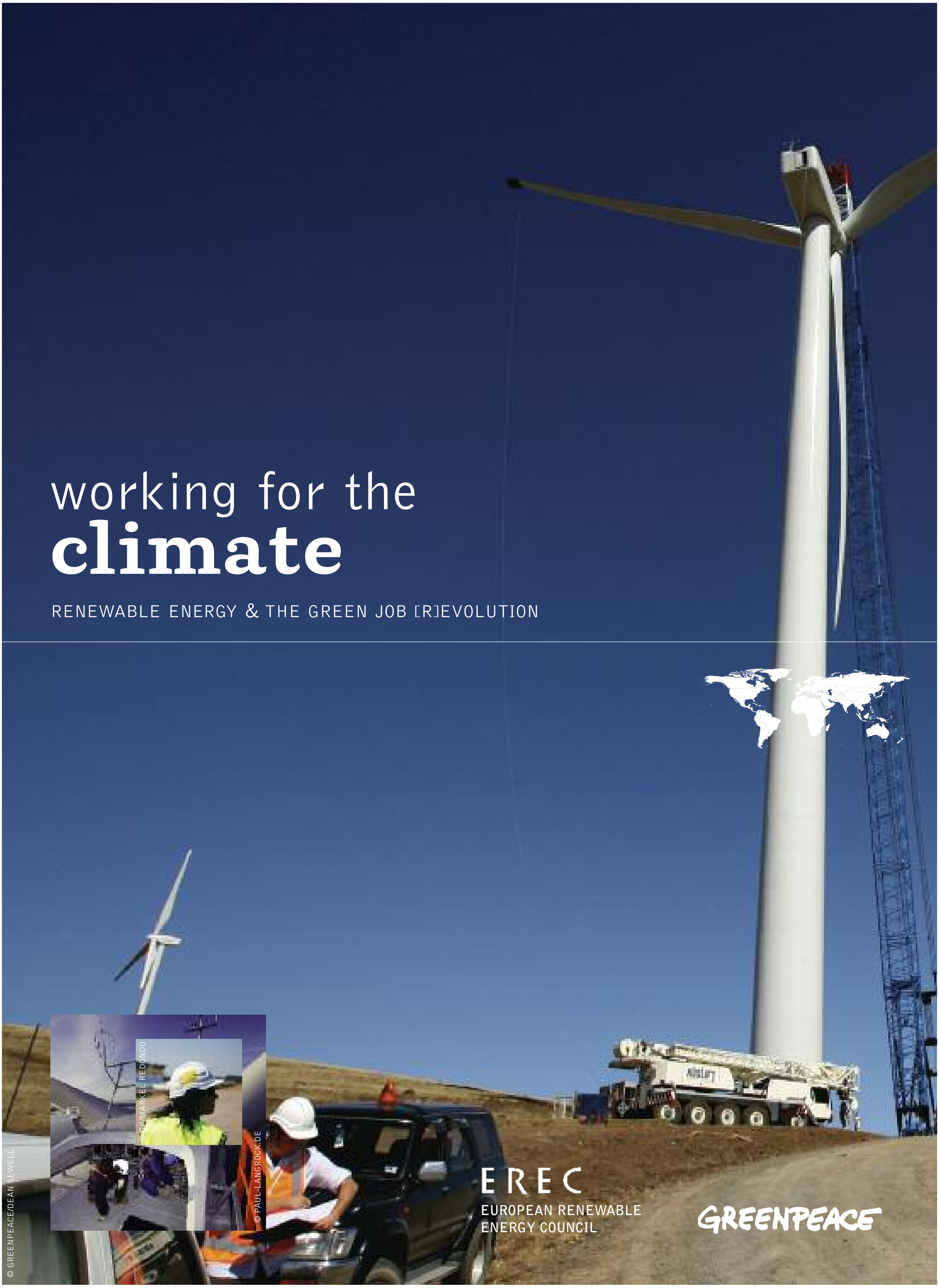
working for the
climate

RENEWABLE ENERGY & THE GREEN JOB [R]EVOLUTION



EREC
EUROPEAN RENEWABLE
ENERGY COUNCIL

GREENPEACE

report global job scenario

foreword

It's not just the economy that is in crisis.

In 2009 the world is reeling from a collapse of the financial markets. The effects have been large job losses in the UK, USA and other developed nations, volatile stock markets, and millions of ordinary people struggling to pay their bills. Governments around the world responded with massive bail-out and fiscal stimulus packages. The United States alone poured $787 billion into its economy to prop up failing businesses and financial institutions.

"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?"**

contents

image A WORKER SURVEYS THE EQUIPMENT AT ANDASOL 1 SOLAR POWER STATION, WHICH IS EUROPE'S FIRST COMMERCIAL PARABOLIC TROUGH SOLAR POWER PLANT. ANDASOL 1 WILL SUPPLY UP TO 200,000 PEOPLE WITH CLIMATE-FRIENDLY ELECTRICITY AND SAVE ABOUT 149,000 TONS OF CARBON DIOXIDE PER YEAR COMPARED WITH A MODERN COAL POWER PLANT.
cover image IN WAUBRA, CENTRAL VICTORIA, ONE OF AUSTRALIA'S LARGEST WIND TURBINE FARMS IS CURRENTLY UNDER CONSTRUCTION.

Right now our earth faces a crisis that dwarfs the global financial one. Climate change will affect the fundamental livelihood of millions of people. We are all going to be affected, rich and poor, by more frequent natural disasters, changes to food production patterns, raised sea levels and coastal destruction.

The climate crisis and the financial crisis are not two competing issues that need to be addressed separately by the world community. The solution to one is in fact, the answer to the other. Investment in energy efficiency and renewable energy helps the economy by increasing employment in the power sector, while reducing energy costs and easing the over-use of precious natural resources. By making the switch to renewable energy we can halt the carbon dioxide building up in the atmosphere and create a path away from irreversible climate change.

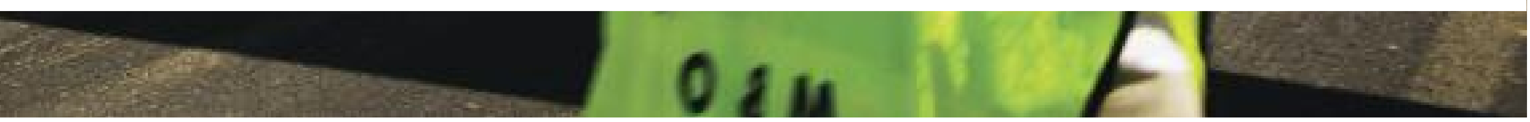
Meanwhile the renewables industry maintains a stable growth - despite the financial crisis. According to the UNEP Report "Global Trends in sustainable Energy Investment 2009", investment in the sustainable energy market has in some ways defied the global recession growing by around 5%—from $148 billion in 2007 to around $155 billion in 2008. Support for sustainable energy investments will now depend on several factors. In response to the economic crisis the G-20 group of nations recently announced stimulus packages totalling $3 trillion or 4.5% of their GDP.

Several economies, from China, Japan and many European ones to the Republic of Korea and the United States, have earmarked multi-billion investments in renewable energies under the banner of a global 'green new deal'. Perhaps the biggest stimulus package of all will happen in both developed and developiong countries at the climate summit in Copenhagen if governments agree a scientifically credible and forward-looking new climate agreement. This includes about €110 billion annually for mitigation, adaptation and stopping deforestation in developing countries.

AUGUST 2009

Greenpeace International, European Renewable Energy Council (EREC)

date August 2009. **EREC** Arthouros Zervos, Christine Lins. **Greenpeace International** Sven Teske, Project Manager. **authors** Jay Rutovitz, Alison Atherton, Rebecca Short, Sven Teske. **editor** Rebecca Short. **research** Jay Rutovitz, Alison Atherton, Institute for Sustainable Futures (ISF), University of Technology, Sydney, PO Box 123, Broadway, NSW, 2007, Australia. **printing** www.primaveraquint.nl **design & layout** Jens Christiansen, Tania Dunster, www.onehemisphere.se **contact** Greenpeace International: Sven Teske; sven.teske@greenpeace.org **for further information** about the global, regional and national scenarios please visit the energy [r]evolution website: **www.energyblueprint.info/** Published by Greenpeace International.
Printed on 100% post consumer recycled chlorine-free paper.



executive summary

"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."

image SOLAR POWERED PHOTO-VOLTAIC (PV) CELLS ARE ASSEMBLED BY WORKERS AT A FACTORY OWNED BY THE HIMIN GROUP, THE WORLDS LARGEST MANUFACTURER OF SOLAR THERMAL WATER HEATERS. THE CITY OF DEZHOU IS LEADING THE WAY IN ADOPTING SOLAR ENERGY AND HAS BECOME KNOWN AS THE SOLAR VALLEY OF CHINA.

global energy supply has to change

Science has confirmed that to avert catastrophic climate change the world's most industrialised nations must cut carbon emissions by at least 40% by 2020, compared to 1990 levels. To do this we need to make a massive, rapid switch to renewable energy to provide around 30% of the world's energy by 2020.

The Greenpeace International's Energy [R]evolution published in October 2008 sets out a vision of how to achieve this. The report outlines two scenarios, the Reference scenario is the International Energy Association's 'World Energy Outlook 2007' projection, extrapolated from 2030 to 2050. The Energy [R]evolution scenario was developed to show how, technically and financially, the world could increase its production of renewable energy by nine times, replacing nuclear and a proportion of coal-fired power, to avoid catastrophic climate change.

renewable energy creates jobs

Greenpeace undertook this study to determine whether there would be jobs created by this nine-fold increase in renewable energy, and massive global energy efficiency measures required for the Energy [R]evolution by researching jobs in power generation and electrical efficiency (excluding heating, cooling and transport). And if so, how many compared to business as usual, with little or no action to avert climate change?

We found that under the Energy [R]evolution scenario, there would be an overall increase of around 2 million power sector jobs over 20 years. But if we carry on without measures to make the shift to clean energy, we will see sector-wide job losses – half a million energy supply jobs would disappear between 2010 and 2030.

With policies to create an Energy [R]evolution, there would be more than 8 million jobs in renewable energy and energy efficiency in 2030, more than three times as many than with a 'business as usual' approach.

image WELDER WORKING AT VESTAS WIND TURBINE FACTORY, CAMPBELLTOWN, SCOTLAND.

table 0.1: global: total power sector jobs

BUSINESS AS USUAL a largely coal dependent economy		ENERGY [R]EVOLUTION huge renewable & energy efficiency deployment	
2010	9.1 million	2010	9.3 million
2020	8.5 million	2020	10.5 million
2030	8.6 million	2030	11.3 million
Total loss in energy sector over period	**500,000**	**Total gain** in energy sector over period	**2 million**
JOBS IN RENEWABLES DO NOT BALANCE OUT LOSSES IN COAL SECTOR BY 2030		2.7 MILLION MORE JOBS IN 2030 THAN WITH 'BUSINESS AS USUAL'	

The balance of jobs is changed because there are more jobs created in the renewable power sector than there are jobs lost in the fossil fuel sector, over time. This can be seen in the detail of jobs in each the fossil fuel and renewable power sectors.

by 2030:

- Under the Energy [R]evolution, the whole power sector would be employing about 2 million more than now (2.7 million more people than the 'business as usual' scenario). Without the Energy [R]evolution, the coal sector would be providing most of the power, but not as much employment.
- Under business as usual, there will be about 500,000 jobs lost in the power sector, because the 2 million reduction in coal power jobs is not compensated for by the rise in renewable and efficiency jobs.
- Coal, gas, oil and diesel sectors would provide around 2.5 million fewer jobs under an Energy [R]evolution scenario.
- The renewable sector would support 6.9 million jobs — about 5.3 million jobs more — under the Energy [R]evolution scenario.

table 0.2: estimated world jobs - breakdown by energy type

(MILLIONS)

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
Jobs	2010	2020	2030	2010	2020	2030
Coal	4.65 m	3.16 m	2.86 m	4.26 m	2.28 m	1.39 m
Gas	1.95 m	2.36 m	2.55 m	2.08 m	2.12 m	1.80 m
Nuclear, oil and diesel	0.61 m	0.58 m	0.50 m	0.56 m	0.31 m	0.13 m
Renewable	1.88 m	2.41 m	2.71 m	2.38 m	5.03 m	6.90 m
Energy supply jobs	**9.1 m**	**8.5 m**	**8.6 m**	**9.3 m**	**9.7 m**	**10.2 m**
Energy efficiency jobs	0	0	0	0.1 m	0.7 m	1.1 m
Total jobs	**9.1 m**	**8.5 m**	**8.6 m**	**9.3 m**	**10.5 m**	**11.3 m**

note THIS UNDERESTIMATES ENERGY EFFICIENCY JOBS BECAUSE IT ONLY INCLUDES JOBS ADDITIONAL TO THE REFERENCE SCENARIO.

We used conservative estimates of how many jobs there could be in all the different renewable power sectors. Job numbers are by necessity indicative only, as there are considerable uncertainties in projecting employment to 2030.

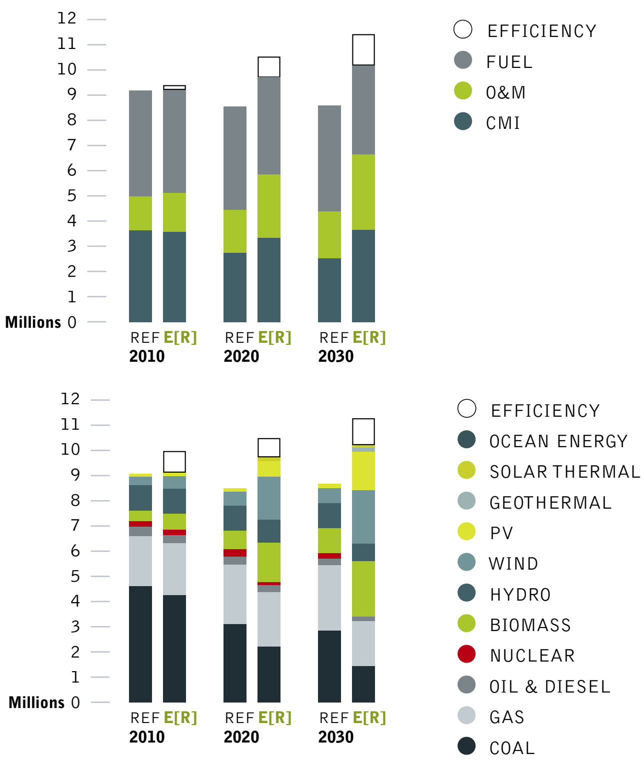
The latest research shows a real-world boom in renewable energy production that looks set to recover very quickly from the 2008 economic crisis. The new installed capacities of renewable energy in 2008 alone added up to at least 40 GW (excluding large hydro power), representing $120 billion in investment. For the first time, there was greater investment in new renewable capacity than conventional power, to the tune of $10 billion, including large hydro power.

The top five countries for new installations were China, Germany, Japan the United States and Spain. Of particular interest is China, where jobs will contract in coal and coal mining in the coming years. The biggest projected growth in jobs will be in solar PV and wind energy, which are already experiencing huge growth in manufacturing and installation.

jobs are diminishing in the coal sector

If the world stays on a "business as usual" pathway, getting much of its energy from fossil fuels, then 500,000 jobs would be lost between 2010 and 2030, even with a projected 37% increase in electricity generation from coal. This is primarily because of the global trend for decreasing employment in coal mining and coal power to produce the same output. Even if gas capacity is increased by 50% to meet rising demand, total power sector jobs would not go back to 2010 levels.

figure 0.1: global: jobs by type and by specific technology in 2010, 2020, and 2030



the energy revolution makes economic sense

The Greenpeace Energy [R]evolution models predict that overall, when averaged out across the energy mix; the cost of generation in 2030 will be lower than under business as usual. Taking into account a carbon price, energy efficiency and fuel savings, the average cost of generation would be 13 c per kW/h compared to 14 c per kWh if we stay on the current fossil fuel–dominated pathway.

strong policy boosts renewable energy

The potential boost in employment described in this study can only occur with aggressive renewable energy policy and targets.

Greenpeace calls for a range of measures from governments to protect us, the citizens, from changes to the employment balance. Doing nothing means we will see significant losses in employment in the fossil fuel sector, and there will not be an expansion in clean energy production to compensate. With renewable energy investment it is possible to provide more replacement jobs to counteract the losses, in areas like wind turbine and solar PV manufactoring, geothermal drilling, solar thermal plant constructions, wave energy installations, energy efficiency, and many other cleaner employment alternatives.

The basic policy incentives urgently needed are:

- A new global climate deal at the UN climate summit in Copenhagen in December 2009 that ensures global emissions peak by 2015, in response to the science of climate change.
- National policies that enable the greening of countries' economies and phase-out of all subsidies and other economic incentives that encourage inefficient use of energy, or supports activities that further contribute to climate change. No new investments into coal, oil or nuclear power plants.
- Renewable energy targets, tariffs, and support for innovation to boost renewable energy volumes.
- Efficiency and emissions standards to curb energy demand to sustainable levels.

More detail on ways to meet this global challenge are given in Sections five and six.

current status of the renewable energy industry

GLOBAL

GLOBAL RENEWABLE ENERGY MARKET SITUATION

GLOBAL RENEWABLE ENERGY EMPLOYMENT

1

"Approximately 800,000 new jobs are created between 2020 and 2030."

GREENPEACE INTERNATIONAL
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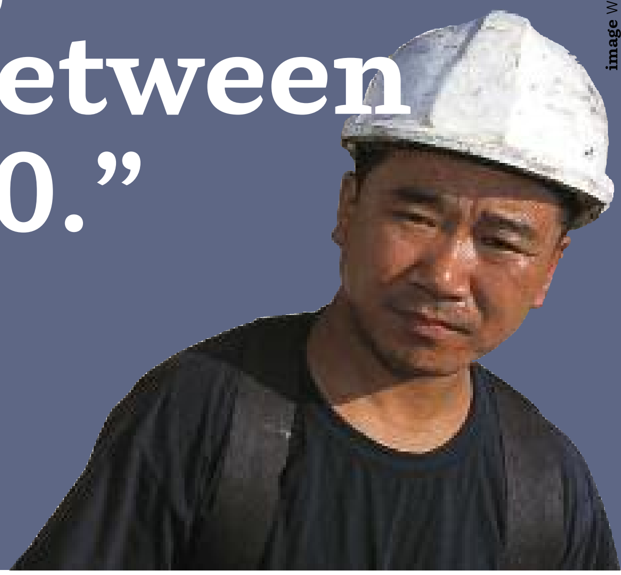


image WIND TURBINE WORKER IN CHINA © GREENPEACE/XUAN CANXIONG

global renewable energy market situation

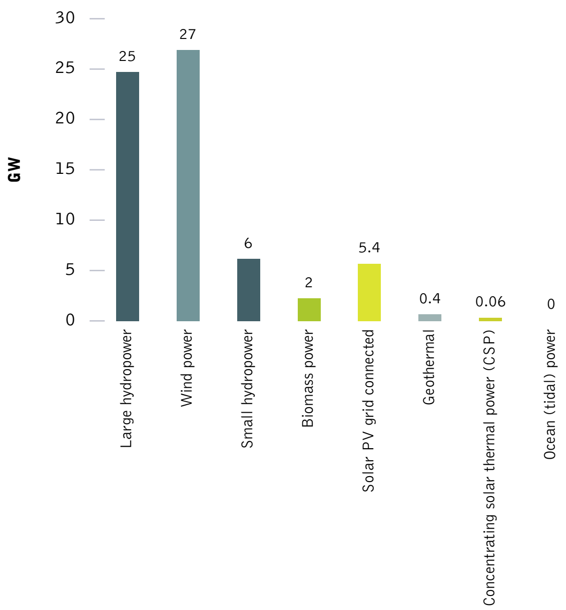
The renewable power sector has been growing substantially for the last four years. In 2008, the increases in the installation of wind and solar power were particularly impressive.

The amount of renewable energy installed worldwide is reliably tracked by the Renewable Energy Policy Network for the 21st Century (REN21). Their Global Status Report 2009 shows how the technologies have grown.

Wind	↑29% in 2008	↑600% since 2004
Solar photovoltaic (PV)	↑70% in 2008	↑250% since 2004
Small hydro power	↑8% in 2008	↑75% since 2004

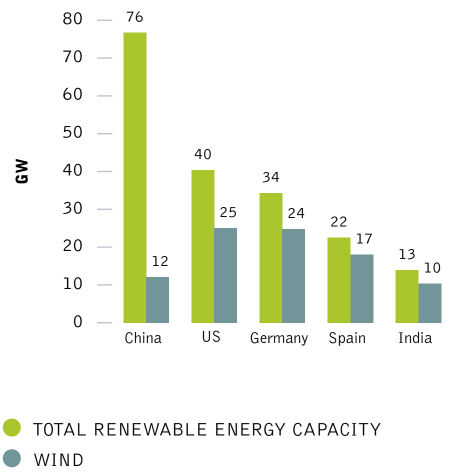
The total installed capacity of renewable energy at the end of 2008 was 1,128 GW. At this point, large hydro power made up around three quarters of the total and wind approximately 11%. The new installed capacities of renewable energy in 2008 alone added up to at least 40 GW (excluding large hydro power), with the highest growth in wind power.

figure 1.1: new renewable energy installed worldwide, 2008, after REN 21 Renewable Energy Outlook 2008



The top five countries for installing renewable energy in 2008 were China, the United States, Germany, Spain and India. China doubled its wind power capacity for the fifth year in a row. The growth of grid-connected solar PV in Spain was five times their new installations in 2007.

figure 1.2: top five countries for renewable energy installation in 2008, after Ren21 (2008)



making the switch For the first time in 2008 both the United States and the European Union added more capacity from renewable energy than from conventional sources (including gas, coal, oil and nuclear). At the end of 2008, renewable energy made up just 6.2% of the world's total energy capacity and 4.4% of generation, and 18% if large hydropower is included in the total. However, the new installations of renewable energy in 2008 made up one quarter of the total new nameplate capacity[1] compared to just 10% in 2004. If large hydropower is included in the equation, 2008 saw more than half of total added capacity from the renewable sector[2].

investment Total global investment in renewable energy was $120 billion in 2008[3], at least four times more than in 2004. The United States contributed around 20 % of this total. According to UNEP, total new investment in developed countries was $82.3 billion, and $36.6 billion in developing countries during 2008, a respective fall of 1.7%, but a gain of 37% on 2007 levels[4]. For the first time, the investment in renewable energy (including large hyrdropower) was greater than the investment in fossil-fuel technology, by about $10 billion.

renewable energy and the economic crisis In 2008, there was a crisis in the world's financial system and a number of banks, mortgage lenders and insurance companies failed. For renewable energy this meant there was less finance available to new projects. The full effects of the crisis are not yet known for renewable energy, but early indicators seem to show that it has weathered the crisis better than most. Wind energy seems to have been relatively unaffected. In several developed countries, economic stimulus packages have included incentives for large-scale renewable energies and energy efficiency programs.

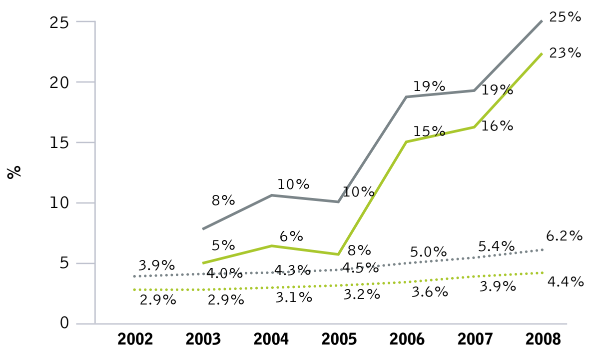
references
1 UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP) AND NEW ENERGY FINANCE (2009) *GLOBAL TRENDS IN SUSTAINABLE ENERGY INVESTMENT 2009 - ANALYSIS OF TRENDS AND ISSUES IN THE FINANCING OF RENEWABLE ENERGY AND ENERGY EFFICIENCY.*
2 REN21 (2009) *RENEWABLES GLOBAL STATUS REPORT 2009.*
3 REN21 (2009) *IBID.*
4 UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP) AND NEW ENERGY FINANCE (2009) *IBID.*

image WORKERS ON A WIND TURBINE BY THE VILLAGES OF NIEBÜLL AND MARIENKOOG, GERMANY.

policies and incentives The world policy landscape includes ever more measures to encourage renewable energy. Examples include new solar PV support programs adopted in Australia, China, Japan, Luxembourg, the Netherlands and the United States. New laws and policy provisions for renewable energy were adopted in many developing countries, including Brazil, Chile, Egypt, Mexico, the Philippines, South Africa, Syria, and Uganda. Several hundred cities and local governments around the world are actively planning or implementing renewable energy policies and frameworks linked to carbon dioxide emissions reduction.

other indicators The drivers of renewable energy are climate change, energy insecurity, fossil fuel depletion and new technology development. The price of many of these technologies is falling due to the global supply-demand equation, for example UNEP predicts the price of solar panels will fall by 43% in 2009[5]. This economic resilience combined with more and more firm mandates like feed-in tariffs and renewable portfolio standards mean that renewable energy will continue to grow.

figure 1.3: renewable power generation and capacity as a proportion of global power, 2003-2008 %



RENEWABLE POWER CAPACITY ADDITION AS A % OF GLOBAL POWER CAPACITY ADDITION

RENEWABLE POWER GENERATION INCREASE AS A % OF GLOBAL POWER GENERATION INCREASE

RENEWABLE POWER AS A % OF GLOBAL POWER CAPACITY

RENEWABLE POWER AS A % OF GLOBAL POWER GENERATION

source "GLOBAL TRENDS IN SUSTAINABLE ENERGY INVESTMENT 2009", UNEP/SEFI. (EXCLUDING LARGE HYDRO).

This report used the projections and scenarios of Greenpeace's Energy [R]evolution to calculate indicative numbers for employment levels if half the world's energy provision came from renewable resources.

global renewable energy employment

This study estimates that current global employment in renewable energy is as high as 1.7 million, totalling the individual countries for which numbers are available.

UNEP observes that so far, it is mostly the advanced economies that have shown technological leadership in developing viable renewable energy but now developing countries have a growing role. China and Brazil account for a large share of the global total, having strong roles in solar thermal and biomass development. Many of their jobs are in installations, operations and maintenance, as well as in biofuel feedstocks. The outlook for the future is that developing countries could hope to generate substantial numbers of jobs, for example Kenya in solar technology.

table 1.0: renewable electricity employment – selected countries and world

ENERGY SOURCE	SELECTED COUNTRIES	
Wind	Germany	84,300[g]
	United States	16,000[a]
	Spain	32,906[b]
	Denmark	21,612[c]
	India	10,000[d]
	World estimate	**300,000[f]**
Solar PV	Germany	50,700[g]
	United States	6,800[a]
	Spain	26,449[b]
	World estimate	**170,000[f]**
Solar Thermal electricity	United States	800[a]
	Spain	968[b]
Biomass power	United States	66,000[a]
	Spain	4,948[b]
Hydropower	Europe	20,000
	United States	8,000[a]
	Spain (small hydro)	6,661[b]
Geothermal	Germany	4,500[g]
	United States	9,000[a]
All sectors	**World estimate**	**1.3[e] - 1.7[f] million**

a 2006 data: Bedzek 2007
b 2007 data: Nieto Sáinz J 2007, in UNEP 2008 Table 11.1-4.
c 2006 data: Danish Wind Industry Association
d 2007 data: Suzlon 2007
e 2006 data: REN21 2008 p7
f UNEP 2008 p295; the world total for renewable sector is the UNEP figure minus estimated jobs in solar thermal as these are nearly all in solar water heating.
g BMU 2008, German Minstery for Environment

To make sure that the renewables sector can provide large-scale green employment, a strong policy environment is essential. Some countries have already shown that renewable energy can form part of national competitive economic strategies. For instance, Germany views its investment in wind and solar PV as a crucial aspect of its export strategy. Their intention is to retain a major slice of the world market in coming years and decades. Most German jobs in these industries will depend on sales of wind turbines and solar panels abroad. Currently, only a few countries possess the requisite scientific and manufacturing know-how, and the markets for wind and solar equipment are experiencing rapid growth.

references
5 UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP) AND NEW ENERGY FINANCE (2009) *IBID.*

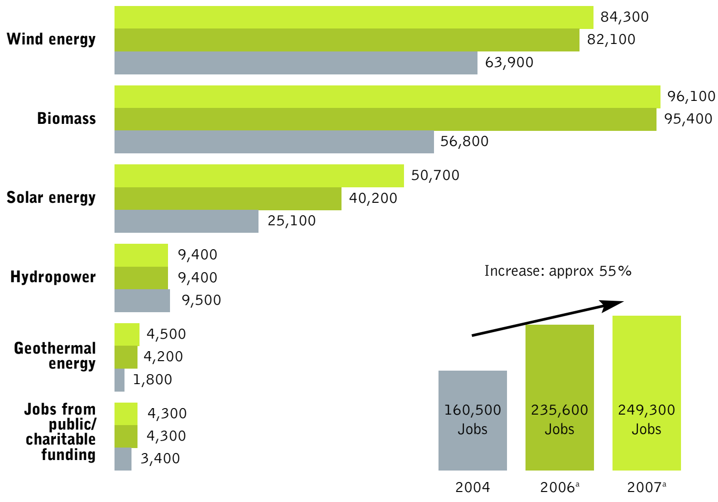
case study: germany

Germany emerged as an early leader in the renewable energy industry, and hence reaped the rewards of some of the first jobs in the green power sector. The current European Union's renewables goal is to reach 20% of final energy consumption from renewables by 2020, and Germany's federal government has adopted a target of 18% of their own consumption to be renewable by the year 2020. The German share of renewable energy has jumped from 3.8% in 2000 to 9.8% in 2007.

