UK Radioactive Waste Disposal Policy; a role for Social Systems Science?

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ABSTRACT

This paper explores whether agent-based systems thinking and analysis could contribute to the highly practical task of resolving major public policy dilemmas – in this case UK policy on RW disposal, where policy has come full circle in 30 years with little net progress on developing a long-term strategy. The paper examines the chronology of events and the key actors and considerations in the decision-making process. Some key factors identified include the tension between national and local interests, and the lack of consensus on the potential role of nuclear power. Looking at the issue from a systems thinking perspective provides some useful insights. The "root definition", a device invented in Soft Systems Methodology, is currently narrowly drawn whereas a broader perspective might assist different groups to accept trade-offs in the environmental area. The technical complexity and CATOWE diversity argue for a strategy supporting accommodation which has been substantially lacking in many stages of the process- particularly the critical stage of obtaining local approval for implementing a national strategy. Overall this preliminary evaluation suggests potential for systems scientists to apply their methodology to this intractable area of policy.

Keywords: radioactive waste, soft systems science, ABSSS, UK Nirex, Sellafield, CORWM.

1. INTRODUCTION

The UK has been debating policy on radioactive waste (RW) for over 30 years. Parliamentary scrutiny, particularly by the House of Lords Science and Technology Committee (HLSTC), provides a detailed chronology [1a-e]. Attempts to develop a strategy, including identifying a suitable RW repository have all failed. Surface stores of RW are growing. Even with concerns over terrorism, recommendations on **how to develop** a policy (not a policy itself) will not emerge before July 2006. An eventual disposal method may not be available before 2040. This author has been involved in providing objective analysis on this issue for Parliament[1] in the past and addresses (albeit from a non-expert standpoint) the question whether Systems Science could help develop a solution.

2.CHRONOLOGY AND ACTOR ROLES

Key events are in Table 1. For readers unfamiliar with UK decision-making structures, see the Annex.

Table 1 Chronology for RW Disposal Strategy

Year	Main Actor	Main Influencers	Key Event
1976	RCEP		Call for RW policy; deep geological disposal option
1978	Govt	RCEP	Set up RWMAC
1979 -81	Nuclear industry	Local public, govt	Abandon attempts to test drill in 1981
1982	Govt		Set up NIREX
1986	Parlia-ment	Local public/ govt	Abandon shallow disposal option
1988 -94	Nirex	Govt, Royal Society, RWMAC	Developed case for Sellafield RCF
1994	Nirex Local Govt	Local public	Initial refusal of RCF planning permission; appeal
1994 -6	Planning Inquiry	Nirex, local govt, NGOs	Refusal of appeal
1996	Govern ment	Public opposition, NGOs	Refusal confirmed
1997			Government changed
1999	Parlia-ment	All stakeholders	RW disposal policy urgently needed
2001	Govern ment	Internal Govt views	Managing RW Safely – consultation
2001	Govt		Set up CoRWM
2001 -5	Parlia-ment		Several reports from Lords and Commons
2001 -5	CoRWM		Consulting and evaluating options
2006	CoRWM		Recommended option
2040			Possible disposal

RW disposal first emerged as an issue in the Royal Commission on Environmental Pollution (RCEP)'s

[1]Director (1989-1998) Parliamentary Office of Science and Technology; advice/comment from the current director (David R Cope) is gratefully acknowledged.

enquiry into the environmental impacts of nuclear power[2]. At the time (1975), RCEP was "*unable to discover any clearly formulated policy for the future disposal of this (RW) waste*" [2]. Most intermediate-level RW (ILW) was in store at the facilities producing it. RCEP concluded there was a need for a national disposal facility for ILW. They made a case for geological disposal, and recommended that:

- The Environment Ministry should develop a disposal strategy informed by an expert 'Nuclear Waste Advisory Committee'.
- A 'Nuclear Waste Disposal Corporation' (also under the Environment Minister) should develop and manage the disposal process.

RCEP also concluded: "*there should be no commitment to a large programme of nuclear fission power until it has been demonstrated beyond reasonable doubt that a method exists to ensure the safe containment of long-lived, highly radioactive waste for the indefinite future*". This has become known as the 'Flowers test' after the RCEP Chairman at the time, Sir Brian Flowers.

