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EAERE Magazine

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EAERE Magazine serves as an outlet for new research, projects, and other professional news, featuring articles that can contribute to recent policy discussions and developments in the field of environmental and natural resource economics. It is published quarterly in the Winter, Spring, Summer, and Fall. Contributions from the wider EAERE community, especially senior level researchers and practitioners, and EAERE Country Representatives, are included in the magazine.

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Dear EAERE friends,

Welcome to third issue of the Magazine. This issue focuses mainly on climate change policy. It features articles by Pauli Lappi, Reyer Gerlagh and Roweno Heijmans, Simon Dietz, Cameron Hepburn and Alexander Pfeiffer, and, last but not least, an interview with Yvo de Boer.

We start with an article by Pauli Lappi who describes that the use of coal and oil also have local impacts on the environment and landscape and how policy must be designed to ensure proper rehabilitation of the extraction site in the end. Reyer Gerlagh and Roweno Heijmans write about the new rules of the European Emission Trading Scheme and how they can help to improve efficiency. Simon Dietz, the first winner of the European Award for Researchers in Environmental Economics under the Age of Forty, asks whether the increased ambition in the Paris Agreement in the form of the 1.5°C target could survive a cost-benefit test. Following this test, Cameron Hepburn and Alexander Pfeiffer describe, very clearly, where we are with respect to the Paris targets and what the remaining options are if we are serious about the targets. Finally, Yvo de Boer, former Executive Secretary of the UNFCCC and this year's winner of the European Practitioner Achievement Award in Applying Environmental Economics, provides his personal insights on what has been achieved so far, what can be expected for the future, and what environmental economists could do to have a stronger influence on policy.

Enjoy reading!

Astrid Dannenberg

University of Kassel, Germany

A model of optimal extraction and site

Pauli Lappi
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How much money should an exhaustible resource producer pay to guarantee that the extraction site is properly rehabilitated in the end? This is one of the research questions posed in the first research paper in the MSCA-project MILO (Mining, lobbying and efficient environmental policy). While acknowledging the research tradition on exhaustible resource scarcity and its implications for public policy, the environmental problems related to exhaustible resources are more visible in current academic research and policy discussions. This is also the aspect on which the project focuses.

At the global level, exhaustible resources are of course tightly connected to the pressing problems related to climate change. But extraction of natural resources like oil, coal and different metals and minerals pose environmental challenges at the local and regional level too. Resource extraction produces, as a side product, pollution and waste rocks, which are stored on the extraction site in tailings dams or in simple piles. Tailings dams, like the ones in oil sands production sites in Alberta, pose a major pollution challenge (Hayes et al. 2018). A particularly difficult problem in hard-rock mining is acid mine drainage (AMD), which means the flow of possibly toxic substances from the extraction site that have been released from broken rock by acidic waters. AMD has an unfortunately large impact on groundwater and on the flora and fauna in streams and other water bodies. Both cases are problematic because the produced pollution causes a stock externality during the extraction operation and because a polluted site is left behind after extraction has ended.

Hence policy intervention is needed, and one option is to apply a pollution tax. This would constrain the amount of produced pollutant, but it does not clean-up or rehabilitate the site. In practice, bond systems or payments to a rehabilitation fund have been used as an instrument in an attempt to return the extraction site safely into alternative uses like forestry, recreation or energy production. However, there is much improvement needed in these policies as the current situation for example in British Columbia shows. In B.C., the collected bonds and other securities were short by 1 273 million dollars in 2015 based on the reports by province officials. In Alberta oil sands, the balance between the collected securities and estimated rehabilitation costs is even worse (Hayes et al. 2018).

In many cases the amount of money (in the form of a bond, trust payment or other security) required from the firm is the present value rehabilitation cost. But to make up a rough figure for the rehabilitation cost is not sufficient, since the cost depends on the rehabilitation effort of the firm and the needed effort depends on how bad the cleanup situation is, that is, on how polluted the site is. And the severity of the clean-up problem is determined by the actions taken during the extraction stage. This means that the regulatory design for the rehabilitation is not independent of the regulatory design for the extraction operation. Instead, to limit the adverse impacts of pollution, optimal regulation must consider jointly both extraction and rehabilitation operations. To this end, the first paper of the project develops a theoretical model that describes the last two stages of exhaustible resource production.[i]

