Getting to Net Zero

We have looked at the two sectors of the American economy that cause over half our greenhouse gas emissions: electric power (28% of total) and transportation (29%). We will not look in detail at industry (22%), residential and commercial (12%), or agriculture (9%), since it would be an endless task to look at all the technologies used in these sectors. But we have already seen enough to make this general observation:

- Electric cars, wind and solar power, and battery storage are already commercially viable. We could shift electrical generation and ground transportation to clean alternatives relatively quickly by putting a price on emissions to provide the incentive and to stimulate innovations that drive down the prices of the clean technologies even further.
- Biofuels require much more work before they become commercially viable, letting us shift to clean alternatives for air travel and shipping.

The same is true: clean alternatives for many technologies are available, but clean alternatives for others need more work before they become viable.

There is no way to predict how soon these new technologies will become commercially viable. If we price emissions, there will be an incentive to develop clean technologies to replace existing dirty technologies, but we cannot predict how long it will take to come up with the breakthroughs that will make it economically practical to use each of these clean technologies

Economic Dislocation

If just a few key innovations take too long to develop, rigid emissions pricing could cause hardship and economic dislocation when prices reach high levels, possibly discrediting the entire pricing system. Here are two examples:

- **Nitrogen Fertilizer** and other synthetic fertilizers increase yield per acre. Organic farming produces about 20% less per acre than conventional farming.[161] It would be good if we could develop new methods of organic farming that increase yield, but for now the fact is that, if we did not use fertilizer, we would have to convert vast areas of forest to farmland to feed the world's population, creating massive carbon dioxide emissions. Nitrogen fertilizer is indispensible for now, but it is the main reason that nitrous oxide in the atmosphere has increased 20% since preindustrial times, making it the third most important greenhouse gas after carbon dioxide or methane.[162] There are easy ways to reduce use of nitrogen fertilizer, such as applying fertilizer when plants need it the most rather than applying massive amounts at planting time,[163] but there is no new technology on the horizon that could eliminate use of nitrogen fertilizer completely. If we put a price on emissions that increased over time, the cost of using nitrogen fertilizer could eventually rise enough to drive up food prices and increase world hunger.

- **Cement**, which is used in concrete and mortar, is the source of about 8% of the world's carbon dioxide emissions. Cement is made by baking material that contains calcium carbonate to break it down into the calcium oxide used in cement plus carbon dioxide. We could reduce emissions by using clean energy for mining and baking, but more than half of the carbon dioxide is an unavoidable chemical byproduct of breaking down calcium carbonate. There are efforts to develop clean concrete—for example, using microbes to create bio-concrete[164]—but there is no way to predict how long it will take for clean concrete to become commercially viable. For now, concrete made with cement is essential for building. If we put a price on emissions that increased over time, the high cost of cement could eventually drive up housing prices enough to create a shortage of affordable housing.

Fertilizer and concrete are two obvious cases where a high price on emissions could create hardships, particularly for the poor, if it takes too long to develop clean technologies to eliminate emissions. There are other industrial processes, such as refining iron ore, where high prices on emissions could cause economic dislocation and unemployment if it takes too long to develop clean alternatives.

Ultimately, there will probably be innovations that will provide clean substitutes for all dirty technologies that we now use, but there is no telling how long it will take—which is why any plan to price emissions should allow for emission offsets.

The IPCC says that offsets are needed to get to net-zero emissions because some non-carbon dioxide emissions "are difficult to mitigate, such as N_2O [nitrous oxide] emissions from fertilizer use and CH_4 [methane] emissions from livestock … [which] will not be reduced to zero, even under stringent mitigation scenarios."[165] In addition, offsets let us avoid economic hardship when clean alternatives are too expensive to be commercially viable.

