



# **CARBON COMPLIANCE**

Setting an appropriate limit for zero carbon new homes

## **National or Regional Weather: Implications for Carbon Compliance**

## Introduction

The current regime for determining compliance with Part L of the Building Regulations is based on a single weather region for England (except for cooling and summertime overheating calculations, which are based on regional weather). Technical analysis carried out as part of the Task Group's work has identified that any change of this assumption has significant implications for house design and construction products specified across the country. As such, for the zero carbon definition of Carbon Compliance, continued use of a single national weather region or a change to multiple weather regions, must be considered and concluded alongside the setting of the level and then cannot be changed without significant implications.

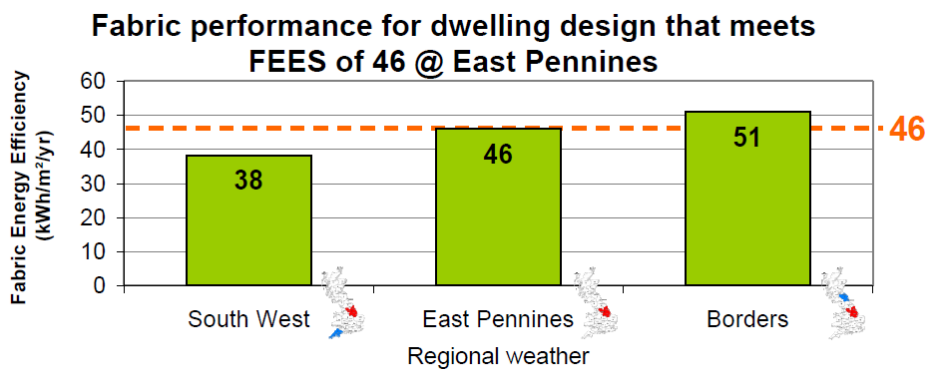
This report summarises the evidence generated and sets out the perceived pros and cons of staying with the current methodology to assess compliance or switching to the use of Regional weather. The Task Group have not come to any conclusions on which regime is more appropriate, but recommend this issue be considered by government and a decision announced alongside an announcement on the Carbon Compliance Levels for 2016.

## Explanation of issues, using semi-detached house as an example

### Looking firstly at the minimum Fabric Energy Efficiency Standard:

Take a semi-detached/end terrace dwelling designed to meet the Fabric Energy Efficiency Standard using the current National weather region (East Pennines). With East Pennines weather data, the FEE achieved is 46. If that exact dwelling is actually located in the South West, the FEE based on South West weather would be 38; if that dwelling is actually located in the Borders, the FEE based on Borders weather would be 51. This is illustrated in Figure 1.

This is the current situation. Designs are based on compliance using National weather (East Pennines), but the dwelling will 'experience' the weather in the location in which it is built.



**Figure 1:** Regional fabric performance of semi-detached/end of terrace house built to the minimum FEE Standard defined using National weather (East Pennines)

If the Fabric Energy Efficiency Standard (46 for a semi-detached house) were to be achieved based on the weather for the region in which the dwelling was built – i.e. a National standard but assessed using Regional weather – the FEE achieved (for a semi-detached house) would be 46 in all locations but the minimum required fabric specification in each location would end up being different.

Figure 2 gives an example specification to meet the minimum FEES based on Regional weather. For locations South of East Pennines, the fabric specification can be less demanding; for locations North of East Pennines the specification required is more demanding than for East Pennines location/weather. The effect of this is that there would be more flexibility on fabric specification South of East Pennines (i.e. more ability to go beyond the minimum standard), and less flexibility North of East Pennines.

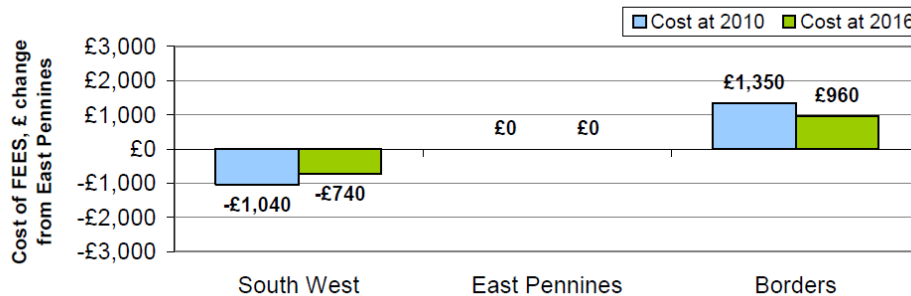
### Fabric specification to meet performance @ regional location

|                              |   | South West                | East Pennines             | Borders                   |
|------------------------------|---|---------------------------|---------------------------|---------------------------|
| U-value (W/m <sup>2</sup> K) | External Walls                                    | 0.22                      | 0.18                      | 0.15                      |
|                              | Party Walls                                       | 0                         | 0                         | 0                         |
|                              | Floor   | 0.21                      | 0.17                      | 0.15                      |
|                              | Roof  | 0.20                      | 0.13                      | 0.13                      |
|                              | Windows / doors                                   | 1.6 (double glazed) / 1.2 | 1.4 (double glazed) / 1.0 | 1.2 (double glazed) / 1.0 |
|                              | Airtightness (m <sup>3</sup> /hr/m <sup>2</sup> ) | 5                         | 5                         | 4                         |
|                              | Thermal bridging (W/m <sup>2</sup> K)             | 0.06                      | 0.04                      | 0.04                      |

**Figure 2:** Example of a fabric specification required to meet a National minimum FEE standard using Regional weather data; semi-detached/ end of terrace house

The cost of this change in specification has been estimated at approx £740 cost saving in the South West, and approx £960 additional cost in the Borders (2016 prices); see Figure 3.

