

# THE AGE OF LOW TECH

TOWARDS A TECHNOLOGICALLY SUSTAINABLE CIVILIZATION

PHILIPPE BIHOUIX



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Sustainable Civilization

Philippe Bihouix

Translated by Chris McMahon

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## Prologue: The Mad Dance of the Shrimps

It is May 1940. German armoured columns have broken through the French lines and the terrified population is pouring onto roads that are quickly becoming clogged by refugees. From his spotter plane, sent on a desperate mission over enemy lines to gather information that nobody will use, Antoine de Saint-Exupéry contemplates the debacle:

Of all these objects the most pitiful were the old motorcars. A horse standing upright in the shafts of a farm cart gives a sensation of solidity. A horse does not call for spare parts. A farm cart can be put into shape with three nails. But all these vestiges of the mechanical age! This assemblage of pistons, valves, magnetos and gear-wheels! How long would it run before it broke down?<sup>1</sup>

Forgive me, my dear Saint-Ex, for using your insightful reflection as an example of low-tech, simple technologies. As an intrepid aviator, you were of course wholly convinced by advanced technologies. But you asked for it, proposing the abandoning of yesterday's elegant cars to return to the horse and cart! Nothing, for me, summarizes better the crucial question facing our industrial society. Exchange electronics for the mechanical – replace pistons and valves by transistors and capacitors – and the insight is as fresh today as it was in 1940. Could our technically complex, globalized, specialized world withstand a catastrophe, whatever it might be – a dearth of easily accessible energy and material reserves, the consequences of pollution – especially climate change – or some new and more acute financial and economic crisis?

This book develops the thesis, radical I know, that instead of seeking top-down solutions to current environmental and societal challenges, instead of seeking ever more innovation, high technology, digitalization, competition, networking, growth – giving them names such as 'sustainable development', 'green growth', 'Economy 2.0' – we must instead direct ourselves, as

quickly as possible, to a society based primarily on simpler technologies, undeniably cruder and more basic, maybe a little less powerful, but much more resource-efficient and locally controllable. This idea is not new: as early as the 1940s and 1950s, writers like Bernard Charbonneau and Jacques Ellul<sup>2</sup> denounced the race towards more technological societies; in the 1960s and 1970s, Ivan Illich<sup>3</sup> and Ernst Friedrich Schumacher<sup>4</sup> argued for the use of 'convivial' or 'intermediate' technologies. More recently, authors like Langdon Winner<sup>5</sup> and John Michael Greer<sup>6</sup> developed the same kinds of ideas, while Kris de Decker launched a very comprehensive website dedicated to historical analysis and refreshment of past knowledge and technologies, now also published as a book.<sup>7</sup>

Before going into detail, I owe readers some explanation about what led me to take such a view. Nothing predestined me to choose the horse and cart, or to take the opposite view to the majority of my fellow engineers, who swear by high technology, research and development, and innovation. In short, I should explain why I must take a view opposite to today's conventional wisdom and in contradiction to those who assume unstoppable progress.

Born two years after the first moon landing, my childhood, like many of my generation, was marked by many scientific and technical exploits, entertained by sci-fi films and regularly filled with 'revolutionary' products. In the year that I was 10, Space Shuttle *Columbia* took off from Cape Canaveral – the poster is still on the wall of the room I had as a child – and a few months later *Paris Match* published the superb images of Saturn that were transmitted by the *Voyager 2* probe. At the beginning of the 1980s, the first wave of consumer electronics began, with electronic calculators, the first Japanese digital watches with their tiny lithium batteries, and handheld video games. As school students, we spent hours programming low-resolution arcade games like *Space Invaders* on early computers provided by the Ministry of Education (provided, I suppose, as support for French technology and for the recently nationalized Thomson-CSF company against its great rival Amstrad – the processor was a Motorola, but hey). And soon the Sony Walkman would let us experience the joys of personal music on the move.

In short, life followed its course, and progress its obviously linear path. There had of course been some technological disappointments. The popular science magazines of the 1950s were a little premature in announcing electricity that was too cheap to meter, nuclear cars and toasters, and even helicopters for urban travel. And, contrary to predictions, supersonic aircraft did not cross the oceans in their hundreds – two oil shocks put a stop to that. But, with the oncoming rush of new information, only a grumpy few remembered.

