The Economics of Land Use Planning

Discussion Paper Series

No. 001

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June 2008

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Contents

Abstract

This paper explores the economic theory behind alternative approaches to the current Land Use Planning (LUP) system around major hazard sites. Analysis in this paper is set out on an individual risk basis, however the concept of societal risk considered briefly as a separate topic. This paper attempts to summarise the LUP system and examines the economic rationale for government intervention in LUP. We also consider the recent changes in policy following the Buncefield explosion and provide a survey of approaches to Land Use Planning adopted in other countries.

This paper aims to encourage discussion of the use of market based instruments (an alternative or complementary approach to the current system) in the context of LUP around major hazard sites, which could lead to a greater understanding of these potential policy options for the future.

Market based mechanisms are used in an attempt to internalise the costs of increased risk. Three options are considered; the introduction of a safety levy on new developments based on the increased exposure to risk that a new development brings. Secondly, mandatory purchase of insurance by developers against any damage arising from an accident. Thirdly, through introducing a ‘Cap and Trade’ system affecting most developers and major hazard sites.

Introduction

1 Major Hazard sites are installations that use, manufacture or store significant quantities of hazardous substances. These include gas and petrol storage depots, gasholders and chemical works which are distributed throughout the country. The substances at these sites have the potential to cause harm to people and property due to toxicity or flammability. However, such sites contribute to improvements in living standards, and productivity, economic development and technological progress, and thus have become an essential part of modern society. In a densely populated country like the UK it is nearly impossible to locate such sites away from developed or developable areas. Many are required to be near densely populated areas (such as cities), so that their product can be easily distributed (and at low cost). A low pressure domestic gas supply site for example needs to be near a population centre, so that gas can be easily distributed to those who require it. While other ways exist to distribute the gas they all have their own inherent risks, thus risk is impossible to eradicate and will always exist to some degree. Furthermore, due to the high population density in the UK, it is inevitable that some developments may be situated within the vicinity of major hazard sites. Not only due to strategic reasons but also due to urban sprawl and honey pot sites. A balance must be struck between the benefits from such sites and the risk faced by society.

HSE's advice on land use planning (LUP) decisions is designed to limit exposure to risk by managing development within the area around a Major Hazard site (controlling residual risk). In addition a Major Hazard site operator must maintain risk As Low As Reasonably Practicable (ALARP), and is bound by various safety and operational regulations, which help to mitigate risk and reassure the public that their exposure to risk is managed.

2 This paper considers the economics of LUP, summarising the current government LUP policy and providing example case studies of the LUP policies adopted in other European countries. This paper also describes the Health and Safety Executive's (HSEs) recent work and presents the economic rationale for government intervention. A focus is placed upon alternative arrangements that could supplement or replace the current LUP system, with discussion of the relative strengths and weaknesses of each.

Current Policy

3 This paper explores the economics of LUP around existing Major Hazard sites and will not look at the development of new Major Hazard sites, thus we do not present a model for how or where new sites should be located. This paper is not written in reference to one site in particular, instead it provides a general overview.

4 Individual risk (as estimated in the UK for LUP analysis) is the probability that an individual receives a 'dangerous dose'[1] or worse from an incident at a Major Hazard site. This paper refers to an individual risk based approach unless otherwise stated

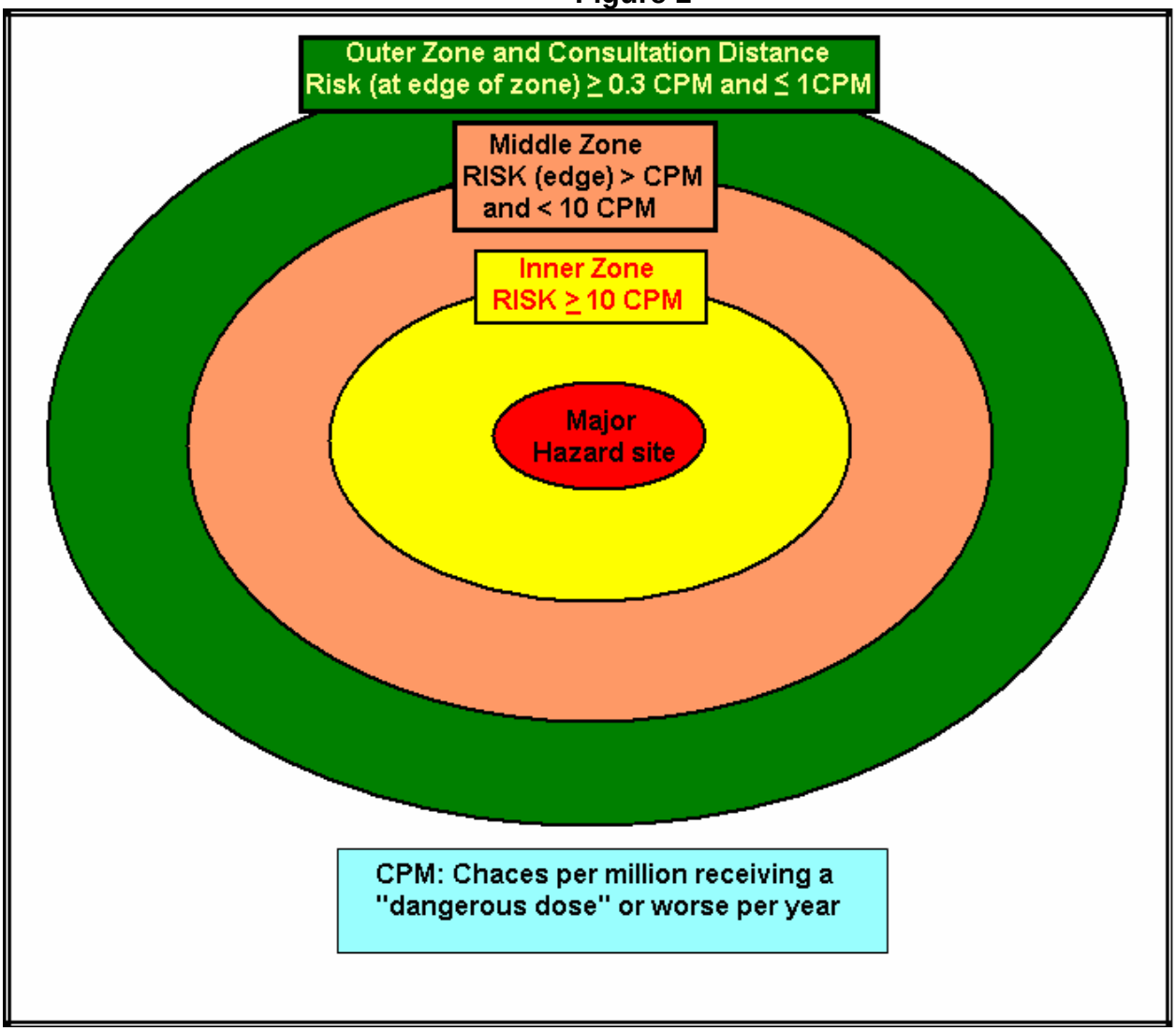
5 Each Major Hazard site has a Consultation Distance which is established by HSE based on the nature and quantity of particular hazardous substances which the operator has consent to hold on site. The consultation distance represents the zone in proximity to a Major Hazard site within which Local Planning Authorises must (by law) consult the HSE with regards to any new use, including changing quantities or substances produced or stocked. HSE 'advise against' or 'do not advise against' a development proposal based on the assessment of risk. Local Planning Authorities have ultimate discretion as to whether planning consent is given but in practice HSE advice is rarely ignored.

6 The Consultation Distance around a Major Hazard site is split into 3 zones (inner, middle and outer zone). The perimeter of each zone has an estimated level of risk. The perimeter of each zone relates to an individual sustaining a specific level of harm from a representative event. The alternative concept of protection zones are not considered in this paper.

7 Figure 1 depicts how zoning around a typical Major Hazard site would look. Sensitive developments such as schools, hospitals and higher population density development (housing and offices) may be advised against closer to the site. The closer the zone is to the Major Hazard the tighter the restriction on development. For example, developments such as medium to large sized shopping centres may be allowed in the outer zone but could be 'advised against' within the middle or inner zones. HSE's advice is founded on historical data and risk estimates.

[1] Dangerous dose in this context may be defined as exposure to a substance or event in quantities such that significant illness or injury will be caused. This is not a medically defined term.

Figure 1



8 The Control of Major Accidents Hazards (COMAH) regulations became law on 1 April 1999 to implement the European Union Directive Seveso II. The Regulations require that the level of risk at a Major Hazard site is As Low As Reasonably Practicable (ALARP). For risk to be ALARP the site operator must demonstrate that the cost of reducing risk further would be grossly disproportionate[2] to the benefit gained. This reflects the fact that in practice it is impossible to spend infinite time, effort and money to reduce risk to zero. Regulations also require that sites are open for inspection by the regulator and can demonstrate that risks have been identified and action has been taken to

[2] Gross disproportion is a concept set in legal precedent that was first established by Edwards v. National Coal Board (1949: 1 All ER 743). For further information on gross disproportion see annex A.

mitigate the risk of an incident. As well as on-site safety measures, the COMAH regulations require the site operator to draw up emergency plans to deal with any identified risk. Local Planning Authorities must draw up adequate emergency plans based on the information supplied by site operators.

9. In order to enforce the aforementioned regulations a joint Competent Authority (CA) exists who's remit of responsibility reflects the broad nature of major hazard accident impacts (human, environmental and economic). In Great Britain the CA is composed of the Health and Safety Executive (HSE) and the Environment Agency (EA) in England and Wales, and in Scotland the HSE and the Scottish Environment Protection Agency (SEPA) are responsible for enforcing the COMAH Regulations.

Planning Advice for Developments near Hazardous Installations (PADHI)

10 PADHI[3] employs a decision matrix through software designed to deliver advice to Local Planning Authorities on proposed developments near hazardous installations. The PADHI methodology and software was developed as an integrated system for use by staff in the Hazardous Installations Directorate of HSE. PADHI was developed in 2001 – 2002 and fully introduced in November 2002 within HSE, and made available to Local Planning Authorities during 2006-7. An example of a PADHI matrix is shown in figure 2 below:

Figure 2

Level of Sensitivity	Development in Inner Zone	Development in Middle Zone	Development in Outer Zone
1	DAA	DAA	DAA
2	AA	DAA	DAA
3	AA	AA	DAA
4	AA	AA	AA
AA = Advise Against DAA= Don't Advise Against			

11 The PADHI matrix has two inputs: the zone in which the planned development will take place, and the 'Sensitivity Level' of the proposed development. This is derived from HSE categorisation system of 'Development Types' (4 being a highly sensitive development). These sensitively levels reflect

[3] For more information on the PADHI methodology and software see www.hse.gov.uk/landuseplanning/padhi.pdf

1 – People at work, and Parking
2 – Developments for use by the general public
3 – Developments for use by vulnerable people
4 – Very large and sensitive developments

12 Some exceptions are made for very large or very small development where they may be assigned to higher or lower sensitivity levels, depending upon their type. The matrix, will either deliver an 'advise against (AA) or a 'do not advise against' (DAA) response.

13 The PADHI matrix system helps to present LUP policy in a simple format providing reassurance and increasing the transparency of the LUP process. *"The clarity of the advice from HSE and the transparency of the information provided are the main drivers for the wide acceptance of them by the side of Planning Authorities*"[4].

The explosion at Buncefield in 2005 has prompted this study of market based instruments. It could be argued that the current LUP system has the potential to be less efficient (in economic terms) than some of the alternative approaches to land use planning. The following section explains the rationale for government intervention, touching on issues such as the creation of risk, associated market failures, and basic supply and demand analysis.

