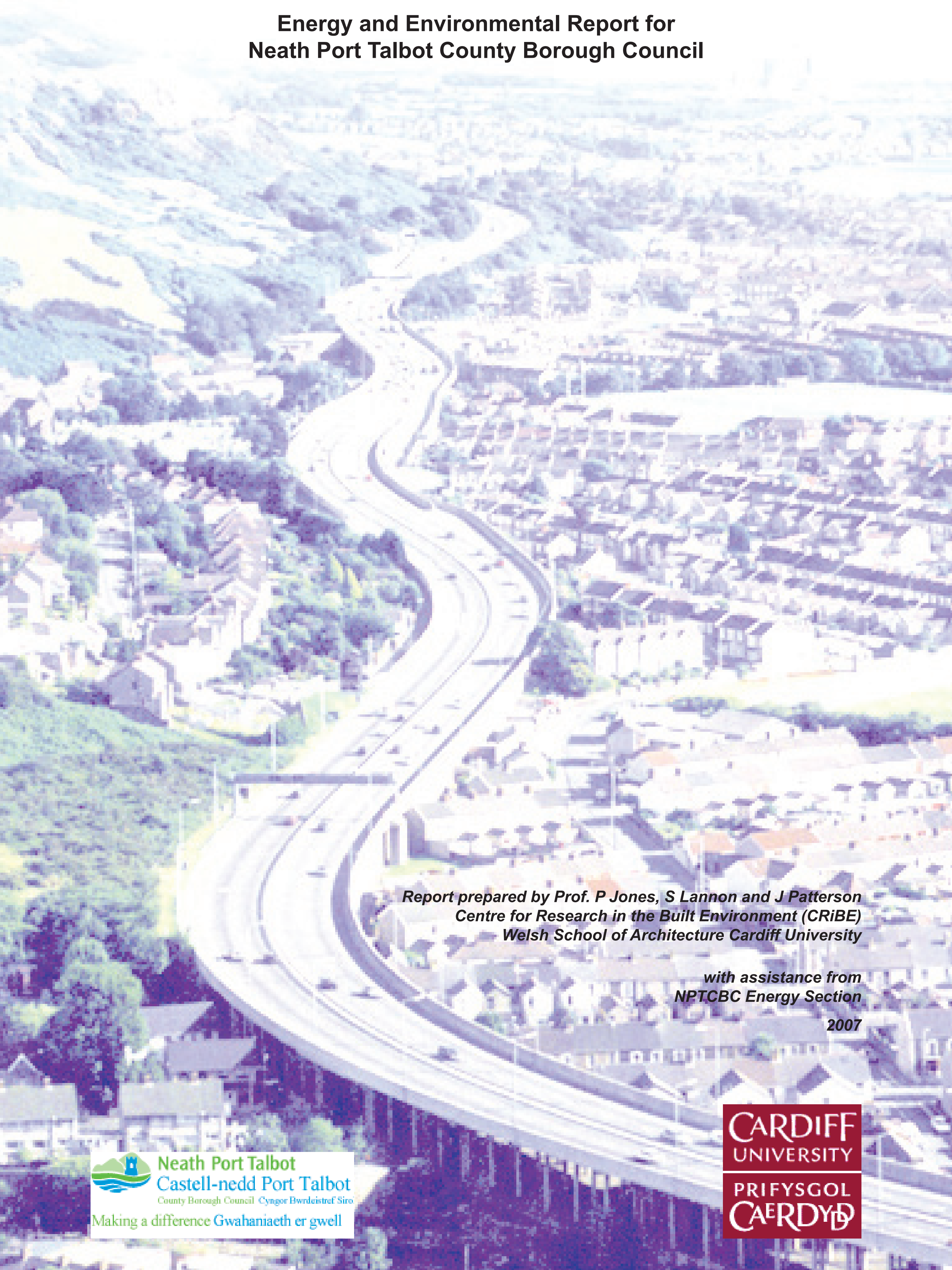
Energy and Environmental Report for Neath Port Talbot County Borough Council



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with assistance from
NPTCBC Energy Section

2007

Neath Port Talbot
Castell-nedd Port Talbot
County Borough Council Cyngor Bwrdeistref Sirol
Making a difference Gwahaniaeth er gwell

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Forward

Neath Port Talbot County Borough Council, as part of its Unitary Development Plan (UDP), is committed to a strategy that will “move towards more sustainable forms of development”. The UDP states “an underlying theme will be to move towards more sustainable types of development and communities”.

As part of the Council’s Environmental Policy development we have been working closely with the Centre for Research in the Built Environment (CRiBE) at Cardiff University for several years, to develop sustainable strategies for the built environment. This collaboration has included the application of the Energy and Environmental Prediction (EEP) model to the whole of NPTCBC. The model was developed by CRiBE and the EEP model can be used as a planning and policy tool that will allow local government to select sites for development that will assist in the drive for sustainability and deal effectively with refurbishment of existing stock.

As part of the UDP the council wishes to “encourage new forms of energy production which are compatible with the other elements of the strategy”. The EEP model has already been applied to the housing stock within the Briton Ferry area to inform an EST ‘Community Energy’ grant funded feasibility study which evaluated the benefits of developing an Energy Services Company Development (ESCo) within the Borough. Data arising from the EEP model about the building stock was provided to the Awel Aman Tawe community energy project, which aims to integrate the use of renewable energy and energy efficiency measures in the overall objective of local regeneration. The model was also used to assess the local traffic flow impact for the development of the Llandarcy Urban Village plan.

This report provides baseline information about the energy consumption and related emissions for NPTCBC. If the council were to improve it’s domestic sector’s energy efficiency as described in Table 3, there would be a reduction in domestic energy use of 34% and the carbon dioxide emissions would drop by 29%. This information can then be used to help make policy decisions for the borough more sustainable.

Will Watson
Director of Technical Services
Neath Port Talbot County Borough Council

The Unitary Development Plan is available on line at;
http://www.neath-porttalbot.gov.uk/

Energy and Environmental Report for Neath Port Talbot County Borough Council

Introduction

This report provides data relating to energy use and carbon emissions produced for the whole of NPTCBC. The results have been broken down into sectors, domestic properties, non domestic properties, industrial processes and traffic. These sectors have been modelled separately at a postcode level using the Energy and Environmental Prediction (EEP) model. For information about the EEP sub-models for each sector see Appendix A.

The following data is presented for domestic and non-domestic properties;

- energy use by ward (GJ/year)
- CO_2 emissions by ward (kg/year)

The following data is presented for industrial process;

- number of processes by ward

The following data is presented for road traffic;

- CO_2, CO, VOC, HC and NO_x emissions by ward
- Traffic flow modelling to predict impacts of developments

An overall assessment is made on the aggregated results of the sectors, to give the following results for the whole NPTCBC area;

- energy use by ward
- CO_2 emissions by ward

The study area is illustrated in Figure 1, the grey areas represent populated areas, the red lines are the major roads, the dark blue line is the M4 motorway and the grey areas represent the surveyed postcodes.

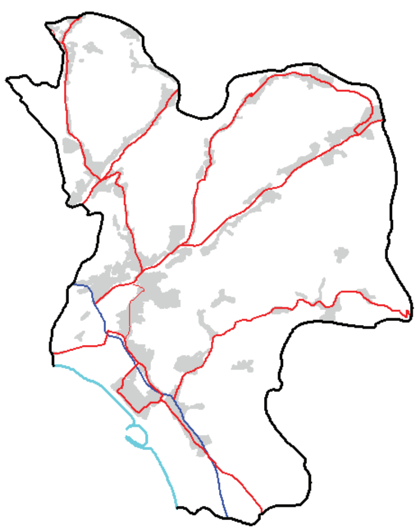

Figure 1 Map of the Neath Port Talbot County Borough area, with surveyed postcodes

The emissions and energy use are presented at a ward level to give a geographic representation of the results The ward boundaries are shown as red lines in figure 2 and the grey areas again represent the surveyed postcodes.

Figure 2 Map of the Wards in Neath Port Talbot County Borough area, with surveyed postcodes

EEP model

The NPTCBC data has been collected using the EEP model. The EEP model is a computer based framework that has been developed at the Welsh School of Architecture (WSA) to be used as an environmental auditing and decision making tool for local authorities. It is designed to be used by planners and others in pursuit of sustainable development. The EEP model is based on Geographical Information System (GIS) techniques and brings together a large database that can be acted upon by sub-models within the model structure. The model can predict the effects of future planning decisions from a whole city level down to a more local level.

Sub-models currently within EEP include information about energy use and emissions produced by both domestic and non domestic properties, industrial processes and traffic that can be analysed independently or combined within the model framework to assess overall energy use and CO_2 emissions for a city or area (see Appendix A for details on calculation method).

The model provides information based on the a borough wide building stock survey undertaken over the period 1999 to 2001.

A detailed description of the EEP model is available in the paper ‘Planning for a sustainable City: An Energy and Environmental Prediction Model’, P Jones, J Williams & S Lannon, *Journal of Environmental Planning and Management,* 43(6), 855-872, 2000

Domestic properties

The list of domestic properties for the county borough was generated from the Postal Address File and the Ordnance Survey Addresspoint file supplied by NPTCBC. This gives 58,041 domestic properties of which 55,148 have been entered into the EEP database (see appendix A for a description of the survey method and appendix B for a breakdown of the surveyed properties).

The Home Energy Efficiency Scheme (HEES), a National Assembly of Wales funded programme, currently provides a grant of up to £2,700 for households on certain benefits, to make homes more energy efficient. HEES data provided by NPTCBC for the period 1991 to 2002 has been incorporated into the survey for 6,008 properties, which have had at least one of the following energy efficiency measures, loft insulation, draughtproofing, cavity wall insulation, and heating system improvements. These measures have been modelled and the results of the energy efficiency measures incorporated into the overall results.

Tenure	Percentage split	No. of properties
Private	82%	45,295
Council	18%	9,853

Table 1 Tenure of domestic properties located within NPTCBC area

Property type

The EEP surveyed properties have been entered into the EEP database. The tables and figures below display the results of our analysis.

The NPTCBC council property database has been analysed, and 9,853 were identified as council owned houses, the rest are sheltered or elderly accommodation, these are dealt with in the non domestic properties.

The ages of the domestic properties has been grouped into four major periods of building construction, and split into council and private tenure.

The breakdown of property ages in Wales and NPTCBC figures 3a and b, shows NPTCBC has more pre 1919 properties (33% to 35%) and less post 1964 properties (25% to 23%), when compared to the Welsh figures.

