

# Defining a Fabric Energy Efficiency Standard for zero carbon homes

## Appendix D Cost analysis

The views and recommendations within this report are those of the Task Group and do not necessarily reflect the views of Government

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# Cost analysis

## Introduction

This appendix should be read in conjunction with the main report entitled 'Defining a Fabric Energy Efficiency Standard for zero carbon homes'.

In the interests of clarity only a limited selection of the capital and whole life costing data has been presented in the main report. In order to understand the significance of the differing construction specifications a number of dwelling types were financially modelled.

This section provides a summary of this additional background research.

It should be noted that due to the overall Task Group delivery timescales limitations had to be set on the variety of scenarios that could be financially modelled. The result of this can be seen in the fact that only cavity masonry constructions have been presented for the fabric specifications.

Other constructions such as timber frame, Structural Insulated Panels (SIP), Light Gauge Steel Frame (LGSF) and Insulated Concrete Formwork (ICF), are capable of achieving the performance requirements with different financial results.

Similarly a simplified approach of using solar thermal and photovoltaic panels to achieve the 70% Carbon Compliance level has been presented. There are clearly a myriad of site and technical choices available in reality, however the Task Group considered this a sufficiently mainstream route to provide useful financial information.

## Sources and Assumptions for Cost Data

### Costs for Energy Efficiency measures

The capital costs are presented in order to demonstrate the extra upfront costs of the various specifications applied to the baseline dwelling. The extra cost of each specification is the sum of elemental costs (e.g. extra wall insulation, window triple glazing, etc) included under each specification. Costs reflect today's prices (real term), both in terms of material and labour. Further criteria and assumptions are listed below.

#### Data sources:

Davis Langdon data for simple fabric elements (e.g. insulation)

Current supplier's quotations for windows and mechanical ventilation

Air-tightness and thermal bridging were based on costs by Davis Langdon plus Working Group 1 - Form and Fabric.

Remaining are Davis Langdon 2009 Q2 prices

All costs include supply and labour and any direct implications of upgrades (e.g. increase in foundation materials due to thicker external walls)

Costs are based on prices for a medium size developer (average between small and large) and for a small development.

#### Assumptions:

- 1) Include preliminaries and overheads/profits
- 2) Exclude external works, drainage and services
- 3) Exclude VAT, professional fees etc
- 4) Assume a basic and minimal specification of finish
- 5) Assume there are no abnormalities
- 6) Cost of land has been excluded

## **Costs for technologies (PV & Solar Thermal)**

Capital costs for the solar thermal and photovoltaics are presented, reflecting the output/size required on top of the various Fabric specifications to achieve 70% Carbon Compliance. Costs reflect today's prices (real term), both in material and labour.

- 1) Include installation, testing & commissioning, attendances and overheads/profits
- 2) Exclude VAT and building services distribution
- 3) No allowance included for grants
- 4) Exclude feed-in tariffs

Costs are based on prices for a medium size developer (average between small and large) and for a small development.

## **CO<sub>2</sub> Emissions Savings and Energy Consumption Savings**

All as calculated by cSAP2009 modelling apart from 70% Carbon Compliance data which is from modified SAP2005 calculations (as per assumptions in CLG Zero Carbon Consultation document<sup>1</sup>).

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<sup>1</sup> CLG, Definition of Zero Carbon Homes and Non-Domestic Buildings: Consultation, 17/12/08

## Energy Efficiency Capital Cost Breakdown (extra-over costs from Baseline)

### Spec A (NV)

	HOUSES			APARTMENTS	
	Upgrade	Semi Detached	Detached	Upgrade	Small Ground Floor
<b>Openings</b>	Double glazed Upvc windows with Low-E coating (soft). 1.5 u-value	£47	£71	Double glazed Upvc windows with Low-E coating (soft). 1.5 u-value	£30
<b>External wall</b>	Increase full-fill cavity insulation by 15mm to 100mm	£264	£463	Increase full-fill cavity insulation by 15mm to 85mm	£30
<b>Party wall</b>	Full-fill 80mm cavity with mineral wool insulation	£110	n/a	Full-fill 80mm cavity with mineral wool insulation	£142
<b>Roof</b>	Increase mineral wool insulation by 25mm to 300mm	£37	£57	Increase full fill cavity insulation by 20mm to 100mm	£54
<b>Floor</b>	Same as baseline	£0	£0	Same as baseline	£0
<b>Lighting</b>	100% energy efficient lighting	£34	£41	100% energy efficient lighting	£30
<b>Air leakage</b>	Improve airtightness to 5 m <sup>3</sup> /hr/m <sup>2</sup> (& include air pressure testing)	£368	£644	Improve airtightness to 5 m <sup>3</sup> /hr/m <sup>2</sup> (& include air pressure testing)	£210
<b>Ventilation</b>	Natural	£0	£0	Natural	£0
<b>Thermal bridging</b>	Improve to 0.06 W/m <sup>2</sup> K	£419	£670	Improve to 0.06 W/m <sup>2</sup> K	£180
	<b>Total</b>	<b>£1,279</b>	<b>£1,946</b>		<b>£675</b>

## Energy Efficiency Capital Cost Breakdown (extra-over costs from Baseline)

### Spec B (NV)

	HOUSES			APARTMENTS	
	Upgrade	Semi Detached	Detached	Upgrade	Small Ground Floor
<b>Openings</b>	Double glazed Upvc windows with Low-E coating (soft). 1.4 u-value	£125	£189	Double glazed Upvc windows with Low-E coating (soft). 1.4 u-value	£82
<b>External wall</b>	Increase full-fill cavity insulation by 75mm to 160mm	£1,730	£3,036	Increase full-fill cavity insulation by 70mm to 140mm	£188
<b>Party wall</b>	full-fill 80mm cavity with mineral wool insulation	£110	n/a	full-fill 80mm cavity with mineral wool insulation	£142
<b>Roof</b>	Increase mineral wool insulation by 60mm to 335mm	£87	£134	Increase full fill cavity insulation by 70mm to 150mm	£227
<b>Floor</b>	Increase rigid PU insulation by 5mm to 15mm	£35	£54	Increase rigid PU insulation by 5mm to 15mm	£39
<b>Lighting</b>	100% energy efficient lighting	£34	£41	100% energy efficient lighting	£30
<b>Air leakage</b>	Improve airtightness to 3 m <sup>3</sup> /hr/m <sup>2</sup> (& include air pressure testing)	£644	£1,058	Improve airtightness to 3 m <sup>3</sup> /hr/m <sup>2</sup> (& include air pressure testing)	£350
<b>Ventilation</b>	Natural	£0	£0	Natural	£0
<b>Thermal bridging</b>	Improve to 0.05 W/m <sup>2</sup> K	£837	£1,339	Improve to 0.05 W/m <sup>2</sup> K	£360
	<b>Total</b>	<b>£3,602</b>	<b>£5,851</b>		<b>£1,417</b>

