning requirements, and direction towards funding packages and grants available. Anecdotal evidence suggests this uncertainty is being exploited to sell inappropriate technologies at inflated prices. This undermines confidence in the low carbon refurbishment market and technologies.

T-ZERO has been developed to address these uncertainties. It consists of a free to use internet tool that gives independent quantitative and qualitative advice on the optimal route for low carbon refurbishment, as determined by the specific type of property. Once the user is happy with the choice of package, they are then able to link through to the Marketplace which will act to bridge the gap between the household and the market.

Methodology

CREATING THE DATASET

The T-Zero modelling engine utilises the UK Government's Standard Assessment Procedure (SAP 2005) for assessing the energy performance of dwellings (BRE, 2005). SAP 2005 is an elaborate calculation that estimates, amongst other things, the energy demand and CO₂ emissions of a building, based on its material construction, thermal insulation, ventilation characteristics, heating system efficiency, solar gains, fuel mix, and the presence of renewable energy technologies. T-ZERO replicates this underlying calculation but narrows the range of permissible entries by defining 'base builds' and 'measures'; the presence/absence of which alter the values used in the calculations.

There are 84 'base builds' used in T-ZERO, each representing a combination of building type, wall type and floor area, with the latter approximated from the number of bedrooms (see Table 1). The build form determines the geometry of the building, as well as parameters such as the exposed wall area,

glazed area, and roof area. This geometry is scaled according to the number of bedrooms selected, with each bedroom number representing a floor area for that build form. The selection under wall type determines both the underlying thermal performance of the facade and the appropriate improvement measures subsequently offered.

A series of optional 'measures' have been defined to enable the performance of buildings that conform to the same 'base build' to be distinguished. There are 8 categories of measures: loft insulation, wall insulation, glazing, draught proofing, CFLs, heating system, renewable technologies, and secondary heating system. The full list of options under these categories can be found in Table 2. The presence or absence of these measures impact upon the SAP 2005 calculation in different but logical ways; the presence of wall insulation reduces the U-value of the exposed walls depending on the type of insulation used for example.

Each measure is assigned a floor-area dependent installation cost (and a maintenance cost if appropriate), with the cost of all measures added to create a total cost for the combination of base build and measure – a combination we term a 'package'. The SAP 2005 calculation is run for each 'package' permutation, except in cases where the measures aren't appropriate for the build form – most notably, the combination of loft insulation, renewable technologies and certain heating systems with flats. In total there are more than 7 million packages. For each package, current fuel costs are used to estimate the fuel bills.

Each package has the following key results:

- CO₂ emissions
- Energy demand
- Package installation cost (and maintenance cost)
- Fuel bills
- EPC rating

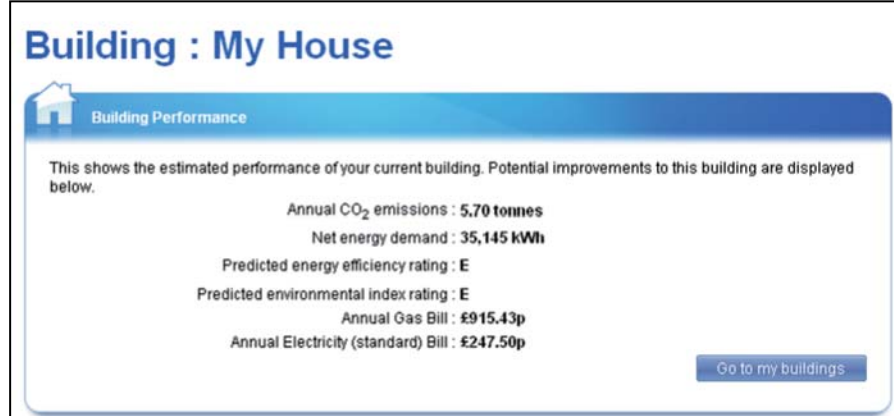


Figure 1. Building performance screen.

