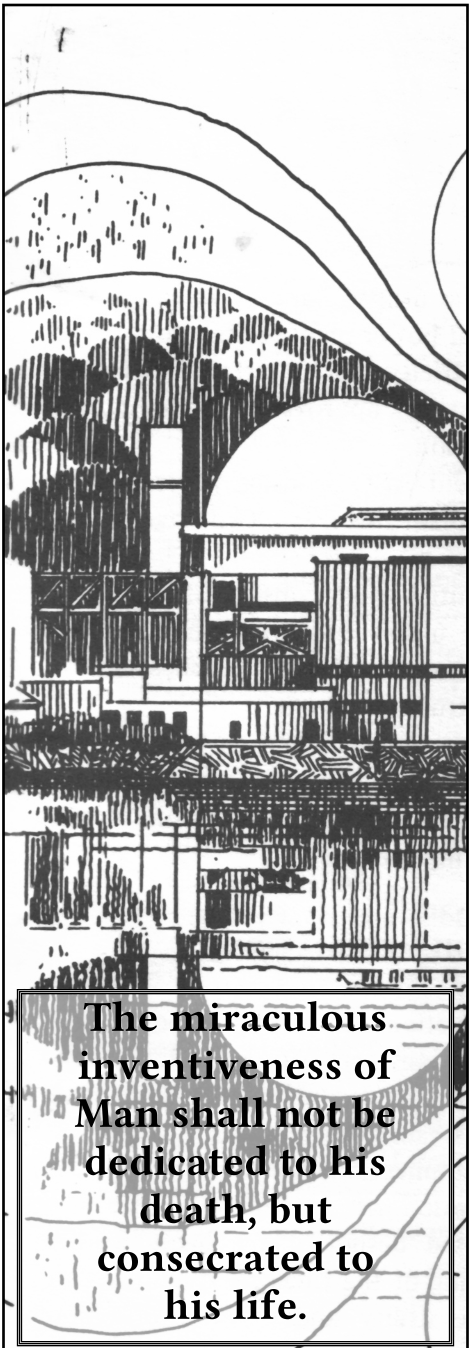


The miraculous inventiveness of Man shall not be dedicated to his death, but consecrated to his life.

Propaganda from the
Man and Atom Society
Number Two — 2024 June
Price One Dollar

www.atomicbla.st

In This Number

READERS might be surprised by our frank and open use of the word *propaganda*. Why employ such a loaded term? Why not stop at trying to inform?

We are not afraid to call this publication what it is, an effort to win the reader over to our point of view. Anti–nuclear campaigners, aware of the basic weakness of their position, like to present their propaganda under the guise of neutral information. We recall, for instance, a book of cartoons, originally titled "The Anti–Nuclear Handbook" but re–published for the mass market as "The Beginner's Guide to Nuclear Power", and reviewed in the *New York Times* as "excellent reading while waiting for your neighborhood meltdown". Since we know that atomic energy really is what we say it is, we require no such misdirection.

Another reason to use the word is precisely the negative character many people associate with it. If those who pick up these booklets take *propaganda* to mean "persuasion by fair means or foul", they may not quite trust what they read. They will look for authoritative sources of information, to support or undermine our positions. When they do, they will find decades' worth of well–documented work on the part of many thousands of the world's most competent and conscientious scientists and engineers, standing as a firm foundation. The credibility of the opposing case, by contrast, is all on the surface.

The motto of that most respected of scientific bodies, the Royal Society of London, surely applies here: *Nullius in verba*, or in colloquial American, "don't take my word for it".

> In the early years of this century there seemed no way ahead for the human species, no way to the stars, nothing but a disaster of fantastic dimensions, followed by what at best might be the village life of immediate post–mediæval times. Nuclear energy changed this apparently hopeless situation within a couple of momentous decades. By 1940, the way to the stars was there for the taking.

Split Atoms — Not Wood

JAMES Burke's marvelous television series *Connections* introduced many of us to one of the key historical reasons why England and France fought over possession of North America: **its forests**. By about the year 1600, the cutting of wood for fuel and clearing of land for agriculture had left much of Europe totally denuded of trees tall and straight enough to furnish the timber needed for shipbuilding, especially for masts. To the maritime powers, the pines and hemlocks growing along the navigable rivers of the Atlantic seaboard were more precious than all the gold of Golconda.

Split wood, not atoms was a favorite anti–nuclear slogan of the 1970s. Of course, not much arithmetic is needed to show that obtaining the energy required by a modern technological society from biological sources is quite impracticable. After all, we need artificial fertilizers just to produce our food! Haiti cannot be called a wealthy, energy–hungry country, and wood–cutting there has led to catastrophic erosion, destroying the fertility of the soil and the agricultural productivity of the country, leaving the people destitute.

At best, this slogan might be taken to express a longing for the purportedly simpler life of former times, on the part of people who grew up with electric lights, to whom lighting a candle or an oil lamp is an amusing novelty, and cooking over a fire part of the fun of camping out. And yet, attempts to put it into practice continue. Again and again, promoters of biofuels promise that agricultural wastes or cover crops are the new energy solution, and every time the reality turns out to be quite different.

Few more egregious examples could be found than Drax, the largest coal–burning electric generating station in Britain, converted for partial firing with biomass in the name of decarbonization. Investigative journalists have repeatedly found that the millions of tonnes of wood pellets annually burned under its boilers — brought by oil–burning ships from as far away as the west coast of North America — are not made from waste wood as claimed, but from trees cut especially for this purpose. The logging of primary forest, among our most valuable resources of biodiversity, to feed this vast maw is well documented by now.

Fighting climate change by cutting down forests is like fighting a war by bombing your own cities.

Chapelcross power station, near Annan, Scotland

A near–duplicate of Calder Hall (forerunner of the Magnox type), this 4×60 MW plant entered service in 1959 and operated until 1996, supplying a lifetime total of 73·2 TWh to the South of Scotland Electricity Board. Reactor 2 suffered melting of experimental fuel in 1967 but was returned to service within about a year. Radiological consequences to personnel and the environment were negligible, and lost power sales considerably exceeded the actual cost of repairs.

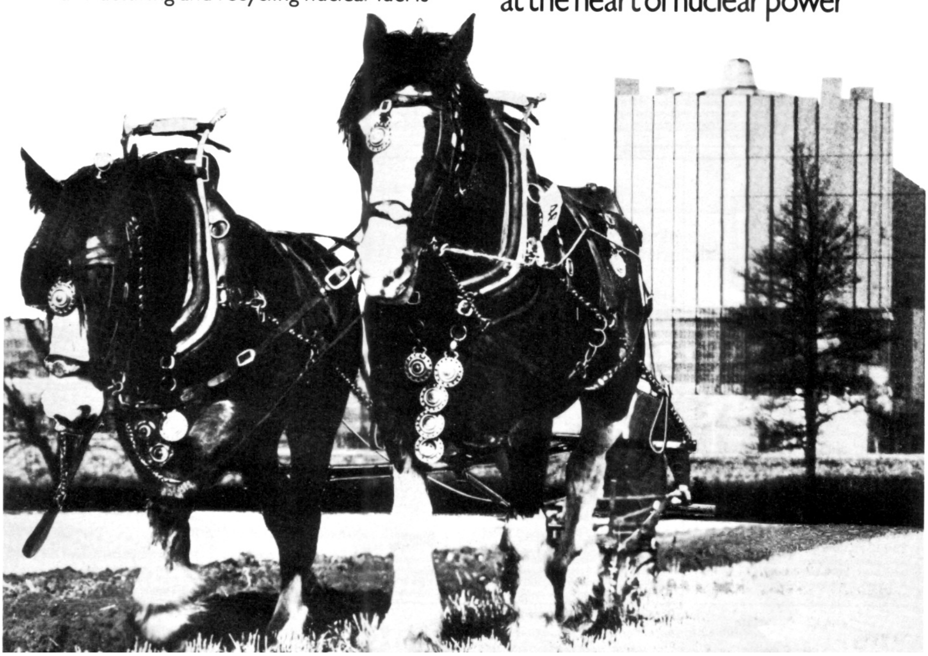
The survival of industry and our entire social structure depends basically upon an unlimited, continuous, and low–cost supply of electrical energy, the present source of which is mostly coal and oil. However, attempts are being made to utilize the energy of the sun and the wind, neither of which is as yet commercially successful. It may well be that in the not too distant future our energy supply may come from the atom.

A key belief which shapes the way many people approach energy questions is that a non–nuclear world based on renewable energy sources will be an inherently peaceful one. This seems to rest on two ideas: first, that since the Sun shines and the wind blows on all parts of the Earth, nobody would bother to fight over them; and second, that there is something in heavy industrial technology itself, especially nuclear technology (although wind turbines with hundred–meter–long composite blades, and even more so photovoltaic cells, are themselves the product of very sophisticated heavy industries), which distorts society into a warlike shape. Industry itself is sometimes described as a form of violence against the Earth or marginalized people.