The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety estimated gross employment in renewable energy for 2008, as a result of the various encouragement policies. They have found:

- There has been a marked increase in jobs in renewable energy, despite an economic crisis in late 2008.
- The gross estimate of jobs in renewable energy was 278,000 in 2008, up from 249,000 the year before; a 12% increase.
- The total investment in renewable energy facilities in Germany was $17 (€13,1) billion, the majority in Solar PV and wind energy.
- The turnover of German manufacturers of renewable energy equipment was approximately $19,1 (€14,7) billion in 2008.
- The total turnover from the German Solar PV industry is estimated at $6,7 (€5,2) billion. This adds up to 57,000 jobs, including operations and maintenance.
- In one year alone, the German solar thermal market almost doubled; the first estimate of the total turnover is approx. € 1.2 billion. This adds up to 15,500 jobs including operations and maintenance.
- Investment in geothermal facilities increased significantly, including deep geothermal and the heat pump market, this sector is providing around 9,100 jobs.
- Even taking the effects of the economic crisis into account the Ministry expects that the renewable power sector will continue to grow, and by 2020 at least it should provide 400,000 jobs in Germany.

figure 1.4: jobs in the renewable sector in germany



a Figures for 2006 and 2007 are provisional estimates
source BMU publication "Renewable energy sources in figures - national and international development", Status: June 2008.

image SOLON AG PHOTOVOLTAICS FACILITY IN ARNSTEIN OPERATING 1500 HORIZONTAL AND VERTICAL SOLAR "MOVERS". LARGEST TRACKING SOLAR FACILITY IN THE WORLD. EACH "MOVER" CAN BE BROUGHT AS A PRIVATE INVESTMENT FROM THE S.A.G. SOLARSTROM AG.

methodology and assumptions

“renewable energy has no fuel costs.”

GREENPEACE INTERNATIONAL
CLIMATE CAMPAIGN

image ASSEMBLING SOLAR POWERED PHOTO-VOLTAIC (PV) CELLS IN CHINA. © GREENPEACE/ALEX HOFFORD

energy cost projections in the energy [r]evolution

To work out how many jobs can be either lost or generated under various future energy scenarios requires assumptions for several parameters regarding the energy market.

fossil fuel costs The Energy [R]evolution scenarios assumed a price development path for fossil fuels in which the price of oil reaches $120/bbl by 2030 and $140/bbl in 2050. This takes into account growing global demand and the dramatic price increases in mid-2008 and recent price volatility. Gas prices are assumed to increase to $20-25/GJ by 2050 because the supply of natural gas is limited by the availability of pipeline infrastructure and there is no world market price for natural gas.

emissions costs The Energy [R]evolution scenarios assume that a CO_2 emissions trading system is established in all world regions in the long term and that CO_2 costs $10 per tonne in 2010, rising to $50 per tonne in 2050. Additional CO_2 costs are applied in Kyoto Protocol Non-Annex B (developing) countries only after 2020. It should be noted that projections of emissions costs are even more uncertain than energy prices, and available studies span a broad range of future CO_2 cost estimates.

table 2.2: assumptions on CO_2 emissions cost development

COUNTRIES	2010	2020	2030	2040	**2050**
Kyoto Annex B countries	10	20	30	40	**50**
Non-Annex B countries		20	30	40	**50**

table 2.1: assumptions on fuel price development

	2005	2006	2007	2010	2015	2020	2030	2040	2050
Crude oil import prices in $2005 per barrel	52.5	60.1	71.2						
IEA WEO 2007 ETP 2008				57.2	55.5		60.1		63
US EIA 2008 'Reference'				71.7		57.9	68.3		
US EIA 2008 'High Price'				76.6		99.1	115.0		
Energy [R]evolution 2008				100	105	110	120	130	140
Gas import prices in $2005 per GJ	2000	2005	2006						
IEA WEO 2007/ ETP 2008									
US imports	4.59		7.38	7.52	7.52		8.06		8.18
European imports	3.34		7.47	6.75	6.78		7.49		7.67
Japan imports	5.61		7.17	7.48	7.49		8.01		8.18
Energy [R]evolution 2008									
US imports		5.7		11.5	12.7	14.7	18.4	21.9	24.6
European imports		5.8		10.0	11.4	13.3	17.2	20.6	23.0
Asia imports		5.6		11.5	12.6	14.7	18.3	21.9	24.6
Hard coal import prices in $2005 per tonne	2000	2005	2006						
IEA WEO 2007/ ETP 2008	37.8		60.9	54.3	55.1		59.3		59.3
Energy [R]evolution 2008				142.7	167.2	194.4	251.4	311.2	359.1
Biomass (solid) prices in $2005 per GJ	2005								
Energy [R]evolution 2008									
OECD Europe	7.5			7.9	8.5	9.4	10.3	10.6	10.8
OECD Pacific, NA	3			3.3	3.5	3.8	4.3	4.7	5.2
Other regions	2.5			2.8	3.2	3.5	4.0	4.6	4.9

image left ANDASOL 1 SOLAR POWER STATION SUPPLIES UP TO 200.000 PEOPLE WITH CLIMATE-FRIENDLY ELECTRICITY AND SAVES ABOUT 149,000 TONS OF CARBON DIOXIDE PER YEAR COMPARED WITH A MODERN COAL POWER PLANT.

image right AS PART OF THE LAUNCHING OF THE BRAZIL ENERGY [R]EVOLUTION REPORT, GREENPEACE INSTALLED 40 PHOTOVOLTAIC SOLAR PANELS THAT SUPPLY THE GREENPEACE OFFICE IN SAO PAULO.

power plant investment costs The Energy [R]evolution scenarios assume that costs for fossil fuel plant development will continue to drop in the future, due to efficiency gains and reduced investment costs. Generation costs and the costs of emissions are expected to rise; the assumptions used in calculations are shown in Table 2.3. Carbon capture and storage costs were not included in the scenario development, even though these are likely to add significant costs to new fossil fuel plants. The current best estimates for infrastructure, transport, storage and monitoring vary too widely based on plant parameters and location to make any useful contribution to the modelling.

renewable energy technology costs Renewable energies have different levels of maturity and the costs assumptions are provided in Table 2.4. More details of the development of each technology is provided in Section 4.

table 2.3: development of efficiency and investment costs for selected power plant technologies

		2005	2010	2020	2030	2040	**2050**
Coal-fired condensing power plant	Efficiency (%)	45	46	48	50	52	**53**
	Investment costs ($/kW)	1,320	1,230	1,190	1,160	1,130	**1,100**
	Electricity generation costs including CO_2 emission costs ($cents/kWh)	6.6	9.0	10.8	12.5	14.2	**15.7**
	CO_2 emissions [a] (g/kWh)	744	728	697	670	644	**632**
Lignite-fired condensing power plant	Efficiency (%)	41	43	44	44.5	45	**45**
	Investment costs ($/kW)	1,570	1,440	1,380	1,350	1,320	**1,290**
	Electricity generation costs including CO_2 emission costs ($cents/kWh)	5.9	6.5	7.5	8.4	9.3	**10.3**
	CO_2 emissions [a] (g/kWh)	975	929	908	898	888	**888**
Natural gas combined cycle	Efficiency (%)	57	59	61	62	63	**64**
	Investment costs ($/kW)	690	675	645	610	580	**550**
	Electricity generation costs including CO_2 emission costs ($cents/kWh)	7.5	10.5	12.7	15.3	17.4	**18.9**
	CO_2 emissions [a] (g/kWh)	354	342	330	325	320	**315**

source DLR, 2008 [a] CO_2 EMISSIONS REFER TO POWER STATION OUTPUTS ONLY; LIFE-CYCLE EMISSIONS ARE NOT CONSIDERED.

figure 2.1: future development of investment costs

(NORMALISED TO CURRENT COST LEVELS) FOR RENEWABLE ENERGY TECHNOLOGIES

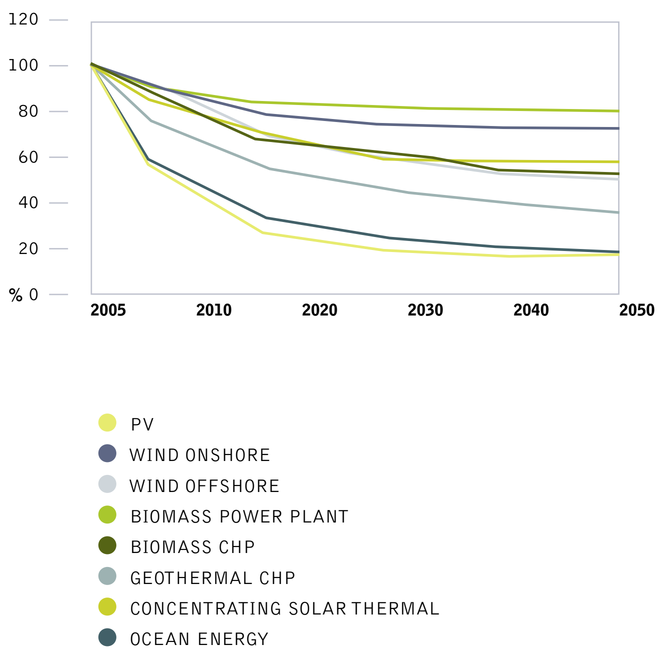


figure 2.2: expected development of electricity generation costs from fossil fuel and renewable options

EXAMPLE FOR OECD NORTH AMERICA

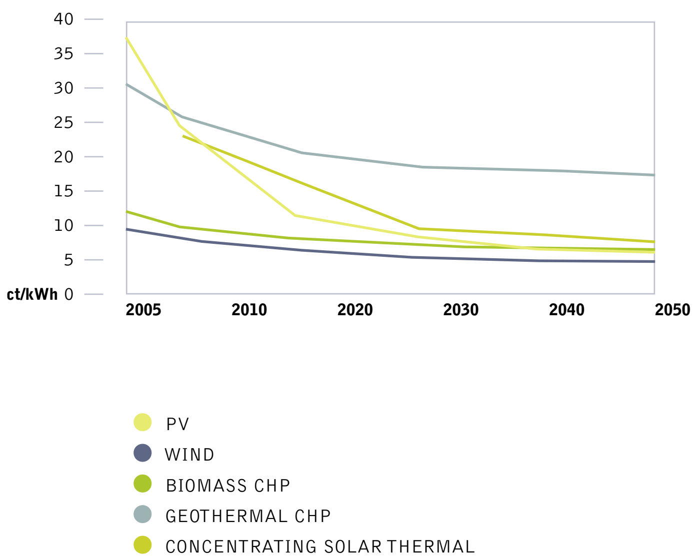


table 2.4: renewable energy cost assumptions

	2005	2010	2020	2030	2040	2050
Photovoltaics (pv)						
Global installed capacity (GW)	5.2	21	269	921	1,799	**2,911**
Investment costs ($/kW)	6,600	3,760	1,660	1,280	1,140	**1,080**
Operation & maintenance costs ($/kWa)	66	38	16	13	11	**10**
Concentrating solar power (csp)	2005	2010	2020	2030	2040	2050
Global installed capacity (GW)	0.53	5	83	199	468	**801**
Investment costs ($/kW)	7,530	6,340	5,240	4,430	4,360	**4,320**
Operation & maintenance costs ($/kWa)	300	250	210	180	160	**155**
Wind power	2005	2010	2020	2030	2040	2050
Installed capacity (on+offshore)	59	164	893	1,622	2,220	**2,733**
Wind onshore						
Global installed capacity (GW)	59	162	866	1,508	1,887	**2,186**
Investment costs ($/kW)	1,510	1,370	1,180	1,110	1,090	**1,090**
O&M costs ($/kWa)	58	51	45	43	41	**41**
Wind offshore						
Global installed capacity (GW)	0,3	1,6	27	114	333	**547**
Investment costs ($/kW)	3,760	3,480	2,600	2,200	1,990	**1,890**
O&M costs ($/kWa)	166	153	114	97	88	**83**
Biomass (electricity only)	2005	2010	2020	2030	2040	2050
Global installed capacity (GW)	21	35	56	65	81	**99**
Investment costs ($/kW)	3,040	2,750	2,530	2,470	2,440	**2,415**
O&M costs ($/kWa)	183	166	152	148	147	**146**
Biomass (CHP)						
Global installed capacity (GW)	32	60	177	275	411	**521**
Investment costs ($/kW)	5,770	4,970	3,860	3,380	3,110	**2,950**
O&M costs ($/kWa)	404	348	271	236	218	**207**
Geothermal (electricity only)	2005	2010	2020	2030	2040	2050
Global installed capacity (GW)	8.7	12	33	71	120	**152**
Investment costs ($/kW)	17,440	15,040	11,560	10,150	9,490	**8,980**
O&M costs ($/kWa)	645	557	428	375	351	**332**
Geothermal (CHP)						
Global installed capacity (GW)	0.24	1.7	13	38	82	**124**
Investment costs ($/kW)	17,500	13,050	9,510	7,950	6,930	**6,310**
O&M costs ($/kWa)	647	483	351	294	256	**233**
Ocean energy	2005	2010	2020	2030	2040	2050
Global installed capacity (GW)	0.27	0.9	17	44	98	**194**
Investment costs ($/kW)	9,040	5,170	2,910	2,240	1,870	**1,670**
Operation & maintenance costs ($/kWa)	360	207	117	89	75	**66**
Hydro	2005	2010	2020	2030	2040	2050
Global installed capacity (GW)	878	978	1,178	1,300	1,443	**1,565**
Investment costs ($/kW)	2,760	2,880	3,070	3,200	3,320	**3,420**
Operation & maintenance costs ($/kWa)	110	115	123	128	133	**137**

calculating job potentials

Greenpeace engaged the Australian-based Institute for Sustainable Futures, which operates within the University of Technology of Sydney, to model the employment effects this sustainable energy scenario would have compared to business as usual.

The model calculates indicative numbers of jobs that would either be created or lost under the Greenpeace Energy [R]evolution, more specifically jobs in power generation and electrical efficiency excluding heating, cooling and transport. The [R]evolution scenario was developed to show how, technically and financially, the world could re-invent its energy mix to dramatically cut carbon emissions. The scenario developed means a nine-fold increase in renewable energy, replacing nuclear and a proportion of coal-fired power, plus widespread energy efficiency improvements. The Reference ('business as usual') scenario is the International Energy Agency 2007 projection.

This section provides a simplified overview of how the calculations were performed and the employment factors were determined. A full and detailed methodology used for each of these steps is available in the ISF report, "*Energy sector jobs to 2030: a global analysis*"[6]. The 2008 Energy [R]evolution provides all the data on how the scenarios were developed. Both documents are available at www.greenpeace.org.

the model The calculations were made using cautious, informed estimates. The main steps were:

- Start with the amount of electrical capacity that would be installed each year, and the amount generated per year under Reference (business as usual) scenario and the Energy [R]evolution scenario.
- Derive 'employment factors' for each technology, or the number of jobs per unit of electrical capacity (fossil as well as renewable), separated into manufacturing, construction, operation and maintenance and fuel supply.
- For the 2020 and 2030 calculations, reduce the employment factors by a 'decline factor' for each technology, which shows how employment would drop as technology efficiencies improve.
- Take into account the 'local manufacturing' and 'domestic fuel production' proportions for each region, to allocate exports to the producing region.
- Multiply the electrical capacity and generation figures by the employment factors for each of the energy technologies.
- For each region, apply a "regional job multiplier", which indicates how labour-intensive the activity is for that part of the world.

The model used a range of inputs, including data from the International Energy Agency, USA Energy Information Association (EIA), European Renewable Energy Council (EREC), European Wind Energy Association (EWEA), USA National Renewable Energy Laboratory (NREL), Renewable Energy Policy Project (REP), census data from the USA, Australia, and Canada, Centre of Full Employment and Equity (CoFEE), and the International Labour Organisation (ILO)[7].

references
6 RUTOVITZ J. AND ATHERTON A. 2009, *ENERGY SECTOR JOBS TO 2030: A GLOBAL ANALYSIS*. PREPARED FOR GREENPEACE INTERNATIONAL BY THE INSTITUTE FOR SUSTAINABLE FUTURES, UNIVERSITY OF TECHNOLOGY, SYDNEY.
7 FOR A FULL LIST, REFER TO THE ISF REPORT. *IBID.*

image BERLINER GEOSOL INSTALLING THE SOLAR ENERGY PLANT (PHOTOVOLTAIK) "LEIPZIGER LAND" OWNED BY SHELL SOLAR IN A FORMER BROWN COAL AREA NEAR LEIPZIG, SACHSEN, GERMANY.

figure 2.3: Methodology overview

MANUFACTURING (FOR DOMESTIC USE)	=	MW INSTALLED PER YEAR	×	MANUFACTURING EMPLOYMENT FACTOR	×	REGIONAL JOB MULTIPLIER	×	% OF LOCAL MANUFACTURING
MANUFACTURING (FOR EXPORT)	=	MW EXPORTED PER YEAR	×	MANUFACTURING EMPLOYMENT FACTOR	×	REGIONAL JOB MULTIPLIER		
CONSTRUCTION	=	MW INSTALLED PER YEAR	×	CONSTRUCTION EMPLOYMENT FACTOR	×	REGIONAL JOB MULTIPLIER		
OPERATION & MAINTENANCE	=	CUMULATIVE CAPACITY	×	O&M EMPLOYMENT FACTOR	×	REGIONAL JOB MULTIPLIER		
FUEL SUPPLY (NUCLEAR, OIL, DIESEL, BIOMASS)	=	ELECTRICITY GENERATION	×	FUEL EMPLOYMENT FACTOR	×	REGIONAL JOB MULTIPLIER		
FUEL SUPPLY (COAL)	=	ELECTRICITY GENERATION + NET COAL EXPORTS	×	REGIONAL FUEL EMPLOYMENT FACTOR	×	% OF LOCAL PRODUCTION		
FUEL SUPPLY (GAS)	=	ELECTRICITY GENERATION + NET GAS EXPORTS	×	FUEL EMPLOYMENT FACTOR	×	REGIONAL JOB MULTIPLIER	×	% OF LOCAL PRODUCTION
JOBS IN REGION	=	**MANUFACTURING**	+	**CONSTRUCTION**	+	**OPERATION & MAINTENANCE (O&M)**	+	**FUEL SUPPLY**

JOBS IN REGION 2010	=	**JOBS IN REGION**
JOBS IN REGION 2020	=	**JOBS IN REGION** × TECHNOLOGY DECLINE FACTOR
JOBS IN REGION 2030	=	**JOBS IN REGION** × TECHNOLOGY DECLINE FACTOR

direct and indirect jobs These calculations only take into account direct employment, for example, the construction team needed to build a new wind farm. They do not cover indirect employment, for example, the extra services in a town to accommodate construction teams. The effect on the results is to provide a lower estimate in some cases.

determining the 'employment factors' An employment factor is a number used to calculate how many jobs are required per unit of electrical capacity. It takes into account jobs in manufacturing, construction, operation and maintenance and fuel. The table below lists the employment factors used in the calculations. These factors are calculated for OECD countries. For other regions, a regional adjustment was used.

table 2.6: employment factors for coal production and employment (MINING AND ASSOCIATED JOBS)

	EMPLOYMENT FACTOR (EXISTING GENERATION) *Jobs per GWh*	EMPLOYMENT FACTOR (NEW GENERATION) *Jobs per GWh*
World average[a]	0.39	0.24
OECD North America	0.03	0.02
OECD Europe	0.34	0.18
OECD Pacific	0.04	0.02
India	0.59	0.25
China	0.55	0.02
Africa	0.11	0.08
Transition economies	0.43	0.20
Developing Asia	Use world average as no employment data available	
Latin America	Use world average as no employment data available	
Middle east	Use world average as no employment data available	

a) for areas where data is available

table 2.5: summary of employment factors for use in global analysis

FUEL	CONSTRUCTION, MANUFACTURING & INSTALLATION *Person years/MW*	OPERATION & MAINTENANCE *Jobs/MW*	FUEL *Jobs/GWh*	MAIN REFERENCE
Coal	14.4	0.10	Regional factors used	NREL (JEDI model)
Gas	3.4	0.05	0.12	NREL (JEDI model)
Nuclear	16	0.32	0.0009	Derived from US and Au industry data
Biomass	4.3	3.1	0.22	EPRI 2001, DTI 2004
Hydro	11.3	0.22		Pembina 2004
Wind (onshore)	15.4	0.40		EWEA 2009
Wind (offshore)	28.8	0.77		EWEA 2009
PV	38.4	0.40		EPIA 2008A, BMU 2008a
Geothermal	6.4	0.74		GEA 2005
Solar thermal	10	0.3		EREC 2008
Ocean	10	0.32		SERG 2007/ SPOK ApS 2008
Energy efficiency	0.29 jobs /GWh (adjusted to 0.23 jobs/ GWh for 2010)			ACEEE 2008

key points: Employment factors for coal were worked out in the most detail, because of its dominance in the current electricity supply. The calculations to arrive at the employment factors included figures from real national employment data where available, established models, projected volumes of international coal trade and regional production estimates (from IEA). The employment and production data was collected for as many major coal producing countries as possible, the full list is provided in the Appendix[8].

When considering employment from coal, it is important to note that coal is mined using extremely different methods around the world. The employment per unit of electricity also varies according to the type of coal and the efficiency of generation. For example, in Australia, coal is extracted at an average of 13,800 tons per person per year using highly mechanised processes while in Europe, the average coal miner is responsible for only 1,843 tonnes per year. China is a special case: even though it currently has a very low average rate of extraction per person (700 tons per employee per year) this will change very soon, as thousands of small mines close and new super-mines open. For this reason, the model uses US employment factors for the future coal production in China that is above current levels.

The factors for gas generation are taken from a publicly available model called JEDI, developed by the National Renewable Energy Laboratory in Washington to help work out local benefits of different types of energy supply.

For nuclear energy, construction, manufacturing and installation factor is derived from a Nuclear Energy Institute (NEI) 2009 factsheet, while the operations and maintenance is calculated using Energy Information Administration (EIA) census data. Fuel employment is calculated from Australian census data.

For the renewable energies, the employment factors were taken from industry data where available, as listed in Table 2.5, or derived, depending on the maturity of the technology[9].

summary: the 'adjustment' factors

regional job multipliers The employment factors used in this model for all processes apart from coal mining reflect the situation in the (typically wealthier) OECD regions. The regional multiplier is applied to make the jobs per MW more realistic for other parts of the world. In developing countries it typically means more jobs per unit of electricity because of more labour intensive practices. The multipliers change over the study period in line with the projections for Gross Domestic Product per worker. This reflects the fact that as prosperity increases, labour intensity tends to fall.

learning adjustments or 'decline factors' This accounts for the projected reduction in the cost of renewables over time, as technologies and companies become more efficient, and production processes are scaled up. Generally, jobs per MW would fall in parallel with this trend.

local manufacturing and fuel production Some regions do not manufacture the equipment needed for wind power or PV, for example. The model takes into account the percentage of renewable technology which is made locally. The jobs in manufacturing components for export are counted in the region where they originate. The same applies to coal and gas, because they are traded internationally, so the model shows the region where the jobs are actually located.

future investment

investment in new power plants The overall global level of investment required in new power plants up to 2030 will be in the region of $11 to $14 trillion. The fleet of power plants in OECD countries is ageing; and this is what will drive investment in new generation capacity. Utilities must choose technologies within the next five to ten years based on national energy policies, in particular market liberalisation, renewable energy and CO_2 reduction targets. Within Europe, the EU emissions trading scheme may have a major impact on whether the majority of investment goes into fossil fuel power plants or renewable energy and co-generation. In developing countries, international financial institutions will play a major role in future technology choices.

It would take $14.7 trillion in global investment volume for the Energy [R]evolution scenario to become reality- approximately 30% higher than in the Reference scenario of $11.3 trillion. Under the Reference scenario, the levels of investment in renewable energy and fossil fuels are almost equal, about $4.5 trillion each up to 2030, but with an Energy [R]evolution scenario the world shifts about 80% of investment towards renewable energy. Then, the fossil fuel share of power sector investment would be focused mainly on combined heat and power and efficient gas-fired power plants.

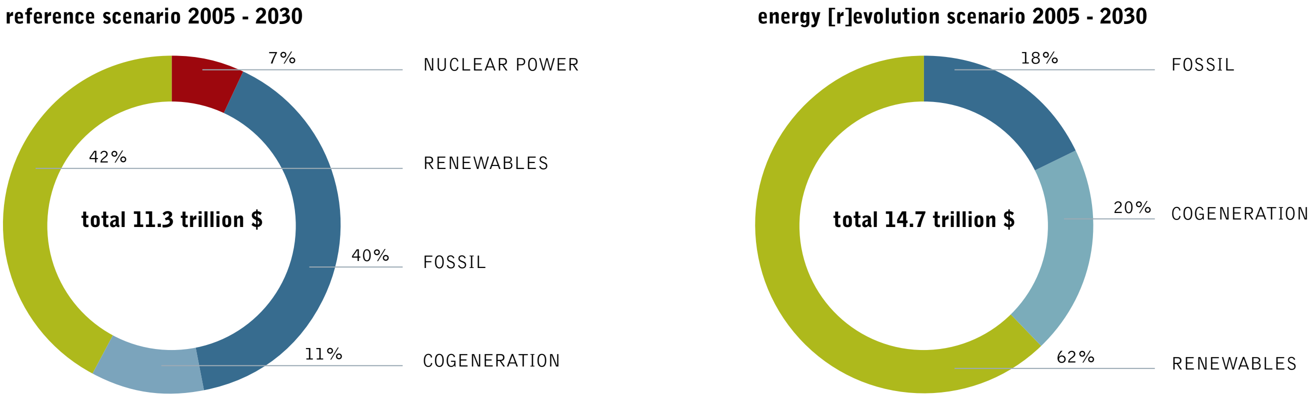
The average annual investment in the power sector under the Energy [R]evolution scenario between 2005 and 2030 would be approximately $590 billion. This is equal to the current amount of subsidies for fossil fuels globally in less than two years. Most investment in new power generation would occur in China, followed by North America, Europe, India, and East Asia, including Indonesia, Thailand and the Philippines, would also be 'hot spots' of new power generation investment.

references
8 THE REST OF THE DETAILED MODEL INPUTS ARE AVAILABLE IN THE ISF REPORT. *IBID.*
9 ADDITIONAL INFORMATION AND TABLES COMPARING VARIOUS DATA SOURCES ARE PROVIDED IN THE ISF REPORT. *IBID.*

image SOLAR POWERED PHOTO-VOLTAIC (PV) CELLS ARE ASSEMBLED BY WORKERS AT A FACTORY OWNED BY THE HIMIN GROUP, THE WORLDS LARGEST MANUFACTURER OF SOLAR THERMAL WATER HEATERS. THE CITY OF DEZHOU IS LEADING THE WAY IN ADOPTING SOLAR ENERGY AND HAS BECOME KNOWN AS THE SOLAR VALLEY OF CHINA.

image WIND TURBINE WORKER IN MARANCHÓN, GUADALAJARA, SPAIN.

figure 2.4: **investment shares - reference versus energy [r]evolution**

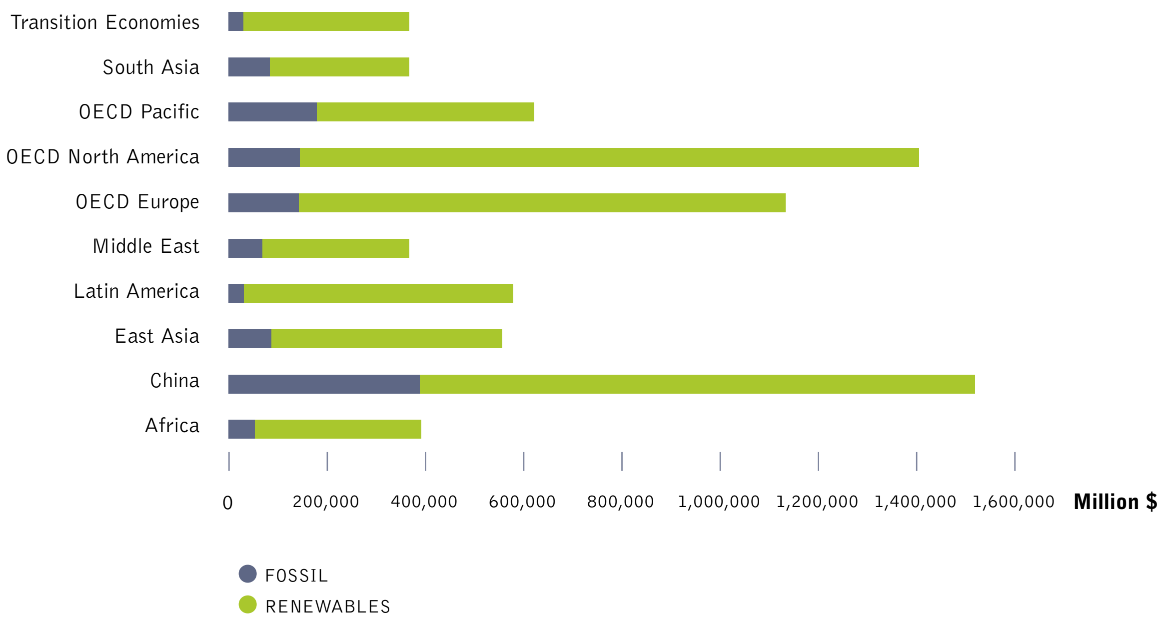


fossil fuel power generation investment Under the Reference scenario, the main market expansion for new fossil fuel power plants would be in China, followed by North America, where the volume required would be equal to India and Europe combined. The Energy [R]evolution scenario would mean far lower overall investment in fossil fuel power stations up to 2030, totaling $2,600 billion, compared to the $4,500 billion required under the Reference scenario.

In both scenarios, China will be by far the largest investor in coal power plants. Under the Reference scenario the current growth trend would continue towards 2030, but under the Energy [R]evolution scenario growth slows down significantly between 2011 and 2030. In the Reference scenario the massive expansion of coal firing is due to activity in China, followed by the USA, India, East Asia and Europe.

