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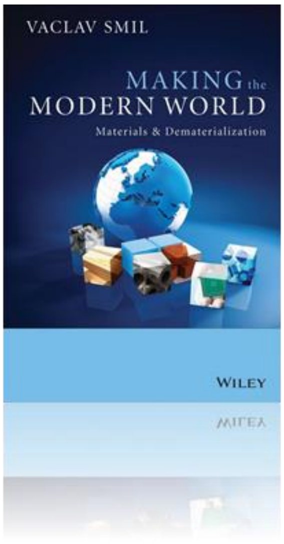
41 Book reviews on global economy and geopolitical readings

Fundación REPSOL

Obra Social "la Caixa"

Making the Modern World: Materials and Dematerialization

Smil, Vaclav, (2014), John Wiley & Sons Ltd, United Kingdom.



"The world now consumes in one year nearly as much steel as it did during the first post-World War II decade, and (even more incredibly) more cement than it consumed during the first half of the twentieth century."

"The pursuit of endless growth is, obviously, an unsustainable strategy, and the post-2008 experience has shown how dysfunctional modern economies become as soon as the growth becomes negligible, ceases temporarily or when there is even a slight decline."

"This calls for a new society where, once basic material needs are taken care of, the sense of wellbeing and satisfaction would be derived from experiences that are not at all, or only marginally, correlated with higher energy flows and expanding material possessions."

Summary

Mankind's history — from the evolution of the species to the spread of Information and Communication Technology (ICT) — would not have been possible without growth in the availability and complexity of materials. Nevertheless, this material progress was not of a linear nature. The first stage in this story was one of slow economic growth in which the masses lived with very few possessions, most of which they crafted themselves in small quantities. This stage lasted until the beginning of the era of rapid economic modernisation — that is to say, until the 18th century in most of Europe, until the 19th century in the United States, Canada and Japan, and until the second half of the 20th century in Latin America, the Middle East and China. The main reason for this was a shortage of energy. The turning point was when the chemical energy found in fossil fuels was turned into kinetic energy at low cost and applied universally in mechanical engines. This marked the beginning of a second stage, which was characterised by a leap in the consumption of materials. Electricity generation and the rise of chemical synthesis boosted this trend exponentially.

In this book, the author takes the reader on a remarkable voyage, revealing the materials that have made modern life possible. He makes us reflect on key questions such as materials' capacity to contribute to economic growth, the limits to growth in our consumption of materials and the extent to which economic growth can be divorced from the consumption of materials. Although the author refuses to make forecasts, his deep analysis of the past and present makes it pretty clear where we might end up.

The author

Vaclav Smil carries out interdisciplinary research in energy, environmental change, population, production of food and nutrition, technical innovation, risk analysis and public policies. He has published over 30 books and 500 papers on these subjects. Smil is Emeritus Professor at the University of Manitoba, a member of *The Royal Society of Canada* and the first non-American to receive the American *Association for The Advancement of Science* prize in *Public Understanding of Science and Technology*. In 2010, he was listed by *Foreign Policy* as one of the fifty top global thinkers.

Key ideas and opinion

Over time, **the modern world has become more dependent than ever on a seemingly endless flow of materials.** The adoption of highly efficient production processes and high levels of recycling have proved insufficient to stem soaring demand for materials — which is driven by population growth and rising living standards.

To convey his main message, Vaclav Smil splits the book into **four sections**: the first **chronologically traces advances in the extraction and production of the main materials** throughout history and describes how those materials were used. The second section looks at **changes in the productivity of material extraction, processing and uses as well as energy costs and social, economic and environmental impacts**. The third section analyses **material flows, growth in demand and the global energy needs that ensue**. The fourth and last section of the book analyses the **prospects for 'dematerialisaton' and 'de-carbonisation' and sketches likely trends** that will determine consumption rates and their implications.