The Government subsequently made the Ministry of the Environment responsible for RW management policy, and accepted the need for a national disposal facility for ILW. In 1978, it set up the Radioactive Waste Management Advisory Committee (RWMAC).

About the same time, a foretaste of future problems emerged when the UK Atomic Energy Authority asked for permission from Local Government to drill boreholes for geological disposal research. The 6 planning applications all generated local opposition, and only one was granted. Public inquiries into the others were discontinued when the Government cancelled the drilling programme in 1981[3].

Policy remained to develop a RW disposal site and in 1982 the Government established the Nuclear Industry Radioactive Waste Management Executive (Nirex). Nirex's first proposals (a disused anhydrite mine for ILW and an abandoned clay pit for low-level waste - LLW) were withdrawn because of public opposition in 1985. The government then considered **co-disposal** of ILW and LLW. Nirex initially proposed shallow burial in clay pits but again there was widespread local opposition. In 1986, the Commons Environment Committee (4) questioned *the principle* of shallow burial for ILW; the Government agreed this would not be considered further.

Nirex thus (1988) turned to a deep underground site (5). 500 areas were identified with suitable geology; these were narrowed down to 11 using a "Multi-Attribute Decision Analysis (MADA)" [6]. However, for practical reasons (already the location of nuclear waste and nuclear industry), the Government decided to first evaluate the geology of the two nuclear sites at Sellafield (not one of the 11 MADA sites) and Dounreay. RWMAC agreed [7], but did warn that there were likely to be better sites on a purely scientific basis. Because of the inaccessibility of Dounreay (Scotland), site investigations were limited to Sellafield from 1991.

Nirex thus developed its safety case based only on one (Sellafield) site. Complex models were developed to predict the passage of radio-nuclides from waste in sealed containers, through artificial chemical/ physical, and natural geological barriers to estimate the potential risk of exposure from any radiation emerging. The design target was to be less than an internationally-accepted 10^{-6} per year risk factor [6]. After evaluating borehole data, Nirex concluded that an underground laboratory (a 'rock characterisation facility' -RCF) was needed to fully develop the risk assessment. The UK's Science Academy (Royal Society) supported the RCF proposal [8], but recommended greater openness to peer review of Nirex's scientific analysis and methods.

Nirex made a planning application for the RCF in 1994. The local County Council (Cumbria) refused the application, and a Public Inquiry was held in 1995-96. During this time, the Government also announced [9] that the policy for radioactive waste management should be based on the principle of sustainable development – this favoured disposal over indefinite storage[3].

Nirex's case for the RCF and supporting data were fiercely contested by NGOs and local interests at the Public inquiry. The models used to predict chemical, physical and biological processes over many thousands of years were highly complex and the scope for expert disagreement at the Inquiry was substantial. Under the UK's adversarial planning inquiry system, there was no resolution to many disputes between the industry, regulators, environment groups, local authorities etc. In 1996, the Inquiry Inspector refused the RCF permission and this was confirmed by the Environment Secretary of State before the 1997 general election. There were several reasons given for refusal, but the most critical

[2] The RCEP is an independent Commission established by Parliament in 1970 to advise on environmental matters. RCEP particularly seeks to identify fields where it feels that inadequate attention has been given.

[3] Sustainable development's focus on intergenerational equity has been used to argue against nuclear power on the grounds that it leaves waste for our descendants to handle. However nuclear power also reduces the carbon dioxide passed on, reducing forcing for climate change.

concern was over the site selection process. The site was more complex geologically and hydro-geologically than would be expected of a choice based on scientific grounds and was seen as an economic/political choice rather than a result of an objective selection process.

This brought into focus a key split in responsibility - **local** government had to approve site-specific activities even though they related to highly technical matters of **national** strategic interest. This reverse was widely seen as a major failure of the system and stopped the search for a disposal strategy dead in its tracks. To try and assess the consequences, Parliament carried out a substantial enquiry (1a) which *inter alia* concluded:

- "*The long time-scales involved might be thought to be a reason for postponing decisions. The contrary is the case……*
- *"…phased disposal in a deep repository is feasible and desirable…*
- *"The future policy for nuclear waste management will... need to secure local acceptance of a recognised national need".*

