The Practicalities of Reaching NHER 20

NHER Information Paper 07/02

January 2007

Authors: Dyfrig Hughes, John Willoughby and Lisa McNeil

National Energy Services Ltd. • The National Energy Centre • Davy Avenue • Knowlhill • Milton Keynes MK5 8NA
Tel. 01908 672787 • Fax. 01908 662296 • e-mail enquiry@nesltd.co.uk

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1 Introduction

The NHER scale has been extended to be a 0 - 20 scale to take account of the fact that modern houses often reached 10 on the old scale. NHER 20 represents zero total fuel costs, which is a very demanding target. The thinking behind this is described in the NHER information Paper 07/01 "The new NHER Scale and BREDEM 12 2006".

This paper (NHER Information Paper 07/02) looks at the new NHER scale in relation to a typical 88m^2 semi-detached house. The aim is to see where a new dwelling sits on the scale, to look at what effect various improvements might make and to show what is required to reach an NHER of 20.

The UK government recently announced its goal that all new homes will be 'zero carbon' by 2016. NHER software is the perfect tool for pursuing this goal, given that the NHER and associated CO_2 emissions are based upon the total energy consumption of a dwelling.

The paper also looks at how the different standards in the Code for Sustainable Homes translate into NHER ratings and investigates how the NHER cost based scale can provide value within a carbon-based strategy for improvement.

2 Methodology

The dwelling used for the modelling exercise is one of BRE's standard house types, located in the East Pennines. It has been modelled using the NHER Plan Assessor Version2.1 software.

We look at where on the new NHER scale the sample dwelling will sit, if built to the various standards including:

- Building Regulations for England and Wales (April 2006)
- Code for Sustainable Homes Level 3 / EST Best Practice Standard
- Code for Sustainable Homes Level 4
- Code for Sustainable Homes Level 5

The Energy Saving Trust (EST) Best Practice and Advanced Practice Standards can be seen at
http://www.est.org.uk/housingbuildings/professionals/standards/goodandadvanced/

The Code for Sustainable Homes standards can be seen at:
http://www.planningportal.gov.uk/uploads/code_for_sust_homes.pdf

Table 1 shows the NHER, running costs and CO_2 emissions for various scenarios, starting with a dwelling built to the 2006 Building Regulations for England and Wales.

		NHER	**Total Running Costs** **£/ year**	**Total** **CO_2/m^2/year**	**DER** **CO_2/m^2/year**
Base Case *MODEL A*	Building Regulations 2006	9.8	664	35.6	22.7
Best Practice Standard *MODEL B*	Code for Sustainable Homes Level 3	10.9	594	29.1	16.9
Advanced Standard Fabric Measures *MODEL C*		11.4	564	26.1	14.2
Advanced Standard Fabric Measures + Solar Thermal *MODEL D*	Code for Sustainable Homes Level 4	11.8	535	23.5	11.7
MODEL D + 2.35 kWp PV *MODEL E*	Code for Sustainable Homes Level 5	13.6	442	14.6	0.00
MODEL D + 3.5kWp PV *MODEL F*		14.5	397	10.4	-5.8
MODEL D + 5.5 kWp PV + Wood Heating *MODEL G*	Code for Sustainable Homes Level 6	15.0	366	0	-20.9
MODEL D + 6.3 kWp PV *MODEL H*	Code for Sustainable Homes Level 6	16.7	288	0	-19.6

Table 1: Effect on NHER and CO_2 of various packages of improvements

2.1 Building Regulations 2006 (Base Case)

There are many ways in which a dwelling can be configured to pass the 2006 Building Regulations. Appendix A (Model A) shows how this was achieved for the sample dwelling. The main characteristics are U-values: Wall = 0.29, Windows = 1.8, Roof = 0.14, Floor = 0.25 and an 'A' rated boiler.

The Building Regulations dwelling has an NHER of 9.8 and associated total annual running costs of £664.

It should be noted that not all homes that comply with the 2006 Buildings Regulations will have as high an NHER as this dwelling. This is because the Building Regulations are carbon based, not cost based. A dwelling with on peak electric heating for example would have similar carbon emissions to one with storage heaters, but would have substantially higher fuel costs and hence a lower NHER.

