Department for Communities and Local Government

Revision of building regulation policy on radon

Impact Assessment

July 2013
Department for Communities and Local Government

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July 2013

ISBN: 978-1-4098-3976-7

Title: Revision of building regulation policy on radon **IA No:** DCLG 0077 **Lead department or agency:** Department for Communities And Local Government (DCLG) **Other departments or agencies:**	Impact Assessment (IA) **Date:** 22/03/2013 **Stage:** Final **Source of intervention:** Domestic **Type of measure:** Secondary legislation **Contact for enquiries:** Guy Bampton

Summary: Intervention and Options

RPC Opinion: GREEN

Cost of Preferred (or more likely) Option				
Total Net Present Value	**Business Net Present**	**Net cost to business per year** (EANCB on	**In scope of One-In, One-**	**Measure qualifies as**
£0.97m	-£3.22m	£0.32m	Yes	IN

What is the problem under consideration? Why is government intervention necessary?

Radon is a naturally occurring radioactive gas linked to lung cancer. Alongside a health and awareness programme and testing and remediation of existing buildings, current Government policy includes targeted intervention through the Building Regulations which requires radon protection in new buildings in areas of elevated radon risk. This combats market failure arising from information failure (householders may not understand radon risks) and from agency issues (housebuilders may not fully take account of health benefits to future occupants when developing a building). This Impact Assessment deals with amending guidance to reference the most up-to-date radon maps.

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What are the policy objectives and the intended effects?

We intend that the Building Regulations and supporting statutory guidance is clear on current radon risks, and ensures buildings are fitted with proportionate measures to prevent the ingress of radon and thus reduce radon-related lung cancers. Current guidance refers to radon maps issued in 1999 but more detailed maps were published in 2007. By amending guidance in Approved Document C we will ensure that radon measures are installed based on the latest assessment of radon risk.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

Option 0 – Do Nothing

Option 1 - Update Building Regulations Guidance to align it with the current radon risk maps

This final stage Impact Assessment considers the chosen policy option, **updating Building Regulations guidance to align it with the current radon risk maps** (Option 1), against a counterfactual 'do-nothing' scenario (Option 0). The Department for Communities and Local Government issued a Circular Letter in 2008 promoting the use of the new radon maps as good practice. Following this non-regulatory action a high proportion of industry started providing protective measures in line with these maps.

The chosen policy will maintain a targeted regulatory intervention (aligned to the most up-to-date radon maps), to ensure that all buildings in higher-risk areas incorporate appropraie radon measures.

Will the policy be reviewed? It will be reviewed. **If applicable, set review date:** 10/2018

Does implementation go beyond minimum EU requirements?			N/A		
Are any of these organisations in scope? If Micros not exempted set out reason in Evidence Base.	**Micro** Yes	**< 20** Yes	**Small** Yes	**Medium** Yes	**Large** Yes
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)			**Traded:** Nil	**Non-traded:** Nil	

I have read the Impact Assessment and I am satisfied that (a) it represents a fair and reasonable view of the expected costs, benefits and impact of the policy, and (b) that the benefits justify the costs.

Signed by the responsible Minister:  Date: 24.04.2013

Summary: Analysis & Evidence Policy Option 1

Description: Option 1 - Update Building Regulations Guidance to align it with the current radon risk maps

FULL ECONOMIC ASSESSMENT

Price Base Year	PV Base Year	Time Period Years	Net Benefit (Present Value (PV)) (£m)		
	2013	10	**Low:** 0.65	**High:** 1.28	**Best Estimate: 0.97**

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	0.48	1	0.23	**2.49**
High	0.59		0.39	**3.95**
Best Estimate	0.53		0.31	**3.22**

Description and scale of key monetised costs by 'main affected groups'

Most of the industry already follows good practice in installing radon protective measures. Referencing the revised radon maps in Approved Document C will ensure all buildings incorporate protection where it is cost-effective. The change will impose additional costs of installing radon protection in new homes (£2.29m) and in extensions (£0.39m). Estimated transition costs of £0.53m may be overstated as many firms will already have experience of working in existing radon areas.

Other key non-monetised costs by 'main affected groups'

None.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low			0.36	**3.14**
High			0.61	**5.23**
Best Estimate	N/A		0.49	**4.19**

Description and scale of key monetised benefits by 'main affected groups'

The policy will deliver health benefits as the installation of radon protection measures will reduce future lung cancer incidence (£4.19m).

Other key non-monetised benefits by 'main affected groups'

Non-monetised social benefits include the reduced emotional stress for families and friends of the people who do not suffer from lung cancer as a result of this intervention. Amending guidance to make clear the status of the radon risk maps and radon risk reports has the potential to ensure even better targeting of radon measures and deliver significant benefits. As this is uncertain it is not included in the monetised estimates but we believe it has the potential to outweigh the estimated costs to business of the policy.

Key assumptions/sensitivities/risks **Discount rate** 3.5

Key assumptions in our assessment include: those about radon and cancer risks (including cancer risks and the link to smoking), the efficacy of radon protection, unit costs of radon protective measures, build rates for the decade from 2013, and the counterfactual of radon protective measures provided as good practice - described in more detail in paragraph 101 onwards.

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			**In scope of**	**Measure qualifies**
Costs: 0.32	**Benefits:** 0	**Net: -**0.32	Yes	IN

Evidence Base (for summary sheets)

What is the problem under consideration? Why is Government intervention necessary?

Background on the Building Regulations

1) The Building Regulations 2010 control certain building work - principally to protect the health, safety and welfare of people in or around buildings.

2) The Regulations themselves are expressed in “functional” terms and do not dictate how the desired level of performance *must* be achieved. However, for the benefit of both industry and building control bodies, advice on how the requirements of the Building Regulations *may* be met are contained in guidance approved by the Secretary of State, known as Approved Documents. These cover some of the more common building situations, but there may well be alternative ways of achieving compliance with the provisions. However, if followed, the guidance in Approved Documents may be relied upon in any proceedings as tending to indicate compliance with the Building Regulations.

3) Part C of Schedule 1 to the Building Regulations requires the buildings it addresses - generally new buildings and extensions including material changes of use - to be constructed in such a way as to deliver reasonable precautions to avoid danger to the health and safety of occupants which might arise from the site or contaminants it contains, and to provide them adequate protection from moisture such as groundwater and rain. Contaminants include radioactive substances including radon gas.

4) In a comparable way to other Approved Documents, the existing guidance in Approved Document C explains technical approaches which it states, if followed, will demonstrate compliance with the regulatory requirements. Approved Document C provides guidance relating to contaminants including guidance on how to protect against radon gas and how to establish where this may be necessary (based on referencing radon maps).

Background on radon

5) Since 1988 the contaminants addressed by Part C have included radon gas. Radon is a naturally occurring colourless and odourless radioactive gas that can seep out of the ground and build up in houses, buildings, and indoor workplaces. Epidemiological studies have established that exposure to radon is a cause of lung cancer, with a linear dose-response relationship. Exposure to radon is now recognised as the second largest cause of lung cancer in the UK after smoking and analysis for the Health Protection Agency indicates that about 1100 UK deaths from lung cancer each year are caused by exposure to radon (most caused jointly by radon and smoking)[1].

