EDEM detailed description: Part 1 - inputs and outputs.

Summary

EDEM is a flexible approach to mapping the possible building carbon and energy performance universe in terms of a matrix of simulation models. Each individual dwelling is then described by a specific combination of parameter which allows a discrete model to be identified which represents its behaviour. The matrix of models can be simulated for a range of different contexts e.g. climate change, changed occupancy patterns etc. to allow building performance to be established for these cases.

The case described here to illustrate the methodology is the 'Scottish Dwellings' project. Other projects exist or are in development and follow the same structure but have different parameter levels or different contexts (climates, behaviours, costs) appropriate to the specific application.

The level at which dynamic simulation is applied depends on the specific application. The 'Scottish Dwellings' application described here has pre-simulated results for the array of thermal models embedded in the tool and applies the system and context calculations to provide instant energy, carbon and cost results.

Other projects have included pre-simulated detailed modelling of plant performance or the ability to run dynamic simulation directly through the interface – these are not described in detail here.

Contents

Note: The detailed calculations and the data tables used in the calculations are described in Part 2 of the EDEM detailed description: Part 2 – Calculations and Tables. If you require a copy of Part 2 then contact edem@esru.strath.ac.uk

1. Primary input parameters (Fabric, System and Context Determinants)

The input parameters are in 3 groups; 'fabric determinants', 'system determinants' and 'context determinants'. The fabric determinants are used to select the appropriate thermal simulation models, the system determinants are used to select the appropriate system calculations, the context determinants are used to set the background for the thermal and system performance assessment and the cost calculations. Each category is described in more detail below.

1.1 Fabric input parameters and associated displayed outputs

The dwellings fabric parameters are used to select the appropriate model within the array. The heating (and cooling) energy demand of this model then represents the dwellings thermal performance. The parameters and levels that can be selected are described below as well as the associated tool output parameters:

Insulation	
poor (pre-83)	Insulation standards applied representing building standards prior to the 1981 Scottish building regulations.
standard (83-02)	Insulation standards applied representing building standards defined by the 1981 Scottish building regulations.
medium (03-07)	Insulation standards applied representing building standards defined by the 2002 Scottish building regulations.
good (post07)	Insulation standards applied representing building standards defined by the 2007 Scottish building regulations.
super (post07)	Insulation standards applied representing building standards defined by the AECB 'Gold' and 'Passivhaus' guidelines.
Outputs:	The insulation value selected is displayed in the 'Determinant levels' 'Insulation' display box.
	The **'Glz U'**, **'Roof U'**, **'Wall U'**, and **'Floor U'** display boxes in the detailed inputs columns give the U-values in W/m2K for the Insulation selection made**.**

Air-changes	
poor	This represents the value of air-changes that would be expected in a property with single glazing without draught proofing. If 'poor' is selected then an air change rate of 1.5ac/h is used.
standard	This represents the value of air-changes that would be expected in a property with good double or draught proofed single glazing. If 'standard' is selected then an air change rate of 0.85ac/h is used.

tight	This represents the value of air-changes that would be expected in a property built to 2007 details or where extensive draught proofing has been carried out (glazing, doors, loft, floor, service openings etc). If 'tight' is selected then an air change rate of 0.6ac/h is used.

Outputs: The Air change value selected is displayed in the 'Determinant levels' 'Air changes' display box.

Capacity

high   This represents a high thermal mass building where the capacity is available to interact with the occupied space. Note for this project there is an assumption that all dwellings with 'poor' insulation have 'high' thermal mass.

low   This represents a low thermal mass building or one where the thermal mass is not available to interact with the occupied space. Note for this project there is an assumption that all dwellings that do not have 'poor' insulation have 'low' thermal mass.

Outputs: The capacity value selected is displayed in the 'Determinant levels' 'Capacity' display box.

Capacity position

Inside   In this project the thermal capacity that is considered is always that available to interact with the occupied space, i.e. 'Inside' is always selected.

Outputs: The Capacity position value selected is displayed in the 'Determinant levels' 'Cap posn' display box.

Window size

Standard   In this project the window size is fixed at 17.5% of the total floor area.

Outputs: The Window size value selected is displayed in the 'Determinant levels' 'Window size' display box.

