SUSTAINABLE CITIES

Assessing the Performance and Practice of Urban Environments

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I.B. TAURIS
LONDON · NEW YORK

Published in 2016 by
I.B.Tauris & Co. Ltd
London • New York
www.ibtauris.com

ISBN: 978 1 78453 232 1
eISBN: 978 0 85772 957 6

A full CIP record for this book is available from the British Library
A full CIP record is available from the Library of Congress

Library of Congress Catalog Card Number: available

Typeset in Garamond Three by OKS Prepress Services, Chennai, India
Printed and bound by CPI Group (UK) Ltd, Croydon, CR0 4YY

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CHAPTER 8

TRANSFORMING THE PSYCHOLOGY OF EMISSIONS

Douglas Mulhall and Michael Braungart

The main challenge of CO_2 is psychological.

The potential for large-scale re-use of CO_2 and other climate change emissions has been known for years but regulators, industries and environmentalists are so focused on CO_2 reduction schemes that they are missing one of the great opportunities of our era.

No-one is to be blamed for this oversight, but rather it is time for us together to grasp the potential by transforming the psychology.

For example, as early as 2007 agencies of the US Government were publishing studies showing that at least half the CO_2 emissions of fossil fuel generating facilities[1] could be profitably captured and re-used to grow algae for biofuel, at a cost of $28 per barrel or less than half of the then world crude oil price.[2]

In 2011, a study by scientists in India calculated that similar technologies would be able to capture and reuse 100 per cent of CO_2 emissions by fossil-fuel power plants.[3]

In 2013 another study concluded that algae biofuel can reduce CO_2 emissions by 50–70 per cent compared to petroleum.[4]

The estimates of those studies are probably conservative on the overall potential for CO_2 re-use because they exclude the potential of using CO_2 for a range of large-scale applications like energy storage and generation, and topsoil manufacturing.

The potential for CO_2 re-use is so great that Dr James Von Ehr, head of the nanotechnology company Zyvex, noted at a conference attended by the authors in 2008[5] that in the future environmentalists will complain that firms extract too much CO_2 from the air to manufacture their products and that the results are likely to freeze the Earth.

Of course, this is not too popular with environmentalists. However, Dr Von Ehr was quite serious and, even if this seems to be an absurd premise and perhaps dangerous, the question makes us think, what does he mean?

The traditional challenge

Our reality is the following:

Countries such as China and India do not love global warming but they see economic growth as a priority and they are delaying the CO_2 challenge until later, in the hope that technology will solve the problem.

Countries such as Canada and Russia in truth want global warming because it opens the northern waterways for shipment and it opens the north to exploitation. For example, ships can shave more than a week from their trips to the Far East using the northern passages.

Due to those inconvenient realities the traditional emissions challenge presents an impassable contradiction for environmentalists, and for Europe which is leading the emissions reduction efforts:

- Climate ambition: reduce emissions!
- Ambition of resource-rich and emerging economies: support industries which are a source of massive emissions to improve the standard of living!
- Conclusion: economic ambitions contradict climate ambitions.

As a result of those impasses at the United Nations Climate Change Conference in Warsaw, Poland in 2013, the world began to abandon the concept that it is possible to limit emissions of CO_2, and began instead to prepare for adapting to climate change – an approach entrenched in the 2015 Paris climate agreement, where countries opted for non-binding reduction targets while encouraging adaptation expenditures.

The positive solution

In the past decades various industries have been using CO_2 profitably in ways which are not well known but which are basic chemistry. These give us new solutions if applied in other industries and scaled up.

The applications currently being used in several industries are based on the reuse of CO_2; not only the capture of CO_2 which is already well known but the reuse for products and processes as well as the production and storage of energy.

To be clear, it is important also to reduce greenhouse gas emissions by adopting renewable energy and other beneficial technologies. However, the reuse of CO_2 will provide the missing ingredient; it will speed the take up and boost the efficiency of renewable energy as well as give us the margin of manoeuvre to scale up new technologies.

Reuse of CO_2 is not an excuse to do less, but rather a tool to make more with positive results. The potential of the approach is far-reaching:

- Climate ambition: reuse emissions!
- Ambition of emerging economies, rich in resources: reuse emissions to develop economic activity!
- Conclusion: economic ambitions support climate ambitions!

CO_2: the potential

The use of CO_2 as an industrial chemical is nothing new. The following profitable practices are already in place:

- manufacture of products;
- agri-food production;
- cleaning;
- improving energy production;
- improving energy storage.

Nor is it a secret. The CO_2 revolution is accelerating in a broad movement across Europe, North America and Asia. Dozens of international conferences have taken place since 2008. Hundreds of studies have been published and in 2013 a new scientific journal on the reuse of the CO_2 was launched.[6]

Why reuse CO_2?