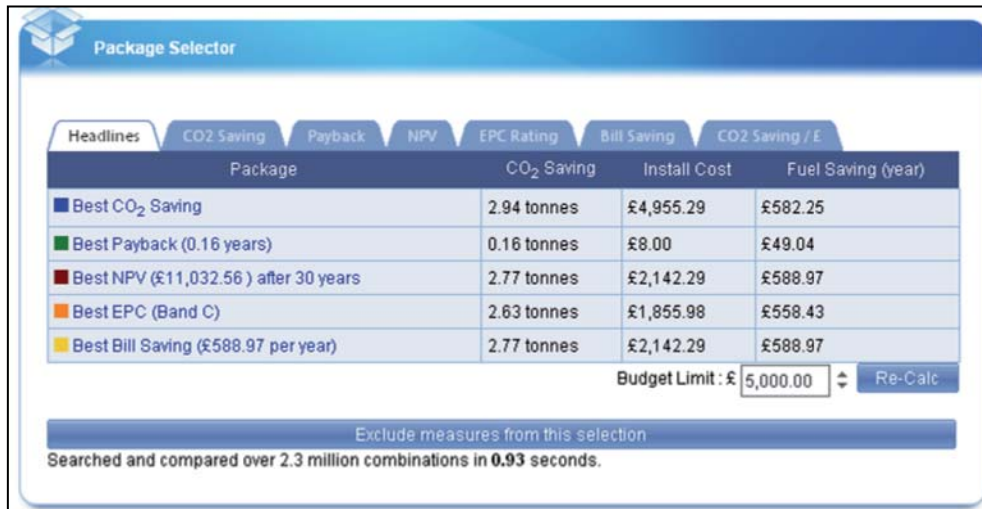


Figure 2. Package Selector screen.

These results are displayed for the user before they choose their refurbishment package, as illustrated in Figure 1.

DETERMINATION OF THE OPTIMAL REFURBISHMENT PATHWAY

Once the user has identified the package that best represents the building they wish to model, they are presented with the improvement packages. These represent the optimal refurbishment paths according to their most important criteria. The T-ZERO tool works by comparing the user's initial package with all other packages of the same base build in the database, returning the best performing 'improvements' by the following parameters:

- CO₂ saving (kg/a)
- Fuel bill saving (£/a)
- Payback (a)
- EPC rating
- Net Present Value (£ after 30 years)

CO₂ saving and fuel bill saving are calculated by subtracting the CO₂ emissions and fuel bill costs of the improved package from the original. The improved packages that show the greatest savings are displayed to the user. Installation costs require

the subtraction in reverse – the total installation costs for the original package are taken from the improvement packages, with the remaining costs representing only those measures that have improved. The Payback can be calculated by dividing the calculated installation cost by the calculated fuel bill saving. EPC rating is calculated directly from the SAP calculator for each package and represents the predicted 'Energy Efficiency Rating' a building with this package would achieve if assessed.

Because measures within a package have different lifetimes, the calculation for NPV involved standardising the package lifetime to 30 years, with the discounted reinstatement of measures as appropriate. The Present Value of each package was therefore the summation of the initial installation cost, the reinstatement costs discounted to the year in which reinstatement occurred (using a rate of 3.5%), annual discounted maintenance costs, and annual discounted fuel costs. Subtraction of this calculation for the original package from the alternatives gives the NPV.

The T-ZERO tool applies these calculations to determine the top improvement packages under each criteria. The user is then able to peruse these, and apply a budget to these to restrict them further as shown in Figure 2.

Figure 3. One of four building entry screens in T-ZERO.

The Web-tool

SELECTING YOUR BUILDING

The first stage of the user's experience is to determine which of the seven million rows in the dataset correspond to the building they wish to model. This is achieved through a series of drop-down menus, in a similar style to popular carbon calculators, asking the user to select the appropriate option as given in Tables 1 and 2, and illustrated in Figure 3. Once the correct entry has been identified the user is presented with the details of their building; the estimate of its SAP rating, fuel bill cost and CO₂ emissions as shown in Figure 1.

PACKAGE RECOMMENDATION

Once the user has entered the details of their home and viewed its current performance, they are taken to the Package Selection table where the possible improvements are displayed as illustrated in Figure 2. Since the motivation for refurbishment will differ between users, the table was designed to show the headline packages on the first tab – the top performing package under each criterion with a reasonable (£5,000) budget applied.

There are several further features which allow the user to determine the optimal package for their needs. Firstly, once the user has determined their most important criteria, they can click on the tab representing it and see a series of further options under a range of differing budgets (Figure 4). They are able to use the 'exclude measures from this selection' button to prevent certain measures from appearing (for example they may wish to exclude biomass boilers if they know their home is unsuitable for one). Finally, they can visually analyse the performance of the potential packages on two charts, one illustrating total cost curves of each package over thirty years, the other illustrating annual CO₂ emissions (Figures 5 and 6). The CO₂ chart simply shows the CO₂ emissions that a building containing that improvement package would emit. The total cost curve chart allows the user to see the costs of each improvement package in comparison to the base build over 30 years. The total costs include the initial installation costs, the discounted maintenance costs, the discounted reinstatement costs for measures lasting

less than 30 years, and the discounted fuel costs. Both the discount rate and the fuel price escalator can be adjusted on this chart to see how they impact on the package performance.