Certainly, since the beginning of the twentieth century, wars have repeatedly been fought over possession of fossil fuel sources — including the only war in which nuclear weapons have so far been used. And control of those fuels has been a decisive factor, not only in the outcome of armed conflicts, but in the international balance of power. Yet wars did not begin in 1859 when Edwin Drake drilled the first oil well. What were they fought over before? Often, the answer appears to be "land", which means food, fodder, and firewood, the energy sources of a pre–industrial society. And often, the decisive factor was the control of the peasants, serfs, or slaves who turned that food into work.

Modern renewable energy sources, just like those of the past, require land and lots of it. Nor is all land equally valuable for the purpose. The mountains of southern Morocco, for example, surpass almost the whole world in annual duration and intensity of sunlight. Some Germans have proposed to develop this energy resource to meet the needs of Europe, which does not seem any more apt to promote international political stability than burning pipeline gas from Russia. In practice, a conflict seems unlikely to arise, because the place is so rugged and arid, and so remote from human habitations, that the cost of construction there (even before transmission lines are considered) would be prohibitive.

> Since man has never moved backwards in the field of science, the development of weapons will not be prevented if the countries which have now mastered nuclear technology stop or limit its civil development. On the contrary, the feeling of frustration and deprivation of energy which would result for the excluded countries could only push them towards developing programmes with military objectives themselves.



British scientists, technologists and nuclear plant operators have proved that nuclear power stations are not expensive luxuries — not scientific experiments with only a prestige value — but are an integral part of the power generation system of every country whose future growth is linked to its ability to provide an adequate and economic electricity supply.

Renewable does not mean Sustainable

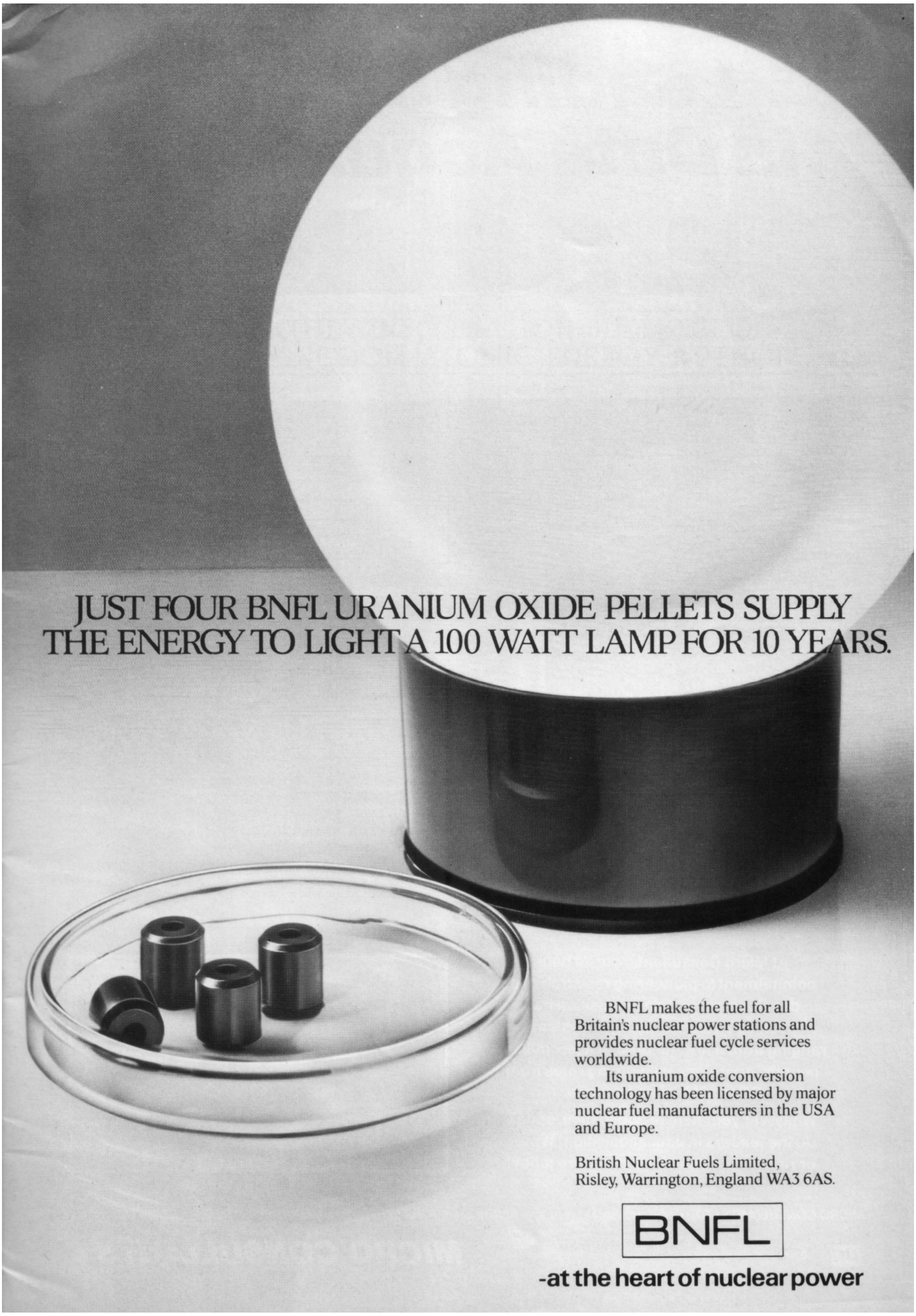
Whale oil is a renewable energy source, from the point of view of the whaler if not of the whale. That does not make it a sustainable energy source. Vast though the oceans are, they do not support enough whales for industrial–scale hunting not to cause a population collapse. (Pause a moment and consider the paradox that those resources which humanity has exhausted have mainly been renewable ones — starting, perhaps, with the wooly mammoth.) All moral questions to one side, powering our civilization with whale oil is not an energy policy option worth considering, because it simply would not work.

On the opposite side of the coin, fission is not a renewable energy source — there is only so much uranium and thorium in the crust of the Earth — and many people feel it is not a moral one either, but it is sustainable. So far as we can see, we can call upon the regenerative fission fuel cycle for considerably more energy than our civilization now uses, for a far longer time than has elapsed from the dawn of agriculture down to the present day, without necessarily incurring any consequences which would compel us to stop using it.

Erosion washes more uranium into the oceans every year than we would need to extract from them, to satisfy any foreseeable energy need. The wastes, as discussed elsewhere in this number, physically cannot build up in such a way as to choke us. Releases of radioactivity are already held to very low levels. The land area occupied is modest, and there are few "hidden costs" in the form of ancillary systems (such as grid–scale batteries) with their own requirements that may prove hard to meet.

Here is the question. Do we follow facile slogans, like the will–o'–the–wisp, ever deeper into a morass of energy policy which does not work either economically or ecologically? Or do we follow the "hard path" marked out for us by the pioneers who, over seventy years ago, made it their first priority to demonstrate the power–producing fast–neutron breeder reactor, thus securing a future with atomic power?

> To think that we can do without a sizable contribution from nuclear power is very high risk thinking. To abandon nuclear power could have incalculable consequences for our society. It could also have incalculable consequences for the less developed countries if the developed countries were to compete for increasingly scarce oil as a result. And it is very easy to show that if the energy supplied by nuclear power had now to be met from other sources, there is no credible answer.



The most efficient coal-fired power stations generate about 3 kWh from a kilogram of fuel. 100 W continuous for 10 years would require 3 tonnes, which does not fit on this page.

Reminiscences of an Atomic Kid

Just where is the radiation?

or, sniffing around for trouble

OUR family had moved to Los Alamos, New Mexico in 1968. I guess I should jump in here and give a bit of history of this town. In WW II, Los Alamos was a ranch school. The place was turned into the primary research center of the Manhattan Project. Its main aim was the designing and building of an atomic bomb. Later the town became the main research center for nuclear weapons design for many years. At the time the reseach organization there was known as the Los Alamos Scientific Laboratory. It was almost always simply called the LAB.

This story comes from when I lived in Los Alamos. It was sometime in the summer of 1979 as I recall.

One nice summer day, I was hanging out at our Amateur Radio Club. They shared part of a former City Fire Station. While the building mostly held the Fire Auxiliary, the Radio Club had one room and most all of the basement. This basement was accessed by a steep road around the back of the building, and on this particular day I was down there looking through a mess of junk and old gear the radio club had stored. I heard a truck drive down the road, so I went out to see who might be about. Some one in a LAB truck got out with some sort of tech equipment. Being a forward gal, I went over and asked what he was up to. This guy was most friendly, and told me he was with a part of the LAB that monitors the city for radiation. He pointed out a device that had been mounted to the building. This he explained it was a radiation monitor that was hooked up to a city–wide network.

