energy [r]evolution

A SUSTAINABLE GLOBAL ENERGY OUTLOOK

THE THREE STEP APPROACH

EFFICIENCY / STRUCTURE / TRANSPORT

3

GREENPEACE

contents

image PREECHA BUATHO, 49, IS A RESIDENT OF A VILLAGE IN LAEM TALUMPUK CAPE. HIS FAMILY, HOUSE AND VILLAGE ARE BEING THREATENED BY SEA LEVEL RISE DUE TO CLIMATE CHANGE. LAEM TALUMPUK IS IN PAK PANANG DISTRICT IN THE SOUTHERN PROVINCE OF NAKHON SI THAMMARAT, ON THE EASTERN SHORE OF THE GULF OF THAILAND. CLIMATE CHANGE-INDUCED WIND PATTERNS HAVE INTENSIFIED THE SPEED OF COASTAL EROSION IN BOTH THE GULF OF THAILAND AND THE ANDAMAN SEA. ON AVERAGE, 5 METRES OF COASTAL LANDS IN THE REGION ARE LOST EACH YEAR.

TO SUCCESSFULLY COMBAT CLIMATE CHANGE, WE URGENTLY NEED A REVOLUTION IN THE WAY WE PRODUCE, CONSUME AND DISTRIBUTE ENERGY.

a blueprint for a global renewable energy future

In the global fight against catastrophic climate change, global greenhouse gas emissions from the energy sector must have peaked by 2015 and have returned to current levels by 2020.

The Energy [R]evolution Scenario provides a practical blueprint for the world's renewable energy future, and was developed in conjunction with specialists from the Institute of Technical Thermodynamics at the German Aerospace Centre (DLR) and more than 30 scientists and engineers from universities, institutes and the renewable energy industry around the world.

The report demonstrates how the planet can get from where we are now, to where we need to be. It shows how the world's carbon emissions from the energy and transport sectors alone can peak by 2015 and be cut by over 50% by 2050.

The Energy [R]evolution Scenario only uses proven technologies and is based on five key principles:

1. Equity and fairness

2. Respect natural limits

3. Phase out dirty, unsustainable energy

4. Implement renewable solutions and decentralise energy systems

5. Decouple growth from fossil fuel use

image *SOLAR PANEL. © BERND JUERGENS/DREAMSTIME*

the energy [r]evolution: the global context

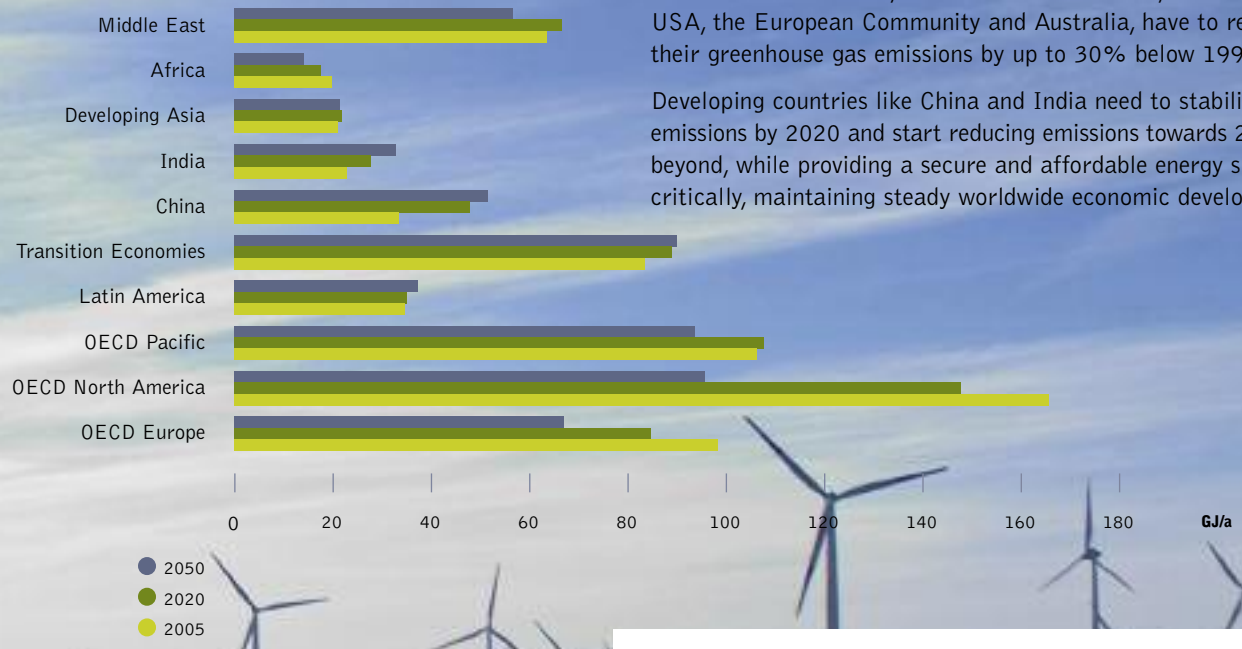
The Energy [R]evolution Scenario creates greater equity in the use of resources while providing a secure and affordable energy supply and maintaining steady worldwide economic development. The report takes into account rapid economic growth areas such as China, India, Brazil and Africa.

