

Measuring what matters: Updating the Treasury's "Green Book" for the Climate Emergency

A Green House Gas by Emma Dawnay

September 2021

Summary

Our proposal outlined here is that the Green Book is updated **to require the key metrics of greenhouse gas emissions** to be at the forefront of each and every project appraisal.

At the moment the method of including greenhouse gas emissions into the project appraisal process is complex and totally obscures the actual amounts of greenhouse gases emitted. In essence, the current method involves:

1. converting the cost of emitting greenhouse gasses into costs in pounds sterling (which increase over time) using complex theoretical arguments, which are disputed (and abruptly change as underlying assumptions change);
2. combining them with other project costs and benefits (also in pounds sterling);
3. discounting them if they occur in the future, by using a discount rate to which the final result is often very sensitive (this discount rate also being derived from complex arguments which are disputed).

This results in a one-dimensional metric (in pounds sterling), which is presented to the decision maker, with other information only an optional extra.

Here it is argued that to control the amount of greenhouse gases in the atmosphere what matters is the amount of greenhouse gases that we're emitting or removing (in tonnes of carbon dioxide equivalent, tCO₂e). Therefore we should estimate *this* amount explicitly (in tCO₂e) for all projects (including indirect project related emissions), and present this estimate to the decision maker together with a reasonable 'budget' for greenhouse gas emissions for the relevant geographic area and sector. This would be in addition to financial data. The decision maker can then decide if the project is the best way to 'spend' some of the remaining greenhouse gas emission budget.

Facts

1. We have a climate emergency and we must cut back global greenhouse gas emissions.
2. Economists are not in agreement about how future costs and benefits should be evaluated, let alone future costs and benefits of greenhouse gas emissions and mitigation/adaptation measures.
3. Government institutions at all levels need a method to compare and evaluate projects to support decision making.
4. **The Treasury's Green Book** is the current system of assessing which government projects or policy interventions should be implemented, primarily based on cost-effectiveness or cost-benefit analyses.

Recommendations

1. Keep the Green Book, but do not aggregate the “costs” of the likely impact of greenhouse gas emissions with other costs.
2. *Every project must be evaluated both for its effect on greenhouse gas emissions as well as other non-greenhouse-gas costs and benefits (both financial and non-financial).*
3. The effect on greenhouse gas emissions should be calculated both for the project implementation and for the ongoing annual greenhouse gas emissions after the project has been implemented.
4. The results of a project's estimated greenhouse gas emissions should be presented alongside a reasonable greenhouse gas ‘budget’ for this sector in this geographical area (estimated from the UK's total remaining greenhouse gas budget).
5. Discounting should be used for projects involving removal of greenhouse gases from the atmosphere where the amount of greenhouse gases removed in the future should be discounted to account for project risks.
6. Discount rates for all calculations should be reviewed often, as underlying assumptions about growth rates are likely to change as the climate changes.
7. Further to the proposals in this report, new evaluation processes must be developed for assessing a project's impacts on other critical environmental systems such as biodiversity, as well as for the widely transformative projects so urgently needed to prevent an ever-increasing severity and frequency of climate disasters.



¹ Video of Jeremy Grantham - What investors need to know about technology & climate change 11th April 2018 from 43:20 to 45:06 <https://youtu.be/cPCblFpqrkl?t=2600>

Background

Climate Emergency

The UK government has declared a climate emergency, as have many councils. The United Nations report on climate indicates that the ambitions declared by the nation states in the Paris Agreement need to be five times higher if the globe is to keep below 1.5 degrees of warming, or three times higher to stay below 2 degrees.² The UK has enshrined greenhouse gas reductions in law, but it is not going to meet its own targets after 2027.³

Tim Jackson has shown⁴ that a fair greenhouse gas budget for the UK compatible with a global budget to remain under 1.5 degrees warming would be 2.5 GtCO₂. Further, to reach a Zero Carbon economy by 2050 and to remain within this budget, absolute reductions of more than 95% of carbon emissions as early as 2030 are necessary. This implies a net reduction in actual greenhouse gas emissions of 35% per year, starting now. (Note, these figures are not what the UK has signed up to under the Paris Agreement, but rather what is required to keep global temperatures under 1.5 degrees, with a fair allocation of the remaining carbon dioxide budget to different countries).