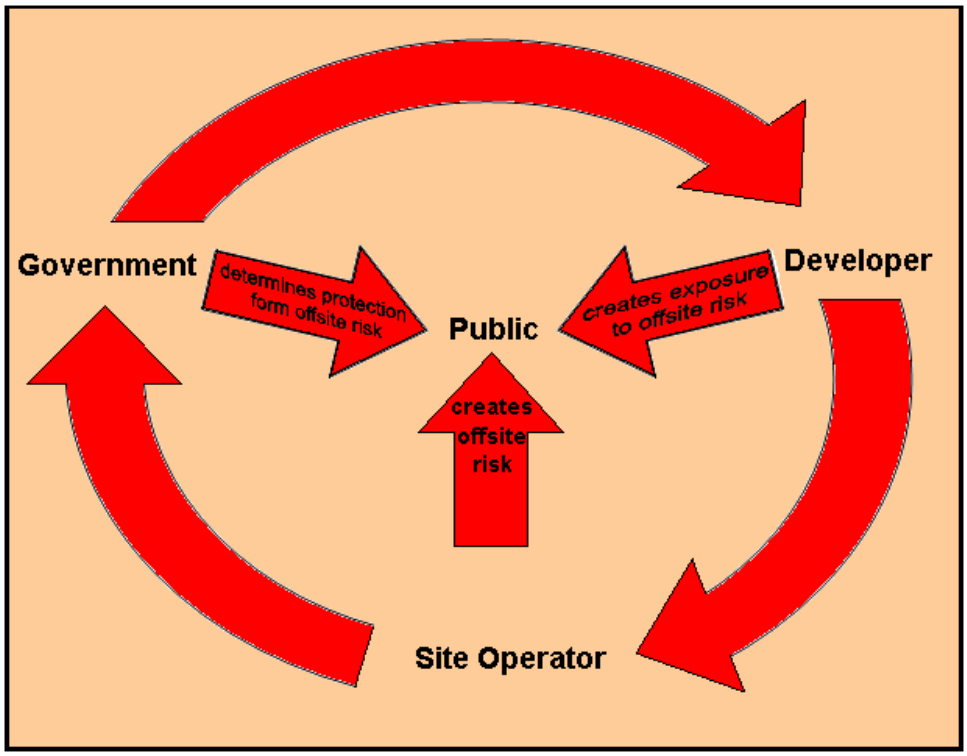
14 Prescriptive planning ignores market based incentives and, as a consequence there is no formal process for negotiation between the Major Hazard site operator and prospective developers. A market based mechanism internalises the costs associated with risk creation, addressing market failure. This will be explored further later in the paper.

[4] Taken From the 'Implementing art.12 of the Seveso II Directive: Overview of Procedures in Selected Member States & 'Roadmap' Proposals, by the European Working Group on LUP

Rationale for Government intervention

15 In the economic analysis of LUP three agents are in operation: the Major Hazard Operator, the developer and the Government. Developers are assumed to be motivated by the maximisation of profits. A Major Hazard site operator, while also being a profit maximising agent, has a legal responsibility to reduce risk to ALARP and to comply with the COMAH regulations. The government is responsible for an equitable society and ensuring maintainence of risk below intolerable levels. This is summarised in figure 3 below.

Figure 3



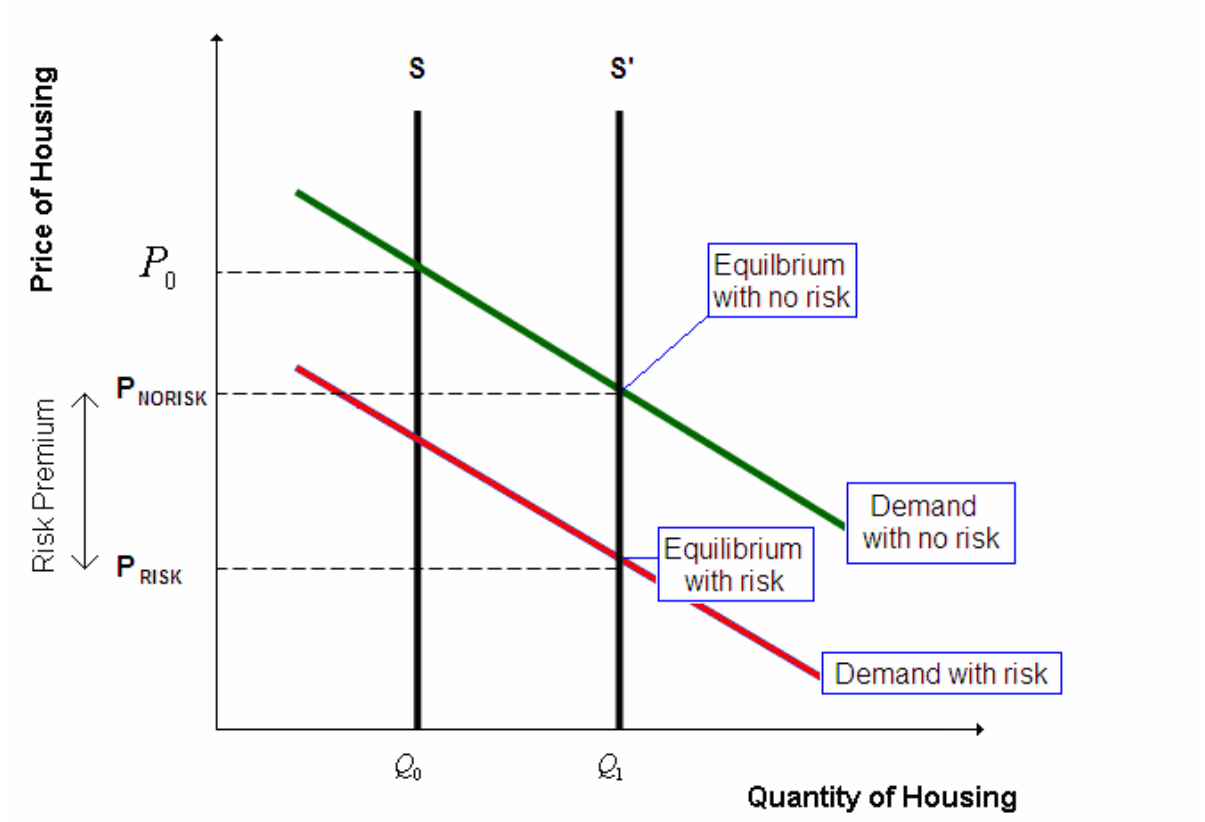
16 The residual risk imposed by a Major Hazard site upon the surrounding area places costs upon individuals within its immediate vicinity. These costs to third parties are externalities, and are an example of market failure (see Annex A). The existence of asymmetric information is another example of market failure. This occurs when one party in an economic transaction knows more about the product being offered for trade. In the case of LUP, the site operator may know more about the risk to the surrounding area than those who are living or working near the site. Likewise in some cases a developer may have more knowledge about the level of risk than those who will work, live or visit the new development.

17 To demonstrate the effect of market failure it is helpful to illustrate how the market would work under perfect conditions as illustrated in figure 4. Annex A provides

both definitions and brief explanations of the economic concepts referred to in this paper.

18 For simplicity it will be assumed that housing is homogenous (i.e. that all housing is the same and that factors other than price and risk exposure, are identical). This demonstrates the effect risk has on demand of housing when all other things are equal and there is perfect information[5]. The horizontal axis shows the quantity of housing, whilst the vertical axis shows the price of housing. The green line marked 'demand with no risk' shows the demand for housing outside the hazard range, where there is no risk from a major incident. The red line, marked 'demand with risk', shows the demand for houses within the Hazard range at a specified level of risk, i.e. demand for housing that is exposed to the risk of an accident at a major hazard site. The lines, **S** and **S'** show the short run fixed supply of housing at quantities Q_0 and Q_1 respectively. The supply curve **S** shows the supply of housing before any new development. If a developer chose to build more houses outside the hazard range, the supply curve will shift to the right (**S').** This will lead to a reduction in price from $\mathbf{P_0}$ to $\mathbf{P_{NORISK}}$.

Figure 4 – The interaction of supply and demand for housing



[5] Perfect information is a term used in economics to describe a state of complete knowledge about the actions of other players that is instantaneously updated as new information arises.

18 If, however, the developer decided to build within the hazard range then with the assumptions of 'perfect information', 'rationality' and 'risk aversion', the price demanded for housing inside the hazard range will be lower at every quantity.

19 The difference between the price levels $\mathbf{P_{NORISK}}$ and $\mathbf{P_{RISK}}$ represents what is known in economics as the risk premium. The risk premium is the price the average person is willing to pay to avoid being exposed to a risky site. This risk premium will offset the risk from a Major Hazard site, so that an individual will be as well off with the risk, as they would be if not exposed to the risk but having to pay the risk premium (i.e. they pay to avoid the risk). As a result individuals (all other factors being equal) will pay less for a house, the closer its proximity to a Major Hazard site.

20 This only holds under the assumption of a free market with 'perfect information', 'perfect rationality' and 'risk aversion'. Allowing house prices to vary according to the level of risk is 'efficient' only if these assumptions hold. In reality information is very rarely perfect.

21 The infrequency of accidents at major hazard sites means that full information on the risk of an accident is not available. Information flows in peaks and troughs, and reactions to risk follow the same pattern - people consistently under and over estimate the level of risk. The regulatory impact assessment (RIA) "Land Use Planning Around Large Scale Petrol Storage Sites" [6] (see Annex E for a summary) assumed that the probability of a major incident at a large scale petrol storage site was once every 10,000 years (1 $x10^{-04}$ per annum). As a consequence of such infrequency there is only media coverage of such incidents from time to time and the public retain little historical knowledge of such events.. In the short term, after an incident, however there will be a large amount of media coverage and the public may therefore over-estimate the risks posed from Major Hazards. This means that the perception of such risks will vary over time.

22 It is unclear if the assumption of rational behaviour is appropriate. Behavioural economics integrates psychology and economics hypothesising that people do not always behave in an economically rational way. The current thinking in behavioural economics and non-rational behaviour fall outside the scope of this paper and are not considered further here.

It is important to point out that when considering valuation of risk, the relevant measurement of risk is people's subjective assessment of risk, rather than a scientifically observed measure. Smith (1992) points out, the use of subjective

[6] http://consultations.hse.gov.uk/inovem/gf2.ti/f/4194/126309.1/PDF/-/cd211ria.pdf

rather than objective risk assessment is more correct if one assumes that the general model of decision-making under uncertainty is prospective reference theory as an extension of standard expected utility theory (Viscusi, 1989).

23 New developments around a Major Hazard site may create costs for the major hazard site operator which are not taken into account by the developers. Major Hazard site operators are responsible for managing the risk so that it is *as low as reasonably practicable* (ALARP) as per the COMAH regulations.

