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Who we are:

We represent a cohort of early career researchers as part of the Centre for Doctoral Training (CDT) programme in BioDesign Engineering, our members being based at Imperial College London, University College London and Manchester University. Our training and individual research projects collectively cover a wide range of interdisciplinary techniques and approaches directly relating to synthetic biology, with technology applications, entrepreneurship, ethics and Responsible Research and Innovation (RRI) being of significant focus. As such, discussions regarding the direction, regulation and acceptance of synthetic biology will greatly impact our current research and shape the future of our careers within this field. With this response, we provide feedback on the draft report from the *CBD Technical Series (No. 82)* focusing on the technical background as cited, but also hope to emphasize the positive potential that we believe further research in this space could have for addressing global challenges including climate change, biodiversity, and human health and wellbeing.

Overall feedback and general comments:

Overall, we feel the report has made a good attempt at fair discourse, and the technical summaries and examples cover a wide range of the current research within synthetic biology. The report acknowledges that the technologies developed under synthetic biology must be considered on an application level, in a case-by-case nature, which we feel is the correct and responsible approach to take to such transformative technology. Misinformation about the safety considerations and ethics involved in developing and scaling up projects needs to be fought with active education and engagement with the general public. We feel the report recognised the importance of transparency, community and public engagement in tackling misinformation.

However, the report does include several references from political organisations and pressure groups, and in doing so includes conjecture at the same level as peer-reviewed scientific content, without immediate delineation between the two. There is no discussion of the biases from such sources, or acknowledgement that the lack of peer review impacts the credibility and impartiality of the information. While we understand the inclusion of these voices may have been in the interest of representing the many diverse opinions on the topic, the ambiguous counter arguments made by these groups often received a significant weighting, while the benefits and reasoning that support the use of synthetic biology technologies were frequently undersold and underrepresented.

The report broadly fails to recognise that new developments in synthetic biology do not exist in a technological vacuum. For the problems that synthetic biology offers solutions to, there are already technologies operating at scale that attempt to address them. We must recognise the impact that existing technologies, such as broad-spectrum antibiotics, large-scale pesticide deployment, inefficient farming practices, and unsustainable fossil fuel-derived chemical precursors have on our world, its people and its environment. We need to compare the risks associated with using synthetic biology solutions with the risks of existing approaches for these current problems, and have evidence-driven discussions on whether the precision of synthetic biology can actually offer more confidence in the safety and sustainability of our efforts.

We must also decide whether the failure modes of synthetic biology-based solutions are more or less damaging than the failure modes (or even merely the continued usage) of traditional techniques. In a world with finite natural resources and an environment that cannot keep up with the demands of our growing population, we feel it is responsible to develop new technologies through synthetic biology to repair and reverse the damage we, as a population, have caused. Finally, we have to consider the opportunity cost of hesitancy regarding the development and use of these technologies; considering the time pressures of many of the global environmental challenges we face, can we really afford to not investigate synthetic biology solutions?

Many issues presented here regard economic displacement and the potential to produce further inequality for marginalised communities. This is certainly a worthwhile consideration, and is an area where governance and management of the technologies needs to be strong and comprehensive. However, this is relevant for all destabilising technologies, which are nevertheless pursued with the expectation that new avenues of work will emerge to replace those industries that are reduced. This shouldn't take focus away from the idea that these advancements have a significant benefit to humankind, and research in the area shouldn't be inherently distrusted as a subversion of the status quo, which for many already involves a level of exploitation as well as barriers to social and economic mobility.

As acknowledged in the report, each technology should be viewed in isolation and in the context of each case. For instance, contained biofuel production through fermentation has a lower risk than engineered gene drives, which itself can be divided further into species, location and time of release. This field is too divergent for blanket regulation, and discourse and governance should happen case by case wherever possible, a nuance that is in danger of being lost when each disparate technology is grouped under the same umbrella of synthetic biology.

To address the commonly-made argument that synthetic biology technologies involve so-called "non-natural" changes to our environment; the saturated use of broad-spectrum antibiotics and pesticides has been the global norm for many years. These technologies are based on small molecules and invoke no gene editing; however, the consequences of these approaches include the generation of resistance in the intended target (such as the emergence of MRSA), and severe damage to non-target organisms (including beneficial insects or pollinators). We should not focus solely on the idea that synthetic biology can change the environment - this is something we've been doing for generations through agricultural practices, urbanisation and the release of pollutants - but instead on how synthetic biology allows for increasingly specific targeting, which is not achieved by many of the methods used currently to address the same problems.