Government appeared in no hurry to re-engage with such a controversial issue and took 2.5 years to propose the next steps [10]. Against the background of 10,000t of ILW already in store, and another 500,000t anticipated from future use and decommissioning of current plants, the paper said "*We must decide how to manage this waste in the long term. Implementing that decision will take decades. So now is the time to start planning for our future.*" Although the same conclusion had been reached by the RCEP 26 years earlier, there were no specific proposals for disposal. Instead, the Government proposed "*a national debate which will lead up to that decision, and beyond it. The aim is to develop, and implement, a UK nuclear waste management programme. .that inspires public support and confidence".*

The Government next set up the Committee on Radioactive Waste Management (CORWM) in July 2002 to advise on a policy. This has (by 10/2005):

- Drawn up an inventory of RW;
- Reexamined all potential disposal routes (including those already rejected nationally and internationally such as disposal to space).
- Experimented with various forms of public involvement (citizen's panels, open meetings, round tables, stakeholder forums).
- Identified a list of viable options (Long-term interim storage, Deep geological disposal, Phased deep geological disposal, and Near-surface disposal) with a view to a final recommended option by July 2006[11].

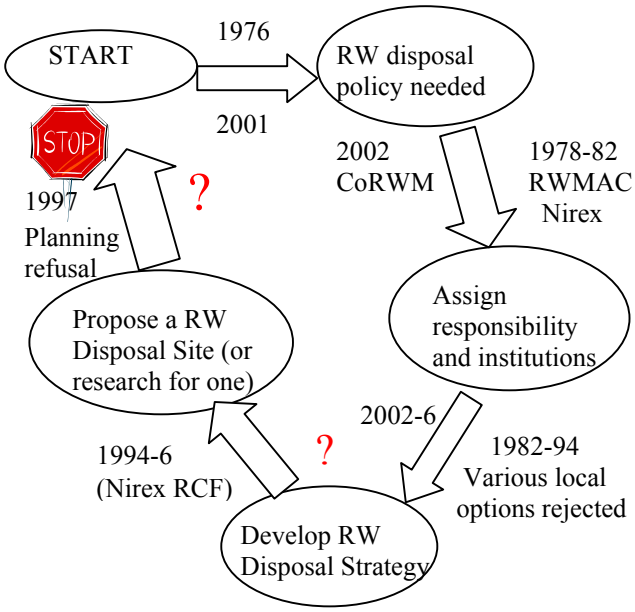
Parliamentary scrutiny has been critical. The House of Commons Environment Committee has asked for an annual progress report [12]. HLSTC [1b,c,d] was:

- disappointed at the slow progress and "*government procrastination*";
- "*astonished*" that CORWM should spend its first year re-examining options long rejected by UK and other countries;
- concerned at CORWM's lack of scientific members. Also over the "*committee's focus on investigating methodologies of decision-making and public and stakeholder engagement at the expense of identifying the right scientific and technical solution*" [4];
- disagreed with the government that developing a strategy for RW disposal is a barrier to considering the role of nuclear power to reduce carbon emissions and enhance security of energy supply. The HLSTC argues that the original RCEP 'Flowers Test' has been met.

CORWM is expected to report in July 2006. An actual RW disposal method is not expected to be operational before 2040. The above events have a degree of cyclicity to them and there is concern whether events will proceed any differently in the second 'lap' if or when a specific disposal method and site is proposed (Fig.1).

FIGURE 1 CYCLE OF EVENTS – THE 2nd LAP?

[4] Royal Society (13) also commented on CORWM's emphasis on public presentation at the expense of waste treatment research, on lack of scientific expertise, and a need to review the possibility of terrorist action.



3. SYSTEMS THINKING ASPECTS

Systems thinking offers two possible approaches-hard systems and soft systems thinking [14]. The former seeks to describe, explain and analyse interactions between the autonomous agents and identify interaction properties. Soft systems thinking tries to design environments and tools to support the decision-making process. It requires consideration of the values and motives of the actors/agents. Some of the main points relevant to soft systems thinking may include:

