energy [r]evolution

A SUSTAINABLE WORLD ENERGY OUTLOOK

THE THREE STEP APPROACH

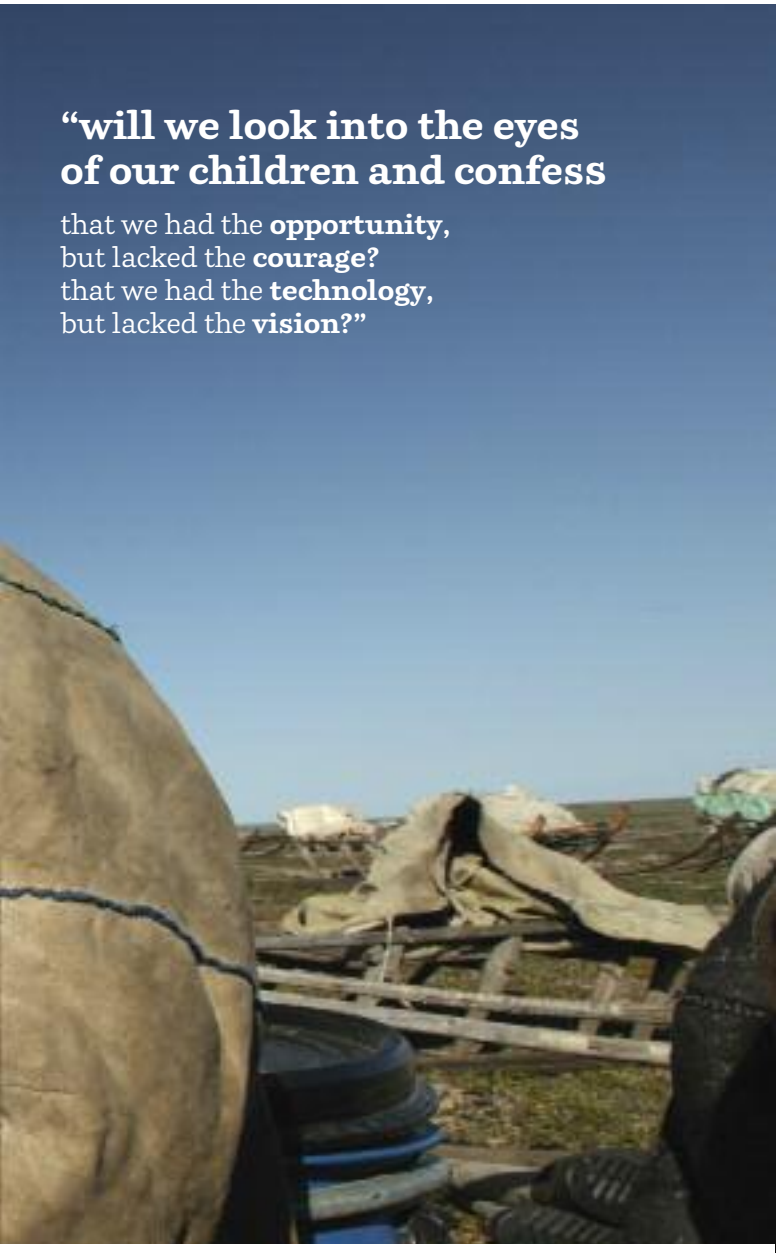
EFFICIENCY / RENEWABLES / STRUCTURE

GREENPEACE

© GREENPEACE/WILL ROSE

contents

image AN INDIGENOUS NENET FAMILY WITH THEIR YOUNGEST SON, OUTSIDE OF THEIR CHUME (TEPEE). IT IS TRADITION THAT THE YOUNGEST SON INHERITS THE CHUME BUT HE ALSO HAS THE RESPONSIBILITY TO LOOK AFTER THE PARENTS WHEN THEY ARE OLD AND SICK. THE INDIGENOUS NENETS PEOPLE MOVE EVERY 3 OR 4 DAYS SO THAT THEIR REINDEER DO NOT OVER GRAZE THE GROUND AND THEY DO NOT OVER FISH THE LAKES. THE YAMAL PENINSULA IS UNDER HEAVY THREAT FROM GLOBAL WARMING AS TEMPERATURES INCREASE AND RUSSIA'S ANCIENT PERMAFROST MELTS.