## Energy Efficiency Capital Cost Breakdown (extra-over costs from Baseline)

### Spec C- (NV)

	HOUSES			APARTMENTS	
	Upgrade	Semi Detached	Detached	Upgrade	Small Ground Floor
<b>Openings</b>	Double glazed Upvc windows with Low-E coating (soft). 1.2 u-value	£1,011	£1,529	Double glazed Upvc windows with Low-E coating (soft). 1.2 u-value	£661
<b>External wall</b>	Increase full-fill cavity insulation by 125mm to 210mm	£2,570	£4,512	Increase full-fill cavity insulation by 120mm to 190mm	£284
<b>Party wall</b>	full-fill 80mm cavity with mineral wool insulation	£110	n/a	full-fill 80mm cavity with mineral wool insulation	£142
<b>Roof</b>	Increase mineral wool insulation by 140mm to 415mm	£203	£313	Increase full fill cavity insulation by 100mm to 180mm	£315
<b>Floor</b>	Increase rigid PU insulation by 30mm to 40mm	£190	£293	Increase rigid PU insulation by 30mm to 40mm	£211
<b>Lighting</b>	100% energy efficient lighting	£34	£41	100% energy efficient lighting	£30
<b>Air leakage</b>	Improve airtightness to 3 m <sup>3</sup> /hr/m <sup>2</sup> (& include air pressure testing)	£644	£1,058	Improve airtightness to 3 m <sup>3</sup> /hr/m <sup>2</sup> (& include air pressure testing)	£350
<b>Ventilation</b>	Natural	£0	£0	Natural	£0
<b>Thermal bridging</b>	Improve to 0.04 W/m <sup>2</sup> K	£1,302	£2,083	Improve to 0.04 W/m <sup>2</sup> K	£560
	<b>Total</b>	<b>£6,063</b>	<b>£9,829</b>		<b>£2,552</b>

## Energy Efficiency Capital Cost Breakdown (extra-over costs from Baseline)

### Spec C (NV)

	HOUSES			APARTMENTS	
	Upgrade	Semi Detached	Detached	Upgrade	Small Ground Floor
<b>Openings</b>	Triple glazed Upvc windows with low-E coating (soft) 0.8 u-value	£3,358	£5,080	Triple glazed Upvc windows with low-E coating (soft) 0.8 u-value	£2,208
<b>External wall</b>	Increase full-fill cavity insulation by 125mm to 210mm	£2,570	£4,512	Increase full-fill cavity insulation by 120mm to 190mm	£284
<b>Party wall</b>	full-fill 80mm cavity with mineral wool insulation	£110	n/a	full-fill 80mm cavity with mineral wool insulation	£142
<b>Roof</b>	Increase mineral wool insulation by 140mm to 415mm	£203	£313	Increase full fill cavity insulation by 100mm to 180mm	£315
<b>Floor</b>	Increase rigid PU insulation by 30mm to 40mm	£190	£293	Increase rigid PU insulation by 30mm to 40mm	£211
<b>Lighting</b>	100% energy efficient lighting	£34	£41	100% energy efficient lighting	£30
<b>Air leakage</b>	Improve airtightness to 3 m <sup>3</sup> /hr/m <sup>2</sup> (& include air pressure testing)	£644	£1,058	Improve airtightness to 3 m <sup>3</sup> /hr/m <sup>2</sup> (& include air pressure testing)	£350
<b>Ventilation</b>	Natural	£0	£0	Natural	£0
<b>Thermal bridging</b>	Improve to 0.04 W/m <sup>2</sup> K	£1,302	£2,083	Improve to 0.04 W/m <sup>2</sup> K	£560
	<b>Total</b>	<b>£8,410</b>	<b>£13,380</b>		<b>£4,100</b>

