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ARTICLE

Geoengineering, the Precautionary Principle, and the Search For Climate Safety

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Abstract

This article considers the application of the precautionary principle as understood in EU law to EU decision-making on geoengineering, in particular solar geoengineering. It finds that the situation is riddled with more complexities than first appears; (i) the principle is used to argue against research, even though more research is usually itself seen as precautionary response; (ii) the risks of research are claimed to lie in its political impact, whereas the principle is traditionally applied to direct physical risks; (iii) while there are legitimate precautionary arguments against geoengineering, it is itself put forward as a precautionary measure and there are precautionary arguments in favour too. Drawing on case law and scholarship we conclude that the precautionary principle can nevertheless be applied and will lead to a procedural requirement to do comprehensive reviews of relevant scientific knowledge before decision-making. This leaves wide – but not unbounded – discretion but may still be valuable in providing a frame for reasoned public debate. We also apply our findings to the recent expert reports on Solar Radiation Modification and show that they have failed to apply precaution correctly.

Keywords: climate governance; EU Law; geoengineering; precautionary principle; solar radiation modification

I. Introduction

Geoengineering is the use of artificial techniques to manipulate the climate, in order to reduce the effects or extent of climate change.[1] It is often attacked as a reckless idea.[2] Opponents point out that small-scale experimental results may not extrapolate to a larger scale, and global climate interventions might have disastrous and unexpected side-effects. They conclude that geoengineering is simply too dangerous to be pursued. Theoretically, some forms of geoengineering might be effective, but from a precautionary perspective they argue against making the gamble: the consequences of losing are too high.

It is then ironic that geoengineering was originally proposed – and continues to be proposed – as a precautionary measure itself, a technique it was hoped would never be

[1] J Reynolds, "Solar Geoengineering to Reduce Climate Change: A Review of Governance Proposals' (2019) 475 Proceedings of the Royal Society A 20190255.

[2] Eg, J Wieding, J Stubenrauch and F Ekardt, "Human Rights and Precautionary Principle: Limits to Geoengineering, SRM, and IPCC Scenarios" (2020) 12(21) Sustainability 8858; F Biermann and Others, "Solar Geoengineering: The Case for an International Non-Use Agreement" (2022) 13(3) Wiley Interdisciplinary Reviews: Climate Change e754; JC Stephens and Others, "The Dangers of Mainstreaming Solar Geoengineering: A Critique of the National Academies Report" (2023) 32(1) Environmental Politics 157.

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necessary, but that should be developed in case humanity ever reached the point where it was faced with impending climate catastrophe – at which point even a risky climate intervention might be a "lesser evil."[3]

The policy context of this discussion is pervaded by uncertainty. How fast, and by how much, will emissions be reduced? How fast will global warming occur and what will its consequences be? Will any geoengineering technique, even if it seems safe and effective in experiments, still be so if unleashed at scale? Moreover, the consequences of getting it wrong are severe – there is a risk of planetary disaster if tipping points are reached and humanity has no way of combatting them, but also if geoengineering is deployed at scale and has destabilising climate effects.

An objectively founded risk of serious harm, and scientific uncertainty, in an environmental context, are triggers in EU law for the precautionary principle.[4] Given the seriousness of the possible, but uncertain, consequences of any policy stance on geoengineering, precautionary thinking should therefore play an important role.

Yet geoengineering is an atypical context for the precautionary principle. In general, it is applied where the status quo is "safe" and a new product or action raises possible risks.[5] Here, both action and inaction entail risks. Although academic literature has considered the possibility, the precautionary principle has never been applied to such a symmetrical situation.[6]

Moreover, some of the risks involved are not directly environmental, but rather political[7]: concern is expressed that funding geoengineering research might reduce public motivation to cut emissions, and that developing viable geoengineering techniques might lead to global conflict over their use. The precautionary principle to date has always been applied to concrete and immediate dangers, actions or substances which may cause environmental or health harm if released for sale or use. It has never been applied to restrain research, nor to contexts where the immediate risk is of negative influence on politics or behaviour.

This article asks how exactly the precautionary principle should apply to geoengineering decision-making by the EU, a matter where it is clearly relevant, but where the novelties of the situation mean that past law and policy cannot be simply cut-and-pasted. The recent publication by a Commission expert committee of recommendations on Solar Radiation Modification, the most controversial form of geoengineering, and the recent news that we may have passed 1.5 degrees of global warming, show how urgent and timely a legally robust frame for that decision-making is.[8] The article also hopes to contribute to thinking about the precautionary principle in EU law more generally. In a world where the seriousness and complexity of human impact on health and the environment is expanding – microplastics, overfishing, and antibiotic resistance are further examples – it needs to be established how far the principle can be constructively extrapolated beyond the specific and concrete harms which have hitherto been its legal home.