When going through this report, we collectively found that there is not enough weighting given to the potential benefits of synthetic biology (see **table 1** for just a few examples of technologies cited without mention of their advantages). It often fails to explain the reasoning behind many current scientific advancements within the field and does not capture the urgency of the problems that these technologies are set to address, for example, the effect of climate change on biodiversity. We feel that by appreciating this context, the argument for continued support of synthetic biology outweighs many of the perceived problems identified here, many of which could be lessened through more tailored governance and better technological traceability. Please see the following (**table 2**) for our line-by-line comments.

Table 1: Highlighting some of the benefits of the technologies listed in the document CBD Technical Series No. 82.

Technology	Benefits	Reference
Improved soya bean oil quality (pg 31 line 15)	Oleic oils contain no trans fats and less saturated fats both risk factors for increased heart disease.	DOI: 10.1056/NEJM199906243402511
Pivot-Bio nitrogen fertiliser (pg 31 line 19)	Reduced soil acidification, reduced nitrogen leaching into rivers/coastal waters etc… Evidence to confirm the true extent of the environmental impact is in preparation (Iowa State Study)	https://www.cals.iastate.edu/inrc/microbial-nitrogen-fertilization
Engineered algae as biofactories for biofuel production (pg 35, line 17)	Unlike bacteria/yeast the algae can fix carbon themselves, not reliant on sugars for fermentation. Often higher photosynthetic efficiency than plants = biomass. Algae do not take up the space needed for food.	https://doi.org/10.3389/fpls.2020.00279
Spidroins / spider silk (pg 35, line 36)	Biomedical use as scaffolds for tissue and nerve regeneration. Raw material is from renewable sources.	https://doi.org/10.1080/09506608.2016.1148894

Table 2: Comments on the Technical Series on Synthetic Biology (No. 82.)#

Page #	Line #	Comment
8	8	It could be argued that synthetic biology, rather than being a risk for biodiversity, could actually expand and/or maintain biodiversity by, for example, preventing the extinction of endangered species.
8	16	Could comment on which types of traits are being spread (e.g. inability to transmit Plasmodium, the malaria-causing pathogen in Anopheles).
9	6-7	Much environmental damage has already been done by other technologies. Synthetic biology can be a tool to undo this damage (e.g engineered cyanobacteria for CO2 absorption).
9	8	First, there is a need to further educate communities in synthetic biology.
9	15	The “current state of synthetic biology” section could be accompanied by a subsection explaining the current situations that lead to the need for synthetic biology (i.e. environmental, health and social issues).
9	44	‘Target species’ which are usually vectors carrying pathogens that might be damaging for the environment (crops) or to society (humans)
10	23	Like with all new technologies, some leading/pioneer countries are the first ones to integrate it, but they are by no means the last.
11	1 - 10	The argument that Synthetic Biology should be regulated similarly to GMOS due to the lack of data of commercialised products is very vague.
11	2	Potential impacts that have been studied in a laboratory context can already provide a lot of information, making our understanding not merely a hypothesis or speculation.
11	8	As well as with experiments carried out in a lab which can provide a huge amount of information on potential impacts.
11	11 - 26	You could argue the same when civilization moved from an agricultural economy to a more industrialised one. Sometimes practices complemented each other rather than replacing each other.

11	23	This also happens when bringing in non-native species. It is not an issue specific to synthetic biology, but of agriculture in a globalised world.
11	26	These paragraphs say that there could be complex and negative impacts, but not a specific case is given (specific technology in specific region).
11	42 - 51	Public engagement is crucial, but also the opinion of scientists and experts working in the field.
12	7	While it’s crucial to understand the public opinion in a community, this community needs to be well informed and educated on the topic. Due to the fast spread of inaccurate information, the general public may not always be in the best position to decide on such technical matters.
12	23	Half sentence randomly inserted
12	41	‘keep-up’ not ‘cope-up’
14	Table	The report should have references for every technology mentioned in the table.
17	25	Remove ‘chemical’ from title because enzymatic synthesis also has potential.
18	11	This misses the fact that directed evolution could help the development of new or more efficient enzymes, allowing medicine to gain access to new chemical reactions or perhaps new compounds with beneficial properties. The targeted evolution of enzymes in fields like drug discovery could boost the arrival of personalised medicine to the clinics (https://doi.org/10.1042/ETLS20200047).
18	32	"Supposed" to be degraded by the cellular metabolism - these oligos have no real long-term permanence and will be degraded. This language makes it feel like there is opportunity for these oligos to survive and cause later damage on non-intended targets; this is almost certainly not the case, as these oligos are fragile and readily degrade without the need for active metabolism.
18	41	"Better oil quality" - could emphasise that this addresses reducing the need for partial hydrogenation of soybean (Trans-fats), which is a significant contributor to heart disease. See also paper on TALENs for increasing crop shelf life/lowering acrylamide levels in potato (https://doi.org/10.1111/pbi.12370)