“will we look into the eyes of our children and confess

that we had the **opportunity,**
but lacked the **courage?**
that we had the **technology,**
but lacked the **vision?”**

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

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 world can get from where we are now, to where we need to be in terms of phasing out fossil fuels, cutting CO_2 while ensuring energy security. This includes illustrating how the world’s carbon emissions from the energy and transport sectors alone can peak by 2015 and be cut by over 80% by 2050.

This phase-out of fossil fuels offers substantial other benefits such as independence from world market fossil fuel prices as well as the creation of millions of new green jobs.

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

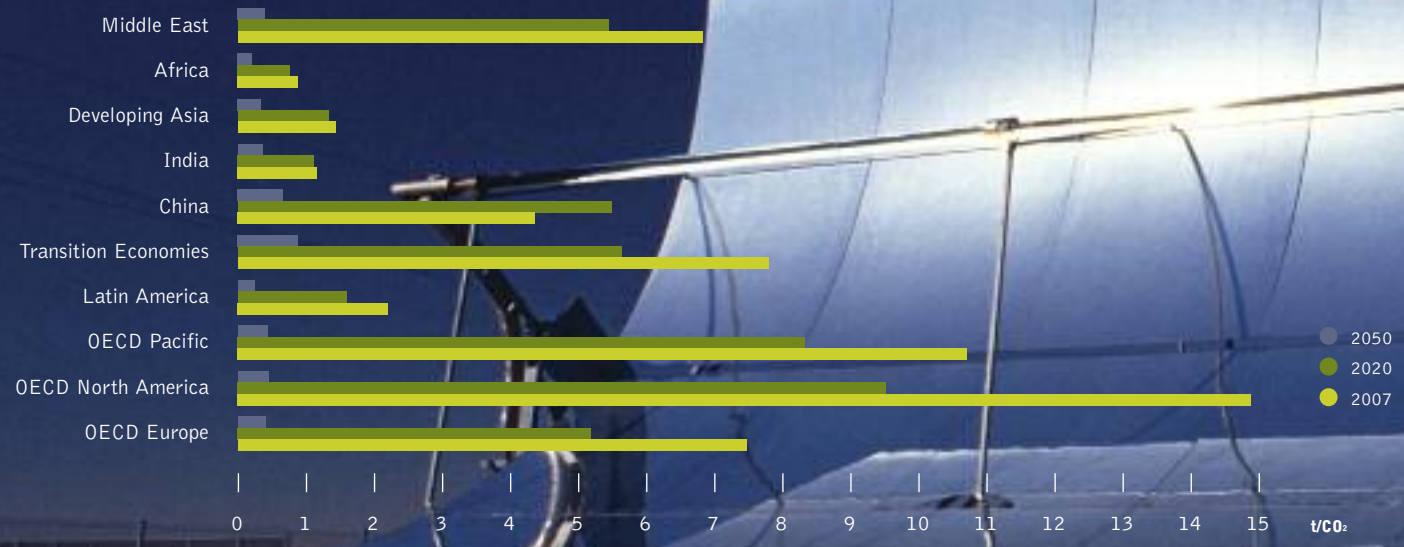
The Energy [R]evolution scenario creates greater equity in the use of resources whilst providing a secure and affordable energy supply and maintaining steady global economic development. The report takes into account rapid economic growth areas such as China, India, Brazil and Africa.

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 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 peak CO_2 emissions by 2025 and start reducing emissions towards 2030 and beyond while providing a secure and affordable energy supply and, critically, maintaining steady worldwide economic development. The Energy [R]evolution provides clear pathways as to how to achieve those reductions.

figure 1: CO_2 emissions 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.