Of course, not everything was perfect on the planet. Developing countries had not developed as fast as expected, but everyone suspected it was partly their fault anyway. Decolonization was still recent, and 'technology transfer' programmes were in full swing, against the backdrop of the Cold War. The people of the Soviet bloc seemed to be having a bit of a hard time, but that made great scenarios for spy movies. There was pollution, but it was localized, at least in people's perception. Yes, the mercury poisoning of Minamata Bay was horrible, but it didn't affect so many people and it was a long way away. One might even say that localized pollution, pollution 'in our backyard', was on the wane.

That was indeed sometimes the case, as a new phenomenon had appeared that partly accounted for lower levels of pollution and that was promised a bright future: deindustrialization. We saw the effects across Europe, especially for coal mining and areas with particularly visible industries such as blast furnaces and metallurgical plants. In the case of the iron and steel industry, deindustrialization was largely a rationalization of productive apparatus, and a downward adjustment in capacity that followed from a reduction in demand. The effort of post-war reconstruction, the era of growth from the late 1940s to the 1970s had passed. For coal mines, it was more a matter of the closure of mines that were no longer profitable. But a new trend, deindustrialization by relocation of production, was taking shape imperceptibly. 'Made in Europe' was moving on to other places. From the 1970s, Japanese products began to roll back 'Made in the USA'. European industry also turned to the east as city-states like Hong Kong and Singapore were beginning their success stories, backed by a China that was preparing to become the factory of the world.

Well, you know the rest. While the fall of the Berlin Wall brought hope of a bright future, the global impacts of human activities emerged in public debate: the hole in the ozone layer, deforestation everywhere continuing apace, then, and soon enough, climate change. This time, things were really starting to look not so good for the planet. For a while, at the beginning of the 2000s, such matters were eclipsed by the first internet madness and the 'dematerialization of the economy', but questions soon returned. Recall French President Jacques Chirac saying in South Africa in 2002: "Our house is burning and we are watching elsewhere. [...] We will not be able to say that we did not know."<sup>8</sup>

While all this was going on, I was getting my education. I had learned at school how to solve equations a little faster than some others and had become a typical product of French meritocracy, promised a bright future in science and engineering, even if my engineering Grande École (college) had begun, like many others, to graduate battalions of traders, financiers, auditors and consultants. A few years of industrial experience,

though, allowed me to discover the material reality of our economic system and its physical consequences. 'Environmental' approaches could have only limited effect and European and global integration was under way. The 'mad dance of the shrimps', in which shellfish were caught in the North Sea and then, for reasons of labour cost, shipped to Morocco to be shelled, or strawberry yoghurts for which, in 1992, the ingredients had travelled more than 9,000 km, helped engender in me a certain scepticism concerning the nature of progress.

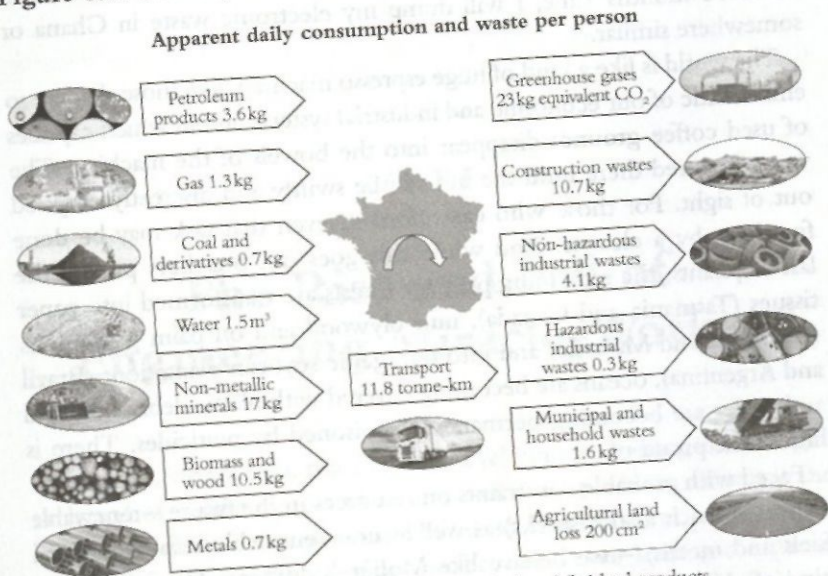
Fortunately, of course, the concept of 'sustainable development' was to arrive to save the day. Amid a surge of activities and publicity the concept was formalized in the Brundtland Report in 1987 and pioneered the response to planetary challenges. Like me, you will have noticed that everything now has become 'sustainable'. There is no product that is not 'eco-designed', no city development that is not an 'eco-neighbourhood', no building of any importance that is not 'low consumption' or 'environmentally friendly'. Even roads, airports and Formula One races are now being declared environmentally friendly, thanks to measures to protect toads from being squashed, or because of progress towards more efficient engines. All major companies and local communities produce thick reports – which were originally on glossy paper and are now from 'sustainable sources' – to present their strategy 'for sustainable growth', to promote their commitment to the planet and to present their key data which are of course all 'green'. This is the time of the 'circular economy™' and 'industrial ecology©', astounding oxymorons and idols for modern times!

