Photo: Barbara Davidson/Dallas Morning News/Corbis

Dialogue of the deaf

There is a disconnection in the way we talk about energy and the way we assess its environmental implications. Energy providers talk in terms of millions of barrels a day, or megawatt hours. Environmentalists talk in tons of carbon. The result is a dangerous confusion, since it obscures the sheer scale of hydrocarbon use and leads to the illusion that all hydrocarbons are equally damaging.

by Chris Cragg

Back in the midsummer of 2007, the newspaper The Guardian wrote about British claims to large areas of the South Atlantic surrounding the Falkland Islands. This was part of a rush to establish claims to the mineral rights of the seabed, widely interpreted as the last great "land grab" open to humanity. 'The value of the oil under the sea in the region', The Guardian wrote, 'is understood to be immense: seismic tests suggest that there could be about 60 million barrels under the ocean floor'.

Embarrassed sub-editors rather rapidly changed this subsequently to 60 billion on the internet, but not before a good many people in the oil industry had had a few hearty laughs about the mistake. After all, who in oil and gas exploration would jump out of bed for 60 million barrels of oil somewhere in the wild and deep South Atlantic? It is about three quarters of one day's global supply!

Indeed the whole "sea-bed" grab had about it an air of unreality. Hydrocarbon numbers were spread about like confetti at a wedding. In the case of the Russians, who started the popular interest by claiming 460,000 square miles of the Arctic, the target was the "10 billion tons" of hydrocarbons that supposedly lies in 200 metres of water. This too sounds an enormous amount. Yet assuming that it is crude oil, not gas and is a recoverable reserve figure – both contentious questions – it represents only around 90% of one year's global primary energy demand! Indeed the whole diplomatic dance about sub-sea reserves does not allow for much complacency about the totality of global supplies.

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What is really important about this is that the average person has very little conception of the sheer scale of the energy supply needed to keep the global economy turning. In 2006 for example, the world used 10,878,500,000 tons of oil equivalent (toe) as primary energy of which 87% was provided by fossil fuels and this grew by 2.5% in that year. By contrast, the total amount of rice, corn, wheat and every other course grain produced for food, amounted to around 2.3 billion tons.

"Big oil" in particular is a trifle bigger than people think, and the main targets for disapproval like Exxon and Shell, actually produce less than 6% of the 82 million barrels produced everyday. Yet this enormous figure of world-wide production is extremely hard for the layman to visualize. For Americans 82 million barrels is roughly two and a half hours of the winter volume of water that flows over Niagara at a rate of 1,416 cubic metres per second. For Europeans, it is almost four hours of the average flow of the Rhine at Cologne.

In relation to natural gas production, it is ridiculous to suggest homespun volumetric comparisons, like the size of the pyramids or St Peter's in Rome. The volume is just too enormous. In 2006 global gas production reached 2,865.3 billion cubic metres, or to put it another way, at standard pressures the size of a building almost 3,000 cubic kilometres in volume.

Nowhere is this confusion over quantity greater than in the production of electricity. Hardly a day goes by without advocates of wind power announcing that some new initiative will "supply several thousand homes"; a 'concept' that ignores the two-thirds of demand that is not residential. To get a realistic assessment of any new power producing facility requires an understanding of load factors; the magic percentage that turns MW of capacity into MWh of supply. If we take a 1,000 MW new nuclear, gas or coal-fired base-load facility, we can normally expect load factors of 80%, which means the plant produces electricity 80% of the time, with the plant off-line for maintenance 20% of the time. Load factors in the wind business are undoubtedly creeping up, but are currently below 30%. Consequently 1,000 MW of wind capacity will actually produce much less than half the electricity provided by the base-load conventional plant.