Exposure

detached   Represents a detached dwelling where all 4 sides are exposed to the external environment.

semi-detached   Represents a semi-detached or end terrace dwelling where 3
                           sides are exposed to the external environment.

mid-terrace   Represents a mid terrace dwelling where 2 sides are exposed to
                           the external environment.

flat(g)   Represents a ground floor flat where 3 sides are exposed to
                           the external environment but the roof is not exposed.

flat(t)   Represents top floor flat where 3 sides are exposed to
                           the external environment but the floor is not exposed.

flat(m)   Represents a mid floor flat where 3 sides are exposed to
                           the external environment but the roof and floor are not exposed.

Outputs: The Exposure value selected is displayed in the
                           'Determinant levels' 'Exposure' display box.

                           The number of external walls is also displayed in the 'Detailed
                           inputs' 'Ext walls' display box.

Shape

1-storey   Represents a single storey dwelling

2-storey   Represents a two storey dwelling.

Outputs: The Shape value selected is displayed in the
                           'Determinant levels' 'Shape' display box.

The fabric determinants allow the heating energy to be determined based on the appropriate
model (or thermodynamic class, TC) by reading the appropriate pre-simulated heating energy
demand value and applying the appropriate calculations. The selected model id number is
displayed in the 'Determinant levels' 'TC ID' display box.

1.2 System input parameters and associated displayed outputs

The dwellings system determinants are used to select the appropriate system calculations and
parameter values. The system input options are described below:

Hsys Fuel

main gas   This selects mains gas as the heating fuel.

electricity   This selects grid electricity as the main heating fuel.

wood / bio   This selects wood or bio-mass ass the main heating fuel.

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lpg / bt gas	This selects LPG or other bottled gas as the main heating fuel.	
oil	This selects oil as the main heating fuel.	
coal / sf	This selects coal or other processed solid fuel (smokeless coal etc.) as the main heating fuel.	
Outputs:	The Fuel selected is displayed in the 'Determinant levels' display boxes.	

Hsys Type

Hsys Type (if main gas, lpg / bt gas, oil or wood / bio Hsys Fuel selected)

fires	Individual room heaters
boiler l.eff	Low efficiency boiler
boiler m.eff	Medium efficiency boiler
boiler h.eff	High efficiency non-condensing boiler
boiler cond	Condensing boiler
u CHP	Stirling engine type individual dwelling CHP Not currently an allowed option for oil or wood / bio Hsys Fuel
com CHP	Reciprocating type community CHP system.

Hsys Type (if 'electricity' Hsys Fuel selected)

fires	Individual room heaters
storage	Individual storage type heaters
ashp	Air source heat pump feeding wet heating system
gshp	Ground source heat pump feeding wet heating system
boiler h.eff	High efficiency boiler direct heating wet radiator system
Outputs:	The heating system type selected is displayed in the appropriate 'Determinant levels' display box.
	The heat source efficiency is also displayed in the 'Heff %' 'Detailed inputs' display box. A second efficiency value for the complete space heating system 'Heff Adj %' takes account of the 'Controls' selection.

HWsys type

main tank   The main space heating source also heats the hot water in a storage tank system.

main combi   The main space heating source also heats the hot water in an instant heat 'combi' system.

elec immer   A separate electric immersion heater is used to heat the hot water in a storage tank system.

inst gas   A separate gas heater is used to heat the hot water in an instant heat system.

inst elec   A separate electric heater is used to heat the hot water in an instant heat system.

Outputs: The hot water heating system type selected is displayed in the appropriate 'Determinant levels' display box.

      The hot water heat source efficiency is also displayed in the 'Hw Eff Adj %' 'Detailed inputs' display box. Note: this value includes any adjustment for the water heating efficiency based on the 'Controls' selection.

Controls

standard   This selection indicates that the controls are typical for the associated Hsys type selection.

advanced   This selection indicates that the controls have been upgraded to the best practice controls for the Hsys type selection.

Outputs: The Controls selected is displayed in the appropriate 'Determinant levels' display box.

      The 'Heff Adj %' and the 'Hw Eff Adj %' 'Detailed inputs' display values include the control adjustments.

Lights

100% lel   This selection indicates that all of the light is provided by CFL lighting.

0% lel   This selection indicates that all of the lighting is provided with incandescent light bulbs.

Outputs: The selection is displayed in the appropriate 'Determinant levels' display box.