The Green Book

*The Green Book: Central Government Guidance on Appraisal and Evaluation*⁵ is published by the Treasury and, according to the foreword, has provided guidance to help officials develop transparent, objective, evidence-based appraisal and evaluation of proposals to inform decision making for nearly half a century.

The approach is based on welfare economics. It has been criticised for hiding ethical judgements,⁶ making the results wrongly appear to be based only on scientific facts. Chapter 2 of the Stern Review⁷ has an excellent review of the philosophy behind welfare economics and its shortcomings for dealing with climate change.

² High-level synthesis report of latest climate science information convened by the Science Advisory Group of the UN Climate Action Summit 2019 https://ane4bf-datap1.s3-eu-west-1.amazonaws.com/wmocms/s3fs-public/ckeditor/files/United_in_Science_ReportFINAL_0.pdf?XqiG0yszsU_sx2vOehOWpCOkm9RdC_gN

³ Committee on Climate Change <https://www.theccc.org.uk/about/our-expertise/advice-on-reducing-the-uks-emissions/>

⁴ Tim Jackson *Zero Carbon Sooner — The case for an early zero carbon target for the UK* CUSP Working Paper by July 2019

⁵ The Green Book published by The Treasury <https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government>

⁶ See, for example, the report *Greening the Green Book* by James Medway 8th July 2019 published on the Commonwealth Website <https://www.common-wealth.co.uk/greening-the-green-book.html>

⁷ The Stern Review (2006) https://webarchive.nationalarchives.gov.uk/20100407172811/http://www.hm-treasury.gov.uk/stern_review_report.htm

Economists are not in agreement about how future costs and benefits in general, and the impacts of future greenhouse gas emissions in particular, should be evaluated.

In the 2008 document *Intergenerational wealth transfers and social discounting: Supplementary Green Book Guidance*⁸ which accompanies the Green Book, the following is quoted from the Stern Review:

“the appropriate trade-off between equity and efficiency, intergenerational or otherwise, raises fundamental issues in political philosophy. Consensus is unlikely, if not impossible...”

and it continues by indicating a reducing discount rate over time is helpful. However, any discounting of environmental impacts at all is disputed by many environmentalists.⁹

Much of the disagreement is based on the philosophical discussion of “strong” versus “weak” sustainability. Weak sustainability assumes that natural capital and manufactured capital are substitutable, so, for example, the loss of a natural ecosystem can be compensated by the benefit of, say, a new road. Another example is that the “costs” relating to greenhouse gas emissions of a new airport (now and in the future due to increased use of kerosene by aeroplanes) could be more than compensated by the economic benefits of the airport. Under weak sustainability, all types of capital can be “monetised”, i.e. reduced to a single financial metric. Strong sustainability maintains that natural and man-made capital are not substitutable: a loss of natural capital is a permanent loss which cannot be compensated. (See the UN report from Jérôme Pelenc et al.¹⁰ for more discussion). The Green Book appraisal is currently based on the idea of weak sustainability.

Major shortcomings of using the Green Book for decision making

There are two major shortcomings, both stemming from using the arguments of weak sustainability rather than strong sustainability:

Firstly, converting the greenhouse gas emissions into financial metrics – however well done from ethical¹¹ and economic¹² viewpoints (the official value of the cost of emitting a tonne of carbon dioxide has suddenly jumped by more than a factor of three¹³) – means that the oversight of the quantity of these emissions is lost. As we have a climate emergency which can only be mitigated by controlling our actual greenhouse gas emissions and keeping them below a threshold, maintaining this oversight for all decision making is crucial.

⁸ <https://www.gov.uk/government/publications/green-book-supplementary-guidance-discounting>

⁹ See, for example, Victor Anderson Protecting the Interests of Future Generations CUSP Working Paper Series No 14 https://www.cusp.ac.uk/themes/p/wp14/#_edn14

¹⁰ Brief for GSDR 2015 : Weak Sustainability versus Strong Sustainability, Jérôme Pelenc, Jérôme Ballet, Tom Dedeurwaerdere <https://sustainabledevelopment.un.org/content/documents/6569122-Pelenc-Weak%20Sustainability%20versus%20Strong%20Sustainability.pdf>

¹¹ Different groups in society would certainly put a different financial value on greenhouse gas emissions.

¹² The methods of calculating financial values for greenhouse gas emissions given in the [Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal](#) are highly complex and would be disputed by many environmentalists.