[1] “Radon and Public Health. Report of an independent Advisory Group on Ionising Radiation”. Chilton, Docs RCE 11, HPA 2009 . Available at: www.hpa.org.uk

6) Radon concentrations within buildings are determined by various factors including the geology of the ground, construction details and factors such as the methods of heating and ventilation. The concentration is measured in Bequerels per cubic metre (Bq m^{-3}). Advice published by the Health Protection Agency explains how health experts estimate that an increase in radon concentration of 100 Bq m^{-3} in a dwelling increases an occupant's risk of lung cancer by up to 31%, with a central estimate of 16%[2].

7) As set out in the previously referenced report by an independent Advisory Group, the available evidence suggests this percentage increase in lung cancer risk applies for men and women, across all age groups and for current smokers, ex-smokers and lifelong non-smokers. Since the baseline risk of lung cancer is much higher among smokers than non-smokers, and as radon appears to act to increase cancer risks in smokers in a multiplicative way, this means that - in absolute terms - the increase in lung cancer risk due to radon is much higher among smokers than non-smokers. The respective cumulative risks of lung cancer affecting people by age 75 years in the UK at 100 and 200 Bq m^{-3} are 0.42% and 0.47% for non-smokers and 17% and 19% for continuing smokers. The risks for ex-smokers will be in between the risks for these two groups, with a risk level which varies according to when they stopped smoking.

8) The Health Protection Agency and others are carrying out additional work examining radon related health risks and the Department welcomes the continued advice from the Agency on this.

The Problem

9) In addition to examining the health risk evidence, the Health Protection Agency carries out surveys and tests of radon activity in existing buildings in the UK. The information from these is used in radon mapping by the Agency with the British Geological Survey. The Agency publishes atlases of probabilistic radon activity maps for the UK. The Building Research Establishment has, since 1998, published guidance[3] that shows the areas of increased radon levels and technical details of measures that can be installed to provide precautions against radon.

10) The current (2004) edition of Approved Document C, by reference to the Building Research Establishment (1999) guidance, outlines the radon action areas (areas of elevated risk) in England where radon protective measures should be installed. These are described as areas where either "basic" or more comprehensive "full" protective measures should be provided: these are the areas where 3-10% and above 10% of homes surveyed were found to have radon levels above 200 Bq m-^{3}, respectively. This publication also provides technical guidance on different construction approaches that can be used in these areas to provide reasonable precautions against radon.

[2] "Limitation of Human Exposure to Radon – Advice from the Health Protection Agency". Available at: www.hpa.org.uk

3 This guidance includes BR211 "Radon: Protective Measures in New Homes" - published in 1999, revised in 2007

11) In 2007, following detailed surveys and studies, the Health Protection Agency and the British Geological Survey published an updated atlas of radon maps[4]. These show how the areas of higher levels of radon are more widespread than those identified in 1999. BRE also published a revised BR211"Radon: Protective Measures in New Homes" in 2007, with the maps of areas where radon protection is required updated in line with the revised atlas. The 2007 map is available at higher resolution than its predecessor and therefore provides a more accurate identification of radon risk in a particular area.

12) In outline, "basic" radon protective measures involve the fitting of a gas tight ground barrier to protect against radon ingress. This, which also acts as a damp-proof membrane, should cover the whole building foot print and be lapped to the damp proof course in the walls and sealed around service penetrations.

13) "Full" radon protective measures requires the radon-proof ground barrier, together with a sump in the foundation, ready to take a fan if high levels of radon are detected after occupancy.

Rationale for intervention

14) In 2008, the Department for Communities and Local Government issued a Circular Letter highlighting the revised radon maps, their implications and the updated BR211 guidance. It also indicated that we would look to update Approved Document C to align it with this revised guidance – work we are now doing. The Department also used that Circular Letter to recommend as good practice the use of the latest revised guidance in BR211.

15) Evidence from Building Control indicates that the 2008 Circular Letter has had considerable influence in promoting this good practice and as a result at least 70% of development in the new areas of higher radon risk is now carried out using appropriate protective measures. This figures is based on the fact that the National House-Building Council (NHBC), who provide the building control service for the majority of new housing developments in England, advise that they would expect developers to provide protective measures in line with the 2007 versions of the radon maps. This figure was tested at consultation (without being opposed) and endorsed by an expert group drawn from industry - including home builders and building control including NHBC - to develop the technical proposals and inform the final Impact Assessment. In practice, it is likely to be a slight underestimate of the actual level of "voluntary" provision, but is used to ensure that we do not underestimate the potential additional cost to other housebuilders of such a change. However, it appears the letter has not been successful in ensuring all new homes, major alteration and extensions are being built with suitable radon protection measures in the relevant areas.

16) This market failure may result from builders lacking sufficient incentive to build radon precautions into work in the new areas, when it is not seen as a regulatory requirement described in Approved Document C. They are exposed only to costs that arise from installing protective measures and do not receive the benefits that subsequently accrue. Furthermore, as householders and homebuyers often lack awareness of radon, they may not make informed decisions about their homes and radon precautions and so fail to create a demand for these precautions.

[4] "Indicative Atlas of Radon in England and Wales" available at:: www.hpa.org.uk

17) If a significant minority of development activity is not providing appropriate radon precautions in line with the latest maps, because this is not seen as a requirement described by the statutory guidance in Approved Document C, the absence of suitable radon protective measures in new developments will place occupants at higher risk of exposure to radon and associated health impacts. We consider intervention to address this in Option 1.

Policy Objective

18) To ensure the existing policy to prevent the ingress of radon into a building, and thus reduce radon-related lung cancers, is properly targeted.

Policy Options considered

19) Two options are considered in this final Impact Assessment:

    i. Option 0 – do nothing ie leave the existing statutory guidance in Approved Document C referencing the out-of-date radon maps and rely on industry following good practice to ensure measures are properly targeted.

    ii. Option 1 – revise statutory guidance in Approved Document C to reference the most up-to-date maps and thereby ensure protective measures are properly targeted.

20) At consultation stage we also gave consideration to extending the requirement to provide radon protection to all new homes. This policy option had a net disbenefit of £112m in the assessment and has not been further considered here.

21) The “do nothing” option is not preferred because:

    i. it undermines the rationale for a targeted regulatory intervention if the provisions are not targeted on the basis of the most accurate and up-to-date information

    ii. consequently some buildings that should be protected would not be leading to an increased incidence of lung cancer, and

    iii. some homes would incorporate radon protection where it is not proportionate to do so.

22) Option 1 is preferred to avoid the adverse impacts set out under the “do nothing” option above. It will require either basic or full radon protective measures, as appropriate, to be provided to new buildings in the newly mapped areas of higher radon risk. This maintains but extends the current policy of targeted intervention in areas of higher risk and has clear health benefits over the current situation. Our analysis shows that this targeted approach has a significant benefit to cost ratio.

23) GIS analysis conducted on the two sets of radon maps indicates that the updated radon risk map increases the number of properties within an identified radon risk area by around 250,000 addresses, an estimated area of approximately 2,172 km^2. This constitutes around 1.1% of the total number of addresses in England.

24) The 2007 radon maps have the further advantage that they are compiled at a more detailed resolution than the 1999 maps. The net figure is therefore made up of both an increase in addresses within a radon risk area (656,007 addresses) less those within a radon risk area in the 1999 maps and now outside of radon risk areas in the updated map (405,985 properties).

Results of the public consultation

25) The consultation specifically asked consultees to provide evidence which might help inform the analysis and assumptions in this Impact Assessment. However, little was provided and therefore the main changes that have been made since consultation have come as a result of the further work described immediately below. A summary of the responses to the consultation is available on the Department's website[5].