Advances in fossil fuel combustion are the largest factor in limiting greenhouse gas emissions

This is not to deny the valuable contribution that wind makes, nor that this will grow. However, capacity numbers of themselves frequently give a very misleading picture of what renewable energy can actually do for the global picture. It suggests that conventional fossil fuel in electricity can easily be substituted, when it cannot, at least not quickly. This misconception creates an environment where the advances in fossil fuel combustion can be derided and scorned, when they are a major weapon in the fight against climate change. An excellent example is the UK's proposed new Kingsnorth coal-fired power station to be built by Eon in Kent; the first new British coal-fired plant for two decades. Four existing units amounting to just under 2 GW built in the 1960s and 1970s with thermal efficiencies of 37% will be demolished and replaced by two "supercritical" or high pressure/high temperature units amounting to 1.6 GW. These will aim for 50% thermal efficiencies and are likely to reach at least 45%.

Eon is now castigated by British environmental groups simply because of the word 'coal', although in fact the new Kingsnorth facility will reduce, rather than increase the UK's emissions from coal. Ever astute, Greenpeace commented: 'Coal is the dirtiest fuel on the planet... and we can't tell the Chinese and the Indians not to build a new generation of coal-fired power stations if we do the same here.' With respect to Greenpeace, if it thinks that Indians and Chinese are going to stop burning their only major source of indigenous energy, it has another think coming. In fact the best way to slow India and China's mutual carbon dioxide output is to maximize the thermal efficiencies of their combustion and this technology is one way of doing it.

In practice, by far the greatest contribution to reducing CO_2 output in electricity supply has been the shift from oil to gas combustion and the invention of combined-cycle turbine systems. Not only has efficiency of combustion moved from 30% to 50%, but the fuel shift has reduced CO_2 output too. Equally, to ignore increasing combustion efficiencies within hydrocarbons is to ignore the entire development of co-generation, or combined heat and power, which has greatly improved thermal efficiency, particularly in the manufacturing sector.

None of this is to devalue the role of renewable technologies, but the only way to "get real" is to recognize how small it currently actually is in the grand scheme of things. By end-2005, the latest consistent figures, renewable solar and wind electricity capacity combined, amounted to 64.3 GW. Let us be generous and assume that it has a load factor of 40%. If so, it will produce around 225.3 TWh a year. This is about 1.2% of the global total.

Given the current dependence on fossil fuels and given a lack of knowledge of the numbers, people have very little comprehension of the state of per capita energy demand either. For example, if we make the obvious assumption that China and India between them aspire to the per capita energy consumption of, say, Europe, then we will have to shift 2.1 billion people from an optimistic average of 1.5 toe to 3.0 toe per capita, per year. To do this we are going to need an extra 1.5 X 2.1 billion or 3.15 billion toe per year in a world that currently uses 10.8 billion!

The overall castigation of hydrocarbon combustion, no matter how efficient, also misses the point that different fuels produce different levels of CO_2 for varying levels of effectiveness in providing heat, light and motive power. Gasoline, for example, has less carbon content and thus produces less CO_2 than diesel, although compression-ignition engines may be more efficient than spark-ignition ones. In the grand hierarchy of combustion, when natural gas is burnt it produces less CO_2 per thermal unit than, say, coal.

However while natural gas, or methane, is a very valuable fuel, it is also a very powerful greenhouse gas, being 21 times more effective than CO_2 if it is not burnt and escapes into the atmosphere. As a consequence, burning potentially "free-to-air" methane, such as landfill or coal-mine gas actually reduces the threat to the environment of global warming.

The hydrocarbon route to energy is thus a much more sophisticated matter than is often suggested. It is both enormous and responsible for 87% of the energy required for comfort, light and motive power used in a massive global economy. Not for nothing does the cost and availability of this energy have a direct correlation with global economic growth. Equally, access to electricity has a strong connection with infant mortality, human longevity and health.

Yet if you look at the terms of the debate over global warming, you will look hard and in vain for phrases like million barrels a day, British Thermal Units, or standard cubic metres a year. Instead you will find one of the most confusing units of all: tons of carbon. Within the numerous papers of the Intergovernmental Panel on Climate Change (IPCC), the single most quoted numerical unit will be Gigatons of carbon (GtC). However, the Panel also use the units $GtCO_2$ and the equally valid $GtCO_2$-equivalent; the latter including appropriate measures of the other greenhouse gases (GHGs), according to their climate warming impacts.