The implementation of efficiency standards is an example of how this can be achieved. By decreasing the per capita energy use in industrialised countries and slowing down the increase of energy demand in developing countries, energy consumption can be 'shared' in a more balanced way. However, by 2020, the per capita energy use in the USA, Europe or Australia is still projected to be two to three times higher than in China or India. Therefore, OECD countries have to reduce their CO_2 emissions earlier than other developing economies, peaking no later than 2015.

Total global emissions need to return to current levels by 2020. For this to be achieved, industrialised economies, such as the USA, the European Community and Australia, have to reduce their greenhouse gas emissions by up to 30% below 1990 levels.

Developing countries like China and India need to stabilise CO_2 emissions by 2020 and start reducing emissions towards 2030 and beyond, while providing a secure and affordable energy supply and, critically, maintaining steady worldwide economic development.

figure 1: energy use per capita



THE LONG-TERM GOAL FOR THE ENERGY [R]EVOLUTION IS TO CREATE ENERGY EQUITY VIA RENEWABLE ENERGY. CUTTING CO_2 EMISSIONS DOES NOT MEAN CUTTING ECONOMIC GROWTH.

image WIND ENERGY PARK NEAR DAHME. WIND TURBINE IN THE SNOW OPERATED BY VESTAS.

shifting the CO_2 trend

Global CO_2 emissions under the Energy [R]evolution Scenario will peak in 2015 and drop thereafter. Compared with today, CO_2 emissions will be more than 60% lower just after 2080, when energy supply is based entirely on renewable energies. While global emissions fall, regional shares shift. OECD countries reduce their emissions faster, which sees their share of the global output drop from just over 50% (51%) today to 38% in 2020. This is achieved by implementing renewable energy and energy efficiency standards.

BY 2020, OECD COUNTRIES CUT DOWN CO_2 EMISSIONS BY ABOUT 30% - SHIFTING THE TREND NO LATER THAN 2015 IS ESSENTIAL IN MEETING THIS GOAL. THE ENERGY [R]EVOLUTION CONCEPT SHOWS HOW IT CAN BE DONE.

figure 2: CO_2 emssions by region in 2005 and 2020

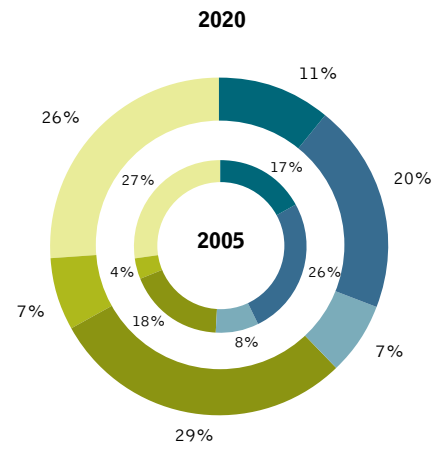


figure 3: CO_2 emssions in 2050 by sector

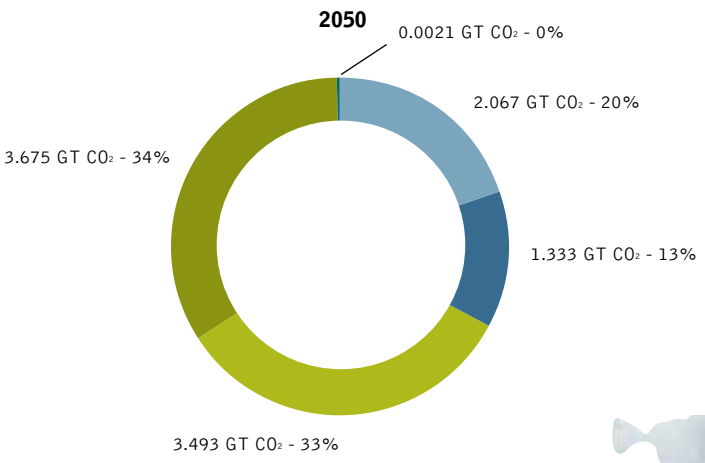


image COAL FIRED POWER PLANT.
© F. FUXA/DREAMSTIME

using and producing smart energy

Business as usual in the way we consume and produce energy is simply not an option any more. Beside the catastrophic climate change due to rising CO_2 emissions, our resources are also limited. Fossil fuel prices are rising and consumers around the world are confronted with unaffordable energy bills. In order to achieve a peak in emissions by 2015 and bring emissions down thereafter, we need to implement proven technologies in renewable energy and in efficiency now.