### Cost to meet fabric performance @ regional location



**Figure 3:** Additional cost of fabric specification required to meet a National minimum FEE standard using Regional weather data; semi-detached/ end of terrace house

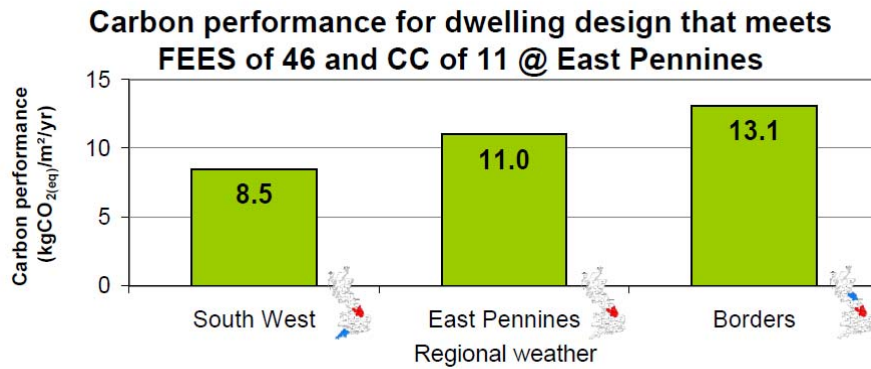
### Now turning to Carbon Compliance:

In the first instance, an assumption has been made that if the FEES is assessed based on National weather, then Carbon Compliance would also be; and if the FEES is assessed based on Regional weather, then so too would Carbon Compliance. For the example given here, the FEE and Carbon Compliance Standards are taken to be National standards (i.e. same figure(s) applied nationally).

Considering the semi-detached house described above (with the fabric specification at the level required to achieve minimum FEES using National weather, and with heat provided by gas boiler and PV panels to reduce CO<sub>2</sub> emissions to a Carbon Compliance level of 11kgCO<sub>2(eq)</sub>/m<sup>2</sup>/yr, again based on National weather) if this dwelling were:

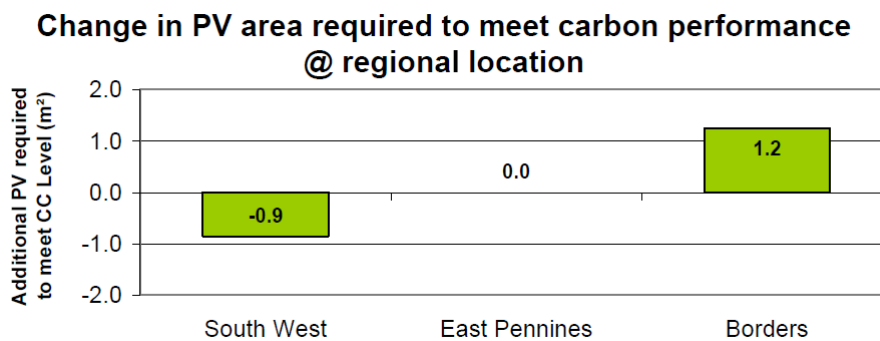
- located in the South West, the carbon performance would actually be 8.5kgCO<sub>2(eq)</sub>/m<sup>2</sup>/yr (due to the generally warmer South West weather).
- located in the Borders, the carbon performance would actually be 13.1kgCO<sub>2(eq)</sub>/m<sup>2</sup>/yr (due to the generally colder weather in the Borders).

See Figure 4. This range of emissions (approx ± 2kgCO<sub>2(eq)</sub>/m<sup>2</sup>/yr) is quite large.



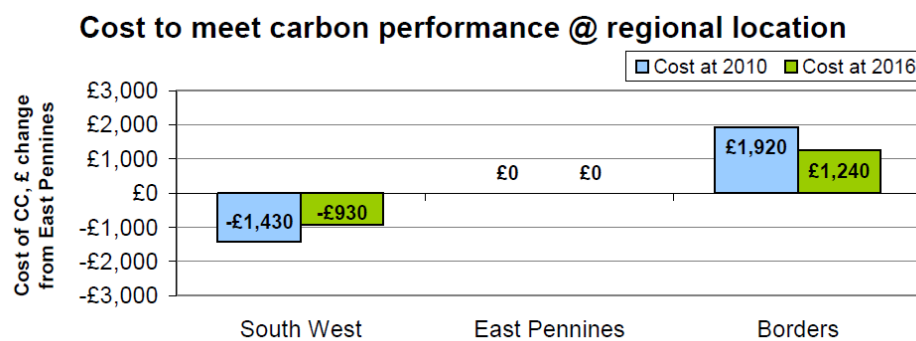
**Figure 4:** Regional carbon performance of semi-detached/ end of terrace house if design meets National FEE and CC Standards, using National weather