Well, we have gone at it for a few years now with little effect. We have cut down trees and burned oil in order to explain to ourselves that we were going to protect forests and economize on fuel. The discourse of sustainable development has been over-used, twisted, diverted, degraded, become ridiculous enough to make us sick. But facts are stubborn, and, like any engineer, I like facts and figures. In reality we have never produced, consumed and discarded as much as we do now. Bees take refuge in cities, preferring diesel soot to the 'innovative' molecules of the agro-chemical – sorry 'phytosanitary' – industry. Our rubbish bins are full and overflowing. Even if the weight of the rubbish can be reduced a little, its harmfulness increases – and recycling rates are progressing at a sluggish pace.

Many European countries consider themselves virtuous, in real environmental transition. But consider what is happening in France (see Figure 0.1; with variations, we will see similar figures for many European countries). Its people produce around 2 tonnes of industrial waste per inhabitant per year, almost 5 kg per person per day! Each day, its



Figure 0.1: One day in France ...



Note: Balance of imports/exports based on semi-finished and finished products.  
 Sources: Institut Francais de l'Environnement (French Environment Institute - IFEN)  
 French Government Ministries, Agence de l'environnement et de la maîtrise de l'énergie  
 (Environment and Energy Management Agency - ADEME)

inhabitants generate 12 tonne-km of freight movement per person – that is about 100 kg of goods moved an average of 120 km – 88 per cent by road. As the urban sprawl shows, about 1 per cent of the country – the size of a French administrative *département*<sup>9</sup> – was built on in ten years, and then a further 1 per cent in only seven years! This has often been on the best farmland, resulting in an irreversible mess – nothing edible will be produced for hundreds of years under the tarmac of supermarket car parks.

On a global scale, 20 per cent of the world's population continue to exploit more than 80 per cent of its resources, and in one generation we are about to extract more metals from the Earth's crust than in the entire history of humanity. It is tempting to blame emerging economies, and China above all, for this increase. But let's not forget that China's resource consumption is also driven by its role as factory of the world, and we import, directly or indirectly, a good part of its output.

The world is like a movie set. The façades, for the consumer, still attempt to look good. In advertisements, in shops on supermarket shelves, everything is fine. But behind the façades there is a reality. There are hidden consequences even when we have the best of intentions. I can buy a mobile phone in France, and in doing so I will have exploited Congolese miners, destroyed primary forests in Papua New Guinea,

enriched Russian oligarchs, polluted Chinese water tables and then, in 12 to 18 months' time, I will dump my electronic waste in Ghana or somewhere similar.

The world is like a kind of huge espresso machine, like those that are so emblematic of our economic and industrial system, and in which capsules of used coffee-grounds disappear into the bowels of the machine. The waste is stored there until the bin can be swiftly and discreetly emptied out of sight. For those who can afford it, even that task may be done for them by a cleaner. And while this goes on, poachers pursue the last elephants, the remaining primary forests are transformed into paper tissues (Tasmania and Canada), into plywood and oil palm plantations (Indonesia and Malaysia) and into transgenic soybean plantations (Brazil and Argentina), oceans are becoming covered with plastic debris and land and water are becoming permanently poisoned by pesticides. There is little to be proud of.

