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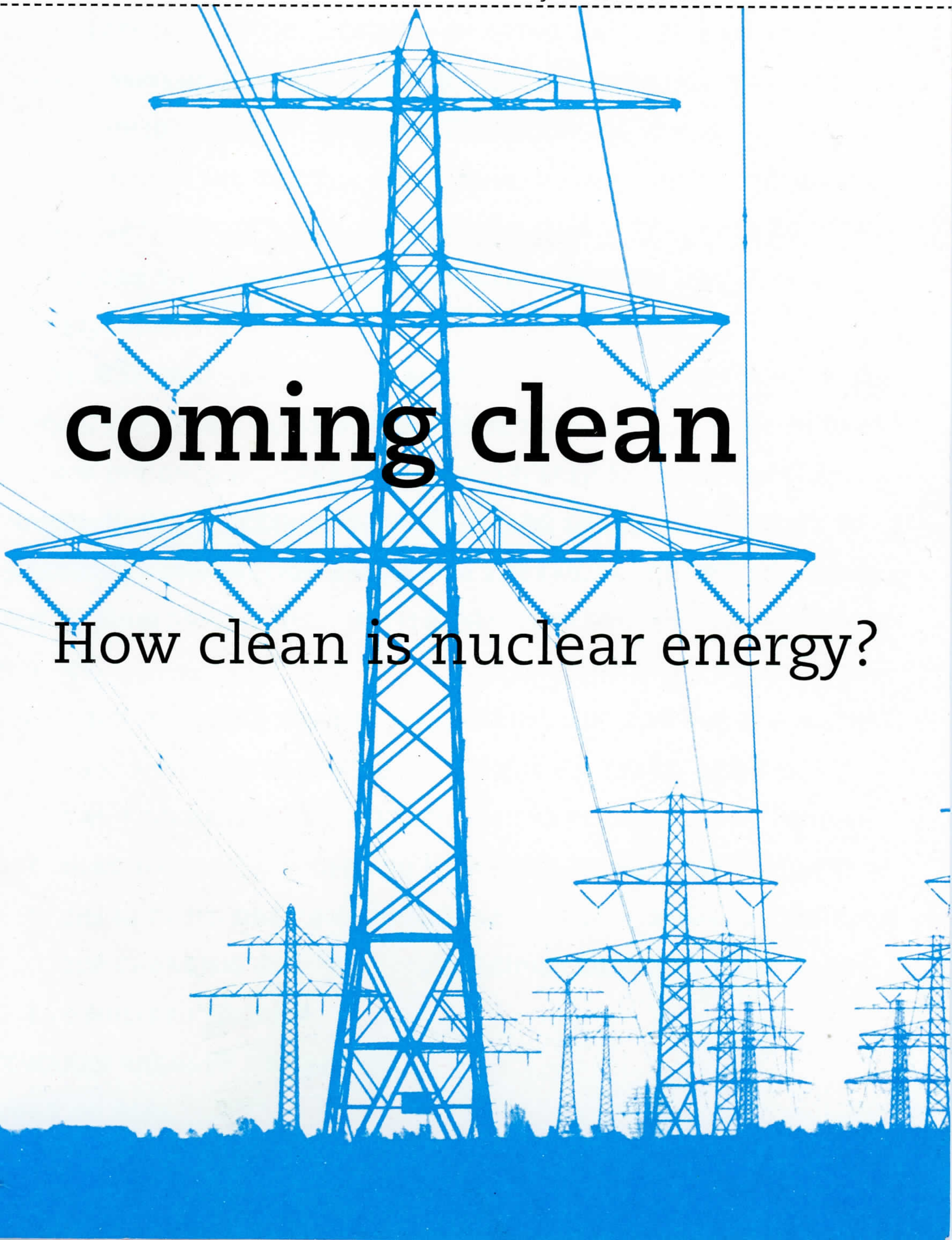
Information brochure



coming clean

How clean is nuclear energy?