I asked "How often do the detectors show radiation?"

"Oh," he said, "we really never see anything."

I asked, "Really?" I had my big amazed face on.

"Well, the truth is, we can tell the wind direction with this," he said, pointing at the radiation monitor. "When the wind is in the right direction, we do see a small spike."

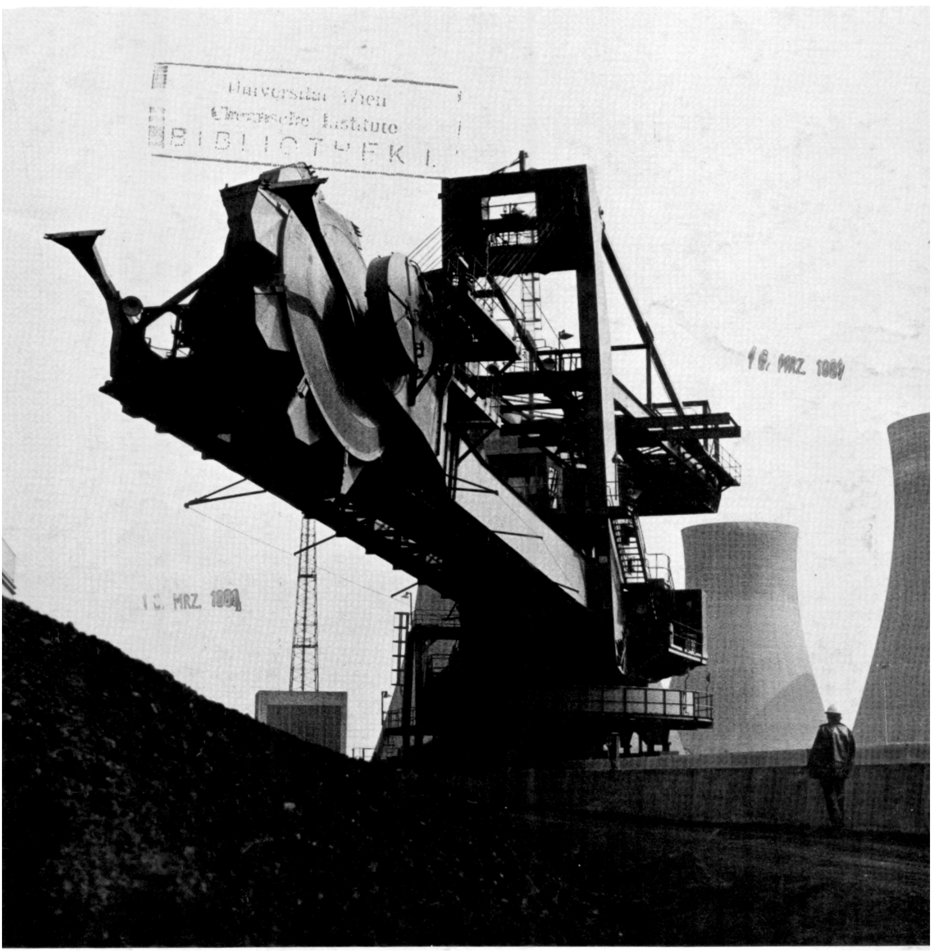
"Oh my," I gasped, "How can that happen! Where is the leak?"

He smiled and said, "No no, not us. You see, when the wind is from the northwest, it carries the smoke from the big coal–fired power plant at Four Corners." He explained to me that coal has a tiny bit of radioactive material in it. When you burn millions of tons of the stuff, well, it releases a fair bit of radiation.

Later I gave this a lot of thought. Here I am living in a town that is the home of nuclear research. I know the town has at least three research reactors, and here is one of the people that continuously checks the town for radiation, and the only hot stuff they find comes from a coal–fired power plant that is more than halfway across the state. Just where is the risk?

After that I have always had bad thoughts about coal burning. Heck, our own home had a small coal stove and I had to help shovel for it. To this day I think coal is awfully dirty.

— *Lisa Hayes*



“A stocking–out and coal–reclaiming machine at the 1980 MW coal–fired Drax power station, in Yorkshire”

What a Waste!

AMONG the most attractive aspects of the nuclear fission fuel cycle is its waste. Does that surprise you? If so, you are in good company. The pioneers of the field took decades to realize this.

Compared to other hazardous industrial wastes, the fission products have three remarkable qualities.

1) **They arise in very small amounts**. For a given production of energy, nuclear fuels leave (in very round figures) one millionth the mass of residue as fossil fuels — and a further thousandfold less by volume, as the wastes are mostly solids. As a result, we have the opportunity to handle them responsibly, rather than discharging them higgledy–piggledy into our surroundings. Even accounting for mining wastes, in the most unfavorable scenario, it has been calculated that ordinary granite, used as a source of uranium and thorium, would give up 50 times as much energy per tonne as burning good coal.

2) **The hazard they present diminishes constantly**. Because of their small quantity, the only reason these wastes cause us concern is their radioactivity. But the very nature of radioactive decay is that the active atoms are continually removing themselves from existence. Better still, the most energetic (and therefore hazardous) atoms tend to remove themselves the most quickly.

3) **They are extraordinarily easy to detect**. The beta–gamma radiation typical of fission products can be picked up, with inexpensive handheld instruments, at about one one–thousandth of the danger level. Any leak can be found, run back to its source, and dealt with long before harm can occur. This is very different from the typical situation with poisonous industrial chemicals.

A Gift to the Future

A concern which many people quite reasonably voice is that of "leaving behind wastes to burden future generations". And this is what inevitably happens — with any process that produces waste, if the process runs at a constant rate, its waste mounts up, and up, and up. The more the process is used, the faster the accumulation.

The exception occurs when some other process, in competition with the first, removes the waste. In an ecosystem, the wastes of one organism, such as the oxygen gas released by green plants, are typically consumed by another organism, but this set of relationships does not necessarily exist in the industrial world. This is the logic behind

"A full-scale model of the vessel to be used for glassification, storage, and eventual disposal of highly-radioactive waste"

If all the electricity used in Britain were produced from nuclear power stations we would produce only about 30 tons of fission products annually. On the other side of the coin the nuclear waste takes much longer to cool down and lose its activity, and so we have to handle it while it is hot at least from a radioactive point of view. Moreover, because the burning of uranium gives out so much more energy than the burning of coal the radiation given out in the process is very much more energetic and penetrating. The whole issue of nuclear waste is therefore connected with handling relatively small quantities of rather nasty material.

biodegradable plastics. Radioactive waste is a special case: it consumes *itself*, totally independent of external factors, at a rate which is strictly proportional to the quantity of active material present.

It so happens that the half–lives of the fission products are such that, when nuclear fuel is consumed at a constant rate, the total radioactivity of the wastes older than 20 years is always less than the activity of the wastes less than 20 years old. That is, no more than two generations' worth of waste can ever, at any time, exist.

Atomic power actively *unburdens* future generations of whatever wastes would have been left behind by other means of meeting the present generation's energy needs.

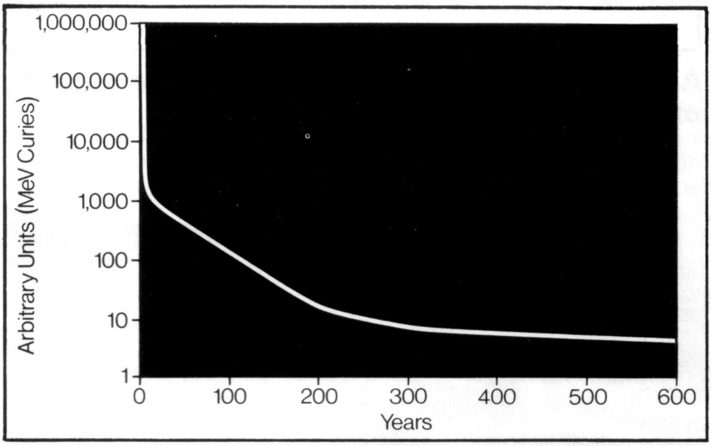
Hostess Bakeries versus Nuclear Waste

A method of final disposal, which has stood up to every scrutiny, was presented by the Canadian delegation to the 1958 Geneva Conference — years before atomic power began to make an important contribution to the economic life of any nation. What other industry can say the same?

The fission products are blended into a glassy material, which will hold them against leaching by water, for tens or hundreds of centuries at least. For extra assurance, this glass is typically cast into stainless–steel canisters, and buried somewhere such that water, if it did touch the glass, would not reach the surface for a very long time. Salt domes and beds, clay, and granite have all been found suitable.