[3] PJ Crutzen, "Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a policy dilemma?" (2006) 66 Climatic Change 211; See now JL Reynolds and F Fleurke "Climate Engineering Research: A Precautionary Response to Climate Change?" (2013) 7 Carbon and Climate Law Review 101.

[4] K De Smedt and E Vos, "The Application of the Precautionary Principle in the EU" in HA Mieg (ed), *The Responsibility of Science* (Cham, Springer 2022) 163; Commission Communication on the Precautionary Principle, COM(2000)1 Final.

[5] See V Heyvaert, "Governing Climate Change" (2011) 74 Modern Law Review 817.

[6] K Elliott, "Geoengineering and the Precautionary Principle" (2010) 24(2) International Journal of Applied Philosophy 237.

[7] Reynolds (n 1), 2.

[8] Group of Chief Scientific Advisors (GCSA) "Solar Radiation Modification" Scientific Opinion No. 17 (European Commission 2024).

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II. The scope and requirements of the precautionary principle in EU law

The precautionary principle is applied by Article 191(2) of the TFEU to activities of the EU in the environmental sphere, whether legislative or other.[9] However, it is not relevant to every act or choice. Rather, it applies in situations where there is sufficient reason, on the basis of science, to fear substantial harm if a certain choice is made, without there being certainty that that harm would materialise. A risk claim not supported by sufficient scientific evidence does not justify precautionary actions. On the other hand, if the dangers are scientifically established and not realistically in doubt, then interventions are not treated as precautionary, but simply as preventative.[10] It is the combination of a significant degree of uncertainty, with nevertheless sufficient scientifically rooted reason for fear, that is characteristic of, and engages, the principle.

Where the principle applies, it requires decision-makers to engage in a wide and as complete as possible survey of the existing scientific knowledge, and what it has to say about the risks in question, before taking their decisions.[11] In practice, this obligation has a significant procedural element.[12] Accordingly, undertaking a precautionary investigation does not necessarily determine the ultimate policy choice, for, as will be discussed below, it is a political question which risks are acceptable, and wider values and norms may legitimately determine this.[13] However, what the precautionary principle demands is that there is a solid grounding for the choices made in the existing scientific knowledge.[14] The precautionary principle is thus in substance a requirement to ensure that policy-makers are scientifically well-informed, and take account of that information in deciding which risks to accept.[15]

In most cases the principle has been facilitative; a Member State has opted-out of, or interfered with EU policy, in a way that would not normally be allowed, but they have been able to justify their actions as precautionary.[16] However, a few cases suggest the principle could also be constraining: that with the right evidence and context the principle could prevent risky EU or national action.[17] The scale and irreversibility of the possible harm, combined with the degree of risk, and an absence of sufficient benefits, might make the action impossible to justify.[18]

Nevertheless, such constraining use has not actually materialized in practice. Moreover, the Court maintains that while the establishment and quantification of risk is a scientific

[9] See F Fleurke, "Future Prospects for Climate Engineering within the EU Legal Order" (2016) 7(1) European Journal of Risk Regulation 60; C-616/17 *Blaise* ECLI:EU:C:2019:800.

[10] E Tedsen and G Homann, "Implementing the Precautionary Principle for Climate Engineering" (2013) 7 Carbon and Climate Law Review 90, 92.

[11] De Smedt and Vos (n 4); MD Rogers, "Risk Management and the Record of the Precautionary Principle in EU Case Law" (2011) 14(4) Journal of Risk Research 467; C-558/21 *Global Silicones Council* EU:C:2023:839 para 66.

[12] K Steele, "The Precautionary Principle: A New Approach to Public Decision-Making?" (2006) 5(1) Law, Probability and Risk 19; Heyvaert, Governing Climate Change (n 5).

[13] De Smedt and Vos (n 4); J Penca, "Science, Precaution and Innovation for Sustainable Fisheries: The Judgement by the Court of Justice of the EU Regarding the Electric Pulse Fishing Ban' (2022) 135 Marine Policy 104864.

[14] Commission Communication (n 4), 16.

[15] Fleurke (n 9); Steele (n 12); R Andorno, "The Precautionary Principle: A New Legal Standard for a Technological Age" (2004) 1(1) Journal of International Biotechnology Law 11.

[16] De Smedt and Vos (n 4).

[17] De Smedt and Vos (n 4); V Heyvaert, "Facing the Consequences of the Precautionary Principle" (2006) 12 ELRev 185; GC Leonelli, "Judicial Review of Compliance with the Precautionary Principle from Paraquat to Blaise" (2021) 22(2) German Law Journal 184.

[18] K Robbins, "Geoengineering and the Evolution of Dueling Precautions" in W Burns, D Dana and SJ Nicholson (eds), *Climate Geoengineering: Science, Law and Governance* (Cham, Springer 2021) 249.