20	30	There’s not only genome search tools to identify off-target effects but also molecular dynamic simulation tools to predict the structure of RNA sequences (hairpins, loops...etc.)
20	40	and diagnostics
21	26	When talking about methylation, they should add that tools such as this one to modify DNA methylation could be extremely useful to do reversible changes in the genome to cure certain diseases.
22	Fig 1	A higher resolution image could be included here.
22	17	Has a typo “Consisting of 27 non-commercial biofoundries”
22	16	Missing the fact that these types of facilities significantly speed up the prototyping process such that Synthetic Biology can compete with other technologies to solve large scale issues such as climate change. This speed is required to address world-wide issues on time, and synthetic biology will play a key role in this in the years to follow.
22	17	No mention that many areas of Biosciences do not have the standardisation capability to speed up research and innovation, whereas Synthetic Biology has that potential and could indeed be used to solve world-wide problems by, for instance, using the DBTL cycle to improve the genetic parts and characterise them in a way that they can be used accurately and in a predictable manner.
24	12	There is an increasing number of well characterised orthogonal components such as the marionnette system (https://doi.org/10.1038/s41589-018-0168-3).
24	20	The fact that protein engineering with the help of Artificial intelligence could revolutionise Biology entirely by accessing new chemistries and functions is not clearly stated. Not many other Biosciences have the potential to tweak biological function as accurately as the tools provided by Synthetic Biology. Additionally, by directly engineering proteins we can shortcut the DNA and RNA steps in the central dogma of biology. Rubisco is mentioned but not the engineered/optimised PETases, which are enzymes capable of degrading plastic (for example: DOI: 10.1126/science.aad6359).
25	33	Doesn’t make sense – maybe ‘conversion of the industrial…’
26	22	And now Sars-CoV-2 (https://doi.org/10.1038/s41586-020-2294-9). The benefits/reasoning of synthesising these specific viruses could be mentioned (e.g. vaccine development), to give context as to why dangerous viruses might be produced in the first place.

27	23	The authors could make a mention of microfluidics here.
27	24	It's not clearly stated that Xenobiology could aid the biocontainment of new synthetic organisms by ensuring that they don't share the same genetic code with naturally-derived organisms. In this way, xenobiology could help the development of separate chassis specialised for research that cannot replicate if they escape into the environment due to this fundamental genetic incompatibility. This strategy could allow for research into genetically distinct organisms that have different ways of storing information, suggesting that they do not pose a risk to the environment if escape does take place.
28	25	A real-world application is not provided. This could be a reference for the CETCH cycle, the first fully synthetic and possibly the most efficient way of capturing CO2 *in vitro*. It makes use of 17 enzymes from all 3 domains. Expressing enzymes from different domains of life in a single host is incredibly challenging, yet, by making the enzymes work in tandem in vitro, the CO2 capture was more efficient than any of the 6 natural CO2 fixation pathways known. (DOI: 10.1126/science.aah5237)
31	18	A comment on the positive impact of this example specifically: the resulting high oleic oils contain no trans fats and less saturated fats (both drivers of increased risk of heart disease). (https://calyxt.com/first-commercial-sale-of-calyxt-high-oleic-soybean-oil-on-the-u-s-market/)
31	23	A much-improved approach over using synthetic nitrogen fertilizer; this leads to soil degradation and acidification, nitrous oxide emissions and nitrogen leaching in groundwater, streams, estuaries and coastal waters. Again, the context of why to use synbio technologies over current approaches is important.
32	15	This misses a comment on current casualty numbers associated with vector-borne diseases (in 2019: 5.2M cases of dengue, 229M malaria, 40.000 of zika). This is an important context that could justify the targeting of a small and limited number of mosquito species.
33	10	Extra space and space missing (2019) recently …'
33	16	This could reduce the need for synthetic fertilisers, the dangers of which we have commented on.
34	29	'described a synthetic biology …' not 'an synthetic …'
35	9	'to be active' or ' to become activated upon …'