When the NPTCBC dwellings are compared to the private properties , figure 3c and 3d, the councils properties are predominately 1945 to 1964 construction with 59% compared to only 20% of private properties for the same period.

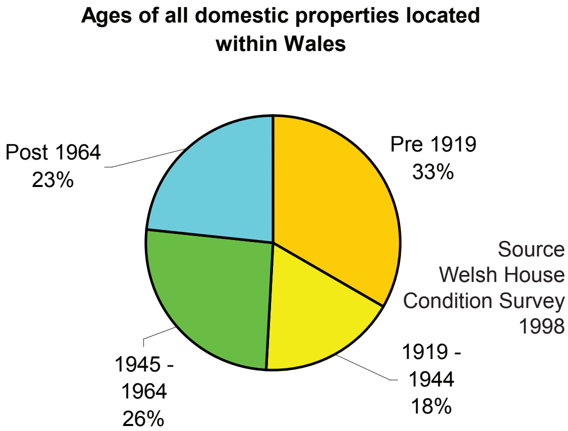

Figure 3a Age breakdown of Welsh domestic properties

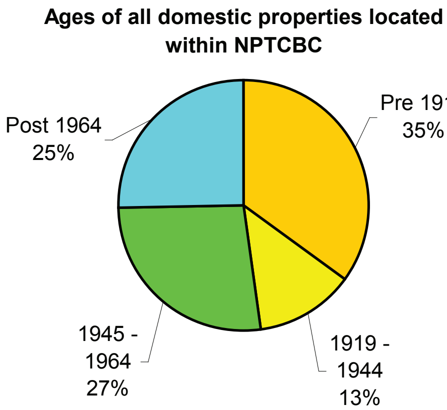

Figure 3b Age breakdown of NPTCBC domestic properties

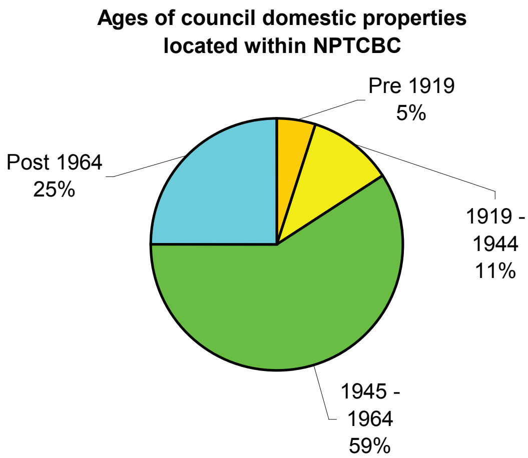

Figure 3c Age breakdown of NPTCBC council domestic properties

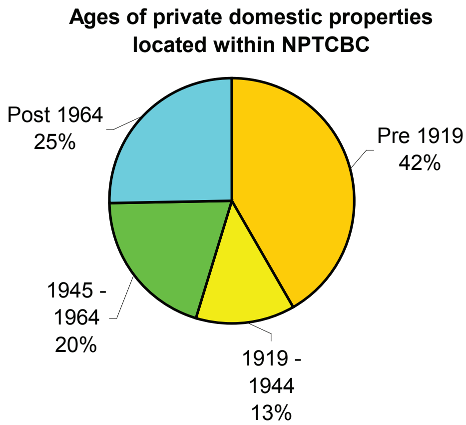

Figure 3d Age breakdown of NPTCBC private domestic properties

Figure 4a shows the breakdown of heated floor areas of all properties in NPTCBC. Figure 4b and c show that the council properties are predominately smaller with 79% less than $100m^2$ compared to only 41% of private properties. This is particularly evident in the largest floor area band where there are only 4% of the council properties and yet 31% of the private properties are of this size. There are 45% of council properties with less than $85m^2$ compared to only 20% of private properties.

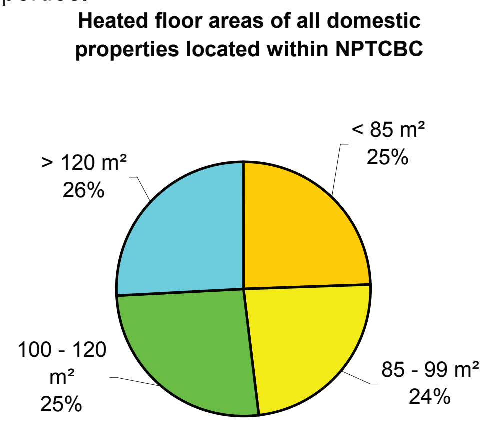

Figure 4a Heated floor area breakdown for all domestic properties

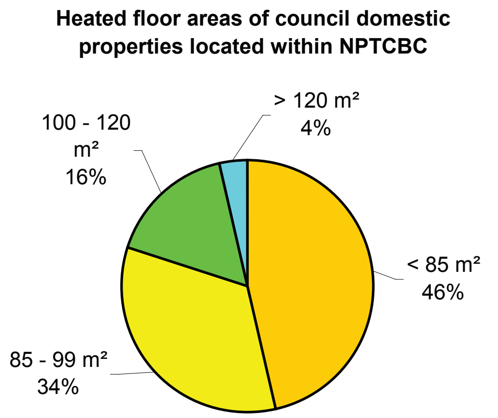

Figure 4b Heated floor area breakdown for council domestic properties

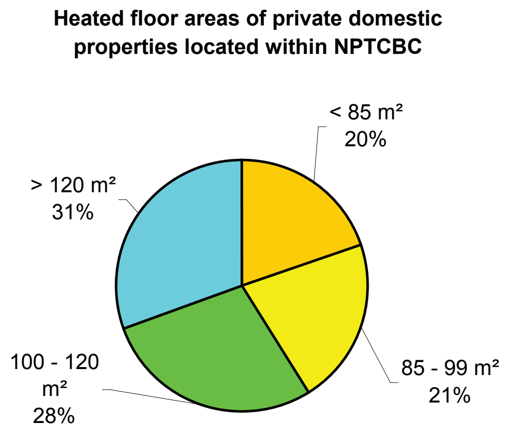

Figure 4c Heated floor area breakdown for private domestic properties

Domestic properties in NPTCBC are predominately two storey, but interestingly figure 5 shows that council properties are more likely to be single storey with 29% (figure 5b) compared to only 13% (figure 5c) of private properties with one storey. This may reflect the major council housing schemes in the period 1945 to 1960. During this period many flats and bungalows were built as the housing needs of the area changed.

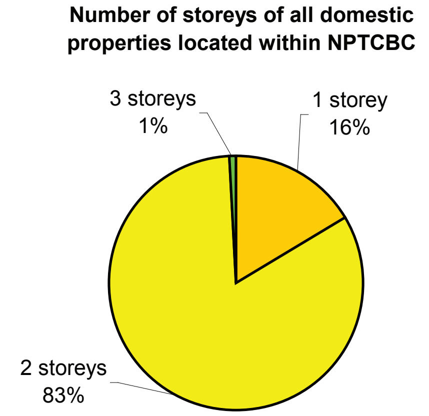

Figure 5a Age breakdown for all domestic properties

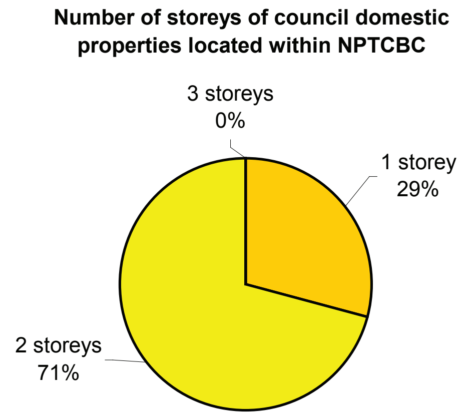

Figure 5b Age breakdown for council domestic properties

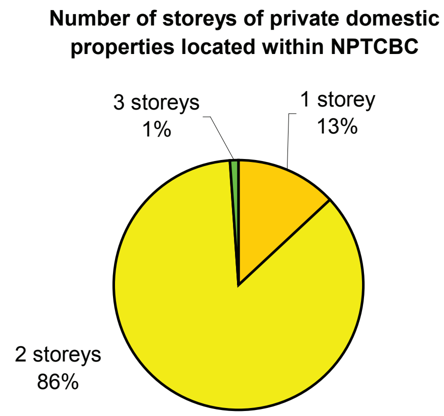

Figure 5c Age breakdown for private domestic properties

Energy and emissions

The EEP sub-model used to predict the energy consumed by the domestic properties is the UK governments Standard Assessment Procedure (SAP). The rating provides ranges from 0 to120, where 0 is the most energy inefficient, 120 is the most energy efficient.

The proposed Home Information Pack (available at http://www.odpm.gov.uk/housing/) uses the SAP rating as a measure of energy efficiency. The scale used in the pack is from A to G, where A is very good with a SAP rating of 100 to 120, and G is very poor with a SAP rating of 0 to 25.

The SAP breakdown of the domestic properties in the NPTCBC is shown in figure 6. The current average SAP rating for the whole NPTCBC area is 47.5 (band E) with a SAP minimum of 28 (band F) and a maximum of 74 (band C).

