

energy [r]evolution

A SUSTAINABLE WORLD ENERGY OUTLOOK



EREC
EUROPEAN RENEWABLE
ENERGY COUNCIL

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foreword



There is now growing awareness on the imperatives for a global energy future which marks a distinct departure from past trends and patterns of energy production and use. These imperatives emerge as much from the need to ensure energy security, as they do from the urgency of controlling local pollution from combustion of different fuels and, of course, the growing challenge of climate change, which requires reduction in emissions of greenhouse gases (GHSs), particularly carbon dioxide.



This publication provides stimulating analysis on future scenarios of energy use, which focus on a range of technologies that are expected to emerge in the coming years and decades. There is now universal recognition of the fact that new technologies and much greater use of some that already exist provide the most hopeful prospects for mitigation of emissions of GHGs. It is for this reason that the International Energy Agency, which in the past pursued an approach based on a single time path of energy demand and supply, has now developed alternative scenarios that incorporate future technological changes. In the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) as well, technology is included as a crosscutting theme in recognition of the fact that an assessment of technological options would be important both for mitigation as well as adaptation measures for tackling climate change.

The scientific evidence on the need for urgent action on the problem of climate change has now become stronger and convincing. Future solutions would lie in the use of existing renewable energy technologies, greater efforts at energy efficiency and the dissemination of decentralized energy technologies and options. This particular publication provides much analysis and well-researched material to stimulate thinking on options that could be adopted in these areas. It is expected that readers who are knowledgeable in the field as well as those who are seeking an understanding of the subjects covered in the ensuing pages would greatly benefit from reading this publication.

Dr. R. K. Pachauri

CHAIRMAN INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
JANUARY 2007

introduction

“TO ACHIEVE AN ECONOMICALLY ATTRACTIVE GROWTH OF RENEWABLE ENERGY SOURCES,
A BALANCED AND TIMELY MOBILISATION OF ALL RENEWABLE ENERGY TECHNOLOGIES IS OF GREAT IMPORTANCE.”



image TEST WINDMILL N90 2500, BUILT BY THE GERMAN COMPANY NORDEX, IN THE HARBOUR OF ROSTOCK. THIS WINDMILL PRODUCES 2,5 MEGA WATT AND IS TESTED UNDER OFFSHORE CONDITIONS. AT LEAST 10 FACILITIES OF THIS TYPE WILL BE ERECTED 20 KM OFF THE ISLAND DARSS IN THE BALTIC SEA BY 2007. TWO TECHNICIANS WORKING INSIDE THE TURBINE.

The good news first. Renewable energy, combined with the smart use of energy, can deliver half of the world's energy needs by 2050. This new report, 'Energy [R]evolution: A sustainable World Energy Outlook', shows that it is economically feasible to cut global CO₂ emissions by almost 50% within the next 43 years. It also concludes that a massive uptake of renewable energy sources is technically possible. All that is missing is the right policy support.

The bad news is that time is running out. An overwhelming consensus of scientific opinion now agrees that climate change is happening, is caused in large part by human activities (such as burning fossil fuels), and if left un-checked, will have disastrous consequences. Furthermore, there is solid scientific evidence that we should act now. This is reflected in the conclusions of the Intergovernmental Panel on Climate Change (IPCC), a UN institution of more than 1,000 scientists providing advice to policy makers. Its next report, due for release in 2007, is unlikely to make any better reading.

In response to this threat, the Kyoto Protocol has committed its signatories to reduce their greenhouse gas emissions by 5.2% from their 1990 level by the target period of 2008-2012. This in turn has resulted

in the adoption of a series of regional and national reduction targets. In the European Union, for instance, the commitment is to an overall reduction of 8%. In order to reach this target, the EU has also agreed to increase its proportion of renewable energy from 6% to 12% by 2010.

The Kyoto signatories are currently negotiating the second phase of the agreement, covering the period from 2013-2017. Within this timeframe industrialised countries need to reduce their CO₂ emissions by 18% from 1990 levels, and then by 30% between 2018 and 2022. Only with these cuts do we stand a reasonable chance of keeping the average increase in global temperatures to less than 2°C, beyond which the effects of climate change will become catastrophic.