Emission Offsets

Emission offsets let businesses offset their own greenhouse gas emissions by reducing emissions in some other way. They are usually called carbon offsets, but we have seen that they are also needed to deal with emissions that contain no carbon, such as nitrous oxide. There are obvious advantages to emission offsets:

- They let us reach net zero emissions more quickly, rather than waiting until we have developed all the new clean technologies that are needed to replace the dirty technologies we use now.
- They let us reach net zero more cheaply, rather than adopting technologies whose cost is still high.
- They provide a source of funding for reducing emissions in the developing nations. For example, businesses could offset their own emissions by subsidizing farming methods in the developing nations that produce fewer emissions.
- They provide an economic incentive to bring down the cost of methods that remove carbon dioxide from the atmosphere, which will be needed when the world reaches net-zero emissions and must move to net-negative emissions.

Multiple Emission Offsets

Multiple emission offsets can reduce emissions even more quickly by letting businesses get out of paying the price for one ton of their own emissions if they reduce emissions somewhere in the world by, say, two tons or five tons.

Multiple emission offsets are economically feasible, since the costs of offsets are well below the costs that are charged by plans that put a price on emissions. For example:

- Under California's cap-and-trade plan, it now costs businesses $17.45 to emit one ton of carbon dioxide equivalent.[166]
- Under the European Union's emission trading system, it now costs over $25 to emit one ton of carbon dioxide from larger factories and power plants.[167]
- A recent German law begins by charging 10 Euros (about $11) to emit one ton of carbon dioxide from transportation and heating, with the price increasing to 35 Euros by 2025.[168]

By contrast, the average price in the private market for carbon offsets is $3.30 per ton,[169] though prices vary.

A government program to let business avoid paying fees would have to set standards for projects that qualify as offsets[170] and presumably would have stricter standards than some of these private programs, so let's assume that offsets would initially cost $5 per ton. And lets assume that offsets should cost about 80% to 90% as much as paying for emissions, to give businesses an incentive to use offsets. California could require businesses to buy offsets that reduce emissions by 3 tons to avoid paying for 1 ton of emissions, the EU could require 4.5 tons of offsets. and Germany could begin with 2 tons and work its way up to 6 tons of offsets to avoid paying for 1 ton of carbon dioxide emissions.

This sort of program could jump-start global emission reductions, as businesses rush to pay for the cheapest emission reductions all over the world in order to avoid paying fees. They would still have a strong incentive to reduce their own emissions, since the offsets would cost almost as much as the fee, but they would also be reducing global emissions dramatically by paying for offsets.

It is not possible to offset all emissions. If it were, we could shift to net-zero emissions immediately, but there are obviously not enough offsets available to balance all of the world's emissions.

Initially, we might let businesses offset, say, 10% of their emissions by reducing emissions anywhere in the world. Over time, allowing offsets would have two opposite economic effects:

- Cheaper opportunities to offset emissions would be used up, driving up the price of offsets. For example, one cheap source of offsets involves sealing landfills and burning the methane that escapes, so the landfill emits carbon dioxide rather than methane. But there are only so many landfills in the world, and if a major economy let business use offsets, it would not be long before methane emissions were eliminated from all these landfills.

- Businesses would invest in developing emission-negative technologies, potentially driving down the price of offsets. Currently there is no economic incentive to develop these technologies, but once the emission reduction can be sold to businesses to use as offsets, we would expect many start-ups to begin developing these technologies and reducing their costs.

Because these two effects are opposite and because we cannot predict what technologies will be developed, we cannot predict whether offsets would become more or less available and whether their cost go up or go down over time.

As years go by and the price of offsets changes, governments would have to vary the multiple so businesses always have to buy offsets that cost 80% or 90% of the fees they are avoiding. As the availability of offsets changes, governments would also have to change the percent of their emissions that businesses can offset.

In the longer run, as the fee for emissions goes way up and emissions go way down, we will have to set the multiple at a level that avoids hardship and severe economic dislocation. For example, we would not want to set the price for emissions from nitrogen fertilizer so high that we drive up the price of food to the point where we cause hunger, so we could set the multiple for these emissions so offsets cost less than the full 80% or 90% of the emissions fee.