Energy for Planet Earth - 30 years on

PART THREE: CO_2 EMISSIONS

Background

In September 1990, Scientific American published a special issue entitled 'Energy for Planet Earth'. In this publication, Scientific American explored the sources of energy, the future for energy, made predictions on technological breakthroughs and suggested solutions for what they considered was an imminent energy crisis. Many of these predictions by Scientific American were made for 2020. Given we have reached that date, we can look back and compare the predictions with what actually happened.

In a **three-part series**, Frontier Economics compares actual outcomes to 2020 with the predictions made by Scientific American. This comparison of actual versus predicted outcomes, especially where technological change is involved, can help us learn about the factors that have been determinative to the global community and provide guidance on how we can improve economic forecasts.

We focus on three areas where Scientific American made long-term forecasts:

- Primary energy demand (covered in Part One)
- Energy intensity (covered in Part Two)
- Emissions intensity.

This is the **third and final part** of this series.

Scientific American gets it right in Part One and Two

Part One – Energy demand: In Part One we reviewed the performance of Scientific American's long-term forecasts on primary energy demand.[1] We found that, overall, Scientific American's forecast was reasonably accurate. However, Scientific American did not perform as well on the growth performance by country. Most significantly, Scientific America materially underestimated the rapid and large increase in the growth of developing nations, such as China and India. That is, countries that were relatively poor in 1990 grew more quickly than expected, and they used energy to achieve this growth.

[1] Frontier Economics (2020), *Energy for Planet Earth – 30 years on (Part One)*, February, Weblink: https://www.frontier-economics.com.au/publications/energy+for+planet+earth+30+years+on+part+one

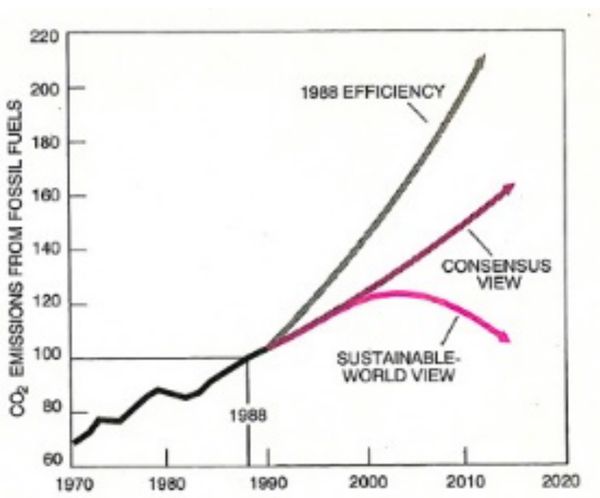
Part Two – Energy Intensity: In Part Two we reviewed the performance of Scientific American's forecast of energy intensity.[2] While Scientific American's original historical depiction of energy intensity was stylised, it did accurately convey the historic profile of energy intensity – rising as countries develop, and then falling as economies mature. Given the size of the populations in developing countries in 1990, there was a genuine concern about the impact on energy demand (and resulting environmental problems) if these countries followed the same energy intensity profile as developed countries. However, Reddy and Goldemberg predicted that developing countries would benefit from improvements in materials science and energy efficiency innovations from developed nations. This technological transfer would avoid the high energy intensity peaks that occurred over the course of the previous 150 years of economic development of, now, developed economies. Reddy and Goldemberg were correct. The energy intensity of developing countries, while starting on the higher side of developed countries in 1990, quickly fell as they adopted the latest technologies. By 2015, developing countries had lower energy intensity than the developed countries originally analysed by Reddy and Goldemberg. In fact, by 2015, developing countries exceeded the most ambitious energy intensity decline forecast by Reddy and Goldemberg.

CO_2 emissions

We conclude our three-part series by looking at Scientific America's global projections for CO_2 emissions from fossil fuels.

In Davis' *Energy for Planet Earth* article, it was hypothesised that in the long-run, technological advances will likely lower the overall costs associated with limiting carbon dioxide emissions from fossil fuels. He considered that the effect of this technological shift would be maximised if policy makers were able to agree on global guidelines and policies to actively reduce CO_2 emissions from fossil fuels, including pursuing afforestation programs which would increase carbon absorption.