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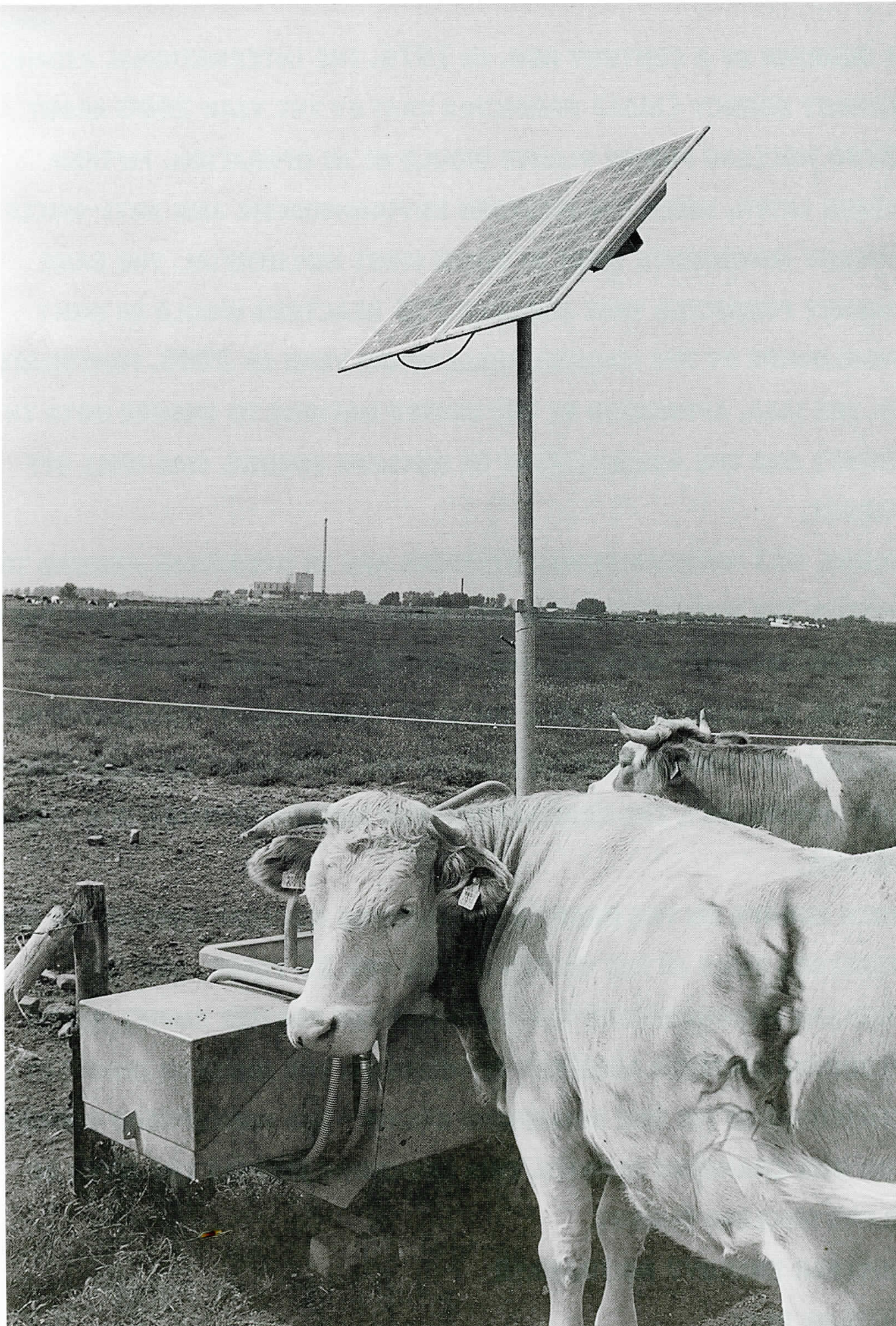
A QUARTER OF A CENTURY AGO, IN 1976, THE INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA) PREDICTED THAT BY THE YEAR 2000 ABOUT 2300 NUCLEAR POWER PLANTS WOULD BE IN OPERATION. FIFTEEN YEARS LATER, WHEN THE WESTERN ENVIRONMENTAL AND ANTI-NUCLEAR ENERGY MOVEMENTS WERE AT THEIR MOST INFLUENTIAL, THE SAME AGENCY PREDICTED THAT ANOTHER 725 REACTORS WOULD BE BUILT WORLDWIDE BY THE MAGICAL MILLENNIUM YEAR OF 2000. FORTUNATELY, THE IAEA, APPOINTED BY THE UNITED NATIONS TO ENSURE BOTH THE SAFETY AND THE ADVANCEMENT OF NUCLEAR ENERGY, WAS WELL OFF TARGET.

TODAY, 433 NUCLEAR POWER STATIONS ARE IN OPERATION AROUND THE WORLD. THE PREDICTIONS DID NOT COME TRUE. THIS WAS DUE IN PART TO NEW INSIGHTS INTO THE LOW COST-EFFECTIVENESS OF NUCLEAR POWER, NUCLEAR ACCIDENTS, THE NEED FOR GREATER FLEXIBILITY IN ELECTRICITY PRODUCTION AND, AFTER THE FAILURE OF BREEDER REACTOR TECHNOLOGY, THE REALISATION THAT NUCLEAR ENERGY IS A FINITE SOURCE.

WITH EUROPE ON THE ROAD TO ABANDONING NUCLEAR ENERGY, NO NEW REACTORS BUILT IN THE UNITED STATES FOR 25 YEARS, AND THE NUCLEAR PROGRAMME IN THE STATES OF THE FORMER SOVIET UNION PLODDING ON FROM ACCIDENT TO INCIDENT, THE NUCLEAR INDUSTRY IS CLUTCHING AT ITS ONE REMAINING STRAW – THE WIDESPREAD CONCERN FOR OUR CHANGING CLIMATE. THIS BROCHURE DISPELS THE MYTH OF CLEAN NUCLEAR ENERGY.

NUCLEAR ENERGY? NO THANKS!!

PEER DE RIJK
WORLD INFORMATION SERVICE ON ENERGY (WISE)



Solar cells in Europe

INTRODUCTION

During the International Climate Convention in Kyoto (1997), it was agreed that the developed nations of the world would reduce their greenhouse gas emissions. The European Union is committed to reducing emissions of the main greenhouse gas, carbon dioxide (CO_2), by 8 percent from 1990 levels by the year 2010. The United States must reduce emissions by 6 per cent and Japan by 7 per cent. These agreements are laid down in the Kyoto Protocol. These reductions represent the first small steps on the road to creating a society that no longer uses fossil fuels. The final objective must be a society that only uses renewable energy sources.

Remarkably the atomic energy industry seems to be actually profiting from the concern about greenhouse gases and global climate change. The nuclear industry expressly profiles nuclear energy as a clean source that does not emit greenhouse gases.

In the industrialised North, nuclear energy's chances of survival are slim. There is very little political, economic or social support for nuclear energy in the wealthy nations. The United States has not built a single reactor since 1979 (the time of the Harrisburg accident). There are no moves to expand nuclear power generation in those European Union Member States that have nuclear power stations. On the contrary, there is support for reduction and dismantlement programmes. Eight Western European countries (Denmark, Iceland, Norway, Luxembourg, Ireland, Austria, Portugal and Greece) have never even had a nuclear energy programme. Outside Europe, only China, South Korea, Japan, Taiwan and South Africa aspire to expand the share of nuclear power generated in their countries.