On the other hand, if the same Carbon Compliance level were to be achieved in all locations, based on Regional weather (with the FEES also achieved using Regional weather), then in addition to the fabric specification differences indicated in Figure 2 there would also be a slight decrease in PV area required South of East Pennines, and a slight increase in the PV area required North of East Pennines due to the solar irradiation difference across the country. This equates to approx ± 1m<sup>2</sup> PV for South West and Borders, compared to East Pennines, see Figure 5.



**Figure 5:** Change in PV area required to meet a National minimum FEE and Carbon Compliance standard using Regional weather data; semi-detached/ end of terrace house

The cost of using Regional weather for Carbon Compliance, including the difference in cost for achieving FEES, is shown in Figure 6 below. It equates to approx savings of £930 in the South West and additional cost of £1240 in the Borders (2016 prices).



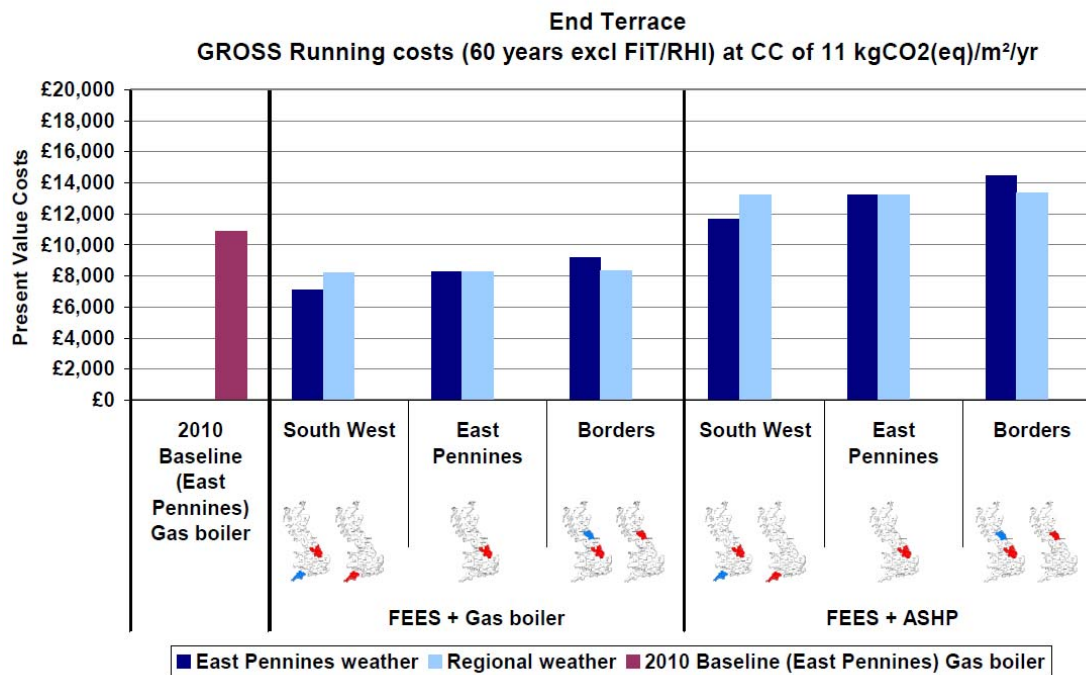
**Figure 6:** Additional cost of fabric and PV required to meet a National minimum FEE standard using Regional weather data; semi-detached/ end of terrace house

So far the analysis has considered the impact on build costs and design standards of national or regional weather. There are implications for the householder too.

Investigating the cost to the occupant over 60 years:

- the use of National weather the costs will **differ** depending on location of the dwelling (in the order of  $\pm 30$  per year).
- the use of Regional weather (but still with a National Standard for FEES and Carbon Compliance), the costs are **equal** wherever in the country the dwelling is located.

See figure 7.



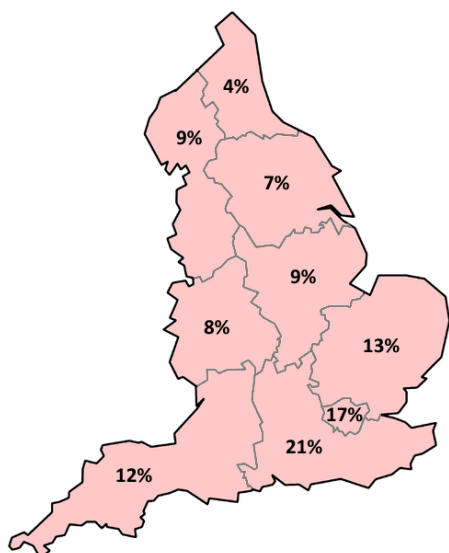
**Figure 7:** Gross running costs over 60 years (excl FIT/RHI) at a Carbon Compliance level of 11kgCO<sub>2</sub>(eq)/m<sup>2</sup>/yr for two energy scenarios. Showing the difference in cost with the use of National (East Pennines) weather or Regional weather for compliance

A similar analysis of the impact on a Detached house can be found in the Appendix.