Further research undertaken since the public consultation

26) To strengthen the evidence base EC Harris in conjunction with Adroit Economics were commissioned to produce an updated assessment of some of the key variables within this assessment. The key outputs from this work that have helped to refine this Impact Assessment include

- costs estimates for basic and full radon protection in different circumstances (see Table 1)
- use of GIS mapping software to work out the number of properties in the radon affected areas more accurately
- use of GIS mapping software to estimate development rates in the radon affected areas

27) Alongside plausible assumptions on the rate of development of new dwellings in the radon risk areas this has allowed us to refine the estimates made at consultation and the outputs of this work are described in the evidence base where they have helped to inform revisions to the previous analysis. A summary of the further work undertaken by EC Harris is available on the Department's website[6].

Further amendments to guidance to be taken forward

28) Alongside the consultation a number of local authorities helpfully volunteered to provide data on how they and developers sought to determine radon risk in practice and consequently whether protective measures were necessary. From the returns received, practice amongst local authorities differs significantly. This is due to the fact that there are effectively two possible ways of deciding whether a particular site needs radon protection - either by using the higher-level information provided by the indicative radon atlas or by using more detailed GIS information provided for which there is a small charge.

[5] The summary of responses is available at: www.gov.uk/government/uploads/system/uploads/attachment_data/file/38700/2012_BR_SOR.pdf
[6] www.gov.uk/government/publications/further-economic-and-analytical-support-for-proposals-to-amend-the-building-regulations-in-2013

29) Guidance in BR211, which is referenced in the Approved Document, suggests the following approach to developers:

- for light grey squares in the radon atlas either install basic radon protection or obtain a radon risk report
- for dark grey squares in the radon atlas either install full radon protection or obtain a radon risk report.

30) Some local authorities automatically provide the householder or developer with the more detailed assessment. Our call for evidence suggest around a half use this approach with the other half relying on the higher level information provided in the radon atlas. Our survey covers around a sixth of local authorities in radon affected areas.

31) For one of the local authorities using the indicative maps to provide advice on levels of radon protection the Department has been able to obtain postcode level radon risk reports from the HPA. A large proportion of those properties classified as requiring 'Basic Protection' in the radon maps would be identified as requiring 'no measures' according to the radon risk report. This is because the indicative radon atlas is based upon the highest risk within a 1km grid square whereas the radon risk report offers greater granularity. Similar findings were true for properties identified as 'Full Measures' through the radon maps, with many suggested to install only basic measures or no measures in the radon risk report.

32) If the local authority does not provide the more exact risk assessment as a matter of course, the information is available from either the UK Radon website or the British Geological Society for a small fee of around £3.50.

33) We propose to amend the wording of the Approved Document to make clear the availability of the postcode level data with the aim of ensuring that building control bodies, developers and householders make decisions regarding radon protection based on the most appropriate local data. We do not believe there will be any additional cost in terms of time in referencing this information as opposed to referencing the information contained in the "traditional" radon maps.

Costs and benefits

34) In developing this Impact Assessment the Department has drawn upon work carried out by the Health Protection Agency and its Advisory Group on Ionising Radiation. The costs and benefits detailed below are calculated using 2012 prices.

35) Radon in the workplace - effectively all non-domestic buildings in which people spend significant amounts of time - is addressed by workplace safety regulations and guidance[7] which the Health and Safety Executive has already updated in line with the 2007 radon maps. It is assumed that non-domestic buildings will be fitted with appropriate radon protective measures (in line with the 2007 maps) or, unlike homes, if they are not management action will identify the need for and introduce remedial work to provide reasonable levels of precautions to safeguard the health of occupants. This is in line with the approach in 2004 when reference to non-domestic buildings was first included in Approved Document C.

Costs – Option 0, do nothing

36) There are no costs for this option since it is the baseline (beyond foregoing the benefits of option 1). We think that around 70% of development is already following good practice and installing radon measures in homes that fall within the new map areas.

Benefits – Option 0, do nothing

37) There are no benefits associated with this option.

Costs – Option 1

38) The costs associated with this option are the additional build costs which will result from updating Approved Document C so it explicitly refers to BR211 2007 and requires that appropriate radon protective measures are installed in all new homes and extensions built in the additional radon risk areas identified on the 2007 maps.

Costs – Option 1, targeted protective measures in new homes

39) Estimates of the additional cost of basic radon measures for new houses (i.e. over and above the cost of installing a normal damp-proof membrane) vary with the size, type and proposed construction of the building. At consultation stage we identified cost estimates for basic radon protection in a new house based on discussions with industry that ranged from £100 and £400, with an additional £85 extra to install the sump needed for “full” measures.

40) EC Harris have undertaken a further piece of work since the consultation to establish the various elements of radon protection relevant to this assessment and the total cost of providing basic and full radon protection in various property types (table 1). These cost estimates have considered in detail each element of installing either basic or full radon protective measures in different types of property and we therefore believe they are more robust than the estimates used at consultation stage.

41) EC Harris have also tested these estimates with developers, the majority of whom supplied similar, or lower, estimates of the cost of installing radon protection, suggesting that these estimates will, if anything, provide an overestimate of costs to business from this policy.

7 Relevant HSE guidance provided in accordance with the requirements of the Health and Safety at Work Act 1974, the Management of Health and Safety at Work Regulations1999 and the Ionising Radiation Regulations 1999 - http://www.hse.gov.uk/radiation/ionising/radon.htm

42) These unit costs are summarised in Table 1 below and a more detailed exposition of the cost build-up is provided in Annex A.

Table 1 - Estimated costs of radon protective measures

Building Type	Basic Protection	Full Protection
Terraced	£318	£418
Semi-detached	£350	£448
Detached	£510	£614
Bungalow	£526	£624
Converted flat	£150	£220
PB low-rise flat	£160	£230
PB high-rise flat	£70	£100

Source: EC Harris[8]

43) At consultation stage the number of new homes assumed to be built with radon protective measures was based on a report by Europe Economics[9] (which assumed 150,000 new units per annum). This identified that 6,830 additional new homes should be built in 2013 with radon protective measures as a result of the 2007 map changes. This was based on an approximate analysis of new home development by local authority and the proportion of the local authority estimated to fall within radon affected areas. However, assuming a counterfactual that industry good practice would be delivering 70% of this target, we calculated the costs of regulating as the incremental increase in costs that would occur by a change in Approved Document C to ensure the remainder (up to 30%) are provided with appropriate protective measures. This led to estimated numbers of properties to be built in radon areas of 2,049 in 2013, rising to 3,244 in 2022 with a 10 year total of 27,147.

44) GIS mapping has been used for this final stage Impact Assessment in order to estimate more accurately the number of properties in radon affected areas. This process used the GIS software to identify the number of addresses in the radon affected map areas according to both the 1999 radon maps and the 2007 radon maps. Because the 2007 radon maps are available at a more detailed resolution this also takes into account the fact that some areas that were identified as medium or high risk in 1999 might no longer be in the 2007 maps.

45) It is estimated that there are 250,022 properties falling within the 2007 radon risk area that were outside the 1999 radon risk area. In cases where householders obtain a radon risk report, or the local authority supplies exact radon risk information, this will be an accurate representation of the cost. The GIS analysis is summarised in table 2.