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matter, the decision as to which risks are tolerable is a political one – at least up to certain limits.[19] In general, the precautionary principle justifies caution but rarely compels it.[20]

III. Applying the precautionary principle to geoengineering

The decision currently being faced by the EU and its Member States is whether, to what extent, at what scale, and under what conditions, to fund or permit geoengineering research, and in particular research into SRM, especially "outdoor" research. Carbon Dioxide Removal attracts in general less resistance than SRM does, but some of the more radical ocean-based techniques that have been proposed could potentially raise similar fears – a reason why CDR and SRM ocean geoengineering are sometimes treated as one category.[21] For that reason, in order not to pre-empt developments, this article uses the general term "geoengineering." Most of the issues that it discusses will be relevant to any proposed technique to engineer the climate at scale.

The approach to geoengineering research will be an ongoing decision process rather than a single moment, as new ideas and new developments reframe the pros and cons, and as the scale of experimentation begins to blur with local and limited deployment.[22] At some point in the future a decision as to wider deployment might also become necessary.

This article focusses on the EU level. There, legislation could conceivably be adopted concerning either research or deployment, although there would be a subsidiarity argument to be had over whether the EU has competence to regulate purely national research decisions. However, the more immediate focus is likely to be on the place, if any, of geoengineering in EU research programmes. This is primarily decided by the Commission as part of its delegated authority to run them.

Whatever it decides would however have legal consequences and be challengeable in court. The question would arise whether the precautionary principle had been applied correctly. This is however a more difficult question than in most precautionary contexts, because of two unusual features of the geoengineering situation – the "political" nature of some of the risks involved, and the fact that there are risks to both researching and not researching.

1. Political risks

There has never been an attempt to restrict research on precautionary grounds. Indeed, research is itself generally seen as the precautionary choice *par excellence*.[23] Given that the essence of the precautionary principle is well-informed decision-making,[24] and the essential point of research is to advance knowledge, it would generally be contradictory to use the principle in this way, to hinder the advancement of understanding.[25] Moreover, the Court has been quite explicit that purely hypothetical fears cannot justify precautionary

[19] C-269/13 *Acino* ECLI:EU:C:2014:255 para 58; C-119/21 *PlasticsEurope* ECLI:EU:C:2023:180 para 127; Commission Communication (n 4), 15.

[20] Elliot (n 6); Andy Stirling, "Precaution in the Governance of Technology" in R Brownsword, E Scotford and K Yeung (eds), *The Oxford Handbook of Law, Regulation and Technology* (Oxford, Oxford University Press 2017) 645.

[21] See the statement adopted by the 45th Consultative Meeting of Contracting Parties to the London Convention and the 18th Meeting of Contracting Parties to the London Protocol (LC 45/LP 18), in annex 4. For overview see J Luczak, "Current State of Geoengineering" in RC Brears and J Lindley (eds), *The Palgrave Handbook of Environmental Policy and Law* (Cham, Palgrave Macmillan 2024).

[22] Tedsen and Homann (n 10), 96.

[23] Elliot (n 6); Tedsen and Homann (n 10).

[24] De Smedt and Vos (n 4).

[25] EA Parson, "Geoengineering: Symmetric Precaution" (2021) 374 *Science* 795.

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measures.[26] They can only be taken once there is a scientific basis for the fears in question. The possible harms of geoengineering are quite clear, but there is some dispute as to how likely and avoidable they are, and an argument could even be made that more research into geoengineering is needed to establish the risks, and is therefore a *requirement* for precautionary interventions. This argument might be more or less forceful regarding different proposed techniques, where the extent of established risks may vary.

However, the arguments against geoengineering research are distinctive, and to some extent subvert the traditional precautionary analysis above. For these arguments are not primarily about the physical risks of geoengineering, which research certainly would help us to understand better. Nor is the fear that experiments themselves will be risky, because it is possible to do them on a scale small enough to have no significant wider effects, and to slowly scale up if necessary.

Rather, the fear is that the political consequences of research will be harmful.[27] There are broadly three kinds of arguments, all interrelated. One is that research will create a dynamic which makes deployment inevitable, or at least hard to stop, the slippery slope argument.[28] The claim is that when individuals and institutions commit to developing a technique, this creates a path-dependency which *de facto* constrains future decision-making on use. A counter-argument to this is that research decreases the chance of ill-informed deployment.

Another argument concerns moral hazard. This suggests that geoengineering research will be seen by the public and policy-makers as a sign that technology can solve climate change, which will undermine motivation for emissions reduction. However, that would be dangerous; geoengineering does not remove the need for such reductions. SRM does not reduce atmospheric CO2 levels, even though it might reduce temperature. Ocean acidification would thus continue. Moreover, rising CO2 levels would require increasing SRM in a way that could not be continued indefinitely. A best-case SRM scenario is that it helps to manage climate change for a limited period while emissions reduction is achieved. CDR might in theory compensate for emissions, but no proposed technique is suggested to be actually usable at that scale, and it would be insane to gamble on this becoming the case. CDR is a possible complement to emissions reduction, not a replacement.