Faced with probable constraints on resources in the future – renewable resources (such as fish stocks) as well as non-renewable resources (fossil fuels and metals) – we behave like Molière's doctors. These were the kind of physicians the English came to call Leeches. They believed that bleeding was a cure, and if the patient got worse, then not enough blood had been drawn – until the patient died, needless to say! For us, we swear by innovation and technology. Millennia of exploration, experiment and innovation brought us to the incredible acceleration of the 19th and 20th centuries. This came at the cost of pollution and has now brought us to unprecedented social and environmental destruction, the ultimate consequences of which we can no longer know. We even have trouble admitting to ourselves the consequences in the here and now. Faced with the unknown, with the troubling, brutal disease of the Anthropocene, we still hope, or pretend to hope, for future growth and that this can become 'green growth', to reverse the effects of our past activities. We even seem to say, absurdly, that such growth should accelerate because 'a little growth pollutes, a lot of growth cleans it up' (thanks to the boost of innovation).

I do not believe it. Not any more, for the many reasons I have shared with you in this Prologue. But rest assured, I don't propose that, as in Dante's *Divine Comedy*, you should abandon all hope (*Lasciate ogni speranza, voi ch'intrate*). On the contrary, I believe there is a way of avoiding a global crisis, conflict and collapse, or, more simply, depression and despair. And who knows, maybe an age of low tech, a time of a technologically sustainable civilization, will come.

## PART I

# 'Engineering Miracle-Workers'

Innovation, we are told: research and development, green growth, high-tech and of course clean and resource-efficient products: these are the answers to all ills of the planet and of our societies as we search for a new lease of life. Sleep well, good people, because in our leading companies and ultra-modern laboratories painstaking researchers and engineers in white coats work and invent for you. We research, and, because we research, we will find, because we always have, haven't we?

Are we not finding oil and gas ever deeper under the oceans, not to mention by fracking which of course will be exploited in an ecological way? Breakthroughs in 'clean' cars and 'green' technologies are imminent. According to the most optimistic among us, we are at the dawn of a third or fourth industrial revolution. Thanks to *smart grids*, and *intelligent* energy and transportation networks (built on a model similar to the internet), we will all become producers and storage providers of green electricity. We will move to a hydrogen economy, to a circular economy that will recycle its wastes thus making available new resources; a future based on ever more mobility and connectivity ...

Thus, at the risk of provoking a certain cognitive dissonance<sup>1</sup> in the attentive reader, listener or viewer, we find that dire observations in the serious media concerning the state of the planet alternate with grand announcements of new technological breakthroughs, inventions, pilot projects and amazing start-up companies. We hear of freight-carrying airships and solar aircraft, of offshore wind turbines and solar plants in the desert, of wave and tidal power. Solar buildings will produce more energy than they use, 'air purifying' paints will clean up your indoor air. And that is not to mention the pages of discussions about 'green consumption' or the 'sustainable economy' that hardly consider the real environmental impact of the products on view: for example a mobile phone in a bamboo

case or a low-consumption headlamp with integrated dynamo specially for 'eco trekking'.

As the planetary indicators show, the present reality, the truth<sup>2</sup> is that the world has never been so polluted and pillaged, even if, compared to the 19th century, there have been local improvements regarding some pollutants and industrial wastes. And yet, paradoxically, according to journalists, economists and scientists, we have never been so chock-full of the technical means for environmental management, never possessed so many remarkable 'ecological' inventions.

But, despite all of the announcements, the truth is they struggle to deliver. It is as if our societies, faced with an ominous situation, have a need to take refuge in almost messianic attitudes, in the promise of paradise the day after tomorrow if we survive the present torment. The key to this seems to be a discourse that cannot be aligned with reality and which has led, at least for the moment, to a world of permanent contradictions, in Bertrand Méheust's words to a *politics of the oxymoron*.<sup>3</sup>

What is the reality behind the façade? Certainly, it is true that scientists, engineers and engineering businesses – our illustrious predecessors – found solutions, often seemingly almost miraculous, to the challenges of resource shortages in their day. Provided, as always, that one does not look closely at the natural destruction or pollution to which these led.