The Government. The chronology above shows Government largely responding to events – to the RCEP, to parliamentary scrutiny and to public opposition. Ministers seldom personally advocated official government policy. In the RCF planning case, the Environment Secretary Of State, in exercising one of his roles, vetoed an important part of his department's strategy. After the change of government in 1997, there have been Ministers whose anti-nuclear views are well known (as well as significant numbers of antinuclear MPs in the governing (Labour) party). Far from having a unified view, Government has been split on the issue of nuclear power, and policy the outcome of compromise between opposing internal 'factions'. Surveys also suggest that politicians have a mistaken perception of the scale of opposition, which causes them to be very cautious [15]. The result is that under current political systems the controversy and expense of dealing with RW may make repository decisions extremely difficult and favour short-term expediency by relying on extending storage [15] or protracted study of 'options'. Not-in-my-backyard (NIMBY) is supplemented by not-in-my-term-of-office (NIMTO). Criticisms of procrastination have come from Parliament (described above) and the Consensus Conference held in 2002 [16].

Local Government and the planning system. RW is the only waste category where responsibility is vested at national level. Local government and officials thus only become involved when a site is suggested and have no chance to become familiar with the national and strategic or scientific issues involved [3,15]. Local agents engage in a competition to avoid becoming the default choice by being too objective and reasonable. The system encourages competitive obstruction.

A key point of principle has been whether planning inquiries should consider only the impact of the proposed trials/tests themselves (borehole drilling, construction of the RCF) or evaluate in the context of likely subsequent developments (construction of a repository in the case of the RCF). RWMAC and others see planning inquiries as the proper forum for land-use and planning issues, but not for deciding on the safety or otherwise of a repository itself. However, in all cases it has proved impossible to restrict local enquiries to such a narrow focus [3,6]. This 'mission drift' and the adversarial system provide scope for almost indefinite argument over the many uncertainties incapable of objective resolution. Failure **to reach a conclusion on acceptable safety is almost guaranteed**[5].

Local Actors. Current systems do not provide an adequate forum within which the tensions between national and local interests can be resolved. Moreover many people only become actively involved in the debate (usually in opposition) when it moves from the general to site-specific[6]. Being host to a RW repository has few advantages in employment or investment and many disadvantages-increased perception of risk and stigma. This makes a case for compensation or volunteer communities with rewards for participating as practiced in France, Sweden and other countries. The UK has not used this approach.

[5] The Royal Society said in 1994 [8] "*the first exposure to alternative interpretations and to the inadequacies of supporting data could come in the confrontational climate of a public inquiry.This could set back the entire programme, with serious consequences for the achievement of satisfactory solutions to the problems of RW management and disposal in the UK".*

[6] Central Government has cited local planning as the primary means of taking into account public concerns despite every attempt having the same pattern of stimulating fierce local opposition [3].

Expert Groups. Departures from the 1976 RCEP recommendations [2] may have contributed to failure. RWMAC had no members from environmental NGOs, no local government members and no role in sponsoring and directing scientific research. This may have made it more difficult to encourage consensus and for scientific data to be seen as independent and trustworthy. Nirex was an industry organisation, and this fuelled challenges to the objectivity of the scientific case, and suspicion that the RCF was a 'Trojan horse' for a repository. After the inquiry, Nirex accepted that gaining public trust and confidence is a prerequisite to securing public acceptance of policies, and has (2005) reconstituted itself as an independent body. The criticisms of CORWM cited above suggest the antithesis of Nirex's original technology-based approach – CORWM is seen as following a public engagement agenda at the expense of technical matters.

Risk assessment. Assessing the risk of release of radiation from waste disposed of in a repository is very complex. Many different radio-nuclides with different radiological, physical and chemical properties have to be modelled, together with their interaction with the container, repository filling material and surrounding geology and hydrogeology. Analysis of possible transport pathways over the long timescales envisaged must consider external scenarios ranging from an ice age to a warmer world. Probabilistic safety assessments are capable of handling such complexities but there is scope for interminable contention between parties over the models and underlying assumptions. Trust and transparency thus become critical factors to engender widespread acceptance of such risk assessments [6].

Risk Perception. Work on mental models of risk assessment [17] reveals the overwhelmingly negative connotations of radioactive waste - consistent across many countries [18]. Individual attitudes towards nuclear energy are largely determined by whether the greatest importance is attached to economic and technical benefits, or focused on concerns about health and environmental risks [19]. Objective and consensual debate on radiation risks is particularly difficult [15]. Many do not accept as reassuring estimates that the potential risk from RW disposal is only 1% of what they already receive from natural radiation. This 'one per million' risk target may be just as readily (mis-) interpreted as meaning that 60 people will die every year from RW (since the UK population is 60 million). Experts who criticise the public for their 'irrationality' characterise ILW as relative innocuousness. However initial proposals for shallow burial, rather than being defended on the basis of objective risk led to proposals for deep burial (to give greater reassurance). On the contrary the search for deep burial enhances the public's perception of the danger of ILW, strengthening further public unease and opposition.

