19 Future energy use and emissions

with both eyes open

We can now recreate our analysis from chapter 11, but enhanced with the sliders on the mixing desk from the previous chapter, to bring in the options of material efficiency and demand reduction.

In effect the whole book so far has led up to this chapter. We've travelled, visited, talked, invented, imagined, cooked, fought, detected, explored, deduced, sung and calculated ourselves to this point to find out if we can create a sustainable steel and aluminium future, defined by our emissions target and with assumed demand growth. With one eye open, we looked for options that reduce emissions by process and energy efficiencies within existing businesses, but are hidden from to final consumers. And we found that we simply didn't have enough options to get close to the target, unless hiding behind the infinitely comforting blanket of carbon capture and storage.

With both eyes open we have a wider set of options, and at our most daring we've seen that, in the limit, we could live well with fewer material services. But this book isn't a radical call for the new richness of poverty: it's about exploring a set of options that have been forgotten, because the incumbent materials industry can't easily pursue them without some external impetus.

So in this chapter, we'll briefly discuss how to make use of the sliders we invented in the last chapter. Our main work is then to play with the sliders, to see whether we can reach the emissions target with our expanded set of options, or whether we need to bring in our slider of last resort, an absolute reduction in demand for material services. Then we can look at which sliders are most effective, and move onto anticipating what our forecasts tell us about future capacity requirements in different industries.

Anticipating energy and emissions with both eyes open

We can start our adding up by remembering where we were with one eye open: everything that was possible with one eye open remains possible, so we will continue to apply all the efficiency options from Part II. We'll stick with our previous forecast of demand, although we'll now interpret it as demand for services and not a demand for metal. As a consequence, the actual flows of metal in 2050 could be lower than before if, for instance, we make a shift towards lighter weight product design or more intense product use.

In the last chapter, for each product type we invented six sliders on a mixing desk to characterise the new options we've found with both eyes open. To forecast future metal stocks and flows, we will sub-divide the flows of both metals into the product categories, and modify the flows according to the sliders. We can move each slider between the limits we set in chapter 18, and to simplify our mixing desk, rather than having six sliders for every product, we'll assume that all sliders of the same type (e.g. all "scrap diversion" sliders) move together.

We also need two further sliders to affect the whole system: one for absolute demand reduction, which we'll apply equally across all products, and one for carbon capture and storage (CCS) which we'll apply to all emissions. We hope we won't need to use either of these sliders, but they are our options of last resort if full application of everything else isn't enough.

As before we will predict emissions in 2050 with a range of values, rather than a single number, to reflect our uncertainty about both demand, and about the scale and impact of our strategies. Our ambition is to reveal likelihoods, not to make precise predictions.

Forecasts of the future with both eyes open

Our first question in looking to the future with both eyes open is "can we meet the target without needing demand reduction or carbon sequestration?" We'll address this by assuming we move all the sliders (but not CCS or demand reduction) forwards together. The results are displayed in Figures 19.1 and 19.2.

For steel, we can see that even without pushing all of the sliders forward to their maximum positions, we can reach a 50% reduction in emissions compared to current levels. For aluminium, for which we're predicting greater demand growth, the story is different. Even if we implement all of our previous strategies from chapter 11, and if we then add material efficiency at the maximum rate we found credible in the previous chapter, our forecast emissions are still approximately 25% above the target. Actually the span of our forecasts, allowing for uncertainty, just reaches the target, but the mean forecast value is 25% too high. As a result,