Once the user has determined which package they wish to proceed with, they are able to get further information on the measures within it which includes a break-down of costs, and guidance on any installation issues (Figure 6). They are also able to download detailed PDFs containing further information on the measures.

LINKING TO THE MARKET

A key feature of T-ZERO is that it can link the user to the companies that supply, install or manufacture the measures that the tool recommends and the users select. The Marketplace lists companies associated with certain products on a database, and displays them to the user in order of proximity to the property, displaying these companies on a visual google map. Users can browse the companies, viewing their personal page, and using a quotation system to contact the company requesting further discussion regarding a product.

Maximising the outcome of T-ZERO

T-ZERO has been developed to address two key barriers in the low carbon refurbishment market: the lack of clear quantitative advice, tailored to specific buildings, that informs on the optimal refurbishment solutions; and the lack of a link between those interested in refurbishment and those in the market of supplying, installing and manufacturing the products. Yet to be successful it must appeal to users, and provide a clear and uncomplicated interface to navigate through a fairly complex subject whilst remaining flexible to the user's needs.

The tool has been designed for two principle user groups: householders and housing managers. To aid the former group in using the tool, two additional sections have been created: case studies and an Information Centre. To enhance the experience for housing managers, a portfolio function has been created.

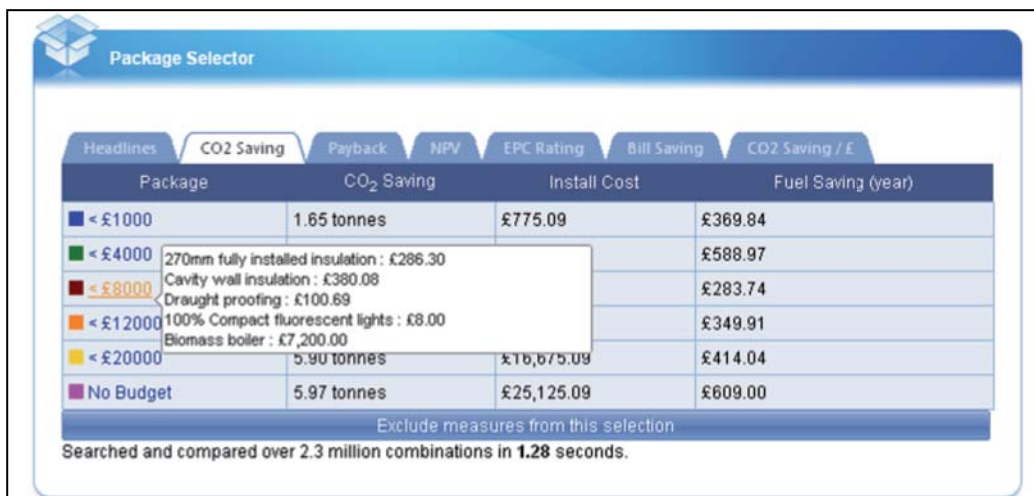


Figure 4. Tabbed page on the Package Selector table.