Thus, if geoengineering research made the public believe that climate change was about to be "solved," that would be extremely harmful. Research into techniques for combatting climate change might, by influencing public behaviour, have the paradoxical effect of making that climate change worse.

The third argument is that geoengineering research could lead to geopolitical conflict. Viable techniques would require some global governance mechanism, for unilateral deployment affecting temperature might be experienced as aggressive, quite possibly colonial, by other states. However, even research could create conflict, for if states, or groups of states – such as the EU – were perceived as close to deployment, this could trigger pre-emptive resistance, just as weapons development is seen as threatening even before the weapon is ready.

Whether or not these arguments are persuasive, what is distinctive about them is that the ultimate environmental harm is not caused by the research, but by the political and public responses to it. Assessing the "risk" created is political as much as scientific.

[26] De Smedt and Vos (n 4); C-77/09 *Gowan* EU:C:2010:803.

[27] Reynolds (n 1), 2.

[28] J Andow, "Slippery Slope Arguments as Precautionary Arguments: A New Way of Understanding the Concern About Geoengineering Research" (2023) 32(6) Environmental Values 701.

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The same is true of the counter arguments. The precautionary argument for research is that humanity should be prepared for a possible future emergency situation.[29] The "risk" of not-geoengineering depends on the likelihood of different emissions scenarios, and on the estimated consequences they entail, a combination of political and environmental science.

Given the emphasis in the precautionary principle on science, it remains an open question whether it should be applied to political risk. It could be compared to rejecting research into a new treatment for lung cancer not because the research itself is dangerous, but because of the fear that it will discourage people from stopping smoking, and lead tobacco firms to lobby with renewed energy, as well as causing anger in countries where the treatment will be too expensive. Such arguments would not be ridiculous, but they are rarely made in the medical context, and decisions about research into lifestyle-diseases are not framed in precautionary terms.

Nevertheless, there is no reason in law why the precautionary principle cannot be applied to political risks. The Treaty applies it to environmental policy, not just immediate environmental risks.[30] That implies a broader role for the principle, and on balance it would be bizarre if this was not the case. The goal of informed risk-decisions can only be achieved if all the factors contributing to the creation of a risk are taken into account. An arbitrary exclusion of considerations because they are the "wrong kind of science" would make precautionary processes unfit for purpose. A precautionary approach to arguments about the dangers of research/not research should therefore entail a balanced and complete survey of the state of scientific knowledge about *all* the risks entailed in each choice.

This begs the question of what is meant by "science." Certainly the terms "political science" and "social science" are in conventional use, so it could be argued that the risks of conflict and moral hazard should be assessed according to the same principles as any other, with experts drawing conclusions based on evidence and prevailing theory, and these should be a part of the survey of scientific knowledge that the precautionary principle requires.

Contra that, the social sciences are less precise, less predictive, and more fundamentally contested in their methodology than the biological and environmental sciences that are usually central to precautionary cases. It is difficult, if not impossible, to establish the kind of scientific basis that is usually required for precautionary measures, and in practice the "science" of moral hazard, or governance risks, is very far from at a consensual stage.[31] Given all this, it could be argued that the geoengineering decision-maker should consider the state of knowledge on the environmental risks of geoengineering and of climate change, and the rest should be discretionary political judgment.

It is suggested that the former position is preferable. The goal of informed decision-making supports a wide use of relevant expertise. If there is no consensus, or no ability to quantify risk, that is something to be taken into account in weighing the impact of the expertise, but it should nevertheless be included in the precautionary investigation.[32]

Nevertheless, there is a scientific threshold for the invocation of the precautionary principle; a measure can only be justified by it if there is sufficient scientific basis to fear

[29] Cf Nils Markusson et al, "'In case of Emergency Press Here': Framing Geoengineering as a Response to Dangerous Climate Change" (2014) 5(2) Wiley Interdisciplinary Reviews: Climate Change 281.

[30] Art 191(1) TFEU.

[31] See A Fujiki, "Reconsidering Precautionary Attitudes and Sin of Omission for Emerging Technologies: Geoengineering and Gene Drive" in T Matsuda, J Wolff and T Yanagawa (eds), *Risks and Regulation of New Technologies* (Cham, Springer 2021) 249; S Low and M Honegger, "A Precautionary Assessment of Systemic Projections and Promises From Sunlight Reflection and Carbon Removal Modeling" (2022) 42 Risk Analysis 1965.

[32] See C-269/13 *Acino* para 58; C-119/21*PlasticsEurope* para 127.