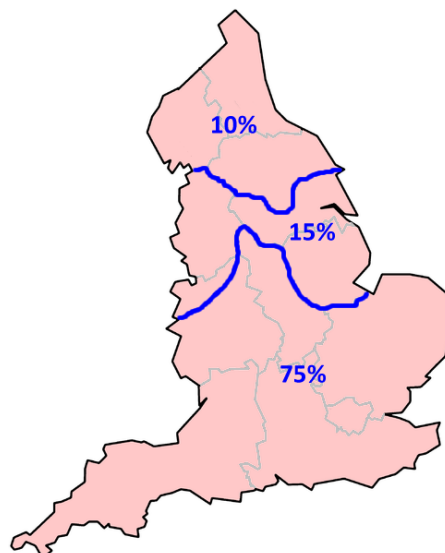
In this analysis we are using an 'average' householder. The 'mean' energy use, of a particular householder, will change across the country due to regional weather changes but we recognise these will be overlaid by differences in occupancy and behaviours at an individual level.

### House building across England

The impact of the differences describe above needs to be taken in the context of where housebuilding takes place. Figure 8a illustrates the percentage of completions by region in 2009/10 in England, and Figure x8b shows how this translates into percentage build North and South of East Pennines region (and adjoining regions where there is no discernable difference in carbon performance from moving to Regional weather).

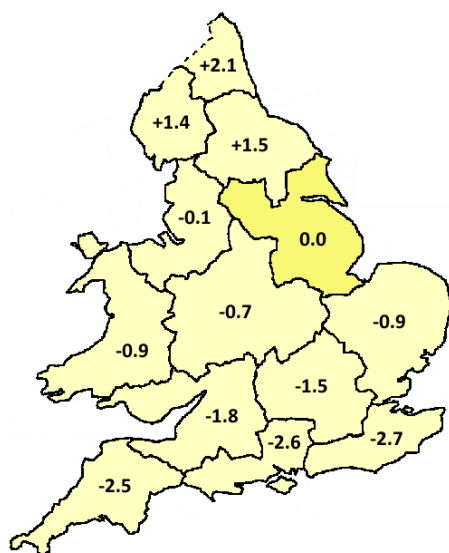


**Figure 8a:** Percentage housing completions by region, 2009/10 (source: DCLG)



**Figure 8b:** Approx percentage housing completions North and South of 'East Pennines' weather region

For further context, Figure 9 shows for each weather region, the difference in on-site carbon emissions accounted for by a dwelling designed using a compliance model based on National weather and the calculated emissions that would occur in that region.



**Figure 9:** Difference in on-site carbon emissions accounted for by a dwelling designed using the current compliance regime; semi-detached house (kgCO<sub>2</sub>(eq)/m<sup>2</sup>/yr)

### 'Overpayment' of Allowable Solutions

An implication of the combination of Figures 8 and 9 is that due to the concentration of housebuilding to the South of East Pennines region, if the compliance regime were to remain as it is today using National Weather to assess all elements of compliance (FEES, Carbon Compliance and Allowable Solutions), the national overall carbon savings of the Zero Carbon Homes policy would actually be negative.

Assuming Allowable Solutions price of £75/tonne CO<sub>2</sub>(eq) over 30 years, a rough calculation puts the 'overpayment' of Allowable Solutions at around £25 million per year (assuming 150,000 homes built per year, all to the Zero Carbon Standard), or circa £170 per dwelling.

**The Task Group therefore recommends that regardless of which weather regime is chosen for compliance, a mechanism should be implemented to ensure that calculated carbon savings from Zero Carbon homes are indeed zero on a national basis.**

### Pros and Cons of Regional / National Weather (with a National standard)

The tables below (Figures 10 and 11) show the pros and cons discussed by the Task Group on moving to Regional weather or staying with National weather to assess compliance. In many ways they are the inverse of each other and both were considered to have compelling arguments for and against. These tables show the pros and cons of a pure approach using National weather, and a pure approach using Regional weather.