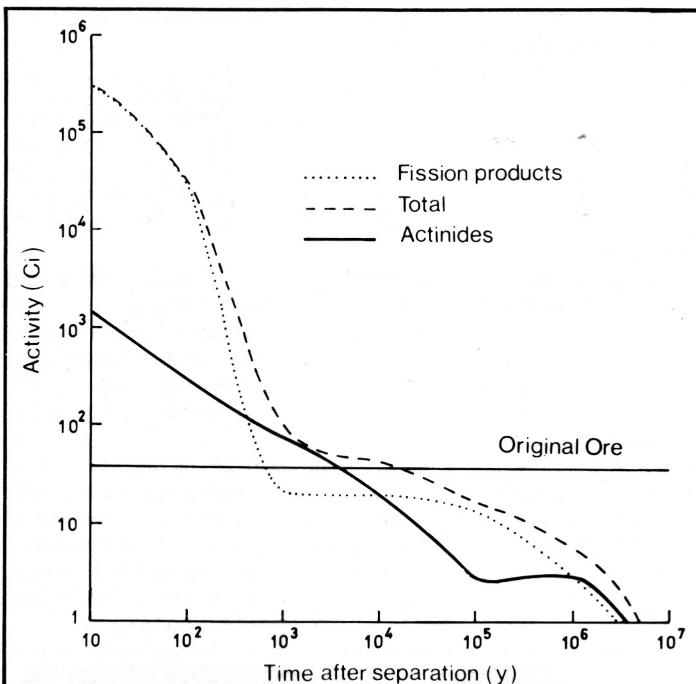
All this precaution and care is especially remarkable since the isotopes of major biological concern all have half–lives of less than 30 years. After 10 half–lives, anything may reasonably be said to have disappeared. And a Twinkie in an ordinary landfill may be expected to last 300 years!

Having taken the authors to task for not presenting the case fairly, I concede that most of the questions that beset nuclear energy are unanswerable scientifically. The authors are correct in their insistence that whether or not nuclear energy over the long term is acceptable is as much, if not more, a social and human problem as it is a technical one. Our profound difference, aside from their having distorted the technical situation, centers around the answers to two questions. Granted that nuclear energy is imperfect, is it possible, and ought we not try, to improve both the technology and the social institutions to remove the imperfections? And is the alternative that is proposed — a "coal–based, fission–free bridge" to a solar world — to be taken as seriously as the authors claim?



Decay in activity of waste constituents in spent 'Magnox' fuel.

Without the use of logarithmic scales, the activity curves would fall off so sharply that they could scarcely be seen.
"Actinides", principally neptunium and americium, can if desired be separated from the fission products and incinerated in the fast-neutron reactor.



Activity of waste from 1t fuel and its originating ore body.

Some people muddy the issue by referring to discharged reactor fuel as "waste". In the case of a typical light–water reactor, only about 4% of the spent fuel is fission products. The remainder is uranium, of a composition close to that found in nature, and about 1% of plutonium.

If someone were to say to you, "I have tonnes of platinum and I do not know how to dispose of it", you would think he had lost the use of his reason. Yet this is just what is said about plutonium. Platinum is valuable because it is a catalyst for certain chemical reactions valuable to industry — it makes them go ahead without being itself consumed. Plutonium, in turn, is (as discussed in ***blast*** №1) the catalyst for the production of abundant energy from cheap uranium–238 and thorium.

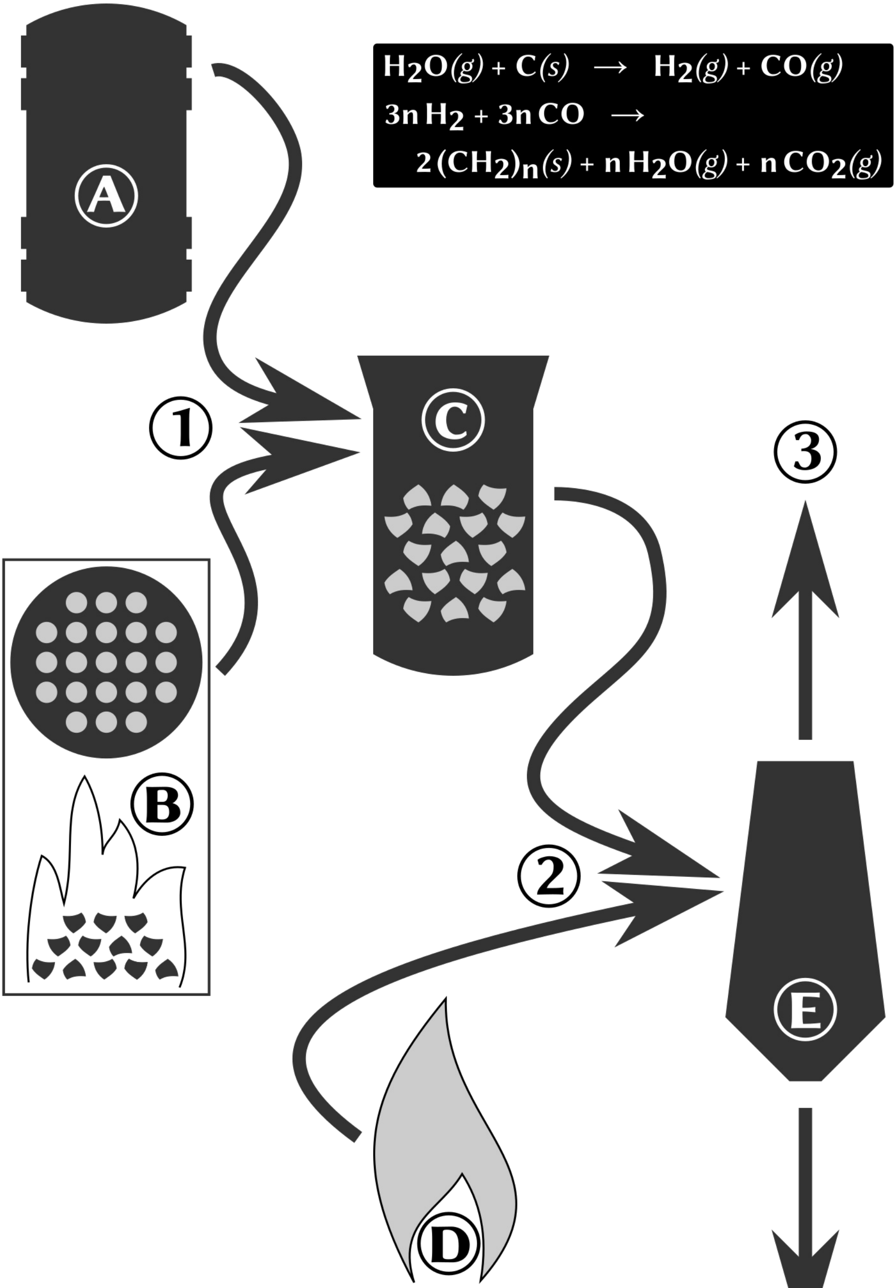
But — someone says — *plutonium has a half–life of 24000 years!* So it has. End all nuclear activities now, and we will need to isolate over a thousand tonnes of this material (which, though far from "the most toxic substance known" as it is sometimes called, is not to be trifled with) from the biosphere for a quarter of a million years. How is this an argument for stopping atomic power?

But plutonium can be used to make bombs! So it can. Continue with atomic power, and all of it that we can get will be recycled into reactor cores. A safer place can scarcely be imagined. As shown in our previous number, the "plutonium economy" implied by the regenerative nuclear fuel cycle does not require much movement of this fuel, except in a dilute form easily safeguarded against diversion for nefarious purposes.