How we got here

Vaclav Smil conducts a chronological **study of mankind's use of biological raw materials and their subsequent processing**, scanning materials from agriculture, forestry, metal-working, non-metallic ores, non-renewable organic compounds derived from fossil fuels, and industrial gases. Smil reviews and quantifies some key uses. The author stresses that the period spanning from Antiquity through the Middle Ages and up to the beginning of the Modern Age (1500-1800) saw remarkable advances in the building of **ships, roads and aqueducts.** Recent estimates of the quantity of material used by the Romans to build some 85,000 kilometers of main roads is of the order of 425 million cubic metres of aggregate (sand and gravel) and quarried stone. **The author finds the rise of metal-working even more remarkable**. For example, the total production of lead in Ancient Greece and Rome was 250 tons a year in 750 BC but rose to 80,000 tons a year in 50 AD. There was a huge rise in the **mining of gold and silver** — mainly in Mexico, Peru and Bolivia — which rose from 40 tons a year in the early 16th century to 600 tons a year during the last four decades of the 18th century.

Up until then, pre-industrial societies were not so different from Medieval ones in terms of diet, life expectancy, living conditions, fuel consumption, daily decisions, the availability of raw materials and the uses to which materials were put. The 19th century upset this balance. **Industrialisation and urbanisation created a modern material civilisation** characterised by two processes: (1) a **large increase in the sourcing of traditional building materials** and (2) **soaring consumption of metals**. The author notes that the first process is usually forgotten. **Haussmann's rebuilding of Paris** required 350 tons of stone for the foundations of each of the 40,000 new buildings and 250 tons of stone for each façade. This meant **25 million tons of stone** were needed for the scheme. Furthermore, wastage arising from transport, stone-cutting and handling could easily double this figure. With regard to metals, this was the first time in history that **cheap steel had been used to build machines, structures and devices that had hitherto been fashioned from iron and wood**. Railway-building alone used 20 million tons of steel between 1850 and 1900.

Last but not least, the author focuses on the **quantitative and qualitative progress made in the use of two key materials that were vital for 20th century society: metals and plastics.** These materials underpinned the mining of fossil fuels, industrialisation, urbanisation and modern land, sea and air transport. In general terms, **demand for metal rose three-hundred fold between 1900 and 1943**, reaching 2 million tons. This unprecedented rise was mainly driven by the building of warplanes — above all in the United States, whose production figures far outstripped those of all the other warring nations. After 1950, many other producers entered the market. In 2000, annual metal production was close on 25 million tons. In 2008, the figure had risen to 40 million tons, with China contributing the biggest rise after 2000. Total production of plastics was under 50,000 tons a year in the early 1930s and did not reach a million tons a year until 1949. It exceeded 6 million tons in 1960. Nowadays, industry offers some 50 kinds of plastic. **Smil stresses the importance of fertilisers, without which it would have been impossible to feed the 4.5 billion persons added to the world's population during the 20th century.** Furthermore, the rich diets we enjoy today were only possible thanks to this massive artificial nitrogen-enrichment of soils. World production of fertilisers rose from just **150,000 tons in 1920 to 3.7 million tons in 1950 and 85 million tons in 2000**.

The most important raw materials

In reviewing the most important raw materials in quantitative and qualitative terms, Smil argues that the top bio-materials are **wood** (used in the building and furniture industries) **and wood pulp**, used to produce paper. The latter's use has soared worldwide, despite a drop in paper use at the beginning of the 21st century due to the advent of digital media and photography. In particular, pulp production in China surged from 127 million tons in 1975 to 325 million tons in 2000 and over 400 million tons in 2011. In his analysis, Smil also stresses that one of the world's oldest industries — **brickmaking** — has surged as a result of **China's building boom**. In 2010, China produced 900 billion bricks, almost 60% of world output in that year. **China has also been the world's biggest cement producer since 1980**. Today, it turns out 1.88 giga-tons a year — that is to say 55% of world output, with its ensuing environmental impact. **In 1950, CO_2 emissions from cement manufacturing made up 1% of all carbon dioxide from fossil fuel use. In 2010, it had soared to 5%.**

