Questions

Basics

Why does the Least-Cost Methodology (LCM) allocate the carbon budget based on the cost of projects, rather than the emissions associated with those projects?

Our methodology approximates the impact of a shift to a low carbon demand trajectory, while remaining neutral on the measures that cause that shift. Accordingly, we assume that companies will approve future projects based on their economics rather than their emissions, due to the generally greater importance of financial metrics – i.e. profitability – in investment decisions. This leads to our proposition that in a low-carbon world with ever-shrinking fossil fuel demand, the corresponding supply will come from the lowest-cost projects, reflecting the way that the market can be observed to react in times of low demand/pricing.

That said, the aggregate levels of emissions that result from a purely least-cost approach can be adjusted on the basis of portfolio emissions intensity for the purposes of target setting. For example, under the methodology used in our report "Balancing the Budget", if a company's future project portfolio (derived on the basis of production costs) in each demand scenario has a higher average emissions intensity than the industry average, we adjust its carbon budget downwards by applying the industry average emissions intensity to its portfolio. Where a future project portfolio has lower emissions intensity than the industry average, a company's carbon budget is simply the aggregate emissions that result from aligning its portfolio with the cost curve. This reflects that companies with higher carbon intensity portfolios likely have greater ability to decarbonise at a faster rate than those that have already taken some steps.

Why shouldn't emissions be allocated based on "fair share" or other principles that would give individual companies a proportional share of production?

The LCM approach approximates an economically rational world behaving under market-based conditions without any top-down allocation of emissions budgets. In other words, it reflects the financial variables used today to inform investment decisions, without a global agreement apportioning supply. "Fair share" approaches to global emissions, meanwhile, remain unimplemented.

The LCM approach has two further benefits in this context. Firstly, it reflects investment risk as well as the imperative for decarbonisation – a high cost producer following a fair share pathway may suffer losses (and perhaps not be able to sustain production along the pathway) as overall oil demand/prices weaken. Secondly, it delivers society with energy at the lowest possible cost (hence delivers the highest consumer surplus). Requiring production from oil sands and low-cost

Middle Eastern fields to fall at the same rate would not achieve either of these, as well as not currently having a mechanism to make it happen.

How are oil/gas production cost estimates made in Carbon Tracker's analysis?

Carbon Tracker uses project-level breakeven prices supplied by Rystad Energy, a data analytics company. Rystad sources its data from a mix of sources including company disclosure, government sources, oil field services reporting, non-profit institutions (e.g. IEA), news articles and, where these are not available, uses analyst estimates. Breakeven is defined as the oil or gas price that gives a net present value of zero at a given discount rate. Importantly, Rystad is one of several data sources available to industry. Some companies maintain their own internal estimates as well.

We typically use a measure of breakeven that assumes a 15% IRR to factor in an allowance for project cost overruns and delays. Accordingly, it is more an approximation of a minimum expected return for sanction, rather than a "breakeven" (which may use an approximation of weighted average cost of capital, perhaps 10%), but we use that term for ease of reference.

Can companies use cost data from third party databases?

Yes, this is Carbon Tracker's approach. Companies should then be aware of the third party's assumptions that feed into its cost calculations, such as the discount rate.

Would companies be allowed to use their own costs data? If so, how can that be verified?

Companies may use their own cost estimates, but it is critical that assumptions used are consistent with those feeding into cost estimates for the rest of the potential supply curve. If companies use a different methodology for their own projects—for example, a lower discount rate—they may wrongly believe that a project fits in a particular budget when it might not if consistent assumptions were used. This would increase the risk of both asset stranding and a quantum of projects going ahead beyond Paris limits.

As companies transfer assets in and out of their portfolio, how does the LCM approach adjust?

Because the LCM is a bottom-up approach and is based on project-level data rather than top-down allocation of budgets, it is flexible and will reflect M&A when periodically updated. If company A sells a project that is within the budget for a given demand scenario to company B, company A's future budget will go down by the amount of the carbon/production associated with that project and company B's will increase commensurately. If an out of budget project is sold, there will be no change to either company's budget – the project is assumed not to go ahead in either portfolio.

Would performing the LCM analysis be a burden on companies?

In its basic form (as done in *Breaking the Habit),* the LCM analysis has a simple logic. Once the supply curve has been established and a demand scenario chosen, at heart it is a case of comparing the volumes and economics to see if a project fits in or not. Companies may wish to make further amendments to methodology but should be careful not to unconsciously "cherry pick" an approach that unduly favors their position.

Like the TCFD process, performing an LCM analysis will also have other benefits for companies, for example understanding their competitive positioning and a greater appreciation of the risks and opportunities that the energy transition will bring.