The total cost for fossil fuel investment between 2005 and 2030 is significantly higher under the Reference scenario – around $80.6 trillion, compared to $61.8 trillion for the Energy [R]evolution scenario. This means that fuel costs under the Energy [R]evolution scenario would be about 25% lower by 2030 and 50% lower by 2050. The investment in gas-fired power stations and cogeneration plants is about the same in both scenarios. However, the finance committed to oil and coal for electricity generation in the Energy [R]evolution is almost 30% below the Reference version.

figure 2.5: **cumulative power plant investments by region 2004-2030 in the energy [r]evolution scenario**



fuel cost savings with renewable energy The total fuel cost savings in the Energy [R]evolution scenario reach a total of $18.7 trillion, or $750 billion per year. This is because renewable energy has no fuel costs (except bio energy).

Under the Reference scenario, average annual additional fuel costs are about five times higher than the additional investment requirements of the Energy [R]evolution. In fact, just the additional costs for coal fuel from today until the year 2030 are as high as $15.9 trillion. This is enough to 'pay back' the entire investment in renewable and cogeneration capacity required to implement the Energy [R]evolution scenario, through savings. These renewable energy sources would go on to 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.

table 2.7: fuel and investment costs in the reference and the energy [r]evolution scenario

INVESTMENT COST	DOLLAR	2005-2010	2011-2020	2021-2030	2005-2030	2005-2030 AVERAGE PER YEAR
REFERENCE SCENARIO						
Total Nuclear	billion $ 2005	225	310	286	821	33
Total Fossil	billion $ 2005	1,190	1,659	1,693	4,535	181
Total Renewables	billion $ 2005	1,193	1,837	1,702	4,702	188
Total Cogeneration	billion $ 2005	271	523	464	1,257	50
Total	billion $ 2005	2,849	4,322	4,144	11,315	453
E[R] SCENARIO						
Total Fossil	billion $ 2005	1,314	995	536	2,845	114
Total Renewables	billion $ 2005	1,299	3,475	4,216	8,989	360
Total Cogeneration	billion $ 2005	360	1,200	1,365	2,926	117
Total	billion $ 2005	2,973	5,670	6,117	14,761	590
DIFFERENCE E[R] VERSUS REF						
Total Fossil & Nuclear	billion $ 2005	-101	-967	-1,443	-2,511	-100
Total Cogeneration	billion $ 2005	89	678	902	1,669	67
Total Renewables	billion $ 2005	136	1,637	2,514	4,287	171
Total	billion $ 2005	124	1,348	1,973	3,445	138
FUEL COSTS						
REFERENCE SCENARIO						
Total Fuel Oil	billion $/a	883	1,902	1,811	4,595	184
Total Gas	billion $/a	1,989	6,136	9,686	17,811	712
Total Coal	billion $/a	6,742	21,296	29,420	57,458	2,298
Total Lignite	billion $/a	148	281	311	740	30
Total Fossil Fuels	billion $/a	9,761	29,616	41,228	80,605	3,224
E[R] SCENARIO						
Total Fuel Oil	billion $/a	855	1,464	862	3,181	127
Total Gas	billion $/a	2,047	6,283	8,396	16,727	669
Total Coal	billion $/a	6,557	17,820	17,179	41,556	1,662
Total Lignite	billion $/a	141	181	75	397	16
Total Fossil Fuels	billion $/a	9,600	25,749	26,511	61,861	2,474
SAVINGS REF VERSUS E[R]						
Fuel Oil	billion $/a	27	438	949	1,415	57
Gas	billion $/a	-59	-147	1,291	1,085	43
Coal	billion $/a	185	3,476	12,241	15,901	636
Lignite	billion $/a	7	100	236	343	14
Total Fossil Fuel Savings	billion $/a	161	3,866	14,716	18,744	750

key results of the global jobs [r]evolution

3

“wind, would become the most important single source of electricity.”

GREENPEACE INTERNATIONAL
CLIMATE CAMPAIGN

image TECHNICIAN ON A WIND TURBINE IBERDROLA, SPAIN. © GREENPEACE/DANIEL BELTRA

global

energy [r]evolution scenario

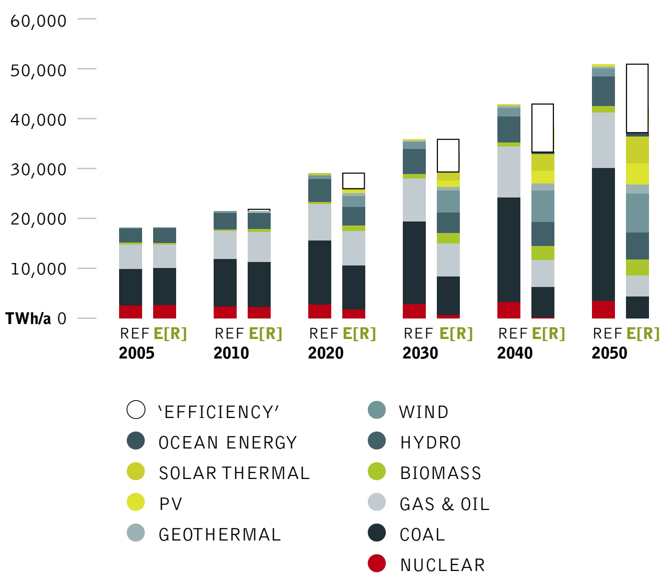
Under the Energy [R]evolution scenario, renewable energy gains a much bigger share of the market through dynamic growth. At the same time, nuclear energy is phased out and the number of fossil fuel-fired power plants required for grid stabilisation is reduced. By 2020, 32.5% of the electricity produced worldwide would come from renewable energy sources. 'New' renewables – mainly wind, solar thermal energy and PV – would make up the majority of this supply. By 2030, renewable energy would form 42% of the mix.

The installed capacity of renewable energy technologies would grow from today's 1,000 GW to 4,536 GW in 2030, and 9,100 GW in 2050. Initially, new highly efficient gas-fired combined-cycle power plants, plus an increasing capacity of wind turbines, biomass, concentrating solar power plants and solar photovoltaics will be required. In the long term, wind would become the most important single source of electricity generation.

For growth in renewable energy technologies to work economically will depend on: a mobilisation that makes best use of their technical potentials; how mature the technology is and where it is on the cost reduction curve. Figure 3.1 shows that hydro power and wind would remain the major contributors up to 2020, then they will be complemented by biomass, photovoltaic and solar thermal (CSP) energy, while wind continues to grow. In particular, biomass, hydro and CSP with efficient heat storage are important elements in the overall mix, because their supply does not fluctuate.

figure 3.1: global: development of electricity supply structure under the two scenarios

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



global: future costs of electricity generation

Figure 3.2 shows that the growth of renewable technologies under the Energy [R]evolution scenario would slightly increase the costs of electricity generation compared to a 'business as usual' approach, but only by less than 0.2 cents/kWh up to 2020. If fossil fuel prices do go up more than this conservative prediction (see Global Cost Development assumptions in Section 2), the difference in cost of generation will be lower. By 2020, renewable energy would be cheaper to generate than fossil fuel-based power, and by 2050 the generation costs would be more than 5 cents/kWh below the Reference scenario.

If unchecked, supply cost would rise from today's $1,750 billion per year to more than $7,300 billion in 2050. Under the Energy [R]evolution scenario, CO_2 reduction targets are met and energy costs are stabilised to relieve this economic burden. Efficiency and the shift to renewable energy would decrease long term electricity supply costs by one third.

figure 3.2: global: development of total electricity supply costs & development of specific electricity generation costs under the two scenarios

(CO_2 EMISSION COSTS IMPOSED FROM 2010, WITH AN INCREASE FROM 15 $/T$_{CO_2}$ IN 2010 TO 50 $/T$_{CO_2}$ IN 2050)

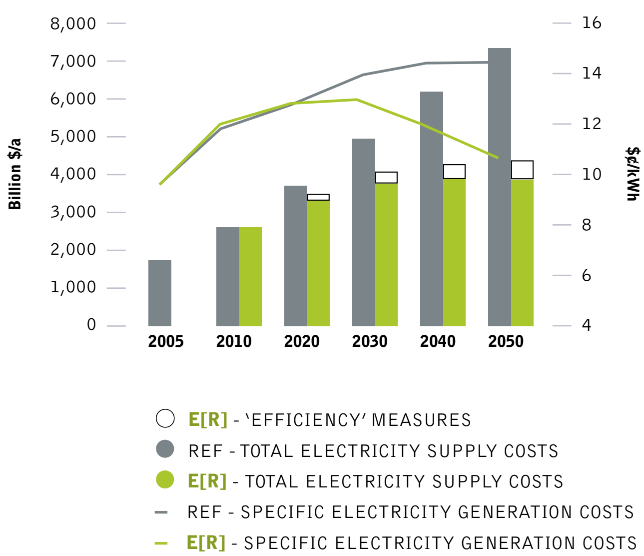
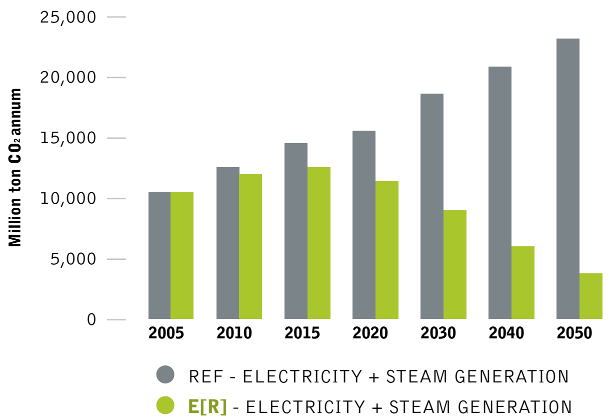


figure 3.3: global: CO_2 emission of the power sector



global: CO_2 emissions from power generation

The majority of carbon emissions in 2050 will be from coal-fired power stations, and mainly those in India and China and the developing world. Those countries' power stations were built between 2000 and 2015, and their average lifetime power is about 40 years. So to achieve the projected reduction, the construction of new coal power stations must end in the developed world by 2015 and in developing countries by 2020. The CO_2 emissions from power generation in the Energy [R]evolution scenario are 52% under the Reference scenario in 2030 and 84% in 2050.

image A WORKER SURVEYS THE EQUIPMENT AT ANDASOL 1 SOLAR POWER STATION, WHICH IS EUROPE'S FIRST COMMERCIAL PARABOLIC TROUGH SOLAR POWER PLANT. ANDASOL 1 WILL SUPPLY UP TO 200.000 PEOPLE WITH CLIMATE-FRIENDLY ELECTRICITY AND SAVE ABOUT 149,000 TONS OF CARBON DIOXIDE PER YEAR COMPARED WITH A MODERN COAL POWER PLANT.

global

global: jobs results

Worldwide, we would see more direct jobs in energy, if we shift to an Energy [R]evolution scenario.

- By 2010 global energy sector jobs in the [R]evolution scenario are estimated at about 9.3 million, 200,000 more than the Reference scenario.
- By 2020, the [R]evolution scenario is estimated to have about 10.5 million jobs, 2 million more than the Reference scenario. More than half a million jobs are lost in the Reference scenario between 2010 and 2020, while 1 million are added in the [R]evolution scenario.
- By 2030 the [R]evolution scenario has about 11.3 million, 2.7 million more than the Reference scenario. Approximately 800,000 new jobs are created between 2020 and 2030 in the [R]evolution, ten times the number created in the Reference scenario.

If the Reference scenario becomes reality, the world would lose 600,000 jobs in the energy sector between 2010 and 2020, mainly in coal generation. This is despite a 37% increase electricity generation from coal.

The main reason is that as prosperity and labour productivity increases, jobs per MW decreases. This is reflected in the **regional adjustments**[10], which model how electricity generation tends to be more labour intensive in poorer countries than in wealthier countries. This change accounts for two thirds of the reduction in coal jobs. Between 2010 and 2020, the regional adjustment falls most sharply in China, dropping from 1.9 in 2010 to 1.2 in 2020 due to strong projected growth in GDP per capita in China. This accounts for about 700,000 of the coal job losses projected in the Reference scenario[11].

The [R]evolution scenario also has job losses in coal generation jobs, because growth in capacity is almost zero. However, job growth in renewable energy is so strong that there is a net gain of 2 million jobs by 2030, relative to the 2010 Reference case.

In both scenarios we have been cautious in the calculations and applied **decline factors** to represent how jobs per unit of energy can decrease over time, making the Greepeace projections lower than other studies.

It may be the case, for example, the job creation per GWh in energy efficiency could increase as energy efficiency options are all 'used up'. For example, a recent analysis of grid management jobs associated with 'Intelligent Grid' operation estimated 280,000 new jobs created in the US during the implementation phase, more than double the total jobs projected here[12]. If no decline factor is applied, energy efficiency jobs would be projected at 1.4 million in 2020 and 2.6 million in 2030.

figure 3.4: global: jobs by type and by specific technology in 2010, 2020, and 2030

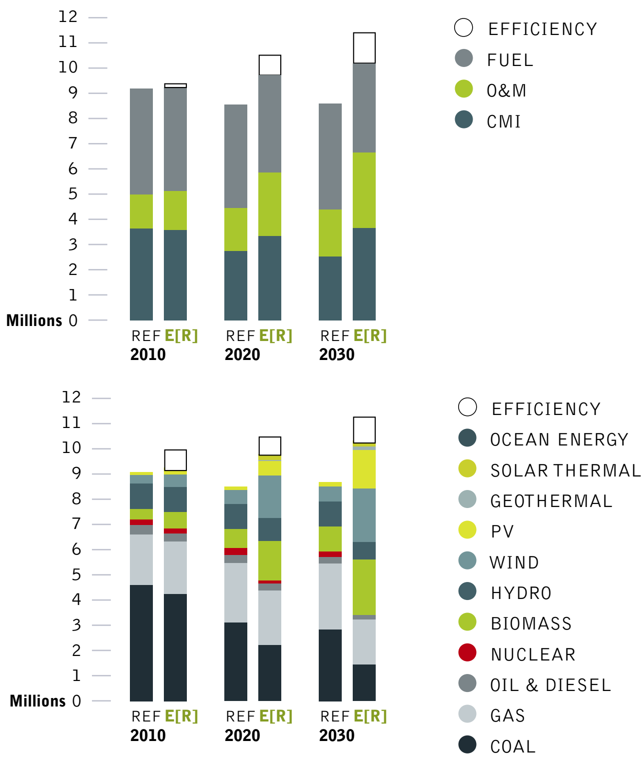
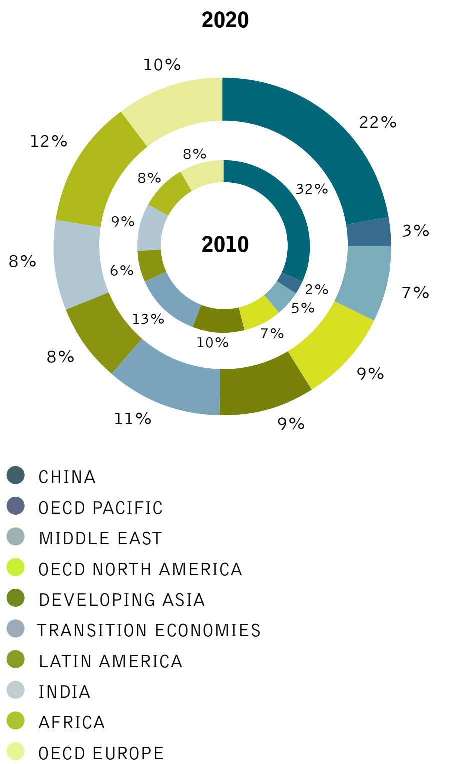


figure 3.5: world power sector employment by region



references
10 THE JOB MULTIPLIERS ARE EQUAL TO PROJECTED LABOUR PRODUCTIVITY IN THE OECD DIVIDED BY THE PROJECTED LABOUR PRODUCTIVITY IN THE REGION.
11 COMPARED TO THE SITUATION OF MAINTAINING THE MULTIPLIER AT 1.9 IN 2020. IF NO MULTIPLIER WAS USED AT ALL, 2010 AND 2020 TOTALS WOULD BOTH BE REDUCED SIGNIFICANTLY.
12 KEMA (2008) *THE U.S. SMART GRID REVOLUTION. KEMA'S PERSPECTIVES FOR JOB CREATION. PREPARED FOR THE GRIDWISE ALLIANCE.*

figure 3.6: **global: employment change in 2020 and 2030, compared to 2010**

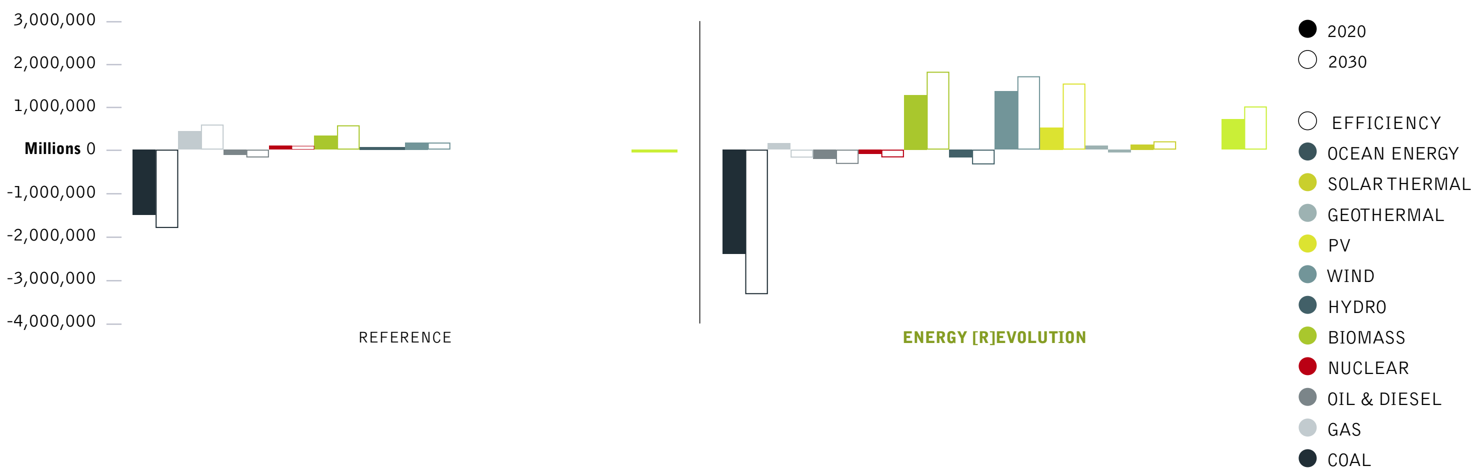


table 3.1: **global: summary of results**

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
	2010	2020	2030	2010	2020	2030
Jobs (millions)						
Coal	4.65 m	3.16 m	2.86 m	4.26 m	2.28 m	1.39 m
Gas	1.95 m	2.36 m	2.55 m	2.08 m	2.12 m	1.80 m
Nuclear, oil and diesel	0.61 m	0.58 m	0.50 m	0.56 m	0.31 m	0.13 m
Renewable	1.88 m	2.41 m	2.71 m	2.38 m	5.03 m	6.90 m
Energy supply jobs	**9.1**	**8.5**	**8.6**	**9.3**	**9.7**	**10.2**
Energy efficiency jobs	-	-	-	0.06	0.72	1.13
Total Jobs	**9.1**	**8.5**	**8.6**	**9.3**	**10.5**	**11.3**
Electricity generation (TWh)						
Coal	9,283	12,546	16,030	8,751	8,953	7,784
Gas	4,447	6,256	7,974	4,704	6,126	6,335
Nuclear, oil & diesel	4,004	4,133	4,079	3,814	2,309	1,003
Renewable	4,047	5,871	7,286	4,254	8,355	14,002
TOTAL electricity generation (TWh)	**21,780**	**28,807**	**35,369**	**21,523**	**25,743**	**29,124**

Note: *This underestimates energy efficiency jobs because it only includes jobs additional to the Reference scenario.*

oecd north america

oecd north america: electricity generation mix

By 2050, 94% of the electricity produced in OECD North America would come from renewable energy sources. 'New' renewables – mainly wind, solar thermal energy and PV – would contribute over 85% of electricity generation. Up to 2020, hydro power and wind will remain the main contributors to the growing market share. After 2020, the continuing growth of wind will be complemented by electricity from biomass, photovoltaics and solar thermal (CSP) energy.

oecd north america: future costs of electricity generation

Figure 3.8 shows that the introduction of renewable technologies under the Energy [R]evolution scenario slightly increases the costs of electricity generation compared to the Reference scenario. This difference will be less than 0.4 cents/kWh up to 2020. Because of the lower CO_2 intensity of electricity generation, by 2020 electricity generation costs will become economically favourable under the Energy [R]evolution scenario, and by 2050 generation costs will be more than 5 cents/kWh below those in the Reference scenario. Under the Reference scenario, on the other hand, unchecked growth in demand, the increase in fossil fuel prices and the cost of CO_2 emissions result in total electricity supply costs rising from today's $420 billion per year to more than $1,350 billion in 2050. Figure 3.9 shows that the Energy [R]evolution scenario not only complies with OECD North America CO_2 reduction targets but 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 in the Reference scenario.

oecd north america: CO_2 emissions from power generation

Whilst North America's emissions of CO_2 will increase by 42% under the Reference scenario, under the Energy [R]evolution scenario they will decrease from 6,430 million tonnes in 2005 to 1,060 million tonnes in 2050. Annual per capita emissions will drop from 14.7 tonnes to 1.8 tonnes. In spite of the phasing out of nuclear energy and increasing demand, CO_2 emissions will decrease in the electricity sector. In the long run efficiency gains and the increased use of renewable electricity in the transport sector will even reduce CO_2 emissions there.

figure 3.7: oecd north america: development of electricity supply structure under the two scenarios

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

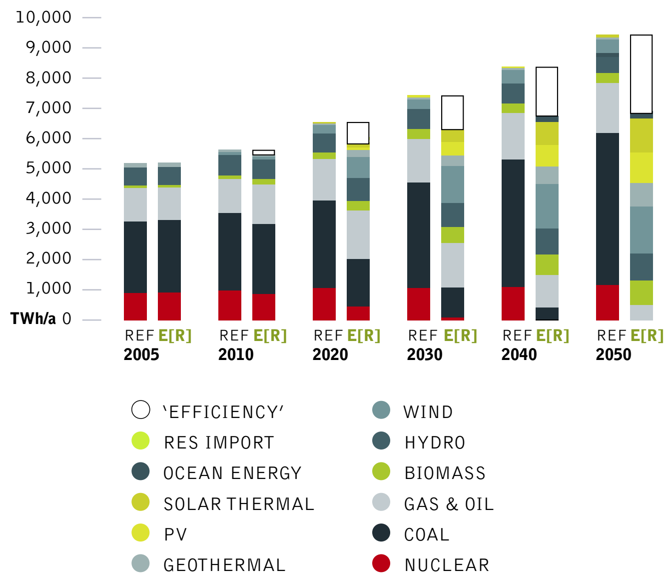


figure 3.8: oecd north america: development of total electricity supply costs & development of specific electricity generation costs under the two scenarios

(CO_2 EMISSION COSTS IMPOSED FROM 2010, WITH AN INCREASE FROM 15 $/$T_{CO_2}$ IN 2010 TO 50 $/$T_{CO_2}$ IN 2050)

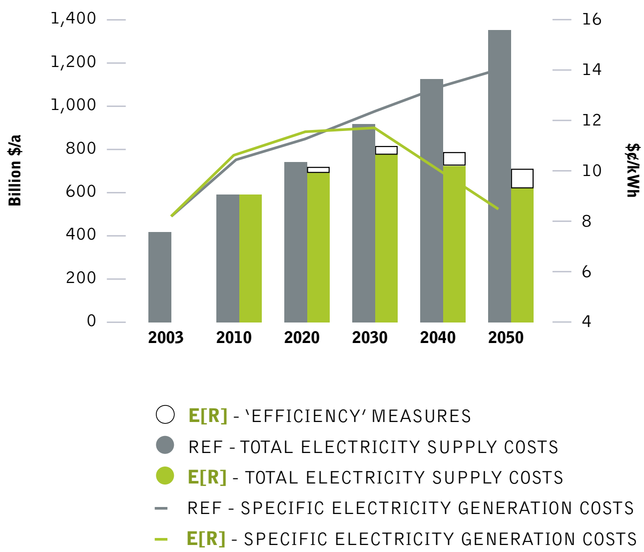


figure 3.9: oecd north america: CO_2 emission of the power sector

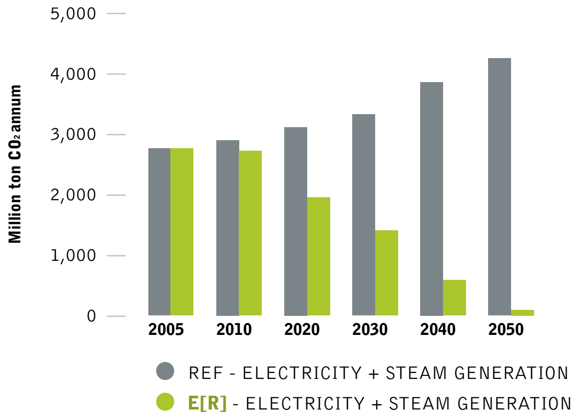
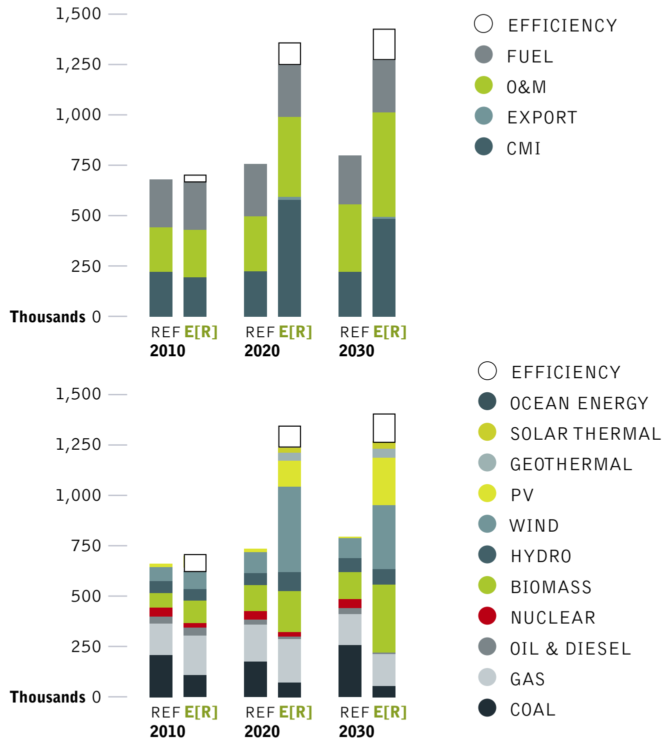


figure 3.10: oecd north america: jobs by type and by specific technology in 2010, 2020, and 2030



oecd north america: jobs results

- There are 694,000 power sector jobs in the [R]evolution scenario in OECD North America in 2010, compared to 665,000 in the Reference scenario.
- In 2020, job numbers reach over 1.3 million in the [R]evolution scenario, 600,000 more than in the Reference scenario.
- Job numbers climb slightly in the [R]evolution scenario by 2030, to nearly 1.4 million, and reach nearly 0.8 million in the Reference scenario.

There are more power sector jobs in OECD North America in the [R]evolution scenario at every stage.

Figure 3.10 shows the change in job numbers under both scenarios for each technology between 2010 and 2020, and 2020 and 2030. Both scenarios show losses in coal generation, but these are outweighed by employment growth in renewable technologies and gas. Wind shows particularly strong growth in the [R]evolution scenario at 2020, but by 2030 there is significant employment in a portfolio of renewable technologies.

It is assumed that all manufacturing occurs within OECD North America, and that the region exports just under 10% of globally traded renewable energy components. In the [R]evolution scenario export jobs reach 5% of the total power sector jobs in 2020, and stay at that level. In the Reference scenario export jobs do not even reach 1%.

table 3.2: oecd north america: employment and electricity generation at 2010, 2020, and 2030

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
	2010	2020	2030	2010	2020	2030
Jobs (thousands)						
Coal	198	175	239	104	52	33
Gas	160	169	169	193	234	181
Nuclear, oil and diesel	81	79	70	67	29	7
Renewable	226	323	316	295	927	1,048
Energy supply jobs	**665**	**745**	**793**	**659**	**1,241**	**1,269**
Energy efficiency jobs	-	-	-	35	105	141
Total Jobs	**665**	**745**	**793**	**694**	**1,346**	**1,410**
Electricity generation (TWh)						
Coal	2,534	2,918	3,446	2,303	1,583	1,052
Gas	1,000	1,211	1,358	1,113	1,560	1,426
Nuclear, oil & diesel	1,153	1,173	1,179	1,046	478	83
Renewable	879	1,179	1,367	948	2,172	3,673
TOTAL electricity generation (TWh)	**5,565**	**6,481**	**7,350**	**5,411**	**5,793**	**6,234**

Note: *This underestimates energy efficiency jobs because it only includes jobs additional to the Reference scenario.*

latin america

latin america: electricity generation mix

By 2050, 95% of the electricity produced in Latin America will come from renewable energy sources. 'New' renewables – mainly wind, solar thermal energy and PV – will contribute more than 60% of electricity generation. The installed capacity of renewable energy technologies will grow from the current 139 GW to 695 GW in 2050 – increasing renewable capacity by a factor of five within the next 42 years.Up to 2020, hydro power and wind will remain the main contributors to the growing market share. After 2020, the continuing growth of wind will be complemented by electricity from biomass, photovoltaics and solar thermal (CSP) energy.

latin america: future costs of electricity generation

Figure 3.12 shows that the introduction of renewable technologies under the Energy [R]evolution scenario significantly decreases the future costs of electricity generation compared to the Reference scenario.