NGOs. Some of the most actively-engaged NGOs are opposed to the *principle* of nuclear power. Since the lack of a long-term strategy for RW waste is often cited as a reason for not building new power stations, there is a motive to avoid a solution to the RW problem so that it remains a barrier and contributes to the more fundamental objective of reducing or eliminating nuclear power. Some groups are well-funded and can have considerable media and political impact. New evidence and data may be adapted to the pre-decided strategy rather than modify the group's position[7]. Such groups may not be motivated to reach consensus through accommodation. To some, 'nuclear' straddles RW, nuclear power, weapons and proliferation concerns and may even resonate with anti-globalisation concerns. Their belief-driven motivation can be very strong and presents major challenges for accommodation strategies.

Public engagement. From 1976-1996, public engagement had primarily been to oppose specific sites. People who previously had no interest in the subject of RW (i.e. were not stakeholders) suddenly become stakeholders when policy proceeded to select a site. Not party to the process which led to the selection of the site, they reacted negatively [15]. Specific attempts at broader – pre-site selection- stages include a Consensus Conference 1999 [20]. The report favoured storage underground which must be *monitorable and retrievable*. Criteria for site selection should be *open and publicised*. They saw a *lack of trust and understanding* and concluded that *public awareness must be raised and the public fully informed of the problems and solutions available*, and decision-making *open and transparent*. A focus on public engagement has been part of the programme since 2002 by CORWM as described above. A second consensus conference was held in 2002 [16].

Overseas policies and experience. Parliamentary and expert inquiries have cited overseas experience where underground repositories are the preferred long-term option for RW, but this has had little effect on UK policy. Neither have many found reassurance from the studies of natural contamination, where a major release of radio-nuclides from a natural chain-reaction millions

[7] For instance, the HLSTC's view [1d] that the RCEP's 'Flowers Test' has been met is not accepted by some NGOs even though the chairman of the HLSTC is the same (now Lord) Flowers.

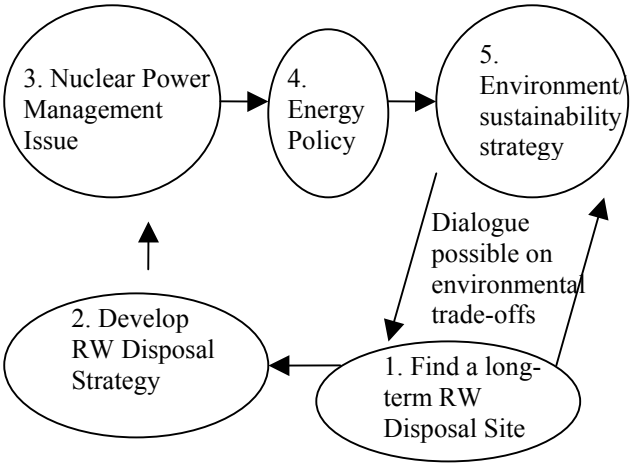
of years ago (in Africa) appears to have resulted in very little movement in less than ideal geological strata.

4. IMPLICATIONS OF SYSTEM THINKING

How might agent-based soft systems science (ABSSS) and thinking have been used in this issue and might it have produced a useful perspective? The first step could have been to consider what is the problem/system we are addressing; this is usually expressed in the form of a "root definition"[21]. Even at this first step, there is a difficulty! RW does not just arise from nowhere-it is part of a system. As shown in Figure 2, RW disposal strategy can be seen at different strategic levels:

1. an issue of implementation (i.e. need to move from the current temporary dispersed storage to a longer term, safer and more secure site);
2. an issue of developing a comprehensive disposal strategy;
3. an important part of the management of the nuclear power programme;
4. an overall part of the UK's energy policy;
5. part of the UK's sustainable development strategy to reduce the environmental impacts of meeting the UK's energy needs.