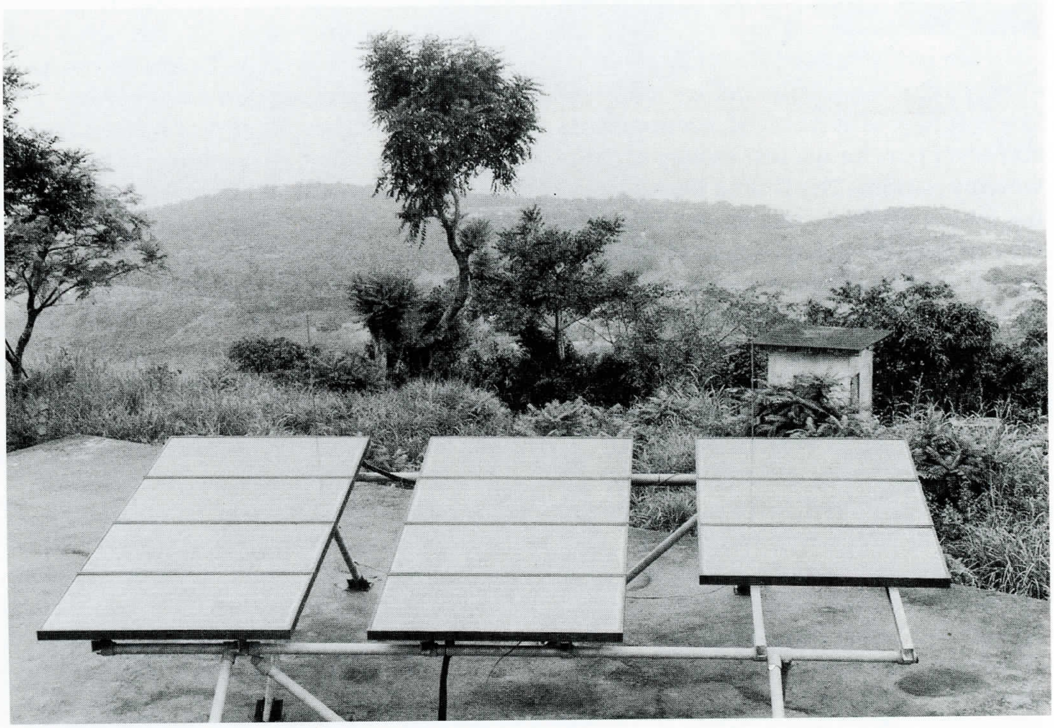
Today, it is the developing countries that are being targeted by the atomic energy industry, and the Kyoto Protocol is paving the way. This Protocol provides the use of so-called flexible instruments, which were introduced so that wealthy nations could achieve their emission reductions in other countries. One of these instruments is the Clean Development Mechanism (CDM). The CDM aims to facilitate the financing of clean technologies (through investment in solar energy, wind turbines, hydroelectric power stations and energy saving technologies) and the transfer of these technologies from the North to the South. The wealthy nations can use the emission reductions achieved via the CDM to meet their Kyoto commitments. At the same time, developing countries gain access to clean (endemic) sources. Is this the ideal win-win solution?

An enormous threat lurks within the CDM: it could allow the nuclear industry to slip in again through the backdoor. The industry sees the CDM as its chance to use financial support from governments to lower the costs of nuclear energy to a level that allows it to compete with fossil fuel-fired power stations and to ensure its survival as an industry by selling nuclear power stations to developing countries. During the plenary meeting of the International Atomic Energy Agency (IAEA) in October 1999, a resolution was passed that makes the industry's standpoint abundantly clear: the director-general of the IAEA was asked "*(...) to help interested Member States to obtain access to relevant information on the role of nuclear power in achieving sustainable development in developing countries and in mitigating greenhouse gas emissions through the Clean Development Mechanism as may be elaborated under the Kyoto Protocol, and to assist in implementing national case studies as well as preparation of potential projects*".

The industry knows that it is make-or-break time: if developing countries say no to nuclear energy, they will be signing the death warrant of what is already a stagnating industry.

In this brochure, the claims made by the atomic energy industry are held up to the light. What is the truth about the claim that nuclear energy can be used as an effective weapon in the struggle to prevent climate change? To answer this question, we must consider a number of components.

- How renewable is nuclear energy?
- How clean is nuclear energy?
- What is the energy recovery time for nuclear power stations?
- Is nuclear energy production CO_2-free?



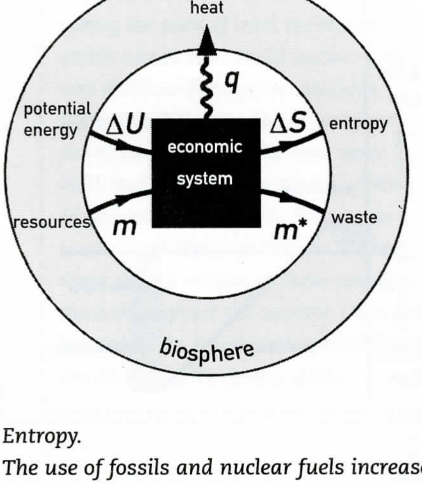
Solar cells in Africa

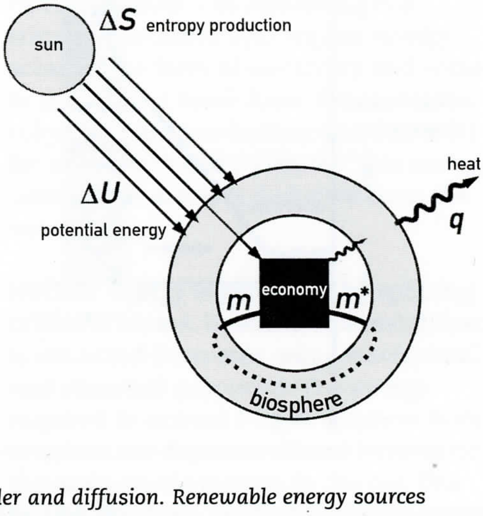
RENEWABLE ENERGY

A renewable energy source is defined as a source that cannot run out and that causes so little damage to the environment that its use does not need to be restricted. None of the energy systems based on mineral resources found in the earth's crust are renewable, because one day the mineral deposits will be used up. This is true for fossil fuels and uranium. The debate about when a particular mineral resource will run out is irrelevant in this context.