If you focus on lowest cost production, would this incentivize the divestment of high-cost upstream assets to owners that are relatively unconcerned by environmental issues and if not, why not?

As the LCM approach links to project risk through its focus on cost, less environmentally conscious parties may buy projects that are outside the budget; however, they are then taking on the risk of stranding as demand weakens.

We would further note that a top down budget allocation approach would suffer from the issue that environmentally conscious companies must comply with specific emissions targets, whereas unscrupulous players may ignore them.

Does the LCM assume the existence of a perfect market? If not, why does it apply a basic market logic in determining which projects are within budget on a cost basis?

The LCM does not assume a perfect market, but it recognizes that over the long-term, market fundamentals will play a role in oil development. Companies such as ExxonMobil focus on long-term market fundamentals as well.

In using a database produced by a third-party provider, we therefore import some of that provider's assumptions about future production profiles. For example, in a market that was truly satisfied by the lowest cost production in the most cost-efficient way, production from some OPEC members might be higher than it is in our modelling. Subject to those constraints, we make the general assumption that the lowest cost projects outcompete the high cost projects, which we believe is appropriate for an exercise of this nature.

It is worth noting that the exercise is based on long term projections of demand and potential supply and does not attempt to predict the unpredictable or incorporate shorter term volatility in prices. It also does not attempt to capture any cyclicality of oil prices, which is an advantage in some senses, given that when the market is at cyclical highs is perhaps when the risk of investing in ultimately stranded assets is highest.

Reserves

Is the LCM analysis limited only to the resource in place that is classified as "reserves" (developed/undeveloped), and if not, what does it cover?

In trying to estimate potential supply available over the next few decades, LCM analysis will need to look beyond assets currently classified as proved reserves and include assets that are not yet at that stage. For example, Rystad Energy's UCube database, used in Carbon Tracker's LCM modelling, includes lower confidence resources and even estimates for resources that are currently undiscovered, although given that we include the timing of potential production these assets tend to only be available in material volumes in the longer term.

Modelling

The Carbon Tracker reports suggest a linear decline rate for each company—but why would emissions or production decline be linear?

Linking to the concept of a carbon budget, an aggregate amount of emissions/production is derived on the basis of production costs for each company using the LCM. However, in setting targets, companies will most likely want to convert that aggregate number into a pathway by assuming a trajectory which then informs the future rate at which and period over which that aggregate is produced.

Companies may choose a different pathway. However, linear projections are the simplest and most intuitive way of turning aggregate budgets into trajectories to inform annual metrics, to allow comparison between companies, and place the budgets in the context of current annual production. As well as being the simplest, a linear approach – starting now – will generally be the somewhat conservative in terms of committing emissions and requires only gradual changes to company business models.

Much like the concept of a carbon budget at a global level, assuming a trajectory where absolute emissions continue to increase in the near term simply uses up the budget quickly to begin with and makes steeper, and more challenging, reductions necessary later. Companies that follow this route may find that the greater implied scale of change is unachievable in practice and hence fail in their ambitions, disappointing investors and sending a difficult message to the markets about their compliance with climate goals.

Can you provide an example of how this method is applied to a company?

A detailed description of this method with examples can be found in our methodology document for *Balancing the Budget,* at https://carbontracker.org/reports/balancing-the-budget/

Natural Gas

Does LCM account for the potential for natural gas to be a "bridge" fuel?

This would depend on which scenario one uses to conduct the LCM analysis, as the scenario is the source of the assumed amount of demand for each fossil fuel separately.

We have typically used scenarios published by the International Energy Agency, in the Beyond 2 Degrees Scenario (B2DS) and Sustainable Development Scenario (SDS). Both of these scenarios assume that gas demand growth will be relatively more resilient than for oil and coal during the energy transition, meaning that gas will account for a relatively greater share of the fossil fuel energy mix over time. However, given the need to reach net zero, even in these scenarios gas demand growth is much slower than under "business as usual" projections, and peaks much sooner, illustrating that even gas has limited space in a low carbon world and remains subject to the risk of stranding.

Coal

Does the use of a fixed scenario give more room for coal than might otherwise be true? Are there any mechanisms in LCM for transferring the carbon budget between coal and gas/oil?

The basis for the LCM approach is a comparison of available supply of different fossil fuels compared to the demand for them under a particular scenario (in our work, typically those published by the IEA). Such scenarios therefore already incorporate differing demand trajectories for the different fossil fuels; demand for coal is generally assumed to fall much more quickly than that for oil and gas, giving oil and gas a greater proportionate share of the future budget compared to today's production mix.