Figure 1: Three emission scenarios



Scientific American presented **three emissions scenarios** (see **Figure 1**). Observed emission data was presented from 1970 to 1988 after which the three projects from 1988 to 2017 were presented.

The first scenario is referred to as the "1988 Efficiency" scenario. This reflects emissions growing at the same emissions rate in 1988 and moving with the forecast rate of economic growth – that is, there is no improvement in energy intensity (see Part Two on the experience on energy intensity that shows

[2] Frontier Economics (2020), *Energy for Planet Earth – 30 years on (Part Two)*, February, Weblink: https://www.frontier-economics.com.au/publications/energy-for-planet-earth-30-years-on-part-two

that intensity has in fact improved greatly in the past 30 years[3]).

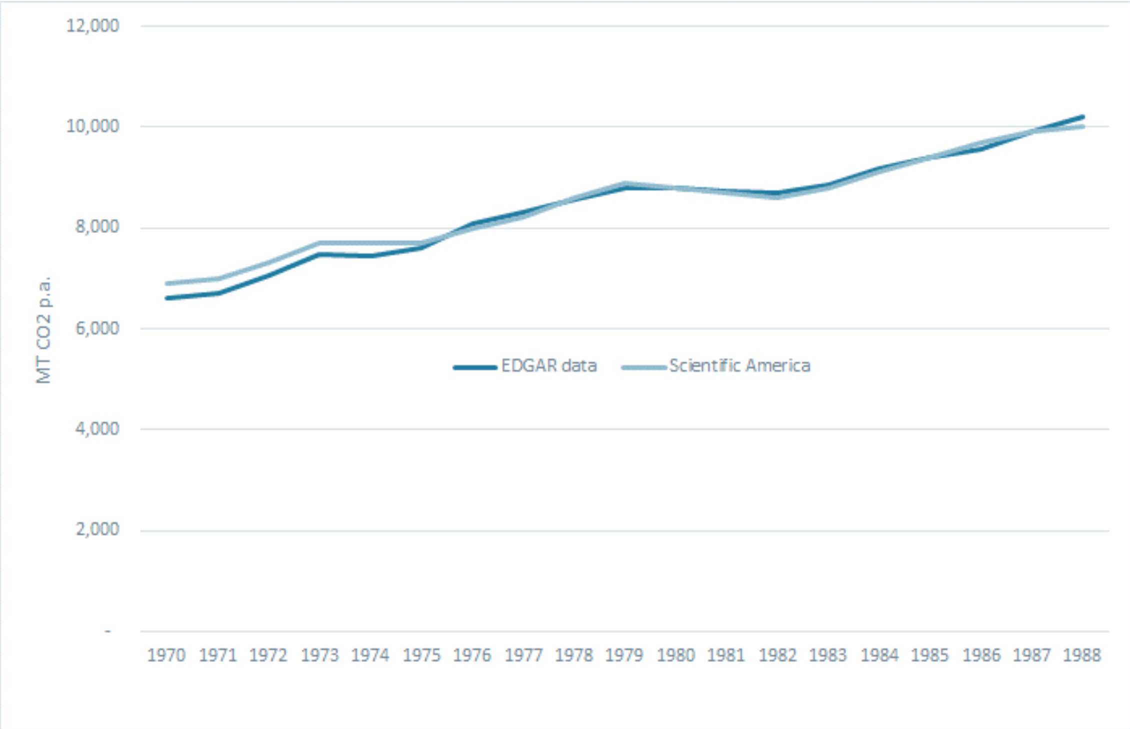
The second scenario is the "Consensus View" trend. This scenario essentially assumes a continuation of the 20-year trend in emissions intensity from 1970.

The third and final scenario is the "Sustainable World View". In this scenario "assumes radical improvements in efficiency with demand stabilizing after 2000".