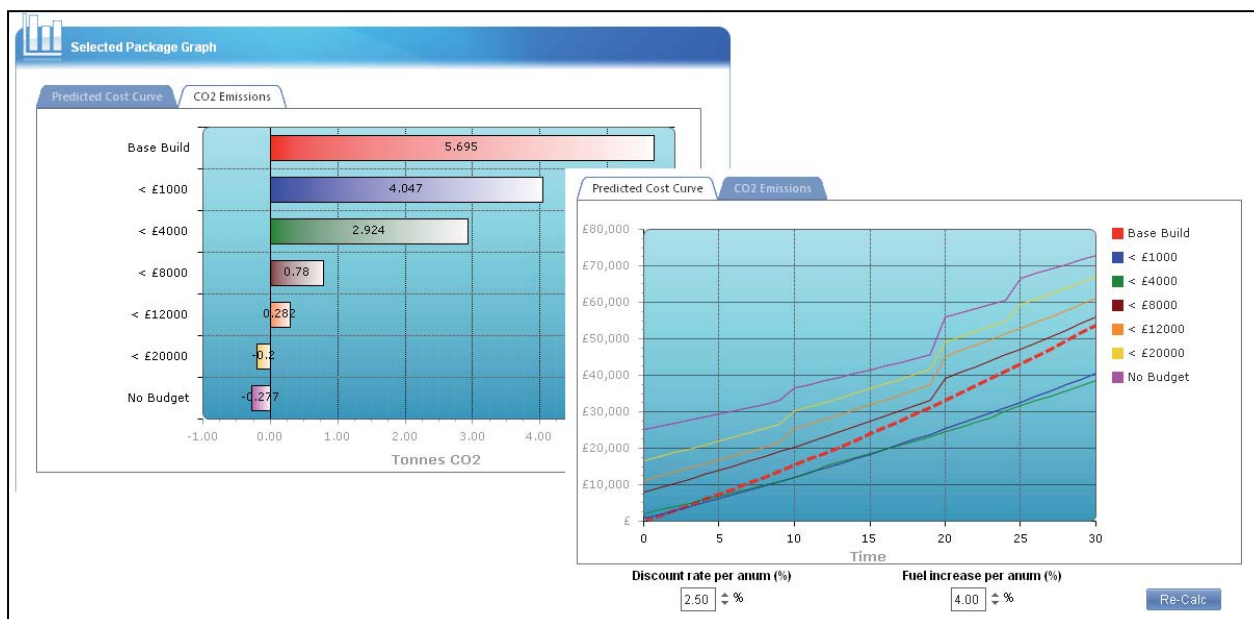


Figure 5. Carbon Dioxide emission chart and Total Cost Curve



Figure 6. Detail of the improvement package selected.

CASE STUDIES

T-ZERO has been designed to hold case studies of refurbishment examples to help inform homeowners when they set out to implement a project. Users can submit their own case studies through the site which focus on qualitative information, asking questions such as: which aspects of the project were successful? Where did the problems lie? These real examples of the measures being installed in homes should be helpful to those considering their installation. The case studies have their own section within the tool, but an example of one pertaining to measures contained within a package a user is exploring are displayed on the webpage at all times.

INFORMATION CENTRE

In a similar vein to the Case Studies, the Information Centre provides users with a huge amount of information related to their refurbishment. Each measure includes a PDF document that details any issues with installation or regulations, and includes pictures and links to sites which provide a more specialist interest. Additional reports cover the availability of grants and finance to support the installation of measures, and accreditation schemes that cover the providers of certain measures. This information should help answer most of the users questions, encouraging them to open dialogue with the marketplace participants.

MANAGE YOUR PORTFOLIO

Housing managers often deal with multiple houses, requiring a portfolio approach in T-ZERO. This approach enables those with multiple properties to view them all in one place, group them as required, multiply up modelled cases, and create templates upon which additional buildings can be grouped. These features enable housing associations to quickly build up their stock in T-ZERO and determining the required improvements in each property.

Areas for further work

There are several areas where the initial version of T-ZERO could be improved to offer more accurate and tailored advice for the user. Whilst most of these changes would be unlikely to change the relative performances of the packages suggested by the tool, they would help to provide more accurate estimates of the parameters for that particular home, therefore improving the trustworthiness of the results. These areas include:

- Increasing the number of build forms, wall types and bedroom numbers that are available, including non-standard building varieties.

- Increasing the number of measures, and granularity within the measures, so that, for example, a user could enter their exact loft insulation thickness rather than having to choose between discreet options.
- Allowing the user to select a mixture of wall types if they have more than one type in their home.
- Letting the user determine how the package costs are calculated, whether using the professionally installed measure costs, or the DIY measure costs. Allowing the user to see how amending these costs impacts upon the output parameters.
- Utilising the user's experience of measure costs and performance to update the costs and assumptions in the tool.

Conclusion

T-ZERO has been developed to provide independent qualitative advice for householders and housing professionals, based on the UK Government's Standard Assessment Procedure (SAP 2005) calculations. By allowing the user to select and personalise their package according to their objectives, the tool helps fill the information void on the relative performance of improvement measures in a specific building. The presence of the T-ZERO Marketplace and its ability to link users directly to companies, bridges the gap between customers and the market, in turn helping to stimulate these industries and encourage them to develop greener products. Additional tool features such as case studies, an information centre, and portfolio management system, help to increase the tool's effectiveness for the various types of user. Though there are parts of the tool that can be improved to provide more tailored advice, these are unlikely to impact upon the relative performance of the different packages suggested.

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