Different scenarios can be used to give different balances between coal, oil and gas.

Carbon Intensity and Scope 1 & 2 emissions

Does the LCM ignore the carbon intensity of production for different oil and gas assets? If not, how does it account for that intensity?

In *Balancing the Budget*, future aggregate emissions levels by company were calculated using the LCM approach combined with asset-level carbon emissions estimates sourced from Rystad Energy. Carbon emissions estimates were made based on a range of factors, for example reported emissions and factors such as hydrocarbon type and quality. Further details on emissions calculations are reported in the appendix to the methodology document for *Balancing the Budget,* at https://carbontracker.org/reports/balancing-the-budget/.

For the purposes of target setting, further adjustments can be made to allow for/incentivise changes in emissions intensity going forward. For example, the approach suggested in *Balancing the Budget* took carbon intensity into account by assuming that companies with higher carbon intensity than the industry average might be able to decarbonise at a faster rate than peers.

How are the scope 1 emissions from projects calculated?

In *Balancing the Budget*, we used asset-level carbon emissions estimates sourced from Rystad Energy. Further details on emissions calculations are reported in the appendix to the methodology document for *Balancing the Budget,* at https://carbontracker.org/reports/balancing-the-budget/. Companies may have alternative ways of estimating the carbon intensity of their project portfolio.

Does the LCM assume that project carbon intensity will improve or worsen over time?

The LCM methodology is used to determine which projects go ahead under a given demand scenario. This can then be translated into carbon targets by combining the production estimates from the modelling exercise with estimates of carbon intensity. Different approaches to this might be taken provided that assumptions and methodologies are described.

In *Balancing the Budget*, Carbon Tracker used estimates of carbon intensity at the asset level sourced from Rystad Energy, based on 2019 estimates. If companies expect that they may be able to improve their carbon intensity, then they are welcome to adjust their carbon targets downwards accordingly.

How are methane emissions accounted for in LCM?

Methane emissions are not captured in company-level outputs using the LCM methodology. Projects within budget are determined by a comparison to supply volumes to demand on the basis on cost, and the results aggregated by company. The results can then be illustrated in terms of production or associated emissions. The measure of emissions used in Carbon Tracker's work to date relates to carbon dioxide only. However, this does not mean that methane emissions are ignored when calculating the amount of production that goes ahead – depending on the scenario used, if it is subject to a warming constraint that will likely include methane as well as CO_2, hence the environmental impact of methane emissions will ultimately be reflected in the resulting constrained level of demand.

NOCs

What assumptions does the LCM make about future oil production by low cost producers, such as the Saudis?

All companies are treated in the same way, based on the economics of their project portfolio. Companies which have a large volume of relatively low-cost production over time can be expected to take up a relatively larger market share, although their production may not be growing in absolute terms.

If LCM is focused on low cost production, why does it not assume that Saudis increase production of oil?

As we use a third-party database of potential supply, we effectively import the database's assumptions around the potential projects that might go ahead and their timescales. It is also worth noting that because the methodology looks at potential production in a time period, rather than just reserves volumes with no time dimension, this means that this reflects the realities of production rates, rather than allowing distortions like assuming that the world runs exclusively off Saudi oil for a period until they are depleted before moving onto the next lowest cost etc.

It is possible that companies with large resource endowments may increase production in a falling demand environment beyond the production profiles reflected in our work; this represents a further risk to oil prices and hence higher cost projects.

Does this approach favor NOCs? If so, why would any IOCs support this?

All companies are treated on the same basis. It will favour some NOCs to the extent that they have lower supply costs – for example, Middle Eastern NOCs may be expected to have more resilient production levels, reflecting their competitive positioning on the supply curve, whereas some other NOCs in different countries will not have the same advantages. Again, this reflects the resilience of different parts of industry in times of oil price volatility.

We believe IOCs and their shareholders have good reason to support the use of LCM in target setting, given that a leaner, lower-cost portfolio gives alignment between limiting stranding and maximising returns under lower demand conditions for the attainment of international climate commitments.

Carbon Costs

Does the LCM ignore the likely increase in carbon costs?

We do not presently make an adjustment to project costs for potential future increases in carbon costs. This is because forecasting carbon costs is highly speculative, and in any case likely to only have limited impact – for example, on average, a $40/t carbon price would increase the upstream cost of the average project by about $1.5-2/bbl. This is likely to therefore only have a minor effect in terms of rearranging projects on the cost curve, and it will only be projects very close to the margin that are affected. This approach or similar could be included in future iterations.