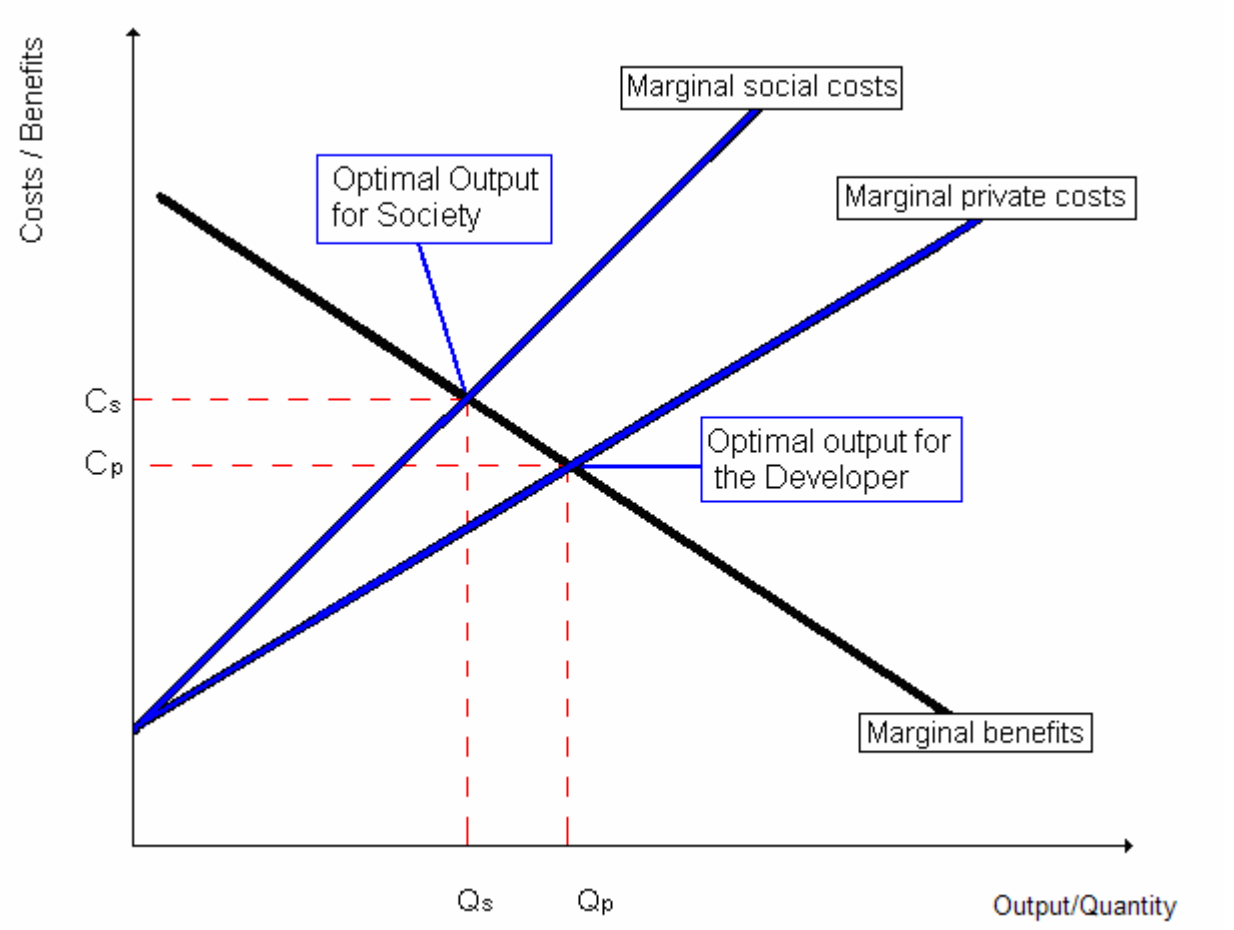
24 Assuming there are no developments currently built within the vicinity of a Major Hazard site and a developer then decides to build a new development on one of these plots, then risk increases due to proximity and number of people exposed to harm (should a major incident occur). The Major Hazard site's risk level may no longer be ALARP, as the offsite consequences of an accident will have increased, thus changing the balance between costs and benefits of new safety measures being introduced onsite. The site operator may have to take further onsite safety measures, so that the risk is ALARP. This increases costs for the major hazard site operator, these costs are not born by the developer (an externality - see Annex A). This situation is known as 'Reverse COMAH'.

25 There are two courses of action that can be taken when faced with increased exposure to risk. Firstly, society can be compensated by increasing the number of jobs, improving infrastructure or selling new properties at prices that reflect the increased risk. Secondly, risk can be controlled either by increasing on-site safety or by restricting development around the Major Hazard site. For these mechanisms to work, it must be clear who is actually creating the externality.

26 The creator of residual risk can be viewed in two ways. One possibility is that the Major Hazard site creates the externality, the very existence of the Major Hazard site can present off site risk. A second possibility is that the developer creates the externality. If the Major Hazard site risk is as *low as reasonably practicable* due to control measures already implemented at the Major Hazard site, then it is new development that disrupts equilibrium operating in close proximity to the Major Hazard and increases exposure to the risk. Hence it should be the developer who is liable and should compensate or pay for appropriate risk reduction measures at the Major Hazard site. This paper assumes that the developer imposes the extra costs on the Major Hazard site operator. This may bean inefficient allocation of resources, as developers only take into account their own costs and not those of society as a whole. This is demonstrated in figure 5.

Figure 5 –

marginal social and marginal private costs of new developments



28 The optimal level of output in society determined by firms' profit maximising behaviour is when private marginal costs equal marginal benefits. These private costs reflect the costs to direct cost to the firm from the new development, with benefits being the revenue received. Using the previous example, developers will keep developing properties until the marginal cost of an additional property exceeds the marginal benefit they will make from the development. The marginal social cost represents the cost to society of producing an additional unit (not just to the firm producing it). These societal costs include the increased exposure to risk to the occupants of the new developments. In a perfect market, the marginal private cost will be the same as the marginal social cost. When externalities exist, the private and social costs differ. There are costs imposed on society that are not included in the firm's private cost function. This means that the firm will produce more of the product than is socially optimal. As can be seen in Figure 5, the optimal output for the developer, Q_p, is greater than the social optimal output, Q_s. Through government intervention, the social optimum can be achieved by either limiting Q_s (socially optimal output) or by making the private firm internalise the costs of the externality, so that the marginal social cost equals marginal

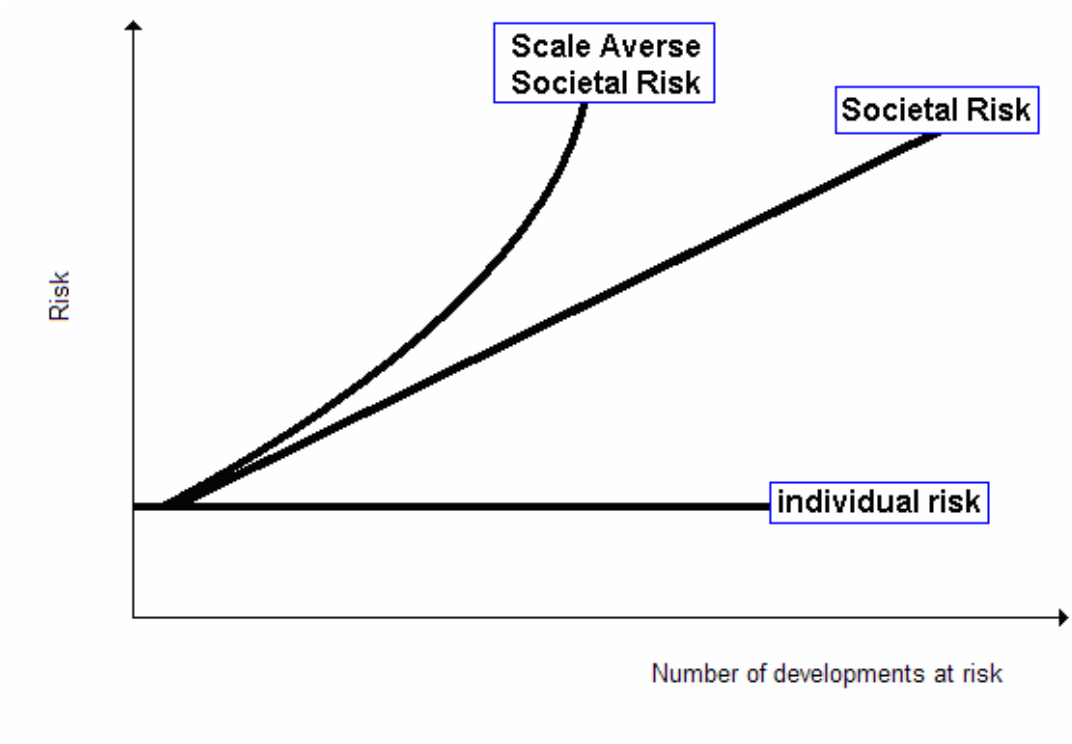
private cost.

Land Use Planning and Societal Risk

29 Together with other Government departments HSE have been considering whether societal risk should be included in the risk assessment process. Currently HSE does not consider societal risk in the risk assessment process, however it has been concluded, after public consultation, that societal risk should be considered in risk assessments. Societal risk considers the risk of multiple injuries or fatalities arising from an incident. If there was the potential for an accident at a Major Hazard site with a large population within the hazard range, there could be a large associated societal risk.

30 An individual within the vicinity of a major hazard site would only take account of their individual risk. An individual may not consider societal risk as they do not face the costs of wider impacts. Societal risk increases as more people are exposed to harm from a single event, whereas an individual's risk remains unchanged no matter how many other people are exposed to harm. This is illustrated in Figure 6. Where individual risk is constant no matter how many people are exposed to risk, societal risk rises at a constant steady rate as more people are put at risk and scale averse societal risk rises exponentially, as more people are exposed to risk.

Figure 6: Comparing societal and individual risk



29 Scale averse societal risk reflects a view that society is particularly averse to large scale accidents that affect large numbers of people. Accidents affecting large numbers of people at one time cause shock to the whole nation and increase the demand to reduce the risk of this kind of accident occurring again. In addition this type of disaster often involves huge damage to property and a great strain on emergency services. Whether the public preference for scale aversion is unclear. Ball and Floyd (1998)[7] suggested that elected officials and senior administrator are more scale averse than the rest of society (most likely due to the political fallout from large scale accidents). However the authors then went on to say that there is 'true merit to the aversion of society to incidents which cause large loss of life'.

[7] Ball, D.J.; Floyd, P.J (1998). Societal risks, Final Report, commissioned by the Health and Safety Executive, United Kingdom

Comparison with the EU

30 This section presents a comparison of the LUP policies of three EU countries' with those of the UK (see Annex B for a more detailed discussion), focusing upon on the tolerability of individual risk, and how societal risk is incorporated. We refer to LUP systems in the Netherlands, France and Germany in this section.

Level of Individual risk tolerability

31 The countries considered provide different perspectives on LUP and on risk prevention. In the UK the HSE and EA have the power to grant or decline planning permission around a major hazard site. However, other systems are used elsewhere which may involve the site operator or developer more heavily in the UK depending on the type and level of the risk involved.

32 The level of acceptable risk in these countries is not directly comparable to the UK as they are based on different measures and criteria. In the UK, the level of individual risk is measured as a probability of an individual's chance of receiving a 'dangerous dose' or worse per year due to an accident at the major hazard. The Netherlands addresses individual risk as the probability of an accident occurring. In France a measure called 'Alea' is used. This is defined as the probability of the event occurring multiplied by the damage caused.

33 The German method of risk assessment rarely requires any sort of explicit accident frequency assessment. Instead a protection-based approach is used, which looks at pre-selected credible worst case scenarios. This type of approach is quite different to that of France, and the Netherlands, which use a risk-based approach. By comparrison the UK uses both protection and risk based approaches depending on the circumstances, however, much of its advice for LUP is based on the level of individual risk. German law states that there should be no off-site risk to the environment, the general public and neighbouring areas. This is achieved by the presumption that if standards are strictly adhered to, this will eliminate major accidents that might have off-site effects. This law contrasts with the principle underlying HSE's approach that the risk level from a Major Hazard site to its neighbouring areas can never be reduced to zero.

35 Only the Netherlands has strict legally binding criteria for individual risk. In the UK there is a level of onsite individual risk which is deemed intolerable by HSE. With respect to LUP however, HSE only acts in an advisory role but ultimate discretion lies with the local Planning Authority. However, if HSE strongly

disagrees with the LPA's final decision it can be called in by HSE for review by the minister. The French have recently changed their policy on Major Hazard sites, after the accident at the fertiliser factory in Toulouse on September 2001, which killed 31 people and injured 2,442. There are no hard and fast rules as of yet, as to the level of intolerable risk.

Societal risk

36 The UK does not always take into account societal risk when advising on proposed developments in the vicinity of a Major Hazard, but the sensitivity levels used in PADHI incorporate some measure of what HSE terms 'case societal risk'. A higher sensitivity level, will lead to more restriction on the development within a consultation distance. Since population density does not generally affect individual risk (as estimated for LUP), the higher sensitivity level reflects societal risk. The sensitivity levels, however, do not take into account incremental build up of developments within the consultation distance of a Major Hazard site. Each new development is judged individually, with no regard to other developments in the area (unless they increase individual risk). For example, within a consultation distance, one housing estate for 100 people may be advised against, whereas two neighbouring housing estates, for 50 people each (which would have a lower sensitivity level) have a better chance of a 'do not advise against' response from HSE.

37 France addresses societal risk by limiting the number of people in the vicinity of a Major Hazard. The French governing body has the right to compulsorily purchase property close to a Major Hazard site. Also, the acceptance of one development may prevent other developments in the area (e.g. the acceptance of one 50-person housing estate may prevent acceptance of another 50-person housing estate).

38 In the Netherlands societal risk is given a high priority. In contrast to the UK the Netherlands look at societal risk explicitly and numerically when advising on proposed developments in the vicinity of Major Hazards. Although the national government produces guidelines, it has no legally defined intolerable levels. If local authorities decide to exceed these national guidelines then they must submit a report outlining their justifications for doing so.

39 Societal risk is not explicitly considered in German LUP. The law states that there should be no off-site risk, so it precludes any consideration to societal risk.