¹³ The value of carbon emissions of £248 /tCO₂e (non-traded, in 2022, central series) published by Department for Business, Energy & Industrial Strategy (BEIS) in [Valuation of greenhouse gas emissions: for policy appraisal and evaluation](#) on 2nd September 2021 has jumped from a value of just £78 /tCO₂e published in BEIS data tables in the aforementioned [Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal](#) which had been last edited less than two months earlier. This shows these ‘values’ are extremely far from being known and stable, even amongst economists in BEIS.

Secondly, using discounting techniques as they are currently used - even with lower discount rates for longer-term projects - means that these projects are prone to the problem that the “benefit” of having a liveable planet in the future can be less than the “cost” today of taking action to enable such a future, as shown by Jeremy Grantham in the film clip.¹

Quoting from the summary of conclusions of the Stern Review:

“This Review has assessed a wide range of evidence on the impacts of climate change and on the economic costs, and has used a number of different techniques to assess costs and risks. From all of these perspectives, the evidence gathered by the Review leads to a simple conclusion: the benefits of strong and early action far outweigh the economic costs of not acting”

After this report, the 2008 Climate Change Act came into force along with a host of green policies and updates to the Green Book. Despite these, too little has been achieved and we are now facing a climate emergency.

The Green Book specifies the required appraisal technique for every significant government project (but it notes there are limitations of this technique for projects with widely transformational effects, see below). There is nothing in the Green Book which would prevent the analysis proposed here from being undertaken, however, it is not currently a requirement for project appraisal. Here the proposal is that the Green Book is updated **to require the key metrics of greenhouse gas emissions** to be at the forefront of each and every project appraisal.

Projects that have widely transformational effects can’t be evaluated on the basis of a cost-benefit analysis and welfare economics (as noted in the Green Book¹⁴). For example, the project “to put a man on the moon” would almost certainly have had a negative net present value under a cost-benefit analysis. The fact that major projects aimed at reducing greenhouse gas emissions by widely transforming the way we live and work may appear to have high “net present costs per unit of greenhouse gas avoided” should not be grounds for stopping such projects, as how people adapt in the post-project environment cannot be known in advance.¹⁵ In these cases the Green Book appraisal should make it clear that a cost benefit analysis of the financial metrics is not suited to informing the decision (however estimates of the effects on greenhouse gas emissions should still be undertaken). By far the majority of government funded projects will not be “transformational”, and therefore can be assessed by the techniques proposed in this report.

A note for those not familiar with discounting and net present value calculations

These are standard techniques used by businesses to calculate the value of future costs and benefits to aid decision making. A typical use is to assess the future cash flows resulting from the cost of buying a machine now. Only if the future cash flows result in a greater return than keeping the money in a savings account (paying interest) at the bank, should the machine be acquired. To assess this, all the costs and benefits are translated into a “present value” by discounting their future

¹⁴ See section 5.1 of the Green Book

¹⁵ In the way no one could have imagined all the new types of businesses that have been enabled by the development of smart phones and tablets

values. If the “net present value” of all present benefits less all present costs is more than zero, the project should go ahead (i.e. it will give a higher return than keeping the money in the bank).

The Green Book requires such assessments for government projects where not only financial costs and benefits are assessed, but also any relevant non-financial costs and benefits which should be monetised and included in the assessment. The technique is explained in section 5.4 of the Green Book, and readers unfamiliar with this approach will find it helpful to read this section.

Proposal

The proposal here is to make the decision maker explicitly aware of the greenhouse gas implications for *each and every* government-funded project alongside the financial implications of all other costs and benefits (monetised, if necessary). This would be instead of the current practise of monetising the greenhouse gas implications and aggregating these with the other (monetised) costs and benefits – thereby losing the information about the actual amounts of greenhouse gases associated with the project.

To do this, it is proposed to keep the current methods of Green Book appraisals, but to also explicitly calculate the following for *every* project:

1. the quantity of greenhouse gas emissions directly or indirectly related to the implementation of the project, expressed in tonnes of carbon dioxide equivalent (in tCO₂e) compared to the baseline case if the project had not been carried out,
2. the net change in ongoing annual greenhouse gas emissions after the project has been implemented (in tCO₂e per year) compared to the baseline case if the project had not been carried out.¹⁶
3. the reasonable greenhouse gas “budget” for this sector in this geographical area (estimated from the UK’s total remaining greenhouse gas budget), and assessments of the annual ongoing budgets for carbon emissions required to meet this.

