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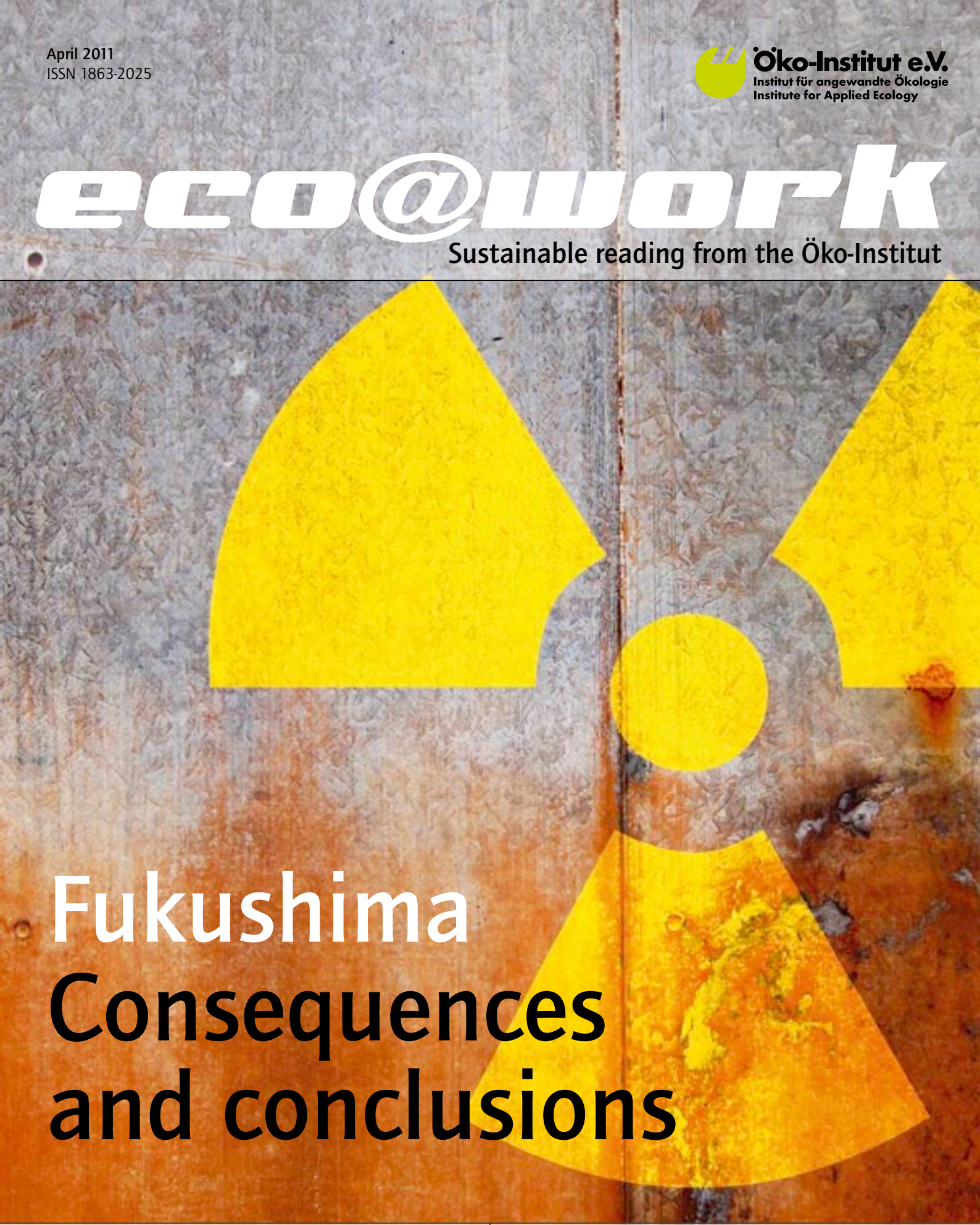
# eco@work