Because of the lower CO_2 intensity of electricity generation, costs will become economically favourable under the Energy [R]evolution scenario. By 2050 generation costs will be more than 8 cents/kWh below those in the Reference scenario. Under the Reference scenario, on the other hand, unchecked growth indemand, the increase in fossil fuel prices and the cost of CO_2 emissions result in total electricity supply costs rising from today's $70 billion per year to more than $551 billion in 2050. Figure 3.13 shows that the Energy [R]evolution scenario not only complies with Latin America's CO_2 reduction targets but 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 in the Reference scenario.

latin america: CO_2 emissions from power generation

Whilst Latin America's emissions of CO_2 will almost triple under the Reference scenario, under the Energy [R]evolution scenario they will decrease from 830 million tonnes in 2005 to 370 million tonnes in 2050. Annual per capita emissions will drop from 1.8 tonnes to 0.6 tonnes. In spite of the phasing out of nuclear energy and increasing demand, CO_2 emissions will decrease in the electricity sector. In the long run efficiency gains and the increased use of renewable electricity in vehicles will even reduce CO_2 emissions in the transport sector. With a share of 53% of total CO_2 in 2050, the transport sector will remain the largest source of emissions.

figure 3.11: latin america: development of electricity supply structure under the two scenarios

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

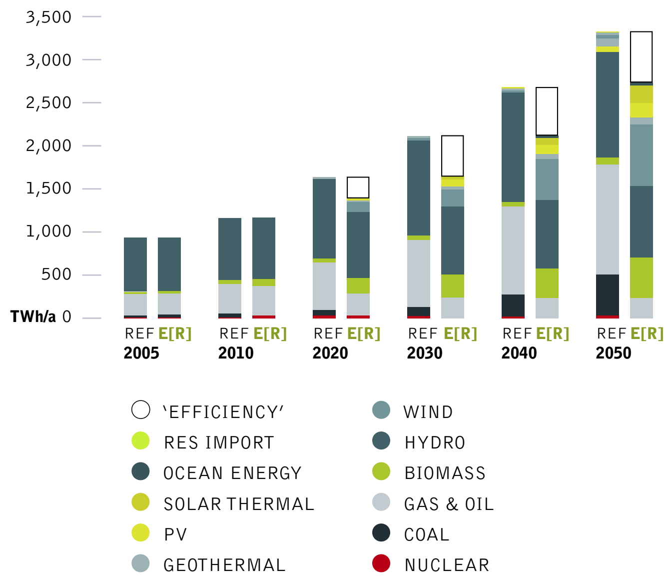


figure 3.12: latin america: development of total electricity supply costs & development of specific electricity generation costs under the two scenarios

(CO_2 EMISSION COSTS IMPOSED FROM 2010, WITH AN INCREASE FROM 15 $/$T_{CO_2}$ IN 2010 TO 50 $/$T_{CO_2}$ IN 2050)

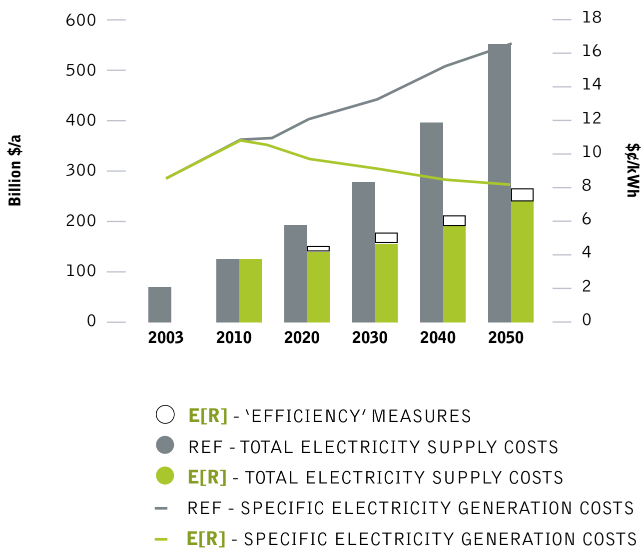


figure 3.13: **latin america: CO_2 emission of the power sector**

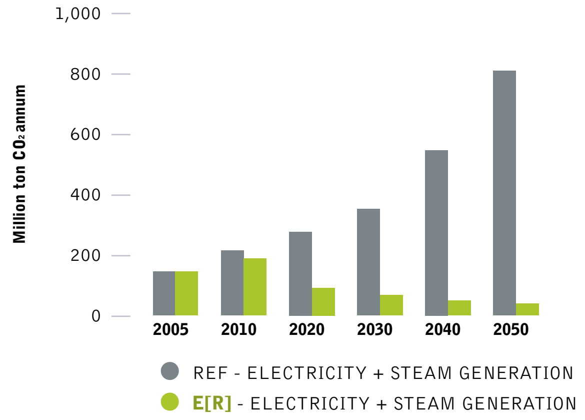
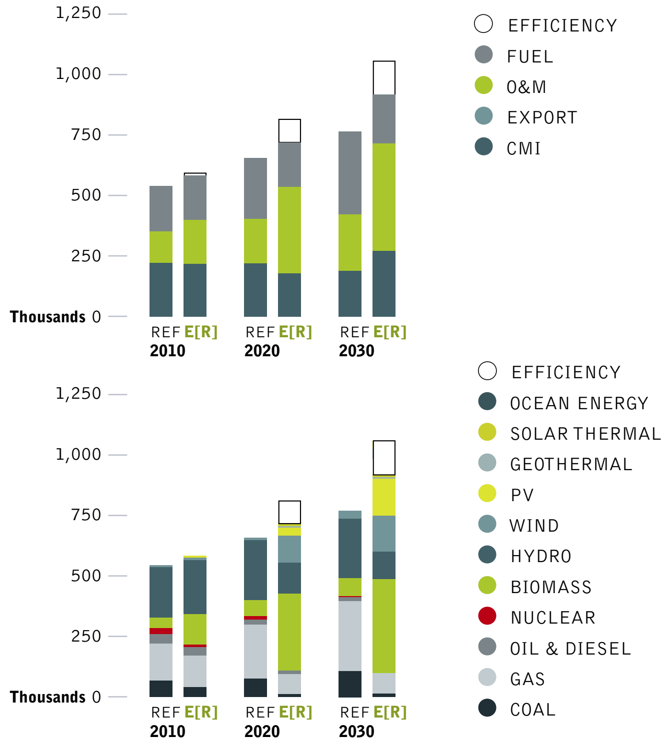


figure 3.14: **latin america: jobs by type and by specific technology in 2010, 2020, and 2030**



latin america: jobs results

- There are 570,000 power sector jobs in the [R]evolution scenario in Latin America in 2010, compared to 541,000 in the Reference scenario.
- In 2020, job numbers grow in both scenarios. The [R]evolution scenario reaches 814,000 and the Reference scenario 651,000.
- Job numbers in the [R]evolution scenario continue to grow strongly, reaching just over a million jobs by 2030, nearly 300,000 more than in the Reference scenario.

There are more power sector jobs in Latin America in the [R]evolution scenario at every stage. In 2010, the [R]evolution has about 50,000 additional jobs compared to the Reference scenario, with 160,000 more in 2020, and 300,000 more by 2030.

Figure 3.14 shows total projected jobs in the power sector, broken down by technology. While there is strong growth in both sectors, employment under the [R]evolution scenario increases much more strongly. It is assumed that only 30% of renewable energy manufacturing occurs within the region at 2010, increasing to 70% by 2030. However, Latin America exports a high percentage of the inter-regionally traded gas, which results in high employment numbers in the Reference scenario, and significant numbers in the [R]evolution.

Employment associated with gas generation grows most strongly in the Reference scenario, but this is dwarfed by the exceptional growth in renewable energy employment, especially biomass, in the [R]evolution scenario.

table 3.3: **latin america: employment and electricity generation at 2010, 2020, and 2030**

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
	2010	2020	2030	2010	2020	2030
Jobs (thousands)						
Coal	58	77	107	32	8	9
Gas	165	232	286	138	90	86
Nuclear, oil and diesel	52	36	19	43	12	4
Renewable	266	306	349	367	609	821
Energy supply jobs	**541**	**651**	**762**	**579**	**719**	**920**
Energy efficiency jobs	-	-	-	2	95	138
Total Jobs	**541**	**651**	**762**	**581**	**814**	**1,058**
Electricity generation (TWh)						
Coal	35	58	92	24	5	12
Gas	241	464	696	209	194	168
Nuclear, oil & diesel	108	100	77	103	40	7
Renewable	754	974	1,186	796	1,095	1,392
TOTAL electricity generation (TWh)	**1,137**	**1,596**	**2,051**	**1,130**	**1,333**	**1,579**

Note: *This underestimates energy efficiency jobs because it only includes jobs additional to the Reference scenario.*

oecd europe

oecd europe: electricity generation mix

By 2050, 86% of the electricity produced in OECD Europe will come from renewable energy sources. 'New' renewables – mainly wind, solar thermal energy and PV – will contribute 67%. The installed capacity of renewable energy technologies will grow from the current 250 GW to 1,030 GW in 2050, increasing renewables capacity by a factor of four. Figure 3.15 shows the evolution of the different renewable technologies. Up to 2020, hydro power and wind will remain the main contributors to the growing market share. After 2020, the continuing growth of wind will be complemented by electricity from biomass, photovoltaics and solar thermal (CSP) energy.

None of these numbers describe a maximum feasibility, but a possible balanced approach. With the right policy development, the solar industry believes that a much further uptake could happen. This is particularly true for concentrated solar power (CSP) which could unfold to 30GW already by 2020 and more than 120GW in 2050. The photovoltaic industry believes in a possible electricity generation capacity of 350GW by 2020 in Europe alone, assuming the necessary policy changes.

oecd europe: future costs of electricity generation

Under the Energy [R]evolution scenario the costs of electricity generation would increase by 0.4 cents/kWh up to 2020 compared the Reference scenario.

Because of the lower CO_2 intensity of electricity generation, electricity generation costs will become economically favourable under the Energy [R]evolution scenario by 2020, and by 2050 costs will bemore than 3 cents/kWh below those in the Reference scenario. Under the Reference scenario, the unchecked growth in demand, the increase in fossil fuel prices and the cost of CO_2 emissions result intotal electricity supply costs rising from today's $330 billion per year to more than $800 billion in 2050. Figure 3.17 shows that the Energy [R]evolution scenario not only complies with OECD Europe CO_2 reduction targets but 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 in the Reference scenario.

oecd europe: CO_2 emissions from power generation

While CO_2 emissions in OECD Europe will increase by 12% under the Reference scenario by 2050, in the Energy [R]evolution scenario they will decrease from 4,060 million tonnes in 2005 to 880 m/t in 2050. Annual per capita emissions will drop from 7.6 tonnes to 1.6 tonnes. In spite of the phasing out of nuclear energy and increasing demand, CO_2 emissions will decrease in the electricity sector. In the long run efficiency gains and the increased use of renewable electricity in vehicles will reduce emissions in the transport sector. With a share of 14% of total CO_2 in 2050, the power sector will drop below transport as the largest source of emissions.

figure 3.15: oecd europe: development of electricity supply structure under the two scenarios

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

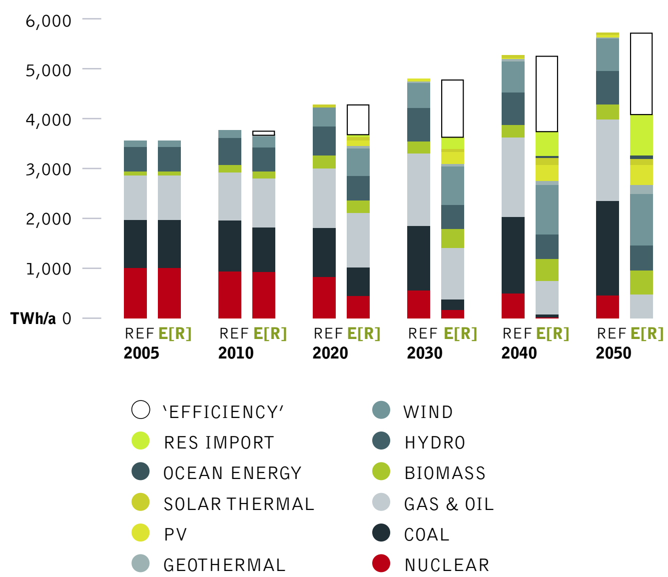


figure 3.16: oecd europe: development of total electricity supply costs & development of specific electricity generation costs under the two scenarios

(CO_2 EMISSION COSTS IMPOSED FROM 2010, WITH AN INCREASE FROM 15 $/$T_{CO_2}$ IN 2010 TO 50 $/$T_{CO_2}$ IN 2050)

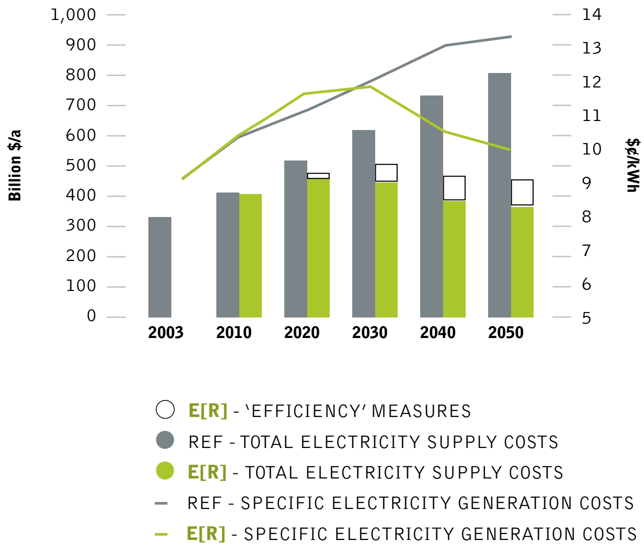


figure 3.17: **oecd europe: CO_2 emission of the power sector**

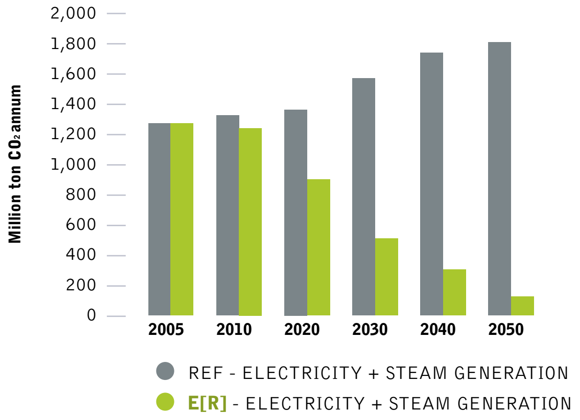
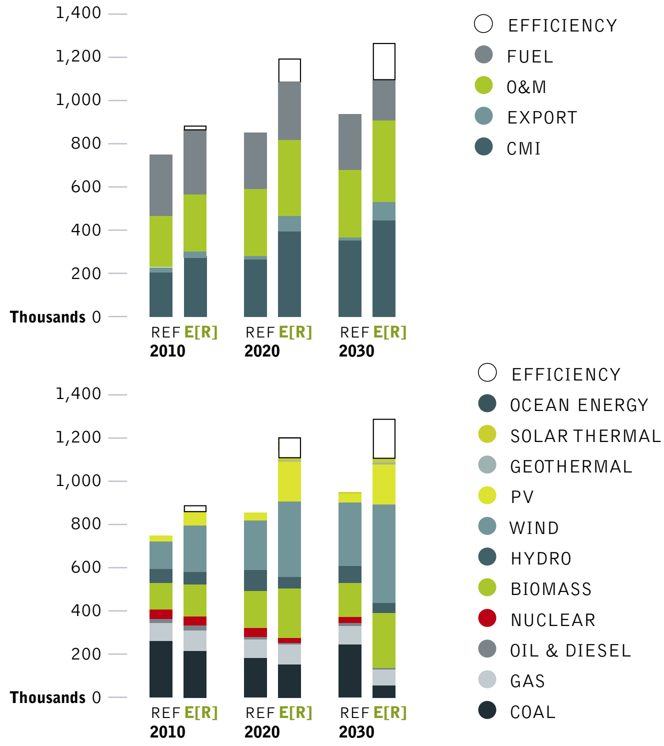


figure 3.18: **oecd europe: jobs by type and by specific technology in 2010, 2020, and 2030**



oecd europe: jobs results

- There are 872,000 power sector jobs in the [R]evolution scenario in OECD Europe in 2010, and 749,000 in the Reference scenario.
- In 2020, job numbers reach 1.2 million in the [R]evolution scenario and 854,000 in the Reference scenario.
- Job numbers reach nearly 1.3 million in 2030 in the [R]evolution scenario, compared to 940,000 in the Reference scenario.

There are more power sector jobs in OECD Europe in the [R]evolution scenario at every stage. In 2010, the [R]evolution has about 140,000 additional jobs compared to the Reference scenario. By 2020, the [R]evolution scenario has 350,000 additional jobs. The gap between the two scenarios remains similar in 2030.

Figure 3.18 shows the change in job numbers under both scenarios for each technology between 2010 and 2020, and 2010 and 2030. New jobs in the [R]evolution scenario are dominated by wind, and there are significant losses in the coal sector in both scenarios.

It is assumed that by 2020 all manufacturing occurs within Europe, and that OECD Europe is a major exporter to other regions. In the [R]evolution scenario export jobs reach 5% of the total energy supply jobs in 2020, and 7% by 2020. In the Reference scenario export jobs fall to 1% by 2020.

table 3.4: **oecd europe: employment and electricity generation at 2010, 2020, and 2030**

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
	2010	2020	2030	2010	2020	2030
Jobs (thousands)						
Coal	260	184	255	221	154	58
Gas	83	86	82	92	95	73
Nuclear, oil and diesel	64	51	34	61	27	10
Renewable	342	533	571	498	821	958
Energy supply jobs	**749**	**854**	**942**	**872**	**1,097**	**1,099**
Energy efficiency jobs	-	-	-	16	105	179
Total Jobs	**749**	**854**	**942**	**888**	**1,202**	**1,278**
Electricity generation (TWh)						
Coal	1,001	995	1,260	890	542	184
Gas	859	1,106	1,394	877	1,090	1,040
Nuclear, oil & diesel	1,071	893	631	1,044	471	175
Renewable	812	1,293	1,521	861	1,496	1,991
TOTAL electricity generation (TWh)	**3,742**	**4,288**	**4,805**	**3,672**	**3,599**	**3,391**

Note: *This underestimates energy efficiency jobs because it only includes jobs additional to the Reference scenario.*

africa

africa: electricity generation mix

By 2050, 73% of the electricity produced in Africa would come from renewable energy sources. A main driver for the development of solar power generation capacities will be the export of solar electricity to OECD Europe. 'New' renewables – mainly wind, solar thermal energy and PV – will contribute more than 60% of electricity generation. The installed capacity of renewable energy technologies will grow from the current 21 GW to 388 GW in 2050, increasing renewable capacity by a factor of 18 over the next 42 years. More than 60 GW CSP plants will produce electricity for export to Europe.

Figure 3.19 shows the comparative evolution of different renewable technologies over time. Up to 2020, hydro power and wind will remain the main contributors to the growing market share. After 2020, the continuing growth of wind will be complemented by electricity from biomass, photovoltaics and solar thermal (CSP) energy.

africa: future costs of electricity generation

Figure 3.20 shows that the introduction of renewable technologies under the Energy [R]evolution scenario significantly decreases the future costs of electricity generation. Because of the lower CO_2 intensity, electricity generation costs will steadily become more economic under the Energy [R]evolution scenario and by 2050 will be more than 9 cents/kWh below those in the Reference scenario.

Under the Reference scenario, by contrast, unchecked demand growth, the increase in fossil fuel prices and the cost of CO_2 emissions result in total electricity supply costs rising from today's $59 billion per year to more than $468 billion in 2050. Figure 3.21 shows that the Energy [R]evolution scenario not only complies with Africa's CO_2 reduction targets but also helps to stabilise energy costs. Increasing energy efficiency and shifting energy supply to renewables leads to long term costs for electricity supply that are one third lower than in the Reference scenario.

africa: CO_2 emissions from power generation

While Africa's emissions of CO_2 will almost triple under the Reference scenario, under the Energy [R]evolution scenario they will increase from 780 million tonnes in 2003 to 895 m/t in 2050. Annual percapita emissions will drop from 0.8 tonnes to 0.45 t. In spite of increasing demand, CO_2 emissions will decrease in the electricity sector. In the long run efficiency gains and the increased use of bio fuels and electricity will reduce CO_2 emissions in the transport sector. With a share of 28% of total CO_2 in 2050, the power sector will drop below transport as the largest source of emissions.

figure 3.19: africa: development of electricity supply structure under the two scenarios

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

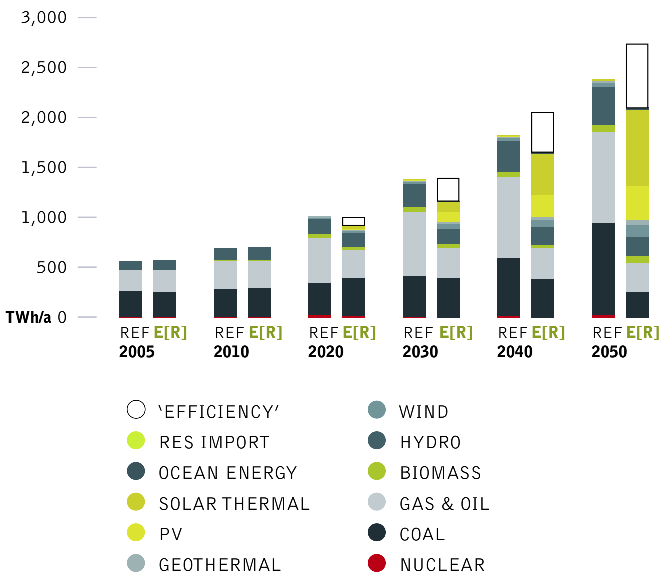


figure 3.20: africa: development of total electricity supply costs & development of specific electricity generation costs under the two scenarios

(CO_2 EMISSION COSTS IMPOSED FROM 2010, WITH AN INCREASE FROM 15 $/$T_{CO_2}$ IN 2010 TO 50 $/$T_{CO_2}$ IN 2050)

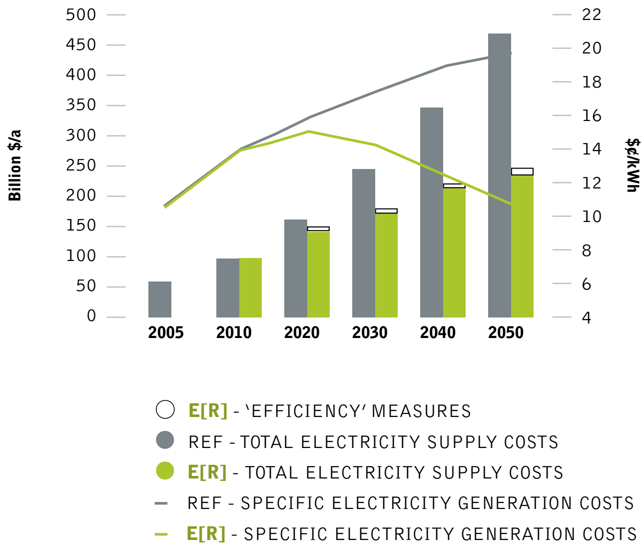


figure 3.21: africa: CO_2 emission of the power sector

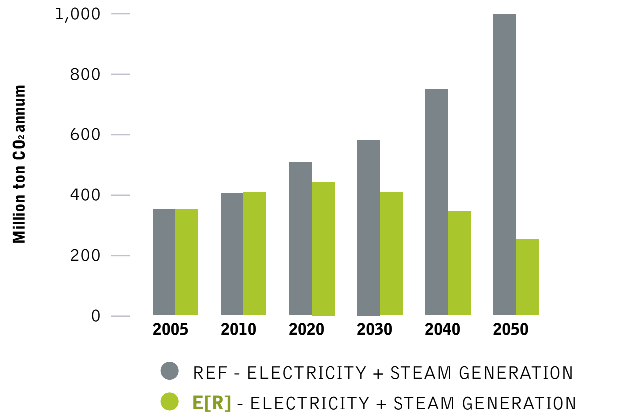
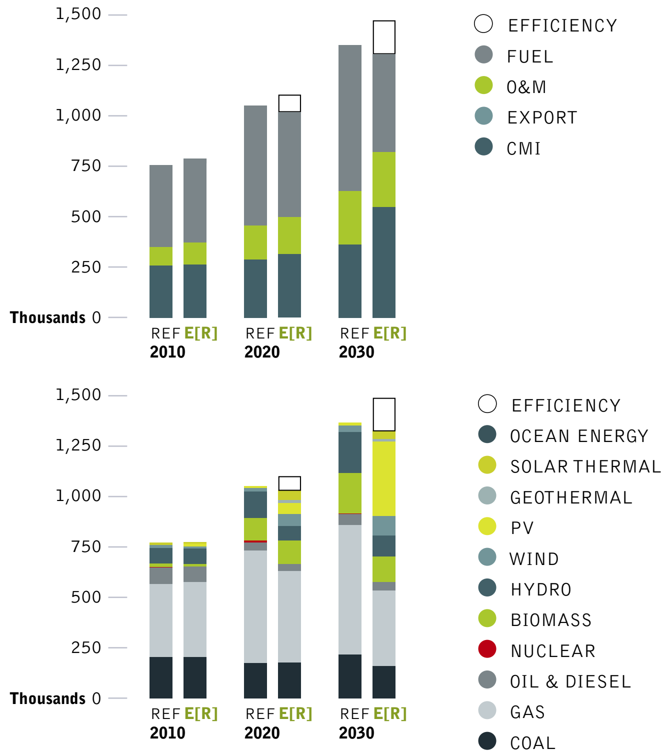


figure 3.22: africa: jobs by type and by specific technology in 2010, 2020, and 2030



africa: jobs results

- There are 783,000 power sector jobs in the [R]evolution scenario in Africa in 2010, compared to 767,000 in the Reference scenario.
- Job growth is strong to 2020, and there are close to 1 million jobs in both scenarios by 2020. The [R]evolution has slightly higher growth, with 40,000 more jobs by 2020.
- Strong job growth is maintained in both scenarios to 2030, with projected jobs in the [R]evolution 1.5 million, compared to 1.4 million in the Reference scenario.

Gas jobs grow very strongly in the Reference scenario, and while they also grow in the [R]evolution, it is less significant, particularly after 2020. Job numbers are almost the same in both scenarios, although the Revolution scenario always has slightly higher results.

Under the [R]evolution scenario electricity use is reduced by 9% in 2020 compared to the Reference case, and by 16% by 2030. The Reference case has slightly higher employment in energy supply jobs in both 2020 and 2030, as may be expected with the generation so much greater, but this is outweighed by the increase in energy efficiency jobs.

Africa is an important gas exporter, with exports accounting for 40% of fuel supply jobs in 2010. This falls to 22% in the Reference scenario by 2030, reflecting the steep increase in domestic use of fuel. The proportion of exports remains higher in the [R]evolution scenario (33% at 2030).