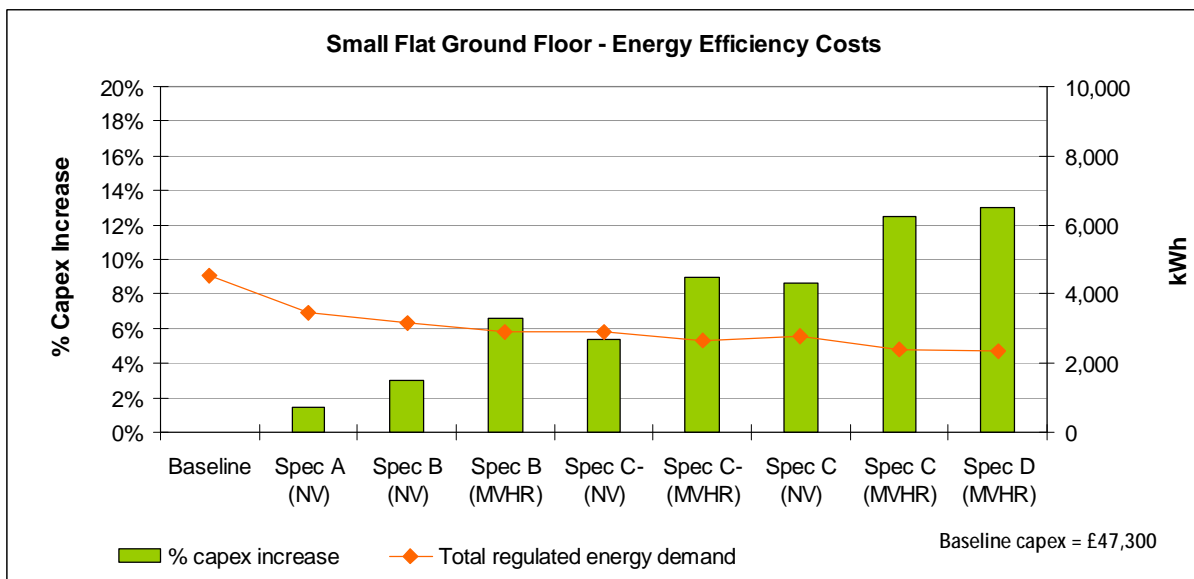
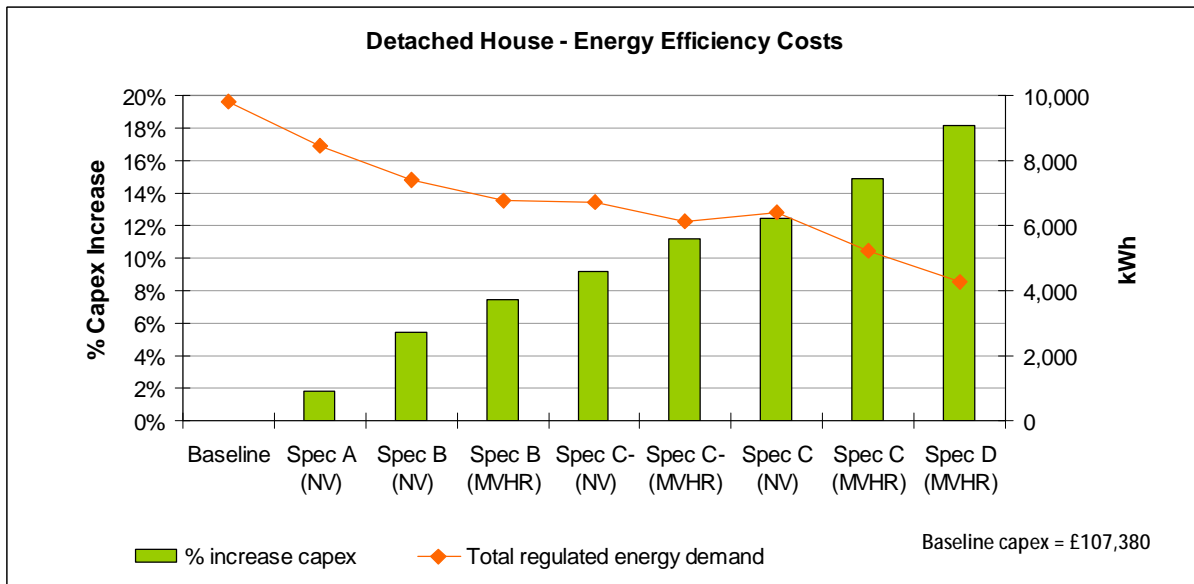
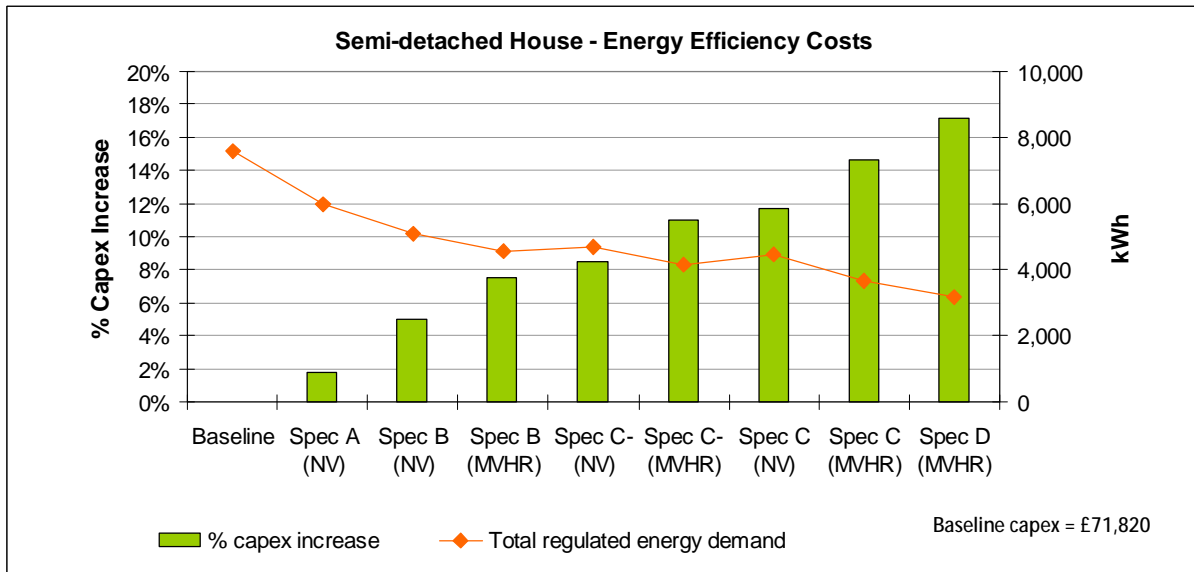