Alongside global warming, other challenges have become just as pressing. Worldwide energy demand is growing at a staggering rate. Over-reliance on energy imports from a few, often politically unstable countries and volatile oil and gas prices have together pushed security of energy supply to the top of the political agenda, as well as threatening to inflict a massive drain on the global economy. But whilst there is a broad consensus that we need to change the way we produce and consume energy, there is still disagreement about how to do this.

image FIRST GEOTHERMAL POWER STATION IN GERMANY PRODUCING ELECTRICITY. WORKER IN THE FILTRATION ROOM.



global energy scenario

The European Renewable Energy Council (EREC) and Greenpeace International have produced this global energy scenario as a practical blueprint for how to urgently meet CO₂ reduction targets and secure affordable energy supply on the basis of steady worldwide economic development. Both these important aims are possible at the same time. The urgent need for change in the energy sector means that the scenario is based only on proven and sustainable technologies, such as renewable energy sources and efficient decentralised cogeneration. It therefore excludes "CO₂-free coal power plants" and nuclear energy.

Commissioned by Greenpeace and EREC from the Department of Systems Analysis and Technology Assessment (Institute of Technical Thermodynamics) at the German Aerospace Centre (DLR), the report develops a global sustainable energy pathway up to 2050. The future potential for renewable energy sources has been assessed with input from all sectors of the renewable energy industry around the world, and forms the basis of the Energy [R]evolution Scenario.

The energy supply scenarios adopted in this report, which both extend beyond and enhance projections by the International Energy Agency, have been calculated using the MESAP/PlaNet simulation model. This has then been further developed by the Ecofys consultancy to take into account the future potential for energy efficiency measures. The Ecofys study envisages an ambitious overall development path for the exploitation of energy efficiency potential, focused on current best practice as well as technologies available in the future. The result is that under the Energy [R]evolution Scenario, worldwide final energy demand can be reduced by 47% in 2050.

the potential for renewable energy

This report demonstrates that renewable energy is not a dream for the future – it is real, mature and can be deployed on a large scale. Decades of technological progress have seen renewable energy technologies such as wind turbines, solar photovoltaic panels, biomass power plants and solar thermal collectors move steadily into the mainstream. The global market for renewable energy is growing dramatically; in 2006 its turnover was US\$ 38 billion, 26% more than the previous year.

The time window for making the shift from fossil fuels to renewable energy is still relatively short. Within the next decade many of the existing power plants in the OECD countries will come to the end of their technical lifetime and will need to be replaced. But a decision taken to construct a coal power plant today will result in the production of CO₂ emissions lasting until 2050. So whatever plans are made by power utilities over the next few years will define the energy supply of the next generation. We strongly believe that this should be the "solar generation".

While the industrialised world urgently needs to rethink its energy strategy, the developing world should learn from past mistakes and build its economies from the beginning on the strong foundation of a sustainable energy supply. A new infrastructure will need to be set up to enable this to happen.

Renewable energy could provide as much as 35% of the world's energy needs by 2030, given the political will to promote its large scale deployment in all sectors on a global level, coupled with far reaching energy efficiency measures. This report stresses that the future of renewable energy development will strongly depend on political choices by both individual governments and the international community.

By choosing renewable energy and energy efficiency, developing countries can virtually stabilise their CO₂ emissions, whilst at the same time increasing energy consumption through economic growth. OECD countries will have to reduce their emissions by up to 80%.

There is no need to "freeze in the dark" for this to happen. Strict technical standards will ensure that only the most efficient fridges, heating systems, computers and vehicles will be on sale. Consumers have a right to buy products that don't increase their energy bills and won't destroy the climate.

from vision to reality

This report shows that a "business as usual" scenario, based on the IEA's World Energy Outlook projection, is not an option for future generations. CO₂ emissions would almost double by 2050 and the global climate would heat up well over 2°C. This would have catastrophic consequences for the environment, the economy and human society. In addition, it is worth remembering that the former chief economist of the World Bank, Sir Nicholas Stern, in his report clearly pointed out that the ones who invest in energy saving technologies and renewable energies today will be the economic winners of tomorrow. Inaction will be much more expensive in the long run, than taking action now.

We therefore call on decision makers around the world to make this vision a reality. The political choices of the coming years will determine the world's environmental and economic situation for many decades to come. The world cannot afford to stick to the 'conventional' energy development path, relying on fossil fuels, nuclear and other outdated technologies. Renewable energy can and will have to play a leading role in the world's energy future.

For the sake of a sound environment, political stability and thriving economies, now is the time to commit to a truly secure and sustainable energy future – a future built on clean technologies, economic development and the creation of millions of new jobs.