Africa is assumed to largely remain a technology importer in these projections, importing 30% of renewable technology in 2020 and 50% in 2030. If 100% of manufacturing occurred locally in 2030 there would be an additional 86,000 jobs in the [R]evolution scenario by 2030, while the same change would only create an additional 16,000 jobs in the Reference scenario.

table 3.5: africa: employment and electricity generation at 2010, 2020, and 2030

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
	2010	2020	2030	2010	2020	2030
Jobs (thousands)						
Coal	189	167	196	184	167	148
Gas	386	556	660	396	451	391
Nuclear, oil and diesel	59	56	47	59	44	27
Renewable	133	277	453	145	363	755
Energy supply jobs	**767**	**1,056**	**1,357**	**783**	**1,025**	**1,321**
Energy efficiency jobs	-	-	-		79	164
Total Jobs	**767**	**1,056**	**1,357**	**783**	**1,104**	**1,485**
Electricity generation (TWh)						
Coal	281	325	396	281	331	360
Gas	220	414	599	220	303	313
Nuclear, oil & diesel	65	61	56	65	49	22
Renewable	118	202	311	118	231	451
TOTAL electricity generation (TWh)	**683**	**1,001**	**1,362**	**684**	**914**	**1,146**

Note: *This underestimates energy efficiency jobs because it only includes jobs additional to the Reference scenario.*

middle east

middle east: electricity generation mix

By 2050, 95% of the electricity produced in the Middle East would come from renewable energy sources. 'New' renewables – mainly wind, solar thermal energy and PV – will contribute about 90% of electricity generation. The installed capacity of renewable energy technologies will grow from the current 10 GW to 556 GW in 2050, a very large increase over the next 42 years requiring political support and well-designedpolicy instruments. Figure 3.23 shows the comparative evolution of the different technologies over the period up to 2050.

middle east: future costs of electricity generation

Figure 3.24 shows that the introduction of renewable technologies under the Energy [R]evolution scenario would significantly reduce electricity generation costs. Under the Reference scenario, on the other hand, the unchecked growth in demand, increase in fossil fuel prices and the cost of CO_2 emissions result in total electricity supply costs rising from today's $133 billion per year to more than $870 billion in 2050. Figure 3.25 shows that the Energy [R]evolution scenario not only meets the Middle East's CO_2 reduction targets but also helps to stabilise energy costs. Long term costs for electricity supply are one third lower than in the Reference scenario.

middle east: CO_2 emissions from power generation

While CO_2 emissions in the Middle East will triple under the Reference scenario by 2050, and are thus far removed from a sustainable development path, under the Energy [R]evolution scenario they will decrease from 1,170 million tonnes in 2005 to 390 m/t in 2050. Annual per capita emissions will drop from 6.2 tonnes/capita to 1.1 t. In spite of an increasing electricity demand, CO_2 emissions will decrease strongly in the electricity sector. In the long run efficiency gains and the increased use of renewable electricity in vehicles will even reduce CO_2 emissions in the transport sector.

figure 3.23: middle east: development of electricity supply structure under the two scenarios

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

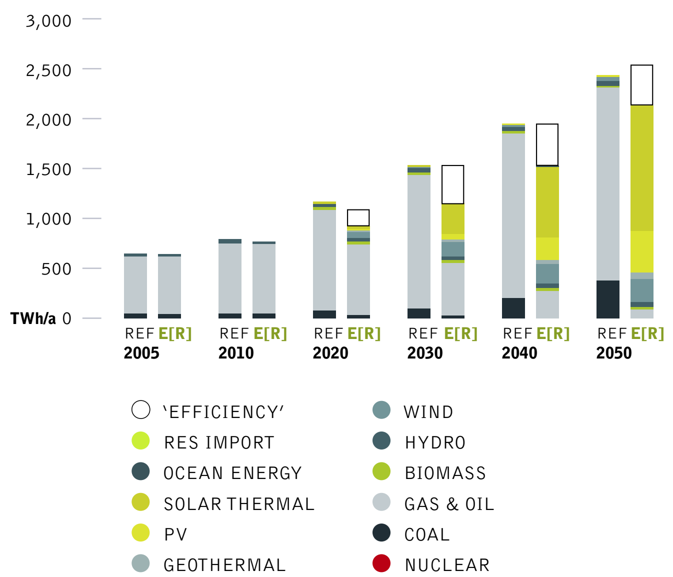


figure 3.24: middle east: development of total electricity supply costs & development of specific electricity generation costs under the two scenarios

(CO_2 EMISSION COSTS IMPOSED FROM 2010, WITH AN INCREASE FROM 15 $/$T_{CO_2}$ IN 2010 TO 50 $/$T_{CO_2}$ IN 2050)

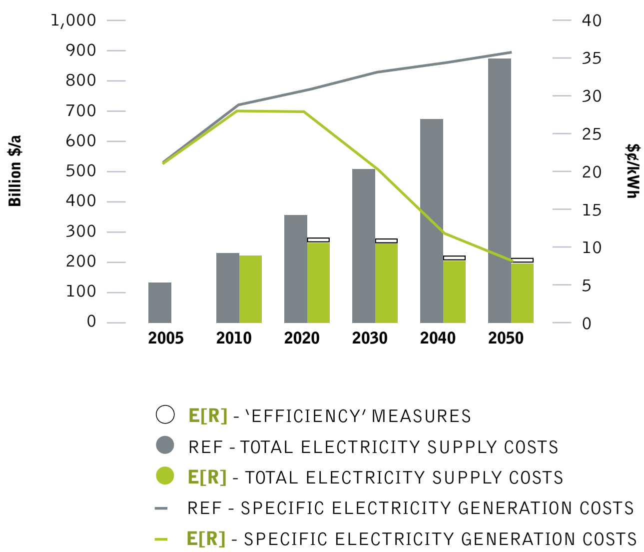


figure 3.25: **middle east: CO_2 emission of the power sector**

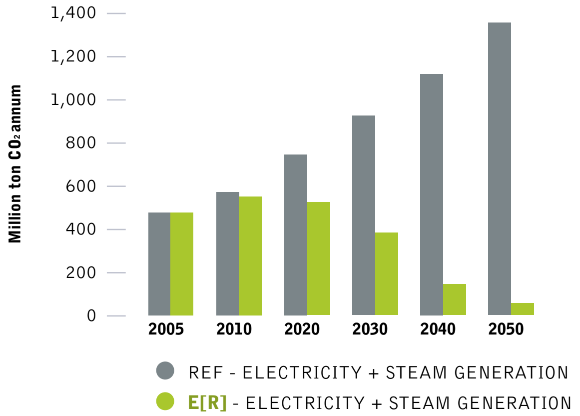
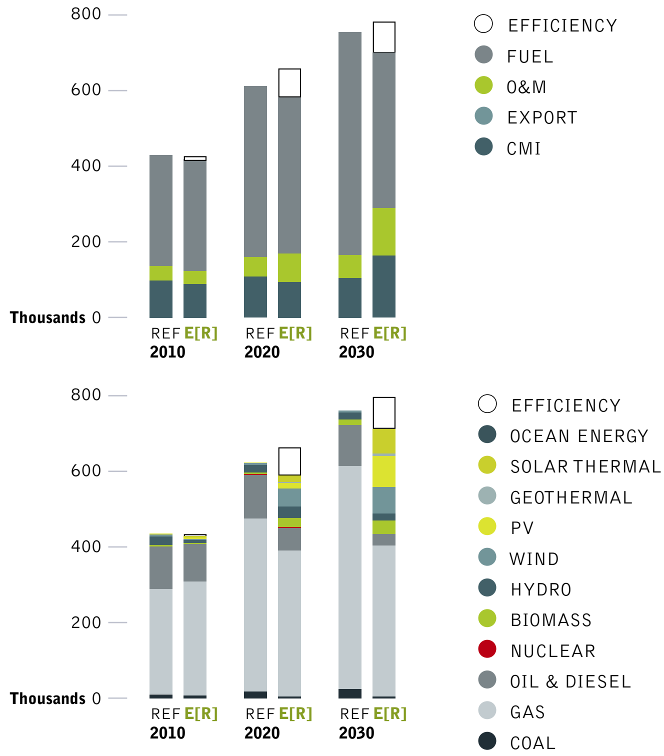


figure 3.26: **middle east: jobs by type and by specific technology in 2010, 2020, and 2030**



middle east: jobs results

- There are 421,000 electricity sector jobs in the [R]evolution scenario in the Middle East in 2010, and 427,000 in the Reference scenario.
- In 2020, jobs in the [R]evolution scenario are slightly higher, with 655,000 compared to 615,000 in the Reference case.
- Jobs in both scenarios grow strongly to 2030. The [R]evolution has 790,000 compared to 753,000 in the Reference scenario.

Gas jobs grow in both scenarios, but the growth is less under the Energy [R]evolution, particularly after 2020. However, growth in renewable jobs make up for the slowing of growth in the gas sector in the [R]evolution scenario. Energy efficiency jobs are also important, resulting from the 19% reduction in electricity use compared to the Reference case in 2020.

The Middle East is a very important gas exporting region, with exports accounting for 30% of fuel jobs in both sectors in 2010. This increases to 40% of fuel supply jobs in the Reference scenario by 2030, and reaches 60% in the [R]evolution scenario.

Only 30% of renewable technology is assumed to be manufactured locally by 2030; securing these manufacturing jobs within the region would add another 85,000 jobs.

Looking at overall change in job numbers, the big difference between the scenarios is the jobs associated with gas generation, which grow very strongly in the Reference scenario, and fall in the [R]evolution. This is primarily because of the reduction in domestic gas generation as a result of improved energy efficiency in the [R]evolution scenario.

table 3.6: **middle east: employment and electricity generation at 2010, 2020, and 2030**

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
	2010	2020	2030	2010	2020	2030
Jobs (thousands)						
Coal	10	13	13	5	2	2
Gas	277	455	592	299	380	394
Nuclear, oil and diesel	111	114	110	89	66	33
Renewable	30	32	37	27	132	279
Energy supply jobs	**427**	**615**	**753**	**421**	**581**	**709**
Energy efficiency jobs	-	-	-	2	74	81
Total Jobs	**427**	**615**	**753**	**422**	**655**	**790**
Electricity generation (TWh)						
Coal	42	63	82	38	26	16
Gas	448	726	1,033	470	535	503
Nuclear, oil & diesel	268	313	336	243	208	108
Renewable	32	51	71	31	164	598
TOTAL electricity generation (TWh)	**789**	**1,154**	**1,522**	**781**	**933**	**1,225**

Note: *This underestimates energy efficiency jobs because it only includes jobs additional to the Reference scenario.*

transition economies

transition economies: electricity generation mix

By 2050, 81% of the electricity produced in the Transition Economy countries would come from renewable energy sources. 'New' renewables – mainly wind, solar thermal energy and PV – will contribute 65% ofelectricity generation.

The installed capacity of renewable energy technologies will grow from the current 93 GW to 550 GW in 2050, increasing capacity by a factor of six over the next 42 years. This will require political support and well-designed policy instruments. Figure 3.27 shows the expansion rate of the different renewable technologies over time. Up to 2020, hydro power and wind will remain the main contributors. After 2020, the continuing growth of wind will be complemented by electricity from biomass, photovoltaics and geothermal energy.

transition economies: future costs of electricity generation

Figure 3.28 shows that the introduction of renewable technologies under the Energy [R]evolution scenario slightly increases the costs of electricity generation compared to the Reference scenario. This difference will be about 0.5 cents/kWh in 2015. Because of the lower CO_2 intensity of electricity generation, by 2020 these costs will become economically favourable under the Energy [R]evolution scenario and by 2050 will be more than 5 cents/kWh below those in the Reference scenario.

Due to growing demand, there will be a significant increase in society's expenditure on electricity supply. Under the Reference scenario, total electricity supply costs will rise from today's $190 billion per year to$520 billion in 2050. Figure 3.29 shows that the Energy [R]evolution scenario not only complies with the Transition Economies' CO_2 reduction targets but also helps to stabilise energy costs and relieve the economic pressure on society. Long term costs for electricity supply are one third lower than in the Reference scenario.

transition economies: CO_2 emissions from power generation

Whilst emissions of CO_2 will increase by 11% under the Reference scenario, under the Energy [R]evolution scenario they will decrease from 2,380 million tonnes in 2005 to 540 m/t in 2050. Annual per capita emissions will drop from 7.0 tonnes to 1.8 t. In spite of the phasing out of nuclear energy and increasing demand, CO_2 emissions will decrease in the electricity sector.

figure 3.27: transition economies: development of electricity supply structure under the two scenarios

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

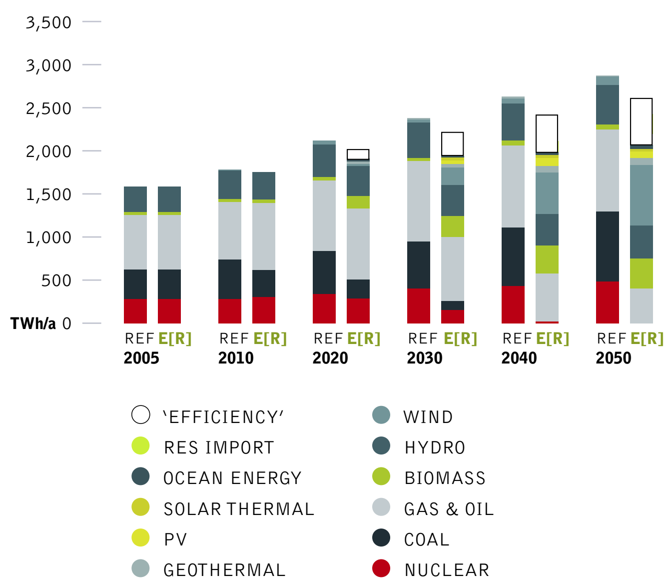


figure 3.28: transition economies: development of total electricity supply costs & development of specific electricity generation costs under the two scenarios

(CO_2 EMISSION COSTS IMPOSED FROM 2010, WITH AN INCREASE FROM 15 $/T$_{CO_2}$ IN 2010 TO 50 $/T$_{CO_2}$ IN 2050)

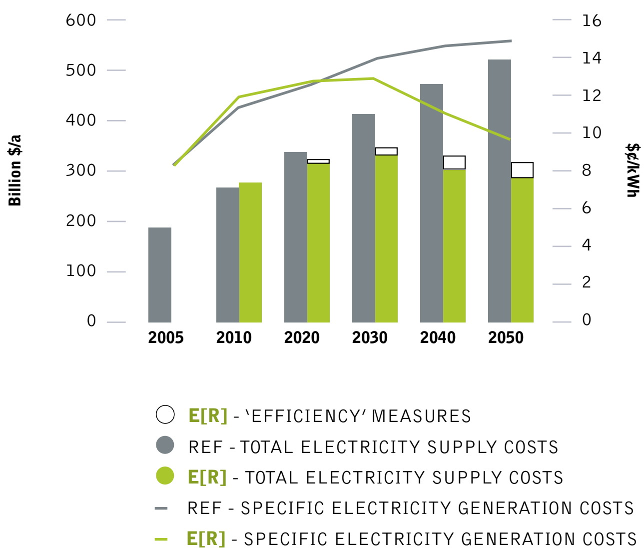


figure 3.29: transition economies: CO_2 emission of the power sector

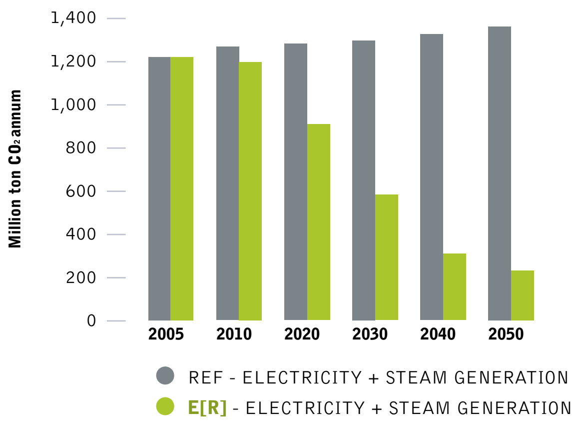
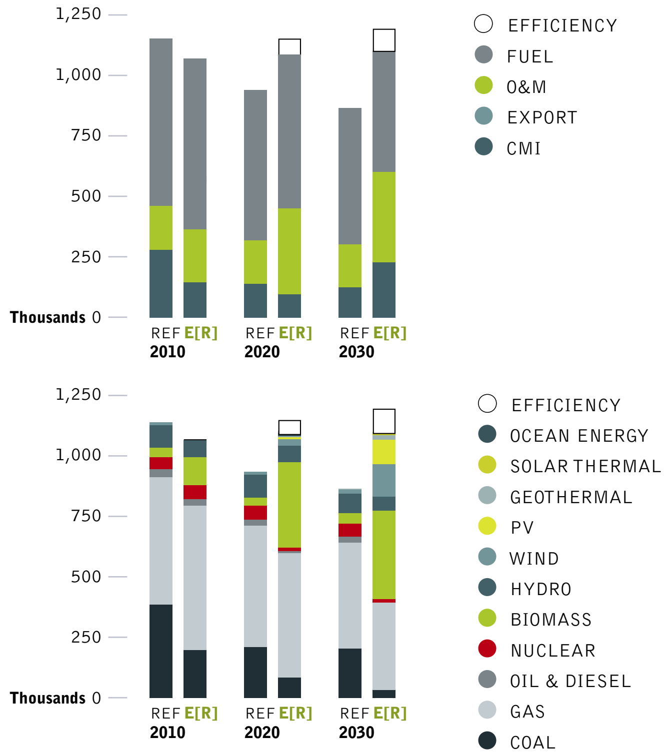


figure 3.30: transition economies: jobs by type and by specific technology in 2010, 2020, and 2030



transition economies: jobs results

- There are 1 million power sector jobs in the [R]evolution scenario in the Transition Economies in 2010, and 1.1 million in the Reference scenario.
- Jobs fall sharply in the Reference case after 2010, while growing in the [R]evolution scenario. By 2020, there are 1.1 million jobs in the [R]evolution scenario, 200,000 more than in the Reference scenario.
- Job numbers continue to fall in the Reference scenario between 2020 and 2030, and strong growth continues in the [R]evolution technologies. By 2030 there are 1.2 million jobs in the [R]evolution compared to 0.9 million in the Reference scenario.

Figure 3.30 shows strong growth in the [R]evolution scenario contrasts with continuing job losses in the Reference scenario. It is assumed that only 30% of renewable energy manufacturing occurs within the region at 2010, increasing to 70% by 2030. However, the Transition economies (mainly Russia) export a high percentage of the inter-regionally traded gas, which results in high employment numbers in the Reference scenario, and significant numbers in the [R]evolution.

Over time, the biggest changes are in coal employment, which drops sharply in both scenarios. In the [R]evolution scenario coal employment almost disappears, to be replaced by biomass as the largest employment sector.

table 3.7: transition economies: employment and electricity generation at 2010, 2020, and 2030

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
	2010	2020	2030	2010	2020	2030
Jobs (thousands)						
Coal	394	220	207	194	84	32
Gas	520	498	441	594	512	364
Nuclear, oil and diesel	86	74	74	87	33	13
Renewable	138	142	137	193	455	676
Energy supply jobs	**1,138**	**934**	**860**	**1,068**	**1,083**	**1,086**
Energy efficiency jobs	-	-	-	0	63	102
Total Jobs	**1,138**	**934**	**860**	**1,068**	**1,146**	**1,188**
Electricity generation (TWh)						
Coal	439	488	532	324	210	100
Gas	662	834	946	758	852	761
Nuclear, oil & diesel	342	377	428	353	305	154
Renewable	346	425	491	354	556	933
TOTAL electricity generation (TWh)	**1,789**	**2,123**	**2,397**	**1,788**	**1,923**	**1,948**

Note: *This underestimates energy efficiency jobs because it only includes jobs additional to the Reference scenario.*

india

india: electricity generation mix

By 2050, about 60% of the electricity produced in India will come from renewable energy sources. 'New' renewables – mainly wind, solar thermal energy and PV – will contribute almost 50%. The installed capacity of renewable energy technologies will grow from the current 38 GW to 915 GW in 2050, a substantial increase over the next 42 years.

Figure 3.31 shows the comparative evolution of different renewable technologies over time. Up to 2030, hydro power and wind will remain the main contributors. After 2020, the continuing growth of wind will be complemented by electricity from biomass, photovoltaics and solar thermal (CSP) energy.

india: future costs of electricity generation

Under the Energy [R]evolution scenario the future costs of electricity generation are greatly decreased compared to the Reference scenario. Because of the lower CO_2 intensity, electricity generation costs will become economically favourable under the Energy R]evolution scenario and by 2050 will be more than 4.5 cents/kWh below those in the Reference scenario. Under the Reference scenario, a massive growth in demand, increased fossil fuel prices and the cost of CO_2 emissions result in total electricity supply costs rising from today's $64 billion per year to more than $930 billion in 2050. Figure 3.33 shows that the Energy R]evolution scenario not only complies with India's CO_2 reduction targets but also helps to stabilise energy costs. Increasing energy efficiency and shifting energy supply to renewables leads to long-term costs that are one third lower than in the Reference scenario.

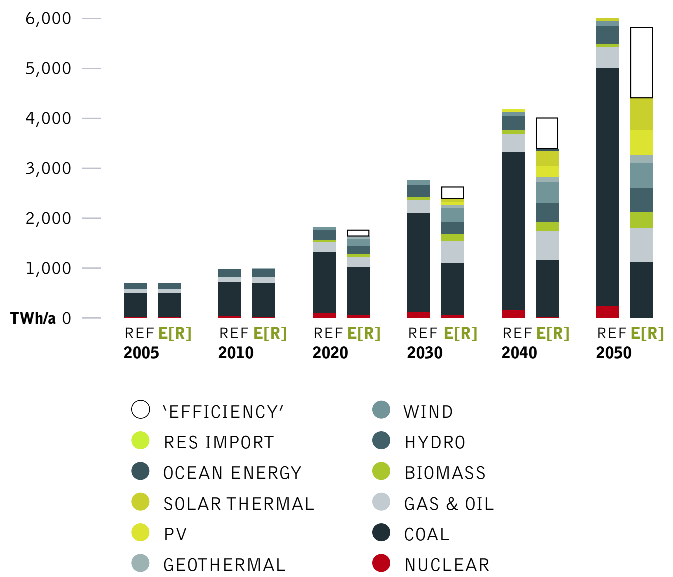
india: CO_2 emissions from power generation

Under the Reference scenario, CO_2 emissions in India will increase by a factor of 5.4 up to 2050, and are not on a sustainable development path. Under the Energy [R]evolution scenario they will increase from the current 1,074 million tonnes in 2005 to reach a peak of 1,820 m/t in 2030. After that they will decrease to 1,660 m/t in 2050. Annual per capita emissions will increase to 1.3 tonnes/capita in 2030 and fall again to 1.0 t/capita in 2050. In spite of the phasing out of nuclear energy and increasing electricity demand, CO_2 emissions will decrease in the electricity sector.

After 2030, efficiency gains and the increased use of renewables in all sectors will soften the still increasing CO_2 emissions in transport, the power sector and industry. Although its share is decreasing, the power sector will remain the largest source of emissions in India, contributing 50% of the total in 2050, followed by transport.

figure 3.31: india: development of electricity supply structure under the two scenarios

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



note GREENPEACE COMISSIONED ANOTHER SCENARIO FOR INDIA WITH HIGHER GDP DEVELOPMENT PROJECTIONS UNTIL 2030. FOR MORE INFORMATION PLEASE VISIT THE ENERGY [R]EVOLUTION WEBSITE WWW.ENERGYBLUEPRINT.INFO/

figure 3.32: india: development of total electricity supply costs & development of specific electricity generation costs under the two scenarios

(CO_2 EMISSION COSTS IMPOSED FROM 2010, WITH AN INCREASE FROM 15 $/T$_{CO_2}$ IN 2010 TO 50 $/T$_{CO_2}$ IN 2050)

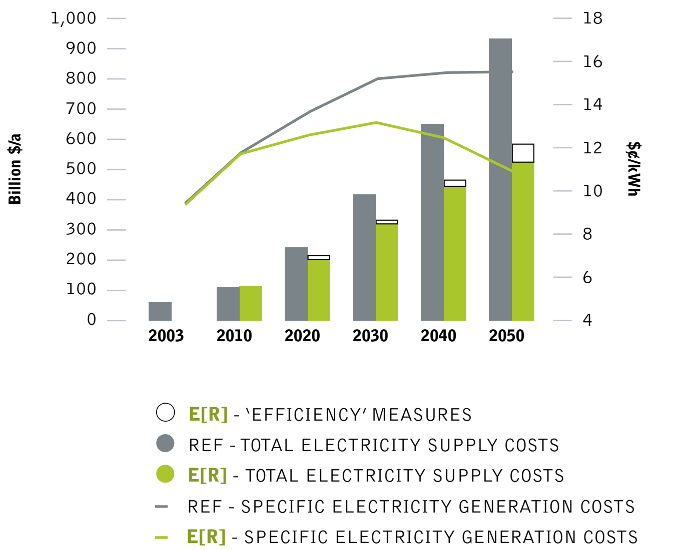


figure 3.33: india: CO_2 emission of the power sector

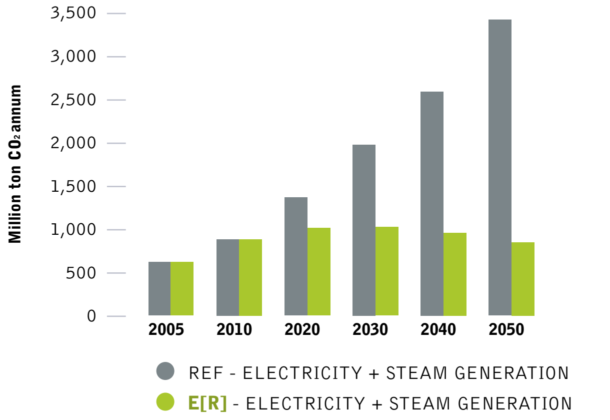
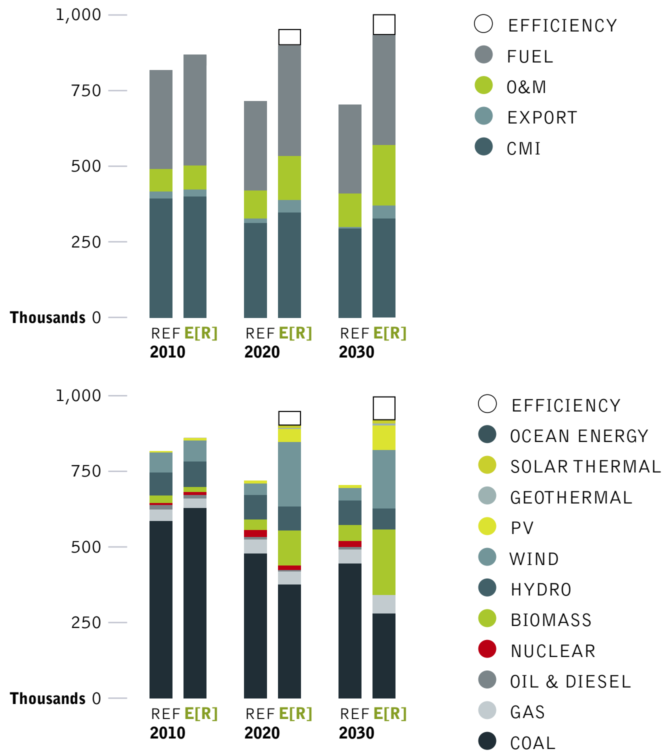


figure 3.34: india: jobs by type and by specific technology in 2010, 2020, and 2030



india: jobs results

- There are 862,000 power sector jobs in the [R]evolution scenario in India in 2010, and 817,000 in the Reference scenario.
- In 2020, job numbers fall in the Reference scenario, but the [R]evolution scenario reaches 949,000.
- Job numbers in the [R]evolution scenario continue to grow, reaching 1 million by 2030, compared to 706,000 in the Reference scenario.

Figure 3.34 shows overall strong growth in the [R]evolution scenario contrasts with continuing job losses in the Reference scenario. Under the [R]evolution scenario electricity use in India is reduced by 8% in 2020 compared to the Reference case, and by 12% in 2030. This will require a program of retrofitting buildings, potentially creating large numbers of energy efficiency jobs.

It is assumed that all manufacturing occurs within the region by 2030, and that India exports nearly 25% of inter-regionally traded renewable energy components. Technology exports account for 5% of energy supply jobs by 2020. In comparison, the Reference scenario shows falling employment, mainly in coal associated jobs.

Over time, there are losses in employment associated with coal generation in both scenarios, but in the [R]evolution scenario these are more than compensated for by gains in the renewable sector. Biomass and wind show particularly strong growth.

table 3.8: india: employment and electricity generation at 2010, 2020, and 2030

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
	2010	2020	2030	2010	2020	2030
Jobs (thousands)						
Coal	588	474	457	628	377	280
Gas	31	42	37	31	40	55
Nuclear, oil and diesel	27	36	27	27	16	3
Renewable	172	167	185	176	475	600
Energy supply jobs	**817**	**719**	**706**	**862**	**908**	**938**
Energy efficiency jobs	-	-	-	-	42	65
Total Jobs	**817**	**719**	**706**	**862**	**949**	**1,003**
Electricity generation (TWh)						
Coal	699	1,248	1,958	699	965	1,080
Gas	85	186	292	85	198	446
Nuclear, oil & diesel	57	116	159	57	65	46
Renewable	156	257	365	156	434	831
TOTAL electricity generation (TWh)	**997**	**1,807**	**2,774**	**997**	**1,661**	**2,403**

Note: *This underestimates energy efficiency jobs because it only includes jobs additional to the Reference scenario.*

developing asia

developing asia: electricity generation mix

By 2050, 67% of the electricity produced in Developing Asia will come from renewable energy sources. 'New' renewables – mainly wind, solar thermal energy and PV – will contribute 55%.