The Energy [R]evolution uses a three step approach:

Step 1: Electrical efficiency

- Exploit all technical potential for electrical efficiency via technical standards

Step 2: Structural changes

- Change the way we produce energy in large centralised power stations towards a decentralised energy system, using large-scale renewable resources that use locally available energy sources such as wind, sun or geothermal
- Cogeneration – end the huge amounts of waste energy via cooling towers

Step 3: Energy-efficient transport

- Build up efficient public transport systems
- Implement efficient cars, trucks, etc.

image PRODUCING WIND ROTORS FOR OFFSHORE WIND ENERGY IN RINGKOBING, DENMARK. © PAUL LANGROCK/ZENIT/GP

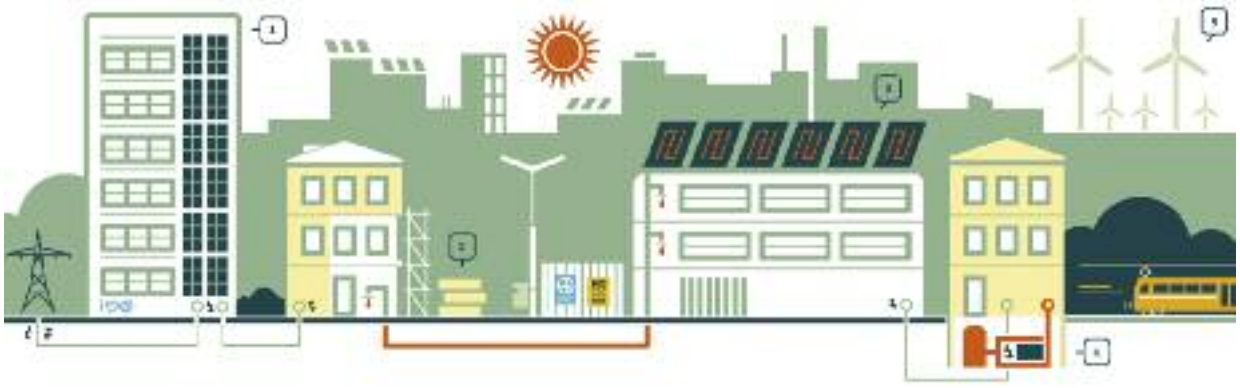
SCENARIO PRINCIPLES IN A NUTSHELL:

- **SMART CONSUMPTION, GENERATION AND DISTRIBUTION**
- **ENERGY PRODUCTION MOVES CLOSER TO THE CONSUMER**
- **MAXIMUM USE OF LOCALLY AVAILABLE, ENVIRONMENTALLY FRIENDLY FUELS**

figure 4: a decentralised energy future

THE CITY CENTRES OF TOMORROW'S NETWORKED WORLD WILL PRODUCE POWER AND HEAT AS WELL AS CONSUME IT. THE ROOFS AND FAÇADES OF PUBLIC BUILDINGS ARE IDEAL FOR HARVESTING SOLAR ENERGY. 'LOW ENERGY' WILL BECOME THE STANDARD FOR ALL BUILDINGS. GOVERNMENTS COMMITTED TO TIGHT CLIMATE-PROTECTION TARGETS WILL HAVE TO IMPOSE STRICT CONDITIONS AND OFFER INCENTIVES FOR RENOVATING THESE BUILDINGS. THIS WILL HELP TO CREATE JOBS.

city



1. **PHOTOVOLTAIC, SOLAR FAÇADES** WILL BE A DECORATIVE ELEMENT ON OFFICE AND APARTMENT BUILDINGS. PHOTOVOLTAIC SYSTEMS WILL BECOME MORE COMPETITIVE AND IMPROVED DESIGN WILL ENABLE ARCHITECTS TO USE THEM MORE WIDELY.
2. **RENOVATION CAN CUT ENERGY CONSUMPTION OF OLD BUILDINGS** BY AS MUCH AS 80% - WITH IMPROVED HEAT INSULATION, INSULATED WINDOWS AND MODERN VENTILATION SYSTEMS.
3. **SOLAR THERMAL COLLECTORS** PRODUCE HOT WATER FOR BOTH THEIR OWN AND NEIGHBOURING BUILDINGS.
4. **EFFICIENT THERMAL POWER (CHP) STATIONS** WILL COME IN A VARIETY OF SIZES - FITTING THE CELLAR OF A DETACHED HOUSE OR SUPPLYING WHOLE BUILDING COMPLEXES OR APARTMENT BLOCKS WITH POWER AND WARMTH WITHOUT LOSSES IN TRANSMISSION.
5. **CLEAN ELECTRICITY** FOR THE CITIES WILL ALSO COME FROM FARTHER AFIELD. OFFSHORE WIND PARKS AND SOLAR POWER STATIONS IN DESERTS HAVE ENORMOUS POTENTIAL.

suburbs

1. PHOTOVOLTAIC
2. MINI-COGENERATION POWER PLANT = COMBINED HEAT AND POWER [CHP]
3. SOLAR COLLECTORS (HEATING)
4. LOW-ENERGY BUILDINGS
5. GEOTHERMAL HEAT AND POWER PLANT [CHP]

smart power

One of the key ways the world can fight climate change is by becoming more energy-efficient. Efficiency measures also reduce energy costs to consumers. If we do nothing, global energy consumption is expected to increase by 33% by 2020. However, if we implement the Energy [R]evolution Scenario, energy efficiency measures allow us to decrease energy consumption in industrialised countries by 10%, while allowing for developing countries to increase their energy consumption by 20%.