Vent / Cool

nat / wet ext	This selection indicates that there is no centralised ventilation system and that the primary ventilation is by natural means i.e. trickle vents, window opening and infiltration. In addition there is intermittent extract by local fans from the bathroom and kitchen areas.
mvhr std	This selection indicates a whole dwelling mechanical ventilation system with heat recovery. In this case the system has standard performance of 66% heat recovery and 2w/l/s specific fan power.
mvhr h.eff	This selection indicates a whole dwelling mechanical ventilation system with heat recovery. In this case the system has good performance of 85% heat recovery and 1w/l/s specific fan power.
mvhr super	This selection indicates a whole dwelling mechanical ventilation system with heat recovery. In this case the system has super performance of 88% heat recovery and 0.6w/l/s specific fan power. This option is only allowed together with 'tight' Air change selection and assumes a very low level of infiltration.
Air-cond	This selection indicates that comfort cooling is installed.
Outputs:	The selection is displayed in the appropriate 'Determinant levels' display box.

Renewables

Sol 4m2 FP	Solar hot water heating with a 4m2 flat plate system
Sol 4m2 ET	Solar hot water heating with a 4m2 evac tube system
PV 8m2 mon	PV generation with 8m2 mono-xtal panels
PV 8m2 poly	PV generation with 8m2 poly-xtal panels
PV 8m2 amor	PV generation with 8m2 amorphous panels
Sol + PV	Solar hot water heating (Sol 4m2 FP) plus PV generation with 8m2 mono-xtal panels
WT 2m	Wind turbine with 2m diameter, tall mast and 4.4m/s local wind speed (rural UK only)
WT 3m	Wind turbine with 3m diameter, tall mast and 4.4m/s local wind speed (rural UK only)
Sol + WT	Solar hot water heating (Sol 4m2 FP) plus wind turbine with 2m diameter, tall mast and 4.4m/s local wind speed (rural UK only)
Outputs:	The selection is displayed in the appropriate 'Determinant levels' display box.
	The local wind speed is also displayed in the 'More details' 'Wind speed' display box.

1.3 Context input parameters and associated displayed outputs

The context determinants are used to select the appropriate context calculations and parameter values. The context input options are described below:

Climate

UK std　　　　This selection gives a climate context similar to that used in the Governments SAP methodology. Note: this is the only option available in the current public release version.

Sco std　　　　This selection gives a standard Scottish climate. Note: this option not available in the current public release version.

London　　　　This selection gives a standard London climate. Note: this option not available in the current public release version.

Paris　　　　This selection gives a standard Paris climate. Note: this option not available in the current public release version.

Outputs:　　　　The selection is displayed in the appropriate 'Determinant levels' display box.

HT demand

Scot std　　　　This selection gives an averaged UK heating profile similar to that used in the Governments SAP methodology. Note: this is the only option available in the current public release version.

Frugal　　　　This selection gives a reduced heating profile and could represent occupant behaviour in the case of very high fuel prices etc. Note: this option not available in the current public release version.

Profligate　　　　This selection gives an increased heating profile (constant 23oC) and could represent occupant behaviour in the case of very low fuel prices etc. Note: this option not available in the current public release version.

Outputs:　　　　The selection is displayed in the appropriate 'Determinant levels' display box.

HW demand

Scot std This selection gives an averaged UK hot water use profile similar to that used in the Governments SAP methodology. <u>Note: this is the only option available in the current public release version.</u>

Frugal This selection gives a reduced hot water use profile and could represent occupant behaviour in the case of very high fuel prices or the use of low water use fittings and appliances etc. Note: this option not available in the current public release version.

Profligate This selection gives an increased hot water demand profile and could represent occupant behaviour in the case of very low fuel prices etc. Note: this option not available in the current public release version.

Outputs: The selection is displayed in the appropriate 'Determinant levels' display box.

Appliances

standard This selection gives an averaged UK appliances use profile similar to that used in the Governments SAP methodology. <u>Note: this is the only option available in the current public release version.</u>

Frugal This selection gives a reduced appliance use profile and could represent occupant behaviour in the case of very high fuel prices etc. Note: this option not available in the current public release version.

Profligate This selection gives an increased appliance use profile and could represent occupant behaviour in the case of very low fuel prices etc. Note: this option not available in the current public release version.

Outputs: The selection is displayed in the appropriate 'Determinant levels' display box.