## Energy Efficiency Capital Cost Breakdown (extra-over costs from Baseline)

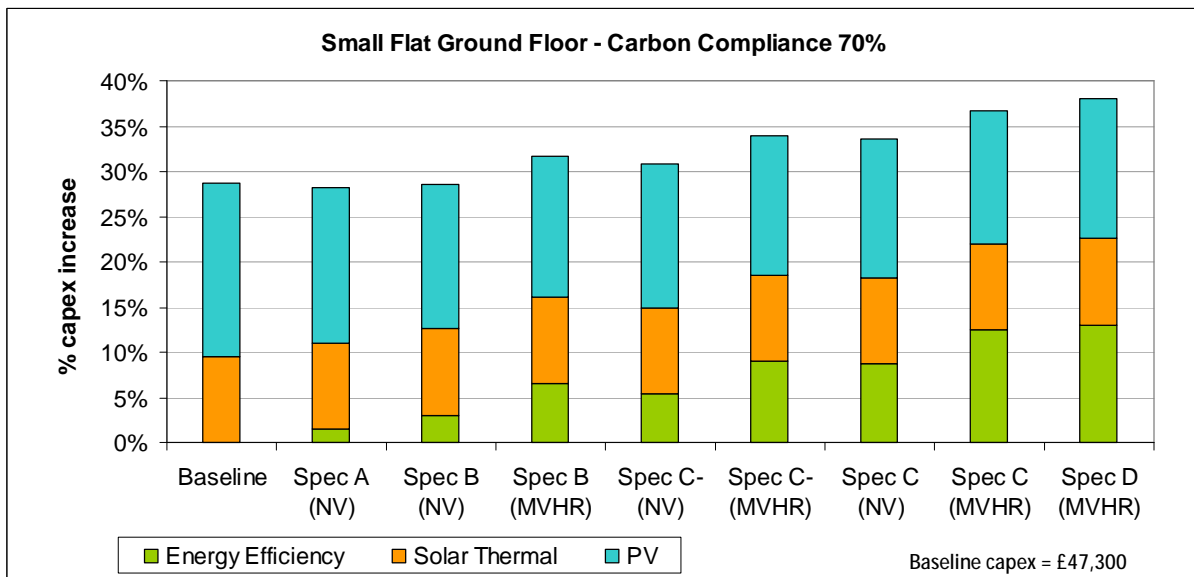
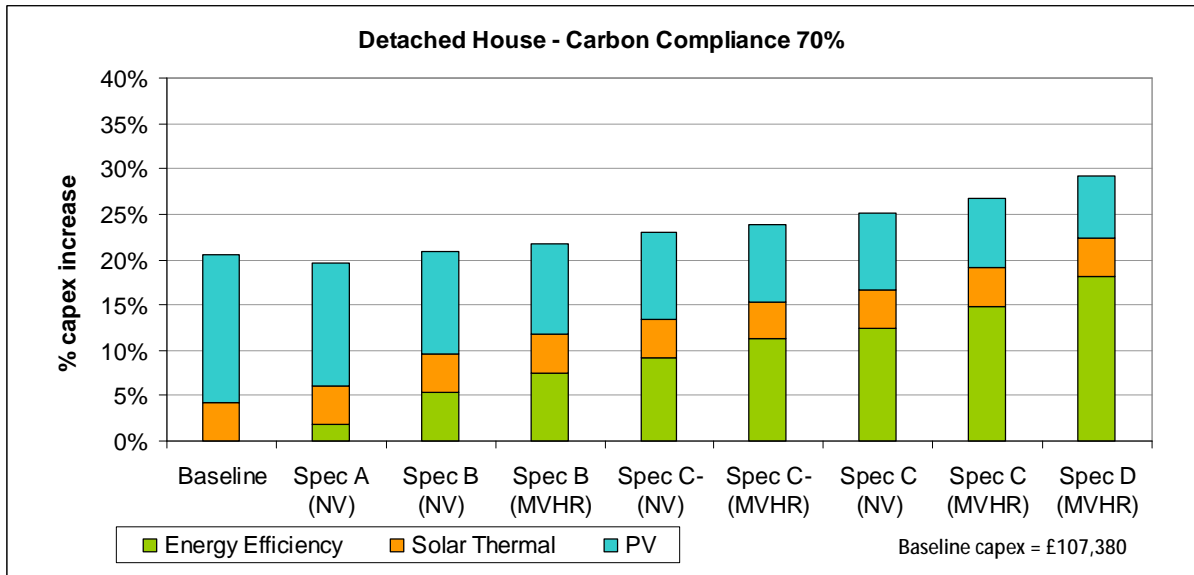
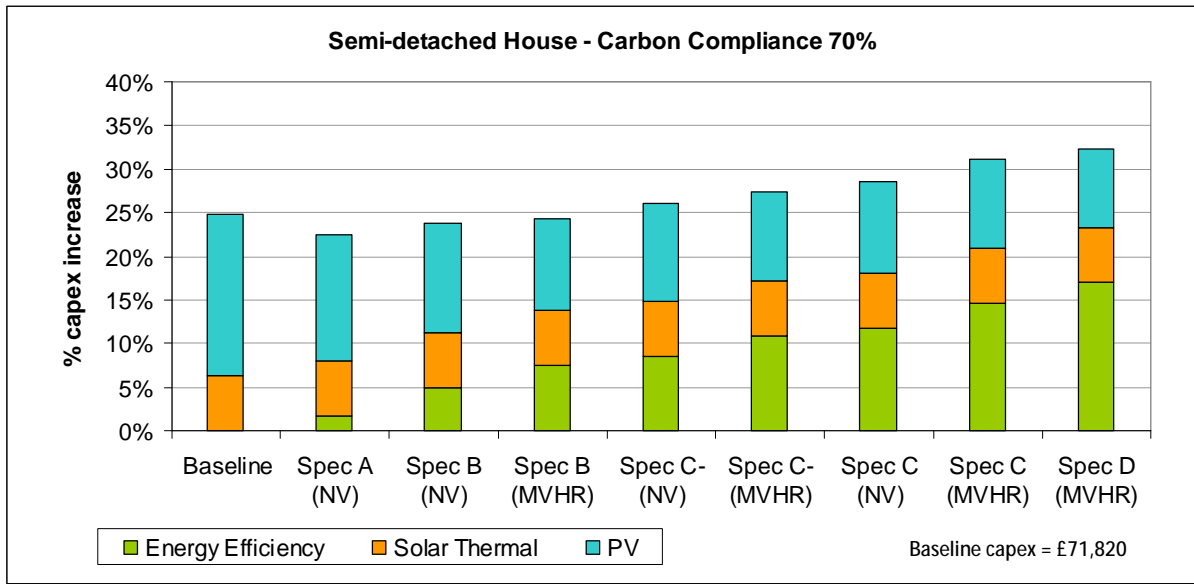
### Spec D (MVHR)

	HOUSES			APARTMENTS	
	Upgrade	Semi Detached	Detached	Upgrade	Small Ground Floor
<b>Openings</b>	Triple glazed Upvc windows with low-E coating (soft) 0.8 u-value	£3,358	£5,080	Triple glazed Upvc windows with low-E coating (soft) 0.8 u-value	£2,208
<b>External wall</b>	Increase full-fill cavity insulation by 215mm to 300mm	£4,994	£8,767	Increase full-fill cavity insulation by 220mm to 290mm	£520
<b>Party wall</b>	full-fill 80mm cavity with mineral wool insulation	£110	n/a	full-fill 80mm cavity with mineral wool insulation	£142
<b>Roof</b>	Increase mineral wool insulation by 170mm to 445mm	£248	£383	Increase full fill cavity insulation by 200mm to 280mm	£612