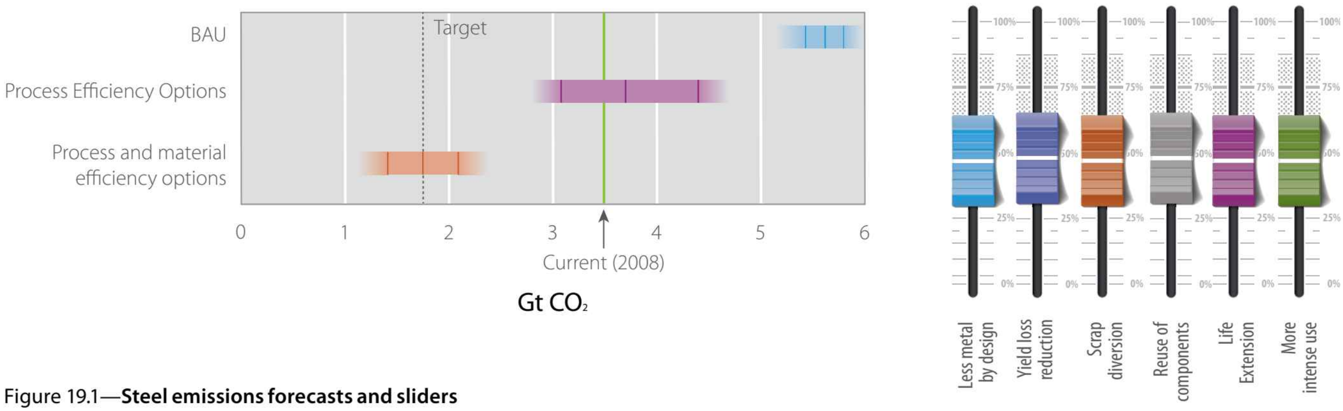

Figure 19.1—**Steel emissions forecasts and sliders**

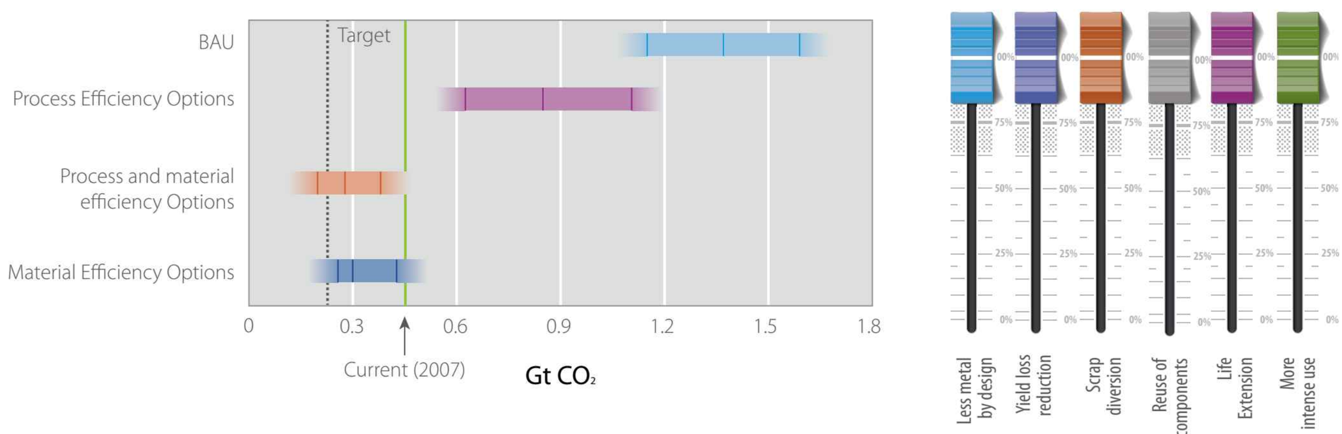

Figure 19.2—**Aluminium emissions forecasts and sliders**

in order to meet the target, we will need to use our sliders for CCS and demand reduction: we could meet the target for aluminium either by using CCS to remove a further 20% of emissions in producing electricity, or by reducing demand for aluminium services by 14%.

These two results are good news: it's been worth reading the book! We can reach the target for steel and nearly reach it for aluminium, without having to foment a revolution in behaviour or believe in the questionable dream of CCS.

Now we have an answer to our overall question, "can we get there?", we can now move on to a more nuanced one and ask what sort of journey we'd like to take to reach the target? To address this, we'll consider alternative ways to move the sliders. In particular we'll look for at two contrasting approaches:

- **Process and technology led change:** what happens if we have a preference for changes that can be implemented within industry? We'll examine this by moving forwards the sliders for using less by design, yield loss reduction, scrap diversion and component re-use, twice as far as those for life extension and more intense use. This approach demands more effort from within the industry, but less change of behaviour by consumers.