35	27	Should be a space between line 26 and line 27.
36	5	Should be a space between ‘to’ and ‘melting’
36	38	Higher Steaks also do this: https://www.highersteaks.com/about-us
38	7	Should be a space ‘… disorders. One …’
39	12	Missing word, should read ‘… prevent transfer of transgenic …’
39	23	Should be a space between ‘ … 2013) and 35 …’
40	1	Should be a space ‘ … 2020) reviewed …’
40	4	Should be a space ‘ … arsenic levels (Wan …’
41	20	This is also target dependent. For instance, non-native and invasive species are unlikely to develop mutually beneficial bonds with other organisms in that niche, and therefore their removal is likely wholly beneficial to the rest of that environment.
41	23	This is very true. However these costs need to be weighted by importance. For instance, there is a very real and measured mortality associated with vector borne diseases such as malaria that could be greatly reduced with this technology; is slow action based on the uncertainties presented here really justifiable?
42	8	This is a critical point; the use of blanket synthetic pesticides has a demonstrably negative impact on biodiversity in the area used, with long term effect of their use still not clear. Compared to this status quo, at least a gene drive has a single intended target species, even if it's effects may be felt further along the food chain.
42	22	Evolutionary resistance to a gene drive, especially CRISPR-Cas9 drives, is almost certainly expected after a period of time. Is that really a bad thing? This could act as a time or spatial limit to drive spread, while we benefit in the short term from the immediate effects of the drive before it is inactivated through evolution. Genomes are filled with transposable elements that became non-functional long ago in our evolutionary development; these are not really detrimental, but possibly lead to an increase in genetic diversity and genome stability. Gene drives that are inactivated due to non functional mutations will likely dilute out of the population over time as it provides no real advantage in fitness. It's unlikely that anything we develop with CRISPR-Cas9 will have the fidelity of the ancient transposases found throughout genomes, which universally acquire mutations and become stationary elements.

43	2	"There is no evidence that (Evarcha culicivora) require Anopheles mosquitoes and will readily consume blood-fed Culex." from a more recent paper (doi:10.1111/mve.12327). This is important as drives will likely target one mosquito species per area at a time, while other species may take their place in the food chain. Although the identity and relative abundance of prey species may be different, biomass available to predators may not.
43	4	This has been looked into for a long time, it appears that no species is significantly dependent on any one mosquito species alone.
43	6	As mentioned, this could be done just as easily with an effective vaccine. Are we really weighing the human cost of malaria against potential changes in land use? This should be considered, but is not a justification against the use of this technology.
43	45	This article by "Critical Scientists Switzerland" has been cited several times. The group is openly against the use of genome editing, GMOs and gene drives for sustainable development (see: https://criticalscientists.ch/images/css/Gene_Editing/Press-release-ENSSER-and-CSS-for-Leopoldina-counter-report_26Apr2021.pdf). The cited report also shows very clear bias against the use of gene drives, and provides no counter arguments for their beneficial application. When this document is cited in this report, it only supports the idea that there is "uncertainty" about their effects and that "further investigation is needed", whilst ignoring that these investigations are always ongoing by multiple parties. We conclude that they are not an appropriate source for this type of report.
44	22	There are strategies in production for self-limiting gene drives that have good confinement (https://doi.org/10.1038/s41467-020-14960-3)
44	38	These last two consequences are a result of choices not directly related to the use of this technology.
45	6	Nice point, mutagenizing chemicals and radiation have been long in use and generate unpredictable mutations that are then selected for through breeding. These have not been nearly as strictly contained as GMO crops, and these "non-natural" mutations do not accumulate and are removed by pressure. There is no reason that achieving the same phenotype by minimal changes through directed mutagenesis will not follow the same trend.