On a global scale, the Energy [R]evolution can save 91 Exa-Joule compared to business as usual - this is enough to satisfy Europe's current entire energy demand.

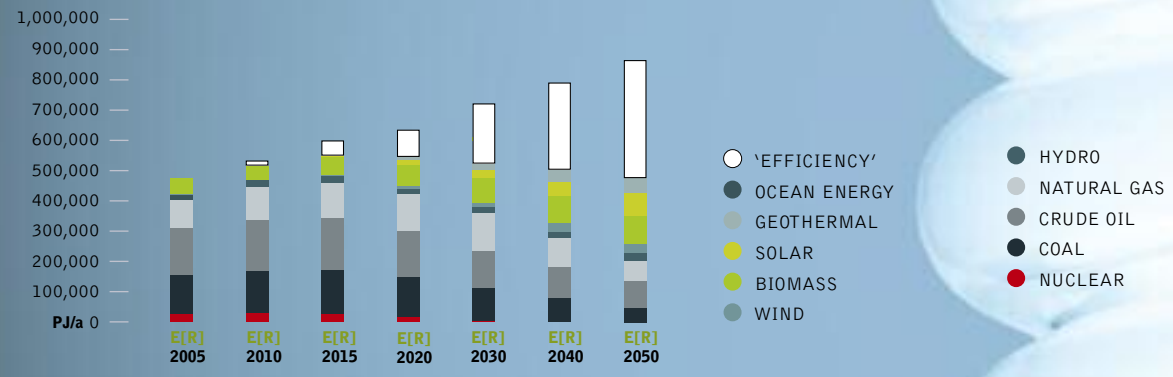
Measures such as:

- improved insulation and design of our homes and offices
- implementation of super-efficient home and office appliances via strict mandatory efficiency standards
- replacement of electrical heaters and conventional hot water systems with renewable heat production (such as solar collectors)

These offer some of the simplest, easiest and most cost-effective ways of reducing greenhouse gas emissions.

figure 5: global development of primary energy consumption under the energy [r]evolution scenario

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



RIGHT NOW, COMPUTER SERVERS WORLDWIDE DEVOUR MORE ELECTRICITY THAN THE ENTIRE DEMAND FROM FRANCE - AND ENERGY USE IS EXPECTED TO DOUBLE AGAIN IN THE NEXT FIVE YEARS. COMPARED TO BEST PRACTICE SERVER TECHNOLOGIES, ABOUT HALF OF THIS ENERGY GOES TO WASTE – ENOUGH TO POWER AUSTRALIA. A STRICT EFFICIENCY STANDARD FOR SERVERS COULD TAKE 48 COAL-FIRED POWER PLANTS OFF THE GRID – SAVING OVER 140 MILLION TONNES OF CO_2.

reducing transport emissions

Under the Energy [R]evolution Scenario, due to fast-growing demand for mobility, energy needs for transport will continue to rise until 2015. After that, energy demand will decrease, falling below current levels from 2020 onwards. This reduction can be achieved by the introduction of highly efficient vehicles, shifting the transport of goods from road to rail and by changes in mobility-related behaviour patterns, such as using bicycles or walking.

Many changes can be can be made in the transport sector to help to reduce our greenhouse emissions, including:

- Reducing the overall use of energy demand by increasing use and efficiency of road and rail transport networks
- Increasing public transport, meaning a shift from road to rail
- Setting strict fuel efficiency standards to deliver more efficient cars
- As a second step, shifting from inefficient combustion engines to efficient electric cars

figure 6: well-to-wheel CO_2 emissions of cars in the reference and energy [r]evolution scenarios from 2000 to 2050