If you throw away the spent nuclear fuel after a single pass through the reactor, you throw away that precious catalyst, and the uranium it could have been used on. You foreclose on the possibility for fission to make more than a small contribution to world energy needs, for a few generations. **And that is precisely the point**.

turn to page 16 ☛

Contrary to most public perception, the basic disagreement over nuclear waste disposal is not over the risk, but rather over the benefits. A key benefit of a publicly acceptable waste–disposal arrangment is to remove an impediment to expanded use of nuclear power. Most anti–nuclear groups are opposed to spent–fuel reprocessing, construction of spent–fuel storage facilities, and early waste repository construction. At the same time, these groups argue that nuclear power should not be permitted unless means are available to accommodate the spent fuel.



$$H_2O(g) + C(s) \longrightarrow H_2(g) + CO(g)$$

$$3n\,H_2 + 3n\,CO \longrightarrow 2\,(CH_2)_n(s) + n\,H_2O(g) + n\,CO_2(g)$$

$$2\,CH_4(g) + O_2(g) \longrightarrow 4\,H_2(g) + 2\,CO(g)$$

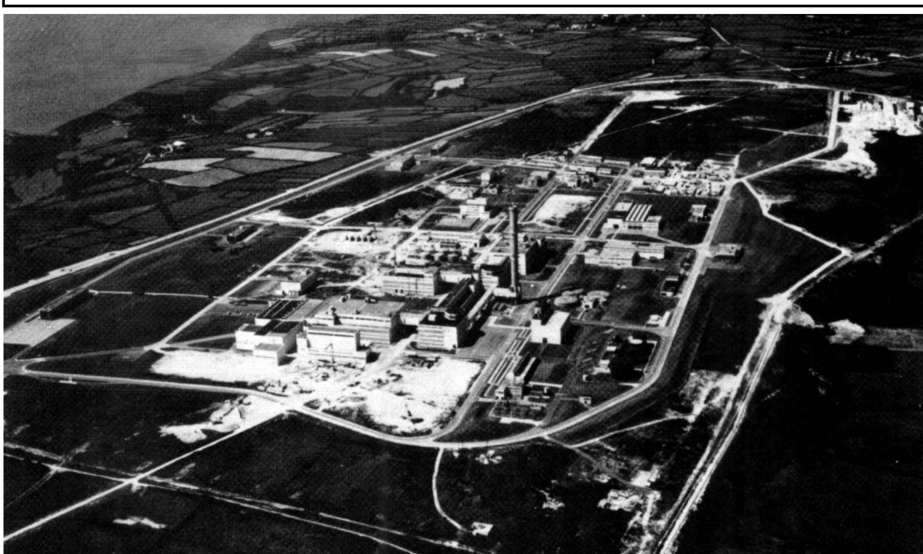
$$2n\,H_2 + n\,CO \longrightarrow (CH_2)_n(s) + n\,H_2O(g)$$

Closing the Plastic Cycle

A........High–temperature nuclear reactor
B........Coal–fired boiler
C....... Reaction vessel filled with coal or waste plastic
D....... Incomplete combustion of methane
E........Final reaction vessel
1........ High–temperature steam (H_2O)
2........ Synthesis gas : H_2 + CO (variable proportions)
3........ Waste gas : H_2O + CO_2 (variable proportions)
4........ Hydrocarbon product

The pair of chemical reactions shown at top right on the facing page represents the "classic" Fischer–Tropsch process, with steam raised by nuclear heat along path **A⟶C⟶E**, or by burning coal along path **B⟶C⟶E**. The pair of reactions at bottom left represents a synthetic process starting with methane, path **D⟶E**. $(CH_2)_n$ is the approximate chemical formula for polyethylene, one of the most common plastics, used here as an example product.

As shown, if coal (assumed to be pure carbon) is fed to the gas–producer **C**, the mass of CO_2 waste ultimately dumped into the atmosphere is greater than that of the desired product in a proportion of 11:7, not even accounting for the boiler fuel. When waste plastic is substituted, the hydrogen it contains carries over into the syngas, and proportionately less CO_2 results.



The nuclear fuel reprocessing plant at Cap la Hague, France

It is a common observation that the rays of the Sun bleach cloth, make paper brittle, and disintegrate plastics. In much the same way, nuclear radiation can denature the toxic organic compounds which are among the most difficult products of our industries to deal with. It is not easy to find a radiation source strong enough, large enough, and cheap enough for bulk treatment of contaminated material, but fuel freshly discharged from a power reactor may meet the need.

This is only one of many ways that atomic energy can contribute to the waste–minimizing triad, REDUCE—REUSE—RECYCLE. In a world where the average human consumes the energy equivalent of 2·7 tonnes of coal a year, *reducing* the wastes of fossil–fuel combustion, by burning less, is the obvious place to start. It never ceases to amaze when the same people who express incredulity at the idea of disposing of a few hundred tonnes a year of fission products, trapped in inert glass and stainless steel, embrace "carbon capture and sequestration".

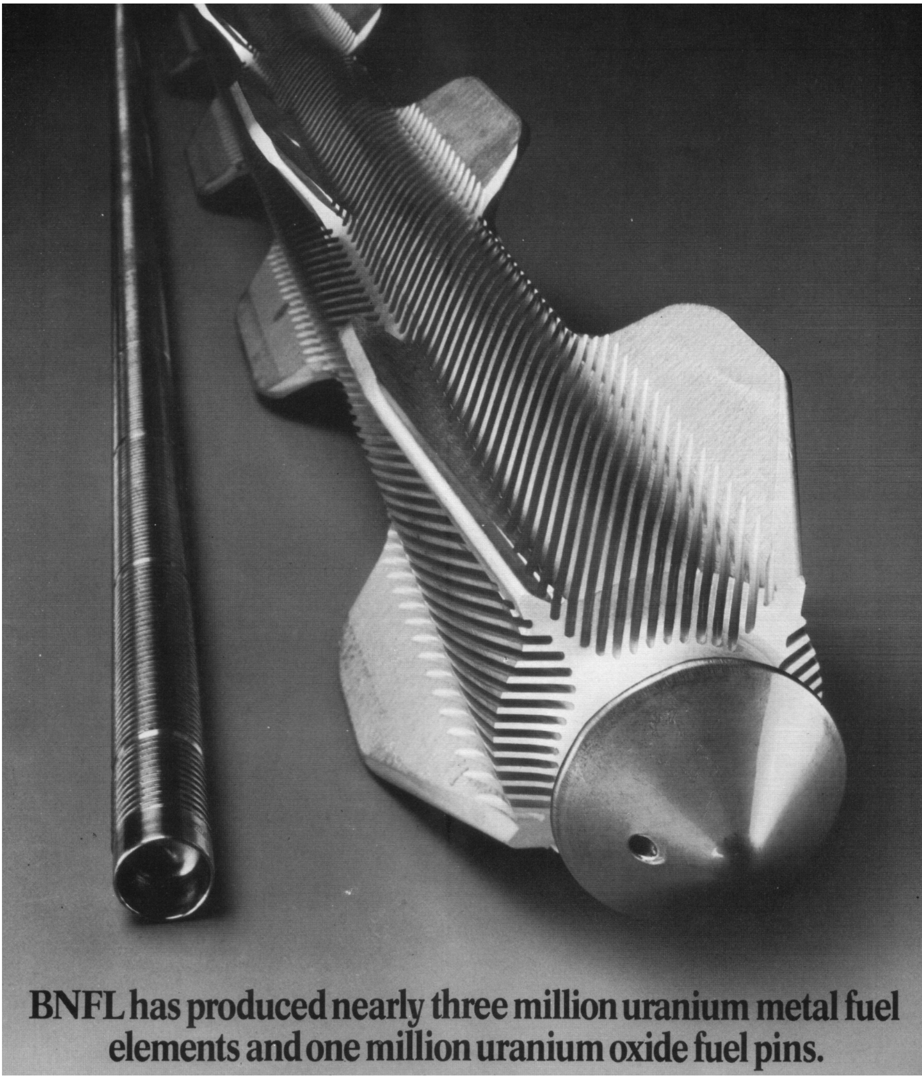
Millions of tonnes a day of a gas which dissolves in water to form an acid which eats away rock, a suffocating gas heavier than air, well known for forming deadly pools when it escapes from underground — the only reasonable way to sequester carbon dioxide is the one we are undoing with every lump of coal we burn.

Recently we have heard a great deal about the problem of plastic recycling. It has proven very difficult to disaggregate discarded goods into clean, reusable resins, and in practice, plastics separated for recycling often go into landfills, or are dumped in poor countries.

Nevertheless, there is a proven way to fully recycle mixed plastics, even in the presence of metal coatings, paper, and food waste. This is to render them down into their starting materials. In the Fischer–Tropsch process for making liquid fuels from coal, steam reacts with carbon at high temperature to produce a mixture of hydrogen and carbon monoxide, known as *synthesis gas.* Any desired hydrocarbon can then be produced from this gas. In fact, most raw plastic is produced by a similar method, although today the syngas is usually obtained by incomplete combustion of fossil methane ("natural gas").

Substitute plastic for coal, and the cycle is about as closed as it can get, with a product indistinguishable from "virgin" material. ***(See centerfold.)*** Even electronic circuit boards can be reclaimed in this

Nearly everybody would now agree that to burn pure methane to generate electricity is a waste this world will come to regret.



A 25–pound Magnox fuel rod, of the type used in Britain's first generation of nuclear stations, produces about as much electricity as 150 tons of coal. After five years in the reactor, only about one per cent, that is just a few ounces, is waste. The remaining 99 per cent is unused uranium and plutonium which can be removed and used again. Thus after 25 years of nuclear power generation in the UK, the waste products from used fuel rods would fill little more space than a four–bedroom house. Even if all our electricity were to be produced by nuclear power, the total quantity of such waste produced each year would be equivalent in volume to only about one pencil per person.

way. This approach is considered uneconomic, for the same basic reason that the Fischer–Tropsch process has never come into wide use: the fuel value of the coal consumed is to the liquid fuel produced as 3:1. Likewise, if the heat for making the steam has to come from burning fossil fuels, it is simpler to use those fuels directly to make fresh plastic. In the aftermath of the 1973 oil price shock, however, a great deal of work was done on coal–to–liquids using the much cheaper heat from nuclear energy. Conventional water reactors cannot reach the necessary temperatures, but helium–graphite reactors can.