45	27	Again, both cited groups are outwardly anti-GMO relating to agriculture. The report from CBAN makes reference to a contentious study on p53-associated arrest in human cells in the presence of Cas9, the implication being that edited cells may be more likely to become malignant. Acknowledging that this process is not at all comparable in plants, the worst case scenario of this would be a damaged, non-viable crop, which can easily be replaced by another with an optimised edit.
46	37	The preceding sentence needs much more weight - many agree that despite the potential risks, using SynBio technologies in this space would be a net benefit to the ecosystem. This is a fairly conclusive justification for these commenters. The ETC suggesting that "considerable uncertainty remains" is not close to being a good justification to not pursue this; uncertainty exists in every scenario where an outcome cannot be definitively predicted, however much work is being done to reduce this uncertainty, and what is much less uncertain is that our current actions globally are wholly insufficient in tackling the climate crisis.
46	41	Biocontainment strategies (synthetic auxotrophies ect.) are being developed to address this specific issue.
46	47	The statements made in the rest of this section are important to understanding the potential of SynBio for applications in climate change. It's a very short summary, and the benefits of these techs do not receive an appropriate weighting in the form presented here.
47	23	A comparison could be made to synthetic diamonds as an example of reducing dependency on an exploitative illegal market, and as such increasing the quality of life of individuals associated with harvesting the commodity.
47	33	As with many technologies, it is predicted that many jobs will be lost in turn. However, new jobs will also become available, especially if SynBio technologies can be democratised and made available to all areas for production of essential goods.
53	8	Biological patents have been an issue within other fields of biology, and were raised long before SynBio as a field was mature. Current ruling is that naturally occurring DNA sequences are not possible to patent, while synthetic material or that which has been isolated or processed from a biological source (recombinant insulin used in large scale production being a high profile example). SynBio could exacerbate concerns on IP, but there are rulings in place currently that govern this, and that can be further built upon.

53	40	For instance; if a species were heading towards extinction, even if man-related issues were not related to the cause, putting mechanisms in place to protect the species could be seen as intervening in a natural process. The effects of man-made climate change and destruction of natural habitats to serve our purpose has already had irrevocable effects on the "naturalness" of the planet, and the use of biotechnology will in most cases not match that level of disruption.
53	46	Agriculture, and the enrichment of certain phenotypes through selective breeding, also involves a disruption to natural homeostasis to serve our needs. There are many instances in nature of species moulding their environment so that they can thrive, this is nothing new, albeit on a larger scale.
53	47	Very true; this could be explained in more detail, to give adequate weight to the side of the argument that suggests
53	48	This sentence doesn't make sense, may need to re-write this.
54	8	This is entirely speculation, and a conversation rooted in the use of animals in science and research. SynBio applications on cell-free systems, minimal cells and differentiated tissues and organoids, for just a few examples, are being developed in part as a means to reduce the need for animals in testing, and would therefore be beneficial in this light. This is not mentioned here, and ought to be.
54	21	Equally, concerns many may have about "Trojan horses" relating to misuse of SynBio tech also need to be grounded in evidence. Overall, this section puts very little focus, and minimal citations, on the side of the conservationists who see the potential benefits of these technologies.
54	46	This is critical; these technologies exist and mechanisms are in place to monitor, legislate and tackle their misuse. Similar indictments occur within the information technology space, and much attention is focused on counter-cyber activities by governments. Further research is needed to understand how to deal with these potential problems, as it is definitely possible that dual use will occur even at the technology level we have today. The only way to counter this is to further understand and evolve the technology and find it's critical potential and limitations.
55	25	Key point, law enforcement will need to develop in step with the technologies, as changing the direction of public research or stopping it all together will likely not be sufficient in stopping individuals from pursuing their own dual use goals.
55	41	This is a case where further research is beneficial; better prediction algorithms that could be employed by these companies to recognise dangerous sequences.