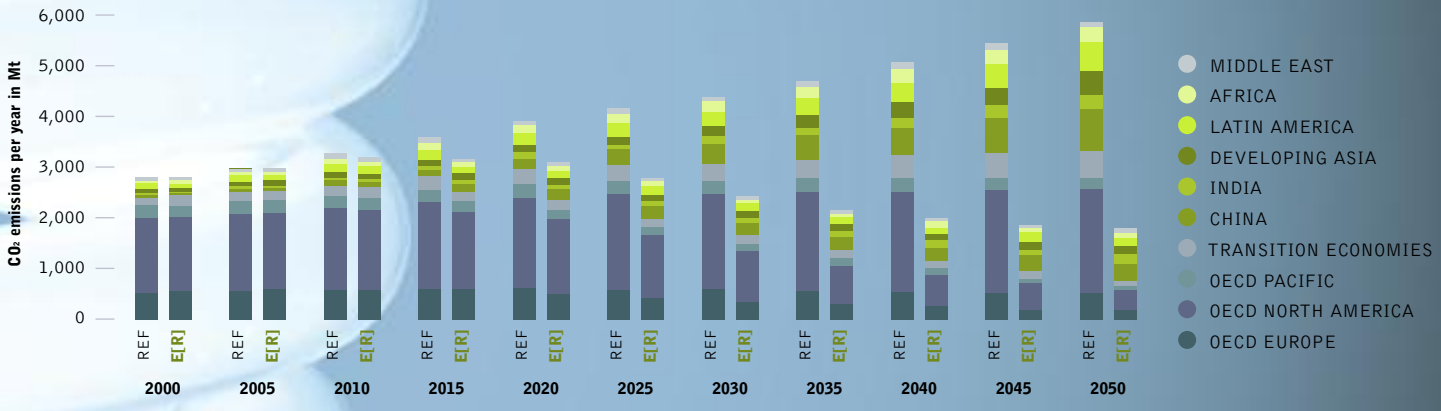


image NEW FUEL EFFICIENT HYBRID CAR DESIGN.

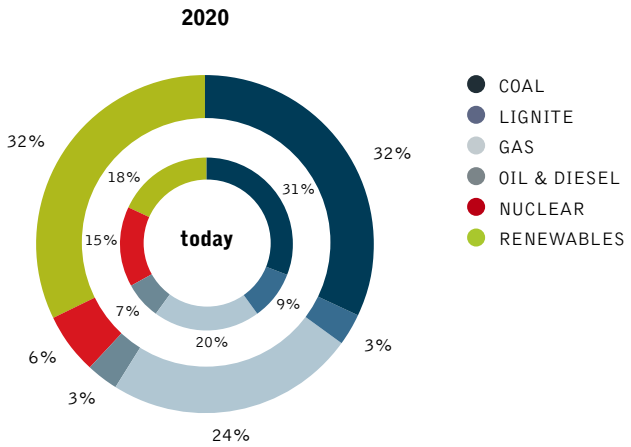
JUST ONE SUBWAY COULD TAKE MORE THAN 500 CARS OFF THE ROAD. MODERN PUBLIC TRANSPORT SYSTEMS RUN WITH ELECTRICITY, NOT OIL. THIS ELECTRICITY, FOR INSTANCE, COULD COME FROM OFFSHORE WIND TURBINES.

10% OF ALL GLOBAL CO_2 EMISSIONS ARE FROM PRIVATE CARS. FUEL-EFFICIENT LIGHT VEHICLES POWERED BY HYBRID ENGINES COULD SAVE OVER 80% OF THE ENERGY USED TODAY TO RUN A CAR.

renewable electricity generation

The Energy [R]evolution Scenario shows how, by 2020, an impressive 32.5% of our electricity needs can be met by renewable energy. Established technologies such as wind and solar take the early lead, but rapidly-emerging technologies, such as concentrating solar thermal, geothermal and ocean energy, all contribute to our 2020 energy mix.

figure 7: global electricity generation today and in 2020 under the energy [r]evolution scenario

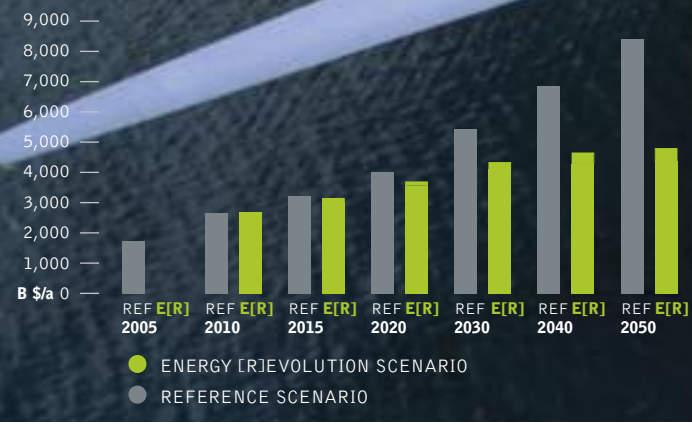


keeping energy affordable

If we carry on with business as usual, electricity supply costs will nearly double by 2020. Unchecked growth in energy demand, increases in fossil fuel prices and the cost of CO_2 emissions result in the total electricity supply costs rising from today's USD 1,750 billion per year to more than USD 3,800 billion in 2020.