To investigate the optimal regulation, a standard exhaustible resource model with resource stock dependent extraction cost is applied together with two different rehabilitation models, one from Caputo and Wilen (1995) and the other from Lappi (2018). It is shown that the regulator can incentivize the operating firm to choose the optimal extraction by using the following instruments: a pollution tax defined on the optimized extraction horizon and a requirement for the firm to pay the present rehabilitation costs. Setting a pollution tax together with a shut-down date is not sufficient, since without payment the rehabilitation is not performed, which leads to welfare loss. Similarly, placing a requirement for the payment is not sufficient either, since then the extraction choice is distorted, too much pollution is produced and, therefore, too few funds are available for eventual clean-up. Both ingredients - a tax with a shut-down date and a payment – are needed to internalize the externalities. Furthermore, it is shown that the firm may pay the reclamation costs at any time during the extraction operation and the social optimum will still be reached. Since bankruptcy is often a concern in practice, it is important to note that this last result implies that there is no loss in requiring the firm to pay the reclamation cost in full at the beginning of the operation.

The model assumes that the regulator has at hand all relevant information about the firm's cost structure, initial resource stock, pollution damages and reclamation costs. Of course, the situation is quite different in practice. For example, it is often the firm who reports its rehabilitation cost to the regulator, who then makes the decision about the payment (Mitchell and Casman 2011). A plausible reason for the real-world mismatch between the required payments and the estimated rehabilitation costs is that the firm is untruthful in its report. Therefore it is important to take into account in the regulatory mechanism the information asymmetry between the regulator and the firm. This is one of the topics that is further investigated in the MILO-project.

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Why the new EU-ETS is almost perfect

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Europe's Emission Trading Scheme and its new Rules

Before the launch of China's National Emission Trading Scheme (ETS) earlier this year, EU-ETS constituted the world's largest carbon market. In many ways, EU-ETS has been a success story. For sure it has been a giant leap in the fight against climate change. Some concerns nonetheless remain. The prices of emission allowances, for instance. These decreased over time and have remained rather low for most of past years. Compared to any reasonable calibration of the social costs of carbon, they were in fact too low. Moreover, prices have been volatile. This too is an undesirable property of a system, where instability means unpredictability and stifling innovation. Finally, it has been argued that the incentive to abate more than strictly necessary is made minimal in Europe, because by construction of the system EU-ETS exhibits a 100 percent leakage of emissions. This is called the waterbed effect.

Under a set of new rules that was approved January 2018 by the European Parliament, when private holdings by firms become too large the EU stores unused allowances in a vault called the Market Stability Reserve (MSR).[i] However, and this is new, when the total amount of allowances stored in the MSR exceeds the amount of allowances auctioned the previous year, fewer new ones will be issued in the following regulatory period. This sounds fairly simple and intuitive, which it is. But in addition, it is a remarkable example of policymaking ahead of economic theory.

In this article, we will elaborate on the difficulty of policy-making, the role of information, and explain how the EU-ETS revisions of January 2018 are very likely to help solve the price volatility and waterbed problems mentioned above. In our view, the new EU-ETS rules entail a most significant contribution to the theory and practice of environmental regulation.

Environmental Regulation, the Market, and Private Information

Tradeable pollution permits are a cornerstone of modern environmental policy. An allowance grants the right to emit a specified amount of some pollutant -- one ton of CO_2, say -- to its holder and can freely change hands between market participants. Successful real-life experiences with this type of policy abound: the NOx Budget Trading Program in the U.S. and the EU Emissions Trading System in Europe are but two famous examples. The free exchange of permits allows for greater involvement of market participants than more traditional policies such as "command and control"'. For this reason, the tradeable pollution permit is what we call a *market-based instrument*.

Economists typically haste to point out the superiority of market-based instruments over more centralized forms of regulation. Why? In the best of all possible worlds (Aquinas, 1273; Leibniz, 1720), a regulator could simply set the optimal quota for each firm individually and save on the cost and hassle of administering the many trades taking place in its jurisdiction. This Utopia is out of reach, however, since the regulator lacks the required *information*.

It appears quite generally understood that in order to make good decisions, more information is better. What is a source of trouble is that at times relevant information can be *asymmetric*, meaning it is available to some party but not to another.[ii] As famously shown by Weitzman (1974), regulating a polluting industry unfolds from being a trivial task to one plagued by great difficulty once an asymmetry of information is introduced.