| Pros and cons of moving to a Regional weather approach (with National Standards)  |  |
|---|--|
| Pros  | Cons   |
| Flexibility on fabric is increased S of East Pennines (EP) (75% of build)   | Flexibility on fabric is reduced N of East Pennines (EP) (10% of build)  |
| Cost of compliance is reduced S of EP   | Cost of compliance is increased N of EP where viability is generally worse                                     |
| AS don't 'overshoot' Zero Carbon nationally (for AS, properties S of EP not "overpaying" and those N of EP not "underpaying") | Necessitates dealing with 'boundary' issues  |
| Reflects 'reality' more accurately & reflects regional differences  | Less on-site reduction of CO <sub>2</sub> nationally   |
| Makes sense to require better fabric in N where colder  | Closer to the technical limits N of EP   |
| Recognises improved solar tech performance S of EP  | If use solar technologies, end up needing more in N than S   |
| Fuel cost to a std occupant approx same across the country (same property type) compared to ± £30pa                           | Potential increased complexity?  |
| Achieves consistency with cooling & overheating calculations (currently based on regional weather)                            | Potential increased supply chain costs (greater spec variability)  |
| There are already other areas of building design treated in this manner (e.g. flood risk, exposure)                           | Potential negative impact on land owners if values are reduced in more challenging regions (market distortion) |
| Implications for EPCs   |  |
| Localism  |  |

**Figure 10:** Pros and cons of moving to compliance based on a Regional weather approach

| Pros and cons of staying with a National weather approach (with National Standards)                         |  |
|---|--|
| Pros  | Cons   |
| Same fabric standard nationally with potential supply chain cost advantages                                 | 'Over-specified' fabric in S and 'under-specified' in N  |
| Same capital cost burden nationally (not increasing costs in N of East Pennines)                            | Not reducing costs S of East Pennines  |
| Avoids 'boundary' issues  | 'Overshoots' Zero Carbon nationally ie increased house builder costs (for AS, more properties S of EP "overpaying" than those N of EP "underpaying") |
| More on-site reduction of CO <sub>2</sub> nationally  | Doesn't reflect 'reality' – doesn't reflect regional differences   |
| Avoids potential increased complexity?  | Fuel cost to a std occupant different across the country (for same property type) ± £30pa  |
| Fabric and solar solutions equally challenging in all regions   | Does not recognise improved solar tech performance S of EP   |
| Is 'known'  | Doesn't encourage better fabric in N where colder  |
| Less potential for Carbon Compliance methodology to negatively affect land value for owners due to location | Inconsistency with cooling & overheating calculations (currently based on regional weather)  |
| Implications for EPCs   |  |
| Localism  |  |

**Figure 11:** Pros and cons of staying with a National weather approach to compliance

However, there are a number of 'flavours' to each option which could address a number of the perceived disadvantages. Regional weather with regional standards would be one example.

### Weather / Standard combinations

The number of weather / standard combinations is quite high. Figure 12 shows the main combinations which were considered and the range of outcomes which would result. There isn't a 'right' answer. The question is; what are the most appropriate set of 'outcomes' for the policy. Inevitably there will be some compromise.

The best way to read Figure 12 is to look at the 'outcomes' first. By assessing which outcomes are more important to you, will then lead to an option (or options) which best represents those priorities.

For example, if one wanted to ensure the minimum fabric specification remained consistent across the country, that Zero Carbon was achieved nationally (rather than negative carbon), and that the technical 'headroom' remained consistent across the country then the options which fulfil these three objectives are: 1a, 1b, 2b and 2d. If then one considered that the accuracy of the performance claim was important, this would bring you to option 2b or 2d.

#### National Standard

In terms of the options, having a 'National Standard' means that the same number is applied to a dwelling type, regardless of location. If a National Standard is utilised with Regional weather, this means that there will be differing challenges to achieving that standard depending on the location of the dwelling.

#### Regional Standard

Having a 'Regional Standard' means that the target on-site CO<sub>2</sub> emissions (or minimum Fabric Energy Efficiency Standard) would be adjusted depending on region such that it represents the same challenge as if the dwelling were located in the East Pennines.

This process would occur within the 'black-box' of SAP and therefore represent no difference from the current regime where the target is not known until the dwelling is entered into SAP. This may sound onerous but in reality is not. For example, an attached houses in East Pennines with a carbon compliance limit of 11kgCO<sub>2(eq)</sub>/m<sup>2</sup>/yr, would translate into a carbon compliance limit of 8.5kgCO<sub>2(eq)</sub>/m<sup>2</sup>/yr for attached houses in the South West. The same dwelling design would comply in each of these locations.

It should be noted that some Task Group members voiced concerns regarding the current weather regions used within SAP and therefore would **recommend that if a Regional weather route were to be chosen then a review of the number of, and appropriate drawing of boundaries between, 'regions' is undertaken.** The technical information presented in this paper necessarily used the current set of SAP weather regions, and the results should therefore be taken as indicative of the potential impact of each compliance option considered.