We might envision regional service centers, receiving plastic wastes by barge or train, in quantities large enough to keep the gas–producing plant fully loaded and operating efficiently. The syngas would go "across the fence" to a cluster of facilities owned and financed by petrochemical companies. If the gasifier were owned by a government agency or a cooperative of municipalities, and paid for by some combination of disposal fees and a tax on plastics made from fossil fuels, the syngas could be sold at a very low price, assuring that it would be the economically preferred source for new plastic.

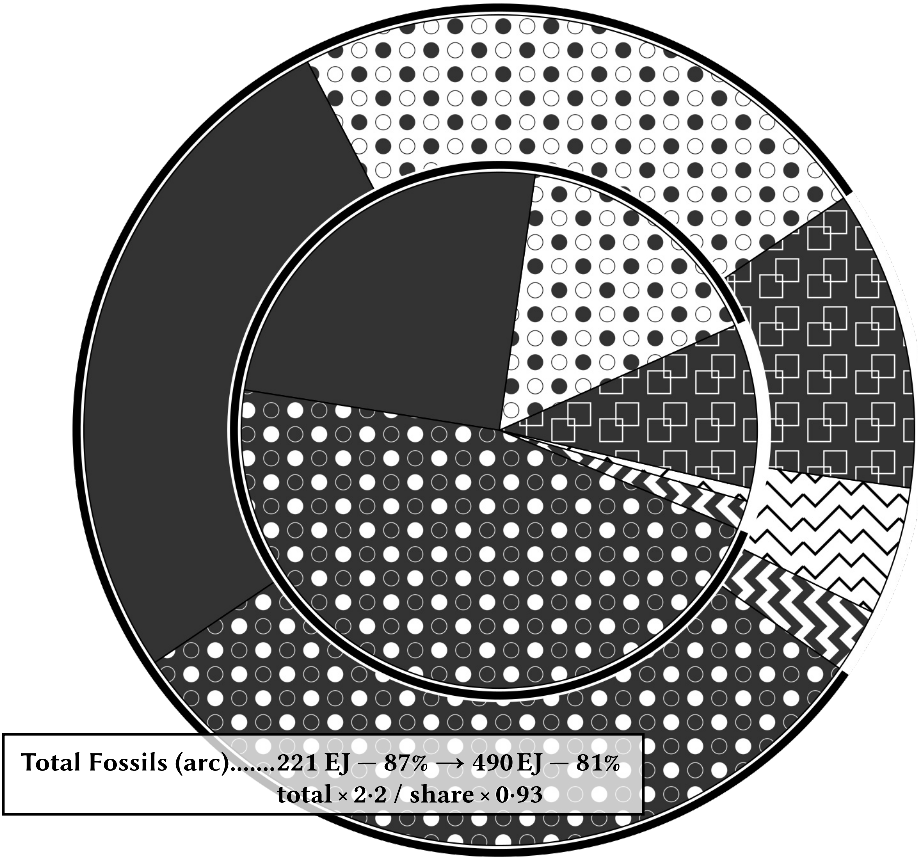
The Heart of the Matter

After reading this far, you may be surprised and confused when the German Environment Minister, for instance, says that atomic power must not be used because it presents an insurmountable waste problem. Nuclear–energy advocates are often stymied because they come from backgrounds in which a very high value is placed on answering questions by resort to empirical facts. And that is precisely what is *not* going on here.

To the scientist or engineer, "there is no acceptable way of managing nuclear wastes" is, in effect, a question looking for an answer. Politically, however, it is an answer in itself: "no method of managing nuclear wastes is acceptable *to us*, because we do not accept nuclear energy." **The true question, then, is not how to deal responsibly with wastes, nuclear or otherwise. It is whether that attitude is a responsible one in a civilization dependent upon energy for its very survival.**

One major mistake often made by the technical community is to assume that it is the technical merits or otherwise of the technology that are the real and only subject of scrutiny. That is very often peripheral; the heart of the matter is social and political, it is much more related to values, life–styles, and dictates of the heart, not the head.

World Primary Energy Supply
1973 (254 EJ) — 2019 (606 EJ)



Oil................................117 EJ — 46% → 187 EJ – 31%
total × 1·6 / share × 0·67

Coal.............................63 EJ — 25% → 162 EJ — 27%
total × 2·6 / share × 1·1

Fossil Gas.................... 41 EJ — 16% → 141 EJ — 23%
total × 3·4 / share × 1·4

Other............................26 EJ — 10% → 70 EJ — 12%
total × 2·7 / share × 1·1

Fission..........................2 EJ — 0·9% → 30 EJ — 5·0%
total × 13 / share × 5·6

Hydroelectricity........ 4·6 EJ — 1·8% → 15 EJ — 2·5%
total × 3·3 / share × 1·4

Holes

EVERYONE knows the First Rule of Holes: *when you're in one, stop digging!* For this reason, it is hard not to feel sympathy for protesters using slogans such as "Just Stop Oil", even when their idea of a useful contribution to policy debates seems limited to throwing paint at famous landmarks. But if it were simple to "just stop", would oil still supply the single largest share of world energy, half a century after OPEC quintupled the price overnight?

In fact, although the share of oil has fallen, the actual quantity consumed has increased by sixty per cent. (See previous page. Further energy statistics may be found in ***blast*** №1.) Much of it is used in transport. If the supply of oil were to "just stop", so must ships, trains, trucks, and tractors. Millions of people would starve in the first month, and every month after that, for who knows how long. Without heating oil, millions more would freeze as soon as winter came. That sounds much less like a platform anyone would care to adopt.

It is easy to say "electrify everything with renewable energy", "eat only locally–grown food", "insulate your house and heat it by burning wood". To actually do any of that on a global scale would be an entirely different matter — so much different that we are inclined to regard these as aspirations, expressing the aesthetic preferences of the people making them, rather than serious policy proposals or any kind of concrete attempt to find a way to meet the needs of the world. The one cannot take the place of the other.

World energy consumption increased about 140% between 1973 and 2019, and the lion's share of that increase was met by fossil fuels. Of these fuels, the easiest to replace is undoubtedly coal, as it is principally burned in electric generating stations. This is, in many countries, the result of a deliberate policy to promote coal at the expense of fission, which does the same job at least equally well. Crucially, consumption is

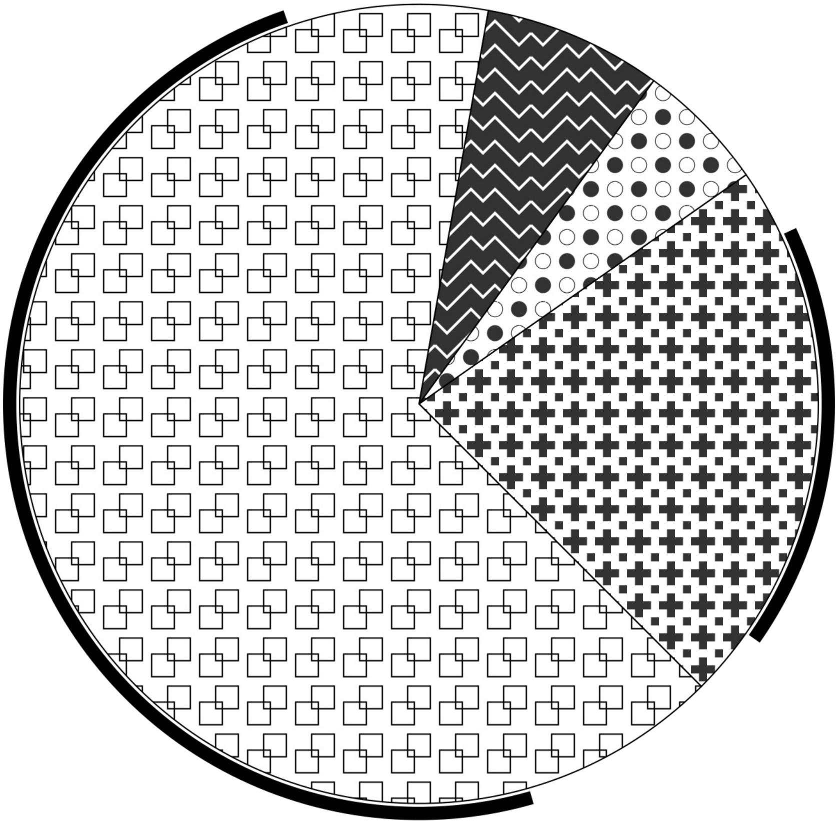
The International System of units of measurement employs prefixes to represent multiplication by powers of ten. When reading the graphs and tables in this publication, it is important to know:

kilo–	k–	10^3 (1000)	tera–	T–	10^{12}
mega–	M–	10^6	peta–	P–	10^{15}
giga–	G–	10^9	exa–	E–	10^{18}

The *joule* is the unit of energy, and the *watt* of power: 1 W = 1 J/s
Electricity is metered by the *kilowatt–hour* of 3·6 MJ (1 GJ = 278 kWh)

World Oil Consumption by Use

2019 — total 169 EJ (4036 million tonnes)



An outer arc attached to a wedge indicates the proportion between the corresponding major and minor items.