Arthouros Zervos
EUROPEAN RENEWABLE
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JANUARY 2007

Sven Teske
CLIMATE & ENERGY UNIT
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executive summary

"THE RESERVES OF RENEWABLE ENERGY THAT ARE TECHNICALLY ACCESSIBLE GLOBALLY ARE LARGE ENOUGH TO PROVIDE ABOUT SIX TIMES MORE POWER THAN THE WORLD CURRENTLY CONSUMES - FOREVER."

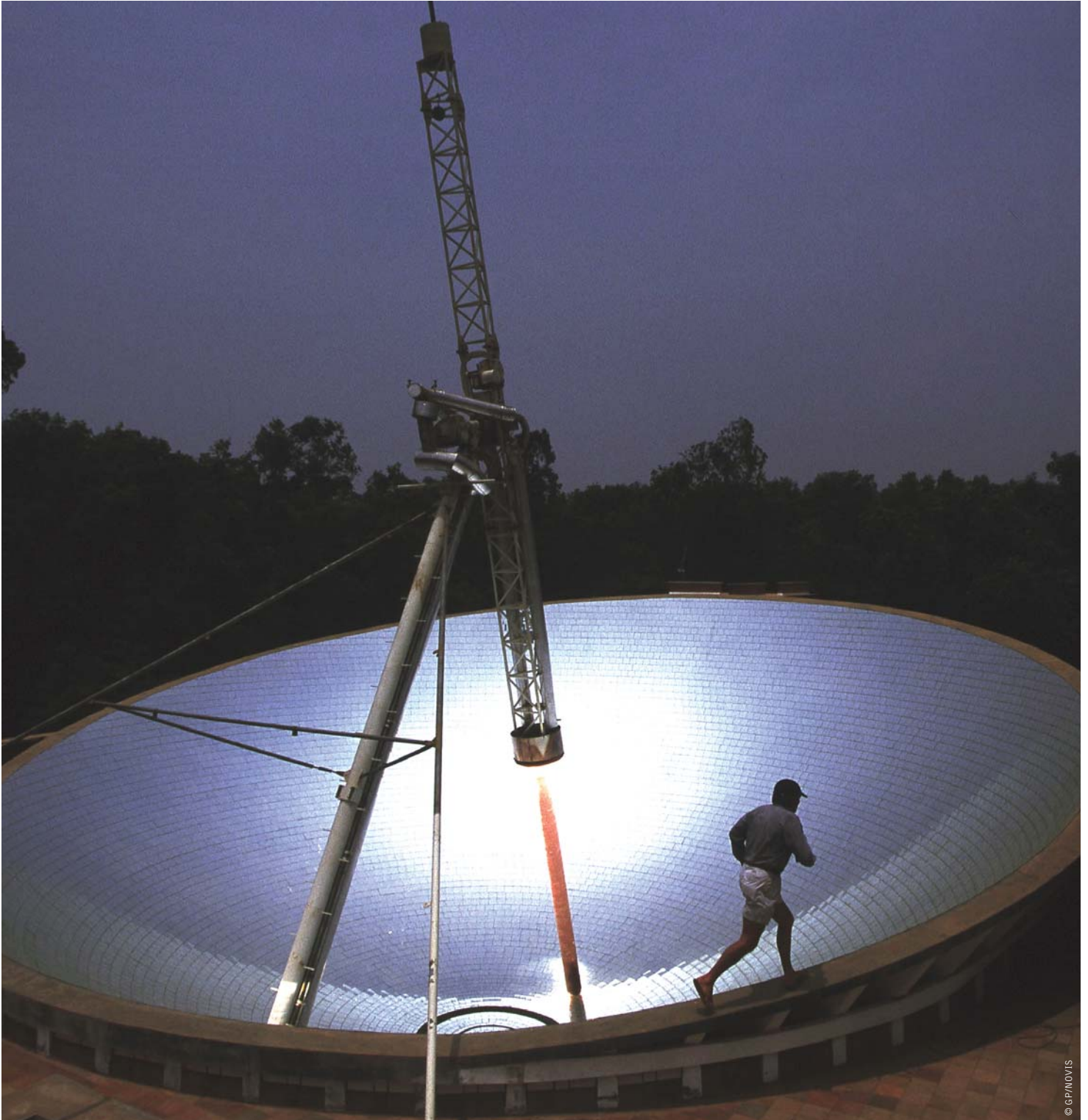


image MAN RUNNING ON THE RIM OF A SOLAR DISH WHICH IS ON TOP OF THE SOLAR KITCHEN AT AUROVILLE, TAMIL NADU, INDIA. THE SOLAR DISH CAPTURES ENOUGH SOLAR ENERGY TO GENERATE HEAT TO COOK FOR 2,000 PEOPLE PER DAY. THE TOWNSHIP OF AUROVILLE WAS CREATED IN 1968 BY PEOPLE FROM OVER 100 DIFFERENT COUNTRIES. AUROVILLE CONCENTRATES ON ACTIVITIES, SUCH AS ENVIRONMENTAL REGENERATION, ORGANIC FARMING, ALTERNATIVE ENERGY, VILLAGE DEVELOPMENT, THEATRE, MUSIC, AND ART.