| OPTION         | Weather used for FEES & CC compliance calc | Fabric Energy Efficiency Standard (FEES) | Carbon Compliance (CC) | Allowable Solutions (AS)   | OUTCOME       |                  |               |               | Minimum fabric spec across country | Difference in regulatory burden of ZC policy across country (semi detached house, 2016 Costs, compared to Option: Current) |            | Zero Carbon         | Average household fuel costs across country (semi detached, compared to East Pennines) | Comparison to 70% CC level (red'n from BR 2006, detached/ attached/ low-rise built performance) | Accuracy of performance claim (std. occupant, assuming designed = built performance) | Geographic optimisation of solar technologies | Technical 'headroom' (Fabric / PV) | Complexity for Industry | Policy Complexity |
|----------------|--|--|------------------------|--|---------------|------------------|---------------|---------------|------------------------------------|--|------------|---------------------|--|---|--|---|------------------------------------|-------------------------|-------------------|
|                |  |  |                        |  | eg South West | eg East Pennines | eg South West | eg South West |                                    | eq. %, ave   | eq. %, ave |                     |  |   |  |   |                                    |                         |                   |
| <b>Current</b> | National Weather                           | National Standard                        | National Standard      | AS calc using National weather                                     | £0            | £0               | £0            | £0            | Negative carbon                    | - £35/yr   | + £30/yr   | eq. %, ave 60/56/44 | 'Worse than' in N, 'Better than' in S  | Same m <sup>2</sup> in North & South  | Reference  | Reference                                     | Reference                          |                         |                   |
| <b>1a</b>      | National Weather                           | National Standard                        | National Standard      | National weather. AS scheme adjusted to avoid National overpayment | -£170         | -£170            | -£170         | -£170         | Zero Carbon on ave. nationally     | - £35/yr   | + £30/yr   | eq. %, ave 60/56/44 | 'Worse than' in N, 'Better than' in S  | Same m <sup>2</sup> in North & South  | Equal / Equal  | Equal   | Slightly more                      |                         |                   |
| <b>1b</b>      | National Weather                           | National Standard                        | National Standard      | AS calc using Regional weather                                     | -£435         | £0               | £360          | £360          | Zero Carbon on all dwellings       | - £35/yr   | + £30/yr   | eq. %, ave 60/56/44 | 'Worse than' in N, 'Better than' in S  | Same m <sup>2</sup> in North & South  | Equal / Equal  | Equal   | Equal                              |                         |                   |
| <b>2a</b>      | Regional Weather                           | National Standard                        | National Standard      | AS calc using Regional weather                                     | -£930         | £0               | £1,240        | £1,240        | Zero Carbon on all dwellings       | Equal  | Equal      | eq. %, ave 56/52/40 | Correct  | More m <sup>2</sup> in North  | Less in N, more in S / Less in N, more in S  | More  | Equal                              |                         |                   |
| <b>2b</b>      | Regional Weather                           | Regional Standard                        | Regional Standard      | AS calc using Regional weather                                     | -£435         | £0               | £360          | £360          | Zero Carbon on all dwellings       | - £35/yr   | + £30/yr   | eq. %, ave 60/56/44 | Correct  | Same m <sup>2</sup> in North & South  | Equal / Equal  | Equal   | Equal                              |                         |                   |
| <b>2c</b>      | Regional Weather                           | Regional Standard                        | Regional Standard      | AS calc using National weather                                     | £0            | £0               | £0            | £0            | Negative carbon                    | - £35/yr   | + £30/yr   | eq. %, ave 60/56/44 | Correct  | Same m <sup>2</sup> in North & South  | Equal / Equal  | Equal   | Equal                              |                         |                   |
| <b>2d</b>      | Regional Weather                           | Regional Standard                        | Regional Standard      | National weather. AS scheme adjusted to avoid National overpayment | -£170         | -£170            | -£170         | -£170         | Zero Carbon on ave. nationally     | - £35/yr   | + £30/yr   | eq. %, ave 60/56/44 | Correct  | Same m <sup>2</sup> in North & South  | Equal / Equal  | Equal   | Slightly more                      |                         |                   |
| <b>2e</b>      | Regional Weather                           | National Standard                        | Regional Standard      | AS calc using Regional weather                                     | -£710         | £0               | £957          | £957          | Zero Carbon on all dwellings       | - £30/yr   | + £25/yr   | eq. %, ave 60/56/44 | Correct  | More m <sup>2</sup> in South  | Less in N, more in S / More in N, less in S  | More  | Equal                              |                         |                   |
| <b>2f</b>      | Regional Weather                           | National Standard                        | Regional Standard      | National weather. AS scheme adjusted to avoid National overpayment | -£445         | -£170            | £430          | £430          | Zero Carbon on ave. nationally     | - £30/yr   | + £25/yr   | eq. %, ave 60/56/44 | Correct  | More m <sup>2</sup> in South  | Less in N, more in S / More in N, less in S  | More  | Slightly more                      |                         |                   |

Figure 12: Various options for compliance regime, showing the outcomes in a number of different areas. The pros and cons in Figures 10 and 11 above relate to options '2a' and 'current' respectively.