Sustainable reading from the Öko-Institut



# Fukushima
# Consequences and conclusions

**In focus**
Hidden treasures – Recycling for rare earths and metals

**The interview**
Professor Osibanjo on the sustainable disposal of e-waste in Africa

# Dear Readers,

The disasters in Japan demonstrate all too clearly the extent to which even a highly developed industrialised nation remains at risk from the forces of nature. The earthquake and tsunami are likely to have claimed tens of thousands of lives and are having a major impact on the country. On top of them comes the nuclear disaster at Fukushima. As a result many people are for the first time becoming aware that serious accidents can occur even in standard reactors in an industrialised country. This is surely the dawn of a new era of risk perception.

The relevance of the Öko-Institut's call for a fundamental transformation of energy systems is now clearer than ever. Since the founding of the Institute we have been studying the risks of nuclear energy and making the findings available to policy-makers and the public. The scenario that is unfolding in Fukushima is one of which we were aware from the theory that has been explored in many studies, including ones that we have carried out ourselves. Because we have always considered alternative approaches that avoid such risks to be essential, we have supplemented our risk research by investigating alternative energy systems from all points of view – technical, economic and legal. Through this work we have repeatedly shown that alternative pathways are both possible and sustainable.

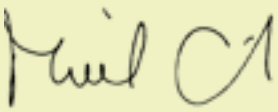
This episode has also highlighted once again the great need for scientific expertise to interpret and assess events. There was and still is enormous public demand for objective and factually based information. Our nuclear and energy experts have worked non-stop to answer enquiries from the media. On pages six and seven you can read some of the views of our scientists, who have been quoted in hundreds of items in the press and on radio and television in recent weeks.

A major article in this issue of eco@work focuses on another very topical issue. With countries all over the world pursuing the path of economic development, global demand for valuable metals, fuels and other key resources is rising. Their extraction entails a growing human and environmental burden. Concerns about shortages and a possible global struggle for scarce resources are addressed in our research, for instance in our recent study of rare earths.

This study shows that sustainable resource management is feasible. Fair and clean resource extraction and the sustainable use of consumer goods are important steps in this direction. In addition, the development of recycling strategies holds huge potential to recover valuable materials from discarded electrical and electronic devices. Read more about this starting on page eight.

As always, we hope to bring you new and interesting insights and outlooks. And we remain confident in our conviction: the future is not fate.

Warmest greetings,



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# "Recycling cycle between Africa and Europe is already a reality"

**In this interview: Prof. Oladele Osibanjo, Director of the Basel Convention Coordinating Centre for the African Region at the University of Ibadan, Nigeria (BCCC-Nigeria), on concepts for sustainable e-waste management in Nigeria.**

**Mr Osibanjo, why is so much e-waste generated in Nigeria?**
With 150 million inhabitants, Nigeria is Africa's most populous country and economic hub for West and Central Africa. A large recycling economy in which used electrical and electronic appliances are repaired and sold has emerged in the informal sector. These devices get broken at some point, but in Nigeria, there is a lack of an infrastructure for the sustainable dispose of e-waste.

**To which extent is the problem attributable to illegal e-waste exports from industrialised countries?**
These exports do play a role. Above all, many broken and not repairable electrical and electronic appliances, which, however, are declared as second hand articles, arrive. In 2010, the National Environmental Standards and Regulations Enforcement Agency NESREA has investigated shipping containers with personal computers and TVs from Europe: the proportion of fully-operative equipment varied between 30 and 70 percent.

**Should the import of used electrical appliances be banned?**
No, that would be an economical disaster for Nigeria. As a developing country, we can hardly afford new PCs or mobile phones. In order to overcome the digital divide, we are dependent on second-hand goods. In Internet cafés, the computer equipment consists to 95 percent of used equipment, the same applies to schools and businesses.