Applying market based mechanisms to Land Use Planning

40 This section analyses three market based mechanisms and illustrates how they would be applied. The different market based mechanisms considered in this paper are

i. Safety Levy
ii. Insurance
iii. Cap and Trade

41 It should be noted that these mechanisms attempt to deal with LUP system as a whole and are not specific to societal risk; indeed the inclusion of societal risk (particularly scale averse societal risk) makes the application of market based systems in LUP more complicated. Precisely how this should be done is not considered here.

Safety Levy

42 A safety levy would be a one-off payment charged to all new developments within a consultation distance of a Major Hazard. The revenue generated by the levy could be used to reduce risk by funding safety improvements at a Major Hazard site. A national 'reserve' would be created in to which all safety levies would be paid. The safety levy revenue could be spent in the most cost effective way using a 'national shopping list' of safety measures.

43 The reason for national rather than local allocation is so that the revenue generated could be more effectively spent on safety measures. It also avoids a 'steeple fund' problem, i.e. where a Major Hazard site receives incremental funds from developments but does not have enough funds to implement a particular safety measure.

44 If we consider that a new development is built within a consultation distance of a Major Hazard site and an acceptable safety levy is agreed between the Local Planning Authority and the developer then to reduce risk further some highly expensive equipment may be required. In order for the new equipment to be purchased, the Local Planning Authority may have to wait for two more developments within the consultation distance before the revenue can be made available for the site operator to purchase it. As development could only go ahead once funds had been raised to mitigate the increased levels of risk (ensuring risk exposure remains tolerable) there would be an associated opportunity cost of lost or delayed development. This situation may occur as the

result of a free rider problem[8], where developers wait for another to pay for safety integrity improvements, due to the staccato nature of major hazard containment measures. With a national "reserve", the safety levy from the new development could be spent where it is most cost effective. The exposure to risk at this site may have increased but it will be offset by a reduction of risk levels elsewhere in the country. In such a system a ranking of sites by cost benefit analysis could be used to prioritise which should be upgraded first.

45 The estimated monetary value of the safety levy may be presented as in the following equation:

Safety levy = 10[9](Risk x Statistical Value of a Fatality x Population at risk)[10]

46 In the formula above **Risk** takes into account the distance of a new development from the site, the probability of an accident at the Major Hazard site and the vulnerability level of those exposed to the Major Hazard. The **Statistical value of a Fatality** accounts for the value of preventing a fatality and, **Population at risk** reflects the number of people at risk at the development. The full term **10(Risk x Statistical Value of a Fatality x Population at risk)**, reflects the monetary value of the increased risk exposure.

47 The formula is multiplied by 10 to reflect the gross disproportion factor. This is essentially a legal precedent (notably in Edwards v. National Coal Board (1949: 1 All ER 743)) that states the duty holder (in this case the new developer) must implement safety measures unless the cost of these measures is 'grossly disproportionate' to the risk reduction. In Major Hazard analysis a factor of ten is used as a rule of thumb.

For Example[11]

A new development of 1000 houses built 500m from a Major Hazard is proposed.

The average occupation in each house is 2.4 (the national average)

The **Population at risk = 2.4 x 1000 = 2400**

The risk of an accident = 1 in 10,000 years)

Reduction of risk due to distance is 90%,

[8] Discussed further in paragraph 55

[9] See paragraph 47

[10] This formula is for illustrative purposes and does not contain all parameters to be used in the calculation of actual safety levy estimates.

So that the **risk** of an accident is now 1 in 100,000 (i.e. 1/10,000 multiplied by 1/10)

The **Statistical Value of a Fatality** is 1.5 million (Source: Economic Analysis Unit in HSE based on Department of Transport estimates)

Safety Levy = (2400 x 1,500,000 x 10) ÷ 100,000 = £360,000

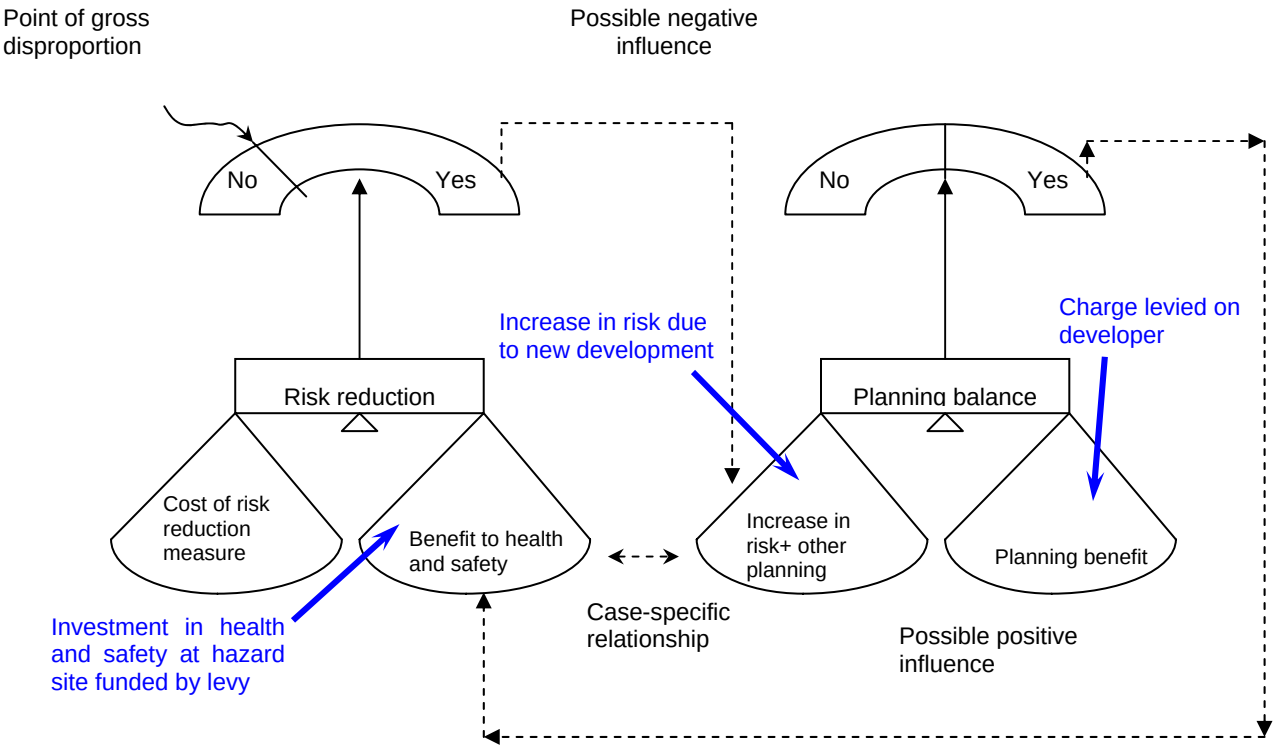
48 Planning obligations could be used as an alternative or to supplement the existing safety levy. A planning obligation is when a developer is required to add something into their planned development that either offsets the risk incurred, or provides a service to the community. Currently in England and Wales the section 106 agreements from the Town and Country Planning Act 1990 allows for Local Planning Authorities to form bilateral agreements with developers. These agreements allow Local Planning Authorities and developers to agree on Planning Obligations in the development to help prevent adverse effects to the local community. For example to offset some of the risk the developer may install blast-proof windows to reduce the impact of an explosion at the Major Hazard site. They could also agree to provide a service to the community. For example a housing developer might provide cheap housing or enhance the infrastructure in the form of roads, or public transport provisions.

49 There are several criticisms of the Section 106 agreements. It is claimed that there is a lack of transparency to the process - all Local Authorities publish guidelines for their planning obligation policies but these guidelines are sometimes seen as vague or poorly worded, which creates uncertainly. Each development is judged on its own merits, which has led to inconsistency in how planning obligations are applied, both between different local authorities and in some cases within the same Local Authority. This has also led to a lengthy negotiation process, which in itself is costly.

50 Effectively the Safety levy and planning obligations are designed to balance out the benefits of more development with the cost of increased risk. This is illustrated in figure 9.

[11] The example presented here is for illustrative purposes only and should not be used for actual safety levy estimates.

Figure 9



51 Figure 9 shows two balancing scales which balance risk reduction and planning restrictions at a national level. The left hand scale balances the level of risk. The scale is in balance when the benefits of health and safety multiplied by a gross disproportion are equal to the cost of risk reduction measures. The scale on the right hand side balances the increased risk against the increased benefits of development. Increased development will bring benefits to the company and the economy (through profits, employment, infrastructure etc.). However, it will also lead to an increased exposure to risk to people who live or work in the new development.

52 The scales are not independent; any increase in development will increase risk to health and safety (on a societal risk basis). A Safety levy charged to developers will increase investment in health and safety (at a national level), causing the costs of development to rise, yet it will also reduce (or negate) the associated increase in risk so both scales stay in balance.

53 The main advantage of a safety levy and planning obligations are their flexibility. Different levies can be charged so that low population developments such as agriculture and warehouses could be encouraged. Planning obligations can be issued to ensure sustainable development, improve the infrastructure or offset some of the risk exposure. This also gives developers a chance to reduce their safety levy through their choice of development (i.e. either by building low

occupancy developments or through planning obligations). This market tool tackles the reverse COMAH problem as developers subsidise any extra risk reduction at Major Hazard sites.

54 There are nevertheless some problems with the Safety Levy and Planning Obligation approach. With regard to planning obligations, the first developer in a consultation distance commits to planning obligations to improve safety measures at the Major Hazard site, for example, financing a re-location of storage tanks, which reduces the level of risk on site. A second developer could then develop, benefiting from the reduced risk. Hence there is incentive to not be the first developer in the area, but to wait until another bears the cost of risk reduction. This is referred to in economics as the 'free rider problem'.

55 Since there is no initial fund, there will be a lag before risk reduction methods are applied. There are also a number of problems that arise in calculating the levy. Firstly, how to set the levy at a level which effectively represents market prices and would lead to an optimal solution? Secondly how to measure the increase in risk from a specific development? Thirdly, what factors should be used in the calculation? Finally how should these funds be allocated. Funds allocation will have associated administrative costs which could either be paid for by charging site operators the levy (which will reduce risk reduction) or by the public (through taxation).

Insurance

56 In theory any development within the consultation distance of a Major Hazard would be required to have insurance against an accident at a Major Hazard. This is similar to the concept of flood protection insurance. The main difference is the time scale of insurance due to the low probability of an accident at a Major Hazard. There is scope for these two issues to be combined into one insurance policy.

57 The insurance would need to be a long term policy (e.g. 100 years) to reflect the small probability of an accident at a Major Hazard site occurring in the short term and internalise the externality, preventing the burden of risk from falling on the public. It is developers who purchase the insurance, as it is they who increase exposure to risk, not residents (who can purchase their own home insurance policies).

58 Insurance could be provided through the private sector, providing a market based mechanism to set prices. The price of insurance will adjust until the demand for

insurance (potential developers) equals the supply of insurance (insurance companies). If the risk from a Major Hazard increases the frequency of a payout will rise. This increased risk would be reflected by an increase in the price if insurance. Risk is calculated on the basis of population at risk in the development and the probability of an accident at the Major Hazard site. Increases in risk exposure from a new development will be reflected through an increase in insurance prices. Insurance premiums will be lower for an agricultural development with a relatively low population density, compared to a housing development with a higher population density.

59 The market mechanism applies a cost to increased risk arising from a new development and in some cases could be more efficient than setting a tax. This is because as the (perceived) risk level or risk exposure changes the price of insurance will adjust. Insurance costs force developers to account for the increased risk they cause. This provides incentives for developers to build low occupancy developments. If the insurance premium is contractually fixed at the time of purchase, then insurance companies may have incentive to invest in extra risk reduction at the Major Hazard site. Insurance companies' main cost equals the *total payout multiplied by the probability of a Major Accident*, so improving safety measures reduces their costs, and if this saving is more than the cost of improving safety, it is worthwhile doing. However, if one insurance company invests in safety measures, then it will benefit all insurance companies who sell policies within the consultation distance. This creates incentive to wait for another firm to implement the safety measures, as every firm has this incentive no one will invest in the safety measures (this is known as the free rider problem). If the insurance premium fluctuates regularly due to changing levels of risk from a Major Hazard site, then it creates uncertainly for developers as they know less about likely future costs of premiums. This volatility may lead to a less than optimal amount of development, as borrowing in order to build new developments becomes more risky.