<b>Floor</b>	Increase rigid PU insulation by 100mm to 110mm	£742	£1,146	Increase rigid PU insulation by 100mm to 110mm	£828
<b>Lighting</b>	100% energy efficient lighting	£34	£41	100% energy efficient lighting	£30
<b>Air leakage</b>	Improve airtightness to 0.6 m <sup>3</sup> /hr/m <sup>2</sup> (& include air pressure testing)	£1,196	£1,840	Improve airtightness to 0.6 m <sup>3</sup> /hr/m <sup>2</sup> (& include air pressure testing)	£560
<b>Ventilation</b>	Mechanical Ventilation with heat recovery, 85% heat recovery efficiency, fan power 1W/l/s	£1,800	£2,200	Mechanical Ventilation with heat recovery, 85% heat recovery efficiency, fan power 1W/l/s	£1,700
<b>Thermal bridging</b>	Improve to 0.04 W/m <sup>2</sup> K	£1,302	£2,083	Improve to 0.04 W/m <sup>2</sup> K	£560
	<b>Sub-Total</b>	<b>£13,784</b>	<b>£21,541</b>		<b>£7,159</b>
	Heating system deduction	£1,500	£2,000	Heating system deduction	£1,000
	<b>Total</b>	<b>£12,284</b>	<b>£19,541</b>		<b>£6,159</b>