The installed capacity of renewable energy technologies will grow from the current 51 GW to 590 GW in 2050, increasing capacity by a factor of more than ten. Figure 3.35 shows the comparative evolution of the different technologies over time. Up to 2020, hydro power and wind will remain the main contributors. After 2020, the continuing growth of wind will be complemented by electricity from biomass, photovoltaics and geothermal sources.

developing asia: future costs of electricity generation

Figure 3.36 shows that the introduction of renewable technologies under the Energy [R]evolution scenario significantly decreases the future costs of electricity generation compared to the Reference scenario. Because of lower CO_2 intensity in electricity generation, costs will become economically favourable under the Energy [R]evolution scenario. By 2050 they will be more than 5 cents/kWh below those in the Reference scenario. Under the Reference scenario, unchecked growth in demand, an increase in fossil fuel prices and the cost of CO_2 emissions result in total electricity supply costs rising from today's $98 billion per year to more than $566 billion in 2050. Figure 3.37 shows that the Energy [R]evolution scenario not only complies with Developing Asia's CO_2 reduction targets but also helps to stabilise energy costs. Increasing energy efficiency and shifting supply to renewables leads to long term costs that are almost one third lower than in the Reference scenario.

figure 3.35: developing asia: development of electricity supply structure under the two scenarios

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

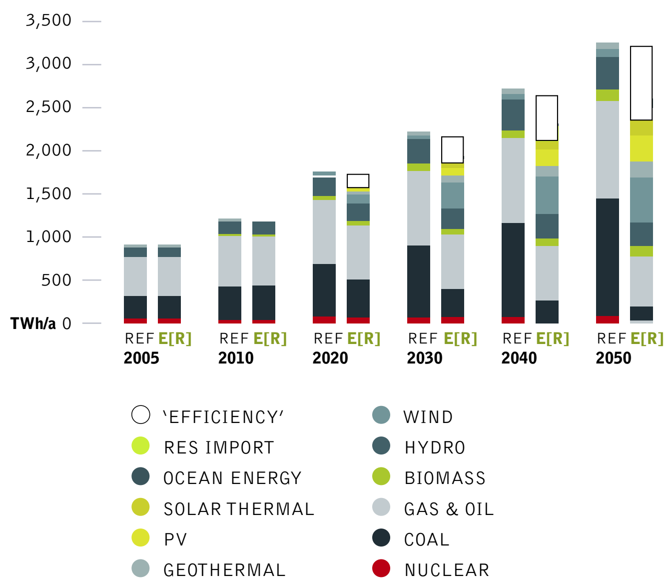


figure 3.36: developing asia: development of total electricity supply costs & development of specific electricity generation costs under the two scenarios

(CO_2 EMISSION COSTS IMPOSED FROM 2010, WITH AN INCREASE FROM 15 $/$T_{CO_2}$ IN 2010 TO 50 $/$T_{CO_2}$ IN 2050)

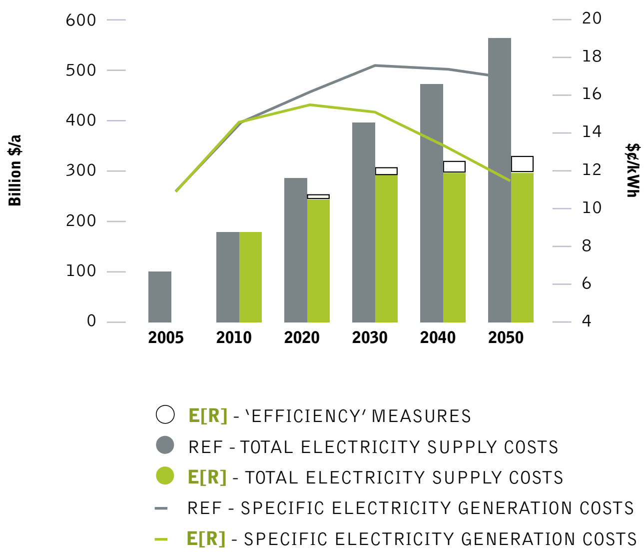


figure 3.37: developing asia: CO_2 emission of the power sector

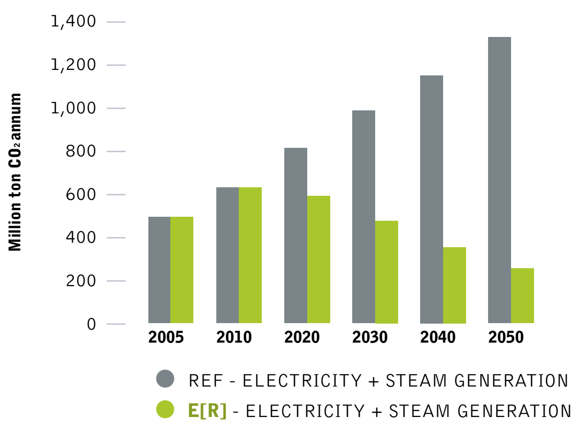
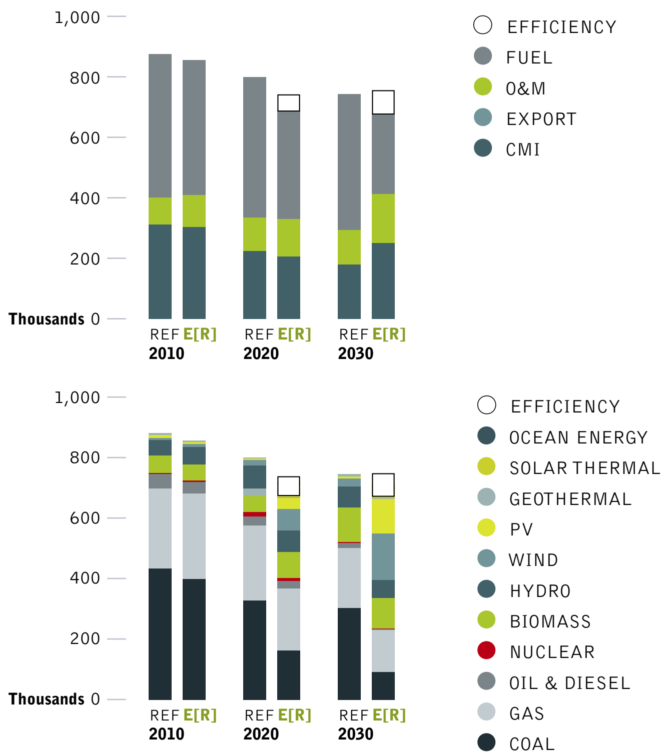


figure 3.38: developing asia: jobs by type and by specific technology in 2010, 2020, and 2030



developing asia: CO_2 emissions from power generation

Whilst Developing Asia's CO_2 emissions will increase by a factor of 2.5 under the Reference scenario, in the Energy [R]evolution scenario they will decrease from 1,300 million tonnes in 2005 to 1,150 m/t in2050. Annual per capita emissions will drop from 1.3 tonnes to 0.8 tonnes. In spite of the phasing out of nuclear energy and increasing demand, CO_2 emissions will decrease in the electricity sector. In the long run efficiency gains and the increased use of renewable electricity in vehicles will stabilise CO_2 emissions in the transport sector. With a share of 22% of total CO_2 in 2050, the power sector will drop below transport as the largest source of emissions.

developing asia: jobs results

- There are 861,000 jobs projected in the [R]evolution scenario in 2010, compared to 881,000 in the Reference scenario.
- In 2020, job numbers in both scenarios fall. There is somewhat better retention of jobs in the Reference scenario, with 799,000 compared to 741,000 in the [R]evolution scenario.
- By 2030 the job numbers in the [R]evolution scenario are increasing, and there are 754,000. Jobs in the Reference scenario continue to fall, reaching 738,000.

Figure 3.38 shows that, if only energy supply jobs are considered, the Reference has slightly higher job numbers in 2020. However, electricity use in the [R]evolution scenario is reduced by 11% in 2020 compared to the Reference case, and 17% by 2030. This will require a major energy efficiency program, potentially creating large numbers of additional construction and energy management jobs.

Over time, both scenarios show significant losses in coal sector employment, with 100,000 coal jobs lost by 2010 in the Reference scenario. While losses in the coal sector are greater in the [R]evolution scenario, strong growth in the renewable sectors, particularly wind power, more than compensates, resulting in significantly higher job numbers in the [R]evolution scenario.

developing asia

Developing Asia (mostly Indonesia) is a major coal exporter, and fuel exports account for nearly a quarter of the fuel supply jobs in 2020 (both scenarios). However, while coal export jobs fall in the [R]evolution scenario, gas exports increase in the [R]evolution relative to the Reference scenario. Figure 3.38 shows the change in job numbers under both scenarios for each technology between 2010 and 2020, and 2010 and 2030.

Developing Asia is assumed to import 70% of renewable technology in 2010 and 30% in 2030. If, however, domestic manufacturing goes up, reaching 100% in 2030, jobs in the [R]evolution scenario would reach 798,000 by 2030.

developing asia: note about job multipliers Power sector job projections for Developing Asia are highest in 2010 in both scenarios, mainly due to high projections of economic growth in this region by the IEA (2007). For this reason, the job multiplier for Developing Asia starts high but decreases over the study period. If no job multiplier was used, jobs would be projected to grow steadily over the study period in both scenarios; however the total job projections would be much lower overall.

figure 3.39: **developing asia: the effect of the job multiplier on employment projections**

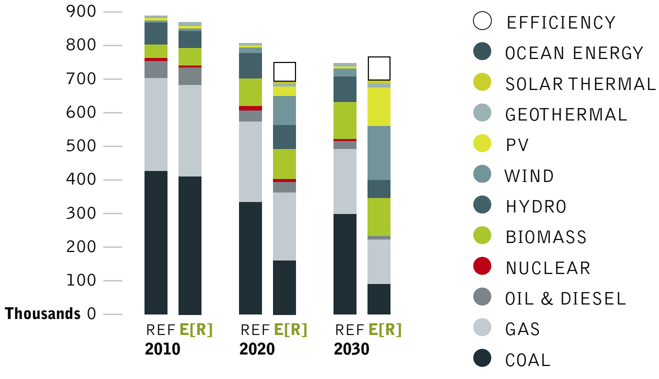


table 3.9: **developing asia: employment and electricity generation at 2010, 2020, and 2030**

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
	2010	2020	2030	2010	2020	2030
Jobs (thousands)						
Coal	423	327	300	399	158	86
Gas	272	239	192	276	208	138
Nuclear, oil and diesel	50	46	26	50	36	15
Renewable	135	188	220	135	286	445
Energy supply jobs	**881**	**799**	**738**	**861**	**688**	**684**
Energy efficiency jobs	-	-	-	0.2	53	70
Total Jobs	**881**	**799**	**738**	**861**	**741**	**754**
Electricity generation (TWh)						
Coal	390	595	820	389	425	342
Gas	456	644	786	456	545	570
Nuclear, oil & diesel	179	208	186	179	170	110
Renewable	184	311	442	184	420	823
TOTAL electricity generation (TWh)	**1,210**	**1,758**	**2,234**	**1,209**	**1,560**	**1,845**

Note: *This underestimates energy efficiency jobs because it only includes jobs additional to the Reference scenario.*

china

china: electricity generation mix

By 2050, 63% of the electricity produced in China will come from renewable energy sources. 'New' renewables – mainly wind, solar thermal energy and PV – will contribute 46% of electricity generation. The following strategy paves the way for a future renewable energy supply: Rising electricity demand will be met initially by bringing into operation new highly efficient gas-fired combined-cycle power plants, plus an increasing capacity of wind turbines and biomass. In the long term, wind will be the most important single source of electricity generation. Solar energy, hydro power and biomass will also make substantial contributions.

The installed capacity of renewable energy technologies will grow from the current 119 GW to 1,950 GW in 2050, an enormous increase resulting in a considerable demand for investment over the next 20 years. Figure 3.40 shows the comparative evolution of the different renewable technologies over time. Up to 2020, hydro power and wind will remain the main contributors. After 2020, the continuing growth of wind will be complemented by electricity from biomass, photovoltaics and solar thermal energy.

china: future costs of electricity generation

Figure 3.41 shows that the introduction of renewable technologies under the Energy [R]evolution scenario slightly increases the costs of electricity generation compared to the Reference scenario. The difference will be less than 1 cents/kWh up to 2020. Because of the lower CO_2 intensity, by 2020 electricity generation costs in China will become economically favourable under the Energy [R]evolution scenario, and by 2050 will be more than 5 cents/kWh below those in the Reference scenario. Under the Reference scenario, the unchecked growth in demand, the increase in fossil fuel prices and the cost of CO_2 emissions result in total electricity supply costs rising from today's $205 billion per year to more than $1,940 billion in 2050. Figure 3.42 shows that the Energy [R]evolution scenario not only complies with China's CO_2 reduction targets but also helps to stabilise energy costs. Increasing energy efficiency and shifting energy supply to renewables leads to long term costs for electricity supply that are one third lower than in the Reference scenario.

figure 3.40: china: development of electricity supply structure under the two scenarios

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

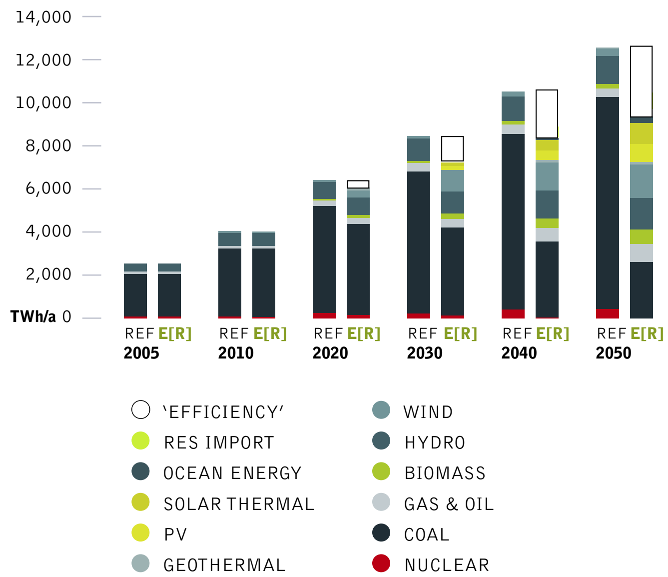
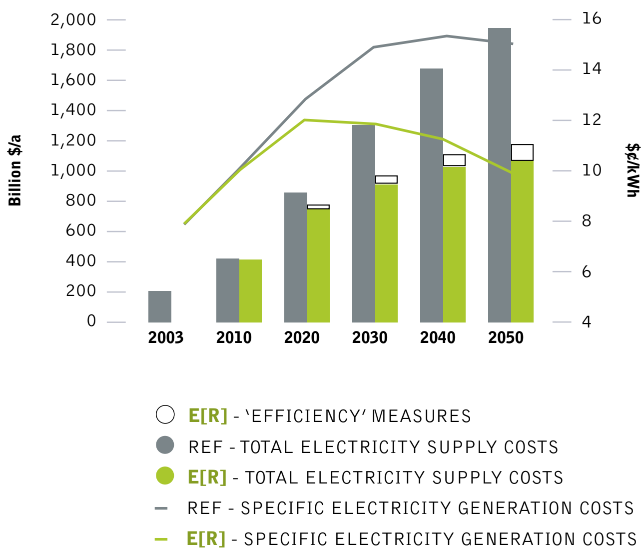


figure 3.41: china: development of total electricity supply costs & development of specific electricity generation costs under the two scenarios

(CO_2 EMISSION COSTS IMPOSED FROM 2010, WITH AN INCREASE FROM 15 $/T$_{CO_2}$ IN 2010 TO 50 $/T$_{CO_2}$ IN 2050)



china

china: CO_2 emissions from power generation

Whilst China's emissions of CO_2 will almost triple under the Reference scenario, under the Energy [R]evolution scenario they will decrease from 4,400 million tonnes in 2005 to 3,200 m/t in 2050. Annual per capita emissions will drop from 3.4 tonnes to 2.3 t. In spite of increasing demand, CO_2 emissions will decrease in the electricity sector. In the long run efficiency gains and the increased use of renewable electricity in vehicles will even reduce CO_2 emissions in the transport sector. With a share of 50% of total CO_2 in 2050, the power sector will remain the largest source of emissions.

china: jobs results

- There are close to 2.9 million energy jobs projected in China in both scenarios in 2010, with about 40,000 more in the [R]evolution scenario (note that these only include jobs associated with the electricity sector)[13].
- In 2020, job numbers in both scenarios fall relative to 2010, but the [R]evolution scenario keeps 2.2 million jobs compared to 1.9 million in the Reference scenario. The [R]evolution has 300,000 more jobs than the Reference scenario.
- In 2030 the [R]evolution retains just over 2 million jobs, while the Reference scenario job numbers fall to 1.5 million. The [R]evolution has 500,000 more jobs than the Reference scenario at 2030.

The most striking feature of the job projections for China is the decrease between 2010 and 2020. Job numbers fall from close to 2.9 million in both scenarios to just 1.9 million in the Reference scenario, and 2.1 million in the [R]evolution scenario.

There are more power sector jobs in China in the [R]evolution scenario at every stage. In 2010, [R]evolution jobs are about 40,000 higher than the Reference scenario. By 2020, the [R]evolution scenario has 300,000 additional jobs, and by 2030 the [R]evolution scenario has about 570,000 more jobs than the Reference scenario.

Over time, both scenarios show significant job losses, but more jobs are retained in the [R]evolution scenario. Coal sector jobs fall substantially between 2010 and 2020 in both scenarios. For example, in the Reference scenario jobs in the coal sector are 100,000 less at 2020 than 2010, continuing current trends world wide. In the [R]evolution scenario coal losses are greater, but only by about 20,000. In the [R]evolution, these losses are counteracted by strong growth in the renewable power sectors, particularly wind energy, combined heat and power, and solar PV, with the effect that more jobs are retained in the [R]evolution scenario. In the Reference case, job growth in renewable energy is weak, so the job losses in the coal sector dominate.

figure 3.42: china: CO_2 emission of the power sector

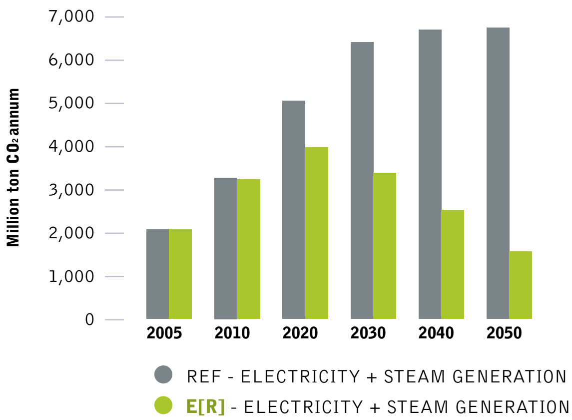
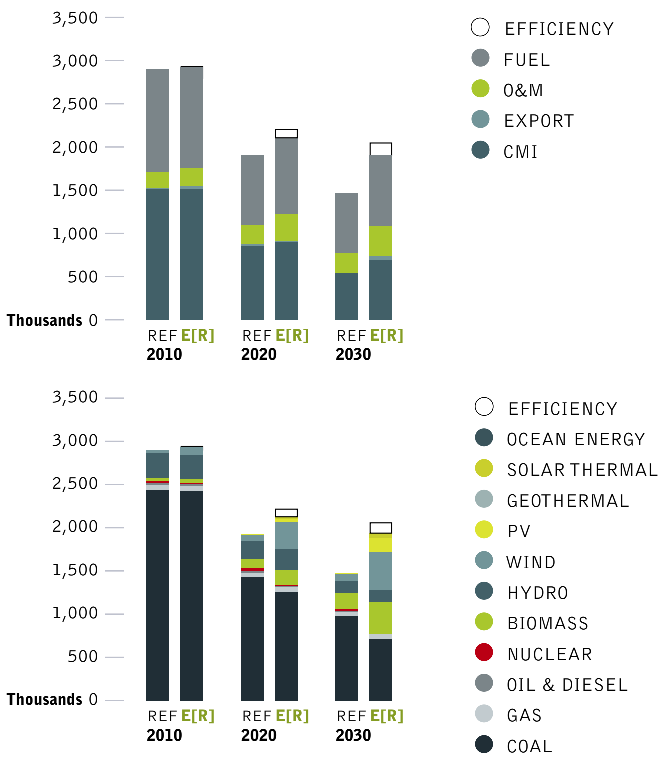


figure 3.43: china: jobs by type and by specific technology in 2010, 2020, and 2030



references
13 ONLY COAL FOR ELECTRICITY GENERATION AND COMBINED HEAT AND POWER IS INCLUDED HERE, IN ORDER TO USE A CONSISTENT METHODOLOGY. THE CHINA YEAR BOOK 2008 REPORTS 3.6 MILLION JOBS IN COAL MINING AND 2.3 MILLION IN ELECTRICITY GENERATION; HOWEVER, AS A LITTLE MORE THAN HALF OF CHINESE COAL PRODUCTION WAS USED FOR NON-ELECTRICITY PURPOSES, APPROXIMATELY 1.9 MILLION OF THESE ARE NOT INCLUDED IN THIS ANALYSIS.

The job losses projected between 2010 and 2020 are largely a result of the increased prosperity in China. The model shows a fall in employment because there is a strong projected growth in prosperity and labour productivity. If no regional multiplier was used, this projection would show more stable levels of employment.

To model the future jobs, we used specific data for the Chinese the coal sector, which could be an underestimate of the change in productivity in coal production. If this is the case, the reality would be an even greater loss of jobs in the coal sector. However, both the increase in productivity and the scale of job losses is very much a matter of policy. Currently it is Chinese government policy to close the small, employment intensive, village coal mines, which would have a huge impact on coal sector jobs. It may also be government policy to transfer these jobs into, for example, energy efficiency, cogeneration, or renewable energy, to better manage regional employment levels. The job multiplier used for China is 1.9 in 2010, 1.2 by 2020, and to 1 by 2030. This fall is a result of the projected 7% annual growth in GDP per capita, derived from IEA 2007[14]. It projected that China will have the same GDP per capita as the OECD average by 2030, so the generating capacity which supported 1.8 jobs in 2010 will only support 1 job by 2030.

figure 3.44: china: the effect of the job multiplier on employment projections

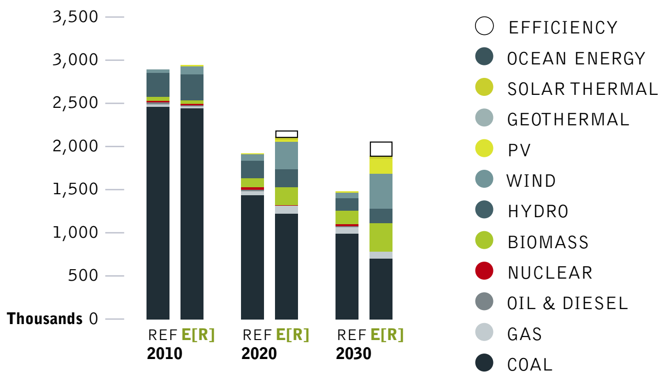


table 3.10: china: employment and electricity generation at 2010, 2020, and 2030

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
Jobs (thousands)	2010	2020	2030	2010	2020	2030
Coal	2,461	1,449	1,017	2,438	1,232	709
Gas	27	42	42	28	59	66
Nuclear, oil and diesel	34	43	33	31	20	5
Renewable	378	379	382	442	811	1,128
Energy supply jobs	**2,899**	**1,912**	**1,474**	**2,940**	**2,123**	**1,909**
Energy efficiency jobs	-	-	-	2	80	151
Total Jobs	**2,899**	**1,912**	**1,474**	**2,942**	**2,204**	**2,059**
Electricity generation (TWh)						
Coal	3,179	5,050	6,586	3,150	4,238	4,105
Gas	62	170	313	62	220	420
Nuclear, oil & diesel	130	222	305	126	148	88
Renewable	587	946	1,268	611	1,378	2,645
TOTAL electricity generation (TWh)	**3,957**	**6,388**	**8,472**	**3,948**	**5,983**	**7,258**

Note: *This underestimates energy efficiency jobs because it only includes jobs additional to the Reference scenario.*

references
14 THE JOB MULTIPLIER IS CALCULATED FROM LABOUR PRODUCTIVITY ACROSS THE NON-AGRICULTURAL ECONOMY, AND THE CHANGE IN LABOUR PRODUCTIVITY IS ASSUMED TO MIRROR THE CHANGE IN GDP PER CAPITA.

oecd pacific

oecd pacific: electricity generation mix

By 2050, 78% of the electricity produced in the OECD Pacific will come from renewable energy sources. 'New' renewables – mainly wind, solar thermal energy and PV – will contribute 68%.

The installed capacity of renewable energy technologies will grow from the current 62 GW to more than 600 GW in 2050, an increase by a factor of ten. To achieve an economically attractive growth in renewable energy sources, a balanced and timely mobilisation of all technologies is of great importance. Figure 3.45 shows the comparative evolution of the different renewables over time. Up to 2020, hydro power andwind will remain the main contributors. After 2020, the continuing growth of wind will be complemented by electricity from biomass, photovoltaic and solar thermal energy.

oecd pacific: future costs of electricity generation

Under both scenarios, the costs of generating electricity rise at about the same rate until 2030, when the cost of electricity generation from renewable energy under the Energy [R]evolution scenario forces overall costs down. By 2050, electricity costs in the Energy [R]evolution scenario have returned to less than 12c/kWh, compared to the Reference scenario, under which electricity costs rise to more than 16c/kWh.

oecd pacific: CO_2 emissions from power generation

Whilst the OECD Pacific's emissions of CO_2 will increase by 20% under the Reference scenario, under the Energy [R]evolution scenario they will decrease from 1,900 million tonnes in 2005 to 430 m/t in 2050. Annual per capita emissions will fall from 9.5 tonnes to 2.4 t. In the long run efficiency gains and the increased use of renewable electricity in vehicles will even reduce CO_2 emissions in the transport sector. With a share of 45% of total CO_2 in 2050, the power sector will remain the largest source of emissions.

oecd pacific: strong policy underpins the energy [r]evolution scenario

The Energy [R]evolution scenario for the OECD pacific region is delivered through strong policies to drive rapid and sustained development of renewable energy. In smaller markets and for newer technologies, upfront investment will be very important. However, for markets with much larger potential, such as Australia, policies that deliver long-term stability and certainty for renewable energy are critical. Feed-in tariffs have been shown to be the most effective policy step in creating a strong and jobs rich environment.

figure 3.45: oecd pacific: development of electricity supply structure under the two scenarios

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

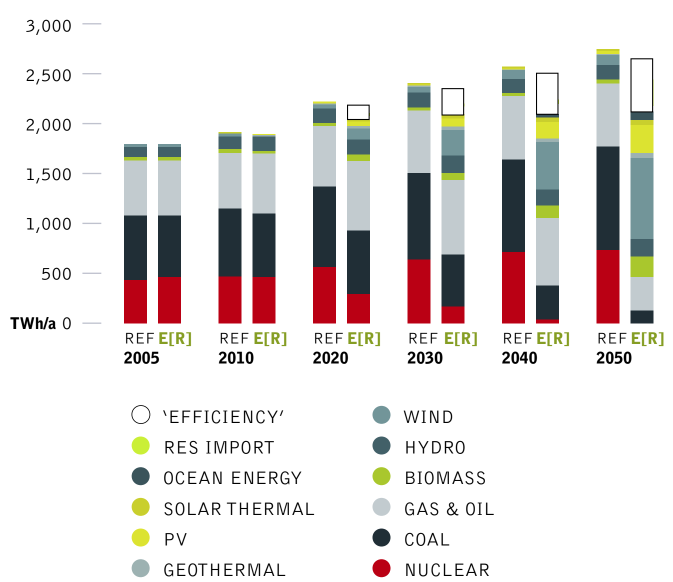


figure 3.46: oecd pacific: development of total electricity supply costs & development of specific electricity generation costs under the two scenarios

(CO_2 EMISSION COSTS IMPOSED FROM 2010, WITH AN INCREASE FROM 15 $/T$_{CO_2}$ IN 2010 TO 50 $/T$_{CO_2}$ IN 2050)

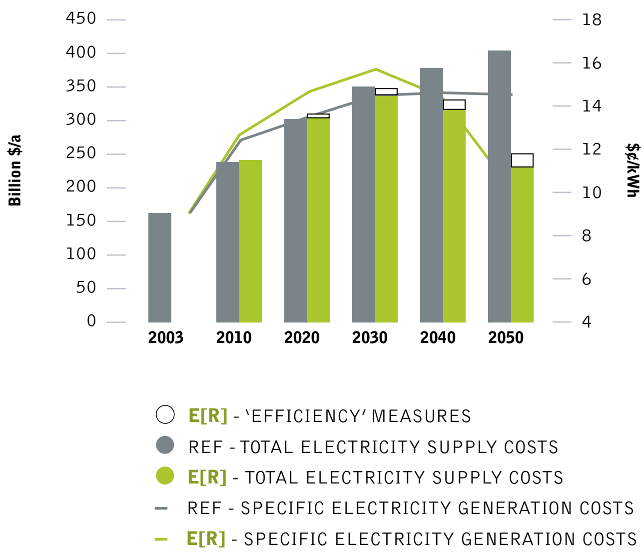


figure 3.47: oecd pacific: developing asia: CO_2 emission of the power sector

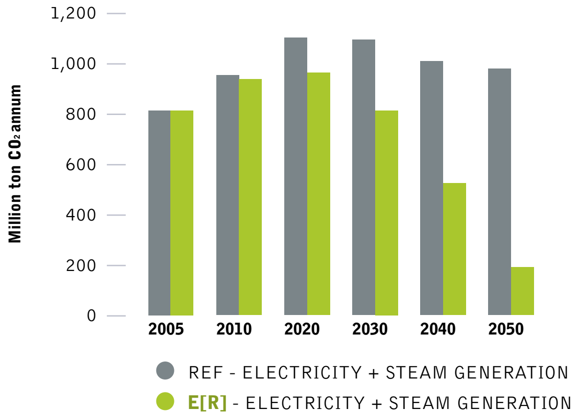
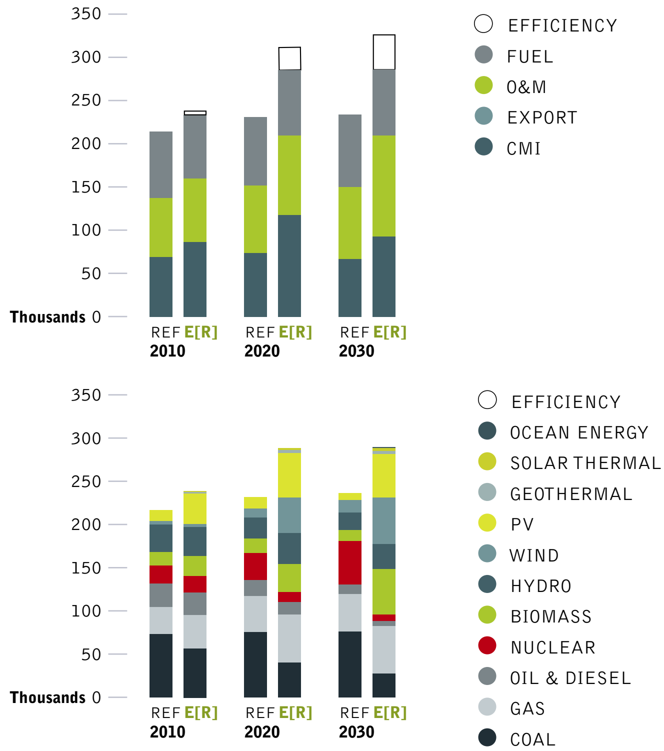


figure 3.48: oecd pacific: jobs by type and by specific technology in 2010, 2020, and 2030



oecd pacific: jobs results

- There are 238,000 power sector jobs in the [R]evolution scenario in the OECD Pacific region in 2010, and 214,000 in the Reference scenario.
- In 2020, job numbers reach 310,000 in the [R]evolution scenario, 80,000 more than in the Reference scenario.
- Energy supply job numbers fall slightly in the [R]evolution scenario at 2030, but growth in energy efficiency means that are there are 324,000 jobs in the [R]evolution scenario by 2030, nearly 90,000 more than in the Reference scenario.