[8] For further details please see Annex A

[9] Europe Economics, 2010, Report of Economic Research related to the 2010 Review of Building Regulations Parts A and C

Table 2 – GIS analysis of radon risk areas

		2011	
	area (sq km)	**postcodes**	**address count**
Areas within 2007 radon risk areas and outside of the 1999 radon risk areas			
3-10%	5,536	36,927	581,538
>10%	2,060	5,811	74,469
>3%	7,597	42,738	656,007
Areas within 1999 radon risk areas and outside of the 2007 radon risk areas			
3-10%	4,478	21,679	340,144
>10%	947	3,811	65,841
>3%	5,425	25,490	405,985
Net additional dwellings in radon risk areas			
3-10%	1,058	15,248	241,394
>10%	1,113	2,000	8,628
>3%	2,172	17,248	250,022

Source: Adroit Economics

46) By using two different years of postcode data the rate of development for the radon affected areas can also be estimated. In 2006 there were 638,553 addresses within the 3-10% areas and in 2011 this had increased to 675,150 addresses, suggesting a build rate of around 1.05% in these areas. For the high radon risk areas the estimated build rate using this approach is 1.47%. As in the consultation stage Impact Assessment we have applied a range of 25% on the number of new homes built per annum to construct the low and high estimates on the summary sheet of the impact assessment.

47) Applying the estimated build rates to the number of dwellings within the relevant areas provides an estimate of the number of properties built per annum that might require radon protection as a result of the policy change. We have assumed that dwellings are built according to the current average stock profile (see Table 3), with an adjustment to reflect higher build rates of flats in recent history compared to the existing stock[10].

Table 3 – National housing stock profile, 2009

Property type	**Number of dwellings in group (000s)**
all terrace	6,450
semi-detached	5,727
detached	3,799
bungalow	2,052
converted flat	900
pb flat, low rise	3,036
pb flat, high rise	371
Total	**22,335**

[10] DCLG 2012Q1 housebuilding report suggests an approximate 70%/30% split between development of houses/flats nationally, compared to current stock proportions of 81%/19%.

48) The figures have been adjusted to account for the higher build rates of flats results in a build rate of 0.91% per year for houses in 3-10%, areas and 1.27% per year for houses in >10% areas, the adjusted build rate for low rise and converted flats is 1.66% per year in 3-10% areas and 2.32% per year, for flats in >10% areas.[11] In 2013 we expect a total of 220[12] flats and 558[13] houses to be developed requiring basic or high risk radon protection, at a total of 2,370 flats and 5,816 houses over 10 years. These figures have taken into account the fact that 70% of developers are already installing radon protection as recommended by the DCLG circular letter of 2008. This leads to an estimated total present value cost for new dwellings of **£2.29m** (range £1.72m - £2.87m) over 10 years when the number of properties is multiplied by the costs of radon protection from Table 1. This results in an average annual cost of £0.27m (£0.20m - £0.33) in 2012 prices.

49) In situations where the BR211 maps, based on 1km grid squares, are used to determine the level of radon protection then more properties may be identified as requiring radon protective measures. As stated previously, some local authorities already provide guidance on the basis of GIS information and because we are amending guidance to provide the use of the radon atlas maps and the BGS data, we believe any such additional costs will be minimised.

50) We identified a total present value cost of £4.9million at consultation stage and an average annual cost of £0.56 million. For this final stage assessment we have refined the analysis further by incorporating more accurate estimates of the number of properties in the affected areas and taking into account the fact that some properties drop out of the radon affected areas in the new mapping. This means the overall cost of the policy is slightly lower despite the use of updated (and indeed higher) estimates of the cost of radon protection.

51) However, the cost effectiveness of the policy is slightly lower as each individual property fitting radon measures will have higher expenditure. The higher cost estimates used here further strengthens the case for continuing referencing only the new map areas and not taking forward the policy considered at consultation stage of expanding radon protection requirements to cover all new homes.

Costs – Option 1, targeted protective measures in domestic extensions

52) Building Regulations also apply to extensions to existing buildings. At consultation stage it was estimated that there might be 1.73 million dwellings in the new radon affected areas, based on approximation of the new map areas along local authority boundaries. Assuming that national trends applied equally in those areas 68% of those would be houses and 0.57% might be extended on the ground floor each year. From this we calculated that there are likely to be 6,811 extensions in these new areas. Using the same counterfactual assumption as for new homes, i.e. that 70% are already being built with appropriate radon protective measures as a result of industry following the 2008 Circular Letter, we calculated that the change to Approved Document C would impact on 2,043 extensions per year.

[11] The rate of development for converted flats has been assumed to increase at the same rate as that of houses and not the same rate of increase at flats.

[12] Split 210 flats requiring basic protection and 11 requiring full protection. Numbers do not sum due to rounding to zero decimal places.

[13] Split 531 houses requiring basic protection and 27 houses requiring full protection.

53) For the purposes of this Impact Assessment we have used updated estimates from EC Harris of the cost of installing radon measures in domestic extensions. This work assumes, in line with previous analysis on the impact of changes to the energy efficiency provisions in Part L of the Building Regulations, that the average size of an extension is 12m^2. This is roughly 25% of the average floor area according to EC Harris's report and is therefore broadly consistent with our assumptions at consultation stage. Evidence submitted by local authority building control to our radon monitoring exercise suggests slightly larger average extension sizes in radon affected areas, some of which are very rural areas, so we have conducted sensitivity testing on this assumption.

54) EC Harris also identified that the cost of "full" radon measures in an extension would depend on whether the dwelling had any existing radon protection, varying between £210 where the existing building already benefits from radon protection and £300 where there is no protection. Since the latter is the more likely scenario, we have based our modelling on that estimate. EC Harris also quantified the cost of 'basic' radon measures in an extension at £90.

55) As stated previously, GIS mapping work has indicated that there are an additional, net, 250,022 addresses found within the new map areas. At consultation stage, we applied an extension rate of 0.57% to this figure. We have subsequently considered further sources in order to establish the robustness of this estimate. For example, extrapolation of the results of the Survey of Building Control[14] suggests around 100,000-135,000 building control applications for extensions per annum on a dwelling stock of around 18 million houses (an extension build rate of around 0.56%-0.75%). In addition, the further evidence supplied by local authority building control bodies during the consultation period indicates extension rates ranging from 0.3% to 1.1%.

56) This further consideration suggests, therefore, that consultation stage estimates were reasonably robust. In this final stage Impact Assessment we have assumed, on the basis of a range from 0.5%-1%, an extension rate of 0.75% for both properties requiring basic protection and full protection.

57) At consultation stage our assessment adopted the same assumption as for new houses that 72% of these new extensions will require "basic" protective measures and 28% will require "full" measures in accordance with the guidance in BR211 2007. The year 1 (2013) undiscounted costs were identified at consultation stage as £240,000.

58) With 250,022 addresses identified in the radon areas, and an assumed extension rate of 0.75% the total present value cost over 10 years totals £0.39m (range £0.29m - £0.49m) when multiplying the total number of extensions[15] by the cost of providing radon protection for an extension (as noted in para 61). This results in an annual average cost of £0.05m (range £0.03 - £0.06) in current prices. As with new dwellings we have assumed that 70% of extensions are currently having radon protection applied as good industry practice.

[14] DCLG, 2008, Survey of Building Control Bodies

[15] Total number of extensions over 10 years in central estimate is 4,697 (range 3,096 - 6,334). The total number of extensions requiring basic radon protection totals 4,535 (range 2,989 – 6,116) and the total requiring full protections is 162 (range 107 – 219).