image ENERGY PLANT NEAR REYKJAVIK, ENERGY IS PRODUCED FROM THE GEOTHERMAL ACTIVITY. NORTH WEST OF ICELAND.



climate threats and solutions

Global climate change caused by the relentless build-up of greenhouse gases in the earth's atmosphere, is already disrupting ecosystems and is already causing about 150,000 additional deaths per year.^a An average global warming of 2°C threatens millions of people with an increased risk of hunger, malaria, flooding and water shortages. If rising temperatures are to be kept within acceptable limits then we need to significantly reduce our greenhouse gas emissions. This makes both environmental and economic sense. The main greenhouse gas is carbon dioxide (CO₂) produced by using fossil fuels for energy and transport.

Spurred by recent large increases in the price of oil, the issue of security of supply is now at the top of the energy policy agenda. One reason for these price increases is the fact that supplies of all fossil fuels – oil, gas and coal – are becoming scarcer and more expensive to produce.^b The days of "cheap oil and gas" are coming to an end. Uranium, the fuel for nuclear power, is also a finite resource. By contrast, the reserves of renewable energy that are technically accessible globally are large enough to provide about six times more power than the world currently consumes – forever.^c

Renewable energy technologies vary widely in their technical and economic maturity, but there are a range of sources which offer increasingly attractive options. These sources include wind, biomass, photovoltaic, solar thermal, geothermal, ocean and hydroelectric power. Their common feature is that they produce little or no greenhouse gases, and rely on virtually inexhaustible natural sources for their "fuel". Some of these technologies are already competitive. Their economics will further improve as they develop technically, as the price of fossil fuels continues to rise and as their saving of carbon dioxide emissions is given a monetary value.

At the same time there is enormous potential for reducing our consumption of energy, while providing the same level of energy 'services'. This study details a series of energy efficiency measures which together can substantially reduce demand in industry, homes, business and services.

The solution to our future energy needs lies in greater use of renewable energy sources for both heat and power. Nuclear power is not the solution as it poses multiple threats to people and the environment. These include the risks and environmental damage from uranium mining, processing and transport, the risk of nuclear weapons proliferation, the unsolved problem of nuclear waste and the potential hazard of a serious accident. The nuclear option is therefore eliminated in this analysis.

references

a KOVATS, R.S., AND HAINES, A., "GLOBAL CLIMATE CHANGE AND HEALTH: RECENT FINDINGS AND FUTURE STEPS" CMAJ [CANADIAN MEDICAL ASSOCIATION JOURNAL] 0 FEB. 15, 2005; 172 (4).

b PLUGGING THE GAP, RES/GWEC 2006.

c DR NITSCH ET AL.

the energy [r]evolution

The climate change imperative demands nothing short of an energy revolution. At the core of this revolution will be a change in the way that energy is produced, distributed and consumed. The five key principles behind this shift will be to:

- Implement renewable solutions, especially through decentralised energy systems
- Respect the natural limits of the environment
- Phase out dirty, unsustainable energy sources
- Create greater equity in the use of resources
- Decouple economic growth from the consumption of fossil fuels

Decentralised energy systems, where power and heat are produced close to the point of final use, avoid the current waste of energy during conversion and distribution. They will be central to the Energy [R]evolution, as will the need to provide electricity to the two billion people around the world to whom access is presently denied.

Two scenarios up to the year 2050 are outlined in this report. The reference scenario is based on the business as usual scenario published by the International Energy Agency in World Energy Outlook 2004, extrapolated forward from 2030. Compared to the 2004 IEA projections, the new World Energy Outlook 2006 assumes a slightly higher average annual growth rate of world GDP of 3.4%, instead of 3.2%, for the 2004-2030 time horizon. At the same time, WEO 2006 expects final energy consumption in 2030 to be 4% higher than in WEO 2004. A sensitivity analysis on the impact of economic growth on energy demand under the Energy [R]evolution Scenario shows that an increase of average world GDP of 0.1% (over the time period 2003-2050) leads to an increase in final energy demand of about 0.2%.