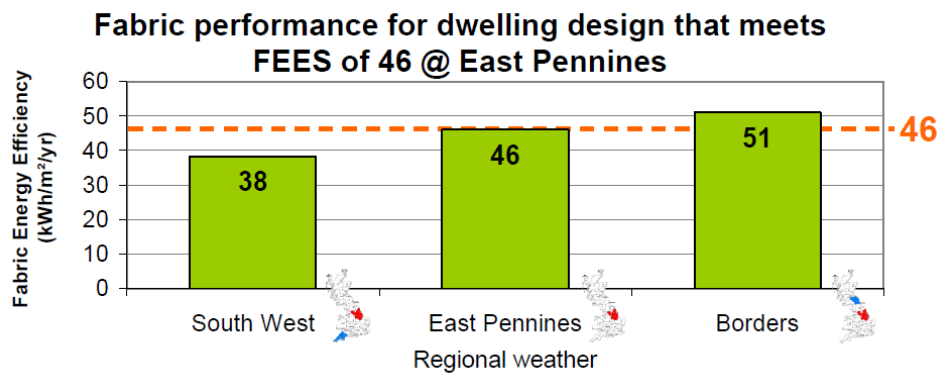
## Summary

The Task Group felt it was not appropriate to recommend the approach the compliance regime should take with regards to use of National or Regional weather or whether a National or Regional standard should be set for Fabric Energy Efficiency or Carbon Compliance. **The Task Group therefore recommend the options be considered by government and a decision announced alongside an announcement on the Carbon Compliance Levels for 2016.**

**The Task Group recommends that regardless of which option is chosen, a mechanism should be implemented to ensure that calculated carbon savings from Zero Carbon homes are indeed zero on a national basis.**

**Should a regional approach to weather be implemented, the Task Group recommend that a review of the number of, and appropriate drawing of boundaries between, 'regions' is undertaken.**

## Appendix: Analysis of Detached house

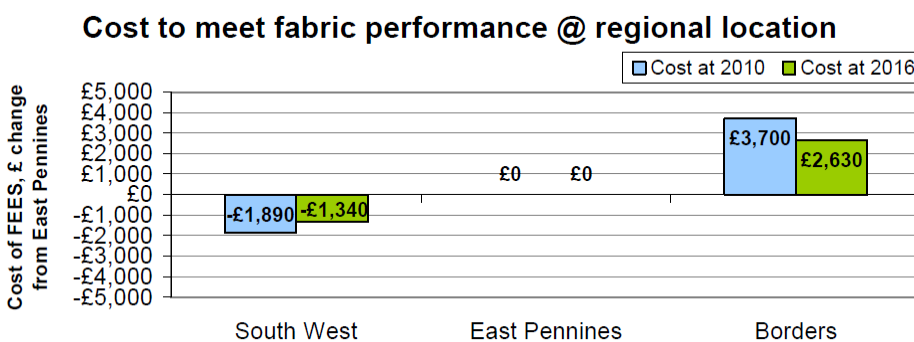


**Figure A.1:** Regional fabric performance of detached house built to the minimum FEE Standard defined using National weather (East Pennines)

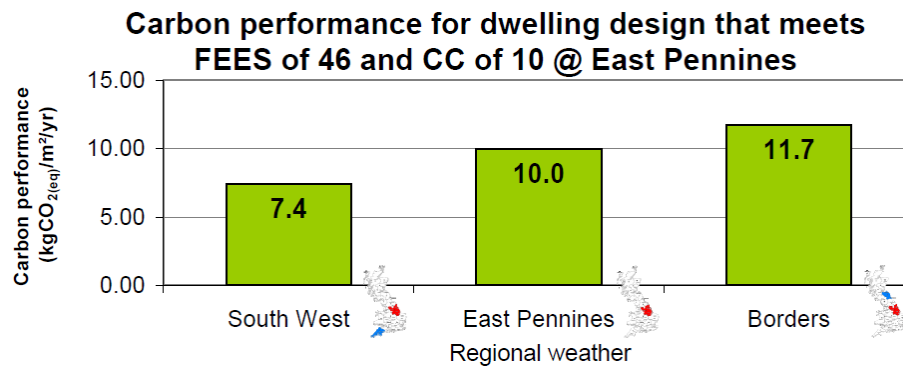
### Fabric specification to meet performance @ regional location

|   | South West                | East Pennines             | Borders                   |
|---|---------------------------|---------------------------|---------------------------|
| U-value (W/m <sup>2</sup> K)                      |                           |                           |                           |
| External Walls                                    | 0.19                      | 0.15                      | 0.15                      |
| Party Walls                                       | n/a                       | n/a                       | n/a                       |
| Floor   | 0.18                      | 0.15                      | 0.15                      |
| Roof  | 0.18                      | 0.13                      | 0.13                      |
| Windows / doors                                   | 1.5 (double glazed) / 1.2 | 1.4 (double glazed) / 1.0 | 0.9 (triple glazed) / 1.0 |
| Airtightness (m <sup>3</sup> /hr/m <sup>2</sup> ) | 5                         | 3.1                       | 3                         |
| Thermal bridging (W/m <sup>2</sup> K)             | 0.05                      | 0.04                      | 0.04                      |