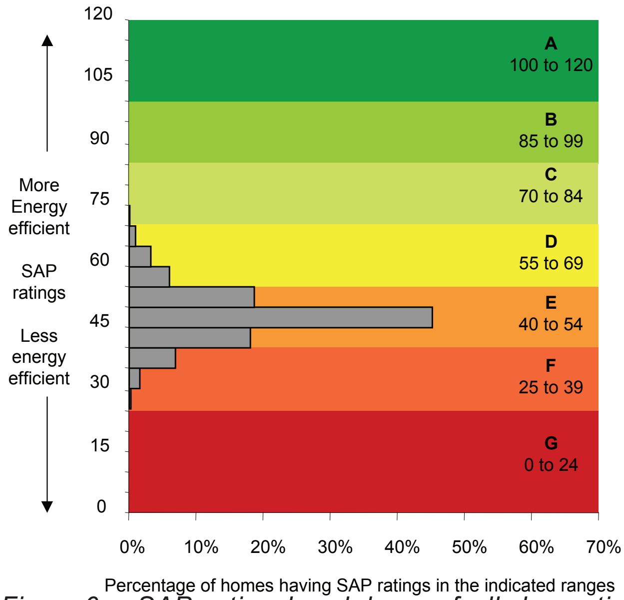

Figure 6 SAP rating breakdown of all domestic properties

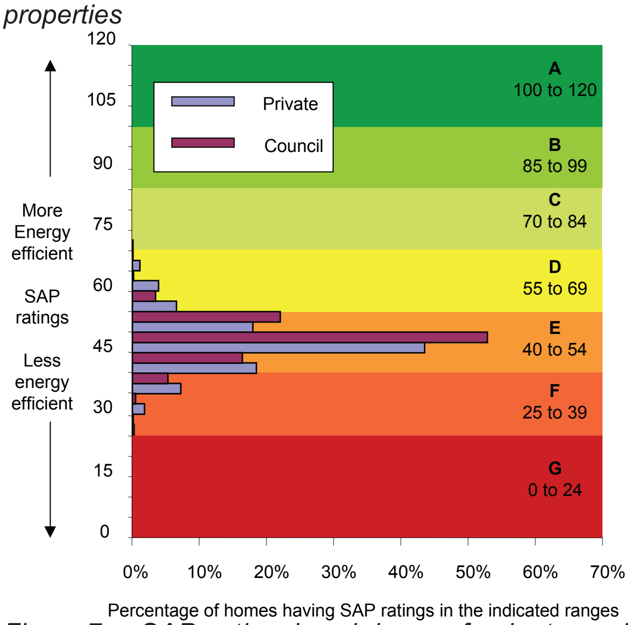

Figure 7 SAP rating breakdown of private and council domestic properties

The comparison of SAP rating between council and private properties is shown in figure 7, indicates the private housing has a wide spread of SAP ratings due to more pre 1919 private properties. The average SAP for council properties was 46.9, whilst the private properties average SAP was 47.6.

Housing Standard

The Welsh Housing Quality Standard (WHQS) is guidance for local authorities on the assessment process. The standard states that the annual energy consumption for space and water heating must be estimated using the SAP method and it sets minimum targets for each property based upon the floor area, as shown in Table 2.

Floor area m²	SAP Rating
Up to 35	58
36 to 40	59
41 to 45	60
46 to 50	61
51 to 55	62
56 to 60	63
61 to 70	64
71 to 80	65
81 to 90	66
91 to 100	67
101 to 110	68
111 to 120	69
Over 120	70

Table 2 WHQS SAP rating guidance

The SAP rating for the council owned properties were compared to the standard set out in the WHQS, and it was found that only one council property had achieved the standard. The rest required a SAP improvement of 18 on average, with some properties requiring a SAP rating improvement of upto 36 points. This level of improvement may be difficult to achieve. The breakdown is shown in figure 8. This comparison only includes energy efficiency information supplied from the HEES data as described on page 5 (*other data sources will be incorporated, when the NPTCBC data can be made compatible with the EEP database*).

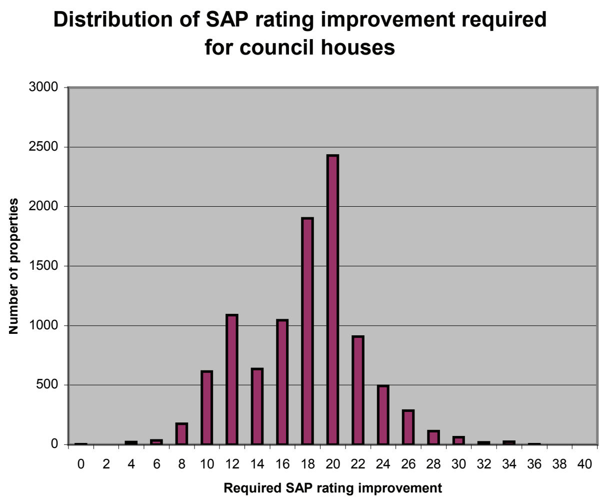

Figure 8 SAP rating improvement breakdown for council domestic properties required by the WHQS

Energy efficiency improvements of council domestic properties

The EEP model contains 9,853 council properties which have been identified from the details supplied by the council and the EEP survey. The surveyed building stock has been combined with the information from the HEES data provided by NPTCBC for the period 1991 to 2002. This has been incorporated into the survey for 6,008 properties.

The distribution of the SAP ratings for the council properties is shown in figure 9, the average rating is 46.9, the minimum is 28.2 and the maximum is 70.6. The colour bands shown in the figure are the proposed energy efficiency bands A to G where A is the most energy efficient and G is the least energy efficient.

The EEP model has been used to simulate various energy efficiency interventions. If the council were to fit double glazing and draught proofing to all the council houses the SAP distribution would improve only slightly (figure 10), the average rating for this option is 48.3, the minimum is 39.9 and the maximum is 75.3.

When increasing the insulation levels of the external walls, through cavity wall insulation or other techniques, are modelled a more significant improvement is shown (figure 11), to an average SAP rating of 57.8, the minimum is 30.9 and the maximum is 74.1. The installation of a new condensing boiler can be a quick fix for SAP rating improvement, but figure 12 shows only a slight improvement compared to wall insulation. The average SAP rating for this is 59.7, the minimum is 41.5 and the maximum is 83.4.

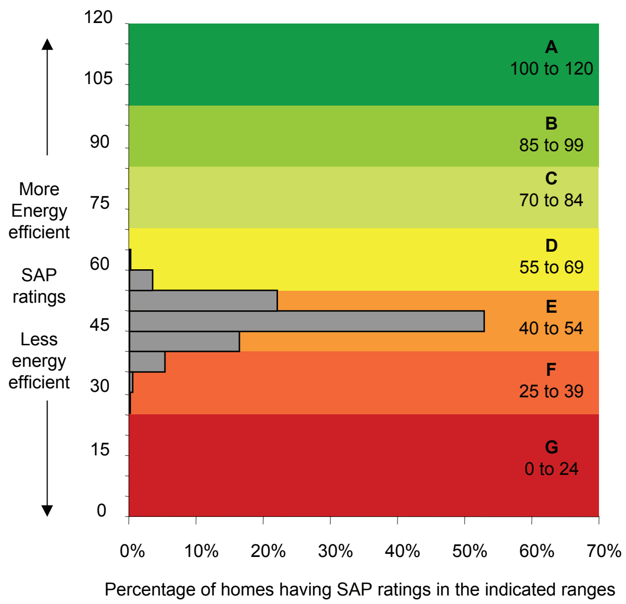

Figure 9 Distribution of the SAP ratings for current council properties

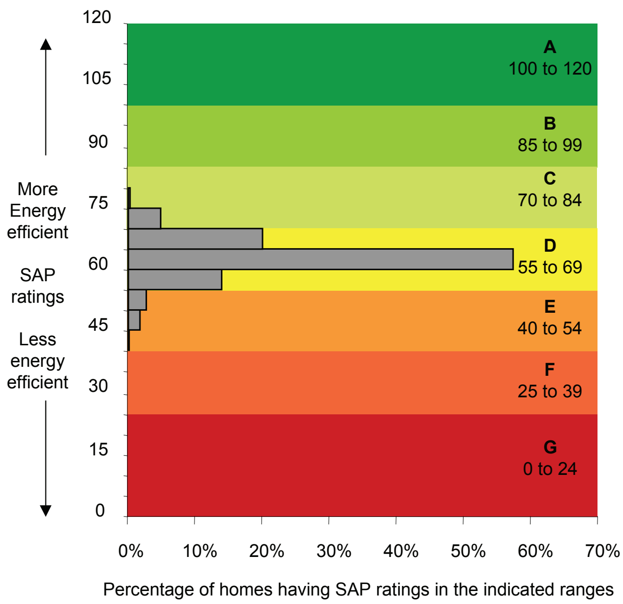

Figure 11 Distribution of the SAP ratings if all council properties had improved wall insulation

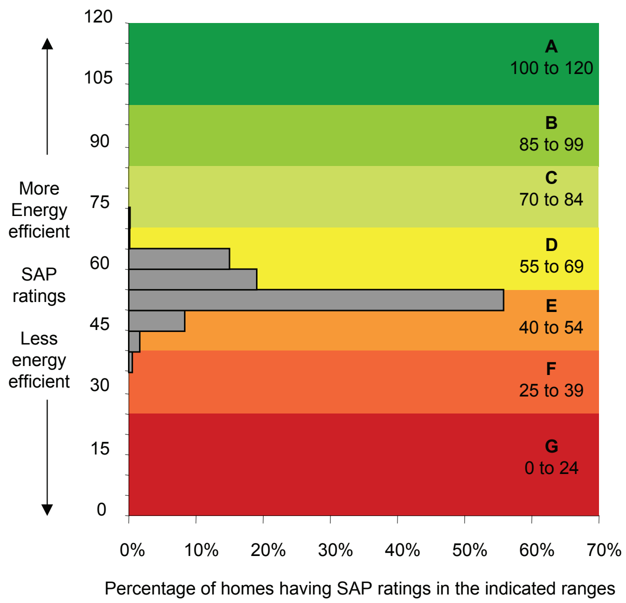

Figure 10 Distribution of the SAP ratings if all council properties had double glazing and draught proofing

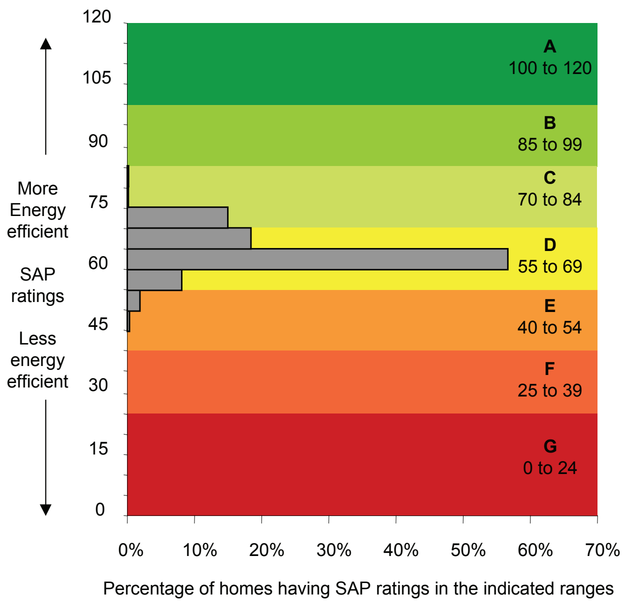

Figure 12 Distribution of the SAP ratings if all council properties had a new condensing boiler installed

EEP model has been used to establish the most economic method of improving the SAP rating to achieve the targets set out in the Welsh Housing Quality Standard (WHQS) guidance. Improvements to the energy efficiency standard have been modelled in the following cost order;

- Wall insulation improvements
- Loft insulation double glazing & draught proofing
- Double glazing
- New boiler
- New boiler and loft insulation
- New boiler and wall insulation

Data on all the installations already undertaken by NPTCBC have not been incorporate in this analysis, therefore the total cost for all these measures are likely to be overestimated.