A renewable energy source is continually 'supplemented'. Renewable energy sources are based directly or indirectly on solar energy, they are: solar cells (often referred to as photovoltaic cells or PV cells), wind, biomass (under specific conditions), waves and tides. Hydroelectric power is not necessarily a renewable energy source, because large-scale projects can cause ecological damage and have irreversible consequences. Geothermal heat is renewable, but must be used cautiously to guard against irreversible ecological effects.

The second law of thermodynamics is an objective yardstick of whether an energy source is renewable. The second law is based on the empirical fact that it is impossible to convert heat into energy without a change in temperature. A circular process that has no effect other than the transfer of heat from a system with a lower temperature to one with a higher temperature cannot exist. The concept of entropy is defined in the second law of thermodynamics. Entropy is a measure of disorder, dispersion and diffusion. Every interference in the biosphere results in increased disorder. By using elements extracted from the earth's crust the balance is by definition negative, which means that, as a whole, entropy and therefore disorder are increasing all the time. Any energy system that obtains its raw materials, fossil fuels or uranium, from the biosphere will inevitably discharge its waste into that same biosphere, thereby increasing entropy in the biosphere.





Entropy.
The use of fossils and nuclear fuels increases the disorder and diffusion. Renewable energy sources (sun, wind) decrease the entropy in the global biosphere.

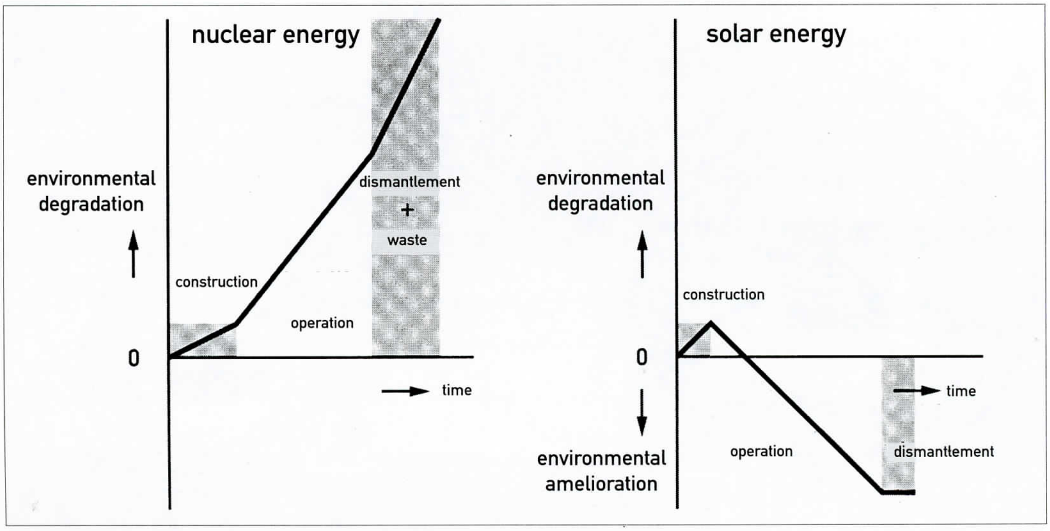
An increase in biospheric entropy always results in the deterioration of the environment. This deterioration manifests itself in several ways, including:

- an increase in CO_2 concentration levels in the air;
- soil, air and water pollution (dispersion of undesirable substances, including radioactive substances originating from nuclear power stations);
- the depletion of finite mineral resources, such as platinum (catalytic agent) and phosphates (agriculture). These substances do not disappear from the earth, but become so diffused that they can no longer be mined;
- decreasing biodiversity: the loss of plant and animal species, which increases the sensitivity of ecosystems, and thus of agriculture and livestock farming, to plagues and disease;
- desertification of dry agricultural and livestock farming areas.

It therefore follows from this second law that an increase in order (i.e. a decrease in disorder and diffusion) in the biosphere can only occur if the necessary 'ordering' energy originates from outside the biosphere. The entropy created when that ordering energy is generated remains outside the biosphere.

The only way to keep the level of entropy in the biosphere constant or to reduce it – something that is essential to the survival of the human species, especially in view of the increasing world population – is to make use of direct or indirect solar energy.

The sun is a giant, inexhaustible energy source. The entropy resulting from the energy production remains on the sun, which means that we receive the benefits without the disadvantages. There are no technical barriers to a complete con-



Entropy impacts from nuclear energy and solar energy version to solar energy – merely political and short-term economic obstacles. When deciding on energy policy, the question is not which energy source (PV, wind, hydraulic, biomass) is 'more renewable' than the other, but which source would cause the least damage to the biosphere and ecosystem.

INDIA RENEWABLE

Demand for electricity is rising rapidly in India, but the government is not taking the path of least resistance, which would be to build nuclear reactors and coal-fired power stations. Instead, within a period of just four years, large wind parks have been built that now provide a total of 900 Megawatts of electricity. Biogas systems are all the rage in India. Today, there are 2.5 million of these installations throughout the country. Most are located in the countryside where there are no electricity supply grids.