The Energy [R]evolution Scenario not only complies with global CO_2 reduction targets, it also helps to stabilise energy costs and relieve the economic pressure on society. Increasing energy efficiency and shifting energy supply to renewables leads to long-term costs for electricity supply that are one-third lower than if we continue in our current trends. It becomes clear that pursuing stringent environmental targets in the energy sector also pays off financially.

figure 8: global development of total electricity supply costs



BY MOVING AWAY FROM FOSSIL FUELS AND REDUCING CARBON EMISSIONS, THE ENERGY [R]EVOLUTION SCENARIO STABILISES ENERGY COSTS FOR CONSUMERS. BETWEEN 2015 AND 2020, MOST RENEWABLE ENERGY SOURCES BECOME CHEAPER THAN COAL.

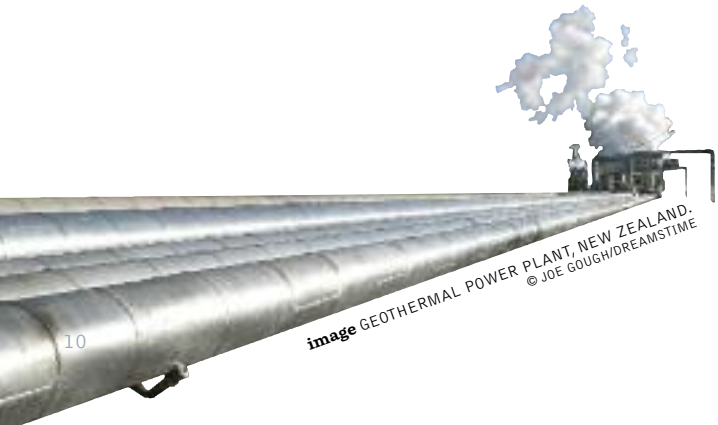


image GEOTHERMAL POWER PLANT, NEW ZEALAND. © JOE GOUGH/DREAMSTIME

© PAUL LANGROCK/ZENIT/GREENPEACE

WITH AN ENERGY [R]EVOLUTION, EVEN BY 2020, WIND FARMS WILL REPLACE THE ELECTRICITY GENERATED BY 450 MEDIUM-SIZED COAL-FIRED POWER STATIONS.

EMERGING ECONOMIES SUCH AS CHINA AND INDIA ARE ALREADY AMONG THE WORLD'S LEADING NATIONS IN WIND TECHNOLOGY, TOGETHER WITH THE USA, GERMANY, SPAIN AND DENMARK. IN 2007, THE WIND INDUSTRY EMPLOYED OVER 330,000 PEOPLE.

image CONSTRUCTION OF THE OFFSHORE WINDFARM AT MIDDELGRUNDEN NEAR COPENHAGEN, DENMARK.

renewable energy = energy security

Nature offers a variety of freely-available options for producing energy. Their exploitation is mainly a question of how to convert sunlight, wind, biomass or water into electricity, heat or power as efficiently, sustainably and cost-effectively as possible.

On average, the energy in the sunlight that reaches the Earth is about one kilowatt per square metre worldwide. According to the Research Association for Solar Power, power is gushing from renewable energy sources at a rate of 2,850 times more energy than is needed in the world.

In one day alone, the sunlight that reaches the Earth produces enough energy to satisfy the world's current power requirements for eight years. Even though only a percentage of that potential is technically accessible, this is still enough to provide around six times more power than the world currently requires.

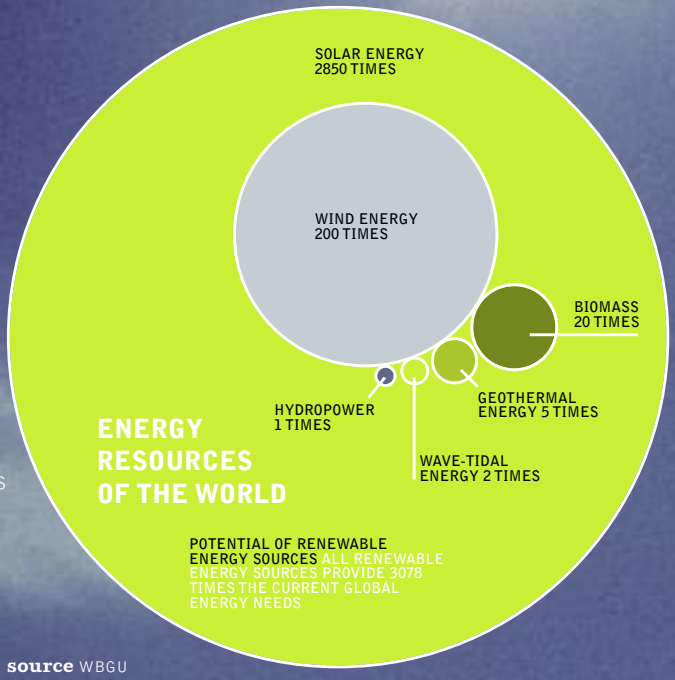
table 9: technically accessible today

THE AMOUNT OF ENERGY THAT CAN BE ACCESSED WITH CURRENT TECHNOLOGIES SUPPLIES A TOTAL OF 5.9 TIMES THE GLOBAL DEMAND FOR ENERGY