**What is being done to prevent the import of e-waste?**
Following our advice, importers of used electrical and electronic equipment have to register with NESREA. The national government tightens controls. Thanks to some hints from the EU environmental protection network IMPEL, two ships with e-waste were sent back to Europe recently. Import fines of $ 200,000 have been imposed for illegal e-waste against some shipping companies.

**What happens to the e-waste?**
E-waste simply ends up in landfills. There, young people with hammers or their bare hands try to open the case in order to get out aluminium or steel, cables are burned to get to the copper. The inappropriate disposal of e-waste causes great harm to humans and the environment.

**How can e-waste management be improved?**
So far, there was little awareness of the fact that e-waste is dangerous. We are trying to change that – addressing both regulatory agencies of government and the local recycling economy. We have conducted training for 100 recyclers in the informal sector: it was explained to them which were the valuable and which the hazardous substances in electronic waste and how to improve their methods with view to a more sustainable recycling. Our message is: „If you burn e-waste, you ruin your health. Stop it, otherwise you have no time left to spend the money you have made!"

**Can you mention further plans?**
E-waste contains valuable metals that are in short supply and that are urgently needed by the high-tech industry. Therefore, recycling loops between Africa and Europe already exist: gold and silver from printed circuit boards passes through dealers and recyclers from Lebanon, India and China back to Europe. These cycles should be improved to become more efficient, fairer and more sustainable to prevent harm to humans and the environment. For this, we need a partnership between highly efficient recycling companies in the industrialised countries and in Africa, ensuring that the informal sector, in which 95 percent of Africans are active, will be integrated. We have already held a workshop, where representatives of the e-waste recycling company Reclaimed Appliances of United Kingdom and Hewlett Packard Company and recyclers from the informal sector have discussed economic potential and aspects of a recycling cooperative. The example might well be a precedent. Moreover, industrialised countries should increase investment in sustainable recycling infrastructure in Africa.

**Thank you for this interview.**
The Interview was conducted by David Siebert.

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*Prof. Oladele Osibanjo researches at the University of Ibadan, Nigeria, in the field of environmental chemistry. As director of the Basel Convention Regional Coordination Centre in Nigeria (BCCC-Nigeria), he is concerned with ensuring successful implementation of the Basel Convention which aims to minimise the cross-border transportation of hazardous waste including e-waste for the region of Africa. Together with the Öko-Institut, he has published a study on e-waste management in Nigeria.*

Rare earths are classed as "critical metals": they are essential to high-tech products and green technologies, and demand for them is rising steadily. But because China, the principal supplier, is cutting back its exports, there is a risk of serious supply shortages. Environmental problems and other obstacles make it difficult to tap new sources of these minerals. The Öko-Institut shows how Europe can manage these valuable resources sustainably.

# Rare earths: the crux of the matter

China has caused turmoil on the resource markets and in high-tech companies. In the past, 97 percent of all the rare earths mined worldwide have come from the People's Republic. Last year the Chinese government, which wants to make greater use of the sought-after metals in its own booming economy, cut exports of rare earths by about 30 percent by comparison with 2008. World market prices soared as a result, sometimes as much as eightfold.

The shortage is being felt particularly hard by the USA, Europe and Japan, who are the main consumers of rare earths: in 2008 they sourced 90 percent of their imports from China. The quantity of rare earths mined each year is fairly small, amounting to around 124,000 tonnes. Yet these valuable minerals play a key part in the technologies of the future: they are essential for computers, digital cameras and lasers, and also for many green technologies. For example, lanthanum, which the Federation of German Industry (Bundesverband der Deutschen Industrie, BDI) cites as currently presenting a major supply problem, is used in the manufacture of catalytic converters, compact fluorescent lamps, flat-screen monitors and batteries for hybrid cars. Neodymium is an important component of the very powerful permanent magnets used in the reading heads of computer hard disks, mobile phone headsets, the engines of electric cars and wind turbines. Around one-sixth of all new wind turbines erected in 2010 used neodymium magnets. Since they need no gears, they require less maintenance, which makes them particularly suitable for offshore windfarms.