There are more power sector jobs projected for the OECD Pacific region in the [R]evolution scenario at every stage. Under the [R]evolution scenario electricity use in OECD Pacific region is reduced by 12% in 2020 compared to the Reference case. This will require a major program of retrofitting buildings, and improving industrial and service efficiency. Jobs in energy efficiency maintain the growth in jobs when energy supply jobs remain level.

The greatest losses occur in jobs associated with coal generation in the [R]evolution scenario, but extremely strong growth in all renewable sectors lead to a substantial net gain in job numbers.

It is assumed that by 30% of renewable energy manufacturing occurs within the region at 2020, and this increases to 50% by 2030.

table 3.11: oecd pacific: employment and electricity generation at 2010, 2020, and 2030

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
	2010	2020	2030	2010	2020	2030
Jobs (thousands)						
Coal	73	76	73	56	41	28
Gas	30	41	46	39	55	54
Nuclear, oil and diesel	47	49	57	45	26	14
Renewable	63	64	58	98	164	189
Energy supply jobs	**214**	**229**	**235**	**238**	**285**	**286**
Energy efficiency jobs	-	-	-	2	25	39
Total Jobs	**214**	**229**	**235**	**240**	**310**	**324**
Electricity generation (TWh)						
Coal	684	808	857	652	629	533
Gas	415	501	557	454	631	687
Nuclear, oil & diesel	632	669	723	600	375	210
Renewable	180	233	265	196	411	665
TOTAL electricity generation (TWh)	**1,911**	**2,210**	**2,402**	**1,902**	**2,045**	**2,096**

Note: *This underestimates energy efficiency jobs because it only includes jobs additional to the Reference scenario.*

highlights for g8 countries

energy [r]evolution

The Energy [R]evolution for the G8 countries sets a greenhouse emissions reduction target of 40% below 1990 levels by 2020 and at least 80% below 1990 levels by 2050. Based on today's CO_2 emissions for the G8 countries – the United States, Canada, Germany, the United Kingdom, Italy, Japan, Russia and France – the total CO_2 reduction in the power sector could be cut by almost 50% by 2030.

Under the Energy [R]evolution:

- In 2020, the scenario for G8 countries projects renewable electricity capacity of 978 GW, supplying 32% of total electricity production, compared to 20% if business as usual continues.
- By 2030, installed renewable energy technologies will grow to 1,500 GW accounting for 50% of electricity generation.
- The total value of the renewable industry would triple from about $100 billion (€70 billion euro) in 2007, to $347 billion in 2020. By 2030 over $420 billion could be invested in renewable energy sources.

g8 countries: jobs results

By 2020, across the G8, power sector jobs in the Energy [R]evolution scenario are estimated at about 1.4 million, about 460,000 more than in the business-as-usual scenario.

By 2030, investing in renewables and energy efficiency will create about 2.1 million jobs, 650,000 more than conventional energy (Reference scenario).

More than 1.8 million jobs in the renewable power sector would be created in the Energy [R]evolution scenario – about 1 million more than in the Reference scenario – compensating for about 394,000 jobs lost in fossil and nuclear power generation.

Figure 3.49 shows the number of jobs under both the Energy [R]evolution and the business-as-usual scenarios by technology and type: operations, maintenance and fuel (O&M and fuel) and construction, manufacturing and installation (CMI) in 2010, 2020 and 2030. Combined heat and power generation is included under the fuel type.

As can be seen, by switching to zero-carbon energy, jobs increase significantly from 1.4 million in 2010 to 1.8 million by 2020, and then reach 2.1 million in 2030. If G8 countries do not switch, power sector jobs will merely stabilise around 1.4 to 1.5 million jobs by 2010 and 2030.

By moving to a power supply based in renewables, G8 electricity use would be reduced by 11% in 2020 compared to business-as-usual. This will require a major programme of retrofitting buildings in every region, creating a large number of additional construction jobs in the next decade.

By 2030, construction jobs from energy efficiency may not be as significant, as building retrofits should be completed and new construction practices to meet improved energy standards should have become integrated into normal construction and manufacturing techniques. However, there is likely to be significant growth in jobs associated with energy management, both at the facilities level and in grid management by 2020 and 2030, but it is beyond the scope of this analysis to assess numbers.

There is a decrease in coal power jobs in both scenarios between 2010 and 2020, but strong growth in renewable energy jobs leading to a net gain in employment. Growth in gas generation jobs in the business as usual scenario is not sufficient to compensate for the losses in coal jobs.

image TECHNICIAN CLIMBING A WIND TURBINE IN BURBO BANK, LIVERPOOL PAY, UK.

figure 3.49: g8 countries: jobs by type and by specific technology in 2010, 2020, and 2030

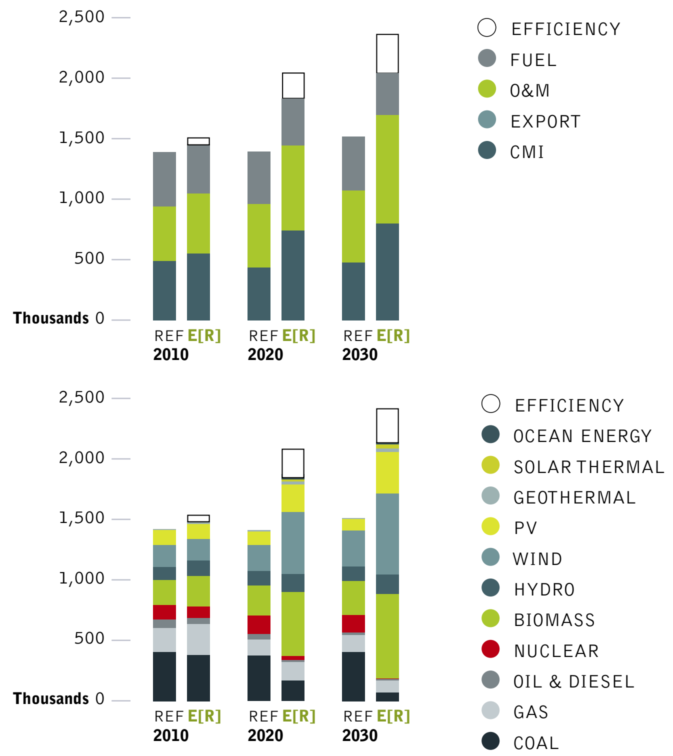


table 3.12: G8 employment, electricity generation and investment at 2010, 2020, 2030

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
	2010	2020	2030	2010	2020	2030
Job (millions)						
Coal	0.42 m	0.38 m	0.42 m	0.37 m	0.16 m	0.08 m
Gas	0.23 m	0.18 m	0.16 m	0.31 m	0.20 m	0.16 m
Nuclear, oil and diesel	0.17 m	0.18 m	0.15 m	0.15 m	0.07 m	0.02 m
Renewable	0.61 m	0.70 m	0.82 m	0.70 m	1.49 m	1.88 m
Energy supply jobs	**1.44 m**	**1.44 m**	**1.54 m**	**1.52 m**	**1.92 m**	**2.14 m**
Energy efficiency jobs	**0.00 m**	**0.00 m**	**0.00 m**	**0.05 m**	**0.21 m**	**0.30 m**
Total Jobs	**1.44 m**	**1.44 m**	**1.54 m**	**1.57 m**	**2.13 m**	**2.45 m**
Electricity generation (TWh)						
Coal	3,439	3,810	4,316	3,209	2,160	1,296
Gas	2,170	2,471	2,674	2,505	3,027	3,062
Nuclear, oil & diesel	2,431	2,442	2,415	2,026	1,161	330
Renewable	1,446	1,954	2,372	1,533	3,111	4,944
TOTAL electricity generation (TWh)	**9,486**	**10,677**	**11,777**	**9,274**	**9,459**	**9,632**

Note: *This underestimates energy efficiency jobs because it only includes jobs additional to the Reference scenario.*

key results by technology

GLOBAL

ALL TECHNOLOGIES COMPARED TO FOSSIL FUELS AND NUCLEAR ENERGY

SOLAR PHOTOVOLTAIC (PV)
CONCENTRATING SOLAR POWER (CSP)
WIND
WAVE AND TIDAL

GEOTHERMAL
BIOMASS
FOSSIL FUELS AND NUCLEAR

4

“there is a far stronger growth in renewable energy, resulting in more jobs.”

GREENPEACE INTERNATIONAL
CLIMATE CAMPAIGN

image WORKER EXAMINES PARABOLIC TROUGH COLLECTORS IN SPAIN

image CONSTRUCTING WINDTURBINES IN HÉTOMESNIL, PICARDIE, FRANCE.

future growth rates

In order to get a better understanding of what different technologies can deliver, it is necessary to examine more closely how future production capacities can be achieved from the current baseline. The wind industry, for example, has a current annual production capacity of about 25,000 MW. If this output were not expanded, total capacity would reach 650 GW by the year 2050. This includes the need for "repowering" of older wind turbines after 20 years. But according to this scenario the share of wind electricity in global production by 2050 would need to grow from today's 1% to 4.5% under the Reference scenario and 6.5% under the Energy [R]evolution pathway.

A relatively modest expansion from today's 25 GW production capacity, however, to about 80 GW by 2020 and 100 GW in 2040 would lead to a total installed capacity of 1,800 GW in 2050, providing between 12% and 18% of world electricity demand.

The tables below provide an overview of current generation levels, the capacities required under the Energy [R]evolution scenario and industry projections of a more advanced market growth. The good news is that the scenario does not even come close to the limit of the renewable industries' own projections. However, the scenario assumes that at the same time strong energy efficiency measures are taken in order to save resources and develop a more cost optimised energy supply.

table 4.1: required production capacities for renewable energy technologies in different scenarios

NEW RENEWABLE ELECTRICITY GENERATION TECHNOLOGIES	2010	2020	2030	2040	2050	TOTAL INSTALLED CAPACITY IN 2050	ELECTRICITY SHARE UNDER E[R] DEMAND PROJECTION IN 2050
			INCLUDES PRODUCTION CAPACITY FOR REPOWERING				
	GW/a	GW/a	GW/a	GW/a	GW/a	GW	%
Solar Photovoltaics PRODUCTION CAPACITY IN 2007 (APPROX. 5-7 GW)							
Reference	2	5	5	5	5	153	0
Energy [R]evolution	4	40	65	100	125	2,911	10
Concentrated Solar Power PRODUCTION CAPACITY IN 2007 (APPROX. 2-3 GW)							
Reference	0.5	0.5	0.5	0.5	0.5	17	0
Energy [R]evolution	1	12	17	27	33	801	12
Wind PRODUCTION CAPACITY IN 2007 (APPROX. 25 GW)							
Reference	25	25	25	25	25	593	4
Energy [R]evolution	30	82	85	100	100	2,733	18
Geothermal PRODUCTION CAPACITY IN 2007 (APPROX. 1-2 GW)							
Reference	1	1	1	1	1	36	1
Energy [R]evolution		5	6	10	10	276	4
Ocean PRODUCTION CAPACITY IN 2007 (APPROX. >1 GW)							
Reference	0.2	0.2	0.2	0.3	0.3	9	0
Energy [R]evolution	0	2	3	5	10	194	2
Total PRODUCTION CAPACITIES PRODUCTION CAPACITY IN 2007 (APPROX.)							
Reference	28	32	31	31	31	808	5
Energy [R]evolution	36	141	176	242	278	6,916	46

figure 4.1: global: cummulative installed capacity: reference and energy [r]evolution

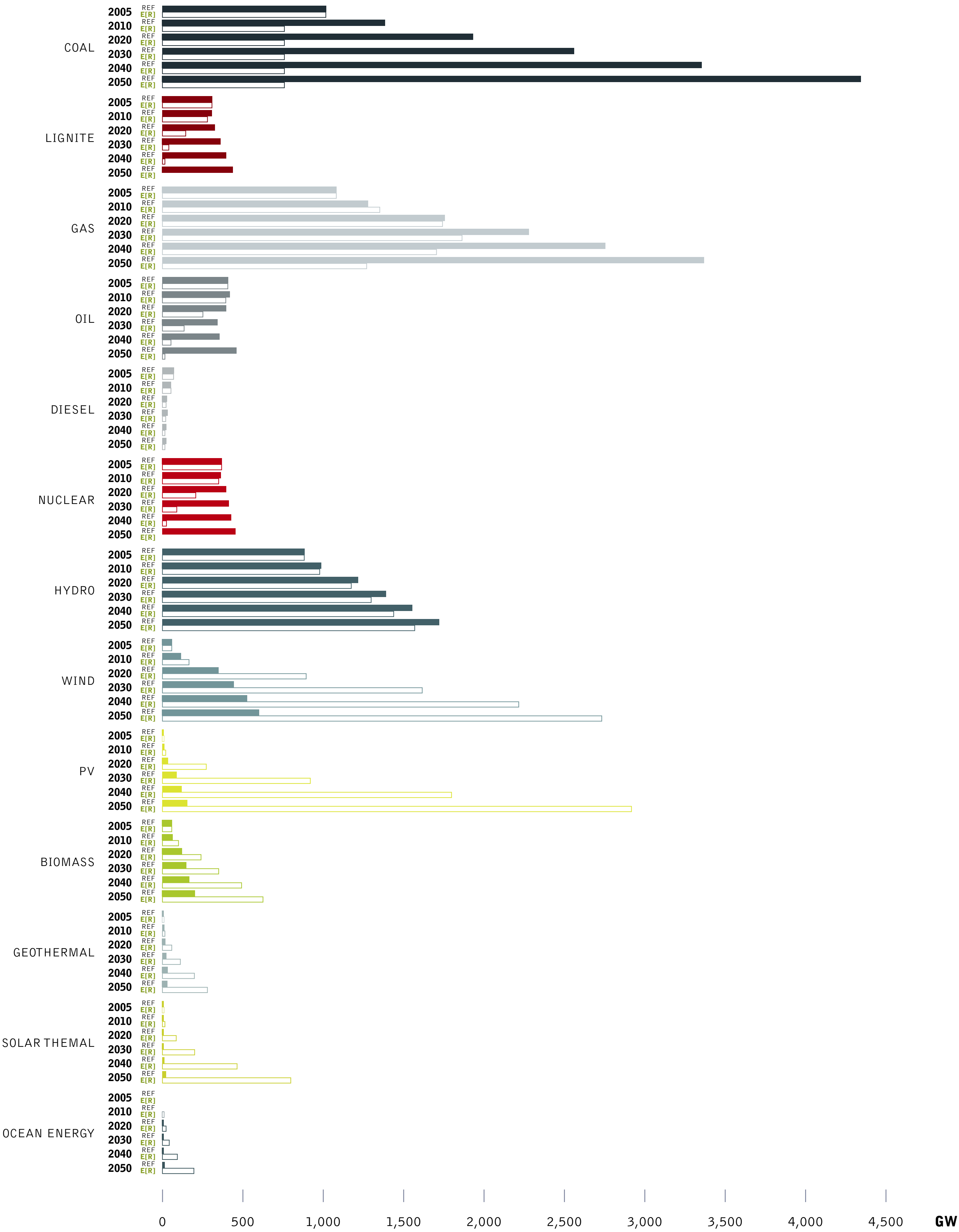


image GREENPEACE DONATES A SOLAR POWER SYSTEM TO A COASTAL VILLAGE IN ACEH, INDONESIA, ONE OF THE WORST HIT AREAS BY THE TSUNAMI IN DECEMBER 2004.

global: jobs results

In 2020, there are 2 million more jobs overall in the power sector, under the Energy [R]evolution scenario than there would be under the Reference scenario. In both scenarios there would be fewer jobs in coal between 2010 and 2020. Under the [R]evolution scenario the jobs losses in coal would be greater, however, there is far stronger growth in the renewable energy and energy efficiency sectors, resulting in more jobs, overall.

Figure 4.2 shows that by 2020, more than half of direct jobs in the [R]evolution scenario are in renewable energy, even though renewable energy accounts for only 36% of electricity generation. In the Reference scenario renewable energy accounts for 28% of power sector jobs and 22% of electricity generation. This reflects the fact that the renewable sector has greater "labour intensity" – or people per unit of power produced.

In 2010 coal is the largest employer in both scenarios, making up nearly half of power sector employment. In both scenarios, coal sector employment drops by 2020, to 34% in the Reference and to just 21% in the [R]evolution scenario. But this reduction is more than compensated for by the strong growth in the renewable sector.

In the [R]evolution scenario, wind power employment grows the most, and has the highest number of direct jobs in both 2020 and 2030. Renewable CHP (mostly biomass) has the next highest employment by 2030, closely followed by solar PV.

figure 4.2: global: employment change in 2020 and 2030, compared to 2010

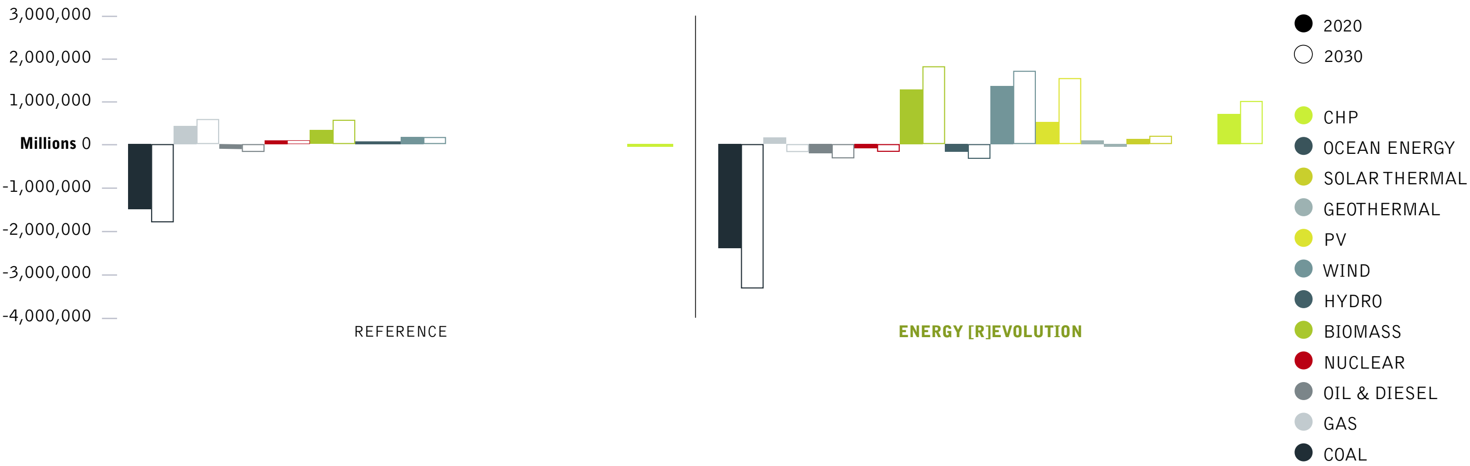


table 4.2: global: summary of results

	REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
	2010	2020	2030	2010	2020	2030
Jobs (millions)						
Coal	4.65 m	3.16 m	2.86 m	4.26 m	2.28 m	1.39 m
Gas	1.95 m	2.36 m	2.55 m	2.08 m	2.12 m	1.80 m
Nuclear, oil and diesel	0.61 m	0.58 m	0.50 m	0.56 m	0.31 m	0.13 m
Renewable	1.88 m	2.41 m	2.71 m	2.38 m	5.03 m	6.90 m
Energy supply jobs	**9.1**	**8.5**	**8.6**	**9.3**	**9.7**	**10.2**
Energy efficiency jobs	-	-	-	0.06	0.72	1.13
Total Jobs	**9.1**	**8.5**	**8.6**	**9.3**	**10.5**	**11.3**
Electricity generation (TWh)						
Coal	9,283	12,546	16,030	8,751	8,953	7,784
Gas	4,447	6,256	7,974	4,704	6,126	6,335
Nuclear, oil & diesel	4,004	4,133	4,079	3,814	2,309	1,003
Renewable	4,047	5,871	7,286	4,254	8,355	14,002
TOTAL electricity generation (TWh)	**21,780**	**28,807**	**35,369**	**21,523**	**25,743**	**29,124**

image VOLUNTEERS CHECK THE SOLAR PANELS ON TOP OF GREENPEACE POSITIVE ENERGY TRUCK, BRAZIL. GREENPEACE TOUR THROUGH BRAZIL IN LARGE TRUCK LOADED WITH A CONTAINER FULL OF FACTUAL INFORMATION ON THE POSITIVE ASPECTS OF RENEWABLE ENERGY.

solar photovoltaic (PV)

The worldwide photovoltaics (PV) market has been growing at over 35% per annum in recent years and it can now make a significant contribution to electricity generation. Development work is focused on increasing the energy efficiency and reducing material usage of systems and modules. New technologies are developing quickly, including PV thin film (using alternative semiconductor materials) or dye sensitive solar cells and these present a huge potential for cost reduction.

Photovoltaics have been following a fairly consistent pattern of cost reduction of 20% each time the capacity doubles; the scenario assumes 5 to10 c/ kWh, by 2050 depending on the region. During the following five to ten years, PV will become competitive with retail electricity prices in many parts of the world and competitive with fossil fuel costs by 2050.

Solar PV is a critical part of the energy mix – it can be used in decentralized or centralised formats, it is useful in an urban environment and has huge potential for cost reduction.

employment in PV

Under the Energy [R]evolution scenario, solar PV would provide 5% of total electricity generation by 2030, and 1.6 million jobs. Growth is much more modest in the Reference scenario, and the increase in employment at 2020 levels out at 2030. In the Reference scenario the additional capacity of solar does not compensate for the reduction that comes from regional job multipliers and decline factors.

If the decline factors were not applied to the model, solar PV jobs would be more than three times greater by 2030, an extra 3 million jobs. Decline factors are used because the cost of PV is expected to fall by half by 2020 and 70% by 2030[15].

table 4.3: capacity, investment, and direct jobs – PV

		REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
Energy parameters	UNIT	2010	2020	2030	2010	2020	2030
Installed capacity	GW	10	49	86	21	269	921
Generated electricity	TWh	13	68	120	26	386	1,351
Share of total supply	%	0%	0%	0%	0%	1%	5%
Market & Investment							
Annual increase in capacity	MW/a	2	4	5	4	25	67
Annual investment	$/a	8,731	9,967	6,689	19,289	60,323	96,019
Direct jobs							
Construction and manufacturing	jobs	0.08 m	0.08 m	0.09 m	0.18 m	0.54 m	1.39 m
Operations and maintenance	jobs	0.00 m	0.01 m	0.02 m	0.01 m	0.06 m	0.20 m
Total jobs		**0.08 m**	**0.10 m**	**0.10 m**	**0.19 m**	**0.61 m**	**1.59 m**

These calculations based on energy supply projects and counting direct jobs only, estimate that the Solar PV sector provides about 190,000 jobs in 2010. The industry itself estimates it provides about 200,000 jobs right now so global numbers are already higher than the model projections.

references
15 IT IS ASSUMED THAT EMPLOYMENT PER MW WILL FALL AT THE SAME RATE AS THE COST PER MW FALLS.

concentrating solar power (CSP)

image WORKERS EXAMINE PARABOLIC TROUGH COLLECTORS IN THE PS10 CONCENTRATING SOLAR TOWER PLANT. EACH TROUGH HAS A LENGTH OF 150 METERS AND CONCENTRATES SOLAR RADIATION INTO A HEAT-ABSORBING PIPE IN WHICH A HEAT-BEARING FLUID FLOWS THAT IS THEN USED TO HEAT STEAM IN A STANDARD TURBINE GENERATOR.

Concentrating solar power is currently experiencing massive new development, and costs are expected to be 6-10 cents kW/h in the long term.

Solar thermal 'concentrating' power stations (CSP) are suitable for areas with high levels of direct sunlight. The technical potential of North Africa for CSP, for example, is much bigger than local demand.

There are various types of solar thermal technologies, offering good prospects for further development and cost reductions. The 'Fresnel' collectors have a simple design, and their costs are expected to fall with mass production. For central receiver systems, efficiency can be increased by producing compressed air at a temperature of up to 1,000°C, which is then used to run a combined gas and steam turbine.

Developments in storing heat will also reduce CSP electricity generation costs. The Spanish Andasol 1 plant, for example, is equipped with molten salt storage with a capacity of 7.5 hours. A higher level of full load operation can be realised by using a thermal storage system and a large collector field. These components increase initial investment costs, it reduces the cost of electricity generation.

employment in CSP

Under the Reference scenario, jobs in solar thermal technologies hold steady at less than 0.01 million over three decades. If the Energy [R]evolution was enacted, then by 2030 we would see more than 20-fold increase in the employment opportunities from this technology. The highest proportion of the jobs growth is in construction and manufacturing.

table 4.4: capacity, investment, and direct jobs – CSP

		REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
Energy parameters	UNIT	2010	2020	2030	2010	2020	2030
Installed capacity	GW	2	8	12	5	83	199
Generated electricity	TWh	5	26	54	9	267	1,172
Share of total supply	%	0%	0%	0%	0%	1%	4%
Market & Investment							
Annual increase in capacity	MW/a	0	1	0	1	8	12
Annual investment	$/a	2,418	2,802	2,422	4,289	35,168	59,283
Direct jobs							
Construction and manufacturing	jobs	0.01 m	0.01 m	0.00 m	0.02 m	0.11 m	0.14 m
Operations and maintenance	jobs	0.00 m	0.00 m	0.00 m	0.00 m	0.04 m	0.08 m
Total jobs		**0.01 m**	**0.01 m**	**0.01 m**	**0.02 m**	**0.15 m**	**0.22 m**

image A WORKER ENTERS A TURBINE TOWER FOR MAINTENANCE AT DABANCHENG WIND FARM. CHINA HAS HUGE WIND RESOURCES, WHICH COULD BE EASILY AND PROFITABLY EXPLOITED BY SWITCHING INVESTMENT FROM CLIMATE DESTROYING FOSSIL FUELS INTO HARVESTING THIS CLEAN, ABUNDANT ENERGY RESOURCE.

wind

There is a flourishing global market for wind, and the development costs are expected to drop by 30% and 50% for offshore installations.

The world's largest wind turbines, several of which have been installed in Germany, have a capacity of 6 MW. The favourable policy incentives in Europe have driven the global wind market as pioneers. However in 2007 more than half of the annual market was outside Europe and this trend is likely to continue.

There are some supply constraints following a boom in demand for wind power technology and this means that the cost of new systems has stagnated or even increased recently. The industry expects to resolve the bottlenecks in the supply chain over the next few years through continuous expansion of production capacities.

employment in wind energy

Under the Energy [R]evolution scenario, wind would ultimately provide 15% of total electricity generation by 2030. In turn, the jobs in this sector would grow half a million in 2010 to over 2 million in 2030. Under the Reference scenario, wind jobs reach only a fraction of this total.

The effect of decline factors on wind power jobs is less marked, because the technology is further along the commercialisation path. If decline factors were not used, wind jobs would be 0.3 million higher in 2020, and 0.8 million higher in 2030.

table 4.5: capacity, investment, and direct jobs – wind

		REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
Energy parameters	UNIT	2010	2020	2030	2010	2020	2030
Installed capacity	GW	114	293	295	154	802	1,405
Generated electricity	TWh	274	887	1,260	362	2,255	4,398
Share of total supply	%	1%	3%	4%	2%	9%	15%
Market & Investment							
Annual increase in capacity	MW/a	11	18	19	19	65	84
Annual investment	$/a	23,526	30,418	26,226	35,058	94,923	111,818
Direct jobs							
Construction and manufacturing	jobs	0.29 m	0.36 m	0.41 m	0.43 m	1.26 m	1.38 m
Operations and maintenance	jobs	0.07 m	0.15 m	0.18 m	0.09 m	0.43 m	0.65 m
Total jobs		**0.36 m**	**0.51 m**	**0.59 m**	**0.52 m**	**1.68 m**	**2.03 m**

image OCEANLINX IS COMMERCIALISING WAVE POWER TECHNOLOGY WHICH USES A COLUMN OF WATER TO DRIVE A TURBINE, PRODUCING ZERO EMISSIONS.

wave and tidal

The current cost of energy from initial tidal and wave energy farms has been estimated to be in the range of 15-55 cents/kWh, and for initial tidal stream farms in the range of 11-22 cents/kWh. For future tidal, wave and stream energy plants, generation costs of 10-25cents/kWh are expected by 2020, and a dynamic growth following the pattern of wind energy.

Ocean energy, particularly offshore wave energy, is a significant resource and it could satisfy an important percentage of electricity supply worldwide. Globally, the potential of ocean energy has been estimated at around 90,000 TWh/year. The most significant advantages are its vast availability and high predictability, plus technology with very low visual impact and no CO_2 emissions. Many different concepts and devices have been developed, to take energy from the tides, waves, currents and both thermal and saline gradient resources. Many of them are in an advanced phase of research and development; large scale prototypes have been deployed in real sea conditions and some have reached pre-market deployment. There are a few grids connected, fully operational commercial wave and tidal generating plants.