59) We believe that the additional costs of radon protection on extensions will ultimately be a cost to consumers, who will be required to pay slightly more for extensions to enable radon protection to be installed where required. The Regulatory Policy Committee identified at consultation stage that this was a pass-through cost, in that it was first incurred by the building firm carrying out the work and that therefore such costs should be included in our calculation of the annual equivalent net cost to business.

Transition Costs

60) EC Harris and Adroit Economics indicated an expectation that there would be some minor transition costs in their report, based upon an estimate of the number of small business operating in the newly classified radon areas. This is likely to be an over estimate since many businesses will be familiar with good practice in the installation of radon protection as a result of carrying out work in the existing radon areas.

61) Assuming that structural engineering firms, developers and contractors are equally likely to be located in radon affected areas, at an estimate of 3,665 firms[16] which might face some transitional costs in understanding the requirements in new areas.

62) Estimates of hourly costs in the transition costs are based on two sources, the EC Harris database of professional fees and the Annual Survey of Hours and Earnings[17]. Hourly rates have been calculated for the central case by attaching a 50% weighting to wage rates from the EC Harris professional fees database and a 50% weight to wage rates derived from the Annual Survey of Hours and Earnings.

63) The EC Harris database has been previously used as a source of evidence on the cost for workers in the construction industry. This reflects the value by the market of a professional including wage, on costs and other business costs to the organisation and is the rate a firm would charge someone else per hour of an individual's time. This approach is widely used in the construction industry. However, more generally in Impact Assessments the Annual Survey of Hours and Earnings (ASHE) forms the basis to estimate the cost of someone's time (plus an additional estimate of 30% for additional overheads such as pension contributions and national insurance contributions)[18].

64) We believe that neither approach is entirely satisfactory – the former potentially overestimates the cost of labour (not least because an individual will not be able to charge 100% of their time out at this charge out rate) and the latter undervalues the opportunity cost of being engaged in non-productive familiarisation (ie the lost income when someone is employed in non-income generating work). We have therefore assumed an hourly rate half way between the EC Harris industry estimate and the ASHE plus 30% approach. For the reasons set out above, we feel this more reasonably reflects the true cost to a firm of familiarisation. This approach has been tested at consultation and was not queried.

[16] Assumed 2.9% of 127,461 firms would be affected. This is based on 2.9% of addresses being within Radon areas in 2007

[17] Survey of Hours and Earnings (ASHE) ONS:

[18] Cabinet Office, Standard Cost Model, 2005, http://www.berr.gov.uk/files/file44503.pdf

65) We believe it will take the 3,665 structural engineering firms, developers and contractors half an hour to become familiar with the changes. A midpoint hourly wage rate across the affected professions of £36.24[19] yields a familiarisation cost of £66k (range £39k - £93k). While the Department's formal consultation did not elicit any comments on this aspect of the Impact Assessment, a small-scale consultation to test this assumption was undertaken with a number of small contractors as part of EC Harris's work and this concluded that there was "general agreement on time to familiarise staff with the regulation/maps (and some firms had already done this)".

66) In the low scenario hourly rates are based on the Annual Survey of Hours and Earnings (which averages £21.50 per hour for structural engineering firms, developers and contractors) and for the high scenario hourly wage rates have been based on the EC Harris professional fees database (with an average hourly wage rate of £50.99 per hour).

67) For small contractors some up-skilling and training might be required. Assuming this takes one day, the estimated cost, in terms of both lost time and the training itself, for 1,248 contractors totals £0.46m (range £0.43m - £0.49m). This cost is based on a direct cost of training of £225 and a loss of earnings of 8 hours based on an hourly wage rate using both ASHE and EC Harris data.[20] However, this is likely to be extremely conservative because many will have experience from installing radon protection in the old map areas.

68) Building control professionals might also require some familiarisation time for the new radon areas. Assuming 300 professionals spend half an hour reading guidance at £41.24 per hour gives an estimated cost of £6k range (£3k - £9k). Again, the wage rate is the midpoint of ASHE and EC Harris.

69) The total transition cost is therefore estimated to be £0.53 million (range £0.48m-£0.59m). The transition cost to business totals £0.53m (range £0.47m - £0.58m).

Costs – Option 1, summary

70) Our 10 year appraisal, using a 3.5% discount factor, shows that Option 1, updating Approved Document C to align it with the 2007 BR211 radon maps, has established:

- **Average annual costs of £0.31m, with a total present value cost over 10 years of £3.22m in 2012 prices**
- **Transition costs of £0.53 million**
- **Total PV cost of £2.29m for new homes and £0.39m for extensions**
- **An annual equivalent cost to business of £0.37million in 2012 prices or £0.35 million in 2009 prices**

Table 4 – Summary table of costs

Costs - 10 Year PV (£m)	Low	Central	High
Transition Costs	£0.48m	£0.53m	£0.59m
Cost of Radon Protection in New Homes	£1.72m	£2.29m	£2.87m
Cost of Radon Protection in Extensions	£0.29m	£0.39m	£0.49m
Total	**£2.49m**	**£3.22m**	**£3.95m**

[19] Weighted average presented based in the text based using the hourly wage rates of: Structural engineer (£24.80 - £64); Developer (£24.60 - £70); and contractors (£15.28 - £21.00).

[20] Hourly wage rate ranging from £15.28 to £21, a midpoint of £18.14.

Benefits – Option 1, targeted protective measures in new homes

71) Radon is linked with lung cancer, and therefore the benefit of the requirement for and provision of radon protective measures will be a reduced number of lung cancers.

72) It is known that both radon and smoking can cause lung cancer and that the combination of radon and smoking increases the risk further in a multiplicative relation. People have about a 25 times greater risk of lung cancer in a high radon atmosphere if they smoke. Indeed, most radon-related lung cancers occur in smokers.

73) In a large population the lung cancers which can be attributed to radon will therefore occur in both smokers and non-smokers, and the average population risk will be a weighted average of the risks to smokers and non-smokers. The Health Protection Agency estimate this risk increases by 16% per100 Bq m^{-3}. Survival rates from lung cancer remain low so the major health benefit of increased radon protection is the additional years of life resulting from the reduction in the number of cancers. Earlier studies have estimated that around 13.5 life years are lost per lung cancer occurrence and this value has been used in this evaluation[21].

74) It is known that radon protective measures reduce radon levels in building and the occupants' exposure to radon. To work towards the number of lung cancers averted we need to estimate the reduction in radon exposure. Different studies take different views on the effectiveness of membranes in reducing the level of radon. Our assessment follows Gray et al and assumes an average 50% reduction in the radon level when a membrane is installed, an assumption we will examine during the consultation as some studies suggest this level may fluctuate, possibly with different construction practices.

75) Table 5 below presents the radon levels before and after the installation of a membrane with a 50% effectiveness:

Table 5 – Mean radon levels with and without a membrane in existing houses

	Percentage of homes over 200 Bq m^{-3}	Arithmetic mean radon level (Bq m^{-3})	Reduction	Mean with membrane (Bq m^{-3})
Minimum in areas requiring "basic" protection	3%	52	50%	26
Mean in areas requiring "basic" protection	5%	64	50%	32
Max in areas requiring "basic" / minimum in areas requiring "full" protection	10%	87	50%	43.5
Mean in areas requiring "full" protection	17%	116	50%	58

Source: Radon and Public Health, Independent Advisory Group on Ionising Radiation, 2009[22]

21 Kennedy CA, Gray AM, Denman AR and Phillips PS. A Cost Effectiveness Analysis of a Residential Radon Remediation Programme in the United Kingdom. *British Journal of Cancer*; 1999; 81(7), 1243-7.