A fundamental challenge is thus to device policies that can deal with this type of informational asymmetry, at least reasonably well. This is exactly what market-based instruments such as tradeable pollution rights achieve. The tradeable allowances with fixed quota require all firms to jointly abate a certain amount, but lets the firms themselves sort out how the bill is split. It follows from very basic economic arguments that trade implements the abatement at lowest possible cost, precisely because it provides firms with an incentive to *act upon their private information*.

Incomplete Information Processing at the EU-ETS level

The point that efficient regulation creates incentives for market participants to de facto *reveal* their private information was well taken by the European Commission. Tradeable allowances have been part of EU-ETS since its launch in 2005. Moreover, firms are also allowed to store allowances in a private banking account, for use later in time. Since firms know better what market developments to expect in the future, this too is a smart choice exploiting information otherwise unavailable to the regulator. Still EU-ETS could not process all relevant information, the symptoms of which were low and volatile prices.

As prices were perceived too low for too long, the European Commission concluded that demand had been depressed unexpectedly. In response it introduced its own \`vault', the Market Stability Reserve (MSR) in which it stores the 'excess' of allowances. The new EU-ETS rules, approved in January 2018, go yet one step further.

In fact, the new EU-ETS rules make a fundamental contribution to the field of environmental regulation in general and the fight against climate change in particular. In an abstract and theoretical framework, where we studied the optimal regulation of stock pollutants, we found a remarkable similarity between the optimal regulation in the model, and the new policy of the EU-ETS (Gerlagh & Heijmans, 2018). It turns out that the updated rules, when calibrated correctly, creates the greatest welfare for society at large. In fact, when increasing the number of trading periods (think of moving from a one-time adjustment of the amount of auctioned permits to yearly updates), we show that despite asymmetric information, optimal regulation can get us as close as possible to maximum social welfare. Because an instrument that achieves the greatest wellbeing for society is perfect, and because the new EU-ETS has frequent updates, we label the new rules Almost Perfect.

The essential element driving this strict superiority is a deep but, upon further thought, also simple insight: that asymmetric information operates at *two* levels. At the firms' level, we have seen how trade can decently process private information. Problem solved. At the broader level of the economy, however, there still remains some unresolved informational handicap. It may well be, for instance, that CO_2 reductions are on average much cheaper or costlier than the regulator initially anticipated. In response, total abatement should go either up or down, respectively. It is not obvious how one best deals with this second type of asymmetric information.

In Gerlagh & Heijmans (2018), we derive mathematically what instrument a regulator can use to efficiently manage both types of asymmetric information simultaneously. Astoundingly, it turns out the best way to do so is by using an instrument conceptually equal to the new EU-ETS rules.[iii]

Key to the enhanced efficiency of the new EU-ETS rules is that stored allowances remain in the hands of individual firms. For a stock pollutant such as CO_2, where global climate change only depends on cumulative historic emissions, keeping the exchange rate between permits at different points in time and between firms equal to one is essential to resolve the problem of *individual* asymmetric information (Gerlagh & Heijmans, 2018). To resolve the *aggregate* asymmetric information, the regulator can revise the future allowance-issues in response to the total amount of permits stored, both privately and in the MSR. It can be shown that a variable as easily observable as the aggregate quantity of stored allowances provides *sufficient information* regarding economy-wide conditions, to which the regulator can thus respond. The underlying logic, and the implications for policies, has heretofore not been noticed, to our knowledge. Until the EU-ETS announced its new rules.

Conclusions

Not only is the dynamic updating of allowance issues a welfare improvement, it also helps to reduce price volatility and solves the waterbed problem (Gerlagh & Heijmans, 2018). The logic is elementary. Updates on available allowances resemble an upward-sloping allowance supply curve: future available allowances increase with prices. Private banking accounts are an essential part, because they measure demand shocks (the private information) as experienced and thus observed by the private sector. A negative demand shock decreases both prices and increases banking. Under the new rules, this implies fewer future allowances will be issued, which means that lower prices equate reduced future supply. The quota supply is upward sloping in prices. It is then immediately understood that, as supply responds to prices, supply partly absorbs a shock in demand, and prices become more stable. Furthermore, a decrease in current demand, thanks to domestic policies, will also decrease future supplies, puncturing the waterbed (Perrino 2018). The new rules are Almost Perfect. For the formal proofs, we refer the readers to our working paper.