Naturally, given the complexity of the science, it is hardly a surprise that scientists want to home in on a particular unit of comparison. Gasoline is around 87% carbon, and a litre contains around 0.639 kg of carbon. However, in combustion each carbon atom is joined with two oxygen atoms and as it happens, oxygen is heavier than carbon. So the amount of CO_2 produced from a litre of gasoline is actually around 2.4 kg. The diesel equivalent is around 2.7 kg.

There is also a strange thing about the use of carbon and CO_2 weight units in the policy debate about climate change. Of course a ton is always the same weight, but they are very different things. Carbon itself, when it is absorbed by the oceans or by trees, is what the environmentalists call a "sink" and harmless. CO_2 is the major GHG and to be avoided at all costs. To jump from one to the other as a matter of statistical convenience is extremely confusing to the debate.

This is particularly tricky in the context of "carbon markets", which do not trade in carbon, but in tons of CO_2. Effectively an artificial market, governed by official "credits", this too is detached from the real markets, which deal in tons of oil equivalent or thermal units. For example, the IPCC 2007 'Summary for Policy Makers' nowhere mentions any figure for a reduction in hydrocarbon use that defines the objective of stabilizing emissions. Everything is defined in $GtCO_2$-equivalent/yr. According to the summary, the worldwide output of GHGs in 2000 was 44.7 $GtCO_2$ equivalent, of which 56.7% came from fossil fuels. By 2004, this output had reached 49 $GtCO_2$ equivalent. Yet this is rather obscure in terms of energy numbers. So how many tons of CO_2 equivalent are produced by, say, a tonne or a barrel of crude oil?

> *The IPCC Summary nowhere mentions any figure for a reduction in hydrocarbon use*

Making it as simple as possible, one tonne of crude oil is roughly 85% carbon, plus or minus 1%. However, as noted, the relative weights of carbon and oxygen mean that one ton of carbon will actually produce 3.7 tons of CO_2. Consequently one ton of crude will roughly produce 3.7 X 0.85 or 3.145 tons of CO_2 equivalent when burnt. Consequently, 1 $GtCO_2$ (1 billion tons of CO_2) is produced by 320 million tons of crude on combustion, or 320 mtoe.

With this rather crude calculation it is possible to put the debate more firmly in the context of hydrocarbon consumption numbers and it is both depressing and encouraging. In 2006, the world consumed 3,890 million tons of crude oil, which released around 12.2 $GtCO_2$. On a pessimistic note, to get back now to the 2000 rate of CO_2 equivalent output would require a cut in emissions of around 5 $GtCO_2$ equivalent/yr. In terms of using crude oil consumption reduction as the only weapon, this would demand a 42% cut in global oil consumption!

Yet we are not just dealing with crude oil consumption, but with all hydrocarbons at around 9,500 million tons oil equivalent a year. To cut out 5 $GtCO_2$ would thus require a cut of 16% in total hydrocarbon usage. Yet the IPCC itself admits that only 56.5% of anthropomorphic GHG emissions are from fossil fuels so the purely hydrocarbon contribution to a cut falls again to around 9%, if appropriate cuts are made in other anthropomorphic emissions.

The crucial thing however is that climate change scientists, combustion engineers and environmentalists have to start talking in mutually understood numbers. Sometimes the debate seems to suggest that the only contribution that the hydrocarbon extracting and consuming industries make to the world is to increase atmospheric CO_2. Radical environmentalists who take this line should occasionally remember that solar cells themselves require temperatures in excess of 600ºC in manufacture and the fuel of choice is natural gas. We are not just trying to save the planet. We are trying to save the people who live on it too. ■

Chris Cragg is a freelance journalist who has written about energy matters for the past 25 years for numerous magazines and newsletters. He edited the Financial Times Energy Economist for 14 years and spent four years working for BP.