THE NUCLEAR ENERGY PROCESS CHAIN

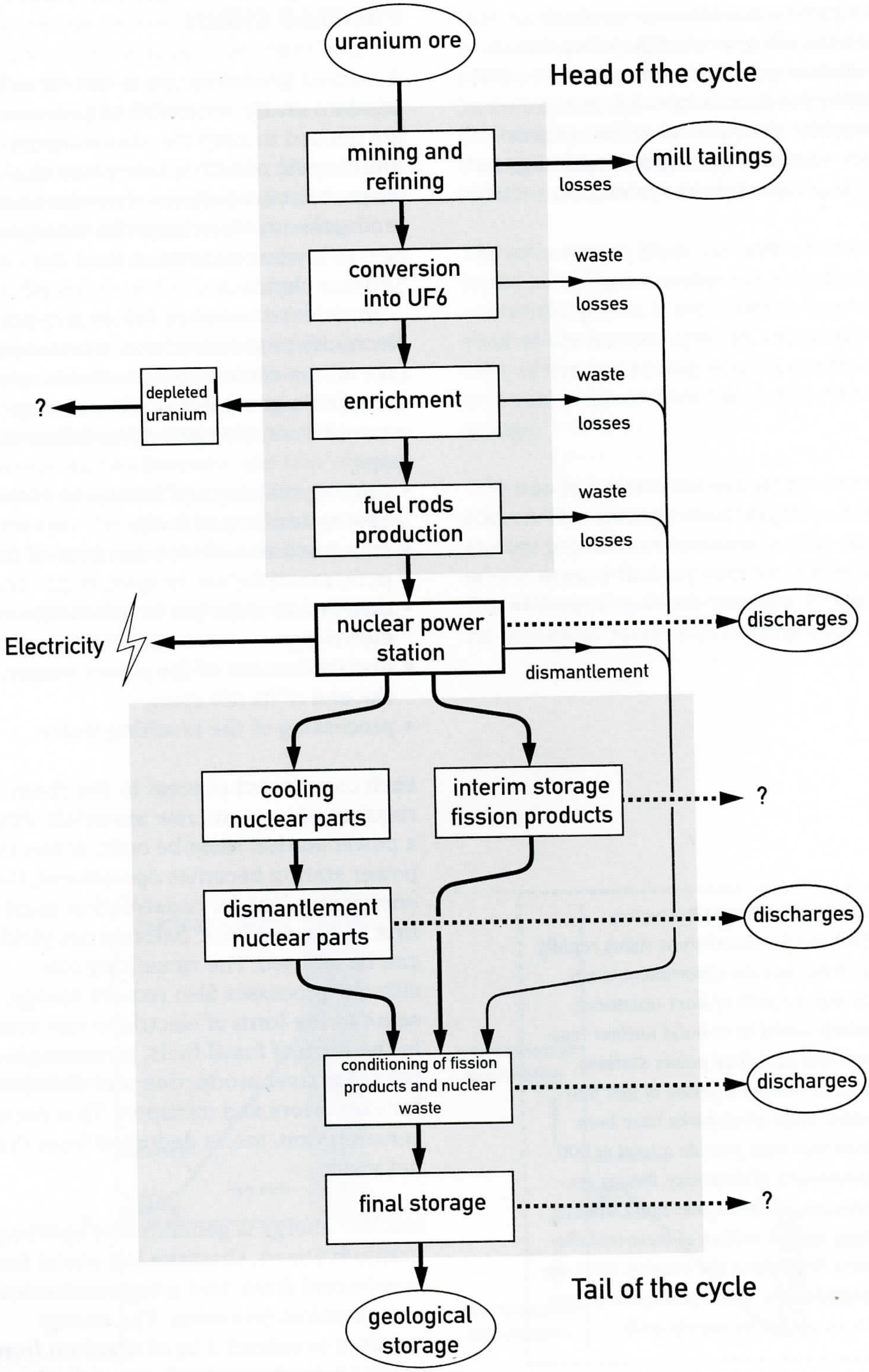
A nuclear power station is not an independent entity. A number of processes are needed to keep the station operational, most of which take place elsewhere or at other times than the actual production of electricity. The total package, as it were, is referred to as the 'process chain'.

In order to compare different types of electricity production, it is necessary to take all the constituent processes into account. In general, a nuclear energy process chain consists of the following steps:

- mining, refining and transport of the raw materials and fuels;
- construction and maintenance of the power station;
- conversion of fuel or uranium into electricity;
- dismantlement of the power station at the end of its life span;
- processing of the resulting waste.

Each constituent process in the chain requires energy and raw materials. First, a power station must be built. When the power station becomes operational, the energy required for construction must first be 'earned back' before a net yield can be realised. The remaining constituent processes also require energy, some in the form of electricity and some in the form of fossil fuels, for example cokes for steel production and diesel oil for excavators and transport. This energy consumption, too, is deducted from the net yield.

Nuclear energy is generated by splitting uranium atoms. Uranium is a metal that is extracted from ores using mechanical and chemical processes. The energy required to extract 1 kg of uranium from uranium ore depends almost entirely on the amount of uranium in the ore. The beginning of the nuclear energy process



Nuclear fuel cycle

chain differs considerably from that of fossil fuels, which are extracted from the ground in more or less ready-to-use form.

The end of the nuclear energy process chain is fundamentally different from that of other energy sources, because we are left with radioactive waste as well as chemical waste. Uranium and uranium ore are radioactive substances. The nuclear reactions that take place in the reactor cause the amount of radioactivity to increase by a factor of ten million. The nuclear reactor itself and the surrounding structures also become highly radioactive. As a result, dismantling a nuclear power station at the end of its life span (approximately 30 years) is a laborious and extremely costly process that requires a great deal of energy and auxiliary materials – perhaps twice the total energy needed to build the power station in the first place. As yet, very little has been learned about this process, as to date only a few nuclear power stations have actually been dismantled.