60 This proposal separates risks because developers pay for the increased risk from an accident at a Major Hazard site, while property owners are free to insure against other issues. Insurance also provides direct support to residents should an accident happen at a Major Hazard site. This mechanism deals with the prevention of a major accident through incentives and caters for the consequences should an accident occur.

61 The policy assumes insurance companies have full information and are not highly risk averse. It is unlikely that the insurance companies will have full information given that these policies will extend into the far future. For insurance companies to have the fullest information set possible HSE would have to release sensitive information about these Major Hazard sites that may cause potential security risks. The long term nature of the policies and the uncertainty of the risk posed by

high consequence low probability events such as these, as well as the high payout given one of these events means it is likely that the insurance companies will be highly risk averse. In this case insurance company may push up the price of insurance or they may simply refuse to insure (a missing market). This would lead to underdevelopment around these Major Hazard sites.

62 However it is also possible that following the creation of the insurance market the insurance companies would have the incentive to collect large amounts of information on the risk of a major incident. For example it is foreseeable that flood insurance firms hold very detailed flood maps. They may also spread the risk by providing insurance at many different sites; this would limit their expose to an accident at any given Major Hazard site.

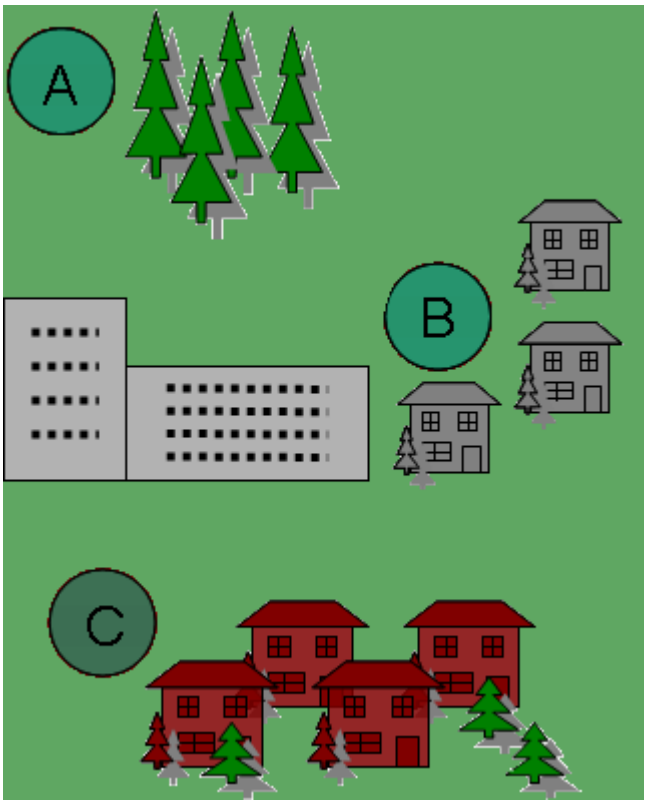
Cap and Trade

63 Cap and Trade is essentially a risk trading system, where risk is bought and sold using a market mechanism. This scheme demonstrated here is based on other cap and trade systems such as carbon trading or tradable permits in flood risk management. The European Union Emission Trading Scheme is the largest example of this kind of system. Greenhouse gas emissions are traded by setting a cap on the amount of carbon dioxide emissions emitted from large installations, such as power plants and carbon intensive factories and then carbon permits are traded for the right to pollute.

A Cap and Trade system for risk from Major Hazards could put a national cap on the risk level; reflected by permits issued to Major Hazard sites. Major Hazard sites could then sell permits to developers or hold them to make changes on site (e.g. types of fuel stored). Permits are traded at a national level so that there can be trading across locations. There is a maximum risk cap at each Major Hazard site; to prevent a build up of development around one site. Major Hazard operators could create extra credits to be sold in the local market by reducing the risk level through a permanent increase in safety on site.

64 Figure 10 shows three Major Hazard sites all of which have reduced on site risk ALARP. Development around any of these sites will require a certain number of development permits. The number of permits required depends on the type of development proposed: A low occupancy development, (e.g. agriculture) will require very few if any permits, whereas a high occupancy development, (e.g. housing, hospital, school, etc) will require more. If a Major Hazard site operator wanted to change the infrastructure or nature of substances held onsite in a way that would increase risk, then they would also need to purchase permits to and ensure that residual risk does not increase.

Figure 10



A = Out of town

B = industrial area

C = Residential area

65 If a developer wants to build houses around site B, the developer has three options

1) Purchase existing permits from site B.
2) Purchase permits from site A or C.
3) Pay site B to reduce on site risk to create credits.

66 Development can take place around site B when a developer has enough permits (credits). The increase in risk at site B, from development, is offset by either an increase in safety measures at site B or a decrease in development elsewhere. If the maximum cap on risk has already been reached at site B, then the developer (should they still choose to develop) will have to use option 3, i.e. invest in safety measures at the Major Hazard site.

67 The Cap and Trade method provides the incentive and flexibility for Major Hazard sites to reduce offsite risk below ALARP. More credits are allocated to rural sites, encouraging development at these sites as there is a greater opportunity cost associated with those in built up areas. It also gives an incentive for the site operator to relocate Hazardous substances away from sites with high population densities (to produce credits) to less densely populated sites. Developers have incentives to move developments away from Major Hazard sites. The lower the

population density of developments the lower the relative cost, providing incentive for low occupancy developments close to Major Hazard sites. Developers who value their potential project the highest (i.e. have the highest opportunity cost), will out bid other developers for plots. Such a market-based system would encourage competition between Major Hazard sites and between developers to result in the most efficient allocation of resources and risk.

68 Implementation of this system creates difficulties. At what level of risk should the national cap be set? The national and local caps could be difficult to change once implemented (although the government could buy national permits). How would the risk be measured and what should it be based on? For example: the number of people, their vulnerability or distance from site? There is the problem of the initial allocation permits between Major Hazard sites. How many permits should be allocated? Should sites have the same number of permits? And what would be the cap on risk within the consultation distance around a Major Hazard?

69 The new legislation may also create uncertainty about the price of future developments, leading developers to rush to buy up all the permits when they are first released onto the market. This could mean that development caps are reached very quickly and would effectively stop new development within the consultation distance. If this was the case then the only way to get new permits is for a Major Hazard site to implement more safety measures to create credits. However, it could be argued that the developer has internalised the cost of the externality imposed on the site operator, and that since the costs outweigh the benefits, the new development should not take place.

70 Finally, there are equity issues: should risk be marketed in this way? As we established earlier, information about risk is not perfect, and consumers may not know what level of risk they are exposed to. Under this system there will be larger amounts of development around some Major Hazard sites. It is also quite possible that there are unanticipated or underestimated risks from the site, e.g. the VCE at Buncefield, which was not thought credible as a worst case scenario.

Conclusions

71 The current UK LUP policy requires that there is a consultation distance around Major Hazard Sites as set out by HSE. The local planning authorities decide whether to grant planning permission within this consultation distance, but they must, by law, consult HSE before giving permission. HSE either 'advise against' or 'do not advise against' a development and in practice local authorities rarely deviate from HSE advice. Whether advice is given for or against depends on how close the development is to the Major Hazard and the sensitivity level of the development. Highly sensitive buildings such as schools, hospitals and densely populated buildings are less likely to receive planning permission.

72 The rationale for government intervention regarding development around Major Hazard sites is that developers do not account for increased exposure to risk due to developments. This is a form of market failure. In a perfect market with full information, the price of a building within the consultation distance of a Major Hazard will be lower than the price of an identical building elsewhere. All other factors being held constant, developers will receive less revenue from developing in these areas. Hence, they will have less incentive to develop there. However, it has been demonstrated that information is not perfect and people will consistently over and underestimate risk. As it is the site operators' responsibility to keep on-site risk ALARP, the increased exposure to risk from a new development will directly increase the site operators' costs. When a firm or individual imposes costs on third party this is known as an externality (see Annex A).

73 Following the Buncefield explosion HSE has decided to review its policy on LUP advice around large scale petrol storage sites. The consultation distances will be extended to the limits of the observed building damage at Buncefield and a new Development Proximity zone 150m around the sites will be set. This new zone will be highly restrictive only allowing buildings that are not normally occupied. In addition, work is being carried out to incorporate societal risk into HSE risk assessment process for determining its LUP advice.

74 Three mechanisms have been introduced in this paper that could either supplement or replace current LUP advice by providing a more market based approach. These market mechanisms are

- Safety levy
- Insurance
- Cap and Trade (trading permits)

75 A safety levy on new developments within the consultation distance of a Major Hazard is effectively a tax on increasing risk exposure. If the increased risk exposure from a new development is relatively high then the developer will pay a higher Safety Levy. Likewise, if the risk exposure is relatively low, they will pay a lower Safety Levy. However, the price of the Safety Levy is not determined by the market and could be set at an inefficient or suboptimal level. If the price of the safety levy is too high, it will lead to under development, restricting economic growth .If the safety levy is too low, there will be too much exposure to risk, due to excessive development.

76 The insurance market mechanism requires the compulsory purchase of insurance by developers wishing to develop within a consultation distance of a Major Hazard site. This insurance will deal exclusively with the risk posed from the Major Hazard site. The advantage of this system is that the price of the insurance premium is market based so it should effectively internalise the costs of the increased exposure to risk caused by development. However, due to the low probability of an accident at a Major Hazard site, the insurance policy must be long term to prevent the burden of cost being transferred to occupants of developments. As these policies extend into the far future, there is a degree of uncertainty about the level of risk that may push up the price of insurance and lead to underdevelopment. There is also a possibility that the insurance companies may refuse outright to insure any new developments within consultation distances of Major Hazards.

77 Cap and Trade introduces a risk trading system. Permits for development within a consultation distance of a Major Hazard are traded at a national level. The maximum exposure to risk is capped at each Major Hazard site. If this cap is reached, the only way for a developer to build at this site would be to buy credits from the Major Hazard site operator. Credits are produced by reducing risk through onsite safety measures. This system should provide an efficient allocation of risk and development close to Major Hazard sites, as the market price should adjust until the price of a permit equals the cost incurred by the increased risk from a development (not necessarily the optimal level of safety). A developer will only develop when the gains from the development are equal to, or more than, the costs of the increased risk associated with the development. There are problems with implementation of this approach. What should the national and local risk cap be? How will risk be measured? And, what should the initial allocation of permits be? All of these, if chosen wrongly, could be difficult to correct once implemented. This system also implies the most uncertainty with regards the price of future development. It may lead to a rush to buy up all the permits when they are first released, effectively stopping development around Major Hazard sites.

78 Though economic theory surrounding market based instruments can provide strong arguments for moving to such an approach more work is needed to establish whether such mechanisms would prove effective in reality. Further research and a cost-benefit analysis of market based instruments, comparative to the current LUP system, would be necessary if the Competent Authority were to develop further the initial thinking presented in this paper.

Annex A - Economic terms and concepts

Gross disproportion

What is Gross Disproportion?

- The concept of gross disproportion requires duty-holders to weigh the costs of a proposed control measure against its risk reduction benefits. Specifically, it states that a proposed control measure must be implemented “if the 'sacrifice' (or costs) are not grossly disproportionate to the benefits achieved by the measure "

Why do we use Gross Disproportion?

- The Courts (notably in Edwards v. National Coal Board (1949: 1 All ER 743) have decided that, in judging whether duty-holders have done enough to reduce risks, practicable measures to reduce risk can be ruled out as not ‘reasonable’ only if the sacrifice (in money, time, trouble or otherwise termed costs) involved in taking them would be grossly disproportionate to the risk.

Other Issues;

- there is no authoritative guidance from the Courts as to what factors should be taken into account in determining whether cost is grossly disproportionate;
- the duty-holder needs to take account of both the level of individual risk and the extent and severity of the consequences of major accidents;
- for a given benefit, the higher these risks, the higher the degree of disproportion (i.e., the ratio costs to benefits) can be before being judged ‘gross’;
- HSE has not formulated an algorithm which can be used to determine, in any case, when the degree of disproportion can be judged as ‘gross’; the judgement must be made on a case by case basis;
- rules of thumb adopted by D/Ds;
    - HSE’s Nucleart Safety Directorate takes as its starting point the HSE submission to the1987 Sizewell B Inquiry that a factor of up to 3 (i.e., costs three times larger than benefits) would apply for risks to workers; for low risks to members of the public a factor of 2, for high risks a factor of 10.
    - HSE’s Hazardous Installations Directorate uses similar rules of thumb.