FIGURE 2 ROOT DEFINITION BOUNDARIES



Policy to date has tended to be focused at level 1,2 with some linkage with level 3. Only by operating at level 5 do we see the current whole system: that dealing with the environmental and safety aspects of radioactive waste is part of the sustainable development priority to reduce the environmental impacts of energy provision. This allows participants to start making value judgements and comparative risk assessments between different environmental risks-those of long-term radiation release and global warming. This makes it more difficult for "single issue" opposition, since it encourages a trade-off approach.

ABSSS thinking also tries to encourage collaborative deliberation from which accommodation of interests can emerge. It recognises that the structure and process for participatory decision-making needs to be matched to the issues involved. One approach looks at the technical complexity and the diversity of CATOWE proposed by Checkland [21]. From Table 2 the issue of RW disposal can be seen to have a diverse CATOWE and, with its technical complexity, requires a decision-making system which encourages and supports accommodation [14]. From the considerations above however it is clear that the UK debate has been the antithesis of this. Two critical areas where accommodation is lacking are the lack of compromise on the principle of whether or not to use nuclear power (whether for energy security or environmental reasons) and the lack of support for accommodation between national and local interests (the 'local veto').

On the former, while some NGOs are fundamentally opposed to nuclear power, it may be difficult to reach a complete consensus. If a decision is to be taken it will require political leadership to carry the wider community in spite of the continued opposition of special-interest groups. This is why the higher level approach, where comparisons can be made between environmental risks and benefits could help the broader community to support a solution. Currently the urgency of tackling global warming is becoming accepted by the public and the role of nuclear power is starting to be re-examined[8]. If the debate on RW management were pursued as part of the overall strategy for energy supplies in a more sustainable world, this could lead to a greater commitment, whether by government, institutions, or the public, to integrate into that policy an effective long-term solution for RW. An opportunity to follow this approach will emerge in 2006 when the Government undertakes a review of future energy needs including those for civil nuclear power.

TABLE 2 CATOWE ANALYSIS OF RW DISPOSAL STRATEGY

Customers	Industry, Public (benefits and costs)
Actors	Industry, National and Local govt, NGOs, regulators,
Transformation	Temporary storage (one set of

[8] Without any new build the current percentage of electricity from nuclear power will reduce from 22% to 7% within the next 15 years as older stations are retired.

concepts	risks) →long-term disposal (different set of lower risks)
Owners	National Government
World view	Variable views on need for Nuclear Power, common acceptance of need to protect health and environment
Environment	International and national radiation safety standards, National and local laws and procedures

However, there remains a lack of linkage between the attitude towards RW management in the abstract (i.e. when it is a national debate) and the involvement which results when local siting issues are reached. Participation in the former tends to be limited to those with professional or belief-driven motives. On the other hand, once the issue comes to deciding a site, huge numbers become stakeholders (in opposition) almost overnight. For instance in one of the 1980 drilling projects, almost 60% of the population in the area signed a petition in opposition [3]. Work to date, including that of CORWM, may not overcome the basic danger that however extensive and protracted the 'national' debate, it will not affect the local reactions to a proposal to build a site (or even to carry out research to evaluate the site). Under the existing system, there is no constituency in favour of radioactive waste disposal in a given area-only a large constituency against such a burden being imposed from outside.

ABSSS thinking would suggest particular effort should be placed into this part of the system. New tools of persuasion and compensation, not just information and engagement may need to be developed. Possible options include a system of rewards and incentives for 'volunteer' communities in locations which meet the criteria for geology, access etc. Another option which has been mentioned would be to establish a high-level independent commission operating in a way designed to attract public trust to identify the most appropriate site(s) on the basis of nationally agreed criteria[9]. However, even this may fail to resolve the issue of the 'local veto' and this has led to some suggestions that for such strategic national decisions, the responsibility for any final siting decision should lie with Parliament.

5. CONCLUSION

Although preliminary, this analysis suggests that soft system science predicts a significant risk of continued failure for current policies. Without new initiatives targeted at the critical points of the "system", Lap 2 of the policy development circuit (Fig. 1) may end up in the same position as Lap 1. A fuller analysis by ABSSS experts could identify strategies with a higher chance of success in resolving this intractable policy challenge.

[9] The Second Consensus Conference on RW suggested RWMAC should become a "*governing*" body [16].

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ANNEX **UK POLICY PROCESS**