"The future supply of rare earths is vital to the development of high-tech businesses and green technologies," says Dr. Matthias Buchert, head of the Öko-Institut's Infrastructure and Enterprises Division. He and other scientists at the Öko-Institut were therefore commissioned by the parliamentary group of The Greens – European Free Alliance in the European Parliament to produce a study outlining sustainable options for the management of rare earth resources in Europe. "Our study provides a comprehensive overview of the issue – including the environmental aspects – and is the first to draw on original Chinese sources," states Dr. Buchert. According to the study, global demand for some rare earths will increase by between 40 and 70 percent in the coming years. However, the study also shows that – contrary to the implications of their name – rare earths are not particularly rare: world reserves of all the commercially useful rare earths, calculated as rare earth oxides, are put at 99 billion tonnes, of which only some 38 percent are in China. Other important deposits are in the USA, Australia and the states of the former Soviet Union.

## New mines – old problems

"However, there are many factors that make it difficult to exploit new sources of these minerals," warns Dr. Doris Schüler, resources expert at the Öko-Institut and head of the study. The crux of the matter is that both the mining and the refining of rare earths is complicated. China's quasi-monopolist position in the rare earth market is partly a result of its extensive investment in mining and processing technologies. Other countries lack the necessary know-how – for example, China is the only country to have access to the complete production chain for the production of neodymium magnets.

The environmental risks associated with rare earth production also pose a major problem: almost all deposits contain radioactive materials that may be released during mining and processing and pollute air or water. In addition, production of rare earths involves large quantities of other toxic substances such as heavy metals, acids, sulphides and fluorides. In China these problems have largely been ignored, resulting in environmental degradation and high levels of illness among workers. "But we shouldn't just point the finger at China," says Dr. Schüler, "since the industrialised countries have been profiting for years from China's cheap exports." China has now imposed environmental standards. It is also seeking to improve efficiency in mining and processing and is conducting research into sustainable rare earth production.

"A feverish search for new mines and new mineral suppliers is now under way worldwide," explains Dr. Schüler. "But at the present state of technology it will be many years before new mines are ready to commence production." She fears that the pressure on time and costs could result in toleration of mining projects with unacceptable environmental standards. The most advanced mining projects outside China are those at Mountain Pass in the USA and at Mountain Weld in Australia; at both sites, systems for protecting the environment are due to be put in place. But other mining projects give cause for concern. For example, at a planned integrated uranium and rare earth mine in Greenland the mining company intends to store the toxic waste in a natural lake that has an outlet to the sea.

## Efficient recycling is an alternative

"The present resource crisis gives us an opportunity to learn from previous mistakes and reconsider resource management," says Dr. Schüler. "Our study identifies the areas that Europe needs to focus on." The EU needs to be committed to environmentally sound mining and sustainable processing. Boosting the efficiency of rare earth production and use could be another way forward, but the necessary scientific and technological foundations for this are not yet in place. The study's authors therefore highlight the importance of setting up a European competence network for rare earths. "In the long term, researching alternatives to rare earths could also help to defuse the resource crisis," continues Dr. Schüler, "but many applications lack technical solutions that would enable rare earths to be replaced." In particular, though, the study emphasises another approach that has so far received little attention in Europe: the development of a recycling system for rare earths. "Recycling has the advantage that it enables the EU to reduce its dependency on foreign suppliers while at the same time building up important know-how in relation to the processing of rare earths," states Dr. Schüler. "Furthermore, recycling produces no radioactive waste, and other environmental impacts are small." The study details the steps involved in setting up an efficient EU recycling system in an eight-point plan. They include closing data and knowledge gaps by launching a programme of research into the refining and processing of rare earths and conducting a European material flow analysis. For Dr. Schüler, an energy and environmental engineer by training, it is equally important to develop pilot recycling facilities and identify pilot products for recycling: "The recycling technology is still in its infancy and