Grid Intensity

UK std This selection gives an averaged UK CO_2 emissions factor profile by fuel type similar to that used in the Governments SAP methodology.

low CO2 el This selection gives a reduced CO_2 emissions factor for the electric grid - consistent with a much higher use of renewable and nuclear generation than the current UK standard assumptions.

high CO2 el This selection gives an increased CO_2 emissions factor for the electric grid - consistent with a much lower use of renewable and nuclear generation than the current UK standard assumptions.

Outputs: The selection is displayed in the appropriate 'Determinant levels' display box.

Tariff £

standard   This selection gives a fuel unit cost and standing charge similar to that used in the Governments SAP methodology.

2Xstandard This selection gives unit cost and standing charge 2X standard to represent possible fuel price increases.

Outputs: The selection is displayed in the appropriate 'Determinant levels' display box.

Capital £

standard   This selection gives capital costs for upgrade of fabric and systems based on current costs.

0.5Xstandard This selection gives capital costs of 0.5X standard to represent possible price reduction due to increased volumes in future.

Outputs: The selection is displayed in the appropriate 'Determinant levels' display box.

2. Secondary inputs (Categories list, Fabric Slider, System slider, More detailed inputs)

2.1 Categories list and sliders

The primary input parameters are used in the calculations as described above in section 1 but there are other ways of selecting these input parameters rather than setting each directly.

The **'Categories list'** can be used to set the fabric and system parameters to those pre-determined for a specific dwelling or dwelling type e.g. selection of 'Detached-pre 1981 – reg boiler l.eff' sets the fabric determinants to 'poor' insulation, 'poor' air changes, 'detached' exposure, 'main gas' fuel, 'boiler l.eff' heating system etc. The categories list can be customised to meet the requirements of a specific project.

The **'Fabric slider'** and **'System slider'** also allow the indirect selection of determinants. In this case the sliders position represents the incremental level of CO_2 performance.

Where the fabric slider position is to the left hand side then the fabric has high associated CO_2 emissions (i.e. poor insulation, poor air-changes), where the fabric slider is moved to the right hand side then the fabric has low associated CO_2 emissions (i.e. super insulation, tight air-changes). The fabric slider follows the insulation and air-changes selections or if the slider is manually adjusted it forces the insulation and air-change settings to those appropriate to the new slider position. In this way the slider can be used to investigate the impact of fabric improvements.

The system slider operates in a similar fashion. When the slider position is to the left hand side then the heating system has high associated CO_2 emissions (i.e. coal, open fires), where the fabric slider is moved to the right hand side then the heating system has low associated CO_2 emissions (i.e. wood fired CHP). The slider follows the heating fuel and system type selections or if the slider is manually adjusted it forces the fuel and system settings to those appropriate to the new slider position. In this way the slider can be used to investigate the impact of system improvements.

2.2 More detailed inputs

The **'More detailed input'** button opens up a window which allows entry of a set of inputs allowing greater resolution than those available through the main interface. This window can be customised to meet the needs of each different project. For the Scottish Dwellings project these more detailed inputs are to allow the building form, insulation levels and systems to be specified in more detail. The details are held until the **'Clear detailed input'** button is selected.

Building form	
non-sep cons	This selection indicates a conservatory has been added to a dwelling but not thermally separated by good quality doors, walls and windows, this has the effect of negatively impacting the thermal insulation of the property.
ceiling height	This selection selects either 'average' or 'high' ceilings.
floor area	This box allows the floor area to be entered directly rather than using the default values of 94m2 for a house and 71m2 for a flat.
wall cavity y/n?	This box allows the type of wall upgrade to be specified to allow appropriate costs to be allocated, wall cavity fill has a lower cost than internal or external insulation.

solid floor y/n?   This box allows the type of floor upgrade to be specified to allow appropriate costs to be allocated, suspended wooden floor upgrade has a lower cost than solid floor insulation.

flat roof y/n?   This box allows the type of roof upgrade to be specified to allow appropriate costs to be allocated, pitched roof upgrade has a lower cost than flat roof insulation.

Insulation

glazing U-value   This allows a glazing-only upgrade to be selected rather than the package of upgrades available through the main screen categories which include wall, roof and floor upgrades.

roof/loft U-value   This allows a roof-only upgrade to be selected rather than the package of upgrades available through the main screen categories which include wall, glazing and floor upgrades.

wall U-value   This allows a wall-only upgrade to be selected rather than the package of upgrades available through the main screen categories which include roof, glazing and floor upgrades.

floor U-value   This allows a floor-only upgrade to be selected rather than the package of upgrades available through the main screen categories which include roof, glazing and wall upgrades.