The cost of double glazing is greater than a new boiler but may have been considered as part of a general upgrading programme, and therefore it is considered before installing a new boiler. The modelling predicts only two properties would achieve the standard if double glazing was installed.

The breakdown of energy efficiency measures required against numbers of council properties is shown in table 3, the costs of the measures has been taken from the EAGA partnership Home Energy Conservation ACT report to NPTCBC for the HEES grant scheme over the period 1st April 2000 to 31st March 2001 and the National Assembly for Wales HECA program.

The total cost for NPTCBC to achieve the required SAP standard (table 2) is £26,135,505 and would require 9852 properties to be modified. The council owns 304 houses that require more measures than specified here to achieve the standard and are shown as 'Unable to reach standard'.

Energy efficiency measure	Number of properties	Percentage of properties	Measure cost	Total cost
Cavity wall insulation installation	253	2.6%	£240	£60,720
Non-cavity wall insulation installation	14	0.1%	£4,000	£56,000
Loft insulation, double glazing and draught proofing	20	0.2%	£3,215	£64,300
Double glazing and draught proof	2	0.0%	£3,075	£6,150
New boiler	898	9.1%	£2,000	£1,796,000
New boiler and loft insulation	407	4.1%	£2,140	£870,980
New boiler and cavity wall insulation	6665	67.6%	£2,240	£14,929,600
New boiler and non-cavity wall insulation improvements	392	4.0%	£6,000	£2,352,000
All measures	897	9.1%	£5,755	£5,162,235
Unable to reach standard	304	3.1%	£2,755	£837,520
Standard achieved	1	0.0%	£0	£0
Total	9853			£26,135,505

Table 3 Number of energy efficiency packages required and costs, to achieve the WHQS guidance.

The application of improved wall insulation would raise 267 properties to the standard. The vast majority of houses would meet the standard with a new boiler and an improvement in wall insulation levels, with 6,665 houses requiring cavity wall insulation and new boiler, and 392 requiring solid wall insulation and new boiler. Nearly 900 of the council properties require all measure to meet the standard

The distribution of the SAP ratings if the improvements described in table 3 were undertaken, is shown in figure 13, the average rating is 68.9, the minimum is 57.1 and the maximum is 80.1.

If all the measures were applied to all council properties the average rating is 74.7, the minimum is 57.1 and the maximum is 93.1, the distribution is shown in figure 14.

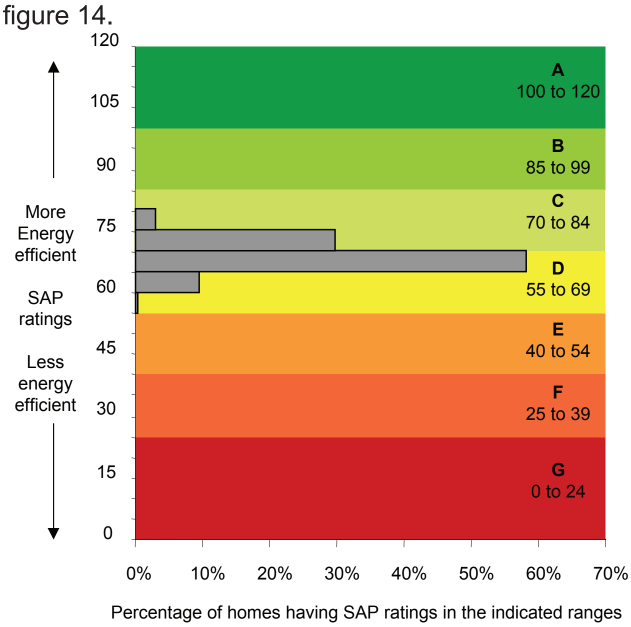

Figure 13 Distribution of the SAP ratings if council properties meet the WHQS guidance

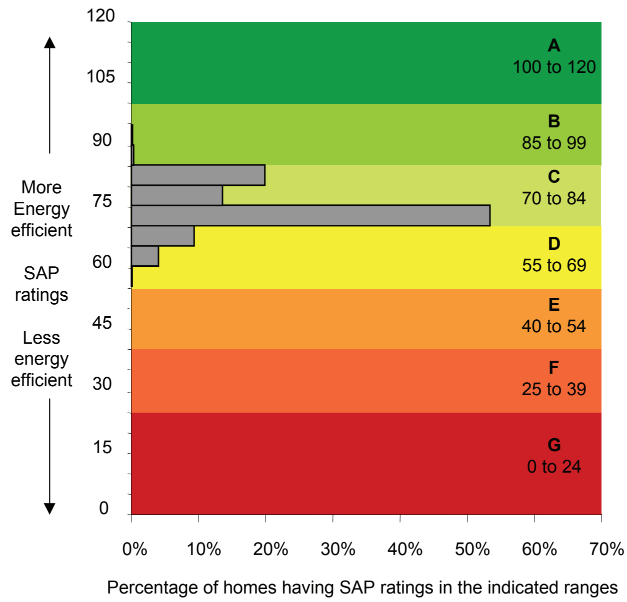

Figure 14 Distribution of the SAP ratings if all council properties had all HEES energy efficiency measures

Domestic results maps

The EEP output of the domestic sector modelling is shown in the maps of average SAP (figure 15), annual energy used (figure 16) and associated annual carbon dioxide emissions (figure 17). The energy density map, shown in figure 18, is the energy used by the domestic properties divided by the area of the ward.

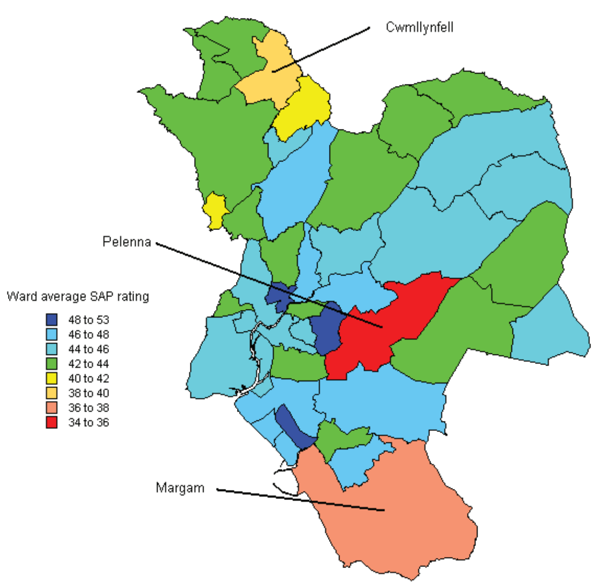

Figure 15 Average SAP rating of domestic properties by Ward

The average SAP ratings by ward (figure 15) shows that there are three areas, represented by the yellow, orange and red, Cwmllynfell, Margam and Pelenna, which have an average rating less 40. These areas may be targeted for further investigation.

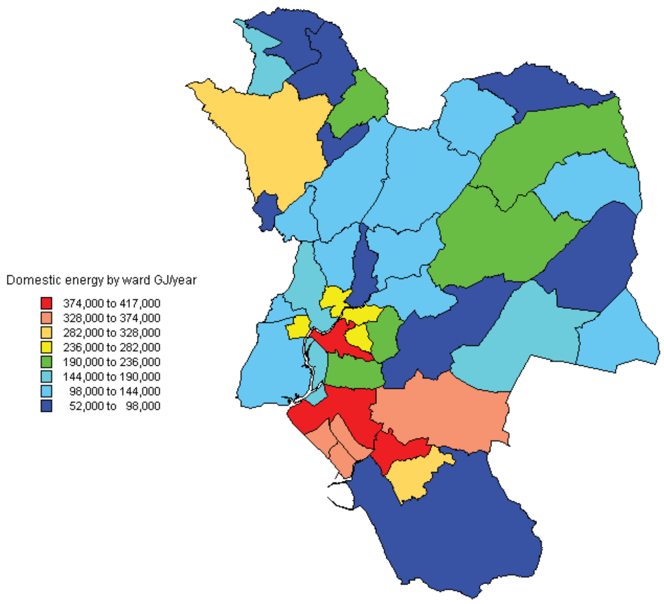

Figure 16 Total energy used by domestic properties by Ward (GJ/year)

The energy and emissions results shown in figures 16 and 17 give a picture of the distribution of energy used and related emissions, but the energy density (GJ/year/km^2) shown in figure 17 give a better picture for predicting the position of energy projects such as community heating.

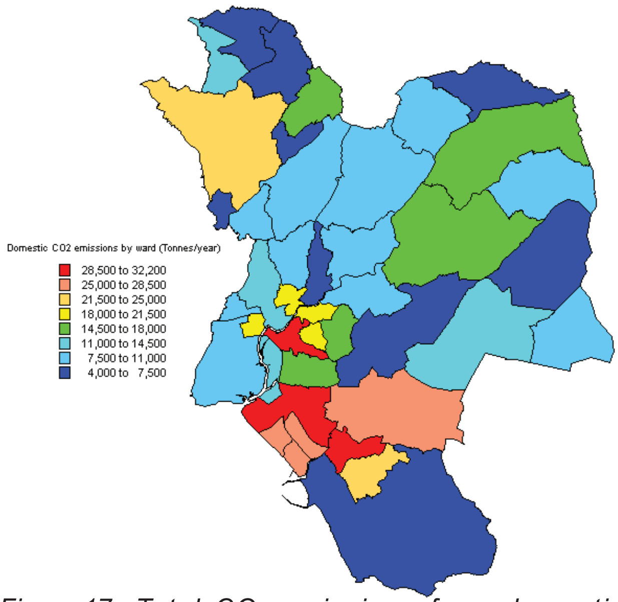

Figure 17 Total CO_2 emissions from domestic properties by Ward (Tonnes/year)

The red, pink and orange areas shown in figure 18 are the urban centres of Neath and Port Talbot. As would be expected they have the highest energy densities. Areas shown in yellow may be of interest to local community schemes to implement energy efficiency. An example of this is the Awel Aman Tawe project in the Gwaun Cae Gurwen ward shown yellow at the top of the map.