the technical problems are large," she explains, "because in the majority of products rare earths are not standalone components that can simply be removed." Despite this, for many product groups recycling is likely to be worthwhile. As an example, Dr. Schüler says that in compact fluorescent lamps the proportion of recyclable rare-earth material may be as high as ten percent. "It may also be worth recycling permanent magnets that use neodymium," she continues, "because they contain a relatively high concentration of the material." The study also emphasises that an efficient recycling system must be backed by suitable legal and financial measures: "Optimising recycling means creating an appropriate legal framework, for example through corresponding EU directives," comments Dr. Schüler. "In addition, long-term investment in recycling facilities involves high levels of risk. The European Investment Bank could help reduce this risk for investors."

## No simple solutions

"When it comes to rare earths there is no magic solution", stresses Dr. Schüler. "Measures such as efficiency increases, environmentally sound mining, recycling and the search for alternatives to the use of rare earths are all complex and expensive." But since the current situation with regard to the production of rare earths is also expensive and beset by many problems, she believes that the time to pursue new pathways has now come: "If we start soon and pursue a variety of new avenues instead of playing them off against each other, we can build a sustainable rare-earth industry in Europe in the coming decades."

*David Siebert*

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## Rare earths: not rare, but "critical"

The European Commission's Raw Minerals Initiative identifies 14 minerals as "critical metals" because they are of particular commercial importance but their supply is not secure. They include rare earths of which there are theoretically large reserves but for which supply is not currently keeping pace with the growing demand. The group of rare earths comprises 17 elements: yttrium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, scandium, lanthanum, cerium, praseodymium, neodymium, promethium, samarium and europium.

## Resources fever online

The Öko-Institut's booklet "Resources Fever – A cool head for sustainable solutions", published in 2007, attracted considerable attention at home and abroad and helped fuel the debate on resource efficiency. The Öko-Institut therefore followed this up in 2010 with a new website www.resourcefever.org, which provides users with more information on the Öko-Institut's findings on resource-related issues.

Under the "News" heading users will find the Öko-Institut's latest studies, publications and presentations on resource efficiency, which can be downloaded free of charge. The topics covered by the different sections of the website are "Mineral resources and minerals", "Renewable raw materials", "Land management and land consumption" and "Smart regulation of resources".

The site's various search functions help visitors quickly find what they are looking for. The material available at www.resourcefever.org includes documents on ongoing projects on the management of electrical and electronic waste in Africa, a new position paper on the use of biomass for energy, the proposals from the Öko-Institut and Eurometaux on implementation of the European Commission's Raw Minerals Initiative and the Öko-Institut's new study of rare earths. The language of the website is English, while some documents are also available in German.

# "There is no alternative to cooperation on recycling"

**The mountain of waste electrical and electronic devices in developing countries is growing rapidly – partly because the demand for computers, mobile phones and similar devices is also increasing fast in these parts of the world. Inappropriate recycling practices in the informal sector put both people and the environment at risk and lead to the irretrievable loss of valuable metals that are urgently needed by high-tech industries. Studies carried out by the Öko-Institut in Ghana and Nigeria explore the problem and identify possible solutions.**

According to a study by the United Nations Environment Programme (UNEP), electrical and electronic waste, also known as e-waste, is the fastest growing waste stream. Each year 40 million tonnes of it are produced worldwide – an increasing amount of it in developing and newly industrialising countries. Experts predict that in China and South Africa computer waste arisings will double by 2020; India could see an increase of 500 percent, while in Uganda and Senegal quantities could increase by 800 percent in the same period.