Radioactivity cannot be destroyed. It disappears through natural decay, a process that takes between thousands and millions of years to complete. Nuclear waste must be stored in such a way that it is prevented from entering the biosphere throughout those thousands or millions of years. This is also a high energy consumption activity. The processing and permanent storage of radioactive waste is an area where no-one has any practical experience. One option being considered is to store radioactive waste in deep mines in stable geological formations. Dumping the waste in the sea or on land, which until recently was common practice, is not a realistic option for the future. It takes 150 to 200 years to complete the nuclear energy process chain, from uranium extraction to permanent storage of the last remaining radioactive waste.

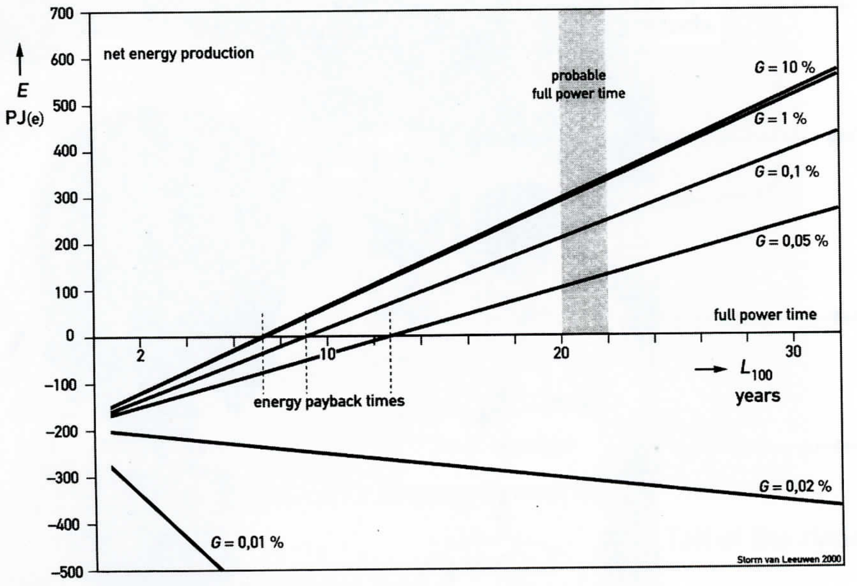
The tail of the nuclear industry

ENERGY RECOVERY TIME

It takes energy to mine uranium ore. The lower the uranium content, the more energy-intensive the extraction process. When the uranium content is low, the nuclear energy process chain uses more energy than it generates in electricity. Most of the uranium ore extracted today has a uranium content of between 1 and 10 percent, which makes extraction cost effective. However, if nuclear energy were to gain momentum, a point would come when uranium ore extraction would no longer be cost-effective. The 'energy recovery time' (i.e. the time the nuclear power station has to have been operational before all the energy consumed in the chain has been earned back and the power station begins to produce net energy) is highly dependent on the uranium content of the ores, and is about 10 years for uranium-rich ores (10 per cent) and 18 years for uranium-poor ores (0.05 per cent).

It is difficult to compare this figure with the energy recovery time for fossil fuel-powered power stations: note that a fossil fuel power station only has to recover the electricity used for construction and other constituent processes in the chain. In such a case, the recovery time for power stations fired by gas and oil is 0.09 of a full-load year (approximately 0.13 of a calendar year) and for coal-fired power stations, 0.15 of a full-load year (approximately 0.21 of a calendar year).

Nuclear power stations, wind turbines and PV systems only generate electricity (unlike modern gas-fired power stations, which also generate and supply heat). All the energy used in the chain is recovered in the form of electricity, which increases the recovery time considerably. To enable a more accurate comparison of power stations fired by fossil and other fuels to be made, we have assumed that the fossil-fired power stations must recover the



Energy recovery time for a nuclear power station.
The use of poorer uranium ore (from 10 till 1 percent) influences the nett energy production (E) and enlarges the energy recovery time (L).

energy used in their construction entirely in the form of electricity. This results in a recovery time of 0.7 full-load years for gas or oil-fired power stations, which is approximately 1 calendar year. Coal-fired power stations have a longer recovery time.

Improvements in conversion yields and production methods will help to reduce the recovery time for PV (photovoltaic) systems in the future. PV technology is at the peak of development and at the moment we are in the sharply rising section of the learning curve, which means that prices are falling significantly as more PV capacity is built. It is conceivable that the recovery time for PV will drop to less than 1 year as technical progress continues.

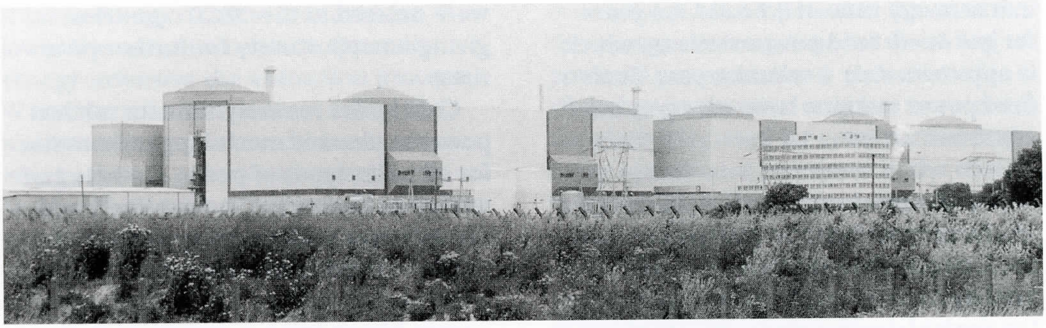
Nuclear energy, on the other hand, is a mature technology: the price of nuclear power will not decrease as more nuclear power stations are built. In the past there were even cost hikes of approximately 14 per cent a year until the mid-1980s. After that time, no new nuclear power stations were ordered in the OECD countries, giving no opportunity for further price rises.