The combination of soaring industrialisation, greater use of transport, the mechanisation of agriculture and the advent of mass consumption drove growing demand for **metals** during the 20th century. **The output of iron — mainly in the form of steel — rose thirty-fold between 1900 and 2000**, reaching almost 850 million tons a year on the eve of the 21st century. It passed 1 giga-ton (1000 million tons) in 2004 and reached 1.52 giga-tons in 2011. China is now the main driver of this trend, accounting for 45% of production (whereas the EU only makes up 12%). Another metal in heavy demand throughout the 20th century was **aluminium**, which is used in the building of military aircraft, houses, communication and spy satellites, vehicles and drink tins.

As with metals and cement, **China has become the world's biggest manufacturer of plastics**, accounting for no less than a quarter of world output in 2010. Even so, Smil notes that in per capita terms, **the Chinese only consume 50 kg of plastic per head per year, compared with 115 kg in the EU and 125 kg in the United States**.

In this round-up of key materials, Smil dedicates a section to the main **industrial gases**. The author underlines the importance of **liquid nitrogen**, which is not only used to conserve vaccines and tissues but also to freeze the ground and make it easier to drill tunnels, for recycling tyres and solvents, boosting oil recovery, and making plastic moulds (among other things). **Nitrous oxide** is used for anesthetic sprays, while **helium** is used in cryogenic applications, for pressuring rockets, in chromatography and for weather balloons. **Hydrogen** is used in oil refineries for *cracking*, as well as to deodorize and desulphurize oil. As a result, **industrial gases are used in sectors making up over half of the world's production.** Their growth rate has outstripped that of the global economy — in 2000 the market in industrial gases was worth USS 34 billion. A decade later, it had almost doubled, reaching $60 billion and **in 2015 it may reach $80 billion.**

Material flows

Following his analysis of the production of the materials vital for modern societies, Smil focuses on the world's biggest consumers — that is to say, those in the United States, the European Union, China and Japan. He notes that in the **United States**, **the combination of economic growth and immigration boosted the nation's population**

3.7-fold and its GDP 26.5-fold between 1900 and 2000, leading to absolute growth in the consumption of all materials. Materials produced for agricultural grew 1.7-fold and non-renewable organic materials 90-fold. The consumption of paper and cardboard grew almost 19-fold. Bulk materials used in construction accounted for 38% of all material flows in the United States and reached 77% in 2006.

Smil notes **the European Union's dependence on imports, especially metallic ores, concentrates and semi-finished products**: in 2009 the EU imported 58% of its consumption in these materials, in comparison with only 4% in non-metallic minerals. Divided by sectors, services make up the lion's share of demand (4.95 giga-tons or 60% of the total), followed by manufactured goods (2.4 giga-tons or 29% of the total) and utilities, agricultural products, mining and quarrying — each accounting for around 360 million tons (4%). These percentages reflect their respective contributions to GDP.

China was fairly backward when it began to modernise under Den Xiaoping. **The country's GDP per capita in 1980 was just $250 — that is to say, less than that of Pakistan.** The author stresses that it was foreseeable that material flows would go through the roof as China industrialised. One estimate is that the country's **mining and quarrying for the building industry grew 25-fold between 1980 and 2010** and has almost tripled since the 2000s. **Cement** production also soared from **80 million tons in 1980 to 2 giga-tons in 2011**. **Metal** production rose 17.5-fold between 1980 and 2010 (that is to say, from 37 million tons to 634 million tons, or 45% of the world total). Yet it is China's **plastic** production that has shown the greatest rise (**the figure for 2010 being 70 times greater than 1980 production**).