There is strong practical justification for the reuse of CO_2, based on the new potential created by human technology. While comparatively rare in nature (albeit sufficiently abundant in the atmosphere to act as the main greenhouse gas), in human technology it is plentiful and concentrated. It is therefore a good industrial chemical with valuable properties:

- it is a safe chemical substance which replaces toxic substances;
- it is an agricultural nutrient;
- profitable uses are already possible and new technologies are accelerating

The path from CO_2 capture and storage to capture and use

The profitability of CO_2 reuse is already established in several industries. Mitsubishi Heavy Industries captures CO_2 in a cost-effective way from the flue gases at the outlets of refineries (notably in Bahrain, Vietnam and Japan) and uses it for the production of urea fertiliser. In Vietnam since 2009 the company has captured and used the CO_2 to produce tens of thousands of tonnes of urea per year.[7]

Other profitable areas for CO_2 reuse include air conditioning, as dry ice for cooling, for caffeine extraction by coffee and tea manufacturers, and in the production of the multi-use chemical, sodium carbonate.

Supercritical CO_2 (S-CO_2)

The supercritical state is a state which is neither liquid nor gas at a pressure greater than 74 bar and a temperature above 31°C. At this level, S-CO_2 has special properties, the ecological strengths of which are undeniable:

- S-CO_2 is chemically inert, natural and non-toxic. It thus replaces many solvents subject to increasingly severe regulations;
- it has a low temperature of use;
- it extracts and refines other materials without residual solvents;
- its power as a solvent is adjustable depending on the pressure and temperature;
- it does not contribute to the greenhouse effect when it is used in a closed circuit, and it is extractable in a closed circuit;
- it has the power of penetration of a gas and the extraction capacity of a liquid;
- it leaves no trace residual on treated materials;
- it has a large diffusive potential and a high density that makes it transportable.

Specific applications

One example of use in the business to consumer (B2C) marketplace is the Dualwash® dishwasher. When the wash cycle begins, the cycle of carbon dioxide is activated, and S-CO_2 is pumped to the cleaning chamber. S-CO_2 has a low surface tension which means it spreads quickly, broadly covering all surfaces.[8]

At present in the textile industry, to dye a kilo of textile needs 100–150 litres of water depending on the type of fabric. According to some estimates,

CO$_2$ AS A RESOURCE FOR THE CIRCULAR ECONOMY

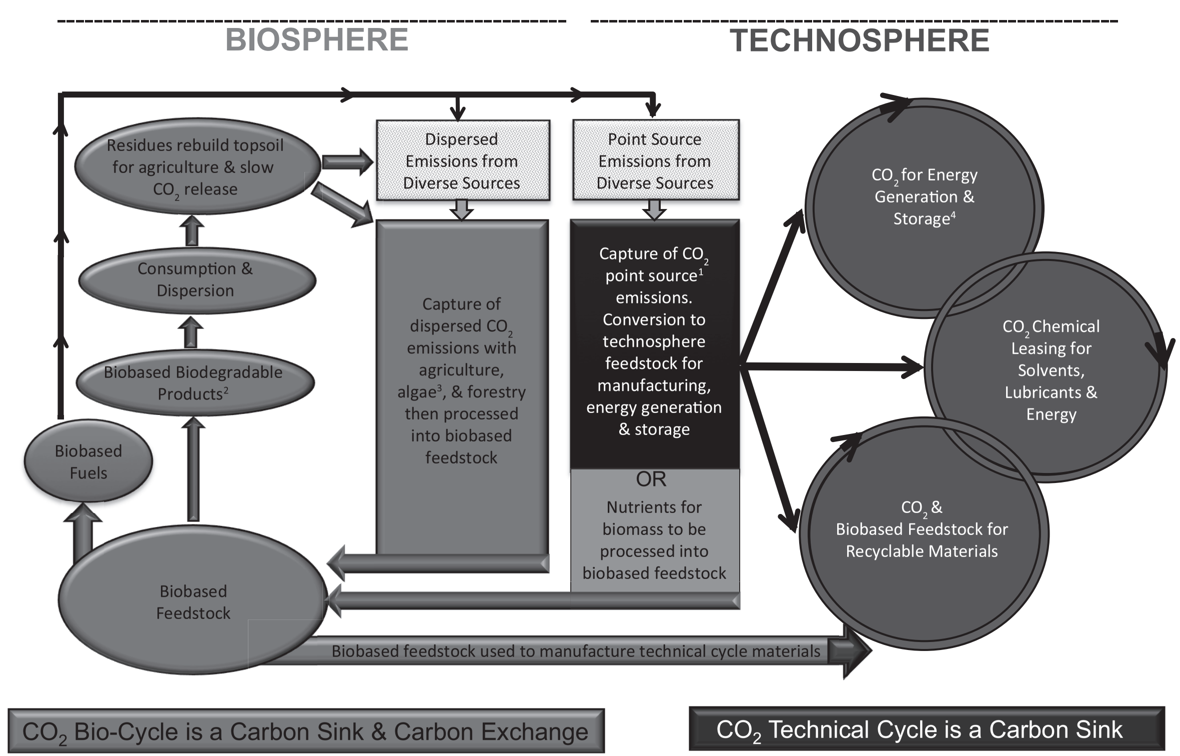

Figure 8.1 CO_2 as a chemical is adaptable for biological or technical cycles in the circular economy. In the biological cycle it is used as a nutrient for growing biomass. In the technical cycle it is used in closed loops as a solvent and for energy storage and generation. Commercially it is suitable for leasing schemes like rent-a-solvent which is commonplace today, based on the Cradle to Cradle Design Protocol.