- **Behaviour led change:** in contrast, what happens if material efficiency becomes a social norm, and is driven by behaviour change? Here we'll shift the sliders more related to behaviour (life extension and more intense use) at twice the rate of the others, to examine what would happen if consumers took the initiative.

In Figure 19.3, we've contrasted these two approaches and can see that for steel, we can achieve the target with either strategy. If we have a preference for behaviour change, we can achieve the target with the sliders at lower values than when we prefer process and technology change. For the aluminium sector, the results in Figure 19.4 show that we still need to rely on CCS and demand reduction to meet the targets. The effect of the alternative preferences above is to move some sliders to only half their limit, while the others remain at full implementation. This increases our need for CCS or demand reduction. As with steel, a preference for process and technology change is less effective than a preference for behaviour change, so results in higher settings for these two sliders.

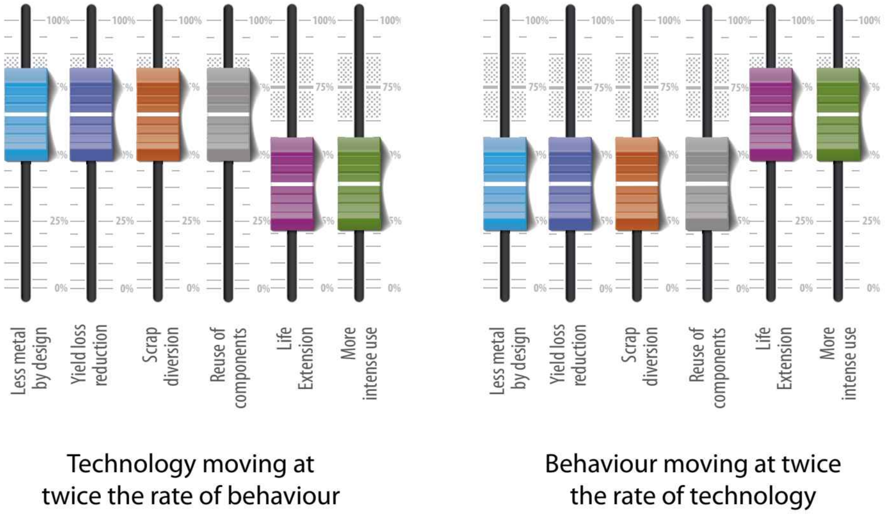

Figure 19.3—**Alternative steel strategies**

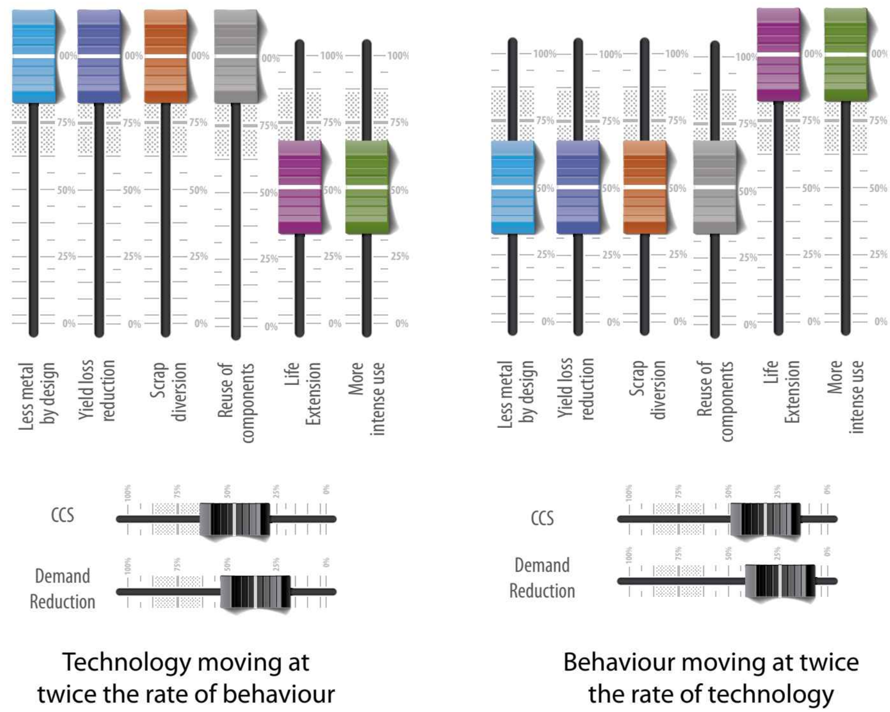

Figure 19.4—**Alternative aluminium strategies**

We've established that the target we set for ourselves can be met—but we've seen that behaviour options appear to be more powerful than those related to technology. In the next section we'll explore this further.

The relative sensitivity of our different options for change

In chapter 2 we established that options for reducing energy use are not all additive, because if you reduce demand for some output, you also reduce the potential for savings from delivering that output more efficiently. So, we must be cautious in exploring the effect of moving each of slider separately. However, we now want to try this, because we've been careful in setting up limits for each slider, so can give physical meaning to small movements of each slider relative to the present. Exploring the sensitivity of overall emissions to each slider will help us to establish priorities for short term action.

Figures 19.5 and 19.6 show the emissions saving from moving each of our sliders forwards by 1%, while leaving the other six at present levels. We've included the slider for demand reduction in order to give some comparison of scale.