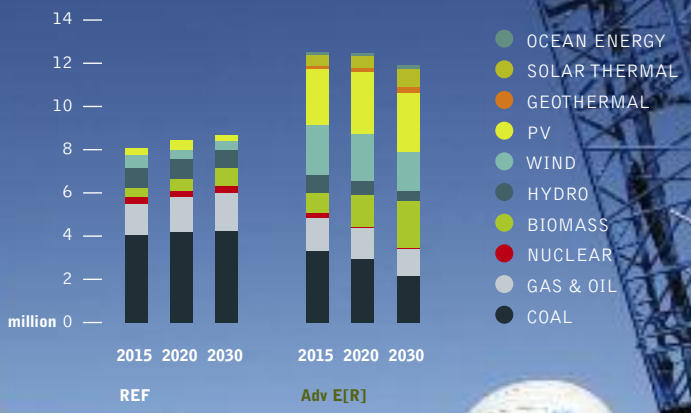
image LUZ INTERNATIONAL SOLAR POWER PLANT, CALIFORNIA, USA.

working for the climate

The Energy [R]evolution is also creating a green jobs revolution.

- By 2015 the global power supply sector under the Energy [R]evolution scenario could create up to 12.5 million jobs. That is 4.5 million more than if business continues as usual.
- By 2020 over 8 million jobs in the renewables sector would be created due a much faster uptake of renewables, four-times more than today.
- By 2030 the Energy [R]evolution scenario will create about 12 million jobs, that is 8.5 million in the renewables sector alone. Without this fast growth in the renewable sector global power jobs will be a mere 2.4 million. Thus by implementing the Energy [R]evolution there will be 3.2 million or over 33% more jobs by 2030 in the global power supply sector.

figure 2: global employment



BY 2020 TWO THIRDS OF THE DIRECT EMPLOYMENT IN THE ENERGY [R]EVOLUTION SCENARIO COMES FROM RENEWABLE ENERGY, EVEN THOUGH RENEWABLES ACCOUNT FOR ONLY 38% OF ELECTRICITY GENERATION. THIS RELATIONSHIP BETWEEN ELECTRICITY OUTPUT AND JOBS ILLUSTRATES THAT THE RENEWABLES SECTOR HAS GREATER "LABOUR INTENSITY" – OR MORE PEOPLE PER UNIT OF POWER PRODUCED.
INVESTING IN RENEWABLE POWER SAVES FUEL COSTS WHICH MEANS IT CAN INVEST IN WORKERS.

image IN WAUBRA, CENTRAL VICTORIA, ONE OF AUSTRALIA'S LARGEST WIND TURBINE FARMS IS CURRENTLY UNDER CONSTRUCTION.

shifting the CO_2 trend

Global CO_2 emissions under the Energy [R]evolution scenario will peak in 2015 and drop afterwards. Compared with today CO_2 emissions will be more than 80% lower by 2050 when the energy supply is based almost entirely on renewable energies. While global emissions fall regional shares shift. OECD countries reduce their emissions faster which see their share of the global output drop from just over 50% today to 38% in 2020. This is achieved by implementing renewable energy and energy efficiency standards.

figure 4: global regional breakdown of CO_2 emissions in the advanced energy [r]evolution in 2050