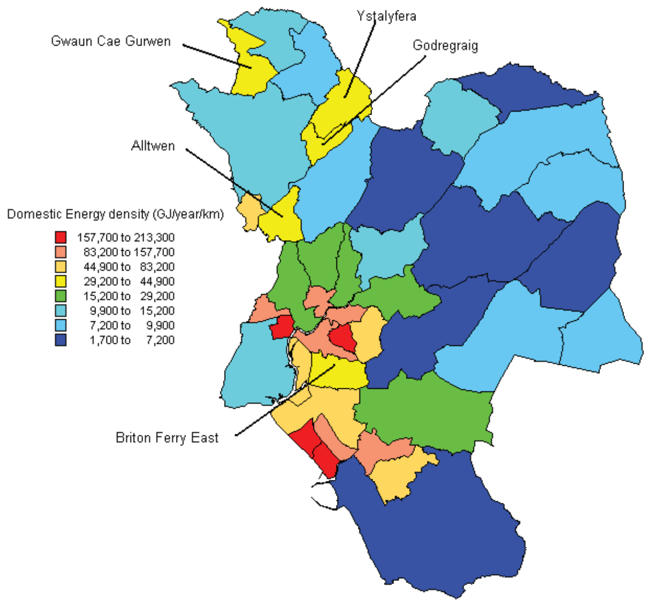

Figure 18 Energy density of domestic properties by Ward (GJ/year/km^2)

Non domestic properties results

A non domestic property provides a service to the public, for example shops, offices, sports and recreation, education etc. The list of non domestic properties for NPTCBC was generated from the Postal Address File, the Ordnance Survey Addresspoint file, and the non domestic rates database supplied by NPTCBC. This gave 3,961 non domestic properties of which 1,797 could be found in both databases and used for the EEP analysis. The non domestic properties in the EEP survey were split in to one of thirteen categories based on the Energy Efficiency Office Best Practice Programme guides, each of which has a number of sub categories (see appendix A). The results of this breakdown are shown in figure 19.

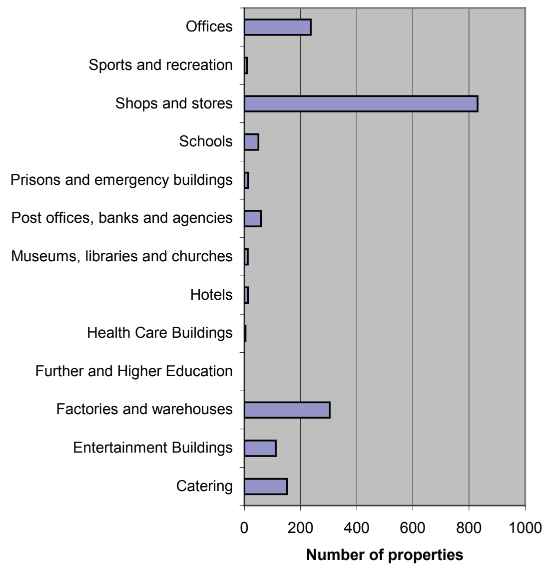

Figure 19 Estimated number of non domestic properties per category in NPTCBC

The Energy Efficiency Office best practice programme guides provide energy used and CO_2 data for the non domestic categories. The results are shown for each of these categories in figures 20 and 21.

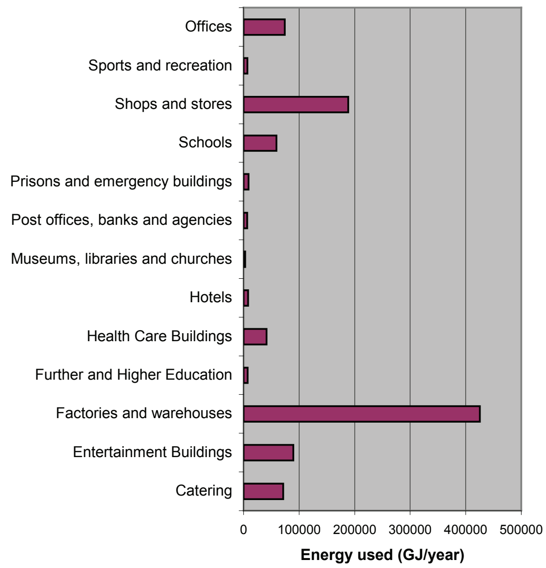

Figure 20 Energy use per category of non domestic properties (GJ/year) in NPTCBC

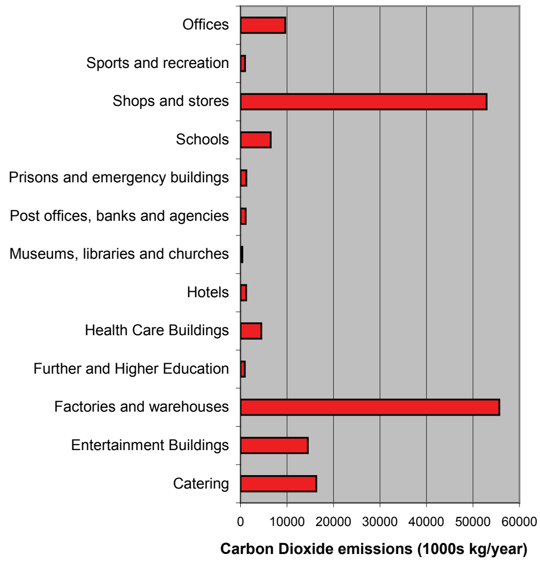

Figure 21 Carbon dioxide emissions per category of non domestic properties (1000s kg/year)

The overall results for all categories of the non domestic sector are shown at a ward level in figures 22 and 23.

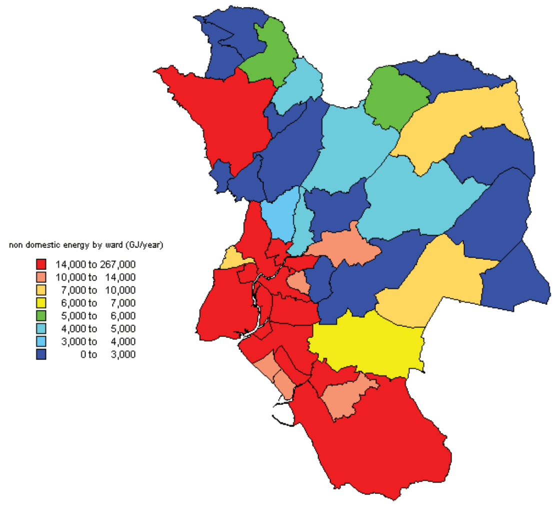

Figure 22 Energy use per ward for non domestic properties (GJ/year)

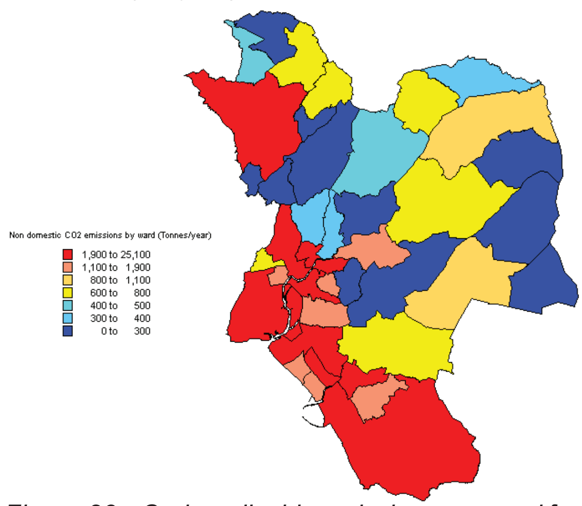

Figure 23 Carbon dioxide emissions per ward for non domestic properties (Tonnes/year)

Road traffic results

The road traffic sector results for traffic flow and emissions were generated using a space analysis model (details of the model can be found in appendix A). This allows the whole of the road network to be modelled, rather than just the main roads, and emissions predicted across the whole network.

The integration map for the whole of NPTCBC has been calculated and is shown in figure 24. This indicates roads that are likely to have high flows due to them being well integrated.

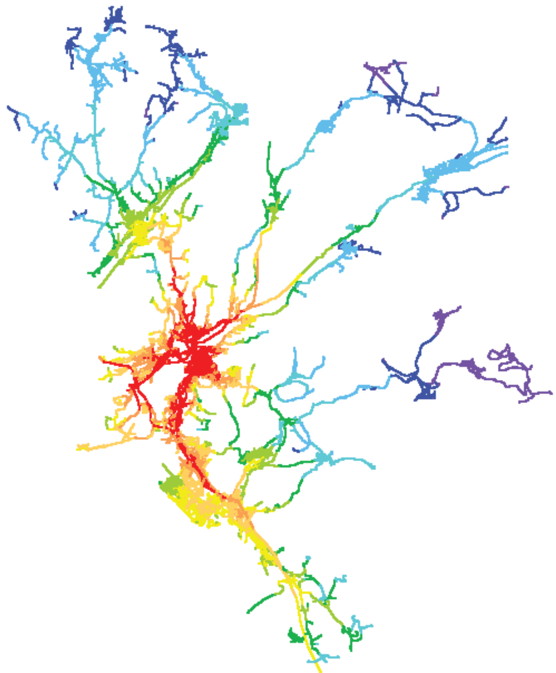

Figure 24 Road traffic integration map for NPTCBC

The results of the model are shown in figures 25 and 26, respectively for annual emissions of carbon dioxide and particulate material (PM_{10}) per ward.

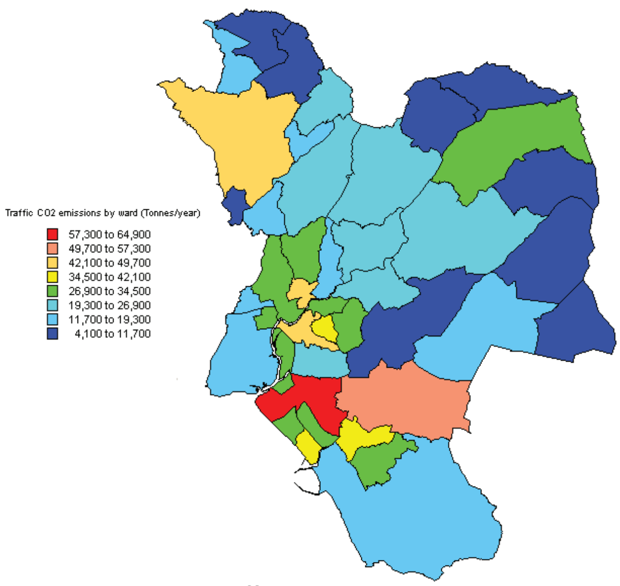

Figure 25 Road traffic carbon dioxide emission per ward (kg/year)

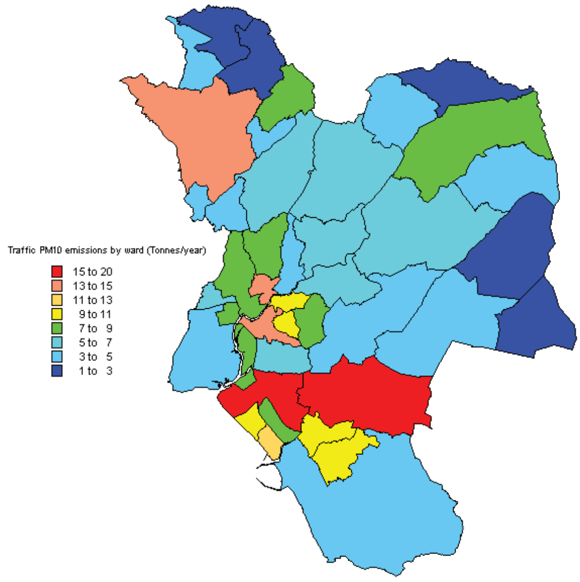

Figure 26 Road traffic particulate material emission (PM_{10}) per ward (Tonnes/year)

Llandarcy example

The integration map can also be used to predict the traffic journey impact of a new development. For example, the impact of an additional 3, 600 daily journeys from the new Llandarcy development in Neath Port Talbot on current road use levels can be assessed, figure 27.