2.2 EST Best Practice Standard (Code for Sustainable Homes Level 3)

The EST Best Practice Standard calls for a 25% reduction on the 2006 TER with design limits on U-values. This is the same standard that is required to achieve the improvement in carbon emissions of Level 3 of the Code for Sustainable Homes. The main design improvements made are:

- 150mm fully filled cavity, small improvements to the U-values of other elements.
- Whole house heat recovery ventilation system instead of extract fans
- Sealing work to improve air tightness
- 75% of internal lighting to be low energy

The NHER increases by 1.1 in moving from the Building Regulations (2006) Standard to the EST Best Practice Standard, to a value of 10.9 with associated total running costs of £554.

See Appendix A (Model B) for the full details of how the 25% reduction on the 2006 TER has been achieved.

2.3 EST Advanced Standard Fabric Measures

The NHER increases by a further 0.5, to 11.4, if the Advanced Fabric Standards are applied instead of the Best Practice Standard. This is a relatively small increase given extensive changes that are required to shift to the higher standard. The heating costs in this case have dropped to zero from just £37 for the Best Practice Standard. Further improvements clearly have to come elsewhere than from improvements to the building fabric.

See Appendix A (Model C) for full details of the EST Advanced Standard Fabric Measures.

2.4 EST Advanced Standard Fabric Measures + Solar Thermal (Code for Sustainable Homes Level 4)

The hot water fuel costs are the next obvious target. Solar hot water systems are now becoming more mainstream and more reasonably priced. The assessment assumes the addition of $4m^2$ of South facing solar thermal panels contributing to the hot water.

The CO_2 emission levels of this model meet the Code for Sustainable Homes Level 4 of a 44% reduction in the DER. The NHER of the house increases by a further 0.4 points to 11.8, with total annual running costs of over £530. Hot water costs reduce by £29 per year to £38.

See Appendix A (Model D) for the full details of the Code for Sustainable Homes Level 4 specifications.

2.5 EST Advanced Standard Fabric Measures + Solar Thermal + PV (Code for Sustainable Homes Level 5)

The next target is electricity usage. Appliances usage costs around £340 per annum, dwarfing all other fuel costs. Photovoltaic panels supplying electricity for internal use and export to the grid could make a big impact, albeit currently at high capital cost. The hipped gable roof restricts the maximum area of PV panels to about 28 m^2 with a peak power output of about 3.5 kWp (Model F). This would contribute about 2800 kWh/yr.

The NHER increases by 2.7 to 14.5 still a long way off NHER 20. This is firstly, because the PV electricity generated only offsets the appliance consumption by 38% to £230. Secondly, because cooking costs a further £52, hot water still costs £38 and then there is £102 worth of standing charges.

It will therefore be very difficult to reach NHER 20 without targeting the appliances consumption and having some form of electricity generation external to the dwelling, e.g. through a communal scheme shared with other residents. The impact of photovoltaics is moderated by the assumption made in the NHER (and SAP) calculations that 70% of the electricity generated is exported to the grid at a fairly low price (3 pence per unit) as compared with the cost of purchasing electricity from the grid (10 pence per unit).

It is interesting to note that although this model is some way off the target of NHER 20, we have reached the Code for Sustainable Homes Level 5.

2.6 EST Advanced Standard Fabric Measures + Solar Thermal + PV (Code for Sustainable Homes Level 6)

Level 6 can be reached with 5.5 kWp of PV, if wood is used as the main fuel for heating and hot water. Introducing a wood based fuel will dramatically reduce the CO_2 emissions but also reduce the NHER due to the higher cost of this fuel. The NHER increases to 15.0 due to the extra PV, with running costs of £366.

If gas heating is retained, 6.3 kWp of PV is needed to reach Level 6. The NHER rises to 16.7 and running costs drop to £288. We are now at zero total carbon, but still have some way to go to reach NHER 20.

See Appendix A (Model E, G, H) for full details of the Code for Sustainable Homes Level 5 and Level 6 specifications.

3 Other ways of increasing the NHER

Other measures not considered so far, which could impact the NHER are:

- Providing a cheaper source of cooking
- Condensing gas fire for secondary heating
- Micro CHP
- Wind turbines, either rooftop or free standing

The standard assumption made is that the **cooker** will be a gas hob and electric oven. Providing a gas only oven would raise the NHER by a further 0.3 to 14.8 and reduce running costs by a further £21. However, this is unlikely to be popular with home purchasers and this option is therefore ruled out.