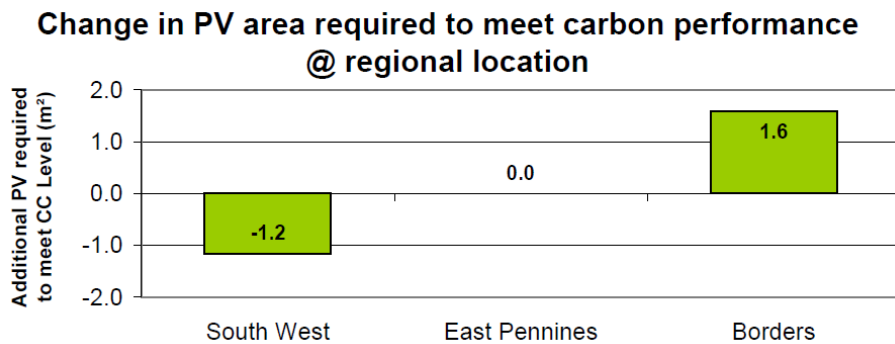
**Figure A.2:** Example fabric specification required to meet a National minimum FEE standard using Regional weather data; detached house



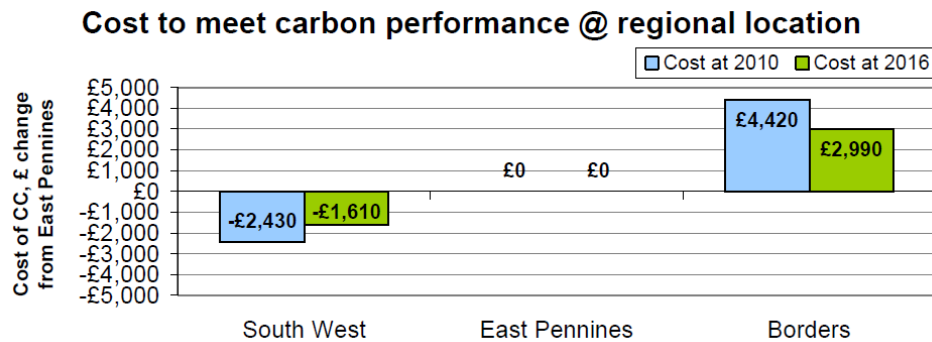
**Figure A.3:** Additional cost of fabric specification required to meet a National minimum FEE standard using Regional weather data; detached house



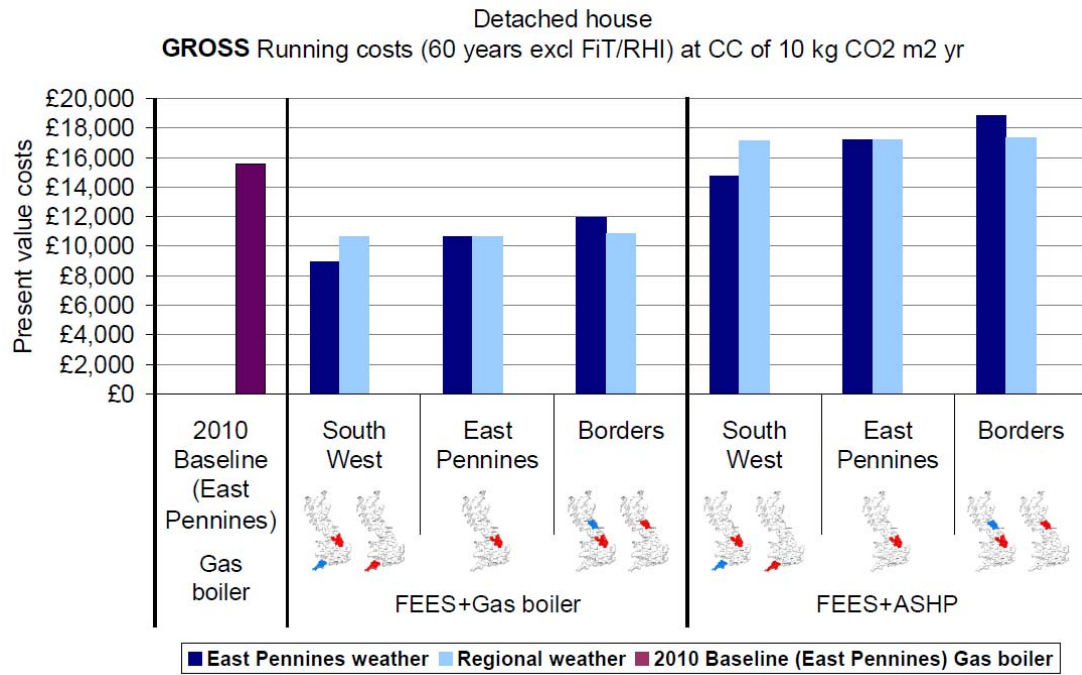
**Figure A.4:** Regional carbon performance of detached house if design meets National FEE and CC Standards, using National weather



**Figure A.5:** Change in PV area required to meet a National minimum FEE and Carbon Compliance standard using Regional weather data; detached house



**Figure A.6:** Additional cost of fabric and PV required to meet a National minimum FEE standard using Regional weather data; detached house



**Figure A.7:** Gross running costs over 60 years (excl FIT/RHI) at a Carbon Compliance level of 10kgCO<sub>2(eq)</sub>/m<sup>2</sup>/yr for two energy scenarios. Showing the difference in cost with the use of National (East Pennines) weather or Regional weather for compliance