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Notes

[i] EU-ETS allows firms to store private allowance holdings for use later in time.

[ii] Many a Nobel prize has been awarded to scientists thinking about this matter: George Akerlof, Leonid Hurwicz, Eric Maskin, Roger Myserson, Michael Spence, and Joseph Stiglitz are examples.

[iii] Gerlagh & Heijmans (2018) also derive a tax-based instrument that deals with both types of asymmetric information.

[iv] Latest version available through https://www.dropbox.com/sh/e53cw2vcf2go9lb/AAAZeeavXBTVocL6_04WaGUFa?dl=0 . A new WP will soon be published.

The economics of 1.5°C climate change

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The 2015 UN Paris Agreement set out the aim of "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels" (Article 2). Previous agreements, notably the 2009 Copenhagen Accord, set a target of limiting warming to "below 2°C", so the Paris Agreement has increased the overall ambition of the UN process.

But in doing so it ran ahead of the evidence base. At the time of the Paris Agreement, there had been precious little analysis of the impacts of climate change or the costs of mitigating climate change on scenarios limiting warming to 1.5°C specifically. Consequently the Intergovernmental Panel on Climate Change (IPCC) commissioned a Special Report on 1.5 Degrees, which will be published shortly. To support the preparation of this report, many academic papers have been published lately, which assess the impacts of 1.5°C warming relative to other warming targets such as 2°C, as well as assessing the greenhouse gas emissions reductions necessary to limit warming to 1.5°C, and their cost.

From an economist's point of view, there is an obvious question to ask of the 1.5°C warming target, in relation to other warming targets: does it increase welfare? Will the benefits to society of limiting warming to 1.5°C exceed the costs? If past form is anything to go by, the IPCC Special Report will tend to avoid making an explicit comparison of economic benefits and costs and of course there are many reasons, some good and some bad, why IPCC reports tend not to provide clear answers. So we have recently reviewed the evidence to try to answer the question, does the 1.5°C target pass a cost-benefit test?[1]

Let's start with the costs of limiting warming to 1.5°C. Perhaps the most intuitive way to think about this is in terms of the size of the 1.5°C carbon budget, versus a more familiar 2°C carbon budget. There are of course greenhouse gases other than CO_2, but CO_2 is dominant and, as a matter of fact, cost-minimising 2°C scenarios appear to already use up most available opportunities to abate non-CO_2 greenhouse gas emissions, so we can just look at the difference in cumulative CO_2 emissions.

There are different measures of a carbon budget, but, whichever one we look at, the 1.5°C carbon budget is much smaller than its 2°C counterpart. On one measure, the 1.5°C carbon budget is 74-86% lower than the 2°C carbon budget.[2] This naturally means CO_2 emissions reductions must be faster on 1.5°C scenarios than on 2°C scenarios, perhaps roughly twice as fast, even on scenarios that overshoot 1.5°C for a time.[3] It also means the point of net-zero emissions is hit earlier, perhaps as early as 2045, 10-20 years earlier than on 2°C scenarios. Compared with 2°C scenarios, limiting warming to 1.5°C in energy models involves bigger reductions in energy demand, faster decarbonisation of the power sector and more reliance on negative emissions technologies, especially bioenergy with carbon capture and storage (BECCS).[3], [4] Doing all this requires higher carbon prices. The median 2020 carbon price from energy models limiting warming to 1.5°C is about \$105 per tonne of CO_2 in 2018 prices. The equivalent price on 2°C scenarios is an optimistic-sounding \$32/tCO_2. Still, the difference indicates how much more costly the immediate and rapid reductions required to limit warming to 1.5°C would be, even in an ideal world where all global CO_2 emissions are under a harmonised carbon price.