### How technology has (always) responded to the shortage of resources

The history of humanity is that of a long struggle with resource scarcity. Every species is constrained by the availability of resources in its environment. It is a principle of Darwinism that natural selection in the face of constraints is, with mutation, the engine of evolution. But humans are almost the only creatures to use exosomatic tools, to extend beyond the limits and constraints of their bodies. Instead of using claws, teeth or bristles, the human uses sharp tools to hunt, contrives clothing for protection against the cold, and uses heat to aid in the digestion of food.

Of course, if food was sufficient, as long as these tools remained rudimentary, and population numbers were limited, then scarcity of tool-making resources would seem to have been a rare constraint. Oh, lucky Palaeolithic man, with immense herds of reindeer or horses – and maybe an occasional mammoth or woolly rhinoceros as a treat – to provide for all his needs: fat for light in the dark, bone for small tools and decorations, skins, furs and tendons for clothing. Maybe a little ochre picked up from

Figure 2.4: The seven commandments of low tech

- |   |   |   |   |
|---|---|---|---|
| 1 | Question the need   | → | Thou shalt ask thyself, why wipe?   |
| 2 | Design and manufacture for true sustainability              | → | Thou shalt make simple and durable. Thou shalt remember that everything has an impact                                 |
| 3 | Orient knowledge towards economy of resource use            | → | Thou shalt seek and transmit knowledge in the right direction. Thou shalt also inspire thyself from ageless knowledge |
| 4 | Search for the balance between performance and conviviality | → | Thou shalt be satisfied with less beautiful or new, designing for lower performance                                   |
| 5 | Re-localize without losing the good effects of scale        | → | Thou shalt re-localize with finesse, at the right level   |
| 6 | De-automate services  | → | Thou shalt replace people by machines with caution  |
| 7 | Know how to remain modest                                   | → | Thou shalt marvel at the complexity of nature   |

pay producers a little more for our food, by modifying the split between producers and distributors (so the producer gets a fair share), but also by spending more, agreeing to pay more for quality meat but eating it less often. The evolution of the 'consumer's shopping basket' over the past 50 years shows that we have never spent so little on feeding ourselves, but with a deterioration in the quality of products. We will have to lower our expectation of menu diversity in canteens, refectories and restaurants. To allow them to serve quality dishes, prepared and cooked on site and not simply reheated, it will be necessary to reduce the number of dishes offered. The most ecological dish is the dish of the day ... as in the old days when we stopped at a restaurant and were offered the soup of the day, and not a menu with 15 different dishes, often frozen or industrially made and with a high level of additives.

Our food choices mean that we have now, and we will continue to have in the future, the agricultural landscapes and the farmers that we deserve.

## Transport and cars

### *The challenges*

Left to itself, the car ends up destroying itself. The time that its speed gives us, it takes away immediately as it carries us elsewhere [...]. It takes us to the countryside, but we will soon fail to find in a 100km car journey the bathing pools or green landscapes that are waiting for us a five-minute walk away.<sup>6</sup>

A prophetic passage from the 1960s. Rural ponds and rivers where people can bathe near cities have disappeared, replaced by viaducts, highways and the no-man's land between strips of bitumen. It is now clear that the freedom created by motorized individual mobility has a high price, from the environmental point of view (emissions of greenhouse gases and pollutants, consumption of resources, paving over of land ...) as well as the societal (noise pollution, fragmented living, health impacts ...). There is no source of energy, now or in the future, that will allow all of humanity to achieve the average mobility of a North American, or even of a European (and certainly not using electric cars). The consumption of energy and metal is such that our only choice is to abandon the civilization of the car, at least in the sense that we use the word 'car', that is to say, an object of the order of 1 tonne in weight carrying an 80 kg payload in most cases. We are far from taking that path, with a global fleet of vehicles that passed the billion mark in 2010. The need for additional roads and car parks leads to

the systematic disappearance of millions of hectares of precious agricultural land (especially in China nowadays), often the richest because it is located in areas undergoing urbanization in the plains and on the coasts. How far should we go in questioning mobility? How could we maintain sufficient mobility considering the current constraints of town planning? Can we rely on a massive development of public transport?