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substantial harm.[33] Purely hypothetical risks – it's new, how do we know it won't be dangerous? – do not legally justify precautionary measures.[34] The precautionary principle therefore requires a minimum level of understanding and knowledge, in order to show a realistic risk, even while it also entails that this knowledge is incomplete.

The risk that a failure to research geoengineering might leave humanity disastrously unprepared seems easy enough to describe, but not to quantify. Such quantification is not a condition for the precautionary principle,[35] but it does leave the door open to a claim that this is just a hypothetical possibility. That is also true of the opposite point of view; the slippery slope, moral hazard, and conflict fears are imaginable, but whether there is enough scientific basis to raise them above the hypothetical is arguable. It might all happen, but the development of every weapon might start a war, and every impending medical treatment might lead to risky behaviour. Where non-physical risks are concerned, it is not only hard to judge if the concern is really science-based, but it is too open a question to be ideally settled by law.

Nevertheless, on balance, the requirement for a minimum level of scientific reason to fear harm should be understood more as a plausibility threshold than as a way to exclude certain types of risk or science.[36] Arguments based purely on prejudice or tradition will not meet the threshold,[37] but in the case of geoengineering the pathways to possible harm, on both sides, are more than this: they are uncertain, but they are also plausible, and they draw on knowledge about how people behave and political dynamics.

If the Commission, or Court – in an eventual challenge – were to take a precautionary approach to geoengineering research policy, along the lines sketched above, that would then require consideration of the risks of each possible policy choice, which in turn would require distinguishing between different kinds of research and the risks created by each.[38] For there is a difference between modelling, for example, the effects of (artificial) cloud cover or sulphur aerosols, and actively developing techniques for implementing SRM.

Moreover, demonstrating risk is not the end of the matter. An important element of the precautionary principle is proportionality.[39] This requires consideration of what would be the least restrictive way of addressing those risks. To be lawful, a precautionary approach must not be more restrictive than necessary to meet the risk threshold chosen.

Where political risks are concerned, it must be considered whether not-researching is the only way of addressing these, or whether the risks could be minimized by counter measures. These might be public awareness campaigns, emphasising geoengineering as a partial and emergency measure, the robust separation in law of emissions reductions from SRM or CDR, and the establishment of governance frameworks. A comparison could again be made with medicine: research into lifestyle-related diseases continues alongside prevention campaigns without the two being significantly in tension. There is a risk of opposition between geoengineering and emissions reduction, but there is no need for that opposition, and it should be considered whether it can be countered. Similarly, the risk of conflict around geoengineering is real, but research could go in parallel with attempts to establish multilateral consensus on future pathways, appropriate knowledge management, and so on. All research is, in a sense, an attempt to acquire new knowledge before others,

[33] De Smedt and Vos (n 4).

[34] De Smedt and Vos (n 4); C-77/09 *Gowan* EU:C:2010:803.

[35] C-269/13 *Acino* para 58; C-119/21*PlasticsEurope* para 127.

[36] A Donati, "The Precautionary Principle under European Union Law" (2021) 49(2) Hitotsubashi Journal of Law and Politics 43.

[37] Commission Communication (n 4), s 5.1; See also G Davies, "The Psychological Costs of Geoengineering: Why It May Be Hard to Accept Even If It Works" in W Burns (ed), *Climate Change Geoengineering: Legal Political and Philosophical Perspectives* (Cambridge, Cambridge University Press 2013) 59.

[38] Elliot (n 6); Tedsen and Homann (n 10).

[39] See Commission Communication (n 4), 17.

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to gain power, and to disrupt the status quo, and accordingly is likely to distress those in competing jurisdictions, those in competing branches of activity, and those invested in the status quo. Innovation entails political risk. Those risks can, however, as a general rule, be managed. As a matter of law, proportionality requires it to be investigated whether such management is possible.

2. *The symmetry problem*

It has been noted by scholars that the natural home of the precautionary principle is a situation where the status quo is "safe" and a proposed action or product creates risks.[40] By contrast, there are arguments that the development and deployment of geoengineering would be risky, and should be approached from a precautionary perspective, but there are also arguments that non-development would be risky, as the arrival of critical climate change moments in the relatively near future is not implausible, and non-development would amount to non-preparation, leaving humanity more vulnerable to the consequences.[41] At a later date, analogous arguments could be made about deployment, with the risks of harm from side-effects being weighed against the risks of harm from increased temperature.[42]

A common critique of the precautionary principle is that it undervalues economic and social development. In inviting a choice for safety, it prevents society from reaping the benefits of innovation.[43] This can be framed as a choice between safety and economic interests, and although that framing is contested, an understanding of precaution in terms of the subordination of economic to safety interests is common.[44]

By contrast, in a geoengineering context, the choice is between risk and risk, rather than safety or wealth.[45] A choice to prioritise safety, unlike the case in most precautionary contexts, does not tell the policy-maker what to do, because precisely the debate is over which choice is safer.