Finding a consistent data source

As with the previous two parts of this series, Scientific American does not provide a reference for the data in their figures, including the data behind **Figure 1**. It was determined that the emissions data was likely derived from Emissions for Global Atmospheric Research (EDGAR) Dataset[4], which contained a full set of data for carbon dioxide total emissions from 1970-2018, by country and sector. The high level of consistency between the EDGAR and Scientific American emission series can be seen in **Figure 2**. It is therefore reasonable to use the EDGAR series to compare the actual emissions over the past 30 years with Scientific American's 30 forecast from 1990.

Figure 2: Consistency of EDGAR and Scientific American emissions data



Source: Frontier Economics analysis

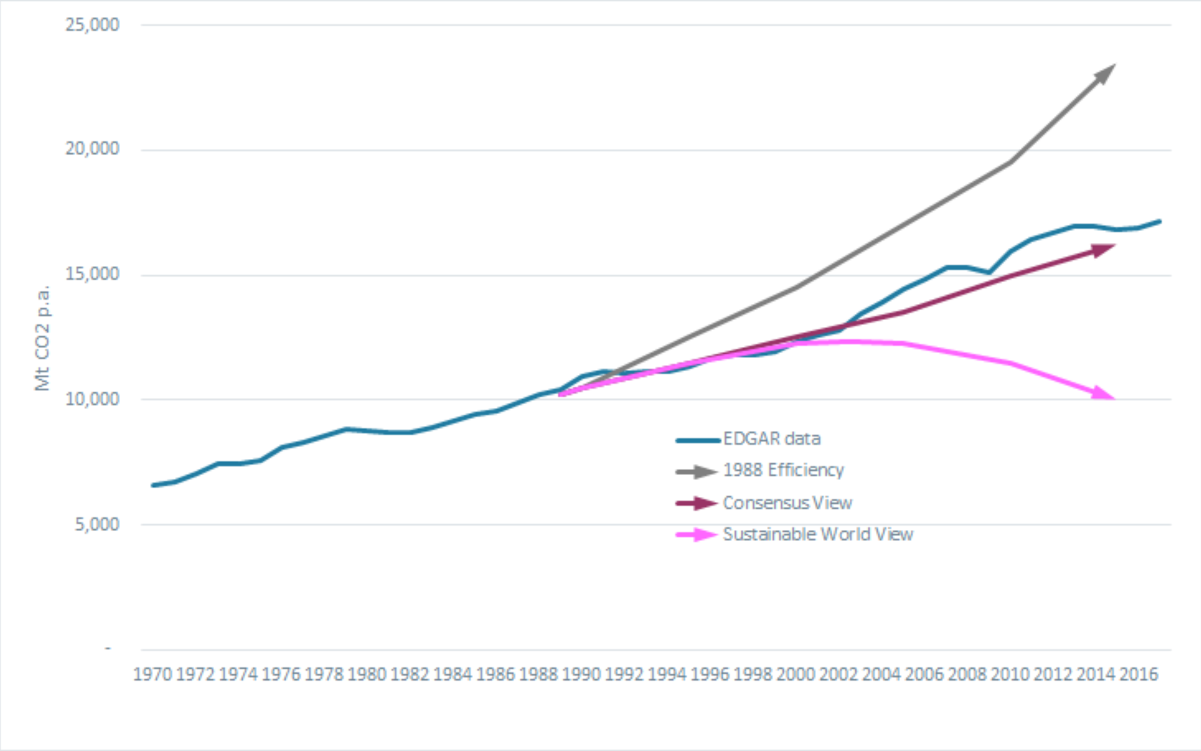
3 *Energy for Planet Earth – 30 years on – energy intensity* (Part Two), Weblink: https://www.frontier-economics.com.au/publications/energy-for-planet-earth-30-years-on-part-two

4 EDGAR – Emissions Database for Global Atmospheric Research Weblink: https://edgar.jrc.ec.europa.eu/overview.php?v=booklet2018

Emissions projections versus actual emission

In **Figure 3** actual emissions over the past 30 years is presented alongside the EDGAR data used by Scientific American.