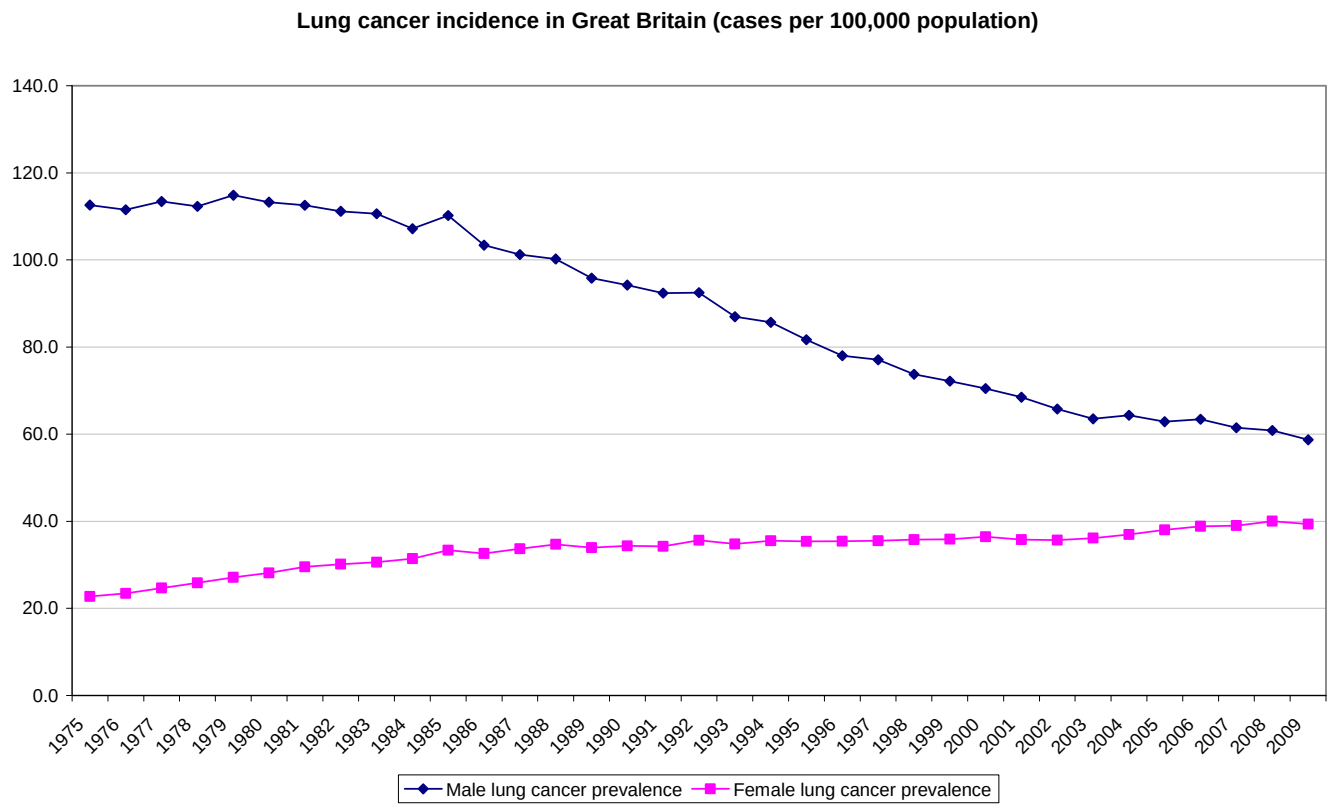
22 http://www.hpa.org.uk/Publications/Radiation/DocumentsOfTheHPA/RCE11RadonandPublicHealthRCE11/

76) A linear relationship between lung cancers and radon exposure is assumed (consistent with HPA publications on radon protection). In calculating the benefit from option 1 - extending regulatory requirements by updating Approved Document C to ensure all new homes in higher radon areas are provided with appropriate protective measures – we have assumed the same counterfactual as for the costs and assessed the potential for cancers to be averted in the 30% of new homes which currently may not receive appropriate radon measures.

77) The mean radon risk reductions (from Table 5) were combined with typical occupancy levels (an average of 2.23 occupants per dwelling). At consultation stage we assumed 15% smoking prevalence (broadly in line with Department of Health projections) to identify how many cancers would be averted by this option for each year of the ten year appraisal period. From this we identified, for each year, how many life-years per annum would no longer be lost if the policy is adopted

78) In 2010 the Department of Health had a target to reduce smoking rates to 10% of the population by 2020 and Fig 1 shows lung cancer incidence in Great Britain over time. We have given further consideration to this issue it is discussed in the sensitivity analysis section of this paper. Overall though, the consultation assumption of a flat 15% smoking rate appears to be reasonable and this is again used to underpin out central scenario.

Fig 1 – Lung cancer incidence in Great Britain, 1975-2009



Data source: Cancer Research UK

79) For each of the 10 years of the policy period assessed we have taken an estimate of the discounted costs incurred in that year. On the benefits side we have taken an estimate for each of those years of the discounted benefits achieved over a notional forty year building life. We have also assumed in our calculation of the benefits a 5 year lag before the benefits start to accrue. We factored in a lag to reflect the construction process and the corresponding time it would take before people move into buildings provided with protection as a result of changing Approved Document C in 2013. We also factored in a period for latency as lung cancers attributable to radon will not occur for a few years after the exposure event, and counting benefits in terms of lung cancers averted from the point of first occupation of the building would overstate the benefits gained. We also explored the significance of different assumption on latency and lag (see paragraphs 109 to 111).

80) In health economics, impacts are conventionally assessed using Quality Adjusted Life Years (QALYs). The NICE (National Institute for Health and Clinical Excellence) approach to assessing the cost effectiveness of medical treatments, described in "Measuring effectiveness and cost effectiveness: the QALY", looks at how many extra months or years of life of a reasonable quality a person might gain as a result of treatment, measured in Quality Adjusted Life Years. In the NICE approach a treatment which costs more than £20,000-30,000 per QALY would not be considered cost effective. We have taken the upper end of this range for our assessments of benefits and used a QALY value of £30,000 for each year gained, discounted using a 3.5% discount rate for the first 30 years and 3% for later years. We also describe in the section below on Risks and Assumptions the impacts on the preferred option if a higher QALY value is adopted.

81) The benefits gained from as a result of option 1 are shown in Table 6. These provide a total benefit assessed to have a present value at 2012 prices of £3.7m, with a range of £2.7m to £4.6m.

Table 6 – Option 1 benefit gained each year, for new homes

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Number of new homes receiving protective measures (30%)	778	787	796	805	814	823	832	841	851	860
Annual lung cancers averted	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07
Estimate of life-year loss averted, each year	0.72	0.72	0.73	0.74	0.75	0.76	0.77	0.78	0.78	0.79
Value of QALYs gained discounted over 40 years/ £000's	403	394	386	377	369	361	354	346	339	332

Benefits – Option 1, targeted protective measures in extensions

82) When assessing the health benefits from option 1 requiring all new extensions in the (additional) areas shown on maps in BR211 to be provided with at least "basic" radon protective measures, we started with a working assumption that a typical extension adds at least a third to the ground area covered by the house. The extension then amounts to a quarter of the resulting ground floor area (illustrated in Diagram 1). This might suggest that an extension with protective measures results in an increase in protection for the occupants of 25% of the level of protection from protective measures provided in a new house. We will examine this assumption during the consultation.