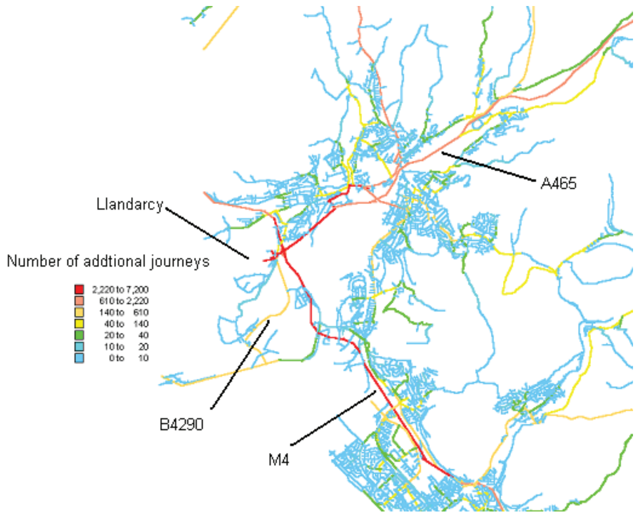

Figure 27 Road traffic particulate material emission (PM_{10}) per ward (kg/year)

The red lines represent the roads with the most additional journeys for commuting or other trips, and the blue lines represent the roads which are least effected by the proposed development. The red lines follow the M4 to the south east and the A465 to the north east.

The model also predicts some extra journeys on minor roads such as the B4290, shown on the map as an orange line.

Industrial processes results

The list of industrial processes was generated from the authorisation database supplied by NPTCBC, which is a list of all part B processes in the county area. This gives 65 industrial processes, all of which have been geographically located.

The industrial processes in the EEP survey (see appendix A) were split in to one of eleven categories. The results of this breakdown are shown in figure

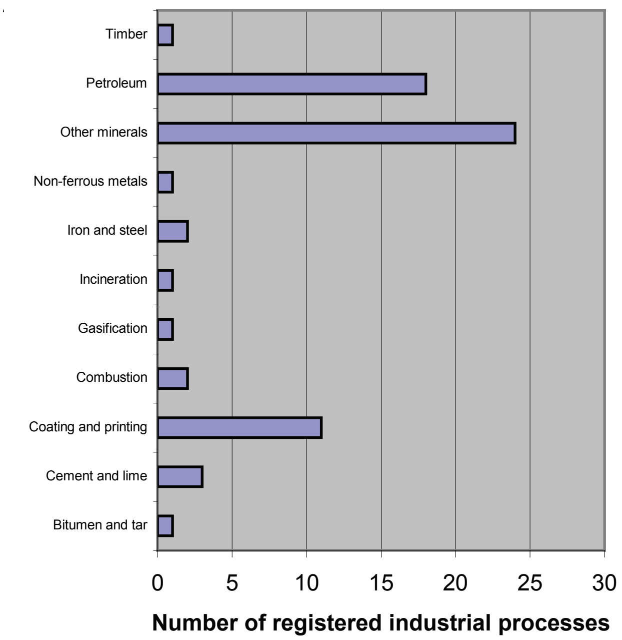

Figure 28 Estimated number of industrial processes per category for NPTCBC

Due to the lack of response from the companies contained in the council's authorisation database, emissions results could not be plotted. Therefore the only information available is the location of the industrial processes, which has been aggregated to ward areas and is shown in figure 29.

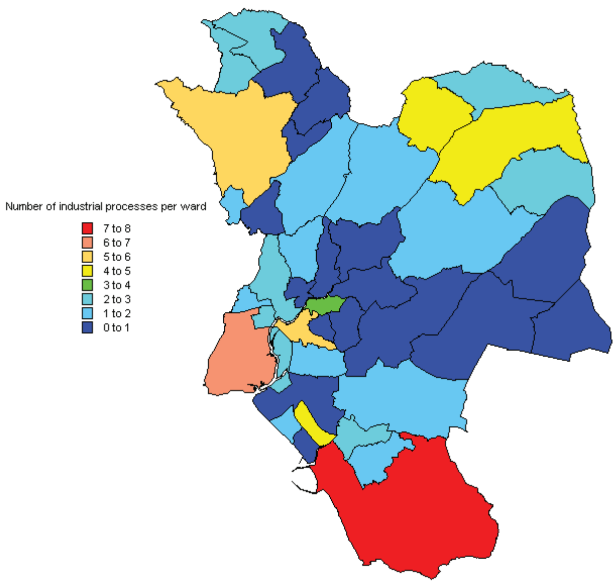

Figure 29 Estimated number of industrial processes per ward for NPTCBC

Overall results

The results from the domestic, non domestic and road traffic sectors have been combined to produce an overall picture of the energy use and carbon dioxide emissions for the whole of NPTCBC. These results are shown in figures 30 and 31.

The energy use for NPTCBC, figure 30, shows that the energy is predominately consumed by domestic properties. The EEP model has a near complete domestic survey, but has a limited industrial and non domestic survey.

The carbon dioxide emissions shown in figure 31 show differences in emissions by sector. Traffic contributes the majority of CO_2 emissions in NPTCBC. The figures given here do not included any industrial processes due to lack of information for this sector.

If the council were to improve it's domestic sector's energy efficiency as described in Table 3, there would be a reduction in energy used. This would reduce the council's domestic energy use by 34% or 390,306 GJ / year and the carbon dioxide emissions would drop by 29% or 22,800 tonnes per year.

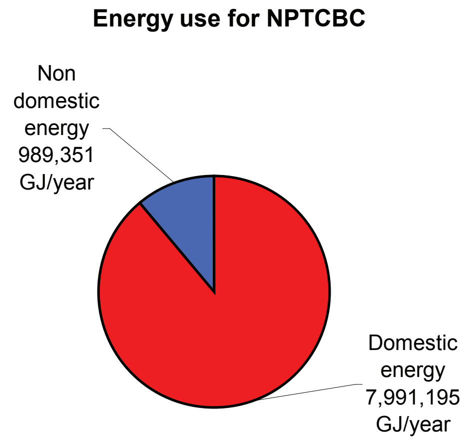

Figure 30 Breakdown of energy use by sector for NPTCBC

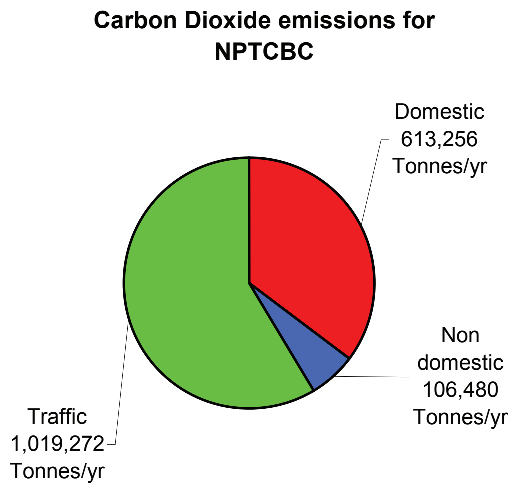

Figure 31 Breakdown of CO_2 emissions by sector for NPTCBC

Appendix A - The EEP Model

Background to Model Development

The EEP model has been developed with the intention that it will be functional within local authorities, and it has therefore been necessary to develop the model to conform to their tasks.

Discussions regarding model requirements took place with the project steering group that comprised representatives from a number of local authorities from the South Wales region. It was established that the requirements of the model were to:

- quantify energy consumption for different activity sectors and spatial areas;
- establish a baseline for energy consumption;
- calculate associated emissions from energy use;
- help assess the cost and other implications of alternative energy management options;
- predict future levels of energy consumption by activity sector and spatial area;
- monitor progress towards agreed targets;
- assess the likely effect of developments on overall travel patterns and new road systems;
- identify sites for future development in accordance with the aims of sustainable development;
- predict the incremental and cumulative impact on energy use and emissions of proposed developments and policies.

Separate submodels have been created for each sector of the built environment within the EEP model. These include procedure for predicting energy use and associated emissions within the domestic and commercial sectors and from industrial processes and traffic energy use. The submodels have been developed using existing procedures accepted by the UK government, with the exception of the traffic submodel, which has been developed using spatial analysis methods (Hillier et al., 1993) (no suitable existing procedures were available).

The EEP model framework is flexible: current submodels can be removed and those conforming to other nations' accepted procedures can be inserted as required. As more accurate procedures are developed, submodels can be altered within the framework and the model can be expanded in the future as further submodels are required.

Typically, each sector of the built environment is dealt with by different departments within a local council. For example, a department that deals with reducing energy use within the domestic sector will generally only consider domestic issues. The model has therefore been developed so that each of the submodels can be used independently. However, when data have been collected for each of the separate submodels for a region, planners can combine the submodels within the model to assess the change in energy use within all sectors throughout a particular area of the city where developments are planned.

Area Resolution

The basic premise of the EEP model is that data within a region or city under investigation can be input and examined in small areas to enable the user to pinpoint excessive energy use and associated pollution 'hotspots'. Areas of the built environment need to be grouped in order to represent data clearly on a city-wide scale; however, information has to be collected and input for relatively small areas so that emissions can be calculated to a significant level of detail.
The following procedures are used to group buildings and roads:

- domestic properties are divided into 100 types every property surveyed can be assigned to one of the types;
- non-domestic properties are surveyed individually;
- industrial properties are surveyed individually;
- for transport every road is represented.