Transport.................... 65% — 110 EJ / 2635 M tonnes
Road Transport 49% — 83 EJ / 1986 M tonnes

Industry..........................7·3% — 12 EJ / 295 M tonnes

Residential.................5·3% — 9·0 EJ / 218 M tonnes

Other...........................22% — 37 EJ / 892 M tonnes
Non–Fuel Consumption 17% — 28 EJ / 674 M tonnes

concentrated in a few thousand large boilers, which can be replaced nearly one–for–one by nuclear reactors. This is a very different situation from literally billions of engines burning oil products, or a similar number of oil and gas furnaces.

A great deal of gas is also burned in large power stations, and can be replaced the same way. But this would do very little to "stop oil", a fuel which is burned to produce electricity only sparingly, except on the smallest scale. Indeed, even if we were to completely eliminate the fossil fuels which now account for more than 60% of the world electricity supply, we would still have to face one crucial fact. **Less than one quarter of the energy consumed in the world is in the form of electricity.**

Multiple Kinds of Energy

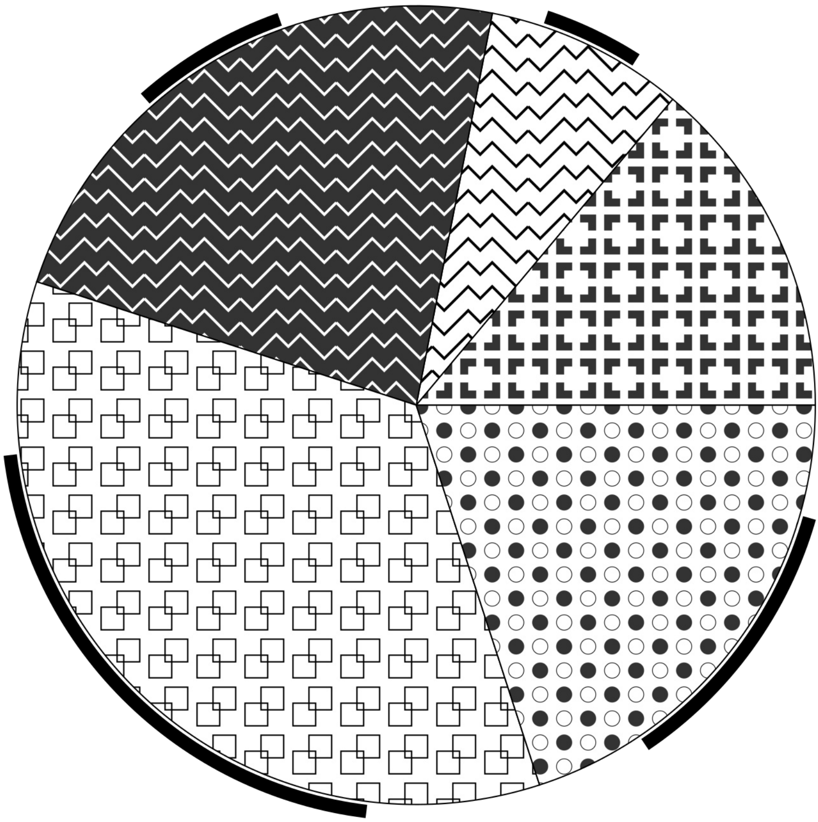
We cannot expect a simple, direct substitution of electricity for fossil fuels. Even where electricity is cheap and plentiful, as in Iceland or Manitoba, it is not used for everything. There are good reasons for this, which cannot all be overcome by saying "batteries are getting better".

Certainly, electricity is particularly suited to stationary loads. The storage battery helps to adapt it for mobile use, but effective electrification often benefits from a change of viewpoint. Battery–electric airliners, for instance, do not appear practical. Thanks to the overhead wire, railway traction can be treated as stationary, and 300 km/h electric trains have proven an attractive substitute for inland air routes — not least because intermediate stops add only a few minutes to the travel time.

Thermal power stations — which, for the future, primarily means nuclear, although solar– and geothermal will both see use in favorable locations — have the advantage that they can supply heat alongside electricity. Much of the energy consumed in the world is in the form of heat, and much of that in turn is provided by fuel. Concentrating solar presents intriguing thermochemical and photothermochemical

> It is not blind technological optimism that leads to the argument for nuclear power, but deeply–considered economic pessimism; a fear that the world in the coming century will, unless special steps are taken, starting now, be gravely short of energy and, as a result, short of everything else — food, employment, goods — but not short of lots of hungry, cold and very angry people. The use of atoms for energy provides one of the best ways we know of trying to avoid this unhappy prospect.

End Use of Energy
in a sample of wealthier countries, 2019



An outer arc attached to a wedge indicates the proportion between the corresponding major and minor items.

Residential..................20%
Space Heating 11%

Transport.................... 35%
Passenger Cars 21% (including personal trucks)

Manufacturing...........23%
Metal Extraction and Refining 6%

Other Industrial..........8% (including agriculture and construction)
Mining 4%

Services....................... 14%

possibilities for those applications which put the high temperature of the flame to use. The greatest share of both domestic and industrial heat consumption, however, is at temperatures easily supplied by present–day water–cooled power reactors.

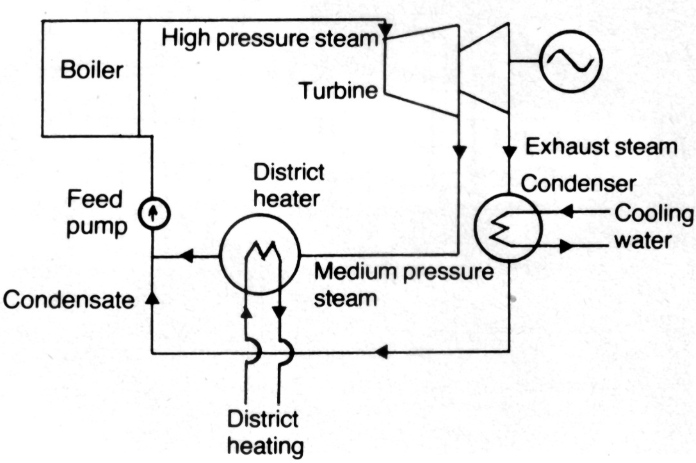
Combined heat–and–power is more than an extremely effective means of conserving energy. It also affects patterns of capital investment. Most uses of fuel for heat are a matter of convenience and cost. Electric resistance heating is cheap in terms of equipment, and ideal where fine control and modest amounts of heat are required, as in a toaster or an electric blanket. For space heating, efficient use of electricity requires a mechanical heat pump. A heat exchanger tied to a hot–water pipeline tapped off a steam turbine represents a much smaller initial cost to the consumer, incurs virtually no maintenance cost, and lasts indefinitely.

On the producer side, CHP makes more efficient use of generating plant, especially as hot–water reservoirs can be refilled during periods of slack power demand. Both daily and annual load factors can be further improved where motor–driven air–conditioning equipment (a very heavy contributor to peak electrical loads in many places) is replaced by heat–operated chillers. The overall infrastructure cost is therefore less than might at first appear.

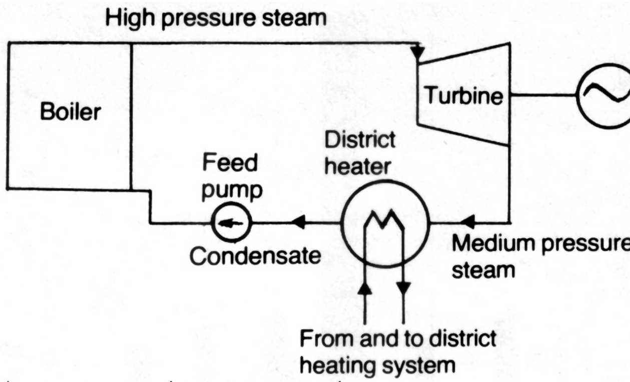
The One–Number Fallacy?