These will be presented to decision makers alongside the standard results of a cost benefit calculation expressed as the net present value of the project.¹⁷

Keeping greenhouse gas emissions separate and explicit will enable these to be controlled more easily. This will also aid government at all levels to reach their Zero Carbon goals. It will entail some more calculations, but these are intrinsically easier to understand than converting emissions into financial costs where they become “hidden” and then diminish over time in the discounting calculations.

The numbers for the greenhouse gas budgets should be taken from relevant neighbourhood or city Zero Carbon plans where these exist, otherwise they can be estimated. These figures aim to put the

¹⁶ For example, for a transport sector investment the emissions associated with the actual use of the road would be absolutely fundamental and dwarf those associated with construction as well as future road maintenance costs (although these are still significant).

¹⁷ Likewise for a desired outcome, both the greenhouse gas emissions to obtain that outcome as well as the non-greenhouse gas costs must be presented to the decision maker

results of calculations (i) and (ii) into perspective by comparing them to what needs to be achieved to meet our Zero Carbon goal.¹⁸

Note that the sections in the Green Book regarding optimism bias, risk and uncertainty are also relevant for calculating expected greenhouse gas emissions. Reductions in greenhouse gas emissions may not be as large as expected. For example, installing home insulation may lead to people heating their houses to a higher (more comfortable) temperature rather than using less fossil fuel (re-bounce effects).

Accounting for the quantity of greenhouse gas emissions

The aim is to calculate the effect of different project options on greenhouse gas emissions of society in general, and to compare these to the baseline, ‘without project’ options. To aid this, the government should provide supporting information such as the projections of greenhouse gas emissions related to electricity use into the future, likewise for car-miles, public bus passenger miles etc. Note that where parts of projects will be out-sourced to the private sector, the relevant greenhouse gas emissions from the private sector must also be included.

Example: closing several antiquated health facilities and building a new centralised facility.

Required calculations:

- 1) Greenhouse gas emissions related to building and commissioning new facility and greenhouse gas emissions related to de-commissioning old facilities and converting them into whatever they are most likely to be used for (tCO₂e). This includes emissions related to production and transport of all materials used including cement (which is very carbon intensive) and emissions related to the energy needed for the building works including diesel for diggers, travel for builders etc.
- 2) Estimations of greenhouse gas emissions of running costs of new facility compared to the old ones, including estimations of the emissions related to heating, electricity and travel for staff, patients, visitors, deliveries and waste collections for the new facility compared to the old ones (tCO₂e per year).
- 3) Net present value of project of delivering new facility and selling old facility buildings (£) (as in the current version of the Green Book, but with the exception of excluding any values placed on greenhouse gas emissions).
- 4) Consider other options (as required currently in the Green Book). In this case it could be refurbishing and extending the old facilities rather than moving to a new one. All of the calculations above should be repeated for each option. Where possible, options that enable a Zero Carbon (or negative carbon¹⁹) future should be included.

Decision makers should consider the results of all of these calculations as well as other “soft” information in a matrix similar to in Figure 10, Section 7 of the Green Book.

¹⁸ It is highly recommended that in the future different sectors – both governmental and non-governmental – are assigned reasonable greenhouse gas budgets. Whilst such formal budgets are not yet available, decision makers should do their best at putting the greenhouse gas emissions in context for the purposes of Green-Book project appraisals

¹⁹ Negative Carbon would be where a more greenhouse gases are removed from the atmosphere than added to it: for example, when a tree is planted.

Geographic nature of greenhouse gas emissions

Where imported goods will be necessary for a project, the embodied greenhouse gas emissions relating to the required resources for manufacture of these goods (and goods in their supply chains and excavation of necessary raw materials) as well as their transport emissions (and also end of life emissions from disposal) should be included. The rationale for this is that if the project were not to take place, these greenhouse gasses would not be emitted.

Mitigation of greenhouse gas emissions outside the territory of the UK should not be accounted for. Planting trees in another country, for example, will suffer from a high risk of double counting. The exception to this will be the UK international development spending: projects receiving funding will necessarily be abroad and the greenhouse gas emissions of such projects should be evaluated.

Projects specifically designed to remove carbon dioxide from the air

For these projects, the greenhouse gas emissions for the entire lifetime of the project (including decommissioning) should be considered, and the “benefits” of future greenhouse gas reductions from such projects should be discounted to account for project risks. For example, a planned carbon capture and storage facility might never get built due to political upheavals or might be destroyed due to an extreme weather event.