83) Local authorities in radon affected areas also submitted information to us on the average size of extensions, with the average floorspace of an extension of 29m^2 and of a single storey extension of 20m^2, suggesting this estimate could be on the low side given the rural nature of most radon areas. Sensitivity analysis on this assumption is carried out in the risks and assumptions section of the impact assessment.

84) There is a competing assumption that householder awareness of radon and protective measures may increase during their purchase of an extension, with some subsequently subscribing to measures which also reduce radon levels in the original house with a consequent increase in the benefits from option 1. However, the effectiveness of protective measures in extensions might also be slightly reduced if there is migration of radon from the original house, if this is not fitted with protective measures, into the extension.

85) At consultation stage we estimated 2,043 extensions per annum (30% of extensions in the new BR211 areas) and that 72% of these new extensions would require "basic" protective measures and 28% would require "full" measures in accordance with the guidance in BR211 2007.

86) Based on our revised assumptions, set out in paragraphs 63 and 64, we have calculated the 10 year benefit from extensions being provided with protective measure associated with updating Approved Document C, shown in Table 7. This has a total (present value) benefit of £0.5 million.

Table 7 – Option 1 benefit gained each year, for extensions

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Number of additional extensions receiving protective measures (30%)	454	457	461	464	468	471	475	478	482	486
Annual lung cancers averted	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Estimate of life-year loss averted, each year	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Value of QALYs gained discounted over 40 years/ £000's	59	57	56	54	53	52	50	49	48	47

87) Our assessment of the savings achievable from amending guidance to make clear the status of radon risk reports in relation to the radon atlas has the potential to deliver benefits to developers and householders building properties or extensions in the 1999 map areas. This was not explored in the consultation stage impact assessment but has come to light from local authority responses to our call for information and as a result of further work carried out for the department by the HPA.

88) Evidence submitted suggests it might be reasonable to assume that 50% of authorities provide advice to developers on the basis of the maps of risk areas rather than on the basis of GIS information. Because the information is less detailed, some projects which install basic measures would not be advised to install measures on the basis of the radon risk report. Similarly for those advised to install full measures the radon risk report would in many cases only advise basic protection or even no protection.

89) Assuming that half of projects rated as requiring basic protection by the maps would not be required to install any protection following the advice of the radon map, and for those advised to install full protection that one third would only require basic and one third no protection, there would be a cost saving from changing guidance.

90) We have only calculated savings here for 10% of new homes, assuming that 80% would use NHBC or other approved inspector advising on the basis of GIS, 10% would use a local authority advising on the basis of GIS leaving 10% where savings could be applicable.

91) For extensions we have assumed that 50% use a local authority that advises on the basis of the maps and therefore a slightly larger potential for savings.

92) There are around 675,150 properties within the former medium risk areas and 423,474 in the high risk areas. This suggests cost savings of up to £0.2 million per year might be possible for new homes and £0.4 million per year for extensions, with a present value over ten years of £5.5 million. This would largely outweigh the additional costs to business, but because these estimates are uncertain **we have not taken them into account in the headline figures of this impact assessment nor in the estimates of the cost to business of the policy**.

Benefits – Option 1, summary

93) Our appraisal of Option 1, updating Approved Document C to align it with the 2007 BR211 radon maps, has established the following benefits:

- **a total 2012 present value of £4.19million (£3.66million for new homes and £0.53 million for extensions);**
- **a range of £3.14 million to £5.23 million (range of £2.75million to £4.58million for new homes and £0.39 million to £0.66 million for extensions); and**

Costs and Benefits – Option 1, summary

94) Our appraisal shows that Option 1, updating Approved Document C to align it with the 2007 BR211 radon maps, has a net benefit with a present value of **£0.97 million** (range of £0.65 million to £1.28 million).

Comparison with Consultation Stage Impact Assessment

95) Comparing the estimates here with those made at consultation suggests the benefit-cost ratio is slightly lower. The more detailed cost information provided here suggests that the cost of installing radon protection is higher than was estimated at consultation. However, the overall cost of introducing the policy is lower as have been able to make more refined estimates of the number of properties within the radon affected areas.

96) Further work on the benefits has led to us maintaining the central scenario from the consultation. We have further investigated the impact of lower future smoking rates on the benefits of the policy and under more optimistic, but still plausible, future trajectories for smoking rates the benefits would be significantly lower. However, except under the most extreme assumptions the NPV of expanding the targeted policy remains positive meaning that intervention remains justified by the economic case.

97) Since the refinements decrease the benefit-cost ratio of targeted measures, the benefit of installing measures in all new homes, which we considered at consultation stage, would be further decreased.

Direct Costs and Benefits to Business

98) The direct costs to business from this policy are the additional costs of radon protection in the new map areas, estimated at an average annual cost of as £0.31m. We have identified potential transition costs of £0.53m. Resulting in an annual equivalent cost to business of £0.37m and £0.35m in 2009 prices[23] for OIOO purposes.

99) We have treated the costs relating to radon protection in extensions as a cost to business in this assessment (even though we expect this is a cost that will be passed on to consumers in a competitive marketplace). Given that consumers may decide not to undertaken an extension project in the face of a price rise there is an impact a business although we believe the approach taken here is likely to, if anything, overstate that impact.

100) The benefits of amending guidance have been excluded from the headline figures of the impact assessment and the costs to business calculations as they are uncertain, but the potential clearly exists for this change to significantly reduce the net cost to business, perhaps to the point of there being a net benefit to business.

Risks and Assumptions

101) Most risks and assumptions have been explained in the text above. The results of the public consultation provided little in the way of formal evidence on the key assumptions in the impact assessment and most respondents indicated that they were not in a position to provide further evidence.

102) Further research by EC Harris and Adroit Economics has helped to refine the estimated costs and benefits and has helped to substantiate the cost assumptions.

103) Health and safety benefits are more uncertain but we have attempted to follow the conventions employed in the Advisory Group on Ionizing Radiation's report 'Radon and Public Health' and elsewhere in the radon literature.

[23] GDP deflator of 0.926

104) We have considered the risk that housing supply, and so the number of new homes used in this appraisal, might vary from government projections. We have in our assessment produced a range showing what would happen if housing supply varied by either 25% above or 25% below. Whilst this is important for estimating the total costs and benefits of the proposal it does not alter the cost-benefit case at the level of the individual dwelling, which is determined by the cost of radon protection and the expected health benefits arising over time as a result of the protection.

Table R1, impact of changing new build rates

	Total Costs (NPV over10 years, 3.5% discount rate, 2012 prices)	**Total Benefits (NPV over10 years, 3.5% discount rate, 2012 prices)**	**Net Benefits (NPV over10 years, 3.5% discount rate, 2012 prices)**
Low end build rates -25%	£2.4 milllion	£3.1 milllion	£0.7 milllion
Mid range build rates (Government 2013-2022 projections)	£3.2 milllion	£4.2 million	£1.0 million
Higher end build rates +25%	£4.0 milllion	£5.3 milllion	£1.3 milllion

105) We have used a QALY value of £30,000 in this impact assessment which is in line with the value used by NICE in their assessments of health care options. However, we are aware of developing views that a higher QALY value might be more appropriate for use in impact assessments and so we have applied a QALY value of £60,000 as a sensitivity test. A higher QALY value would significantly increase the benefit-cost ratio for the chosen policy option.