Do the benefits outweigh the costs? As a preliminary step, let us just scrutinise the non-economic impacts literature to see what it tells us in broad brushstrokes. Among the key differences in modelled climate impacts at 1.5°C and 2°C are a greater incidence of heat waves, greater water stress in the Mediterranean and more intense precipitation globally and in South Asia in particular.[5] In addition, limiting warming to 1.5°C appears to be particularly important in avoiding loss of Arctic sea ice,[6] and terrestrial biological diversity.[7] One of the reasons why the benefits of reducing warming by an incremental 0.5°C from 2°C might be substantial is that various kinds of physical impact function, for example heatwave days per year or population exposed to drought, appear to exhibit substantial curvature as a function of global mean temperature in the region 1.5-2°C.[8]

Trying to extract generalities from the large and disparate impacts literature that is emerging to address the 1.5°C question, we might make three points. First, going from 2°C to 1.5°C appears to be particularly beneficial for natural ecosystems and biological diversity, which is consistent with the idea that such impacts are one of the first "reasons for concern" as temperatures rise.[9] Second, going from 2°C to 1.5°C appears to provide the greatest benefits in poor regions. Part of the reason for this is that, although the largest absolute increases in temperature will be experienced in high-latitude, continental regions, the largest increases relative to variability – the largest signal to noise ratio – will be in tropical regions, and this is where many poor countries are to be found.[10] Tropical countries are also unfavourably hot already, and poor countries are more sensitive to warming.[11], [12] Again, all of this is consistent with the idea that poor regions are one of the principal reasons for concern in relation to climate change. Third, driven by these benefits in natural ecosystems and in human systems in poor regions, the aggregate benefits may be large. Instinctively we might be sceptical that the incremental benefits of limiting warming to 1.5°C could be so large as to justify a carbon price roughly three times higher than in 2°C scenarios. This was also my prior, but now I am not so sure.

Parameter	Value	Source
ϱ	1.1%	Expert survey [21]
η	1.35	Expert survey [21]
n	0.5%	UN population projections [22]
g	2.06%	Expert survey [23]
φ	0.00126	IPCC AR5 Working Group III multiple models [24]
ζ	0.00048	IPCC AR5 Working Group I multiple models [25]

*Table 1 Parameter values for T**

The question remains, does the *economic value* of these benefits exceed the associated mitigation costs? It would be nice to obtain an answer from an Integrated Assessment Model. But while cost-benefit IAMs like DICE, FUND and PAGE have contributed immensely to our understanding of the economics of climate change over the years, the quality of the underlying damage cost data just isn't there, nor perhaps do these models have the right structure of damages to capture the key issues.[13] Nobody puts it more plainly than Bob Pindyck.[14]

Alternatively we could compare 1.5°C carbon prices from energy models with estimates of the social cost of carbon from a suite of IAMs and beyond. The problem of poor-quality underlying damage cost data remains, although at least this approach takes model error seriously and has the additional advantage of simplicity. As many of you will know, the range of estimates of the social cost of carbon is enormous, ranging from much lower than the median \$105/tCO_2 marginal abatement cost of 1.5°C in 2020 to much higher. Comparing marginal costs from energy models with marginal benefits estimates from the economic literature on climate damages is tricky, however. Even if one puts aside concerns about the reliability of the numbers, there is the problem that the marginal cost of 1.5°C rises at roughly the interest rate, following Hotelling's rule due to the fixed carbon budget, whereas the social cost of carbon may not rise as fast, as it depends on climate dynamics.[15], [16]

Therefore we prefer a different thought experiment based on a simple formula for optimal peak warming developed together with Frank Venmans.[16] Since there appears to be no meaningful delay between CO_2 emissions and resulting warming,[17] contrary to popular belief, we show that optimal peak warming of the planet *T** is given by:

$$T^* = \frac{[\rho - n + (\eta - 1)g]\phi}{\zeta\gamma}$$

where ϱ is the pure rate of time preference and η is the elasticity of marginal utility. These are of course the parameters determining the discount rate (according to the Ramsey rule, r = ϱ + ηg). Population growth is represented by n and growth of GDP per capita by g; these are assumed constant. φ is the marginal cost of zero emissions, ζ is the Transient Climate Response to Cumulative Carbon Emissions (TCRE), a physical parameter capturing how much the global mean temperature increases per unit of cumulative CO_2 emissions,[18] and γ is the coefficient of the dreaded damage function.