Certainly, it can be argued that the safest choice is emission reduction. However, geoengineering is not put forward as an alternative to emissions reduction, but as a backstop in case it does not sufficiently occur. A safety-oriented policy must consider that possibility and prepare for it.[46] That is particularly so because of the vulnerability of Europe to what happens elsewhere in the world: successful European emissions reduction does not guarantee climate safety. It cannot be simply assumed that Paris goals, or safe greenhouse gas levels, will be achieved.

A precautionary approach therefore entails planning for failure. The challenge is that developing geoengineering could be a way to reduce the risks of that failure, but on the other hand, it is in itself risky. Whether it is more dangerous to develop it, or not to, is contested. There is no clearly precautionary path.

[40] Fleurke (n 9); Heyvaert, Governing Climate Change (n 5).

[41] Tedsen and Homann (n 10), 95; Reynolds and Fleurke (n 3); DA Farber, "Coping with Uncertainty: Cost-Benefit Analysis, the Precautionary Principle, and Climate Change" (2015) 90(4) Washington Law Review 1659.

[42] Tedsen and Homann (n 10).

[43] See discussion in JS Applegate, "The Taming of the Precautionary Principle" (2002) 27 Wm & Mary Envtl L & Pol'y Rev 13, 15.

[44] See discussion in De Smedt and Vos (n 4); Applegate (n 43); T-141/00 *Artegodan* EU:T:2002:283; C-183/95 *Affish* EU:C:1997:373.

[45] Fleurke (n 9); G Davies, "Framing the Social, Political and Environmental Risks and Benefits of Geoengineering: Balancing the Hard-to-Imagine Against the Hard-to-Measure" (2012) 46(2) Tulsa Law Review 261.

[46] Tedsen and Homann (n 10); Reynolds and Fleurke (n 3); Heyvaert, Governing Climate Change (n 5); OECD, *Understanding and Applying the Precautionary Principle in the Energy Transition* (Paris, OECD Publishing 2023).

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It is tempting then to conclude that the precautionary principle cannot be applied to such a symmetrical situation,[47] also described as a risk-risk or "self-defeating" situation, or "duelling precaution."[48] However, it can be argued that precisely the absence of scientific consensus increases the chance of irrational decisions being taken; the evidential constraints on opinion-forming are weaker, which invites political posturing and over-simplification.[49] That makes the evidence that there is, and a systematic, balanced and complete assessment of it, more, not less important. Science is needed more than ever precisely where it is inconclusive.

Moreover, there is nothing in the law or logic of the precautionary principle which prevents it being applied to symmetrical situations.[50] It is perfectly possible and coherent to survey and assess multiple risks and consider how they are related to each other. Thus in the case of geoengineering, the precautionary principle should demand that before decisions are taken there is as wide and complete a survey as possible of the state of scientific knowledge on the risks of all available courses of action: of research or not researching, of deploying or not deploying.[51] The Commission Communication on the precautionary principle speaks of assessing the risks of "action and inaction."[52]

IV. The independent expert report on solar radiation modification

This is the point where the Commission's recent "Independent Expert Report" on SRM goes wrong. The report recognises the need to comply with the precautionary principle, but only applies this to SRM, and the risks of development and deployment.[53] The experts fail to consider the risks of extreme climate change, and what a precautionary approach would be to planning for these. Their assessment of risks is not the comprehensive and balanced one that the precautionary principle requires. They seem to have confused the risks linked to a certain outcome with the chance of that outcome being achieved,[54] assuming that if a certain outcome – zero or low global emissions within a reasonable time – is safe or optimal, then a choice to pursue this exclusively is also safe and optimal. However, in this context, the risk is not that success turns out to be dangerous, but that it is not achieved. That risk they neglect.

The misguidedness is not surprising, because the evidence review on which the report was based was similarly unbalanced, considering the risks of SRM, but not the risks of not developing it, of being unprepared for an emissions worst-case.[55] If fails to meet the

[47] D Humphreys, "Smoke and Mirrors: Some Reflections on the Science and Politics of Geoengineering" (2011) 20 Journal of Environment and Development 99; C Sunstein, *Laws of Fear: Beyond the Precautionary Principle* (Cambridge, Cambridge University Press 2005).

[48] Elliot (n 6); Robbins (n 18); Fleurke (n 9); Fujiki (n 31); Parson (n 25).

[49] C Shaw, "The Dangerous Limits of Dangerous Limits: Climate Change and the Precautionary Principle" (2009) 57 The Sociological Review 103.

[50] Elliot (n 6); Robbins (n 18); Tedsen and Homann (n 10); Fleurke (n 9).