A **condensing gas fire,** rather than a balanced flue, would seem a promising option. However, these are not currently available and at this level of energy efficiency there is zero heat requirement. Therefore, for the dwelling with advanced standard fabric measures, this would have no impact on the NHER.

Micro CHP has not been considered, despite its recent addition to NHER Plan Assessor. There are no commercially available units suitable for new housing, presumably because they are unsuitable for dwellings with a low heat demand. Manufacturers have not submitted any details for inclusion in the Boiler Efficiency database so that systems cannot in practice be modelled in NHER Plan Assessor.

Wind Power cannot yet be modelled accurately in NHER Plan Assessor, although this is expected to change at some point during 2007 by using the Special Features option (SAP 2005, Appendix Q). However, it is possible to estimate the impact on the NHER by selecting the amount of PV that would generate the equivalent output of a wind generator. There has been much talk about micro wind turbines attached to buildings with many exaggerated claims being made.
The output from the turbines are often quoted using an unrealistically high wind speeds such as 12 m/s, whereas average wind speeds in urban areas are more likely to be around 2 or 3 m/s. Since the output of a wind generator is related to the cube of the wind speed, electricity production is likely to be far below expectations. Better outputs might be achieved from a small turbine mounted remotely from the building. If it is a fairly windy site and a high mast can be erected, then a small wind turbine is a potential option. The NHER is estimated to increase by between 0.5 (1 kW turbine) to 3.0 (2.5 kW turbine).

4 Reaching NHER 20

NHER 20 is a highly ambitious target. It can only be achieved in a dwelling, which generates sufficient income from generated energy to offset unavoidable fuel costs and standing charges. To reach NHER 20 in the Advanced Standard Fabric dwelling with solar thermal would require the generation of around 30GJ of electricity, which is equivalent to 10kWp of PV (around 90m^2) or a 6 kW wind turbine on a fairly windy site. It would be ridiculous to even contemplate this without first taking steps to reduce electricity consumption through low energy appliances. It will be possible in a future release of NHER Plan Assessor to model these.

5 An Interim NHER Target

A new NHER target for developers working to exceed Building Regulation standards would be between 11.0 and 12.0. The measures required to achieve this differ between regions due firstly to the colder climate as you move north and secondly higher fuel prices in some regions. To achieve an NHER of 11.0 in the South of England, it would be sufficient to adopt the Best Practice Insulation Standards, provide 4m^2 of solar thermal, add additional heating controls to the boiler and provide a fan assisted gas fire as secondary heating. Further north, it would be necessary to either install whole house ventilation with heat recovery or go some way towards the advanced standard insulation. In Northern Ireland the Advanced standard would be required. A target of approaching 12 would require some means of electricity generation.

Table 2 illustrates the different measures required to reach an NHER in the region of 11.0 -12.0 depending on the dwelling location.

Region	Package	NHER	Package	NHER	Package	NHER
South of England[1]	Best Practice Insulation + Heating Measures + Solar Thermal	11.1	MODEL D[2]	11.8	MODEL D + 0.5 kWp PV	12.2
North of England[3]	As above + whole house MVHR	11.0	MODEL D	11.8	MODEL D + 0.5 kWp PV	12.2
Scotland[4]	As above + reduce air permeability	11.0	MODEL D	11.6	MODEL D + 0.5 kWp PV	12.0
Northern Ireland	MODEL D[2]	11.0	MODEL D + 0.7kWp PV	11.6	MODEL D + 1.1 kWp PV	12.0

Table 2: Comparison of different parts of the UK

[1] Degree Day Region 3
[2] Advanced Standard fabric measures + 4m^2 solar thermal
[3] Degree Day Region 10
[4] Degree Day Region 17

6 Discussion and Overall Conclusions

NHER 10.0

This corresponds to the 2006 Building Regulations standard for England and Wales for a gas heated home.

NHER 11.0

This is a good initial target for developers wishing to go beyond the Building Regulations. This can be achieved in England and Wales for a gas-heated home with the EST Best Practice Standard, possibly with the inclusion of solar water heating. In Scotland, it would require the EST Advanced Standard Fabric Measures rather than Best Practice Standard, and in Northern Ireland on site electricity generation as well. This corresponds roughly to the Code for Sustainable Homes Level 4.