### *The bicycle, the true 'clean car'*

What can be done without a car, when there is no alternative public transport, and while we still have significant need for mobility (because our neighbourhoods have not had time to adapt), and journeys, such as from home to work, that we have to make? It is likely that more and more of our fellow citizens will be forced to ask this question, as they face increases in fuel prices arising from the sharing of a constrained resource between more motorists. In the long run, fuel poverty will not allow them to continue as they do today.

The first possibility is to give up or reduce that which is not essential: travel less far for holidays, or at weekends, be more selective about outings, and so on. It will be very hard and frustrating, and will not achieve so much: 15 per cent of trips are made for leisure purposes, and 85 per cent for 'economic' reasons, that is, commuting, business trips, shopping, visits to the doctor ...

A second possibility, which does address the 85 per cent of journeys, is carpooling. It is a rather simple measure: of course, you have to start to talk to others in your locality, to organize a little, to be prepared to wait, to lose a little time and to accept additional constraints, but, in the face of rising prices and impoverishment, or based on ecological convictions, there are people already doing this. There are internet tools and apps available to facilitate contacts. Although undeniably very effective, this solution will, however, end up topping out at perhaps a 20-30 per cent reduction in total fuel consumption (which is nevertheless huge) so it can only be temporary.

There is a third and more radical possibility: riding a bike. These are by far the most energy-efficient vehicles, since in addition to the payload only a few kilograms are moved. They have the added advantage of being extremely durable and repairable. Of course, their use will be better for the young urban professionals who live only a few kilometres from their work, in city centres or near upscale suburbs, than for the working classes who are pushed ever further into suburbs and who have to travel dozens of kilometres, every day, even when it is rainy or windy.

The arguments are valid, and can be answered in four ways. First, it is only a suggestion for the direction to take, knowing that trying to maintain the status quo of a car-based civilization is doomed to resounding failure in the medium or long term. Second, it's not just for long commutes between home and work. Much car use comprises trips of less than 3 km: to buy bread, pick up the children from school, to take the elder one to her music class and the little one to his dance class. Journeys of less than 3 km are becoming easier, providing that roads are safe – which is the case when everyone is riding a bike and not driving – and we have the appropriate equipment: bicycles with baskets for shopping, a box for heavier loads and seats for young children. Europe is more fortunate in that, for reasons of historical development, its neighbourhoods are more amenable to cycling, at least compared with the United States, where people may have a hard time without their pickups, and are therefore prepared to desecrate landscapes to pump the last barrels of shale oil. But then, everyone has a cross to bear.

Third, enormous technical progress has been made – but at a low technological level – with developments such as electric bicycles, foldable bicycles that can be carried on public transport, and recumbent bicycles that offer the possibility of travelling long distances with lower energy expenditure while avoiding back pain. Fourth, let's go back to Ivan Illich's notion of an overall average speed.<sup>7</sup> If we just consider journey time, we go a little faster by car than by bike (say 30–50 km/h compared with 10 km/h). But if we add in the time that we needed to work to be able to afford the means of transport (initial purchase price then fuels, insurance, maintenance ...), we can calculate a kind of overall average speed, and the bike then goes back to the top, because its cost is so modest.

Of course, this is all rather hypothetical, because it is difficult to see someone who spends 1 hour a day in their car and 9 hours at work, transforming their day into 4 hours of cycling and 6 hours at work. And that is without trying to get the agreement of the employer, who might not be so keen on such a pattern 5 days per week, 47 weeks a year, especially if the job itself is physical. But, for a moment, let's imagine that it is possible to organize ourselves a little better, and to develop a better working time balance, in parallel with the decline in our need for consumption. Consider the share of gross domestic product (GDP) that is fully or partially devoted to the car and its associated technical system.

First there are the various manufacturers: the car manufacturers themselves, together with the manufacturers in their supply chains, the manufacturers of the equipment needed to build and maintain the factories (robots, machine tools), the producers of raw or processed materials: steel



aluminium, plastics (polypropylene, polyesters ...), artificial rubber, paints, glasses ...