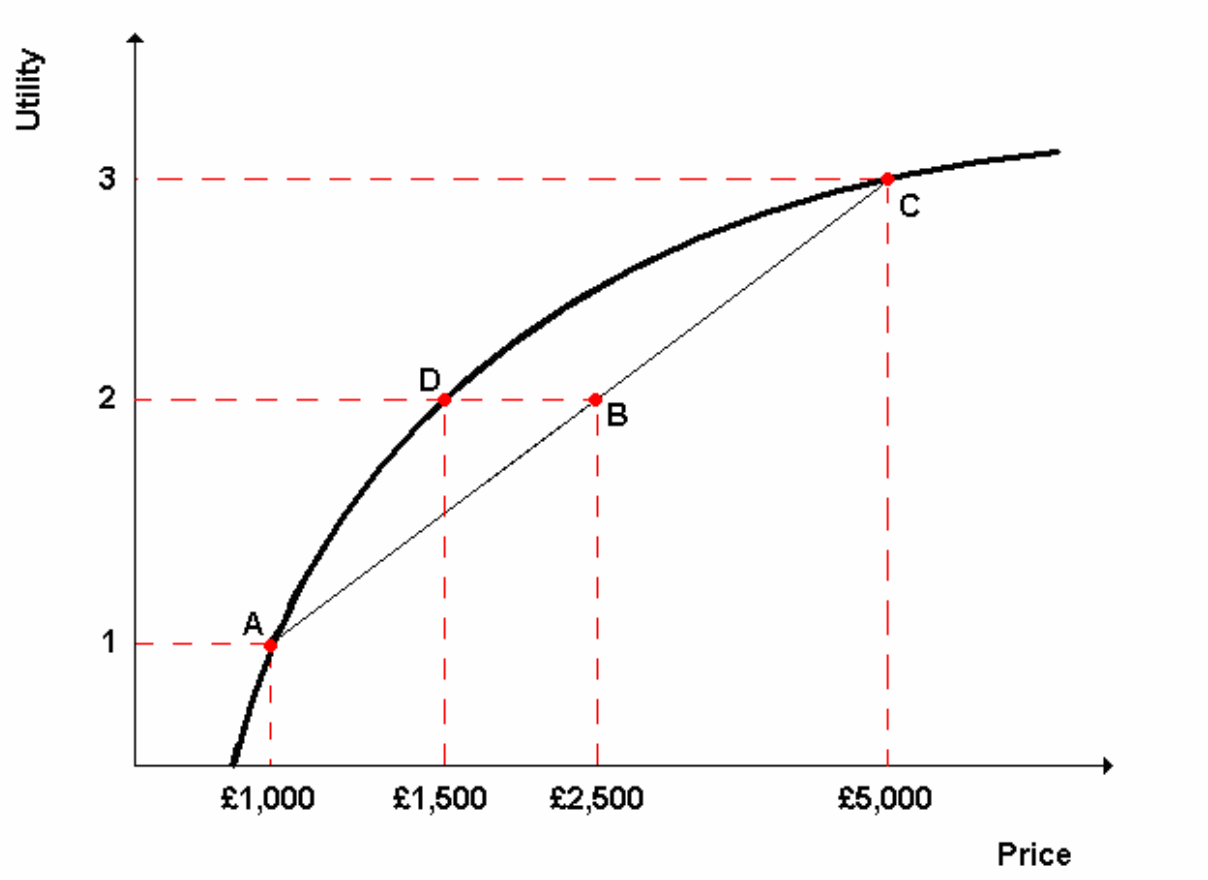
Risk Aversion

1 Risk aversion is apparent when an individual prefers an expected outcome over a bet between two different payoffs. A risk loving individual prefers the bet and a risk neutral individual indifferent. For example if a choice is given of either a 50/50 bet of receiving £10 or nothing, or a certain outcome receiving £5 (the expected value of the bet) a risk averse individual would choose the £5. A risk loving individual would choose the bet, and a risk neutral individual would be indifferent. Risk aversion is best demonstrated using a utility function diagram (Figure a1).

2 Utility is a theoretical measurement of an individual's benefit or pleasure. Utility can be considered in terms of the number of goods and services an individual can consume dependant upon their level of disposable income. The utility function on figure a1 shows an individual consumer's preference for money. The utility function is concave so that the individual receives less additional benefit from each additional pound received, due to of the law of diminishing marginal returns.

3 The Law of diminishing marginal returns states that the additional benefit (utility) gained from the consumption of an additional new unit of a product is less than the benefit gained from the previous unit. For example, the benefit gained from owning your first home will be quite high whereas the benefit of owning a second home may still be high but not as great as the benefit gain from the first home. The marginal benefit from the third or forth home will be lower still (possibly even negative, due to maintenance costs etc.).

Figure a1



4 If this individual were to take a gamble in which they would have an equal probability of receiving either £1,000 or £5,000. The utility received from £1,000 is 1 (point A), and the utility of receiving £5,000 is 3 (point C), so the expected utility they receive from this gamble is 2 (point D). The individual would value this gamble at £1,500. This is less than the expected value of the gamble which is £2,500 (point B). If they were to receive £2,500 they would gain more utility than if they were to take the gamble.

5 The difference between the expected value (£2,500) and the individuals valuation of the gamble (£1,500) gives a risk premium of £1,000, this is the amount the individual is willing to forgo to avoid the risk. The individual values the expected value of a gamble (a certain prospect of receiving £2,500), more than they value the gamble, and are willing to pay up to their risk premium to avoid this gamble.

Expectations

6 The two key strands of expectations theory are rational expectations (RE) and adaptive expectations (AE). Rational expectations is when an individual computes all available information in order to make a best guess of the future outcomes using all available information. With RE there are no systematic errors in prediction, i.e. agents do not make consistent errors in their predictions. RE assumes people have access to all available information and that obtaining information is cost free. This is clearly not observed in reality, as information about the future is costly and hard to obtain (especially when applied to risk from Major Hazards). The future cannot be predicted so that no form of expectations can be truly 'rational'.

7 Individuals exhibit adaptive expectations when their expectations are based upon past events. Under AE people make judgements based upon outcomes from previous periods, given lower importance/weighting to events further in the past. For example, an explosion at a major hazard site in the last decade would be given a higher weighting than a similar event that happened several decades ago.

Perfect Information

8 Perfect information describes a state of complete knowledge. Individuals are instantaneously updated as new information arises: all consumers know everything, about all products, at all times and therefore always make the best decision regarding purchase. In a perfect market the price level would reflect all available information about a product.

Externalities

9 An externality occurs when a transaction between two parties has (A and B) has some effect (positive or negative) on a third party (C) not involved in the given transaction. Externalities prevent the efficient allocation of resources. Typically cited examples of negative externalities include environmental pollution, noise pollution and traffic congestion. A music concert imposes a negative externality by causing noise pollution to a third party (or a positive externality if the third party enjoys the music). The concert organizers or its patrons do not take into account the cost imposed on those in the surrounding area who do not want to hear the music

Annex B – Land Use Planning systems of the Netherlands, France and Germany

i) Netherlands Land Use Planning system

11 The Netherlands is has a decentralised unitary state with a three-tier government: A national government and 12 provinces each under a Governor. Provinces are broken down into municipalities of which there are 450 in total. All these different government levels have planning powers. The Netherlands is currently the most densely populated European country.

12 According to the Dutch constitution the three levels of government are not hierarchically organized, since each of them have their own powers and competences; although there is still supervision from one level to another.

13 The Netherlands is often seen as having one of the most advanced spatial planning systems in the world. Due to the large number of populated areas being below sea level and the historical background, flood risk has been the focus of much of the Dutch LUP policy. The approach of quantifying the probability of an event was developed in the 1970's to address flood risk.

14 The rise of liquid petroleum gas (LPG) in the 1980's and its associated storage hazards prompted early safety regulations. Studies into LPG storage and LUP led to the development of quantitative assessment procedures and more sophisticated quantitative criteria for the evaluation of risk, based on the probability of an event occurring. A coloured series of books (among which the famous 'purple book') were commissioned by the National Research Centre, and are used as references by several EU countries.

15 The Netherlands has a comparatively high density of top-tier Major Hazard establishments. This is mainly due to the Rijnmond petrochemical area in Rotterdam. The explosion of the fireworks factory in Enschede in 2000, which left 22 people dead and 947 injured, prompted the Dutch government to assign to the ministry of Spatial Planning, Housing & Environment, the responsibility of coordinating 'external safety matters'. To this end the ministry formed the External Safety Directorate.

16 Most of the law regarding LUP comes from the Spatial Planning Act and the Environmental Management Act. The Ministry of Housing, Spatial planning and Environment, is responsible for drawing up the national policy on spatial planning. They produce an official document on 'National Policy on Spatial Planning'

(NPSP) every five years. This document often contains outlines of national structure plans, national structure policy, sector plans and concrete policy decisions that outline the national spatial planning policy.

17 The Spatial Planning Act lays down the implementation process of the National Policy on Spatial Planning (NPSP). It requires advice from the Country Planning Commission and the State or Town, as well as a stage of public consultation, and then finally its adoption by parliament.

18 For the most part LUP in the Netherlands is done by the local Authorities. A Regional Spatial Plan (RSP) can be adopted by local Provinces and Municipalities for the entire area of the province/municipality or certain parts in which developments are planned. The Regional Spatial plan is broken down into three parts; the Structure Plan, the Individual Project procedure and the Local Land Use Plan. The Local Land Use Plan regulates safety around a Major Hazard site; it is a legally binding document that regulates the use of land for a period of up to ten years. The Dutch have a strong tradition of successful negotiation between different government levels. The coordination and mediation of different levels of spatial planning is assured by the common reference to the Spatial Planning Act. When plans are not consistent with the larger-scale plans, the Spatial Planning Act allows the corresponding Authorities to impose binding measures.

19 Under the Environmental Protection Act all planned developments require a licence for all possible environmental effects outside their boundaries; this includes possible consequences to it from accidents from a Major Hazard. The Act also requires safety reports (on what)? to be submitted to whom?. For any new development or modifications of existing developments, a full quantitative risk assessment is required (risk assessment of what to what?). To obtain an operation permit the development must fulfil the environmental quality criteria defined in the External Safety Decree. Does this include risks from major hazards.

20 The Dutch assessment process is based on three guiding principles;

1) The individual risk assessment through an analytical approach accounting probabilities;
2) The evaluation of the individual risk and the definition of thresholds of acceptability
3) The evaluation of the societal risk.

21 There are legally binding thresholds for individual risk, the equivalent to intolerable risk levels put forward in the UK, individual risk is usually represented on a map. The evaluation of societal risk is done using representations of location-based risk contours and a societal-risk diagram. There are no legally binding target criteria for Societal risk but Municipalities have to document how societal risk is taken into account in their planning decision, evaluations are

carried out on a case-by-case basis. Societal risk is represented in the form of an FN graph.

21 The Dutch take account of sensitivity levels of developments by dividing buildings into categories; 'vulnerable' such as hospitals, residential areas, schools; and 'less vulnerable' such as, hotels, restaurants, shops, etc.

- The legal individual risk limit value for all 'vulnerable' developments in the vicinity of a Major Hazard is 10^{-6} events per year.
- The target (not legally binding) individual risk limit value for 'less vulnerable' objects is between10^{-5} and10^{-6} events per year with the 10^{-5} level of risk only being allowed in exceptional cases.

ii) French Land Use Planning system

22 The French Republic is a unitary, semi-presidential republic. In the past France has focused its LUP on a 2 zone deterministic approach through the assessment of a number of possible scenarios, all based on individual risk. Following the explosion of a factory in Toulouse there have been recent changes in French legislation. The new legislation passed in July 2003, relates to the prevention of technological and natural risks, for which the French acronym is PPRT. The new legislation now considers the consequences and the probability of possible events.

23 Four types of measures are used as means to control risk

1 Reduction of risk at source so that risk is as low as reasonably practical. These measures are listed in a safety report. From this report, permission are given for the development of a Major Hazard site or new development near a Major Hazard site.