Clearly, the recovery time for nuclear power stations is much longer than that for all other types of power stations and will never decrease. On the other hand, the recovery time for PV systems in particular is certain to decrease.

RECOVERY TIME	
wind	*0.62 – 0.9 years*
gas and oil	*1 year*
PV (photovoltaic) system	*1.5 – 3 years*
nuclear power station	*10 – 18 years*

Windturbines: the fastest energy recovery time

Six French nuclear power stations at a row in Gravelines



FRENCH PRIDE

France is the world champion when it comes to the share of the nation's electricity that is produced by nuclear energy. Nearly 76 per cent of the electricity generated in France is produced by nuclear power stations. Together, the country's 59 nuclear reactors swallow up the output of 4.5 reactors a year. The sector consumes nearly 8 per cent of its own production. Thanks to a mammoth nuclear construction programme, France has considerable overcapacity, which it disposes of by trying to get French households to use electric heating and by dumping cheap surplus electricity in foreign countries (e.g. the Netherlands). Nevertheless, the tide appears to be turning. No more nuclear reactors are being built, breeder technology is being mothballed and (small-scale) combined heat and power production (CHP) is on the rise.

GOOD THINGS COME IN SMALL PACKAGES

The cost of electricity depends entirely or largely on the size of the power supply station. Between 1960 and 1980, the ideal size for a station rose from 400 to 1000 MW. It was no coincidence that this was the size of a nuclear power station. These days, 5 MW is regarded as the ideal size, because small-scale power generation permits a flexible response to energy demand. Small-scale units such as wind turbines, photovoltaic cells, fuel cells and biogasification plants are the future. Nuclear power stations are many times too big.

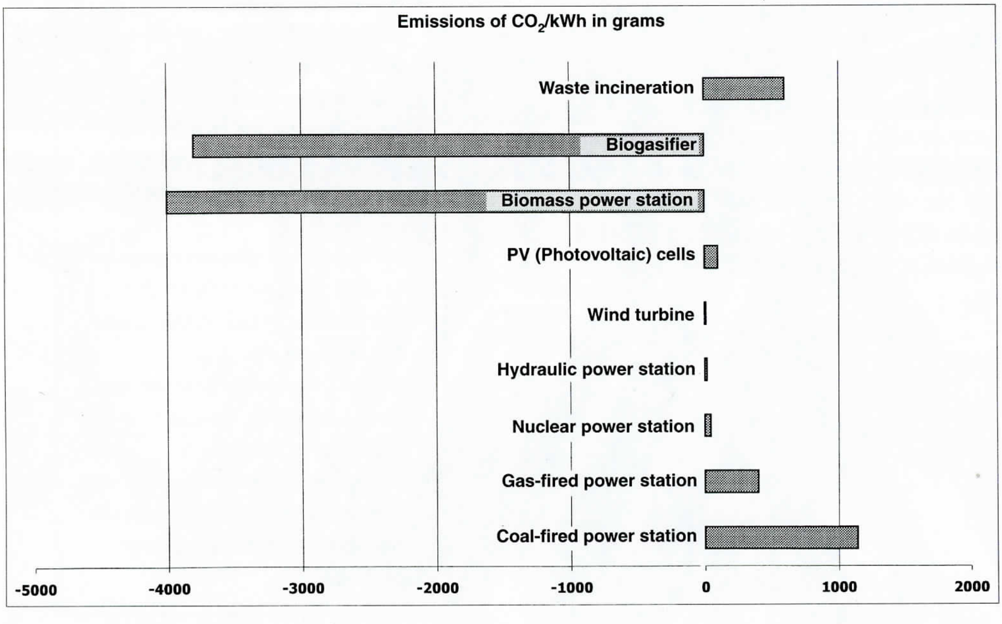
EMISSIONS

Contrary to the nuclear industry's claims, the nuclear energy process chain produces significant amounts of CO_2 during the construction of power stations, ore extraction and transport, and so on. In fact, it is only after 7 to 10 years that a nuclear power station begins to generate electricity with a lower level of CO_2 emission per kWh than a gas-fired station. In the best-case scenario, a nuclear power station still produces a third of the amount of carbon dioxide produced by a gas-fired station.

The table below compares CO_2 emissions for different types of power stations:

High levels of radioactivity are produced when nuclear energy is generated from uranium. Currently all the tritium and krypton produced, and nearly all the iodine, ruthenium and caesium produced, are discharged into the air or the oceans. Even some of the uranides, such as plutonium and americium, find their way into the oceans. The nuclear industry is granted government licences for this type of disposal.

CO_2 emissions per energy source



CONCLUSIONS

The atomic industry would have us believe that nuclear energy is the only renewable solution to the climate problem. However, after close consideration this claim has been shown to be hollow. The objective of the Clean Development Mechanism is to get wealthy countries to invest in clean energy sources in developing countries, in order to reduce carbon dioxide emissions. Nuclear energy has no business there.

Nuclear energy is not renewable
Uranium ore is needed to feed nuclear power stations, and one day uranium, like fossil fuels, will have been used up. And when they're gone, they will be gone for ever.

Nuclear energy produces radioactivity

Although nuclear energy emits less carbon dioxide, it releases life-threatening radioactive substances into the environment.

Nuclear energy is not CO_2-free
Although nuclear power stations emit little CO_2, the entire nuclear energy chain produces at least a third as much carbon dioxide as a modern gas-fired power station does.

Nuclear energy is expensive
Nuclear energy costs more per KW/hour than the alternatives. Added to this, the energy recovery time is very long compared to other energy sources. It takes a great deal of energy to produce nuclear energy.