Data for domestic, non-domestic and industrial processes are displayed to postcode level within the model; traffic can be represented either as lines or by postcode. Postcode units consider areas to a suitable level of detail for use within the model and are designed to simplify the identification of an address by allocating a six or seven figure code to one property/group of properties (up to approximately 50) and the associated road. Postcodes are designated nationally and can therefore be identified by users new to the EEP model. In other countries, alternative property grouping methods, such as zip codes, can be used within the model as an area identification method.

The Model Framework

Although the main intended use of the model is as a prediction tool, the model can also act as a database for environmental survey data. The model is based on a Personal Computer Windows environment in order to suit local council facilities and is currently based on the geographical information system (GIS) commercial software MapInfo Professional Version 4.1 and MapBasic 4.1. The framework is illustrated in Figure A1. The model is accessed via a primary user interface that guides the user to a number of submodels, via a series of menu options.

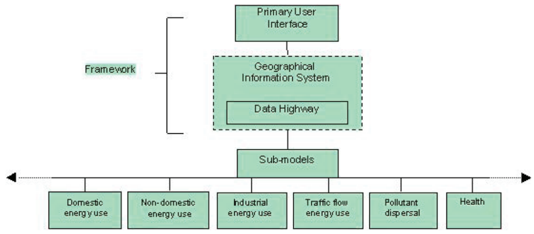

Figure A1   Model EEP Framework

Submodels

Domestic submodel.

The domestic submodel used within the EEP model is based on the UK government SAP, which is an energy rating method for dwellings (Building Research Establishment, 1994). The energy rating is expressed on a scale of 1 to 100; the higher the number, the better the standard. A computer based version of the SAP has been created for use within the EEP model; this is called DEAP (domestic energy assessment procedure).

The energy rating scheme aims to inform users of the overall energy efficiency of a home in a manner that is easy to understand and provides a method of comparison between buildings. Energy ratings enable decision makers to consider different types of energy efficiency measures available when designing new properties or refurbishing existing dwellings. Information regarding fabric, glazing, ventilation, water heating, space heating and fuel costs is required to carry out a SAP calculation.

As large numbers of properties are included within the domestic submodel when studying a city or region, information about each property has to be collected with relative ease and speed. A procedure has been developed for use within the model that groups together properties with similar energy performance characteristics. An initial survey has to be carried out on a range of sample properties within a region. Once this is complete the remaining houses can be assigned to a predefined group using a rapid survey technique (therefore using the group's assumptions).

The EEP model uses a cluster analysis technique to identify properties with similar energy consumption and emissions. The cluster analysis procedure 'forces' properties into a specified number of groups or 'clusters' based on selected built form characteristics and the age of the properties. The five characteristics used to describe an individual property in order to create clusters are: heated ground floor area (m^2); facade (m^2); window to wall ratio; exposed end area (m^2); and age. These features are considered to have the greatest influence on domestic energy performance.

Four main steps are involved in creating the clusters, and these are indicated in Table A1. The information required to describe properties during the initial survey (estimated to be 10% of the total number of dwellings) in order to carry out the cluster analysis is as follows.

Method	Cluster analysis using built form within Statistical Package for the Social Sciences	20 clusters are split using five age groups	SAP ratings are calculated for 100 properties nearest to the centre of each cluster	100 clusters are sorted using SAP ratings; the lowest SAP rating = cluster 1
Number of clusters	20	100	-	100

Table A1 Steps involved in the creation of clusters within the domestic submodel

(1) Location: each property can be located in the GIS using postcode, road name, subpostcode, subcategory (suffix to postcode for identification of cluster), number of properties within subpostcode and property numbers.

(2) Building dimensions obtained from the GIS: an estimate for each property of heated ground floor area (m^2), exposed end area (m^2), storey area (m^2) and facade area (m^2).

(3) Age obtained from historical sources. Each property is assigned to one of five different age groups: pre-1919; 1919–44; 1945–64; 1965–80; and post-1980.

(4) Built form: an unobtrusive site visit surveying number of storeys, number of chimney pots, window area (m^2) and storey height (m). Calculations made using these results comprise facade including window area (m^2), facade area excluding windows (m^2), storey area (m^2) and ratio of windows to wall area.

Assumptions made during data entry into DEAP include: number of rooms (controlled by number of floors); U values for walls, floor and roof based on age (as illustrated in Table A2); easterly facing single-glazed windows; water heated by heating source; water tank volume (120 l); space heated by wall-mounted gas boiler with balanced or open flue; and a gas mains heating system. These assumptions were based on results obtained from a questionnaire that was distributed to a sample of 2000 properties (with a 20% response rate) within Cardiff. Assumptions can be designed to suit conditions within the region under investigation.

Age Group	Wall U values
Pre-1919	2.1
1919–44	1.5
1945–64	1.2
1965–80	1
Post–1980	0.5
Property type	Floor U values
Pre-1919 mid-terrace	0.6
Pre-1919 mid-terrace	0.6
Pre-1919 other	1
Post-1919 other	0.7
Property type	Roof U values
All	0.4

Table A2 Relationship between age group/property type and different U values

The cluster analysis method enables the model to allocate a property to one of 20 built form types and one of the five age groups, producing 100 cluster types. This is similar to the HECA. The HECA also classifies dwellings into 100 different types using five age groups, four types of tenure and five types of built form. Discussions with the local council questioned the HECA classification due to large differences between properties that are assumed to have the same energy use. For example, a large privately owned three-storey end-terrace pre-1919 property may be assumed to have the same emissions as a very small privately owned two-storey mid-terrace property. It was on this basis that more built form types were included in the grouping process.

A cluster identifier tool has been created for use within the submodel. Once the clusters have been created through the initial survey, maximum and minimum values are input into a data entry file. A cluster identifier data entry screen has been produced. This tool enables the user to input the five characteristics used to identify the cluster within which the property is located.

Each of the 100 clusters has a representative calculated carbon dioxide emission value, SAP rating and yearly energy cost; these can be assumed for the property that is being analysed. For example, the carbon dioxide emissions associated with cluster 41 and therefore the property under analysis are 7250 kg/year, the annual energy cost is £569 and the SAP rating is 39.

Non-domestic submodel

The non-domestic submodel quantifies energy used within the commercial sector of the built environment. This sector includes properties that provide a service to the public but do not use energy to manufacture a product. This submodel has been developed using energy consumption and emission figures from the series of guides produced by the DoE (now the Department of the Environment, Transport and the Regions) (Energy Efficiency Office, 1994). The guides were produced for use by managers of individual commercial buildings in an attempt to highlight the importance of reducing energy consumption. This series divides non-domestic properties into 13 different groups, which are further subdivided into 48 subgroups, as illustrated in Figure A2. For example, the 'hotels' group is split into three subgroups: small hotel, business/holiday hotel and luxury hotel (illustrated in Figure A2). The number of subgroups per group varies.

The figures from the energy efficiency guides used within the submodel are provided as an energy consumption yardstick m^{2}. These indicate to building managers the level of energy consumption that is considered good, average or poor for their type of business, therefore illustrating possible savings.

Within the EEP model, data for the non-domestic submodel are collected for every single property. However, information is input and displayed by the model on a postcode basis. Data required to assess energy use and the associated emissions for non-domestic properties include the floor area (m^{2}) and the type of the property (in order to place the property in the appropriate group/subgroup). The type of property is identified using data sources such as the local council rates database and site visits. Floor area is obtained from the Ordnance Survey map or its equivalent in MapInfo.

Figure A2 The non-domestic submodel classifies buildings into 13 different groups; these are subdivided into 48 subgroups.

An energy standard (low, medium or high consumption) can be selected from the data editing screen. This is a general assessment of the current energy efficiency of the building and is usually based on the age of the property unless other information has been obtained. Every non-domestic property that has been entered is listed when a postcode is selected in MapInfo.

Industrial process submodel

The industrial process submodel includes properties where energy is being used for the production of goods. The submodel has been produced using figures presented in ETSU (1996). This document includes a database in which the emissions of a set of industrial sectors are related to energy consumption data. The database splits industrial processes into 16 different sectors, illustrated in Figure A3.

The units used to calculate energy consumption and related emissions for each of the 16 sectors vary from sector to sector due to the nature of the output. For example, output is assessed in GJ/t output for the glass and glassware industry. This information can be obtained directly from the industries within the region.

The output figure, obtained from each industry, is entered into the data entry/editing form. Information is input at a postcode level for each individual process.

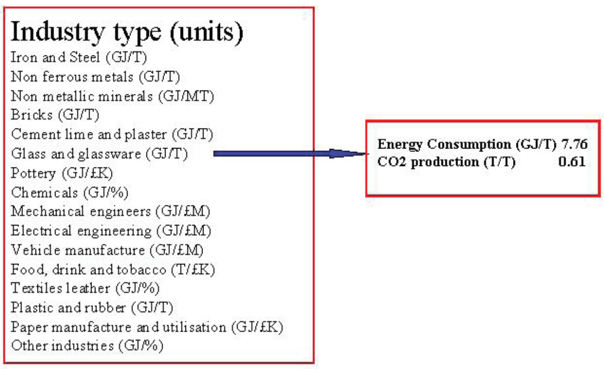

Figure A3 Sixteen different industrial sectors used in the industrial process submodel.

Traffic submodel

A method was required for the traffic submodel that would predict energy use and emissions from traffic flow on every road within the city or region. Although there are models available, such as SATURN (Van Vliet, 1982), that take into account the main junctions within a city, there are no established models that consider every single road within a region. The traffic submodel therefore uses spatial analysis procedures (Hillier *et al.*, 1993). Spatial analysis is a collective name given to a set of computer-based spatial modelling techniques used objectively to represent, quantify and analyse space at all levels within the built environment, from a single building to entire cities.

The model includes the concept of spatial integration, which provides an objective measure of the relative accessibility of each road within a region. This is a measure of the degree to which each road within a city or region is present on the simplest routes to and from all other roads, with the assumption that roads that are more integrated will be used by more traffic. A road is represented on a map (in MapInfo) by a line or a series of axial lines that follow the line of sight along a road. Any change in direction or an inaccessible route is represented by a break in the line.

The data for the road network in a region are input as a layer within MapInfo using an Ordnance Survey map or equivalent as a template. The axial map can be altered when changes in the road system occur and new roads can be inserted as required. An axial line or road that is easily accessible from all points is described as being well integrated, whilst roads that are relatively isolated are described as segregated.