The approach we suggest is to plug in point values for all of these parameters (see Table 1), except the coefficient of the damage function γ, which is too poorly understood to treat as implicitly certain. Then, we can investigate the switching value of γ that results in optimal peak warming of 1.5°C. The answer we get corresponds with the assumption that 3°C warming, which is a common point of comparison, would result in a welfare loss equivalent to 9.8% of global GDP.[i] This is an outlier relative to most of the climate damages literature in economics,[19] but not if our point in comparison is the recent 'New Climate Economy' literature estimating the empirical effect of historical fluctuations in temperature on GDP growth: 9.8% of global GDP at 3°C is close to the middle of the range of estimates from this work.[11]

Whether these empirical estimates are externally valid when applied to damage functions that map long-term average trends in temperature to welfare losses remains a major debating point. Nonetheless, especially when we consider that these estimates include neither the non-market impacts of climate change on, for example, natural ecosystems, nor the costs of sea-level rise, nor the co-benefits of reducing CO_2 emissions via improving local air quality, which appear to be very substantial,[20] it seems clear that welfare-equivalent impacts of climate change of roughly 10% of GDP for 3°C warming are well within the range of possibility. This makes me conclude, conservatively, that <u>it cannot be ruled out that the 1.5°C warming passes a cost-benefit test</u>.

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[i] To replicate this calculation, note that the damage function D(T) = exp(-γ/2*T2).

Committed CO_2 emissions and the electricity sector

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Many intellectual and practical challenges involved with climate change relate to system inertia and the associated long time lags. There is inertia in the physical climate system, leading to impacts in decades or centuries hence, which is of course why discounting and time preference has featured so significantly in the economics of climate change. There is also vitally important inertia in social systems that must be understood and tackled if climate change is to be managed in an economically rational way.

In the electricity sector, so-called 'committed emissions' are defined as the expected future CO_2 emissions of the installed fleet of power plants under normal economic conditions. The future emissions of coal-fired, gas-fired and other fossil-fuel-fired electricity generation plants depends on their current age, expected age, utilisation factors, and expected future technological enhancements such as efficiency improvements or carbon capture and storage technologies. In a recent paper, through a laborious but straightforward process of mapping different databases together, we calculate the total (or cumulative) 'committed emissions', from existing power plants, to be around 300 billion tonnes of carbon dioxide.

Now, this is problematic, because to achieve the Paris climate goals – limiting warming to well below 2°C above pre-industrial levels – the budget for the electricity sector is estimated to be around 240 billion tonnes of CO_2, generously (and unrealistically) assuming that all other sectors are on track with their Paris goals. So with the existing stock of power plants, we're already 60 billion tonnes over budget.

Even more problematic is the fact that over 7 trillion dollars will be spent on new power plants and other downstream infrastructure over the next decade (IEA, 2017). Using data on the power plants that are already under construction, in planning, pre-construction or financing around the world (many of them in Asia), we can estimate the embodied emissions of the fossil pipeline (Pfeiffer *et al.*, 2018). The future pipeline would add another 270 billion tonnes of CO_2 to the existing committed emissions of 300 billion tonnes (which is already 25% over budget), as shown in Figure 1.

That leaves us with a pretty difficult dilemma. The choice is between the following options,

1. Shut down existing fossil plants ahead of their useful end-of-life to keep within the CO_2 budget;

2. Run all (or some combination) of plants at lower utilisation factors;

3. Install carbon capture and storage on some combination of plants;

4. Deploy technologies that capture CO_2 directly from the atmosphere; or

5. Give up on the Paris climate goals.

Shutting down power plants ahead of their useful end-of-life, or running them at much lower utilization, would be costly and hurt investors and electricity consumers alike. Many fossil-fuelled power plants require a minimum utilization at high enough financial spreads, or compensation in some other form (such as a capacity payment), to operate profitably. The resulting cost from uneconomically operating capacity or written down investments would either be passed through to electricity consumers, or be incurred by utilities and their investors, if the taxpayer does not step in.

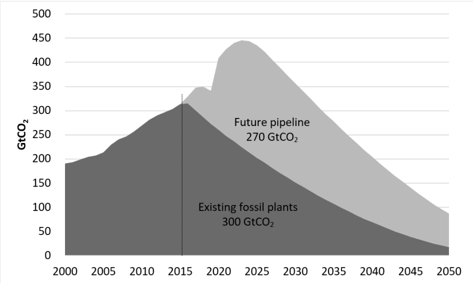

Figure 1: Committed emissions (GtCO2) to 2050.
Source: Pfeiffer et al (2018).