NHER 14.0

On site electricity generation is essential if higher NHER values are to be achieved. It is just about possible to achieve NHER 14.0 with roof -mounted PV.

NHER 20

NHER 20 is a highly ambitious target, which will require technological innovation and shifts in the pricing mechanism for on-site electricity generation. NHER ratings of 20 can currently only be achieved by additionally including off-site generation of electricity. The NHER will eventually be made sensitive to the efficiency of fixed appliances, so that the provision by developers of appliances with high-energy labels will also contribute to raising the NHER.

Zero Carbon is much easier than NHER 20

This is because technologies that deliver low carbon have fuel cost penalties associated with them, and so reduce the NHER. For example:

- Wood pellets are very low in carbon emissions, but have a relatively high cost per kWh.
- Electricity generated on-site from PV or from wind power generates similar levels of CO_2 reduction regardless of the relative proportion of electricity used and exported. The cost saving of exported electricity is however a third of the saving from electricity consumed on-site. The assumptions made about the pence per unit received for exported electricity and about the percentage that is used within the dwelling make a huge difference to the resulting NHER and associated running costs.

Reaching Zero Carbon by 2016

The NHER software has a crucial role to play in meeting the Government's aim of having all new housing be zero carbon by 2016. It is the only commercial software that produces estimates of total carbon emissions and total dwelling running costs. The carbon based levels of the Code for Sustainable Homes will be the framework for new house design from now onwards, in England and Wales at least. The NHER software provides NHER Assessors with a way of demonstrating compliance with Level 6 of the Code by providing total CO_2/year and total CO_2/year/m^2 as standard outputs. This is not possible with SAP based software, as these do not consider fuel usage by appliances and their interaction with the space-heating requirement.

Why invest in a low carbon home?

The NHER rating itself also has a key role to play in providing a way of communicating the financial benefits to the householder arising from living in a low carbon house. The NHER Cost Table (Appendix B) provides a developer / estate agent with a way of providing prospective purchasers with an estimate of the running cost of any home issued with an NHER rating.

Affordable Housing and Fuel Poverty

The NHER also has much to contribute to the debate on Affordable Housing, which is about much more than building cheap housing. Again, the NHER Cost Table can help assess whether the home is truly affordable by bringing fuel running costs into the debate.

NHER software also has a key role in helping to tackle fuel poverty. The NHER rating continues to be used in Scotland as a way of satisfying the Housing Quality Standard.

Appendix A: Specifications

MODEL A

There are many ways in which a dwelling can be configured to pass the 2006 Building Regulations. The assumptions made in this paper are as follows:

a) The wall has been assumed to be built with partial cavity fill, AAC blocks and plasterboard on dabs. U-value = 0.29 W/m^2K. This seems to be the element developers are least inclined to change.

b) Accredited details have been assumed for the thermal bridging, with a y value = 0.08 W/m^2K.

c) The heating system comprises an A rated combination boiler which is the most common central heating system. The controls are programmer, TRVs and roomstat with interlock as required by the Regulations. A reasonable secondary heating system of a balanced flue fire has been chosen, as this is a straightforward way of improving the DER.

d) Air permeability has been set at 9 m^3/hm^2 @ 50 Pa.

e) Other elements have then been 'tweaked' to give a DER just below the TER. The floor has 50 mm PU insulation, the roof has 100 + 200 mm of air based insulation and the windows have a U-value of 1.8 W/m^2K.

Table 3 Building Regulations 2006 Base Case Specifications

Measures	Description	U Value
Fabric		
Walls	Partial cavity fill, AAC bricks and plasterboard on dabs	0.29
Main roof	300 mm (100 + 200) loft insulation	0.14
Ground floor	Beam and block 50 PU chipboard	0.25
Windows	PVC double glazed super low E argon	1.80
Doors	Timber insulated	3.00
Thermal bridging	y value = 0.08	
Air Permeability & Ventilation		**Air Changes**
Air Permeability	Trickle vents and extract fans	9 m^3/hm^2.
Lighting		**% LEL**
Low Energy Lighting	% that are low energy	44.4%
Heating & Controls		
Main Heating	Programmer, Roomstat & TRVs	
Secondary Heating	Balanced flue gas fire, 'A' rated boiler	

MODEL B

This standard has been achieved in the sample dwelling as follows:

- 150mm fully filled cavity
- Small improvements to the U-values of other elements
- Whole house heat recovery ventilation system instead of extract fans[5]
- Sealing work to improve air tightness
- 75% of internal lighting to be low energy

Savings on the wall construction balance more expensive glazing and marginal improvements in floor and roof insulation.