## Capital Costs of Energy Efficiency



## Capital Costs for 70% Carbon Compliance



## Whole life costing: Semi-detached House, 60 years

Whole life costing was carried out in order to establish the lifetime costs and savings applicable for each specification, along with the 70% Carbon Compliance scenario. The various specification upgrades and achievement of 70% Carbon Compliance (through the addition of solar thermal and PV in this case) can be seen as capital investments with additional upfront costs and whole life costs (maintenance and replacement), and the savings resulting from lower energy consumption and hence lower energy bills.

The whole life costing methodology then took into account 3 elements:

- The upfront capital costs for each specification and the additional solar thermal and PV required to achieve 70% Carbon Compliance
- The maintenance and replacement costs of building elements during a 60 year life: Maintenance costs are mainly for the solar thermal, PV and the MVHR (Specification D only). Replacement during the 60 years life is applicable for windows, lighting, MVHR, solar thermal and PV. Other maintenance and replacement of elements that are part of the baseline (e.g. roof tiles, flooring) are not included in this analysis.
- The savings accrued through less energy consumption, resulting from better energy efficiency and low/zero carbon technologies. Savings in energy are transformed into money savings, practically expressed in lower energy bills

In terms of whole life costing parameters and sensitivities, the following were adopted:

- All capital costs, maintenance and replacement costs are expressed in real terms (not subject to any general inflation rates)
- Two scenarios for the future cost of energy are applied: the first is where energy prices remain constant in real terms, and the second is where energy prices increase by 2.5% per annum in real terms.
- To express whole life costs and savings in “present values”, two discount rate scenarios were applied: the first is 3.5% discount rate (the rate adopted for Government economy-wide investment appraisals), and the second is 5% discount rate (reflecting a rate applicable for private sector investments)

Further criteria and assumptions used in the whole life costing include:

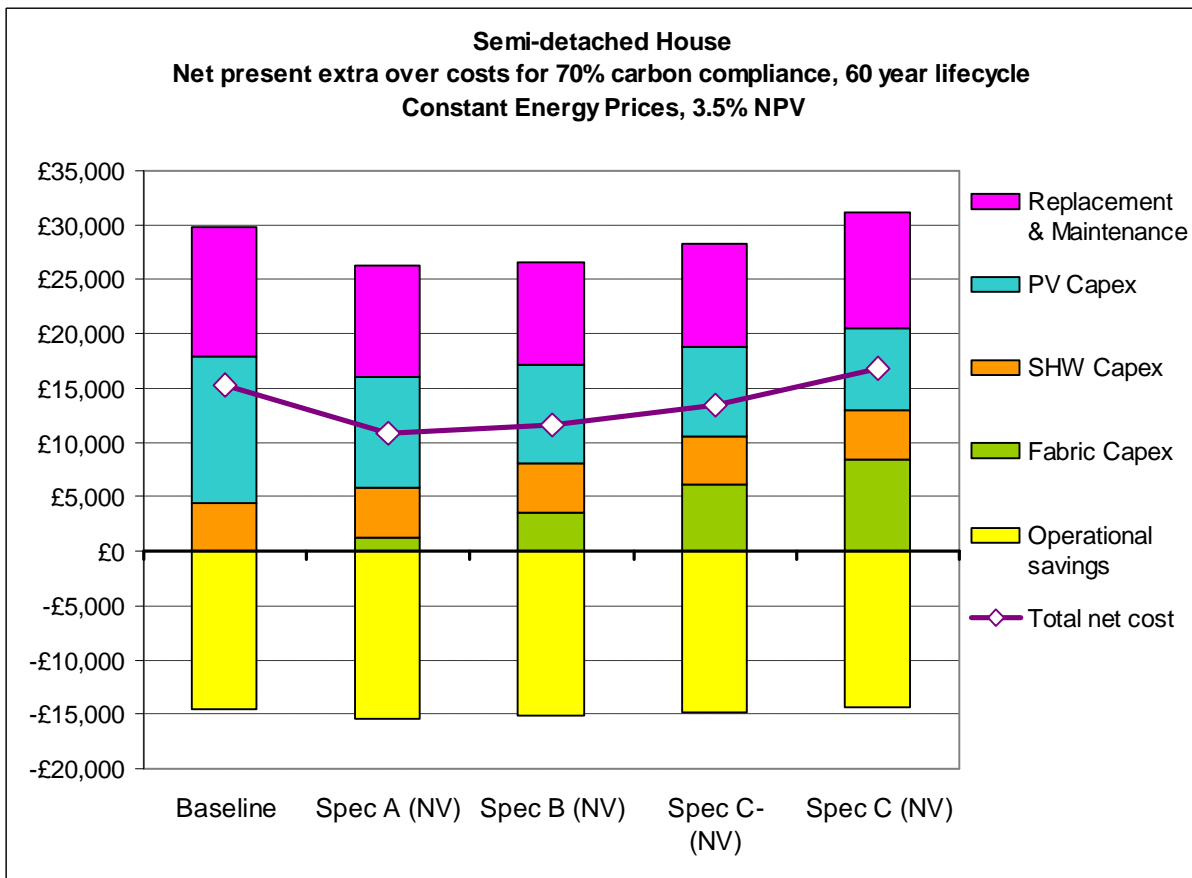
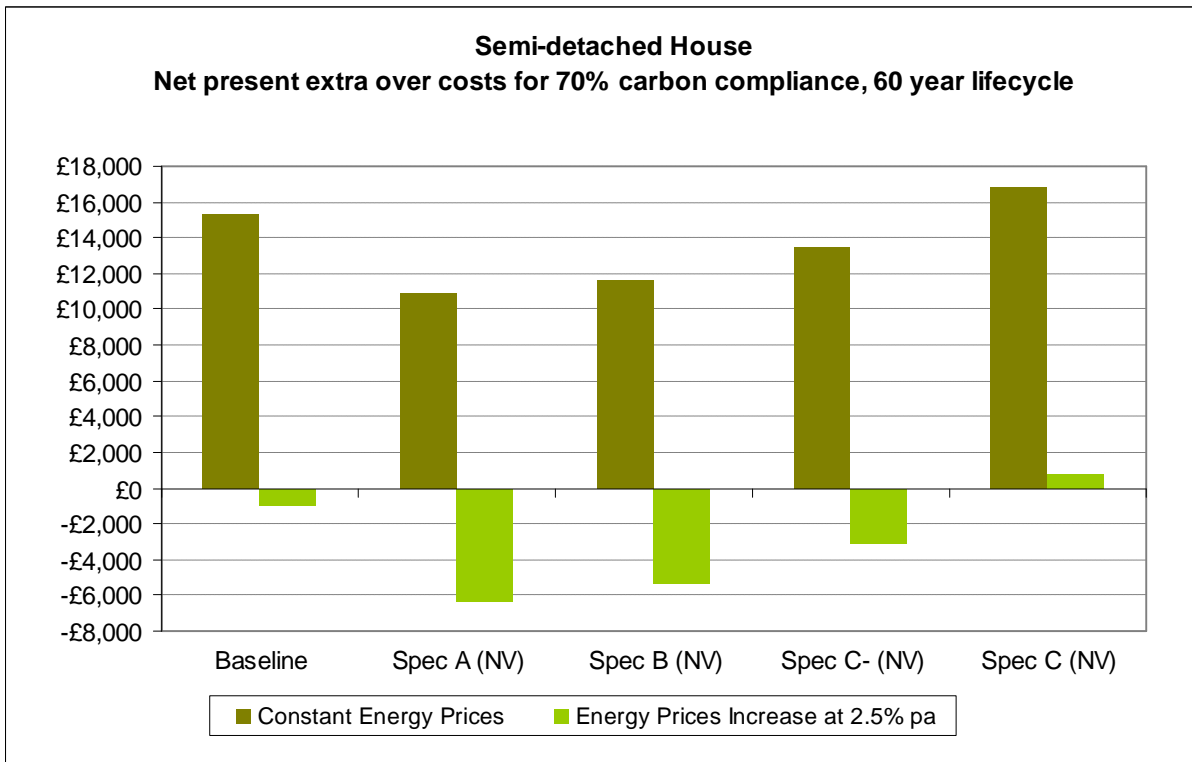
- Savings for energy efficiency measures based on SAP 2009 energy outputs and current gas/ electricity price factors
- Savings from solar thermal and PV based on modified SAP 2005 energy outputs (as per CLG Zero Carbon Consultation document) and current gas/ electricity price factors