The track-record of (retrofit) carbon capture and storage (CCS) or negative emissions technologies (NETs) is mixed. While the technological feasibility of both is beyond doubt, questions remain open about scalability at moderate cost. Recent developments in CCS scale-up projects have remained far behind previous expectations and given the average efficiency of many existing power plants, especially coal, it is questionable whether there will ever be a business case to retrofit CCS technologies to such existing power plants, rather than integrate them into new ones. Finally, bioenergy with carbon capture and storage (BECCS) – still viewed by many as one of the most promising NETs – rather than create additional atmospheric space for fossil plants, might actually increase the rate at which they are retired, because the bioelectricity generated reduces residual demand for other generation technologies.

Finally, how attractive is a pathway that discards the Paris climate targets? Some observers argue that 1.5-2°C warming is unachievable, and that we should prepare for warming beyond 2°C. The merits of the Paris agreement may be debated in some quarters, but scientists, civil society and nations of the world are largely unanimous in supporting the overall objective, not least because of the significant risks to human life, economic growth and overall welfare as global mean temperatures rise beyond 1.5°C. Furthermore, even in much less restrictive climate scenarios (only 50% chance of 2C), our analysis shows the carbon budget will already be spent by existing capital stock. Figure 2 shows that the remaining budget for a 50% chance of 1.5°C warming – the grey dashed line – was exceeded by the cumulative committed emissions (in heavy black) in 2010. The remaining budget for a 50% chance of 2°C warming – the red dotted line – was exceeded in 2016.

Given the analysis, it is unlikely to be economically rational to sink capital into new fossil plants that will then need to be scrapped before their end of life, in a context where the cost of the alternative is rapidly reaching parity, or in some places falling below the cost of fossil. Given the rapid learning curves in renewable energy and storage, funds invested in clean energy sources contribute to further reducing the overall cost of energy, which will both increase economic output and avoid scrapping assets before the end of their useful lifetimes.

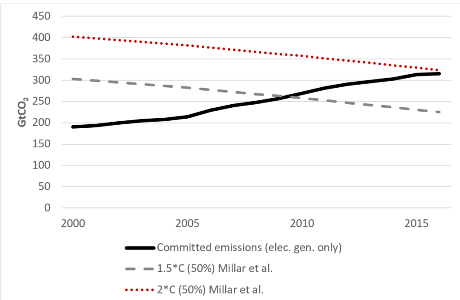

Figure 2: Carbon budgets for electricity generation for 1.5oC and 2oC (50% chance) compared with cumulative committed emissions (GtCO2) to 2050 over time.
Source: Pfeiffer et al (2018).

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Juniors ask Seniors

Dedicated to addressing the issues of climate change in a more resilient and sustainable manner, Mr. de Boer has spent much of his career focused on the economics of climate change and the issue of sustainability. Having built the internal capability of such organisations as the GGGI, UNFCCC and the Dutch Ministry, by internally assessing the skills within that organisation, and examining their relevance against their internal structure and the organisational mandate, Yvo has the capability and expertise to assist the UNSSC, in establishing an organisational structure that can effectively and efficiently, deliver on its mandate.

From 2014 to 2016 he served as Director-General of the Global Green Growth Institute (GGGI), a treaty-based International Organisation with 28 member countries, currently working in 25 countries to develop and implement green growth strategies.

Before this, Mr. de Boer served as KPMG's Global Chairman of Climate Change & Sustainability Services (CC&S). Before joining KPMG in 2010, Mr. de Boer led the international process to respond to climate change in the role of Executive Secretary of the United Nations Framework Convention on Climate Change (UNFCCC) from 2006 to 2010.

Prior to his UN role, he was extensively involved in European Union environmental policy, served as the Vice-Chair of the U.N. Commission on Sustainable Development, and acted as an advisor to the Government of China and the World Bank. In 2011 he was appointed as Chair for the World Economic Forum's Global Agenda Council on Climate Change.

You have been involved in the international climate negotiations for many years, including as Executive Secretary of the UNFCCC from 2006 to 2010. With hindsight, do you think that the climate negotiations have been as successful as they could have been given the challenge and the information that was available at each point in time or do you think the negotiations could have achieved more? Do you think that mistakes were made during these negotiations that slowed down progress (if so, what were the mistakes)?

I think they could have achieved more. One of the fundamental mistakes that we've made is by addressing climate change primarily as an environmental threat as opposed to an economic challenge. It really took far too long for climate change action as an issue to enter the debate of economics, to move beyond environmentalism, to really engage the economics and the finance communities, to really identify the policy and economic solutions that need to be addressed.