The U-values and other characteristics assumed are shown in Table 4 below.

Table 4: Best Practice Standard Specifications

Measures	Description	U Value
Fabric		
Walls	Plasterboard on dabs, dense block, 150 gf filled cavity with plastic wall ties, brick	0.21
Main roof	350 mm (100 + 250) loft insulation	0.12
Ground floor	Beam and block 100 PU chipboard	0.16
Windows	PVC double glazed super low E argon	1.50
Doors	timber insulated	1.00
Thermal bridging	y value =	0.04
Air Permeability & Ventilation		**Air Changes**
Air Permeability	Air tightness measures and mechanical ventilation with heat recovery	3 m^3/hm^2.
Lighting		**% LEL**
Low Energy Lighting	% that are low energy	75%
Heating & Controls		
Main Heating	Programmer, Roomstat & TRVs	
Secondary Heating	Balanced flue gas fire	

5 Modelled using the Special Features (Appendix Q) procedure with 85% efficiency and SFP = 1.0

MODEL C

This has been achieved using the insulation levels detailed in Table 5 and the same heating system as the Best Practice standard with the addition of better controls and secondary heating.

Table 5: Advanced Standard Specification

Measures	Description	U Value
Fabric		
Walls	wet plaster, dense block, 250 gf filled cavity with plastic wall ties, brick	0.15
Main roof	tiles on battens, tyvek underfelt, 50 Kingspan PU board, 400mm rockwool between rafters, vcl, plasterboard	0.09
Ground floor	Beam and block 200 PU chipboard	0.09
Windows	Triple glazed super low E argon	0.80
Doors	timber insulated	0.70
Thermal bridging	y value =	0.02
Air Permeability & Ventilation		**Air Changes**
Air Permeability	Air tightness measures and mechanical ventilation with heat recovery	1 m^3/hm^2
Lighting		**% LEL**
Low Energy Lighting		100%
Heating & Hot Water		
Main Heating	Delayed start thermostat and a weather compensator in addition to programmer & TRVs	
Secondary Heating	Fan flued fire with appliance stat	

MODEL D
The specification of model C with the addition of :

Solar Thermal
- $4m^2$ flat plate, glazed
- South facing
- 30º collector tilt
- <20% overshading
- 160L solar store volume
- PV powered pump

MODEL E
The specification of model D with the addition of :

Photovoltaic
- $28m^2$ panels
- South facing
- 30º collector tilt
- <20% overshading
- 2.35 kW

MODEL F
The specification of model D with the addition of :

Photovoltaic
- $28m^2$ panels
- South facing
- 30º collector tilt
- <20% overshading
- 3.5 kWp

MODEL G
The specification of model D with the addition of a wood pellet boiler and 5.5kWp PV.

MODEL H
The specification of model D 6.3kWp PV.

Appendix B: NHER Cost Table (2006)

Table 6: NHER Cost Table

Floor area:	**40**	**60**	**80**	**100**	**120**	**150**	**180**	**220**
NHER								
0	1710	2400	3090	3780	4450	5500	6500	8000
1	1290	1780	2250	2730	3200	4000	4500	5500
2	1060	1420	1790	2150	2500	3000	3500	4300
3	910	1200	1490	1780	2070	2500	3000	3500
4	810	1050	1280	1520	1750	2100	2500	2900
5	750	930	1130	1320	1520	1820	2100	2500
6	700	840	1010	1170	1340	1590	1840	2180
7	650	760	910	1050	1190	1410	1610	1900
8	600	685	820	930	1060	1240	1390	1660
9	550	615	730	810	920	1070	1190	1410
10	500	550	650	700	800	900	1000	1200
11	450	495	585	630	720	810	900	1080
12	400	440	520	560	640	720	800	960
13	350	385	455	490	560	630	700	840
14	300	330	390	420	480	540	600	720
15	250	275	325	350	400	450	500	600
16	200	220	260	280	320	360	400	480
17	150	165	195	210	240	270	300	360
18	100	110	130	140	160	180	200	240
19	50	55	65	70	80	90	100	120
20	0	0	0	0	0	0	0	0

Table of total annual fuel running costs by NHER and floor area