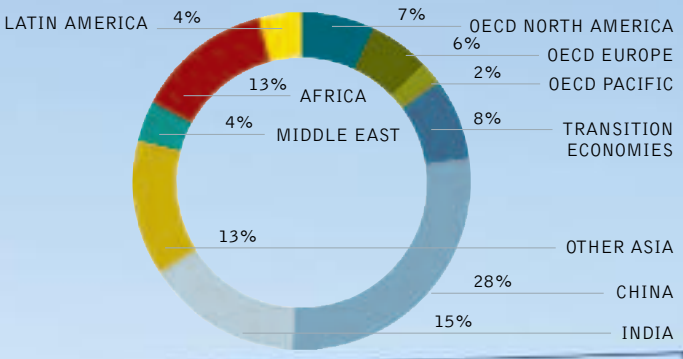
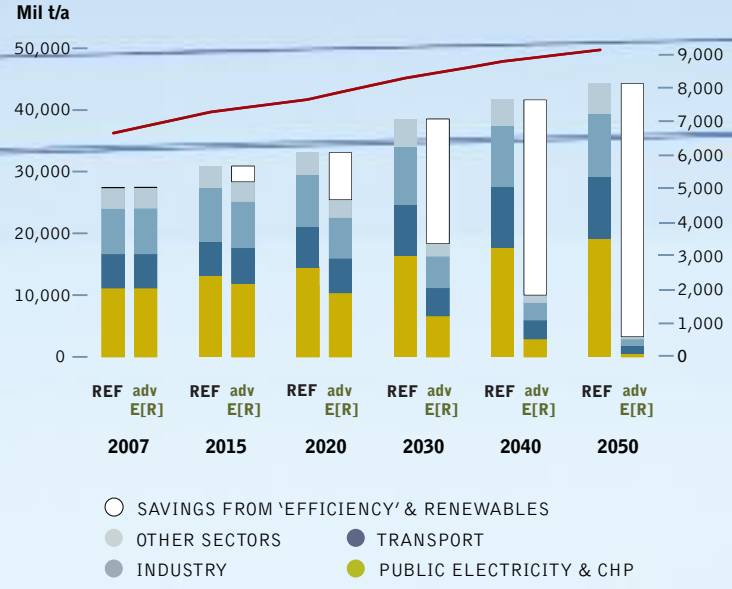


figure 3: global development of CO_2 emissions by sector under the two scenarios



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

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 20% by 2020 and up to 60% by 2050. However if we implement the Energy [R]evolution scenario, energy efficiency measures allow us to **decrease** energy consumption within the next 10 years in industrialised countries by 20%, while allowing for developing countries to increase their energy consumption by 20%.

On a global scale the Energy [R]evolution can save about 70 Exa-Joule compared to business as usual - this is enough to satisfy Europe's current entire energy demand.

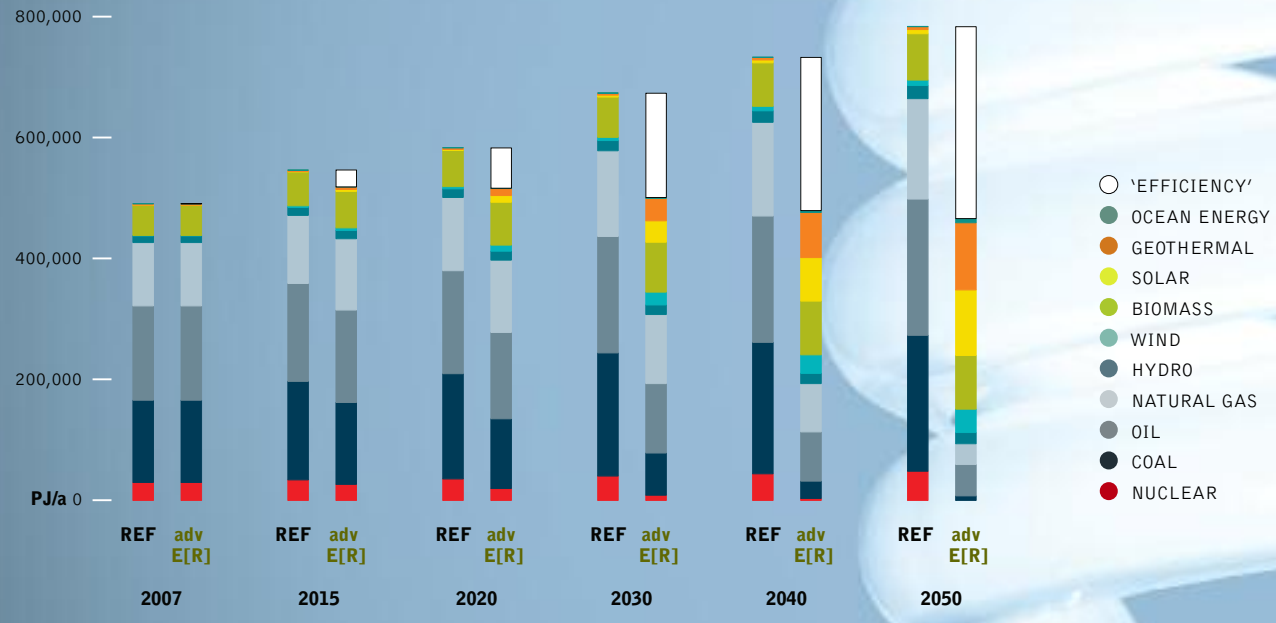
Measures such as:

- 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, most cost effective ways to reduce greenhouse gas emissions.

figure 5: global development of primary energy consumption under the two scenarios

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



"RIGHT NOW ALL 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 POWER PLANTS OFF THE GRID – SAVING OVER 140 MILLION TONNES OF CO_2."

using and producing smart energy

Business as usual in the way we consume and produce energy is simply not an option any more. Besides catastrophic climate change due to rising CO_2 emissions, our resources are limited. Fossil fuel prices are increasing 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 afterwards, 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 which 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:

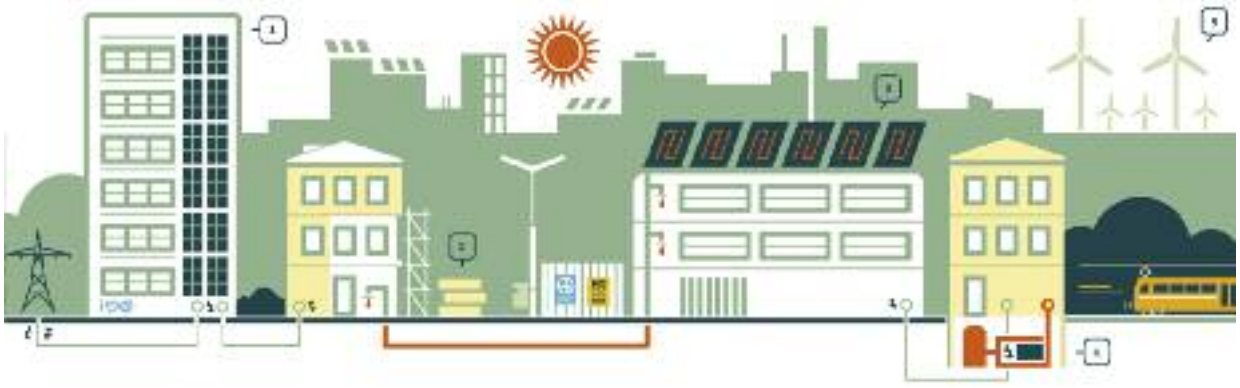
- **SMART CONSUMPTION, GENERATION AND DISTRIBUTION**
- **ENERGY PRODUCTION MOVES CLOSER TO THE CONSUMER**
- **MAXIMUM USE OF LOCALLY AVAILABLE, ENVIRONMENTALLY FRIENDLY FUELS**

image THE TECHNOLOGY FOR SOLAR PANELS WAS ORIGINAL INSPIRED BY NATURE.

figure 6: 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.

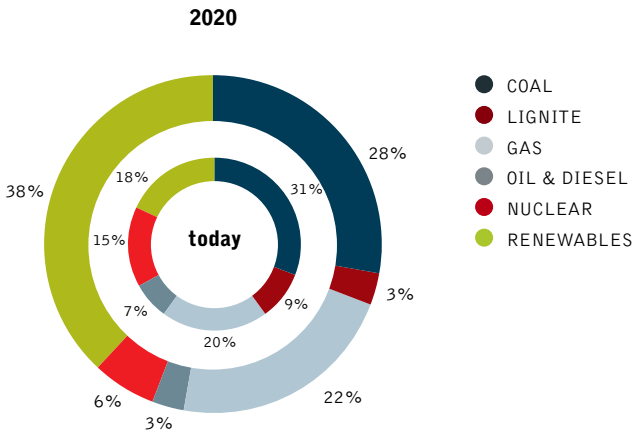
suburbs

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)

renewable electricity generation

The Energy [R]evolution scenario demonstrates how by 2020 an impressive 38% 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