55	43	Having the knowledge to produce these threats is different from being able to accurately produce them functionally at scale. There is accessible information online on how to develop high explosive, chemical or small nuclear weapons. However, non-state actors lack the materials and facilities to build them, and as such they may pose little threat in actuality.
57	20 - 21	It is critically important to stress that risk assessment is informed by the scientific data at all points, and that all stakeholders are sufficiently and correctly informed of the risks, the available mitigation strategies and control mechanisms in the engineered implementation. Proper stakeholder education of which failure modes are possible, which are impossible, and the likelihood of all on the risk spectrum, is of critical importance to prevent misunderstanding and fear of new technologies. Further, conversations with stakeholders must also discuss risk assessment of the solutions currently utilised. As an example, growing insecticide resistance in mosquito populations (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7477762/) presents a looming danger of critical failure for this method of malarial control, and a failure to discuss this side of the problem when weighing up alternative solutions such as gene drives (6.1.1.) is flawed at best, and dangerous at worst. For many important applications of emerging technologies, we must stress whether or not we can afford to maintain the status quo, whether we can afford to pass on these emerging solutions.
58	35	The report does not mention risk assessment strategies and outcomes for existing technologies, such as widespread pesticide use. It is important to recognise that existing methods, such as widespread utilisation of pesticide-laden mosquito nets, carry with them their own risks, and these must also be considered in the risk assessment of applications such as gene drives. Whilst the complexity of the mosquito and its environment are significant the report fails to mention that existing technologies, which are already deployed at scale, are also making an impact.
58	34 - 35	Risk assessment for gene drives and bioengineered solutions are hard, but risk assessments for blunt instrument technologies, such as widespread pesticide use, are harder. One of the main advantages of pursuing an engineering biology approach to solving problems such as the malaria issue is that of precision. Gene drives (as an example) will target only a single species, and induce a well-defined effect in that population, limiting the number of variables and interactions that must be considered when assessing failure modes and performing risk assessment. This is in contrast to pesticides, which might have primary off-target impact upon multiple species, both through direct contact and by leaching into the environment from discarded mosquito nets. Secondary impacts due to, for example, bioaccumulation (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6140630/) or ecosystem disruption via the impact of primary off-target effects, might also present problems.

59	7-8	The larger the genome, the greater the risk of unintended effects by any modification scheme, be that by spontaneous mutation, traditional mutagenesis, or precision editing. In crops with large genomes, precision editing is still more precise than traditional techniques. The last sentence here is phrased as an argument against precision engineering, when it should not be. It misrepresents the fact that for any given crop, editing by modern precision techniques is safer than by traditional ones. Consideration of the risk of off-target effects is only relevant when discussing different editing methods on the same organism.
59	12 - 13	No mention of what criticisms have been levelled at untargeted metabolomics.
59	23 - 24	Precision of a technique is not an indication of safety of the resultant modified organism. However, this closing sentence fails to address that the targeted nature of precision editing increases the likelihood that any and all off-target effects will be discovered under a given testing regimes compared to less precise traditional techniques. The extra precision increases our confidence in safety under a given testing regime.
60	42	Need a space after the full stop “…2020). At …”
70	17	Need a space after the bracket “…2011) involving …”
70	17 - 18	The Asilomar Declaration focused on biosafety, which represents the first level of ethical consideration that should be investigated, before discourse moves onto subjects such as the societal impact of technological deployment. The moratorium was declared upon investigation at this first level, and hence there was no need to discuss the societal impacts at that stage. Further, the authors of the declaration - being largely scientists - were most qualified to provide discourse on the biosafety aspects, rather than social aspects of the technology involved. The ETC group chooses to view the focused nature of the declaration as a product of elitism and conspiracy, an attempt to subvert public involvement in regulation, rather than one that recognised the slow pace of legislature, and the need for fast action in the name of public good. The ETC group refers to the declaration as a "move by a handpicked group of elite scientists to pre-empt government oversight" (ETC Group, 2007), a claim that is conjecture at best, and a wilful attempt to misrepresent and undermine the ethical standing of the synthetic biology community at worst.
70	31 - 32	Direct engagement between governments and researchers is of critical importance here, to build a discourse that is both informed by the realities of risk and opportunity, and interpretable enough to be accessible by the public and legislators.

72	2	Does not emphasise the impact that all the teams are causing by coming up with brilliant Synthetic Biology strategies to solve world-wide problems. Some of these projects, if funds are available, could be taken from the lab bench into start-ups seeking a change in our society.
75	1	This is a very important point to consider, and should remain emphasised. However, it is also important to ensure that said procedures emphasise the project-specific nature of said assessment, and ensure that both the procedures and groups utilising them are dissuaded from undue extrapolation to a technology level. Differing implementations of the same technologies might yield significant benefits to biological diversity, through minimising land use and ecological disruption, and assessment procedures should encourage modifications to proposals to embody this kind of approach.