"Technical progress and ever-shorter innovation cycles mean that in the industrialised countries electronic devices quickly become outdated," says Andreas Manhart, resources expert at the Öko-Institut, as he seeks to explain the global surge in waste. "But in Africa, Asia and Latin America, too, more and more mobile phones, computers and refrigerators are being purchased and later disposed of: almost every village in the world is now generating e-waste." The growing mountains of e-waste in developing countries are the result both of the often highlighted illegal export of e-waste from the industrialised countries and of the increasing demand in developing countries for electrical and electronic goods. This demand is often met by importing secondhand goods from the industrialised countries. "There is in principle no objection to this, if it means that functionable and high-quality used appliances get a new lease of life," says Manhart: "It prevents waste, saves resources and provides developing countries with high-tech products at low cost." But the other side of the coin is that developing countries lack the structures for recycling and disposing of electronic equipment sustainably at the end of its useful life.

The complexity of the problem is highlighted by two socioeconomic studies conducted by Andreas Manhart with his colleague Siddharth Prakash of the Öko-Institut and local partners in Nigeria and Ghana. "In both cases a flourishing recovery and recycling industry has emerged in the semi-formal and informal sector," says Manhart. The researchers estimate that in Lagos, Nigeria's business metropolis with a population of 17.5 million, there are more than 8,100 shops dealing in imported secondhand goods. Surveys suggest that 21,600 people are employed in repairing, recycling and selling used mobile phones, televisions, refrigerators and other appliances in these shops. Several thousand more work as collectors and recyclers of

e-waste. "Some of the repair businesses and secondhand shops are registered with the local authorities, generating annual tax revenue of around 419,000 US dollars," comments Manhart.

In Ghana the picture is similar: "In the capital, Accra, between 10,000 and 15,000 people make a living by repairing and selling secondhand electrical goods; another 5,000 survive by collecting and dismantling e-waste," says Prakash as he describes the research results. "We can assume that in Ghana as a whole the repair and recycling of electrical appliances and the recycling of electronic waste brings in between 100 and 150 million US dollars per year and provides a livelihood for up to 200,000 people."

According to surveys carried out by the researchers, satisfaction among workers in repair businesses is comparatively high. "Working conditions there – by comparison with those in recycling – are relatively good," explains Prakash. "There are certainly health risks and other problems, but the wages enable people to live above the poverty line and confer a certain social status." Conditions in the final stage of the recycling process are significantly less good. There, recycling is carried out by the simplest possible means. Televisions, monitors and computers are broken up with hammers or bare hands to access aluminium and steel parts, cables are burnt to retrieve copper, circuit boards and plastic housing are thrown away or likewise consigned to the flames. The result is poisonous smoke containing carcinogenic dioxins, as well as other toxics such as cadmium, lead or halogenated flame retardants that leach from fire sites and refuse dumps into soil and water.

This is the starting point for a solution that the two scientists term the "Best of two worlds approach" – an approach that combines the respective strengths of the recycling structures of developing and industrialised countries. Manhart and Prakash have worked it out using computers as an example. "In Ghana and Nigeria the collection of e-waste functions extremely well," says Prakash. "Moreover, improving the dismantling of the equipment would require only a few measures and would prevent environmental and health problems. The established recycling pathways for steel and aluminium could in principle be retained." As it is, 90 percent of the steel and aluminium is already being recovered and sold to local metal smelters or car repair shops. With the money raised from the copper, which is usually exported, the proceeds amount to around seven US dollars per computer. A sensitive issue is the burning of the copper cable, which produces dioxin-containing smoke. "It would be better to shred the cable mechanically," Manhart proposes.

## Lagos – Africa's largest turntable for secondhand appliances

Another problem is that the circuit boards are usually thrown away, burnt or exported to China or Vietnam, where some of the gold they contain is recovered, but usually by highly inefficient means that are harmful to health and the environment. "Yet the circuit boards are the jewel of computer waste," explains Manhart. They contain not only gold but also silver, palladium and other scarce and sought-after metals that are on the EU Commission's list of critical minerals. "If they were sold to specialised recycling businesses in the industrialised countries, up to 17 valuable metals could be recovered from them," Manhart continues. He calculates that the proceeds – including those from the recovered steel, copper and aluminium – would amount to around 13 US dollars per computer. The excess of six dollars over the present method could be used to pay for transport, metal smelting and improvements in social and environmental standards and the infrastructure of the local recycling economy. "Whether the business model also applies to other product groups would have to be investigated on a case-by-case basis," Manhart concedes. For CRT monitors, for example, it is uneconomical. In Ghana the first steps are already being taken: last year a recycler set up in business who intends to adopt many features of the "Best of two worlds" approach.