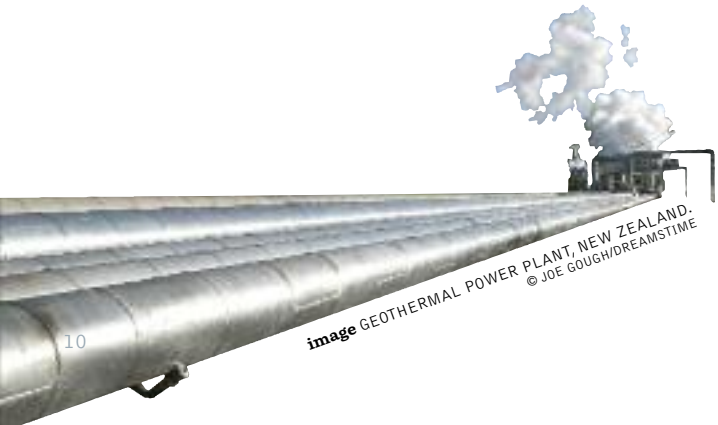


image GEOTHERMAL POWER PLANT, NEW ZEALAND. © JOE GOUGH/DREAMSTIME

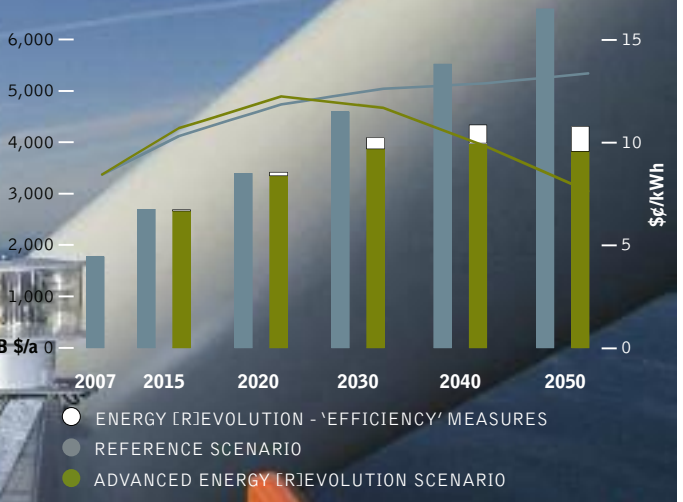
keeping energy affordable

If we carry on, 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 total electricity supply costs rising from today's $1,450 billion per year to more than $2,800 billion in 2020, and 5,300 billion by 2050.

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.

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 generation 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 & development of specific electricity generation costs under two scenarios



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 2009, THE WIND INDUSTRY EMPLOYED OVER 400,000 PEOPLE.

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. TWO TECHNICIANS WORKING INSIDE THE TURBINE.

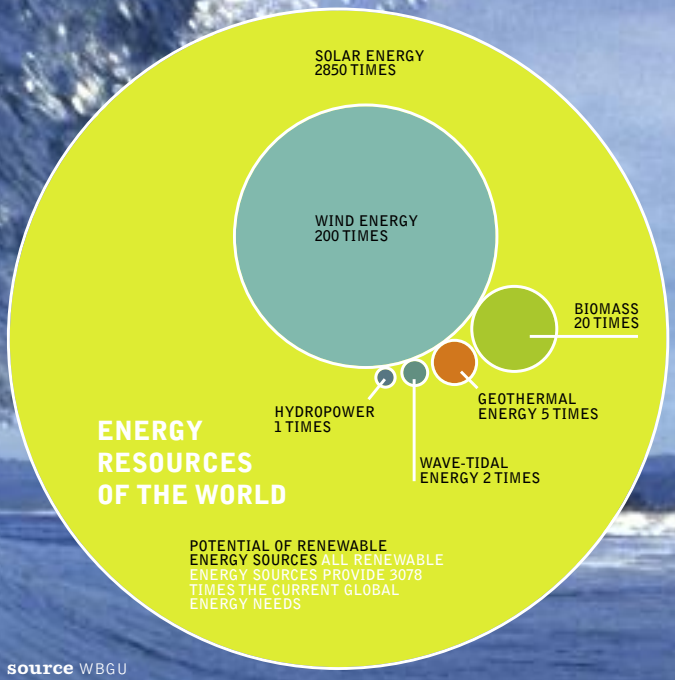
renewable energy = energy security

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 sunshine 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 which 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.