THE COST OF NUCLEAR ENERGY

- *The huge investments made in nuclear power stations draw funding away from renewable sources and energy-saving technologies.*
- *Highly educated managers and qualified personnel are needed to manage and operate nuclear power stations.*
- *Nuclear energy requires large-scale infrastructure and expensive grids.*
- *Nuclear power stations require a long planning and construction period of at least six years, which makes them a highly inflexible solution.*
- *Nuclear power stations can only be used for large-scale production.*
- *The problem of radioactive waste has not been solved.*
- *With nuclear power stations and related activities, there is an inherent risk of accidents.*
- *The misuse of nuclear fuel for military purposes is increasing as the development of nuclear energy progresses.*

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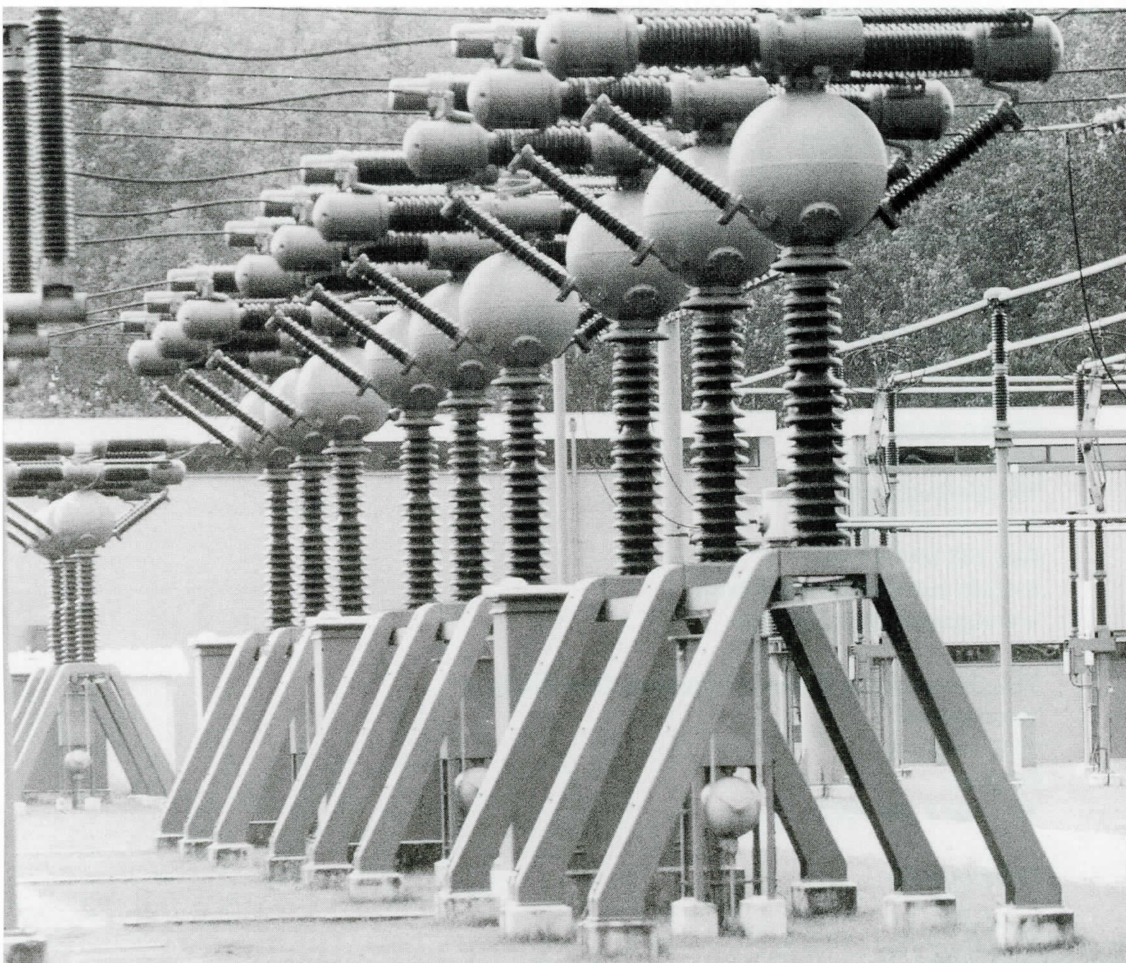

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GroenLinks in the European Union
The Greens / European Free Alliance

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IT SOUNDS MORE AND MORE LIKE AN EMPTY ADVERTISING SLOGAN: 'NUCLEAR ENERGY GIVES YOU A CLEANER WASH'. CAN NUCLEAR POWER HELP MAN REDUCE CO_2 EMISSIONS AND AVOID CLIMATE CHANGE?
JAN WILLEM STORM VAN LEEUWEN EXPLAINS THE FACTS ON BEHALF OF GROENLINKS IN THE EUROPEAN UNION. HIS RESEARCH REVEALS THAT THIS SO-CALLED CLEAN ENERGY SOURCE DOES NOT, AND CANNOT, LIVE UP TO THE CLAIMS MADE ON ITS BEHALF.

THIS BROCHURE EXAMINES TWO INDICATORS - GREENHOUSE GAS EMISSIONS AND ENERGY RECOVERY TIME - TO EXPLODE THE MYTH THAT NUCLEAR ENERGY IS A CLEAN ENERGY SOURCE.
NUCLEAR ENERGY HAS FAILED. RENEWABLE ENERGY SOURCES AND ENERGY-SAVING PROGRAMMES ARE THE ONLY SOLUTIONS TO THE CLIMATE PROBLEM, FOR WEALTHY NATIONS AND DEVELOPING COUNTRIES ALIKE.