System

Heating eff %   This allows the heating efficiency to be entered directly rather than accepting the default values from the main inputs.

Sec heat type   This allows a secondary heating system to be specified which is assumed to supply 10% of the heating demand. If not selected then the main heating system is assumed to deliver all of the heating demand.

Local wind speed   This allows a specific value to be entered rather than the default of 4.4m/s.

Outputs: The selections are displayed in the appropriate 'Detailed inputs' display boxes.

Where detailed inputs have been used then 'yes' is displayed in the 'Detailed inputs?' box.

3. Results (Energy, Carbon, Cost, Comparison to base, Ratings)

The 'Results' area is at the bottom right hand corner of the tool. The results are given as a comparison between the 'base' and the 'current' dwellings. The base is set using the **'Select base'** button and cleared using the **'Clear base'** button. Note that when a base has been selected then the building form is kept constant for the base and current dwelling (i.e. exposure, shape, ceiling height, floor area) until the base is cleared.

3.1 The CO_2 rater

The results can also be displayed in the form of an energy certificate, this has been calculated based on the SAP2005 method utilising the 'Environmental Impact' (EI) parameter to establish the rating band and score for the base and current dwelling. The rating is based on the EI score which is calculated from the Carbon Emissions rate for Heating, Hot water, Ventilation and Lighting (but excludes Appliance energy use).

CER kgCO2/m2 p.a.   This value represents the annual carbon emissions in kgCO2 per m2 of floor area including heating, hot water, ventilation and lighting but not appliances. This value is consistent with the CER from SAP 2005.

EI score   This value the Environmental Impact with a value between 1 and 100, 100 being best. It is calculated from the CER in 2 stages, the first being to apply a factor to eliminate the effect of floor area on the CER, then the second is to apply a function relating the adjusted CER to a 1 to 100 EI score. (SAP2005).

Rating   The ratings have been calculated based on the EI score and the bands defined in SAP2005.

3.2 Energy results

Heating kWh/m2 p.a.   This value represents the fuel used in kWh/m2 per year to satisfy the heating demand.

Hot water kWh/m2 p.a.   This value represents the fuel used in kWh/m2 per year to satisfy the hot water demand.

Lighting kWh/m2 p.a.   This value represents the fuel used in kWh/m2 per year to satisfy the lighting demand.

Appliances kWh/m2 p.a.   This value represents the fuel used in kWh/m2 per year to satisfy the appliances demand.

Vent Cool kWh/m2 p.a.   This value represents the fuel used in kWh/m2 per year to satisfy the ventilation and cooling demand.

Sol thermal kWh/m2 p.a.   This value represents the solar thermal contribution in kWh/m2 per year towards the hot water heating demand.

RES el gen kWh/m2 p.a.   This value represents the electricity generated from renewables (PV or wind turbine) or CHP systems normalised to the dwelling floor area in kWh/m2 per year.

H,HW,L,A elec kWh/m2 p.a. This value represents the annual electricity demand in kWh per m2 of floor area including heating, hot water, lighting, ventilation and appliances.

H,HW,L,A other kWh/m2 p.a. This value represents the annual non-electricity fuel demand in kWh per m2 of floor area including heating, hot water, lighting, ventilation and appliances. (i.e. the non-electric fuel demand).

3.3 Carbon results

H,HW,L,A kgCO2/m2 p.a. This value represents the annual carbon emissions in $kgCO_2$ per m2 of floor area including heating, hot water, lighting, ventilation and appliances.

CER kgCO2/m2 p.a. This value represents the annual carbon emissions in $kgCO_2$ per m2 of floor area including heating, hot water, ventilation and lighting <u>but not appliances</u>. This value is consistent with the CER from SAP 2005.

Carbon footprint kgCO2 p.a. This value represents the dwellings annual carbon emissions in $kgCO_2$ including heating, hot water lighting, ventilation and appliances.

3.4 Cost results

Running cost £ p.a. This value represents the annual running costs for fuel (unit cost plus standing charges) including heating, hot water, lighting, ventilation and appliances.

Capital cost £ This value represents the capital cost for the upgrades required to change the base dwelling to match the current dwelling including fabric, fuel change and system costs.

Payback (years) This value represents the capital cost for the upgrades required to change the base dwelling to match the current dwelling divided by the running cost annual savings.