A weighting factor from the Department of Transport (1990) can be applied to the integration and road length data. This enables the traffic submodel to generate corresponding emission levels, which are presented for each axial line or postcode within the region. Traffic flow can be calculated by assigning trips, either on a random basis or associated with specific developments.

Appendix B - Results tables for NPTCBC

Domestic properties

Type of Property	Number of Properties
Surveyed (those that have been surveyed and were missed during data entry)	237
Isolated properties	407
Non domestic properties	358
not visible (due to tall hedges,fences)	489
Not surveyed (should be surveyable)	837
Derelict	41
Wrong address	345
Double entry (where a house has a number and a name)	158
Does not exist	21
Total domestic properties that are entered into the EEP model	55148
Total domestic properties in NPTCBC	58041

Table B1 The breakdown of missing domestic properties from the EEP model

	Pre 1919	1919 - 1944	1945 - 1964	Post 1964
Number of private properties	18837	5935	9046	11477
Percentage of private properties	42%	13%	20%	25%
Number of council properties	480	1087	5822	2464
Percentage of council properties	5%	11%	59%	25%
Total number of properties	19317	7022	14868	13941
Total percentage of properties	35%	13%	27%	25%
Percentage of Welsh properties	33%	18%	26%	23%

Table B2 Age breakdown of domestic properties

	< 85 m²	85 - 99 m²	100 - 120 m²	> 120 m²
Number of private properties	8987	9658	12757	13893
Percentage of private properties	20%	21%	28%	31%
Number of council properties	4567	3319	1618	349
Percentage of council properties	46%	34%	16%	4%
Total number of properties	13554	12977	14375	14242
Total percentage of properties	25%	24%	26%	26%

Table B3 Heated floor area of domestic properties

	1 storey	2 storeys	3 storeys
Number of private properties	5967	38883	445
Percentage of private properties	13%	86%	1%
Number of council properties	3015	6833	5
Percentage of council properties	31%	69%	0%
Total number of properties	8982	45716	450
Total percentage of properties	16%	83%	1%

Table B4 Number of storeys of domestic properties

Ward	Domestic SAP	Domestic energy	Domestic CO2 emissions	Domestic energy density	Non domestic energy	Non domestic CO_2 emissions	Industrial processes	Traffic CO2 emissions	Traffic PM10 emissions	Total Energy	Total CO2 emissions
		GJ/year	Tonnes/ year	GJ/year/ km^2	GJ/year	Tonnes/ year		Tonnes/ year	Tonnes/ year	GJ/year	Tonnes/ year
LOWER BRYNAMMAN	43.1	83,289	6,279	10,544	1,516	164	2	8,661	2,593	84,805	15,104
G.C.G.	43.2	188,636	14,281	33,007	2,887	401	2	14,999	4,490	191,523	29,682
CWMLLYNFELL	38.7	77,588	5,809	8,355	5,100	681	0	8,367	2,504	82,688	14,856
ONLLWYN	43.7	71,156	5,422	6,564	2,819	318	2	6,281	1,880	73,975	12,021
YSTALYFERA	41.5	206,974	15,669	30,541	4,670	615	0	26,541	7,945	211,644	42,825
PONTARDAWE	42.6	286,516	21,863	9,904	19,761	2,103	5	46,822	14,016	306,277	70,788
SEVEN SISTERS	43.6	135,642	10,317	11,684	5,668	606	4	10,745	3,216	141,310	21,668
GLYNNEATH	44.1	211,197	16,150	8,173	7,910	948	4	27,976	8,374	219,107	45,074
RHOS	47.7	134,882	10,504	8,338	811	89	1	21,429	6,414	135,693	32,022
CRYNANT	43.9	117,394	8,958	5,426	4,232	488	1	19,435	5,818	121,626	28,881
GODREGRAIG	44.5	89,610	6,840	29,227	1,028	95	0	12,020	3,598	90,638	18,956
BLAENGWRACH	44.4	119,899	9,124	8,076	1,857	222	2	10,900	3,263	121,756	20,246
RESOLVEN	44.5	191,437	14,597	6,460	4,868	612	1	22,002	6,586	196,305	37,211
ALLTWEN	42.8	139,657	10,523	31,980	877	81	0	15,288	4,576	140,534	25,891
TREBANOS	40.6	86,345	6,527	44,901	1,530	183	1	11,131	3,332	87,875	17,841
GLYNCORRWG	42.1	62,806	4,819	3,163	612	63	0	4,201	1,258	63,418	9,083
ABERDULAIS	45.7	106,567	8,186	11,199	835	84	0	21,637	6,477	107,402	29,907
CADOXTON	47.1	84,330	6,531	20,296	4,117	370	0	12,924	3,869	88,447	19,825
BRYNCOCH NORTH	43.2	137,112	10,587	23,941	3,744	399	1	29,284	8,766	140,856	40,270
TONNA	47.5	130,160	10,090	17,315	12,639	1,129	0	21,520	6,442	142,799	32,739
PELENNA	34.3	52,690	4,025	2,642	1,833	181	0	10,720	3,209	54,523	14,926
CYMMER	42.4	170,251	12,986	7,232	9,926	1,015	0	16,553	4,955	180,177	30,555
BRYNCOCH SOUTH	52.0	261,797	20,746	143,293	57,885	7,207	0	48,244	14,441	319,682	76,197
GWYNFI	44.6	101,297	7,704	8,184	2,307	253	0	4,168	1,248	103,604	12,125
NEATH NORTH	43.3	262,089	20,073	157,695	138,811	18,975	3	34,196	10,236	400,900	73,244
CIMLA	49.6	200,310	15,751	51,467	2,753	244	0	29,031	8,690	203,063	45,026
NEATH SOUTH	44.6	272,806	20,802	183,337	12,552	1,212	0	36,591	10,953	285,358	58,605
BRITON FERRY E	43.9	204,012	15,587	41,131	14,126	1,642	1	21,327	6,384	218,138	38,555
BRYN & CWMAVON	46.3	351,574	27,275	15,228	6,567	741	1	52,432	15,695	358,141	80,448
ABERAVON	48.6	332,658	25,717	148,111	58,030	6,128	4	28,601	8,562	390,688	60,447
SANDFIELDS WEST	47.3	337,359	26,259	199,032	12,608	1,275	1	33,273	9,960	349,967	60,807
PORT TALBOT	43.9	386,779	29,311	98,442	45,091	5,527	2	35,609	10,659	431,870	70,447
SANDFIELDS EAST	47.8	358,301	27,783	213,274	10,664	1,226	0	39,512	11,828	368,965	68,521
TAIBACH	46.3	288,732	22,094	52,612	13,328	1,608	1	30,752	9,205	302,060	54,454
MARGAM	37.7	86,871	6,630	1,738	266,189	25,023	8	16,492	4,937	353,060	48,145
DYFFRYN	45.2	169,240	13,096	24,552	24,591	2,302	2	29,240	8,753	193,831	44,638
COEDFFRANC N	44.0	140,992	10,727	83,230	7,714	766	1	17,589	5,265	148,706	29,082
COEDFFRANC C	45.6	243,939	18,674	199,297	15,425	1,897	2	29,644	8,874	259,364	50,216
COEDFFRANC W	44.5	132,538	10,101	10,050	69,738	6,655	6	14,262	4,269	202,276	31,019
NEATH EAST	44.8	383,934	29,346	122,977	77,488	7,480	5	45,284	13,555	461,422	82,110
BRITON FERRY W	44.6	175,360	13,375	62,921	26,507	2,517	2	28,706	8,593	201,867	44,597
BAGLAN	46.6	416,469	32,117	46,244	27,740	2,954	0	64,885	19,423	444,209	99,956
TOTALS		**7,991,195**	**613,256**	**2,201,785**	**989,351**	**106,480**	**65**	**1,019,272**	**305,109**	**8,980,546**	**1,739,007**

Table B5 Ward data for each of the sub models

Appendix C - Collaborations between NPTCBC and CRiBE

The link between NPTCBC and CRiBE was started with the application of the EEP model to the local authority. This has led to a number of other research projects.

Housing and Neighbourhoods and Health (HANAH)

The HANAH project is a collaborative project between Cardiff University, the University of Wales College of Medicine and NPTCBC. The project is funded by the Medical Research Council and the Engineering and Physical Sciences Research Council, the initial funding runs from January 2001 to December 2003.

The project will develop a collaboration between architectural, environmental, public health, social and information scientists within the Cardiff University in order to study the impact of the built environment in relation to public health.

The aim of the project is to find out how the homes and communities in which people live affect their health.

Work has begun by exploring links between the type and quality of housing and neighbourhood in which people live, and relating this to asthma, heart disease, injuries and depression.

The results of the research will help planners to identify the type of housing and neighbourhoods that will improve people's health.

For more information visit the project web site at

http://www.hanahproject.com

Awel Aman Tawe

Community energy project set up by a group of residents in 1998. The aim of this project is to integrate the use of renewable energy and energy efficiency measures in the overall objective of local regeneration.

The EEP model will be used to establish baseline energy consumption figures and target areas most in need.

For more information visit the project web site at

http://www.awelamantawe.co.uk/

Energy Service Company Development

CRiBE has been asked to utilise and build upon information that has been collected as part of the EEP model in the NPTCBC. The model will help to provide information on the current energy use levels of the Briton Ferry area as part of the application to the Community Energy programme for support for development work for a community heating scheme.

Design Advice - Gateway development

CRiBE was commissioned in 1999 to prepare a design strategy and provide specialist design advice for this low energy factory for NPTCBC. The factory (figure 32) is the first to achieve BREEAM excellent in this part of the UK. The environmental laboratory at the CRiBE was used to predict the performance of the factory, including daylight, ventilation and overall energy performance as part of the BREAM submission.

In spite of these low energy design strategies the building costs are the equivalent of a standard speculative factory proving that low energy design need not incur prospective building owners in additional cost.

The building was completed this year on time and to budget and has won the 2000 CORUS design award for best industrial building and was the only building in

Figure 32 Gateway factory at Baglan Energy Park

Design Advice - Margam Country Park

Margam Country Park is a diverse and varied landscape within which there is evidence of over 4,000 years of continuous habitation and use by man and as such represents a rare and valuable learning resource and a heritage attraction of considerable distinction.

Through the design advice scheme, the potential for the use of renewable energy sources and sustainable technologies in the Park has been investigated. The Park could become a 'role model' for sustainable technology in relation to a heritage building and site.

Figure 33 Margam Park

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