## Whole life costing results using a 3.5% discount rate

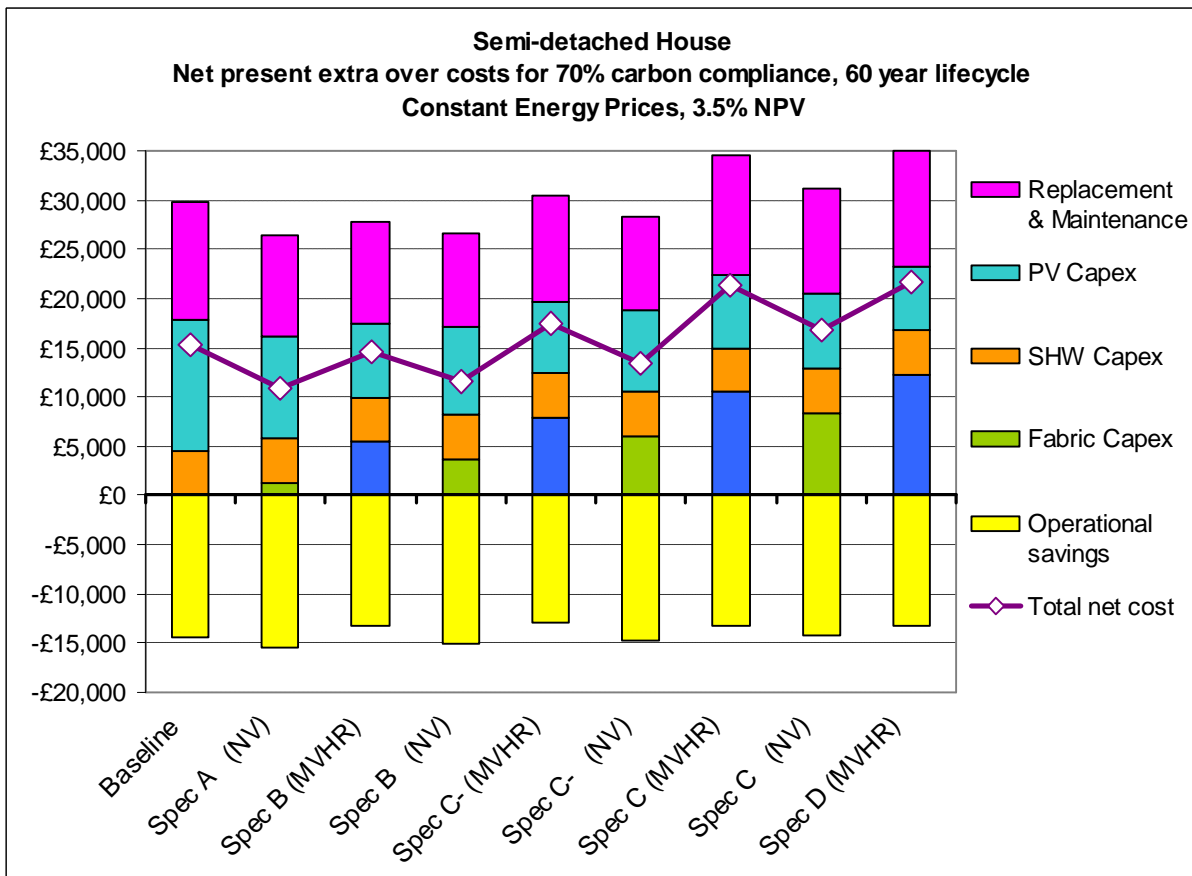
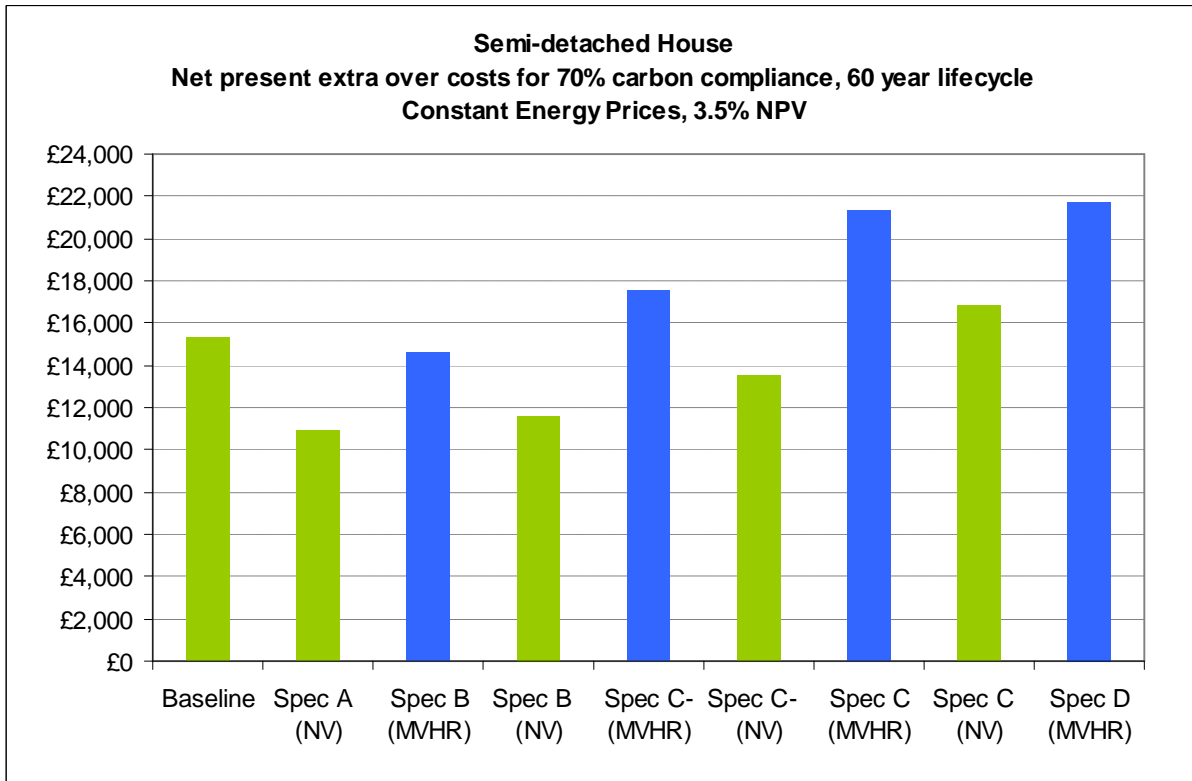
Build specs	Fabric Capex	SHW Capex	PV Capex	Replacement & Maintenance	Energy prices constant in real terms		Energy prices increase at 2.5% pa in real terms	
					Life cycle savings	Total net cost	Life cycle savings	Total net cost
Baseline	£0	£4,515	£13,330	£11,963	-£14,515	<b>£15,293</b>	-£30,781	<b>-£973</b>
Spec A (NV)	£1,279	£4,515	£10,320	£10,207	-£15,403	<b>£10,918</b>	-£32,665	<b>-£6,344</b>
Spec B (MVHR)	£5,402	£4,515	£7,568	£10,344	-£13,195	<b>£14,634</b>	-£27,982	<b>-£153</b>
Spec B (NV)	£3,602	£4,515	£9,030	£9,480	-£15,046	<b>£11,581</b>	-£31,907	<b>-£5,280</b>
Spec C- (MVHR)	£7,863	£4,515	£7,310	£10,749	-£12,900	<b>£17,537</b>	-£27,356	<b>£3,081</b>
Spec C- (NV)	£6,063	£4,515	£8,170	£9,523	-£14,787	<b>£13,483</b>	-£31,359	<b>-£3,088</b>
Spec C (MVHR)	£10,486	£4,515	£7,310	£12,233	-£13,244	<b>£21,299</b>	-£28,087	<b>£6,457</b>
Spec C (NV)	£8,410	£4,515	£7,568	£10,644	-£14,323	<b>£16,814</b>	-£30,374	<b>£763</b>
Spec D (MVHR)	£12,284	£4,515	£6,450	£11,715	-£13,261	<b>£21,703</b>	-£28,122	<b>£6,842</b>