Then there are all the associated technical and commercial networks: car dealers, garages and service stations, breakers yards and scrap-metal dealers, landfill sites; the entire fuel supply system, from oil wells to petrol stations (with thousands of employees just to check and maintain the operation of petrol pumps), through exploration platforms, tankers, port infrastructure, refineries and pipelines. There are also public works and the associated equipment, underground car parks (with steel, cement, sand and aggregates ...), road construction and maintenance companies, manufacturers of bitumen, road stone, traffic lights and other road furniture, painters of street marking; and all advertising expenses, with the associated consumption of paper and ink in newspapers and posters ...

Finally, there are all the ancillary activities involved, such as inspection, regulation or dealing with traffic and incidents: radar, police officers and their equipment, manufacturers of breathalysers, hospitals, surgeons, nurses, physiotherapists, judges, insurers (all with their buildings and equipment); administration (vehicle and driver registration documents, traffic offences); the regular cleaning of buildings made dirty by pollution, the treatment of contaminated water (drainage systems), and ultimately, the cost of climate change; and even part of the duties of the armed forces, with their technical equipment, to secure our oil or material supplies ...

So, what does this mean about the number of jobs that depend exclusively on the car? We might find the answer in one of two ways. We could start from the average expenditure per household, but this approach would lead us to underestimate a large part of the system (for example, everything that goes through taxes and feeds the budgets of local authorities, and government ministries of transport, health, justice, defence, industry ...) and it does not take into account the labour intensity of different economic sectors (€1 of added value in an oil refinery and €1 in an insurance company do not necessarily create the same amount of employment). To determine an approximate percentage of jobs allocated to the car, sector by sector, requires a long-term study.

I would say that, at the very least, all this represents 30–40 per cent of the entire system. This means (given the number of unemployed) that, if we were able to divide up work between us appropriately, then once we are free of the car there would only be two or three working days left per week, just by saving the work generated by our current motorized freedom (see Part IV).

Personally, I would buy this right away, and this would be my personal weekly diary: on Monday morning I would ride my bike to work, irrespective of distance, season or weather. I would spend Monday night

on a camp-bed in a corner of the office and then go home on Tuesday evening to start my 5-day weekend! All this without affecting, at least in the short term, urban planning and the current zoning between commercial activities and housing. Urban planning would then have to evolve gradually to adapt to new transport schemes.

Of course, my calculations are a little misleading, because the road system would still be needed for uses other than the car: bicycles and buses for personal transportation, and trucks to transport food and goods whose production has not been re-localized. So, it is true that there will still be need for a little more bitumen. But it is also sheer numbers that create the need for ever more complicated infrastructures: additional carriageways, separated by crash-barriers; interchanges, traffic lights and roundabouts, instead of simple 'give-way' junctions, and so on. Many fewer in number, our trucks could use the existing roads, even if it means letting some of them get overgrown. Part of the urban and suburban public space would revert to pedestrians and greenery.

Of course, my five-day weekend is a little optimistic, because there is a good chance that my wife would need to work from Thursday to Friday or from Friday to Saturday! Because, obviously, if we are to apportion our work better, it will be to allow production apparatus to be shared, not for everyone to work at the same time, otherwise nothing much would happen for the rest of the week. But no matter! All this is therefore a little hypothetical, I agree, but the purpose of this 'demonstration' is not to present the ideal solution, but to show that it would be possible, without much development of our neighbourhoods, to divide our time differently between travel, 'external' (especially salaried) work and 'home' work, based on more free time, which we could use to cultivate our vegetable gardens, to prepare the toothpaste for next month, or to make jam with this year's fruit ...