NOTES (see also colour version at Plate 5b):

1. Point source capture utilises industrial and agro-industrial processes. Atmospheric capture utilises natural & agro-industrial processes. Synthetic photosynthesis might lead to large-scale industrial capture without those intermediary processes.
2. Biodegradable products are designed to be consumed then the residues used as topsoil components which sequester CO2, or conversely are dispersed into the environment where they decompose & release CO2 as part of the carbon exchange bio-cycle.
3. Studies by the US National Renewable Energy Laboratory (Pienkos 2007) suggest algae have rapid scale-up potential for CO2 re-use when integrated with processes like wastewater purification to make them more economic.
4. CO2 replaces gas and other fuels to drive turbines which generate electricity used for industry. CO2 phase change & chemistry is used to store energy. CO2 is also being used for artificial photosynthesis.
5. Materials in the technical cycle are recyclable continously. In practice there is leakage which is often recoverable by physical or chemical capture.NOTES (see also colour version at Plate 5b):

Source: Illustrative Diagram © 2014 Mulhall, Hansen and Braungart.

upwards of 30 billion kilos of textiles per year are dyed requiring some 4,000 billion litres of water. In addition, during the process, countless chemicals are added which have serious consequences for the environment; according to the World Bank, the textile industry is responsible for 17–20 per cent of water pollution at the global scale.[9] The technology of dyeing with CO_2 begins to solve these problems. Dyecoo, a Dutch company has successfully pursued the CO_2 based colouring of textiles without using water and companies such as Nike have adopted the technology.[10]

In yet another application, central banks are starting to use supercritical CO_2 to clean money without damaging security features in the banknotes.[11]

Supercritical CO_2 can be used as a propellant to operate turbines and also to store energy from wind and solar energy. It is therefore an accelerator of renewable energies and a business model to improve their economics. The resulting turbines can be:

- 50 per cent more efficient than power plants using steam turbines;
- 40 per cent more efficient than power plants using gas turbines;
- 3–5 per cent of the usual size of turbines (20MW electricity for $4m^3$)

The level of investment in supercritical CO_2 turbines is increasing rapidly. Investment in the United State rose to $500 million in the six years to 2013.

The effective potential

Critics contend that despite the many profitable uses of CO_2 its capture is still too expensive and will not consume sufficient emissions to make a difference. This is an inaccurate perception because the critics do not calculate the economies of integration. For example, the earlier referenced calculation by the US Government's National Renewable Energy Laboratory showing the ability to capture CO_2 with algae that would generate biofuels is based on a calculation by Energy Biosciences Institute (University of California, Berkeley) that integrating the purification of wastewater by algae with the production of biofuels is feasible at a competitive cost compared to the per-barrel price of crude oil despite the recent drop in oil price.

In addition, and based on the same technologies, the earlier-referenced calculation by researchers in India shows that India could become self-sufficient in oil by using 100 per cent of emissions of CO_2 from thermal electricity generators to produce bio-fuels from algae. The difference between the US and India calculations is due to the high solar intensity across India.

Figure 8.1 shows the diverse ways in which CO_2 is used as a resource, and how this might develop into a systematic solution for the economy.

Those estimates do not include the many examples described above for the reuse of CO_2 for industrial processes and the products that are already in the market.

CO_2 is a resource, not a diabolical enemy

The examples presented here describe how carbon dioxide could be the basis for a CO_2 economy with positive impacts on the environment, health and the overall economy, as opposed to the prevailing strategy where we just try to minimize our negative impacts. The reuse of CO_2 is not the only way to solve the climate challenge, but it will give us valuable time to transform our industrial society and move it in that new direction. Using for example the 'Cradle to Cradle' design protocol that puts the emphasis on positive impacts, industry and governments will be able to re-use CO_2 for a circular economy, instead of only capturing CO_2 and perpetuating the old paradigms of energy from fossil fuels.

Among the other gains are to replace toxic substances, renew agriculture, and accelerate renewable energy, as well as maximise the effectiveness of old energy technologies instead of building more plants based on fossil fuels.

The fastest way to take advantage of these positive impacts is to change our perception of CO_2 from that of a diabolical substance to a beneficial resource.

Notes

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