[51] Elliot (n 6); Robbins (n 18); Tedsen and Homann (n 10); Steele (n 12); J Zander, "Commentary: Risk, Uncertainty and Innovation: What Does This Mean for the Dutch Energy Transition?" (2024) 27(5–6) Journal of Risk Research 1–5; OECD (n 46); S Arduin, "Precautionary Principle and Impact Assessment: The Case of School Closures during the Pandemic in Ireland" (2024) 15(4) European Journal of Risk Regulation 1; See also similar understandings of the do no harm principle as requiring consideration of alternatives; C De Vincenti, "Green Investments: Two Possible Interpretations of the 'Do No Significant Harm' Principle" in F Ceniglia and F Saraceno (eds), *Greening Europe* (Cambridge, Open Book Publishers 2022) 177; MJ Bernstein et al, "The European Commission's Green Deal Is An Opportunity to Rethink Harmful Practices of Research and Innovation Policy" (2023) 52 Ambio 508.

[52] Commission Communication (n 4) para 6.

[53] GCSA (n 8), 7, 26.

[54] See Fleurke (n 9), 70; Applegate (n 43), 35, on hazard vs risk.

[55] SAPEA, *Evidence Review Report – Solar Radiation Modification* (Berlin, SAPEA 2024).

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Commission's own requirements for an evidence review founding precautionary measures.[56]

A similar critique can be made of the report on the ethical implications of SRM, produced for the Commission by the European Group on Ethics in Science and New Technologies.[57] They conclude that precaution justifies a moratorium on large-scale SRM experimentation, albeit a temporary one that should be constantly reviewed in the light of ongoing research.[58] In practice, most people would concede that large-scale outdoor experiments should only occur once theory and small-scale experiments provide a sufficient basis, so the conclusion as such is not radical.

However, the report's reasoning is based purely on the fact that SRM involves risks, some of which may yet be unknown.[59] By contrast, it does not consider the risk that delaying major experiments might lead to SRM being available "too late" to avert a catastrophe, despite acknowledging that the absence of such experiments limits understanding.[60] The report seems to assume that the risks of SRM are evident, and justify approaching it with precaution, whereas the risk of failure to otherwise stop extreme climate change is hypothetical and does not need to be taken account of until it materialises. There is no rational basis for that view, and it leads to a one-sided, and not at all precautionary, approach to precaution.

V. The role of discretion

The application of the precautionary principle is rarely, if ever, prescriptive. The question of which risks to accept is value-based and political, and the Court emphasises the role of discretion in deciding what to do with the scientific knowledge that a precautionary investigation gathers.[61] Precaution in EU law is about ensuring that decisions are informed by the best possible understanding of the risks involved, not about determining which decision should be taken.[62]

That space of discretion will be increased if there are risks to both action and inaction, and where the measurement of those risks is partly done by relatively imprecise social sciences. Indeed, it is quite imaginable that the scientific assessment of political risk and the value judgments on which risks are acceptable will overlap, and that the scientific phase will be hard to present as value free, further decreasing the constraining effect of that science. There may be a special role here for public participation in decision-making, because of the depth and diversity of values which are relevant: some may have religious or spiritual objections to climate meddling, while others may see the rejection of geoengineering as anti-science and anti-progress.[63]

Nevertheless, the precautionary principle can be more than just a legitimation of a political choice. It is clear from a few cases that in the right circumstances it could prevent, compel, or invalidate EU actions.[64] Policy-making discretion is rarely, if ever, unbounded, and not in this context. There can be bounds such as rationality or reasonableness, but in the environmental law context it is more likely to be the Treaty requirement that the

[56] See Commission Communication (n 4), 19.

[57] European Commission: Directorate-General for Research and Innovation, *Opinion on Solar Radiation Modification – Ethical Perspectives* (Brussels, Publications Office of the European Union 2024).

[58] Ibid, 42.

[59] See on "unknown unknowns" P Toussaint, "Between a Rock and a Hard Place: Climate Impacts, Geoengineering and the Precautionary Principle" (2012) 24(5) Environmental Law and Management 235.

[60] European Commission *Opinion* (n 62) 13.

[61] De Smedt and Vos (n 4); Penca (n 13); Donati (n 36).

[62] Fleurke (n 9); Donati (n 36).

[63] Elliot (n 6); Stirling (n 20); European Commission *Opinion* (n 62).

[64] De Smedt and Vos (n 4), 179; Heyvaert, Facing the Consequences (n 17); Leonelli (n 17).