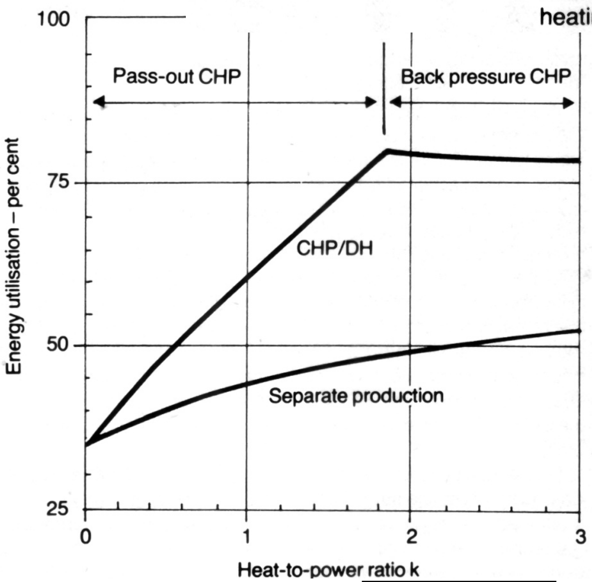
There is a tendency today to oversimplify all environmental questions to a single quantity labeled “carbon”. Real–world problems have multiple aspects which may pull in different directions. Some people, nonplussed that the Intergovernmental Panel on Climate Change rates

> I know it is argued that electricity as at present produced is an inefficient way of using primary energy, but this to a large extent misses the point. Yes, we should use primary energy more efficiently, and I believe the economic pressures of the price of fuel will drive electricity producers to use their waste heat. But far more important is the fact that uranium is otherwise a useless material. Far better to use it relatively inefficiently than burn oil or coal, which are valuable materials in their own right for chemical feedstocks. When one considers that the uranium remaining from such “wasteful” use can in the future be put into fast reactors and produce prodigious amounts more energy, it serves to emphasise the point and the shallowness of the objections to nuclear electricity from overall primary energy utilisation considerations.



Above, "pass-out" system for combined heat-and-power with district heating. Below, "back-pressure" CHP/DH system.





present–day nuclear electricity as having smaller life–cycle equivalent CO_2 emissions than wind or solar, say that this emphasis on carbon makes fission look better than it should. But a corollary to *when in a hole, stop digging* might be *when in an environmental crisis, stop burdening the ecosystem.* In other words, it is important to pursue technologies which occupy less land, consume less of raw materials that have to be extracted from the ground, and give rise to less of toxic wastes.

Fission energy already scores very well on all these counts. It is easy to get excited about the amount of concrete and steel in atomic power stations, but while each station is large and visible, few of them are needed. Wind and solar require much more material overall, spread over the landscape where it cannot all be seen at once. A recent study concluded that the total amount of earth moved for atomic power, per lifetime kilowatt–hour, was comparable to that for wind or solar — principally in the course of uranium mining. The regenerative fuel cycle will reduce the consumption of uranium per kWh by a factor of fifty at least, and centuries will be occupied just in drawing down the stocks already mined, now held as spent fuel and enrichment tails.

That above–ground uranium will supply us with more energy than burning all the fossil fuels we could ever hope to extract. As a result, so far as fuel minerals are concerned, **the breeder reactor literally allows us to *stop digging***.

We all know that there is sufficient coal to last this country for possibly 200 or 300 years, but no amount of economically worthwhile effort by men and machinery will enable the industry to dig enough coal out of the ground fast enough to meet Britain's energy needs. Even if we were able to dig out the coal in sufficient quantities we would soon find that it was essential to use much of it as a feedstock for the petrochemical industry.

What about the renewable sources of energy such as wave, wind, and solar power? That is the question people up and down the country are asking today and they certainly want a straight answer. In time they may make an extremely valuable contribution. Present estimates suggest that we might achieve in the region of 10 per cent of our energy requirements from these sources. And remember we as consumers still want electricity on the days when the sun does not shine or when the wind does not blow.

Quotations

front cover...... Dwight D Eisenhower, before the United Nations General Assembly, 8 December 1953

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3......................... JF Petit, Commissariat à l'Energie Atomique, to a colloquium on "Energy and Society", Paris, 1981 September

4......................... ES Booth FRS, "Electricity from the Atom — Britain's Second Decade" to the Société Royale Belge des Ingénieurs et des Industriels, Brussels, 2 October 1967

5......................... Sir Jack Rampton, Permanent Under Secretary of State at the Department of Energy, at the Nuclear Power Exhibition, Westminster, 20 September 1979

10....................... Sir John Hill, Chairman UKAEA, to the Institution of Electrical Engineers, 1978 February

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16....................... Sir John Hill, Chairman UKAEA, *The role of nuclear energy in the total energy mix*, to the 1972 AIF—ANS conference, Washington, DC, 13 November 1972

17....................... Norman Lamont, Parliamentary Under Secretary of State for Energy, to a conference on the future of nuclear energy in Britain organized by the Rotary Club of Manchester, 1980 June

18....................... Alan Wyatt to the Canadian Nuclear Association, 17 June 1980

22....................... Sir Alan Cottrell FRS, Master of Jesus College Cambridge, at the opening of the "Atoms for Energy" exhibition, Birmingham, November 1981

24....................... Con Allday, Managing Director BNFL, Presidential Address to Risley Nuclear Engineering Society, 11 September 1979

26........................David Nickson, Chairman Confederation of British Industry (Scotland), opening the "Atoms for Energy" exhibition in Aberdeen, 1 May 1980

back cover.......Dr Glenn Seaborg (sometime Chairman, United States Atomic Energy Commission) and William Corliss, Foreword to **Man and Atom : Building a New World Through Nuclear Technology** (1971)

Illustrations

**Comments? Send us a letter, and we may print it in our next number. See back cover for address.
Text and graphical contributions for future numbers are also most welcome. If submitting quotations, please be sure to attribute them thoroughly, so that we can double–check them.**

Prospectus of the Man and Atom Society

FEW today would believe that the means are at hand for every human on Earth to live in peace and prosperity, amid a thriving biosphere. And yet it is so. Through the development of scientific technology, humanity has gained (and begun to exercise) immense power to alter the conditions of life on Earth — for good or ill.

People in past ages could do little more than trust to divine providence. Antibiotics and vaccines, agricultural fertilizers and pesticides, instantaneous world–wide communication, and so many more innovations have changed all that. And yet this very change has left many people more fearful than when they were helpless.

The world as we see it is beset with unease, distrust, and conflict. Everywhere one meets with prophets of one sort of doom or another, and a feeling that “something’s got to give” is widespread. The young blame the old, and the old (far less reasonably) the young. Countries with shrinking populations turn away immigrants and refugees. The scientists and engineers, and their creations which make modern life possible, become objects of derision and fear.

We humans, it seems, can resign ourselves more readily to the inevitable, than we can take up the burden of choice. This would account for the prevalence of worldviews, whether religious or nominally secular, which trade in inevitabilities. **And experience teaches us that, if people think things are going from bad to worse, that is just what will happen, regardless of the material conditions**.

Of all the choices which lie before us, the greatest are presented by the nuclear fission chain reaction and the high–speed rocket. With these tools, we grasp the forces that light the stars and shape the galaxies — but many people can see in them only the V–2s that fell on Antwerp and London, and the bombs that burst over Hiroshima and Nagasaki. The paradox is, that until we embrace their uses to build us up and lift us up, a menace of destruction is all that they can be to us.

So that the choices actually taken may be those which affirm life rather than destroy it, these great powers must be made a beacon of hope rather than a specter of fear. Nuclear energy and space travel, above all, must be used wisely and vigorously — holding back, out of superabundant caution, is no more wisdom than is blindly rushing ahead. Herein lies the work of the Society: in cooperation with all friends and willing helpers, to advocate for, promote, and advance their use “**in peace for all mankind**”.

The control of intra–atomic energy, through the nuclear fission chain reaction, stands in the foremost rank among the accomplishments of the human intellect. That the energy so released now lights and heats homes, and turns the wheels of industry, from Argentina to Korea, is a true sign of hope in our times. *And this world needs hope.*

Broadly speaking, a deficiency of public understanding of science poses a problem in a democratic society — especially one that is also a technological society so dependent for its human progress on scientific progress. But in recent years we have become impressed with the fact that public understanding of the atom specifically is an even more urgent problem, as to a growing extent our very future may hinge on how wisely we manage this great new source of energy and its myriad applications.

Human civilization is rapidly approaching a series of crises that can be managed only through some radical departures in Man's dealings with the relationship between energy and matter. Nuclear energy holds one key — a crucial one — to the successful resolution of these crises. Without it there is no doubt that civilization, as we know it, would slowly grind to a halt. With it not only will we be able to raise a greater part of the world's people to a decent standard of living, but we will be able to move all mankind ahead into an era of new human advancement — human advancement which takes place in harmony with the natural environment that must support it.

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