Clearly, any such project should have a positive net return on investment in terms of greenhouse gas removal i.e. the greenhouse gas emissions related to building and operating the facility considering all impacts to wider society (e.g. new homes for workers which need to be built and heated/cooled, travel of workers, transport of carbon dioxide etc) must be less than the quantity of greenhouse gases removed from the atmosphere.

Different projects to remove carbon dioxide from the atmosphere can be compared by comparing the “net present cost per tCO₂e removed”.

Valuing the costs and benefits of non-greenhouse gas emissions

Monetised financial costs of the impact of greenhouse gas emissions should be excluded totally from the net present value calculations, as they are being calculated separately. However, the financial costs relating to the energy required to carry out the project should be calculated as in the Green Book.

All other costs and benefits will be calculated as in the Green Book. Although it is made clear in the Green Book it is worth repeating here that great care must be taken with costs and benefits that have no price such as access to green spaces (which must be monetised) – and where these will change significantly in a project they should be made explicit to the decision maker.

It should be noted that the changes proposed here to the Green Book will not directly improve our assessment of other critical environmental problems such as biodiversity loss. Reducing measures of the value of nature to financial metrics as in the Dasgupta Review²⁰ - to be amalgamated with other

²⁰ Dasgupta Review: <https://www.gov.uk/government/collections/the-economics-of-biodiversity-the-dasgupta-review>

financial metrics and time-discounted - only obscures what is important.²¹ Further development of the appraisal techniques for projects that impact on other critical environmental problems is needed.

Discount rates

Discount rates have an ethical as well as technical dimension. For example, should the financial benefit of access to green spaces be discounted, and if so, at which rate? Why should access to green spaces for future generations not count as much as for present generations?

Below the different discount rates are discussed in more detail, however, in the end the choice of discount rate will always involve an ethical evaluation to which different people will give different values.

It is for this reason that here it is proposed to explicitly calculate the net quantity of greenhouse gas emissions of the project as well as the change in annual emissions after the project has finished, so the decision maker can see these quantities – alongside their greenhouse gas budgets – together with the financial net present value of the project (including all monetised non-financial costs and benefits except those relating to the impacts of greenhouse gases emissions). This is instead of aggregating financial “values” of the impacts of greenhouse gas emissions with other financial costs as is currently the case. However, this does not completely remove the subjective ethical valuation of projects due to discounting. Potentially a different discount rate could lead to significantly different courses of action.

One way to ensure that discount rates properly reflect values held by society could be to have a citizen’s assembly informed by economists, climate scientists and philosophers. This assembly would set the components of the discount rates to be used as standard.

A good overview of discount rates and the philosophical conundrums surrounding their application is given by Pearce et al.²² A highly relevant conclusion is that when different discount rates need to be “averaged” – due to uncertainties from different plausible scenarios about the future (e.g. different growth rates) or due to different groups placing different values on to future costs and benefits – the discount rate will vary over time, and tend towards the lowest of any of the discount rates after long time periods.

As we can expect society to re-evaluate what is important over time, especially as the climate changes, such assemblies should be convened once every few years.

Discount rates for financial costs and benefits including monetised values of non-financial costs and benefits

The Green Book has a good summary of the calculations for the discount rate in Annex 6. The Green Book discount rate, known as the Social Time Preference Rate (STPR), for use in UK government

²¹ Clive L. Spash & Frédéric Hache (2021) [The Dasgupta Review deconstructed: an exposé of biodiversity economics](#), Globalizations

²² David Pearce, Ben Groom, Cameron Hepburn & Phoebe Koundouri *Valuing the Future - Recent advances in social discounting* World Economics Vol. 4 • No. 2 • April–June 2003
<https://pdfs.semanticscholar.org/1ee4/15fece1a2d55f176fef7f59da41a63892fbc.pdf>

appraisal is set at 3.5% in real terms. Different, lower values are used for health projects and for longer term projects (over 30 years), with projects over 75 years having a discount rate of 2.14%.

The STPR is expressed as:

$$r = \rho + \mu g$$

where: r is the STPR; ρ (rho) is time preference comprising pure time preference (δ , delta) and catastrophic risk (L); and μg is the wealth effect which comprises of the marginal utility of consumption (μ , μu), multiplied by expected growth rate of future real per capita consumption, g .

The Green Book uses a time preference of 1.5% (decreasing to zero for longer term projects), a marginal utility of consumption of 1 and a growth rate of 2% for regular projects. These numbers are justified with references.