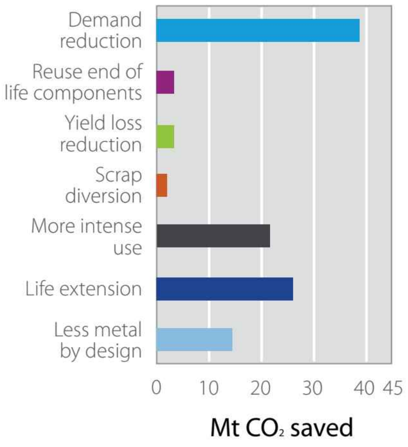

Figure 19.5—**Sensitivity analysis for the steel options**

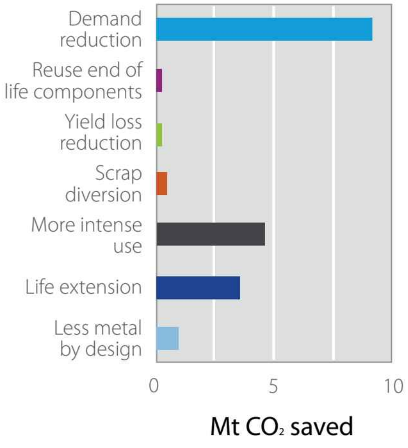

Figure 19.6—**Sensitivity analysis for the aluminium options**

These results are not additive: if we applied two of the strategies together, we would not necessarily see a total emissions reduction equal to the sum of the two applied separately. However they show us the relative impacts of starting to implement each strategy. Scrap diversion, yield loss reduction and component re-use have the least effect. Even though these are the easier strategies to implement, because they are 'internal' to the industry, they apply only to a subset of the secondary stream of metal which will be recycled, so has a lower emissions intensity than primary production. In contrast, life extension, more intense use, and design with less metal all lead to a reduction in total material demand, so are more effective. This result is highly significant as we plan for a sustainable materials future. To date, virtually every effort related to the goal of sustainable materials has focused attention on the sites where material is produced. The forecasts of chapter 11 and those here, show that this simply won't have a substantial effect—because these sites are already operating remarkably well. Instead, the three strategies that we've found give a big effect. All cause a reduction in demand for production of new materials. By designing with less material we continue to produce the same number of goods, but use less material when doing so. The other two strategies aim to provide the same service with fewer new goods, by maintaining existing goods for longer and using them more intensely. A sustainable materials future therefore has reduced materials production, and for materials producing businesses with no other revenue stream, this is bad news. However, it is not bad news for the economy as a whole, as we've seen that lost revenue in materials production can be replaced by increased activity in maintaining, repairing, and upgrading existing stocks. So a sustainable materials future requires a change in the balance of our activity, but does not require a recession.