Figure 3: Performance of Scientific American emissions intensity forecast



Source: EDGAR, Scientific American and Frontier Economic analysis

Figure 3 shows that actual CO_2 emissions from fossil fuels over the past 30 years is similar to Scientific America's "Consensus View". It appears that emissions are levelling out towards the end of the series, about 20 years later than Scientific American considered necessary in the Sustainable World View.

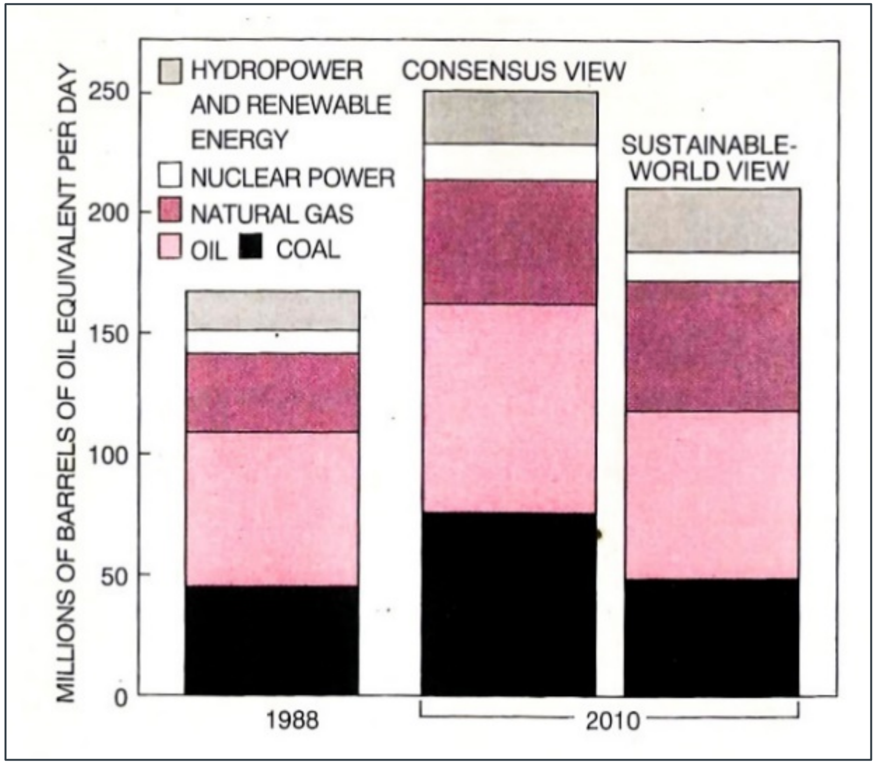
Prediction of composition of emissions

In addition to predicting total fossil fuel emissions Scientific American also predicted the global energy mix in 2010 – 20 years after the publication of the article.