Sun	3.8 times
Geothermal heat	1 time
Wind	0.5 times
Biomass	0.4 times
Hydrodynamic power	0.15 times
Ocean power	0.05 times

source DR. JOACHIM NITSCH

figure 10: energy resources of the world



source WBGU

© MIZUKOSHI/GREENPEACE

THE ENERGY [R]EVOLUTION SCENARIO USES ONLY 1.3% OF THE KNOWN AVAILABLE RENEWABLE ENERGY RESOURCES OF DEVELOPED ECONOMIES BY 2020 - THIS ALONE WILL PROVIDE 21% OF GLOBAL ENERGY NEEDS (BY 2020).

© GP/FLAVIO CANNALONGA

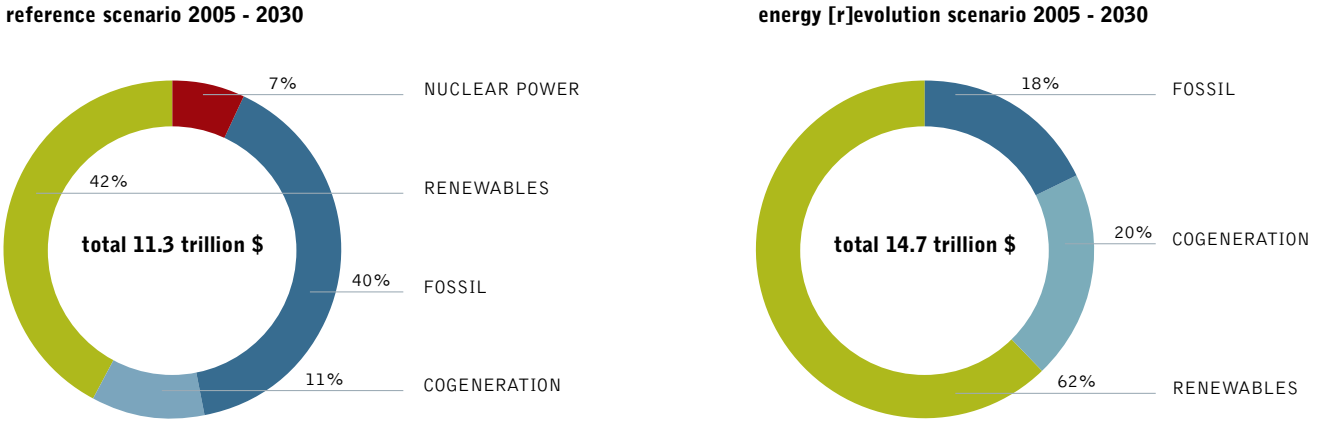
image ICE FLOES ON THE SNOW COVERED LAKE BAIKAL, RUSSIA, IN THE SUN.

renewables: no emissions, no fuel costs, no problem

Because renewable energy has no fuel costs, the total financial savings until 2030 outlined in the Energy [R]evolution Scenario reach a total of USD 18.7 trillion, or USD 750 billion per year. A comparison between the extra fuel costs associated with business as usual and the extra investment costs of the Energy [R]evolution shows that the average annual additional fuel costs of the former are about five times higher than the additional investment requirements of the Energy [R]evolution Scenario.

In fact, the additional costs for coal fuel, from today until the year 2030, are as high as USD 15.9 trillion: this would cover the entire investment in renewable and cogeneration capacity required to implement the Energy [R]evolution Scenario. These renewable energy sources will produce electricity without any further fuel costs beyond 2030, while the costs for coal and gas will continue to be a burden on national economies.

figure 11: investment shares - reference versus energy [r]evolution



A COMPARISON BETWEEN THE EXTRA FUEL COSTS ASSOCIATED WITH BUSINESS AS USUAL AND THE EXTRA INVESTMENT COSTS OF THE ENERGY [R]EVOLUTION SHOWS THAT THE AVERAGE ANNUAL ADDITIONAL FUEL COSTS OF THE FORMER ARE ABOUT FIVE TIMES HIGHER THAN THE ADDITIONAL INVESTMENT REQUIREMENTS OF THE ENERGY [R]EVOLUTION SCENARIO.

image BIOGAS FACILITY "SCHRADEN BIOGAS" IN GROEDEN NEAR DRESDEN, GERMANY.

quitting coal

The single biggest contributor to global greenhouse gas emissions is burning coal. The Energy [R]evolution shows that, by greatly increasing the amount of renewable energy in our system, using gas as a transitional fuel and introducing assertive energy efficiency measures, we can start removing coal-fired power plants from the grid, shutting them down at the end of their working life. From 2020 onwards, the coal electricity share starts to decrease. By 2020, 30% of the currently operating coal-fired power plants are retired and replaced by a mix of renewables, cogeneration and energy efficiency.