We'll conclude our exploration of options for change by developing two more forecasts for steel. In both cases we'll move forwards all six sliders at the same rate, but in the first we'll include capture and storage of 25% of all emissions and in the second we'll include reduction of demand for final services by 25%. Contrasting these results in Figure 19.7 with the earlier ones, we can see that this level of CCS or demand reduction, requires that the other sliders move forwards about 40% less.

Capacity requirements and roadmaps

We don't know which of our options will be implemented at which rate, so having worked to establish credible limits for each strategy in each product area, we'll stick to our first forecast with no demand reduction and no sequestration, but all

Figure 19.7—**Steel slider options with CCS or demand reduction**

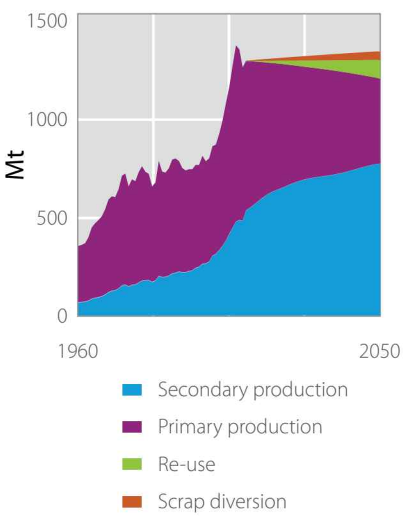

Figure 19.8—**Capacity required for steel processes to 2050**

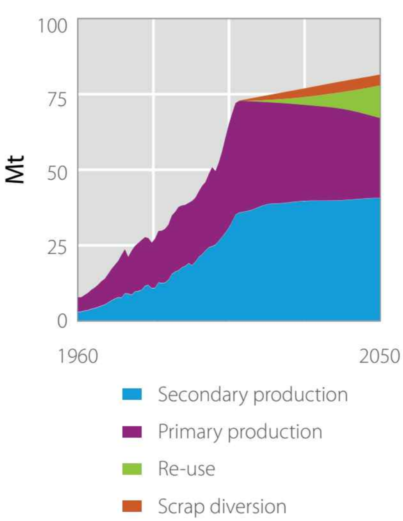

Figure 19.9—**Capacity required for aluminium processes to 2050**

sliders moving together. If we apply this approach to our model of metal flow, we can now extract two further useful insights.

Firstly, for both metals, we can anticipate the total global capacity required for each major stage of production, between now and 2050. The graphs in Figure 19.8 and 22.1 show that: we already have enough global capacity for steel and aluminium primary production; we must increase our capacity for recycling steadily between now and 2050; we must grow our capacity for processing diverted scrap and reusing components. These graphs give an unequivocal message to politicians considering emissions reduction targets: if we wish to achieve a 50% cut in emissions, we must not build any new primary production facilities. Instead, globally, we need to reduce primary production by around one third over the next 40 years. This is a direct consequence of primary production driving most emissions in materials processing. Reduced emissions requires reduced primary production, and the options for change we have identified throughout Part III are about living well with less new material. We've found plenty of those options, but we cannot avoid the simple fact of these graphs: to cut emissions globally we have to cut global primary production.

Secondly, we can develop start to predict the changes required to allow changes in metal service delivery to take place. Over the next four decades, changes in capital investment (related to plant capacity) will be required, alongside technology innovation (for example new manufacturing process development) and new approaches to design (for instance to enable component reuse) are required in order to meet the targets. Changes in the systems (such as safe lightweight cars), legislation and behaviour required to help us meet the targets will be our focus in Part V of the book.

Outlook

The great news of this chapter is that a sustainable material future looks much more feasible with both eyes open than it did with just one. We have now identified enough options for big change to have a choice about how to reach our emissions target. In Part IV we'll explore whether similar approaches would allow similar relative reductions for other materials.