*Negative figures are savings or net cost/savings*

### 3.5% discount rates scenario example graphs



### 3.5% discount rates scenario example graphs



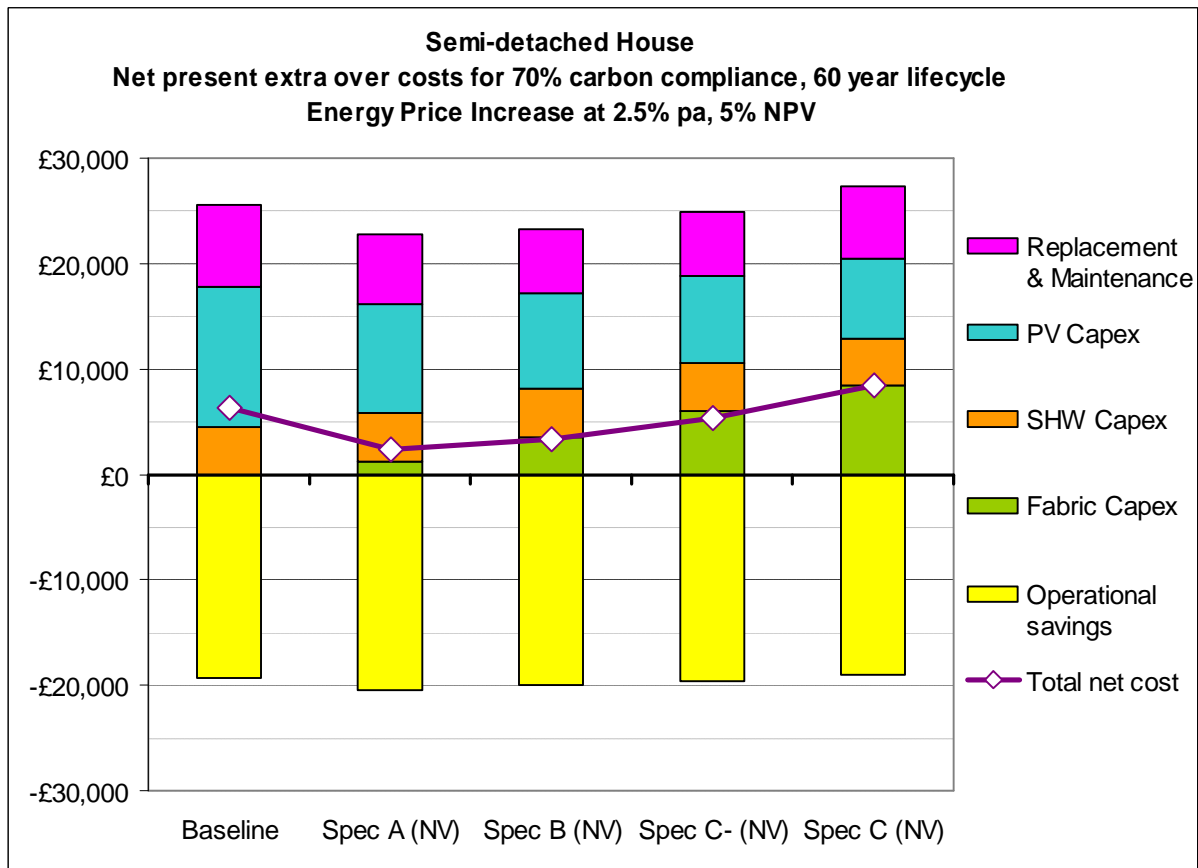
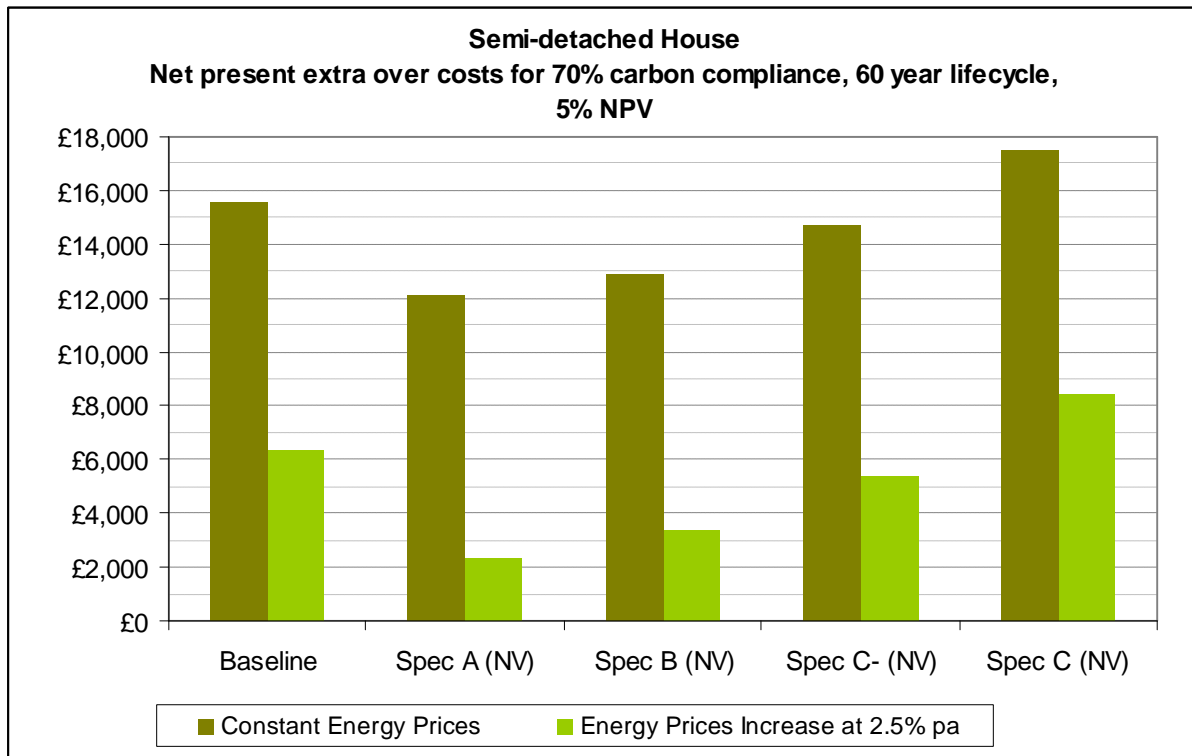
## Whole life costing results using a 5% discount rate

Build specs	Fabric Capex	SHW Capex	PV Capex	Replacement & Maintenance	Energy prices constant in real terms		Energy prices increase at 2.5% pa in real terms	
					Life cycle savings	Total net cost	Life cycle savings	Total net cost
Baseline	£0	£4,515	£13,330	£7,753	-£10,053	<b>£15,546</b>	-£19,244	<b>£6,354</b>
Spec A (NV)	£1,279	£4,515	£10,320	£6,639	-£10,668	<b>£12,085</b>	-£20,422	<b>£2,331</b>
Spec B (MVHR)	£5,402	£4,515	£7,568	£6,770	-£9,138	<b>£15,117</b>	-£17,494	<b>£6,762</b>
Spec B (NV)	£3,602	£4,515	£9,030	£6,177	-£10,420	<b>£12,904</b>	-£19,948	<b>£3,376</b>
Spec C- (MVHR)	£7,863	£4,515	£7,310	£7,028	-£8,934	<b>£17,782</b>	-£17,103	<b>£9,613</b>
Spec C- (NV)	£6,063	£4,515	£8,170	£6,204	-£10,241	<b>£14,711</b>	-£19,605	<b>£5,347</b>
Spec C (MVHR)	£10,486	£4,515	£7,310	£7,970	-£9,173	<b>£21,108</b>	-£17,560	<b>£12,722</b>
Spec C (NV)	£8,410	£4,515	£7,568	£6,916	-£9,920	<b>£17,490</b>	-£18,990	<b>£8,420</b>
Spec D (MVHR)	£12,284	£4,515	£6,450	£7,641	-£9,184	<b>£21,706</b>	-£17,581	<b>£13,309</b>

*Negative figures are savings or net cost/savings*



## 5% discount rates scenario example graphs



## 5% discount rates scenario example graphs