2 Preparations of emergency plans, which must be tested regularly

3 Public information on the nature of the risk

4 Strict control of urban development

24 For building a new Major Hazard site it is relatively simple, as the site can and will be located away from any densely populated areas. For an existing Major Hazard this is more of a problem because there may already be residents living close to the site.

25 Risk and zoning rules are put forward in the PPRTs risk prevention plan, this plan looks at;

1 The statutory zoning plan sorting regulated areas, and the rules
2 A report justifying zoning and rules

26 Drawing up a PPRT risk prevention plan is done with the following 'players'

- The Prefect who is the local representative of the state.
- The state's specialist services which consists of firstly the Installation Inspectorate and secondly the Departmental Directorate for Public Works (DDE) who investigate the application together.
- The local Authorities
- Site Operator.
- Local Information Dialogue Committee
- Local Players Chosen by the Prefect e.g. Associations

27 The process starts with the Classified Installation Inspectorate establishing the PPRT study zone, to do this they study all the dangers listed in the site's safety report provided by the site operator. Then the maximum distance, for which all dangerous accidents can occur is plotted on a map, the area within this limit defines the PPRT study zone (which performs much the same function as the UK's Consultation Distance). One of the national rules in France states that certain highly dangerous and extremely unlikely events (where heightened safety precautions are demonstrated) are excluded from those listed in safety report, as these come under a national emergency plan and not local development

28 Once the PPRT study zone is draw up the Prefect organizes a meeting with the Local Information Dialogue Committee. The Prefect must explain to the committee the PPRT objectives, its different stages, ways in which dialogue will be organized, and the ways in which stakeholders are called to participate. After the meeting and organizing participants, the prefect makes a PPRT decisions decree, this marks the official launch of the plan.

29 The next phase of the PPRT is the technical phase. It starts with the Classified Installation Inspectorate drawing up what the French call the 'ALEAS' map. The most hazardous effects of each point in the PPRT Study Zone are determined.

30 Next all the aggregate probability of occurrence is determined, so that at each point in the PPRT Study Zone a level of potential damage and probability of various accidents are obtained. This combination of damage and probability of an accident is called in French the technological 'alea' (potential risk)

31 These 'aleas' are ranked into 7 levels, these are

- VH+ => a high probability of occurrence and high level exposure
- VH
- H+
- H
- M+
- M
- LOW => a low probability of occurrence and low exposure

32 A regional ‘alea’ map it then drawn up by combining the original Study Zone map with the level of ‘alea’ to each point in the Study Zone. Using the PPRT Study Zone the potentially exposed population are identified, this is done by the departmental directorate for public works (DDE) in close liaison with Local Authority’s Technical Services and their Regional Managers.

33 This process involves identifying people living in the area (types of housing/population density etc.), people working in the area (industrial and other activities), people who visit the area (so public buildings and parks will be listed), people passing through (transport infrastructure will be studied), as well as other useful information such as urban development projects in the region. Then all this information is transferred into the PPRT Study Zone map, this produces what is call the States map of the region.

34 Superimposing the Alea map onto the State’s map shows how the population are exposed to risk, this gives the preliminary Zoning map; this process also may produce areas in need of further investigation.

35 The ‘Strategy’ phase of the PPRT is the decision making stage and is organised by the Prefect in partnership with the stake holders (local Authorities, industry and other players are chosen by the Prefect). The decisions are aimed at reducing the population exposure to risk. Three principles are followed;

1) To avoid increasing the vulnerable of the population in the Study Zone, e.g. stopping new housing projects etc.
2) To reinforce the protection provided for buildings in the Study Zone
3) When there is no other choice, to reduce the human presence. i.e. compulsory purchasing

36 In some of the inner zones, regulations will be imposed, e.g. compulsory purchase of homes in the inner zone (VH+), in the VH zone, a manager of building may have to put protective film on all glass windows or, in public area

crowd gatherings such as a public concert will not be permitted. In less exposed zones relinquishment rights may be introduced, so that the property owner will have the right to sell to the state. Also there is limited development within these zones. So, for example, two housing developments could be planned on two separate sites inside the Study Zone, once one is chosen the other will probably be declared unfit for construction, to avoid increasing exposure to risk in the region.

37 The PPRT State services are then charged with writing the draft of the PPRT, this comprises of a Statutory zoning plan, regulations to be applied sector by sector, and finally a report explaining the zoning and rules with which to regulate. The draft is then presented to all players for comment. The final draft of the PPRT is then subject to a public inquiry .At the end of this process it is signed by the Prefect and appended to the local urban development plan.

38 A tripartite funding agreement is draw up between the state, local authorities and industry in order to finance any real estate measures in the PPRT.

iii) Federal Republic of Germany's land using planning system

39 Germany is a federal parliamentary republic consisting of 16 states. It's 'Basic Law' assigns relative power to the Federation and the States, the 'Basic Law' performs much the same function as a constitution.

40 The law regarding LUP consists mainly of the Law of *Raumordnung* ('territorial planning') and the Public Building Law. Urban LUP is the responsibility of the local Municipalities under the rules of the Federal Building Code and in coordination with the Regional Plan.

41 The 16 States have the responsibility of producing a State plan and releasing licenses for new developments. The plan has to be submitted to the local community and local authorities also known as 'Municipalities' . The State is informed on external safety, internal safety and relative safety measures by the Installation Safety Commission, a technical body called The *Stoerfallkommission.* Regional Councils supported by the *Landesumweltamt* (national environmental agencies at *State* level) produce safety procedures. In most cases the applications from a site require an external safety assessment. There is a legal requirement in German law that states there should be 'no-danger' outside the boundary of the Major Hazard site (no off site risk). To this end operational permits are only given when there is land use compatibility and a guarantee that risk reduction measures will be put in place..

42 A zoning evaluation is required by who, for who?that provides the appropriate distance for any proposed land use that might increase the exposure to risk. More sensitive developments, such as housing, parks etc. are kept away from Major Hazard sites. Consequently the existence of housing etc. near Major Hazard sites (and vice versa) appears to be in direct conflict with German law and its legal principles of LUP.

43 Each state is required to outline general objectives of LUP planning through the use of comprehensive over-scale plans what are over scale plans? These objectives must be met by the public Planning Authorities, especially the Municipalities.

44 Urban planning in Municipalities has two stages; the preparatory land-use plan (Flaechennutzungssplan) which is a plan for the local municipal area, and the various legally-connected land-use plans (Bebauungsplan) which are the legal outline for LUP in the adjacent area.

45 It is the local Authorities that are mainly responsible for LUP. Six types of area have been identified, all of which have different LUP policies

1. - Small housing estates;
2. - Exclusive and special residential areas;
3. - Village and mixed areas;
4. - Trading areas;
5. - Industrial areas;
6. - Special areas.

46 The main legal reference point for risk assessment in Germany is the Federal Environmental Pollution Control Act; this law regulates risk in terms of

1. Products
2. Installations
3. Areas.

47 For LUP permission, site operators of new establishments must abide by a licensing procedure, and be subject to inspections by the Authorities. Enforcement of operational safety standards is the responsibility of the states whereas setting standards and identifying generic risk reduction measures are the responsibility of the Installation Safety Commission (the Stoerfallkommission). When a site ‘matches’ these requirements a permit is granted (unless there are objections by the public who are informed through official publications and consultation procedures).

48 It is generally concluded that there is no German equivalent to UK's 'risk assessment'. Instead a risk judgment is made on the basis of interpreting legal requirements and technical guidelines. The main reasons for this is that German law states there should be 'no-danger' outside the boundary of the site, that a high risk plant should be established in such a way, so no risk is extended outside its boundary. Therefore risk is assessed on the basis of 'state of the art of safety' (which is well defined in German law) and a number of regulations which apply to industrial areas.

49 In some rare cases different methodology is used, these are;

1. A probabilistic method (with certain conventions, as the pre-selected scenario);
2. · Case – by – case (e.g. existing situations).

50 Generally a 'consequence – based' approach is used, which looks at pre-selected 'worst credible' or 'representative' scenarios. The evaluation of the safety distance is based on the link between;

- The maximum permitted amount of substance, its temperature and pressure
- The vulnerability of the surrounding environment.

51 The effects of a Major accident are looked at in terms of;

- · Individual/societal risk (though only in exceptional cases);
- · Injuries or fatalities of a large number of people;
- · Material damage.

52 The intolerable level of risk is based on the maximum permitted amount of substance, its temperature and pressure; as well as the vulnerability of the surrounding environment. Endpoint values are put forward to assess tolerability of risk.

53 Unlike many other European countries the German Regional Authorities have much greater power in the final decision making and can exceed any of the Endpoint criteria if justified. German legislation is addressed to give general safety objectives but it is the State which decides to follow or not follow these criteria.

54 There is, however, a Federal data-base being prepared by the central Government that provides a map of all plants within the country, and will provide standardized target criteria to support the Regional Authorities decision making.

Annex C - Buncefield and Land Use Planning Reforms

55 The incident at the petrol storage depot on 11 December 2005 led to a large vapour cloud explosion (VCE). An explosion of this type was not considered to be a credible 'worst case scenario' upon which to base land use planning advice. The incident prompted HSE to review its existing Land Use Planning (LUP) advice policy around large-scale petrol storage sites. HSE looked at four possible options for LUP advice policies around large scale petrol storage sites.

56 Option 1 - No change to HSE's LUP advice system - HSE would assume that improvements to on-site safety arrangements at petrol storage depots would reduce the risk of such an incident happening again to such an extent that the offsite risks could be considered acceptable without further planning restrictions.

57 Option 2 – Extend the current CD and planning zones around petrol storage depots, based on the observed building damage from the VCE at Buncefield. However the 'sensitivity levels' of developments HSE would advise to be permitted within the zones would not change

58 Option 3 - Extend the CD and zones around petrol storage depots, and limit development in the Inner Zone more than at present, i.e. allow only buildings that are 'not normally occupied'.

59 Option 4 – Extend the CD and planning zones as in Options 2 and 3, and introduce a new development proximity zone (DPZ) at a radius of 150m from the site. Within the DPZ HSE would advise against development other than those involving buildings that are 'not normally occupied'

60 An initial regulatory impact assessment was used to evaluate the four options using cost benefit analysis. The gain from the reduction of risk from each of the four options where weighed up against the costs. Part of the cost of increasing LUP restrictions (options 2, 3 and 4) represent opportunity costs. The opportunity cost is the difference between the first choice (developing within the current Consultation Distance of a Major Hazard) and the next best alternative one (developing outside the consultation distance). The costs to restricting developments are not the full decrease in the value of the land, because it is likely that the loss of the value of land within the consultation distance will increase the value of land elsewhere. Likewise, if a development is stopped within the consultation distance of a Major Hazard, it will take place in another location outside the consultation distance (see Annex E for more details on the initial regulatory impact assessment)

61 After a public consultation[12], it was decided that Option 4 was the most preferred one. This option would add a new zone within the consultation distance, called the Development Proximity Zone. The new zone will only allow the development of buildings that are not normally occupied. This option would offer better risk reduction and reassurance to the public than option 2 and it would be less restrictive to development than option 3.