Table R2, sensitivity of assessment to changing QALY value

	Option 1 present value costs, new homes	**Option 1 present value benefits, new homes**	**Option 1 net benefits**
£30,000 QALY value	£2.3 milllion	£3.7 million	£1.4 million
£60,000 QALY value	£2.3 milllion	£7.3 milllion	£5.0 milllion

106) Another factor that might change is the smoking prevalence rate, for which we have expended further effort following the consultation. Current smoking rates are 21.5% and at consultation stage a working assumption of 15% smoking prevalence over the entire assessment period was assumed, broadly taking into account forecasts of falling smoking activity over time.

107) To develop the analysis further we have extrapolated lung cancer incidence rates given the strong downward trend visible in the data for males. For the central scenario in the IA we have maintained the assumption of a flat 15% smoking rate over the entire appraisal period. Table R3 shows the results of various alternative assumptions, including a flat smoking rate at current levels of 21.5%, a flat 10% smoking rate and a several approaches that extrapolate current downward trends in smoking rates and link this to lung cancer incident rates over time.

108) The impact on the NPV of the policy dependent on different assumptions about future smoking rates and methods of forecasting changes are shown in the table.

Table R3, sensitivity of assessment to changing smoking prevalence

	Option 1 present value costs, new homes	Option 1 present value benefits, new homes	Option 1 net benefits, new homes
21.5% smoking prevalence	£2.3m	£4.8m	£2.5m
15% smoking prevalence	£2.3m	£3.7m	£1.4m
10% smoking prevalence	£2.3m	£2.7m	£0.4m
21.5% current, downward linear trend in lung cancer prevalence	£2.3m	£2.9m	£0.6m
21.5% current, downward exponential trend in lung cancer prevalence	£2.3m	£3.6m	£1.3m

109) The policy period which has been covered in this assessment is the 10 years from 2013. It was assumed that there is a two year lag before new buildings covered by changing Approved Document C in 2013 are occupied so that the first year in which benefits might accrue is 2015. We also took into account a consideration that lung cancers attributable to radon will not occur for a few years after the exposure event, and counting benefits in terms of lung cancers averted from the point of first occupation of the building will overstate the benefits gained. We made an allowance for this and extended the assumed lag to five years, by simply shifting the future stream of benefits back in time so that in NPV terms they are less valuable.

110) However, as it has been suggested that most of the cancers appear in the period 5 to 14 years after exposure. This would suggest a mid-range latency of about 8 years might be added to the two year lag as a sensitivity test. To explore the significance of this on overall costs and benefits we shifted the future stream of benefits further back by another 5 years.

111) The results are shown in Table R4. A ten year period reduced the benefits by around 20 per cent, although the reduced net benefit is still greater than the total NPV costs, and this remains our preferred option.

Table R4, sensitivity of assessment to changing latency

	Option 1 present value costs, new homes	Option 1 present value benefits, new homes	Option 1 net benefits
5 year lag	£2.3m	£3.7m	£1.4m
10 year lag	£2.3m	£3.1m	£0.8m

Wider impacts

Equalities Impact Test

112) An initial equalities screening of the proposed policy was carried out and determined that a full equalities impact test was not required as the proposal does not adversely affect any equalities groups.

Competition Assessment

113) The preferred option is not expected to alter the home building or extension building markets and the competition within those. Whilst it would require some technical changes to construction approaches, these are done within the current set of Building regulations that apply to these types of activities and it is not considered to set up barriers to entry and is considered unlikely to affect the size, number or profitability of firms.

Small firms Impact Test

114) There could be some transitional costs to firms, particularly small builders carrying out extensions, although we believe the estimate included here is higher than that which will be incurred in reality, since many firms will already have experience of installing radon protection having carried out work in the existing risk areas.

Environmental impact

115) We do not expect this either of these options to affect the wider environment outside the homes and it will not result in additional greenhouse gases being emitted.

Health and Well Being Impact

116) These options are primarily focussed on population health improvement. The proposed amendments are likely to lead to a positive impact on public health and welfare which will bring a number of non-monetised social benefits including those that will be received by families and friends of people who have avoided cancers which might otherwise have been caused by radon.

Sustainable Development

117) We do not expect the proposal to have any sustainable development implications, although ensuring buildings are built with appropriate precautions for the occupants supports the principle of building the right buildings in the right places, suitable for future generations.

Summary and preferred option with description of implementation plan

118) Option 1 is preferred as it ensures that regulation continues to be targeted at the right buildings. The changes will come into force from October 2013.

Annex A – Estimated Costs of Radon Protection

The estimated costs of radon protection include the cost of installing a radon membrane (even where a damp proof membrane is used the radon membrane will require additional detailing) and installing a barrier in cavities and party walls. Installation costs of the radon membrane are £4m^2 more than a regular damp proof membrane where installed and £6m^2 where none is required.

Full protection for homes built with ground bearing slab includes installation of a sump. For homes built wit ha suspended ground floor this is not required and the additional costs of full protection are minimal.

Table A1 and A2 present the estimated costs of installing radon protection in new homes built with ground bear slabs and suspended ground floors respectively.

Table A1 – Estimated radon protection costs for new homes built on ground bearing slabs

House - Ground Bearing Slab (40% new build houses)	Area (m2)	Basic Protection (£/House)	Full Protection (£/House)
All terrace	83	£270	£490
Semi-detached	93	£290	£520
Detached	148	£420	£650
Bungalow	76	£430	£660

Table A2 – Estimated radon protection costs for new homes built with suspended ground floor

House - Suspended Ground Floor (60% new build houses)	Area (m2)	Basic Protection (£/House)	Full Protection (£/House)
All terrace	83	£350	£370
Semi-detached	93	£390	£400
Detached	148	£570	£590
Bungalow	76	£590	£600

Assuming that 40% of new homes are built with a ground bearing slab and 60% are built with a suspended ground floor the average cost of radon protection for houses, used in the analysis and presented in the main body of the IA, are given in table A3.

Table A3 – Estimated costs of radon protection - houses

Basic Protection (£/House)	Full Protection (£/House)
£318	£418
£350	£448
£510	£614
£526	£624

Table A4 presents estimated costs of radon protection for flats. This assumes that there are three converted flats to a building (this is maintained as part of new-build estimates on the assumption that it is a suitable proxy for small or infill newbuild apartments), twelve flats in a low-rise block and 28 in a high-rise block.

Table A4 – Estimated costs of radon protection for flats

Flat Type	Storey	Basic Protection (£/Flat)	Full Protection (£/Flat)
Converted Flat, 67m2 per flat	3	£150	£220
PB Flat, low rise - 56m2 per flat	3	£160	£230
PB Flat, high rise - 58m2 per flat	7	£70	£100

Table A5 presents estimates of the cost of installing radon protection in an extension. EC Harris have estimated the average ground floor extension size to be 12m^2 and we have used this assumption here.

This produces similar results to the consultation stage impact assessment, which assumed an average extension would add around 33% the ground floor size of the existing house and therefore the costs would be around 25% of the costs of radon protection for the existing dwelling, leading to a cost per extension of around £100.

Table A5 – Estimated costs of radon protection for house extensions

House Extension	Area (m2)	Basic Protection (£/House)	Full Protection (£/House)
Radon barrier already installed in existing building	12	£90	£210
No radon barrier in existing building	12	£90	£300