AUSTRALIA CAN TAKE COAL-FIRED POWER STATIONS OFF THE GRID AT THE RATE OF MORE THAN ONE A YEAR. COAL CAN BE PHASED OUT ENTIRELY IN AUSTRALIA BY 2030.

image UPPER HUNTER VALLEY COAL MINES, NSW, AUSTRALIA.

image [large] HIGH MARNHAM COAL-FIRED POWER STATION ON THE RIVER TRENT IN NOTTINGHAMSHIRE, UK.

phasing out nuclear power

Nuclear energy is a relatively small industry, but one with big problems. It covers just one-sixteenth of the world's primary energy consumption, a share set to decline over the coming decades. The average age of operating commercial nuclear reactors is 23 years. This means that more power stations are being shut down than built. In 2007, world nuclear production fell by 1.8 % and the number of operating reactors was 439, five less than the historical peak of 2002.

In terms of new power stations, the amount of nuclear capacity added annually between 2000 and 2007 was, on average, 2,500 MW. This was six times less than wind power (13,300 MW per annum between 2000 and 2007). In 2007, newly constructed renewable energy power plants in Germany generated 13 TWh of electricity – as much as two large nuclear units.

Despite the rhetoric of a 'nuclear renaissance', the industry is struggling with a massive increase in costs and construction delays, as well as safety and security problems linked to reactor operation, radioactive waste and nuclear proliferation

The dangers of nuclear power

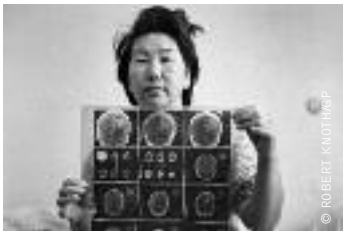
Although the generation of electricity through nuclear power produces much less CO_2 than fossil fuels, there are multiple threats to people and the environment from its operations. The main risks are:

- Nuclear proliferation
- Nuclear waste
- Safety risks

image SIGN ON A RUSTY DOOR AT CHERNOBYL ATOMIC STATION. © DMYTRO/DREAMSTIME

© I. BRACEGIRDLE/DREAMSTIME

BY 2020, UNDER THE ENERGY [R]EVOLUTION SCENARIO, THE GLOBAL SHARE OF NUCLEAR ELECTRICITY ENERGY DROPS FROM TODAY'S 15% DOWN TO 6%. AFTER 2030, THE SHARE IS ONLY 1%.



© ROBERT KNOTHE/GP

© N. BEHRING-CHISHOLM/GP

images left to right 1. DSUNUSOVA GULSUM (43) IS SUFFERING FROM A BRAIN TUMOUR. SHE LIVES IN THE NUCLEAR BOMB TESTING AREA IN THE EAST KAZAKH REGION OF KAZAKHSTAN. **2.** DOCTOR PEI HONGCHUAN EXAMINES ZHAI LISHENG, A YOUNG BOY WHO IS SUFFERING FROM A RESPIRATORY ILLNESS DUE TO THE HEAVY POLLUTION IN LINFEN. LINFEN, A CITY OF ABOUT 4.3 MILLION, IS ONE OF THE MOST POLLUTED CITIES IN THE WORLD. CHINA'S INCREASINGLY POLLUTED ENVIRONMENT IS LARGELY A RESULT OF THE COUNTRY'S RAPID DEVELOPMENT AND CONSEQUENTLY A LARGE INCREASE IN PRIMARY ENERGY CONSUMPTION, WHICH IS ALMOST ENTIRELY PRODUCED BY BURNING COAL.

we must take action now!!

Governments around the world must show that they are serious about climate change by acting now to bring about an Energy [R]evolution. We need our global leaders to:

1. Phase out all subsidies for fossil fuels and nuclear energy
2. Internalise the external (social and environmental) costs of energy production through "cap and trade" emissions trading
3. Mandate strict efficiency standards for all energy-consuming appliances, buildings and vehicles
4. Establish legally binding targets for renewable energy and combined heat and power generation
5. Reform the electricity markets by guaranteeing priority access to the grid for renewable power generators
6. Provide defined and stable returns for investors, for example by feed-in tariff programmes
7. Increase research and development budgets for renewable energy and energy efficiency

you can make it happen!

Get active! For a full copy of the report and to join the Energy [R]evolution, go to: **www.greenpeace.org/energyrevolution**

STANDBY POWER IS WASTED POWER. GLOBALLY, WE HAVE 50 DIRTY POWER PLANTS RUNNING JUST FOR OUR WASTED STANDBY POWER.

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project manager and lead author: Sven Teske, Greenpeace International **online version** of the full Energy [R]evolution scenario (212 pages): www.energyblueprint.info **editor:** Alexandra Dawe, **design & layout:** Tania Dunster, Jens Christiansen, onehemisphere, Sweden **printing:** PrimaveraQuint, The Netherlands **contact:** sven.teske@greenpeace.org, October 2008.