[12]See HSE consultation document CD 211 available at www.hse.gov.uk/consult/condocs/cd211.htm

Annex D – Summary of initial regulatory impact assessment of Land Use Planning around large scale petrol storage sites

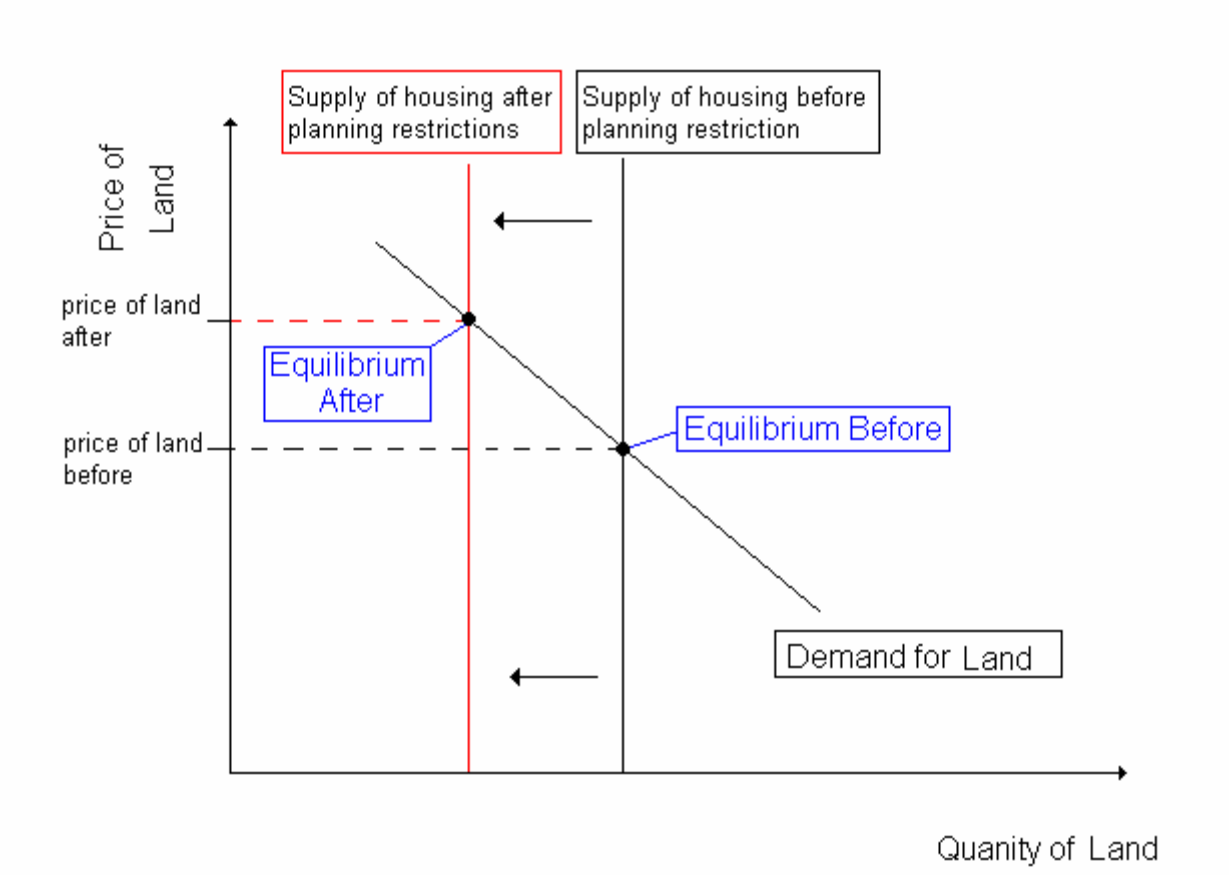
62 The initial regulatory impact assessment looked at and evaluated the different change in policy options, using the limited data available. Six sites were chosen based on data availability of the last ten years. The sites were spread across the UK, and were assumed to give an accurate picture of LUP nationally. It was also assumed that if HSE advised against a development it will not proceed in the area, but would outside the Consultation Distance. The data was divided by 10 to give the yearly average.

63 The methodology looked at the marginal analysis of risk levels and opportunity cost. Marginal analysis is the effect of adding or subtracting one more unit. Economic theory suggests an optimal solution can be reached when marginal benefits equal marginal costs: it is worth reducing risk until the benefits of the last unit is equal to the cost of reducing it. This kind of analysis is useful as it doesn't matter if its one or a hundred developments being looked at, it only looks at the threshold level, i.e. the last unit of a good being sold and its costs of production, or in the case of risk the last unit of risk reduction implemented and the opportunity cost associated with this risk reduction.

64 The opportunity cost is the difference between the benefits of the first choice and the next best alternative, i.e. the missed opportunity. The opportunity cost in the impact assessment of not developing was assumed to be 10% of the uplift of land value when planning permission is granted. The rationale for it only being 10% and not the full value of the land is as follows.

65 There is a fixed supply of land suitable for development in the UK, therefore any restrictions on development within a consultation distance would reduce supply and lead to higher prices of other suitable land. Figure a2 shows the supply and demand for land suitable for development. The black straight line shows the supply before any land use restrictions, where the demand for land intersects (is equal to) the supply curve is the equilibrium level. This is the clearing point where there are an equal number of those who wish to buy and sell land at the market price. If restrictions are put on LUP then there will be less land available for development. This will reduce the supply of development land, which is represented by the supply curve moving to the left. The new supply curve is represented by the red vertical line. The new equilibrium level for supply and demand now produces a higher market price as development land is now scarcer.

Figure a2

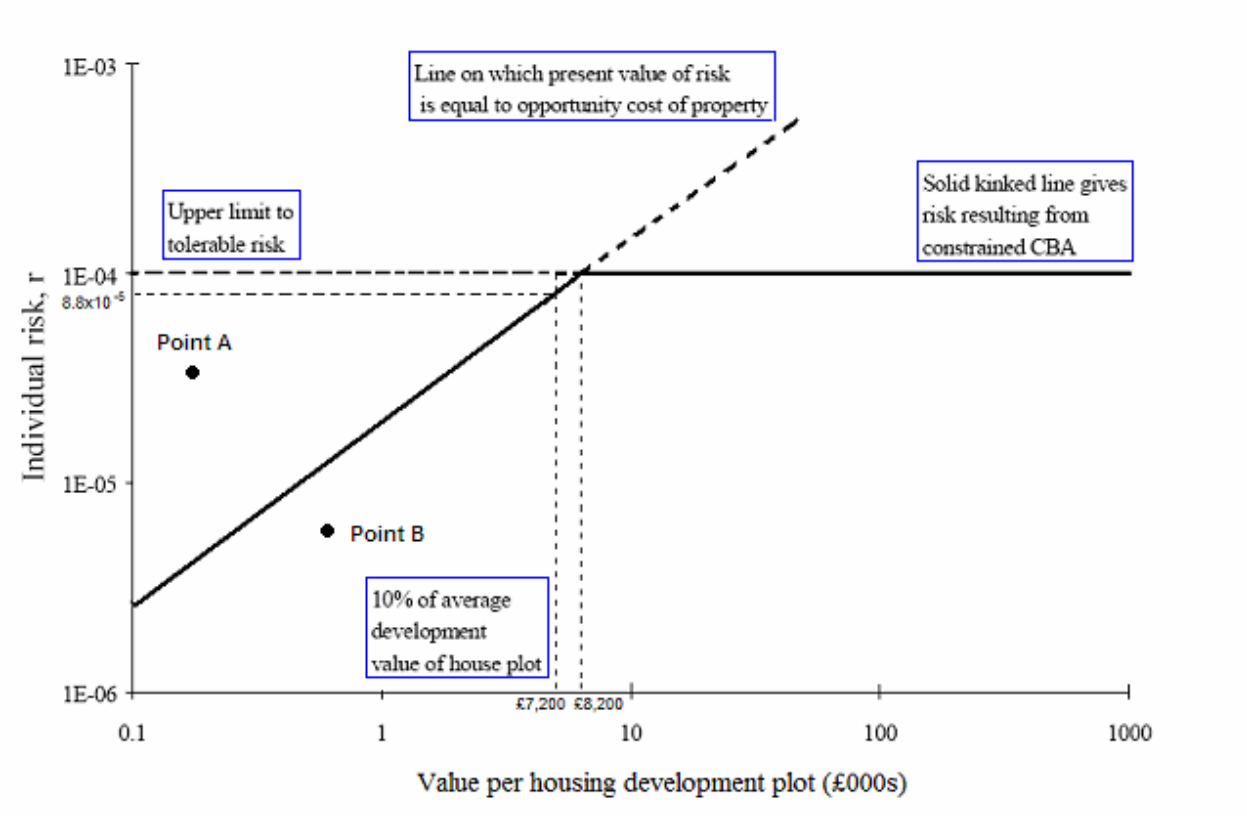


66 Even though an individual land owner inside a consultation distance may lose value in their land when planning restrictions are implemented, the value of land increases elsewhere. The 10% opportunity cost is meant to reflect that the developer's second choice (outside the consultation distance) may not be as suitable for their planned development as the first choice (inside the consultation distance). This value was chosen because of its use in the Evans et al (1997) paper 'Third Party Risk Near Airports And Public Safety Zone Policy'. It should be noted that this figure is subject to great uncertainty, as very limited data is available. Hence the economic cost of LUP restrictions is unclear.

67 Figure a3 shows the relationship between opportunity cost per house plot and the value of individual risk. The dotted horizontal line towards the top of the diagram shows the constraint, this is the highest level of risk society will normally tolerate. The kinked curve shows the level at which the marginal Net Present Value (NPV) of risk control (by preventing development) is equal to the opportunity cost. At the point where it reaches the constraint of the upper tolerable limit of risk it flattens out. Put another way this line plots the highest level of acceptable risk for any given value of housing development plots. When the marginal valuation of risk is more than the opportunity cost (point A) then it's worth decreasing the level

of risk by reducing development in the area, likewise if the NPV of marginal risk is less than the opportunity cost (point B) then it is worth allowing more development in the area. This holds so long as the risk does not exceed the upper tolerable limit of risk. So for example if the value per housing development plot was £7,200 then the level of acceptable risk would be $8.8x10^{-5}$.

Figure a3



Note: This diagram is taken from initial regulatory impact assessment and was a modification of the one used in Evans et al. It uses a logarithmic scale simply for the purposes of demonstrating a wide range of values

68 The optimal level of risk is worked out so that marginal benefits of reducing risk level equals the opportunity cost of not developing land.

69 The value of risk and opportunity cost is looked at in terms of its Net Present Value (NPV). The optimal level of risk will have a NPV attached to it. The NPV of risk shows the price the average household would be willing to pay for the elimination of this risk. This value reflects the cost of the risk today and the cost of the risk in all future periods for an average household.

70 The NPV of opportunity cost would account for the '*missed opportunities*' of stopping a development, over a full life cycle (i.e. taking into account future earning) minus the benefits (profits) of the next best alternative.

71 The opportunity cost was calculated using Valuation Office Agency (VOA) figures on land values. The average value of mixed farmland was subtracted from the average value of housing development land, or industrial land value where applicable, to produce the uplift value. The NPV of the opportunity cost was used with a future discount rate of 3.5% (this value was taken from the Treasury).

72 The NPV of risk reduction was worked out twofold. First, it works out the monetary value of risk. This was done by multiplying the number of people in a household (***n***) by the statistical value of life (***v***) and the probability of an accident (***r***).

73 Then future risk had to by taken into account. nvr is then multiplied by a function of number of year in the future (***m***) and the future discount rate (***d***), which reflects that risk reduction in the future is not valued as highly as risk reduction now.

74 Algebraically it looks like this;

$$NPV = nvr \left[\frac{\left(1 - \frac{1}{(1 + d)^m} \right)}{1 - \frac{1}{(1 + d)}} \right]$$

75 Where the future discount rate (d) was assumed to be 1.5%, this value was taken from the Treasury green book for health related benefits. It was assumed that there are 2.4 people per household and 40 households per hectare (national average). The Department of Transport's value of preventing a fatality (cost of death ***v***) was used. This was based on the public's willingness to pay for a reduction in the risk of death, as well as the cost associated with lost output and medical costs. The probability of an accident (***r***) would be set to the optimal value (worked out by equating marginal benefits of risk reduction with opportunity cost), this will give the NPV of the optimal risk level.

76 The number of developments that would be 'advised against' under this option that would have been 'not advised against' under the current regulations can be worked out, according to 5 different sensitivity categories (education, housing, parking etc.). The opportunity cost was worked out for each option. This opportunity cost is then compared to the NPV of the optimal risk level.

77 There are problems with this approach, firstly due to the lack of available data. The limited data means that the results obtained are unlikely to be statistically significant and it may not reflect national trends.

78 The opportunity cost was based on the average value of housing land. Not all land around a large scale petrol storage site has the potential for housing development. Hence it may have overestimated the opportunity cost. Also there has been very little work done on measuring the opportunity cost of LUP, and due to this lack of information opportunity costs of this type are educated guesses at best.

79 Finally this analysis only takes into account fatal consequences and doesn't take into account non fatal consequences and long term health issues (or any non-health and safety consequences). There are clearly significant costs to non fatal accidents (NHS costs, lost earnings, compensation etc.), this means that all cost of risk (marginal and NPV) are being underestimated.

80 However this sort of analysis is still useful as it promotes evidence based policy and helps to give comparisons between possible policy options.

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