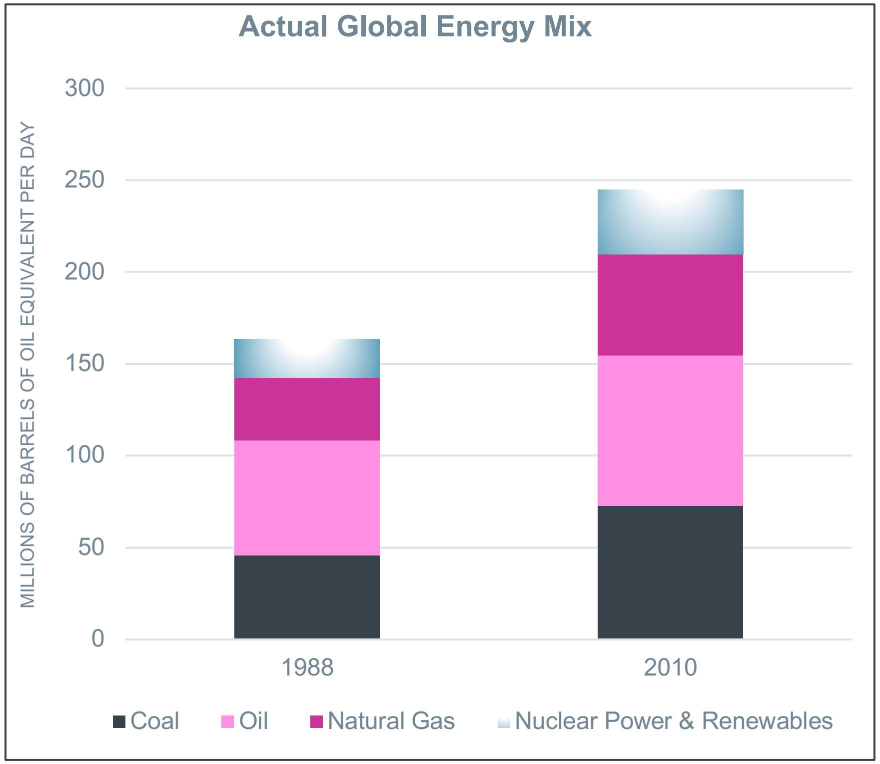
Scientific America presented two scenarios for 2010, which correlates to the same scenarios seen from the line graph – the Consensus View and the Sustainable World View (see left hand panel of **Figure 4**). The Consensus View assumes there is an overall growth in consumption of energy, whereas the Sustainable World View assumes radical changes in energy efficiency with a worldwide drop in energy demand.

Figure 4: Global energy mix – predicted versus actual

Scientific American emission scenarios



Actual emissions – EIA data



Concerning the energy mix for the Consensus View, we see that coal and oil expand rapidly with less of a change for natural gas, renewables and nuclear. In contrast, in the Sustainable World View, coal and oil production stagnates whereas natural gas and renewable sources experience a surge, with hydropower and commercial renewable fuels increasing by 60 per cent.

Sourcing primary energy production data from the U.S. Energy Information Agency (EIA)[5], Frontier Economics was able to reconstruct the stacked bar chart for 1988 and 2010 (see right hand panel of **Figure 4**). Although EIA does not separate nuclear power and renewable power, it can be seen by a comparison of both the 1988 charts in the left and right hand side panels on **Figure 4**, that the data Scientific American and EIA data sets as the total energy from both sources is approximately the same at 160 MMBOE/day for 1988.

Comparing the two charts in **Figure 4**, the Scientific American Consensus View is very similar to the actual 2010 energy mix. For the actual 2010 data, coal and oil experienced the largest increase, in fact an increase that is almost the same as the Scientific American Consensus View scenario. It shows a change of coal production from around 46 MMBOE/day to 73 MMBOE/day, and a change of oil production from around 63 MMBOE/day to 82 MMBOE/day. Finally, the actual total energy production figure also mirrors Scientific America's scenario figure of around 250 MMBOE/day.

Scientific American is on the money again

Scientific American's Consensus View, the more likely scenario, has proven to be accurate in terms total emissions from fossil fuels and they predicted the global energy mix 20 years out.

This high forecasting accuracy by Scientific American is consistent with their performance on forecasting overall energy demand and energy intensity.

Conclusions

The world has managed to achieve significant economic growth while reducing energy intensity and mitigating the growth in emissions through the use of ever-more advanced technologies – precisely what Scientific American predicted would happen.

Technology change and productivity improvement is integrally linked. Improving productivity improves the economic welfare of people. This is because productivity improvements mean that more wants and needs can be met with society's scarce resources.

While there are many seminal contributors to thinking into the importance of productivity to society, arguably the work of Robert Solow is the most important in the context of the Scientific American *Energy for Planet Earth*. Solow won a Nobel prize in economics in 1987 for his work showing the link between technological innovation and economic growth. Our analysis of the Scientific American forecasts illustrates the importance of technology in improving energy and emissions efficiency over the past 30 years. Technology will be critical in achieving continued gains over the next 30 years to reach a net zero emission target by 2050. Given this, it would be

5 Energy Information Agency, Weblink: https://www.eia.gov/

beneficial if governments focussed policy efforts on improving productivity across all sectors of the economy and relying on the collective innovation of industry to achieve this aim.

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