"At present, important resources are being scattered all over the world in electrical and electronic products," comments Manhart. "As resources become ever scarcer, we can not in the long term afford to ignore this resource potential – especially as many of these substances are needed for the technologies of the future, such as electromobility, wind power and photovoltaic systems. There is therefore no alternative to cooperation on recycling." In view of the high market prices for metals and other resources, he says, there is a good chance that businesses and policy-makers in the industrialised countries will soon come round to this point of view. *David Siebert*

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# The incalculable residual risk

**Twenty-five years after the Chernobyl nuclear disaster, the situation long foreseen by nuclear critics has occurred in Japan. The residual risk has once again become reality – and the consequences can still not be fully assessed. From its initial comments onwards, however, the Öko-Institut has been in no doubt: if the power supply were to fail at a German nuclear power plant, we would face the same scenario as in Fukushima. As well as feeling sympathy and concern for the Japanese people, the German public is now pondering one particular question: What conclusions should we draw from these events? Nuclear experts Dr. Christoph Pistner and Beate Kallenbach-Herbert cast light on the issues.**

**The German government has announced a safety review of all 17 German nuclear power plants. On what basis should this review be conducted?**

**Dr. Christoph Pistner:** On the basis of a new safety standard. In general a nuclear power plant in Germany must meet a level of safety that was defined when the plant was approved. Thereafter, new standards are not necessarily applied to the plant through additional requirements and retrofitting. In other words, none of the German power plants meet the safety standards that now apply to a new plant in Europe.

**Beate Kallenbach-Herbert:** The current basis of the safety standard is the set of nuclear guidelines and standards. But these are out of date on many points. An updated version has been available since 2009 and this should at the very least be used to define a new safety standard. The review, must, however, also take account of knowledge that has been gained from the events at Fukushima, as well as of all other recently acquired findings.

Beate Kallenbach-Herbert heads the Öko-Institut's Nuclear Engineering & Facility Safety Division and is, among other things, a member of the German Government's Nuclear Waste Management Commission. Her colleague Dr. Christoph Pistner is a specialist for facility safety and systems analysis, event evaluation and accident management. Together with other Öko-Institut experts, Kallenbach-Herbert und Pistner provided key input to the recent amendments made to the set of nuclear guidelines and standards applicable in Germany.

**What safety issues do you regard as particularly relevant?**

**Dr. Christoph Pistner:** Definitely those that arise after possible multiple failures of the power supply to the backup systems and of the emergency cooling system. This could occur as a result of a plane crash, floods, fire or internal flooding of the plant or as a consequence of a terrorist attack.

**Beate Kallenbach-Herbert:** Unrecognised design faults, maintenance failures and human error are also important. And retrofitting can result in unexpected interactions between old and new parts in a power plant. For plants such as Neckarwestheim, Philippsburg and Biblis we must also consider whether they are sufficiently well-built to withstand earthquakes. In those places there is a higher risk of earthquakes than in other parts of Germany.

**Is it possible to retrofit German power plants to meet the most up-to-date safety standards?**

**Beate Kallenbach-Herbert:** It depends what standards we apply. If we apply the standard to which the plant in Olkiluoto in Finland is currently being built, I consider it to be difficult to impossible in Germany. Retrofitting does not provide a solution that is on a par with a new plant. It has technical limits and is, moreover, very expensive.