So the mistake was more in the framing of the problem than any actual details?

There were more mistakes than the successes, I think, but a mistake was the framing of the problem. A problem is also the fact that many people that are part of this issue really don't understand how you can have both economic growth and poverty eradication, and address climate change at the same time. There has been a lack of technical and financial support to developing countries. There has been a lack of clear market signals to the private sector.

How successful do you think that the Kyoto Protocol has been overall on a scale from 1 (not successful at all) to 5 (very successful)? What do you think is the Kyoto Protocol's greatest strength and what is its greatest weakness?

It was a 5, or maybe a 4.5 because the US vice-president flew all the way to have his picture taken and then Clinton tore it up. But I would say 4.5 because it led to industrialized countries taking the lead; it was a science based commitment and there were quantified targets.

Same question for the Paris agreement

I think a 1 and a 5. It was a 5 in terms of the very clear political success that it represents, because pretty much every country in the world signed up for climate action. But it was the 1 in terms of the level of ambition that what was promised actually being represented.

How confident are you that all countries will fulfil the pledges they have made in the Paris Agreement? How confident are you that countries' pledges will become more ambitious in the future?

Mixed. I think the European Union will deliver, or probably over deliver, and the United States will slightly under deliver, only because the states at the end of the day are more powerful than the president when it comes to this issue. The problem I have with a lot of developing countries is that their targets are conditional on international financial support being provided, which is not currently happening.

In an interview on climate change some years ago, you were asked "Would you call it insanity to know catastrophe is coming and do nothing about it?" and your answer was "No, I don't think it's insanity, I think it's reality." Would you answer this question in the same way today? Do you think that catastrophe is inevitable and what do you think will happen if we are really approaching catastrophe?

Yes, I think I would. In the sense that we still haven't done enough to create the economic conditions, the right policy frameworks. We haven't created the right vision of value that actually makes it possible for there to be a strong enough business case around climate action.

More and more people are talking about "engineering the climate," for example by capturing CO2 and storing it underground or by installing a solar radiation filter. Do you think that this is a legitimate solution for the climate problem? Do you think that more research should be done in this field? Do you think that geoengineering could buy us more time in order to develop cheaper mitigation technologies or that it could help in a climate emergency?

Carbon capture and storage is a very expensive end of pipe technology that doesn't really contribute to innovation. Geoengineering I don't think is a problem, but you can't prevent cancer with filtered cigarettes, and I don't think you can prevent climate change with geoengineering.

The field of environmental economics has been growing a lot in the past years. Do you think that environmental economists have contributed enough to environmental policy and, in particular, the climate negotiations? What are the most important questions that environmental economists should focus on, in your opinion? What do you think environmental economists should do in order to have stronger influence on policy?

I don't think they've contributed enough, not because of lack of effort on their part, but because of the lack of opportunity to engage with policy makers. One of the things that struck me in the negotiations is that there is always this sort of divide between the bureaucrats and politicians involved in the political negotiations on the one hand, and all of the people that really understand the issue in side events somewhere else.

What could environmental economists do to have a stronger policy influence?

Interestingly, when we went into the Kyoto negotiations, the Europeans wanted an approach that focused on policies and measures, so trying to agree on particular policies and technical measures that need to be implemented. And the Americans wanted targets and timetables. The American are bigger and stronger than the Europeans, so the Americans won, and we got targets and timetables. Then the Americans walked away. I think it would be helpful to revisit that notion of policies and measures. To identify what, in the key areas of the global economy, are the things you could do that make economic sense, and that by addressing them, by taking those measures in a systematic way, you could also help to avoid economic distortions and level the playing field.

What is your favorite role that you've played over the course of your career?

My favorite job is the one that I had until about a year and a half ago. It was based in Korea, working for an organization that helps countries on green economic growth. We were working in 28 countries, with everyone from the United Arab Emirates to Uganda and Rwanda, in countries like Indonesia and in between, and we had policy advisors in ministries of finance, economy, transport, agriculture, and environment, really helping governments to understand how they can achieve a stronger economic growth, but with less negative environmental impact. I enjoyed that because it was very practical; it was results oriented, there was no politics, it was all substance.

E A E R E

The European Association of Environmental and Resource Economists (EAERE) is an international scientific association which aims are:
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