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Union preserve, protect, and improve the quality of the environment.[65] Although a degree of balancing against economic, social and other concerns is inevitable, in some circumstances the degree of possible environmental harm resulting from an action, combined with the best assessment of the risk of that harm arising, could preclude a decision to take the action. The EU cannot lawfully dismiss very serious risks without persuasive reasons why this is necessary. Merely economic concerns do not suffice.[66] Value concerns – such as a decision that human management of the environment is inherently immoral – might, perhaps, but it is likely that any Court decision on this would, despite its rhetoric on the freedom to determine which risks are acceptable, balance such views against the risk and severity of harm entailed.

In any such balancing process, worst-case thinking may be relevant. The Commission's note on this says:

> "[w]hen the available data are inadequate or non-conclusive, a prudent and cautious approach to environmental protection, health or safety could be to opt for the worst-case hypothesis. When such hypotheses are accumulated, this will lead to an exaggeration of the real risk but gives a certain assurance that it will not be underestimated."[67]

It would of course be contested what the worst case is – runaway climate change with no geoengineering techniques available, or climate disruption and global conflict because of the side-effects of geoengineering.[68] Nevertheless, the idea that some situations are so disastrous that even risky countermeasures may be justified is an extra element in the precautionary decision-making frame.[69]

Whatever conclusions are reached, any precautionary decisions are temporary and subject to regular review. An element of the precautionary principle is provisionality.[70] Because the principle is, by definition, applied in situations of uncertainty, it follows that advancing understanding of the risks may change assessment of their magnitude and severity and so of the appropriate response.

Thus the Court has ruled that precautionary decisions must be revisited, to see whether new science or circumstances justify a different stance.[71] It is likely that the science of both climate change and of geoengineering will advance. Moreover, circumstances may also have changed – emissions and greenhouse levels, and projections, will not be the same as they are now. That new data may lead to a new assessment of the relative risks of action and inaction.[72] This is the original logic of geoengineering proposals: that while it may be risky, and it would be undesirable today, there could come a time where the risk-benefit balance leads to a different conclusion.

One consequence is that any attempt to take a "permanent" decision on either research or deployment can only be seen as both irrational and unlawful.[73] We may hope that a situation will never arise in which the least bad option would be unilateral SRM deployment by the EU or a Member State, but it is fanciful to pretend that such a situation is impossible. It depends on the climate situation, climate projections, the behaviour and

[65] Article 191(1) TFEU.
[66] De Smedt and Vos (n 4), 181.
[67] Commission Communication (n 4), 28.
[68] Elliot (n 6).
[69] Cf L Hartzell-Nichols, "Precaution and Solar Radiation Management" (2012) 15 Ethics, Policy & Environment 158.
[70] Andorno (n 15); De Smedt and Vos (n 4); Applegate (n 43) 32 et seq; Commission Communication (n 4), 19–20.
[71] C-601/11 *France v Commission* EU:C:2013:465; Case C-504/04 *Agrarproduktion Staebelow* EU:C:2006:30.
[72] Tedsen and Homann (n 10).
[73] OECD (n 46).

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capacity of other states, and the state of geoengineering science. From the other side, a decision to definitely pursue geoengineering until a viable technique is in the EU's hands is also not irrevocable: it could be that research leads to an imminent threat of conflict, while meanwhile emissions reductions proceed adequately, so that the changed circumstances make abandonment of geoengineering the only sensible choice.

Provisionality creates a moral hazard problem. A negative policy-stance towards geoengineering, taken to emphasise that emissions reduction is the only pathway, is less effective if the stance is reviewable. Nevertheless, it may be doubted whether publics and indeed governments are so sensitive to moral incentives, and whether the moral hazard risks of provisionality outweigh the policy merits of staying scientifically up-to-date.

VI. Conclusion

In situations of risk and uncertainty decisions still have to be taken, but the precautionary principle requires decision-makers to show they have taken all relevant knowledge and/of risks into account. In a politically charged context like geoengineering, where values, ideas of nature, and vested interests in certain policy choices all clash, that comprehensive scientific basis for decisions is particularly important.[74]

The final decision may still be value-based – political and social norms are relevant to choosing which risks to take. But with so much at stake, a precautionary approach demands holistic, well-informed assessment, as science-based as possible, as a starting point for ethical and political further reasoning.

That sounds like common sense, but it is also a rule of law, applicable within the environmental sphere to all the actions of the EU where uncertainty and risk come together, whether distributing research funds or legislating.[75] It overlaps with other requirements, such as impact assessments, but the precautionary principle has a logic and flexibility of its own, as well as a binding force, which potentially make it an adaptable, deployable and highly relevant tool for evidence-based rational decision making in situations where the environmental and normative stakes are high.

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Competing interests. Julie Vinders is employed by Trilateral Research, one of the partners in Co-CREATE.

[74] G Davies, "Regulating Geoengineering" in A Zahar and L Reins (eds), *Climate Technology and Law in the Anthropocene* (Bristol University Press 2025) forthcoming.

[75] C-616/17 *Blaise*, para 42.

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