So, let's assume that there are a few cars left, at least in the early days. Not to transport our politicians (they will travel in the same way as everybody else, that will motivate them), but for ambulances, for slightly longer journeys, for the elderly or people with reduced mobility. But we should radically change vehicle designs. Consider, for example, bubble cars or quadricycles that are even smaller and lighter than the old Citroen 2CV - very lightweight, with puncture-proof tyres, made of low-grade steel or glass-fibre, with limited engine power (40 to 60 km/h maximum speed), without gadgets, without luxury or sophisticated safety systems (with lower protection people are less inclined to go fast). With such a machine, we could already make great progress: fuel consumption of less than 1 litre per 100 km,<sup>8</sup> fewer and more recyclable resources, easier road-sharing with bicycles (lower speed differential), reduced noise ..

and of course lower mobility than today, but still appealing to those who are most reluctant to cycle, and still tremendously superior to anything that humanity has known except for the last two or three generations.

### *Public transport: consider reducing train speeds*

You will not want to hear this, but the total energy consumed in transportation depends on roughly three parameters: the distance travelled, the mass transported and the speed. Therefore, we don't have a lot of ways to reduce our footprint. It comes down to reducing speed, reducing mass, and ultimately reducing distance travelled, that is, making it increasingly time-consuming and arduous to use individualized transportation, while adapting our economy appropriately.

What about public transport? Isn't it much more environmentally friendly? Of course, trains, trams, metros and buses are more efficient, but only if they are properly filled. And it is important to distinguish their very different characteristics.

Even if their image is less 'green', buses are probably the most ecological and sustainable system by far, even if it is difficult to convince oneself of this from behind their exhaust pipes. They have low infrastructure costs, the flexibility to adapt to changing conditions and roads, minimalist technological content and robust, simply maintained vehicles. Trams partly share these characteristics, because once the first infrastructure investment has been made, their low speed does not place too much stress on the equipment or track, even if the 'technological' content of the latest models (such as digital display systems) could be reduced without too much discomfort.

Metros, light rail and suburban trains, using modest speeds, use much more infrastructure and maintenance costs (labour, energy and materials) are much higher. They are more 'fragile', require sophisticated and computerized systems for safety management, and rely on extensive technical networks to support rapid intervention by maintenance technicians, management of spare parts stocks and so on. These characteristics reach their peak in the case of long-distance, high-speed trains, because the constraints increase exponentially, in order for the track to support speeds of 300 km/h or more, while the tolerance margins decrease proportionally.

Public transport can be a good response to the gradual but partial disappearance of cars. For trains, existing networks are fast approaching capacity, and it will be difficult to reopen abandoned local lines, as many have already been built over. It is in any case already difficult for passenger

trains, freight trains and maintenance activities to coexist on the same network. Buses can contribute because they are a simple and inexpensive system, and for this reason almost the only one that works in many poor countries. As for high-speed trains, since the energy expended increases with the square of the speed, in order to simultaneously drastically reduce energy and maintenance expenditure, it would be enough simply to reduce the operating speed – currently aiming to compete with air travel, which should in any case disappear, at least over distances of less than 1,000 km. If we maintain the status quo it may well be difficult to maintain high operating speeds, and they may eventually be decreased gradually to save on the costs of maintaining an ageing network of an over-indebted rail system, while other aspects of society will surely also experience some deterioration once the energy and materials resource peak is passed.

## Construction and urban planning

### *The issues at stake*

The building, public works and infrastructure sector is an incredible consumer of materials and energy. When it comes to products with a long lifespan, say 30 years, the consumption of materials is a priori less unacceptable than that of mass-produced consumer products, automobiles and new technologies, which rapidly become obsolete. However, this is not always the case, because buildings are also subject to trends towards a general speeding up in society: ever more rapid renewal of shops and offices, change of logos, signs and paintwork as a result of mergers and acquisitions or rebranding, reconfiguration of buildings to support changes in end use, spending of municipal budgets on 'visible' urban renovations on sidewalks and pedestrian streets ...

The question of urban planning and our built-up environments is a delicate one. We can seek inspiration from many prestigious utopians, in the tradition of Nicolas Ledoux and Charles Fourier, but fundamentally there are now too many of us to live in the ideal city or in the utopian *phalanstères*<sup>9</sup> and we will not be able to 'transport the city to the countryside'.

We can, however, identify four major issues for this sector. First, reducing the amount of energy consumed by existing buildings is a matter of necessity. Second, as an issue of absolute urgency, we should stop building on greenfield land. Daily, we are destroying the last natural areas reducing the ability of future generations to feed themselves, preventing