figure 9: energy resources of the world



source WBGU

table 2: technical potential by renewable energy technology for 2050 vs world primary energy demand 2007 WORLD ENERGY DEMAND 2007: 502.9 EJ/A[a]

TECHNICAL POTENTIAL VERSUS WORLD POWER DEMAND IN 2007	
Solar CSP	3.4 times
Solar PV	16.0 times
Hydro power	0.1 times
Wind on-shore	0.8 times
Wind off-shore	0.1 times
Ocean energy	0.7 times
Geothermal electric	0.1 times
TECHNICAL POTENTIAL VERSUS WORLD HEATING DEMAND IN 2007	
Geothermal direct uses	9.9 times
Solar water heating	0.2 times
TECHNICAL POTENTIAL VERSUS PRIMARY ENERGY DEMAND - TOTAL	
TOTAL	32 times

source DLR, WUPPERTAL INSTITUTE, ECOFYS; ROLE AND POTENTIAL OF RENEWABLE ENERGY AND ENERGY EFFICIENCY FOR GLOBAL ENERGY SUPPLY; COMMISSIONED BY THE GERMAN FEDERAL ENVIRONMENT AGENCY FKZ 3707 41 108, MARCH 2009; POTENTIAL VERSUS ENERGY DEMAND: S. TESKE **a** IEA 2009

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

image BREAKING WAVE, MEXICO.

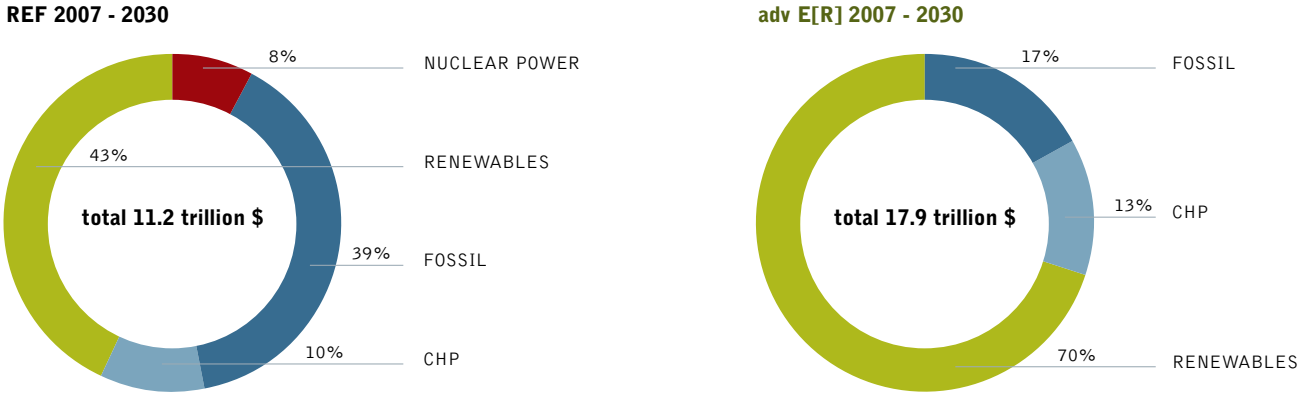
renewables: no emissions, no fuel costs, no problem

Because renewable energy has no fuel costs, the total financial savings until 2030 outlined in the Energy [R]evolution reach a total of $6.5 trillion, or $282 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 higher than the additional investment requirements of the Energy [R]evolution.

The average annual investment in the power sector under the Energy [R]evolution Scenario between 2007 and 2030 would be approximately $782 billion. This is equal to the current amount of subsidies paid for fossil fuels globally in under three years.

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. The Energy [R]evolution pays for the environment, the climate and the economy.

figure 10: investment shares - reference versus advanced 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 ARE HIGHER THAN THE ADDITIONAL INVESTMENT REQUIREMENTS OF THE ALTERNATIVE SCENARIO.