The most contentious of these is the growth rate of 2%. The Green Book justifies this by citing one study showing the average growth from 1946 to 2016 was 2.2%, and another showing from 1996 to 2016 it was 1.7%. However, if we look over the last 1000 years, the growth rate was effectively zero until the start of the industrial revolution. For richer “post-industrial” nations such as ourselves, the growth rate appears to be declining. Even apart from climate issues, there are arguments as to why this is the case,²³ and that growth rates are only likely to decline further in the future. A warmer climate is also forecast to reduce growth (though this effect is stronger in hotter countries), however it is extremely difficult to forecast an economic loss of growth due to adverse weather events. Further to this, there is increasingly likely to be strong political pressure to reduce consumption – and therefore growth – as consumption is causing many environmental problems.²⁴ We may take future productivity gains in the form of more free time rather than the basis for more consumption. All of the above makes the estimate of 2% growth in the future likely to be over-estimated, with a zero or negative growth in the next decades seeming strong possibilities.

Value for the discount rate for quantities of greenhouse gas removal

Greenhouse gas removal has not yet been achieved at scale. There are many risks involved – forests used for carbon offsetting have burnt down,²⁵ trees can die from disease or be cut down, carbon capture and storage facilities might not work as planned etc. For these reasons it is necessary to use discounting when calculating greenhouse gas removal.

As choosing a reasonable discount rate will be difficult, it is suggested that a group of citizens advised by experts make these decisions, as with financial discounting.

²³ See, for instance, Richard G. Koo *The other half of macroeconomics* Wiley 2018

²⁴ For example, the British Fashion Council is urging the big fashion companies to reduce the amount of clothing they produce - <https://www.edie.net/news/12/Fashion-giants-urged-to-decrease-clothing-production-as-part-of-their-sustainability-plans>.

²⁵ “[US forest fires threaten carbon offsets as company-linked trees burn](#)” Financial Times, 3.8.21. It is chilling to note that in the first draft of this report the fact that forests planted to offset carbon may burn down was hypothetical, but it has subsequently actually happened.

Further Development of Project Appraisal

Transformative projects

As mentioned in the section above on shortcomings of the Green Book, the methods in the Green Book alone are not useful for assessing widely transformational projects. So section 5.1 of the Green Book states:

“Social CBA [cost benefit analysis] and Social CEA [cost effectiveness analysis] techniques are “marginal analysis” principally employed to consider changes between alternative options, and compare alternative options based on a static model of the world.”

Widely transformative projects would have wide-ranging consequences and the price of many goods and services in the economy would be expected to change. A good example is the government funding of fundamental research which enabled the development of smart phones and tablets.²⁶ The effect of this research on goods and services in the economy could not have been known in advance, yet the development of these has benefited society greatly.

Transformative projects are urgently needed to prevent ever increasing climate disasters. The proposals in this report are only applicable to “marginal analysis” type appraisals (although the supplementary guidance on valuing infrastructure spend does touch on non-marginal changes, suggesting that extra information should be given to the decision maker²⁷). A process for appraising and prioritising transformational projects is beyond the scope of this report (and the Green Book in general). Making sure the consequences of interventions for such projects are just and fair is likely to be a key part of the appraisal process.

Other planetary boundaries

Climate change is only one planetary boundary which we are running up against if we are to avoid unacceptable environmental degradation or a high risk of reaching a ‘tipping point’ where planetary conditions suddenly deteriorate. Others include biodiversity loss and ocean acidification. A future appraisal technique might be based on Kate Raworth’s Doughnut Economics²⁸ where we must remain within an ecological ceiling – an outer ring of 9 environmental boundaries - whilst making sure people everywhere exceed a social foundation ring of the 12 dimensions we need such as food, water and energy. Future project appraisals could be presented with a metric for each critical social foundation and ecological ceiling. These metrics (e.g. tons of carbon dioxide equivalent for climate) should not be reduced to a single financial metric, but presented together on an easily-understandable dashboard to give the decision maker information covering the full complexity of likely outcomes for the alternative implementations under consideration for each project .

²⁶ Mariana Mazzucato (2018), *The Value of Everything: Making and Taking in the Global Economy*, Public Affairs ISBN 978-0-241-34779-9

²⁷ [Green Book supplementary guidance: valuing infrastructure spend](#)

²⁸ Raworth, K. (2017), *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist* (London: Random House).