Finally, the author notes that the figures for **Japan** can be applied to any other economic power. The country's **consumption of materials rose 40-fold between 1878 and 2005**, most of this dating from Japan's economic miracle from the 1950s onwards. The bulk of this consumption was (and still is) based on imports — a dependence made all the more acute by the country's need for fossil fuels. **Today,** while Japan remains a rich country dependent on the massive import of materials, the combination of an **ageing population, economic reverses and de-industrialisation has led to a drop in imports** and either stagnation or a fall in consumption.

Following this analysis, Smil goes one step further, combining production rates with unit energy inputs to determine the **global energy needs arising from each material**. Thus **steel**, with a relatively high energy input by weight (25 giga-Joules per ton) and massive production (1.43 giga-tons) in 2010 is the **material making the highest overall energy demand** (around 50 EJ (or 10% of the Total Primary Energy Supply (TPES) needed to produce all metals in 2010. it is followed by **plastic,** with an energy input by weight of around 80 giga-Joules per ton. With plastic production of 265 million tons in 2010, it accounts for 20 EJ, or 4% of TPES. Third come **building materials** (cement, bricks, glass) at 15 EJ, or 3% of TPES; fourth is paper, at 10 EJ; fifth, fertilisers at 8 EJ.

By way of example, the author notes that if the energy per ton figure for steel were the same as in 1900, the global production of 1.5 giga-tons of the metal in 2010 would have represented 20% of TPES rather than today's figure of 6%. The point he makes here is that **modern civilisation can only allow the present levels of production thanks to scientific discoveries and technical advances**, which improve energy efficiency. In recycling, however, the road ahead is still quite long. **International re-cycling rates are currently 30% for zinc, 33% for aluminium, 37% for steel and 40% for copper.** The benefits of recycling include lessening environmental impact and energy-savings. Full recycling would slash the energy needed to produce each ton of steel by 75% and for each ton of aluminium by 74%. **Recycled paper could be produced with 40% less energy while saving 45% in water and 50% in solid wastes**.

Prospects for 'dematerialisation' and de-carbonisation

While the quest for greater productivity and lower costs in manufacturing industry has made for more efficient use of materials, the trend towards 'dematerialisation' is anything but simple. For Smil**, "even in a case that appears to be the perfect example of dematerialization, the reality is nothing but a complex form of material substitution."** The author gives the example of Computer-Aided Design (CAD). Although use of CAD has reduced the wood harvesting, production of pulp, paper and drafting implements, and steel storage, it has created additional demands in the form of the power and hardware used by high-tech electronic equipment.

Likewise, the author notes that **the process of 'decarbonisation' that took place after the Second World War was less than clear-cut**. Making comparisons of the energy contribution of high-carbon fuels (wood and coal) over time reveals that they made up almost 94% of the world's total energy output in 1900, 73% in 1950 and 38% in 2000. Even so, **the process of decarbonisation has slowed since 1990**, the proportion of global hydrocarbons has stabilised and natural gas has risen from 26% of fossil fuel supplies in 1990 to 28% in 2010. Smil acknowledges that there have been spectacular advances so far and that more will be forthcoming (especially thanks to progress in the production of natural gas and greater use of renewable energies — hydro, wind and solar). Even so, **he stresses that there are no prospects of major cuts in absolute CO_2 emissions in the near future**.

Beyond the environmental catastrophes that may stem from failure to cut our absolute consumption of materials and to reduce CO_2 emissions, the present gulf (as of 2013) between the world's 'haves' (1.5 billion) and 'have-nots' (5.5 billion) remains huge. **Even if the poorest four fifths of mankind were to only aspire only to a third of the living standards of the wealthiest fifth, the world's material needs would continue to soar over the next few decades**. Smil considers that growth of this kind is unsustainable. The timing of 'the crunch' will be determined by complex interactions among various factors: population dynamics, wishes and attitudes, economic growth, production costs, technological innovation, international relations and worldwide environmental changes. Although we can hope that humankind's ingenuity and adaptability will sooner or later show us the path we must take, the fact is that **changing the use we make of materials is neither easy nor quick** – making the final outcome of such a process necessarily uncertain.