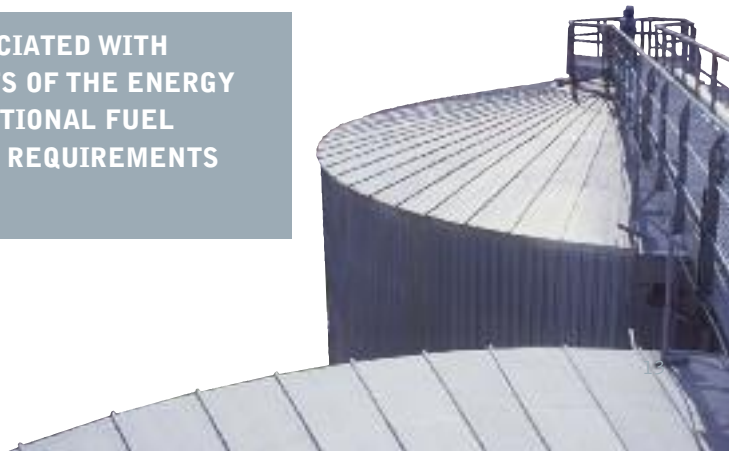


image BIOGAS FACILITY "SCHRADEN BIOGAS" IN GROEDEN NEAR DRESDEN, GERMANY.

quitting coal

The single biggest contributor to global greenhouse 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 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 power plants in industrialised countries are retired and replaced by a mix of renewable, co-generation 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] SIGN ON A RUSTY DOOR AT CHERNOBYL ATOMIC STATION, UKRAINE.

phasing out nuclear power

Nuclear energy is a relatively minor industry with major 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, so more power stations are being shut down than started up. In 2008, world nuclear production fell by 2% compared to 2006, and the number of operating reactors as of January 2010 was 436, eight less than at the historical peak of 2002.

In terms of new power stations, the amount of nuclear capacity added annually between 2000 and 2009 was on average 2,500 MWe. This was six times less than wind power (14,500 MWe per annum between 2000 and 2009). In 2009, 37,466 MW of new wind power capacity was added globally to the grid, compared to only 1,068 MW of nuclear. This new wind capacity will generate as much electricity as 12 nuclear reactors; the last time the nuclear industry managed to add this amount of new capacity in a single year was in 1988.

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 carbon dioxide 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**

BY 2020, UNDER THE ENERGY [R]EVOLUTION SCENARIO THE GLOBAL SHARE OF NUCLEAR ELECTRICITY ENERGY DROPS FROM TODAY'S 14% DOWN TO 7%. AFTER 2030 THE SHARE IS ONLY 1%.

© ROBERT KNOTHEK

© I.BRACEGIRDLE/DREAMSTIME

© DMYTRO/DREAMSTIME

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.** HIGH MARNHAM COAL-FIRED POWER STATION ON THE RIVER TRENT IN NOTTINGHAMSHIRE, UK.

we must take action now!

Governments around the world must to show 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 a chance to join the revolution go to: **www.greenpeace.org/energyrevolution**

Note: The Energy [R]evolution report published in June 2010 has 2 different energy [r]evolution scenarios. A moderate one with a global target of reducing 50% energy related CO_2 globally by 2050 and an advanced one with a target of over 80% CO_2 reduction (Basis 1990 level) In this publication we only present the results of the advanced energy [r]evolution scenario.

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

GREENPEACE

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project manager and lead author: Sven Teske, Greenpeace International **research & co-authors:** DLR, Institute of Technical Thermodynamics, Department of Systems Analysis and Technology Assessment, Stuttgart, Germany: Dr. Wolfram Krewitt (†), Dr. Thomas Pregger, Dr. Sonja Simon, Dr. Tobias Naegler, Ecofys BV, Utrecht, The Netherlands: Wina Graus, Eliane Blomen **online version** of the full Energy [R]evolution scenario: www.energyblueprint.info **editor:** Alexandra Dawe **design & layout:** onehemisphere, Sweden **printing:** PrimaveraQuint, The Netherlands **cover image:** © Paul Langrock/ Zenit/Greenpeace **contact:** sven.teske@greenpeace.org, or info@greenpeace.org June 2010.