**We are not in a position to calculate all the risks associated with the use of nuclear energy. Do we have to go on living with these risks? And for how long?**

**Dr. Christoph Pistner:** It is true that safety assumptions can be inadequate. Fukushima has demonstrated that. If a so-called "residual risk" does occur, despite its likelihood being assumed to be small, the consequences are catastrophic. What risks we want to incur, and for how long, is a question for society to answer. A new debate will need to be held about that.

**How can we make our European neighbours more strongly aware of the risks of nuclear energy?**

**Dr. Christoph Pistner:** A review of the safety of nuclear plants will also be carried out in Europe. That is an important first step and we welcome the fact that Germany will be able to contribute its expertise to the international discussion. The crucial point is the need to establish exacting new safety standards at both German and European level.

**Thank you for taking the time to speak to us.**

Interviewer: Katja Kukatz.

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# Fukushima – consequences and conclusions

## Arguments under scrutiny

Nuclear energy is safe, cheap and environmentally sound. These arguments are often put forward to support the use of nuclear power. But how valid are they? Read a background paper on the subject (in German) at www.oeko.de/laufzeit. Other information (in German) is available at www.streitpunkt-kernenergie.de

## The dawn of a new energy era

Nuclear energy could be completely phased out in Germany by 2020 – without supply shortages or sharp price rises. That is what the Öko-Institut calculated for WWF Germany. Read the full summary (in German) at www.oeko.de/ausstieg

www.oeko.de/111/inthenews

**Non-stop work for the Öko-Institut's nuclear and energy experts**

The nuclear disaster in Japan triggered a flood of requests to the Öko-Institut for scientifically based, objective and independent advice and information. Our nuclear and energy experts worked non-stop to meet the general public's need for information. On the first page of the German-language version of www.oeko.de, under the heading "Informationen des Öko-Instituts zu den Atomunfällen in Japan", we present a selection of comments by our scientists that were published in various media.

**Michael Sailer,**
CEO of the Öko-Institut, nuclear engineering expert, member of the German Reactor Safety Commission

The risks that speak against nuclear energy have been known for a long time. Fukushima raises new awareness of them in society. But it is not only technical questions that have been troubling me for years: worldwide the vast majority of nuclear safety experts are over 50 years old – in 25 years they will be pensioners. In pro-nuclear countries, too, there is a shortage of scientists able to take over from those who will be retiring. Who is going to ensure the safety of those nuclear plants that are still operating? We must also face up to the question of costs. Further retrofitting can be so expensive as to make continued operation of the reactor unviable, or for cost reasons it may not be carried out at all. So the fact remains: nuclear energy is neither safe nor cheap.

**Dr. Felix Ch. Matthes,**
Research Coordinator for Energy and Climate Policy, Energy and Climate Division

Nuclear energy could be completely phased out in Germany by 2020 at the latest without jeopardising the security of supply, with no detrimental consequences for the climate and with only a slight impact on electricity prices. Ten nuclear power plants could be replaced immediately by existing over-capacities and "cold reserves". Improved load management and the opening of new power plants that are currently under construction would enable four more plants to be shut down by 2013. The three remaining nuclear plants could be replaced by building new power plants using biomass, combined heat and power generation and natural gas. An accelerated phase-out by 2020 is thus feasible. This opportunity should be seized.

**Christof Timpe,**
Head of Energy & Climate Division (Freiburg), sustainable energy expert

The $CO_2$ emissions of the energy industry and other industrial sectors have been "capped" at European level until 2020 and beyond. Through the EU emission trading system, the temporary additional emissions from some power plants as a result of the accelerated phase-out of nuclear energy in Germany automatically lead to emission reductions in other power plants, industrial sectors or countries. On the basis of current market analyses we think it unlikely that the price of emission rights will rise appreciably as a result. Nevertheless, it is important that the phase-out of nuclear power is accompanied by a redoubling of our efforts to improve energy efficiency, develop renewable energies and expand electricity grids and storage systems.