The Energy [R]evolution Scenario has a target for the reduction of worldwide emissions by 50% below 1990 levels by 2050, with per capita carbon dioxide emissions reduced to less than 1.3 tonnes per year in order for the increase in global temperature to remain under +2°C. A second objective is to show that this is even possible with the global phasing out of nuclear energy. To achieve these targets, the scenario is characterised by significant efforts to fully exploit the large potential for energy efficiency. At the same time, cost-effective renewable energy sources are accessed for both heat and electricity generation, as well as the production of biofuels.

Today, renewable energy sources account for 13% of the world's primary energy demand. Biomass, which is mainly used for heating, is the largest renewable source. The share of renewable energy in electricity generation is 18%, whilst the contribution of renewables to heat supply is around 26%. About 80% of primary energy supply still comes from fossil fuels, and the remaining 7% from nuclear power.

The Energy [R]evolution Scenario describes a development pathway which transforms the present situation into a sustainable energy supply.

- Exploitation of the large energy efficiency potential will reduce primary energy demand from the current 435,000 PJ/a (Peta Joules per year) to 422,000 PJ/a by 2050. Under the reference scenario there would be an increase to 810,000 PJ/a. This dramatic reduction is a crucial prerequisite for achieving a significant share of renewable energy sources, compensating for the phasing out of nuclear energy and reducing the consumption of fossil fuels.
- The increased use of combined heat and power generation (CHP) also improves the supply system's energy conversion efficiency, increasingly using natural gas and biomass. In the long term, decreasing demand for heat and the large potential for producing heat directly from renewable energy sources limits the further expansion of CHP.
- The electricity sector will be the pioneer of renewable energy utilisation. By 2050, around 70% of electricity will be produced from renewable energy sources, including large hydro. An installed capacity of 7,100 GW will produce 21,400 Terawatt hours per year (TWh/a) of electricity in 2050.
- In the heat supply sector, the contribution of renewables will increase to 65% by 2050. Fossil fuels will be increasingly replaced by more efficient modern technologies, in particular biomass, solar collectors and geothermal.
- Before biofuels can play a substantial role in the transport sector, the existing large efficiency potentials have to be exploited. In this study, biomass is primarily committed to stationary applications; the use of biofuels for transport is limited by the availability of sustainably grown biomass.
- By 2050, half of primary energy demand will be covered by renewable energy sources.

To achieve an economically attractive growth of renewable energy sources, a balanced and timely mobilisation of all renewable technologies is of great importance. This depends on technical potentials, actual costs, cost reduction potentials and technological maturity.

development of CO₂ emissions

Whilst worldwide CO₂ emissions will almost double under the reference scenario by 2050 - far removed from a sustainable development path - under the Energy [R]evolution Scenario emissions will decrease from 23,000 million tonnes in 2003 to 11,500 million tonnes in 2050. Annual per capita emissions will drop from 4.0 t to 1.3 t. In the long run, efficiency gains and the increased use of biofuels will even reduce CO₂ emissions in the transport sector. With a share of 36% of total CO₂ emissions in 2050, the power sector will be overtaken by the transport sector as the largest source of emissions.

costs

Due to the growing demand for power, we are facing a significant increase in society's expenditure on electricity supply. Under the reference scenario, the undiminished growth in demand, the increase in fossil fuel prices and the costs of CO₂ emissions all result in electricity supply costs rising from today's \$1,130 billion per year to more than \$4,300 bn per year in 2050. The Energy [R]evolution Scenario not only complies with global CO₂ reduction targets but also helps to stabilise energy costs and thus relieve the economic pressure on society. Increasing energy efficiency and shifting energy supply to renewable energy resources leads to long term costs for electricity supply that are one third lower than in the reference scenario. It becomes obvious that following stringent environmental targets in the energy sector also pays off in economic terms.

to make the energy [r]evolution real and to avoid dangerous climate change, the following assumptions need to be implemented:

- The phasing out of all subsidies for fossil fuels and nuclear energy and the internalisation of external costs
- The setting out of legally binding targets for renewable energy
- The provision of defined and stable returns for investors
- Guaranteed priority access to the grid for renewable generators
- Strict efficiency standards for all energy consuming appliances, buildings and vehicles

figure 1: development of primary energy consumption under the energy [r]evolution scenario

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)