Future areas for development will include concept design, optimisation of the device configuration, reduction of capital costs by exploring the use of alternative structural materials, economies of scale and learning from operation. According to the latest research findings, the learning factor is estimated to be 10-15% for offshore wave and 5-10% for tidal stream. In the medium term, ocean energy has the potential to become one of the most competitive and cost effective forms of generation. Present cost estimates are based on analysis from the European NEEDS project.

employment in wave and tidal energy

Under the Reference scenario, employment in various forms of ocean energy is negligible. Under the Energy [R]evolution projections, it would become a new entrant to the energy market, and could provide over 10,000 jobs by 2030. Under "business as usual approach" this innovative, clean technology would employ less than one thousand people.

table 4.6: capacity, investment, and direct jobs – ocean

		REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
Energy parameters	UNIT	2010	2020	2030	2010	2020	2030
Installed capacity	GW	0	2	4	1	17	44
Generated electricity	TWh	1	6	12	3	58	151
Share of total supply	%	0%	0%	0%	0%	0%	1%
Market & Investment							
Annual increase in capacity	MW/a	0	0	0	0	2	3
Annual investment	$/a	15	802	624	1,389	7,362	8,649
Direct jobs							
Construction and manufacturing	jobs	0.000 m	0.001 m	0.000 m	0.001 m	0.012 m	0.007 m
Operations and maintenance	jobs	0.000 m	0.000 m	0.000 m	0.000 m	0.004 m	0.004 m
Total jobs		**0.000 m**	**0.001 m**	**0.001 m**	**0.001 m**	**0.016 m**	**0.011 m**

image GEYSER AT EL TATIO, ATACAMA DESERT, CHILE.

geothermal

Geothermal power is considered to be a key element in future renewable energy supply. For conventional geothermal power costs are likely to drop from 7 cents/kWh to about 2 cents/kWh. A new type of energy development called 'Enhanced Geothermal Systems' presently have high figures (about 20 cents/kWh), but electricity production costs - are expected to come down to around 5 cents/kWh in the long term, depending on the payments for heat supply. These price drops assume a global average market growth for geothermal power capacity of 9% per year up to 2020, adjusting to 4% beyond 2030.

Geothermal energy has been used since the beginning of the last century for electricity generation, and even longer for supplying heat from below the earth. New intensive research and development work is widening the potential of sites that could be used to produce power. Particular new developments include large underground heat exchange surfaces (Enhanced Geothermal Systems - EGS) and the improvement of low temperature power conversion, for example with the Organic Rankine Cycle.

The economics of geothermal electricity will also be improved by advanced heat and power cogeneration plants and further development of innovative drilling technology is expected.

Geothermal energy has a non-fluctuating supply and a grid load operating almost 100% of the time. Until now we have just used a marginal part of the geothermal heating and cooling potential. Shallow geothermal drilling could deliver heating and cooling at any time anywhere, and can be used for thermal energy storage.

employment in geothermal energy

Geothermal could see a significant jump in the proportion of the world's energy supply, nearly triple under the Energy [R]evolution in 2030, compared to the Reference scenario. This would correspond to triple the amount of jobs, around 60,000 in 2030.

table 4.7: capacity, investment, and direct jobs – geothermal

		REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
Energy parameters	UNIT	2010	2020	2030	2010	2020	2030
Installed capacity	GW	11	17	22	12	33	71
Generated electricity	TWh	72	119	158	82	231	488
Share of total supply	%	0%	0%	1%	0%	1%	2%
Market & Investment							
Annual increase in capacity	MW/a	0	1	1	1	2	4
Annual investment	$/a	16,489	11,050	11,641	21,068	30,479	45,158
Direct jobs							
Construction and manufacturing	jobs	0.00 m	0.00 m	0.00 m	0.01 m	0.01 m	0.02 m
Operations and maintenance	jobs	0.01 m	0.02 m	0.02 m	0.01 m	0.03 m	0.04 m
Total jobs		**0.02 m**	**0.02 m**	**0.02 m**	**0.02 m**	**0.04 m**	**0.06 m**

image PUBLIC BATH HOUSE THAT USES SOLAR THERMAL TECHNOLOGY IS SEEN BESIDE A FARM. THE CITY OF DEZHOU IS LEADING THE WAY IN ADOPTING SOLAR ENERGY AND HAS BECOME KNOWN AS THE SOLAR VALLEY OF CHINA.

biomass

There is a broad spectrum of energy generation costs for biomass, reflecting the different feedstocks that can be used. Costs range from a negative cost (or credit) for some waste woods, to inexpensive residual materials or more expensive energy crops. Using waste wood in steam turbine / combined heat and power (CHP) plants is one of the cheapest options. Gasification of solid biomass has a wide range of applications but is still relatively expensive.

In the long term it is expected that using wood gas both in micro CHP units (engines and fuel cells) and in gas-and-steam power plants will be economically favourable. There is good potential to use solid biomass for heat generation in both small and large heating centres linked to local heating networks. In recent years, converting crops into ethanol and 'bio diesel' made from rapeseed methyl ester (RME) has become increasingly important, for example in Brazil, the USA and Europe. Processes for obtaining synthetic fuels from biogenic synthesis gases will also play a larger role.

Latin and North America, Europe and the Transition Economies, have the potential to exploit modern technologies either in stationary appliances or the transport sector. In the long term, Europe and the Transition Economies will realise 20-50% of the potential for biomass from energy crops, whilst biomass use in all the other regions will have to rely on forest residues, industrial wood waste and straw. In Latin America, North America and Africa in particular, an increasing residue potential will be available.

In other regions, such as the Middle East and all Asian regions, the additional use of biomass is restricted, either due to a generally low availability or already high traditional use. For the latter a cleaner option is to use modern, more efficient technologies, improving current sustainability and positive effects like less indoor pollution and current heavy workloads.

employment in the biomass industry

Biomass power would be supporting 2.27 million jobs in 2030 in the Energy [R]evolution scenario, compared to just over a million in the Reference scenario.

table 4.8: capacity, investment, and direct jobs – biomass

		REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
Energy parameters	UNIT	2010	2020	2030	2010	2020	2030
Installed capacity	GW	70	119	143	95	233	341
Generated electricity	TWh	318	595	841	430	1,084	1,826
Share of total supply	%	1%	2%	3%	2%	4%	6%
Market & Investment							
Annual increase in capacity	MW/a	3	5	3	9	14	11
Annual investment	$/a	7,339	8,821	9,442	11,331	8,131	8,509
Direct jobs							
Construction and manufacturing	jobs	0.02 m	0.03 m	0.02 m	0.06 m	0.09 m	0.05 m
Operations and maintenance	jobs	0.45 m	0.77 m	1.00 m	0.64 m	1.62 m	2.22 m
Total jobs		**0.47 m**	**0.80 m**	**1.02 m**	**0.69 m**	**1.71 m**	**2.27 m**

image SMOKE BILLOWING OUT OF A CHIMNEY AT THE PATNÓW POWER COAL FIRED POWER STATION, POLAND.

fossil fuels and nuclear

An understanding of the international coal trade is important to make projections for how a switch to renewable energy will affect energy sector jobs around the world. The full ISF Report for this study provides detail on all the factors we used to calculate the employment related to coal powered electricity generation[16]. These include:

- employment and production data for as many of the major coal producing countries as possible
- proportion of lignite in current electricity production
- international trade, import and domestic coal production proportions
- proportion of domestic coal production
- the amount of "new' electricity generation in any given year (that is generation above the 2005 baseline

The global trend for energy generation from coal is for bigger mines that employ fewer people. China, the world's fastest developing economy is expected to close at least 10,000 small mines, and will develop 16 super mines that will produce an average of 70 million tonnes per year each. Of course, the older-style rural mines rely on a lot more manual labour. For comparison, a village miner in China produces 100 tonnes per year, while a single worker in one of the large Chinese super mines produces 30,000 tons per year. Examples of average production in other places is 14,000 tonnes per year in the US and 13,800 tonnes per year in Australia.

There is a significant reduction in coal sector jobs by 2020 and 2030 under both scenarios.

under the Reference scenario jobs in coal go down by more than a third by 2020 despite 40% more generation. By 2030 there is a further reduction of 200,000 jobs. The reasons are:

- Jobs per MW across all technologies falls as prosperity and labour productivity increases. In the model, regional job multipliers are applied to OECD employment factors in non-OECD regions to reflect this. As labour productivity reaches a par with OECD countries, employment per MW falls to OECD levels. If no regional multiplier is used, coal employment by 2020 only drops by 5% relative to 2010, rather than 32%. That would model a future where China's projected rapid increase in labour productivity does *not* occur.
- The decline factors applied to each technology reflect the reduction in price of that technology. An annual decline of 0.9% is applied between 2010 and 2020 and 0.3% between 2020 and 2030. If no decline factors are used then coal employment falls by 25% rather than 32% between 2020 and 2030.
- Because annual growth in coal generation falls from 71 GW per year in 2010 to 58 GW per year in 2020, construction and manufacturing jobs. If growth was maintained coal sector jobs would fall only 26% rather than the 32% projected.

Under the [R]evolution scenario, growth in coal capacity is almost zero, and by 2030 there is a slight reduction in coal capacity, so there would be a correlating reduction in coal sector jobs. Consequently, the installation and manufacturing jobs in the coal sector would fall to almost zero. The same influences that operate in the Reference scenario compound the losses that would occur for an Energy [R]evolution. The key point of this study is that this loss is off-set by very high labour projections in renewable energy, which would not occur if coal is allowed to continue to dominate the global energy mix.

gas, oil and diesel and nuclear Unsurprisingly, there are corresponding large drops in gas, oil and diesel and nuclear energy jobs under an Energy [R]evolution scenario.

- For **gas**, global employment is projected to increase by more than 30% between 2010 and 2030 under "business as usual". Under the Energy [R]evolution, gas plays an important role as a transition fuel, so there would be more jobs in 2010 than under the Reference scenario (1.63 million compared to 1.59 million). However, by 2030 there are 1.97 jobs in the sector, 220,000 less than without the [R]evolution measures.
- For **oil and diesel** jobs drop quite sharply, as we must reduce dependence on the volatile oil markets. Jobs in 2030 would be about 90,000, around 40% less than without the measures to curb emissions.
- For **nuclear**, annual investment would drop to zero by 2030, with a corresponding sharp decline in employment in the sector.

table 4.9: capacity, investment, and direct jobs – coal

		REFERENCE SCENARIO			[R]EVOLUTION SCENARIO		
Energy parameters	UNIT	2010	2020	2030	2010	2020	2030
Installed capacity	GW	1,477	2,054	2,665	1,400	1,460	1,263
Generated electricity	TWh	8,575	11,771	15,117	8,110	8,313	7,067
Share of total supply	%	40%	46%	52%	38%	32%	24%
Market & Investment							
Annual increase in capacity	MW/a	71	58	61	58	24	3
Annual investment	$/a	149,848	103,290	104,294	134,828	53,028	20,306
Direct jobs		2.01 m	1.11 m	0.94 m	1.76 m	0.50 m	0.05 m
Construction and manufacturing	jobs	0.26 m	0.27 m	0.29 m	0.25 m	0.20 m	0.14 m
Operations and maintenance	jobs	1.93 m	1.49 m	1.38 m	1.90 m	1.25 m	0.88 m
Total jobs		**4.20 m**	**2.87 m**	**2.60 m**	**3.91 m**	**1.94 m**	**1.07 m**

references
16 RUTOVITZ J. AND ATHERTON A. 2009, *ENERGY SECTOR JOBS TO 2030: A GLOBAL ANALYSIS*. PREPARED FOR GREENPEACE INTERNATIONAL BY THE INSTITUTE FOR SUSTAINABLE FUTURES, UNIVERSITY OF TECHNOLOGY, SYDNEY.

implementing the energy [r]evolution in developing countries

GLOBAL

BANKABLE SUPPORT SCHEMES
LEARNING FROM EXPERIENCE
EXPERIENCE OF FEED IN TARIFFS
EXPERIENCE OF INTERNATIONAL FINANCING
FEED IN TARIFF SUPPORT MECHANISM
KEY PARAMETERS

5

image SOLAR POWER SYSTEM INSTALLED IN A COASTAL VILLAGE IN ACEH, INDONESIA.

“the aim is to expand renewable energy in developing countries...”

GREENPEACE INTERNATIONAL
CLIMATE CAMPAIGN

This chapter outlines a Greenpeace proposal for a way to support renewable energy in developing countries. The system would use a feed-in tariff, whose additional costs are financed by a combination of new sectoral emissions trading mechanisms and direct finance from technology funds to be developed in the Copenhagen climate deal. The Energy [R]evolution scenario shows that renewable electricity generation has huge environmental and economic benefits. However its investment, and hence total generation, costs, especially in developing countries, will remain higher than those of existing coal or gas-fired power stations for the next five to ten years. A support mechanism is needed to bridge this investment and cost gap between conventional fossil fuel-based power generation and renewables. The Feed in Tariff Support Mechanism (FTSM) is a concept conceived by Greenpeace International[17]. The aim is to expand renewable energy in developing countries with financial support from industrialised nations – a mechanism to rapidly deploy renewable energy technologies via a new sectoral no-lose mechanism or technology transfer fund under the UNFCCC.

Kyoto countries are currently negotiating the second phase of their agreement, covering the period from 2013-2017. An FTSM mechanism could be built around new sectoral "no-lose" mechanisms for developing countries. Using such a mechanism, emission units could be generated for sale in a sectoral no-lose Mechanism in a developing country power sector. Proceeds can be used to fund the additional costs of the Feed in Tariff system in that country. For some countries, a directly funded Feed in Tariff Support Mechanism may be more appropriate than a sectoral no-lose.

need for bankable renewable energy support schemes

Since the early development of renewable energies within the power sector, there has been an ongoing debate about the best and most effective type of support scheme. The European Commission published a survey in December 2005 which provides a good overview of the experience so far. According to this report, feed-in tariffs are by far the most efficient and successful mechanism. Globally more than 40 countries have adopted some version of the system. Although the organisational form of these tariffs differs from country to country, there are certain clear criteria which emerge as essential for creating a successful renewable energy policy. At the heart of these is a reliable, bankable support scheme for renewable energy projects which provides long term stability and certainty[18]. Bankable support schemes facilitate lower-cost projects because they reduce the risk for both investors and equipment suppliers.

For developing countries, feed-in laws would be an ideal way to implement new renewable energies. The extra costs, however, which are usually covered in Europe, for example, by a very minor increase in the overall electricity price for consumers, are still seen as an obstacle. In order to enable technology transfer from Annex 1 countries to developing countries, a mix of a feed-in law, international finance and emissions trading could be used to establish a locally-based renewable energy infrastructure and industry with the assistance of OECD countries.

The four main elements for successful renewable energy support schemes are:

- Clear, bankable pricing system.
- Priority access to the grid with clear identification of who is responsible for what regarding interconnection and transition, and incentive methods.
- Clear, simple administrative and planning permission procedures.
- Public acceptance and support.

The first is fundamentally important, but it won't provide the whole solution without the other three elements.

learning from experience

The proposed Feed-in Tariff Support Mechanism program brings together three different support mechanisms and builds on the experience from 20 years of renewable energy support programmes.

experience of feed in tariffs

Feed-in tariffs are seen as the best way forward and very popular, especially in developing countries. The main argument against them is the increase in electricity prices for households and industry, as the extra costs are shared across all customers. However, by using a combination of energy efficiency programs and moving the cost burden towards governments and recipients of higher incomes, this policy can be introduced more equitably. This is particularly important for developing countries, where many people can't afford to spend more money for electricity services.

experience of international financing

Finance for renewable energy projects is one of the main obstacles to an Energy [R]evolution in developing countries. Large scale projects have fewer funding problems, but small, community based projects, usually face financing difficulties even though they have a high degree of public acceptance. The experiences from micro credits for small hydro projects in Bangladesh, for example, as well as wind farms in Denmark and Germany, show there can be strong local participation and acceptance. The main reasons for this are the economic benefits flowing to the local community and careful project planning based on good local knowledge and understanding. When the community identifies the project rather than the project identifying the community, the result is generally faster, bottom-up growth of the renewables sector.

feed in tariff support mechanism

The basic aims of the Feed in Tariff Support Mechanism (FTSM) are to facilitate new feed-in laws for developing countries by providing additional financial resources at a scale appropriate to the circumstances of each developing country.

- For countries with higher levels of capacity, the creation of a new sectoral no-lose Mechanism that can generate emission reduction units for sale to Annex I counties, with the proceeds being used to offset part of the additional cost of the Feed in Tariff system could be appropriate.

references
17 *IMPLEMENTING THE ENERGY [R]EVOLUTION*, OCTOBER 2008, SVEN TESKE, GREENPEACE INTERNATIONAL
18 '*THE SUPPORT OF ELECTRICITY FROM RENEWABLE ENERGY SOURCES*', EUROPEAN COMMISSION, 2005

image WORKERS IN THAILAND INSTALL A WIND TURBINE IN THEIR COMMUNITY. THE IMPACTS OF SEA-LEVEL RISE DUE TO CLIMATE CHANGE ARE PREDICTED TO HIT HARD ON COASTAL COUNTRIES IN ASIA, AND CLEAN RENEWABLE ENERGY IS A SOLUTION.

- For other countries a more directly-funded approach to paying for the additional costs to consumers of the Feed in Tariff system would be appropriate.

The aim of the FTSM would be to provide bankable and long term stable support for the development of a local renewable energy market in developing countries. The tariffs should bridge the gap between conventional power generation costs and those of renewable energy generation.

the key parameters for feed in tariffs under FTSM are:

- Variable tariffs for different renewable energy technologies, depending on their costs and technology maturity, paid for 20 years.
- Payments based on actual generation in order to achieve properly maintained projects with high performance ratios.
- Payment of the 'additional costs' for renewable generation will be based on the Spanish system of the wholesale electricity price plus a fixed premium.

A developing country which wants to take part in the FTSM would need to establish clear regulations for the following:

- Guaranteed access to the electricity grid for renewable electricity projects.
- Establishment of a feed-in law based on successful examples.
- Transparent access to all data needed to establish the feed-in tariff, including full records of generated electricity.
- Clear planning and licensing procedures.

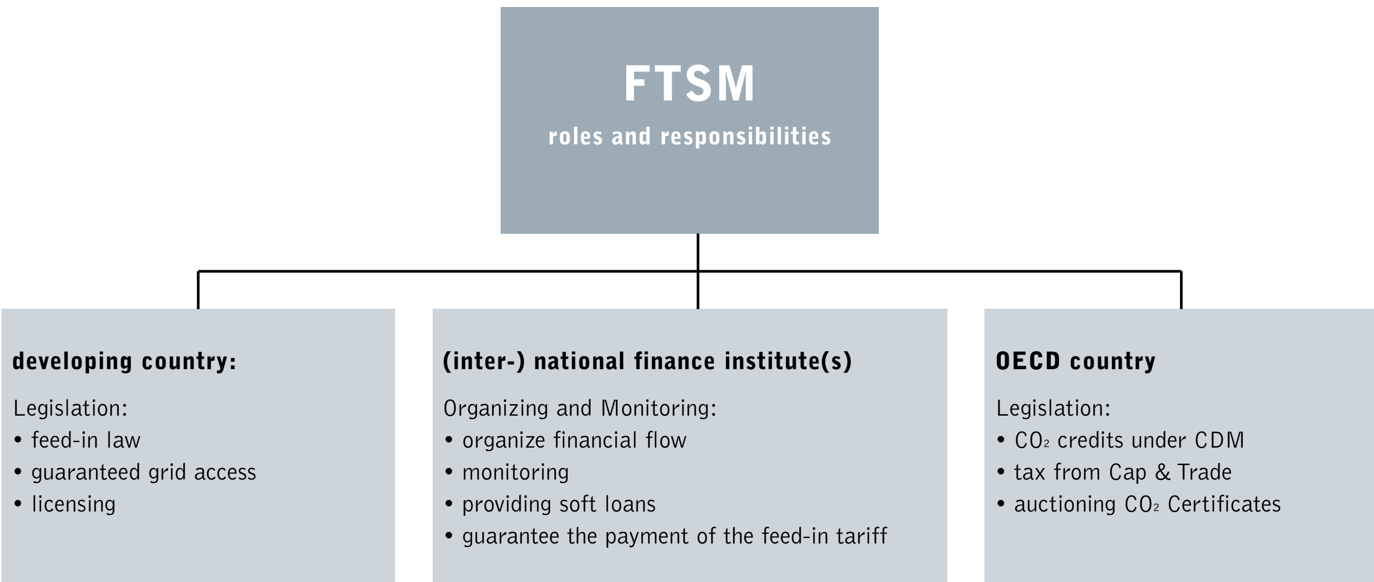
Funding could come through the connection of the FTSM to the international emission trading system via new no-lose sectoral trading mechanism to be developed in the Copenhagen Agreement. The Energy [R]evolution scenario shows that the average additional costs (under the proposed energy mix) between 2008 and 2015 are between $1 and $4 cents per kilowatt-hour so the cost per tonne of CO_2 avoided would be between $10 and $40, indicating that emission reduction units generated under a no-lose mechanism designed to support FTSM would be competitive in the post 2012 carbon market. The design of the FTSM would need to ensure that there were stable flows of funds to the renewable energy suppliers and hence there may need to be a buffer between fluctuating CO_2 emissions prices and stable long term feed-in tariffs. The FTSM will need to secure the payment of the required feed-in tariffs during the whole period (about 20 years) for each project.

All renewable energy projects must have a clear set of environmental criteria which are part of the national licensing procedure in the country where the project will generate electricity. Those criteria will have to meet a minimum environmental standard defined by an independent monitoring group. If there are already acceptable criteria developed, for example for CDM projects, they should be adopted rather than reinventing the wheel. The board members will come from NGOs, energy and finance experts as well as members of the governments involved. The fund will not be able to use the money for speculative investments. It can only provide soft loans for FTSM projects.

the key parameters for the FTSM fund will be:

- The fund will guarantee the payment of the total feed-in tariffs over a period of 20 years if the project is operated properly.
- The fund will receive annual income from emissions trading or from direct funding.
- The fund will pay feed-in tariffs annually only on the basis of generated electricity.
- Every FTSM project must have a professional maintenance company to ensure high availability.
- The grid operator must do its own monitoring and send generation data to the FTSM fund. Data from the project and grid operators will be compared regularly to check consistency.

figure 5.1: ftsm scheme



financing the energy [r]evolution for developing non-OECD countries with a FTSM program

Based on the Energy [R]evolution scenario for non-OECD countries, the following calculation for a FTSM program has been done with the following assumptions:

table 5.1: assumptions for the calculation for a ftsm for non-oecd countries

Key parameter	CONVENTIONAL POWER GENERATION COSTS [CT/KWH]	AVERAGE FEED-IN TARIFF EXCL. SOLAR PV [CT/KWH]	AVERAGE FEED-IN TARIFF FOR SOLAR PV [CT/KWH]	SPECIFIC CO_2 REDUCTION PER KWH [GCO_2/KWH]
2010	5	12	20	0.871
2020	10	11	15	0.857
2030	10	10	10	0.864

power generation costs The average feed-in tariffs – excluding solar – have been calculated with the assumption that the majority of renewable energy sources require feed-in tariffs between 7 to 15 cents per kilowatt-hour. While wind and bioenergy power generation will need feed-in tariffs below 10 cents per kWh, other technologies such as geothermal and concentrated solar power will need higher tariffs. If FTSM was to be implemented in India, exact tariffs should be calculated on the basis of specific market prices in India. The feed-in tariff for solar photovoltaic reflects current market price projection. The average conventional power generation costs are based on new coal and gas power plants without direct or indirect subsidies.

specific CO_2 reduction per kWh The assumed specific CO_2 reduction per kWh is crucial for the result of specific CO_2 costs per tonne. In Non-OECD countries the current specific CO_2 emission is 871 gCO_2/kWh and will go down to 857 gCO_2/kWh by 2030. Therefore the average specific CO_2 emission is 864 gCO_2/kWh.

Financial parameters With the beginning of the financial crisis in mid-2008, it became clear that inflation rates and capital costs can change very quickly. The cost calculation of this program does not include any interest rates, capital costs or inflation rates all cost parameters are nominal and on the basis of 2009 level.

figure 5.2: feed in tariffs with conventional power generation

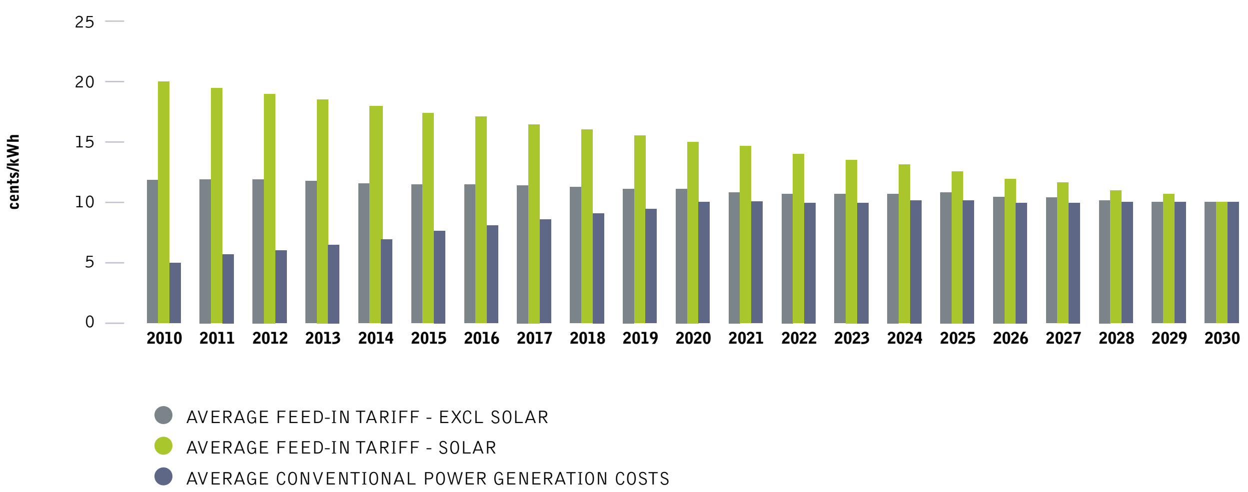


image left A SOLAR POWER SYSTEM BEING INSTALLED IN A COASTAL VILLAGE IN ACEH, INDONESIA, ONE OF THE WORST HIT AREAS BY THE TSUNAMI IN DECEMBER 2004.

image right AS PART OF THE GREENPEACE AFRICA OFFICE LAUNCH, GREENPEACE OPENS A SOLAR ENERGY WORKSHOP IN BOMA. A MOBILE PHONE GETS CHARGED BY A SOLAR ENERGY POWERED CHARGER.

key results

The FTSM program would cover 129,837 TWh new renewable electricity generation and save 112 Gt CO_2 between 2010 and 2030, or 5.2 Gt CO_2 per year. With an average CO_2 price of $ 19.8 per ton the total program would cost $1.56 trillion in total or $74.4 billion annually.

The FTSM will bridge the gap between now and 2030 when specific electricity generation costs for all renewable energy technologies are projected to be lower than conventional power generation such as coal and gas power plants. However this case study has calculated even lower generation costs for conventional power generation than we have assumed in our price projections for the Energy [R]evolution scenario as we excluded CO_2 emission costs. In this case coal power plants would have generation costs of 10.8 $cents/kWh by 2020 and 12.5 cents/kWh by 2030, the FTSM assumed costs of 10 cents/kWh by 2020 and 2030 for new coal power plants.

The FTSM program is divided into two periods of ten years. The annual costs for the first period of $717 billion per year and $847 billion per year for the second period. The annual costs are among the same order of magnitude. The difference between renewable and coal electricity generation is projected to decrease, so more renewable electricity can be financed with roughly the same amount of money.

highlights

- The overall FTSM program would bring more than 1,700 GW of new renewable energy power plants on the grid
- About 4.7 million jobs created in Non-OECD countries to annual cost of around $15,000 per year.

table 5.2: results of study of costs of proposed Feed-In Tariff Support Mechanism

KEY RESULTS TOTAL NON-OECD	YEAR	TOTAL RENEWABLE ELECTRICITY GENERATION UNDER FTSM PROGRAM [TWH]	AVERAGE ANNUAL CO_2 EMISSION CREDITS [MILLION T CO_2]	TOTAL CO_2 CERTIFICATES PER PERIOD [MILLION T CO_2]	AVERAGE CO_2 COST PER TON [$/T$CO_2$]	TOTAL ANNUAL COSTS [BILLION $]	TOTAL COSTS PER PERIOD [BILLION $]
Period 1	2010-2019	36,326	3,217	32,169	26	72	717
Period 2	2020-2030	93,511	7,330	80,633	13	77	847
Period 1+2	2010-2030	129,837	5,273.6	112,802	19.8	74.4	1,564

table 5.3: renewable power for non-oecd countries under ftsm program

ELECTRICITY GENERATION [TWH/A]	2005	2010	2015	2030	2030
Wind	10	80	310	956	2,296
PV	0	4	18	139	1,080
Biomass	41	124	296	529	950
Geothermal	20	31	54	123	288
Solar Thermal	1	4	26	388	1,708
Ocean Energy	0	0	9	33	77
Total-new RE	**71**	**243**	**713**	**2,167**	**6,398**

INSTALLED CAPACITY [GW]	2005	2010	2015	2030	2030
Wind	5.65	36.46	135.45	353.12	891.07
PV	0.08	2.64	12.51	60.77	506.23
Biomass	10.03	27.90	65.30	111.00	168.74
Geothermal	3.57	4.96	8.66	17.95	42.17
Solar Thermal	0.24	1.71	10.28	38.10	130.35
Ocean Energy	0.00	0.00	2.51	9.20	21.00
Total-new RE	**19.57**	**73.67**	**234.71**	**590.13**	**1,759.56**

policy recommendations

GLOBAL

WORKER AT WIND FARM IN CHINA. © GWEC/WIND POWER WORKS

image GEO-THERMAL RESEARCH DRILLING IN THE SCHORFHEIDE DONE BY THE GEOFORSCHUNGSZENTRUM POTSDAM IN COOPERATION WITH THE GERMAN MINISTRY OF ENVIRONMENT AND VATTENFALL.

© PAUL LANGROCK/ZENIT/GP

The climate crisis and the financial crisis are often portrayed as two competing issues that need to be addressed by the world community. But such competition does not need to be the case. Deep reductions of greenhouse gas emissions can be achieved by drastically reducing our demand for energy and strongly increasing the deployment and integration of renewable energy. Investments in energy efficiency and renewable energy will at the same time deliver economic benefits by increasing employment in the power sector, reducing energy costs and minimizing the use of scarce natural resources. The level of investments needed will only happen if the right policy framework is put in place.

Greenpeace is therefore calling upon world leaders to:

1. Agree on a new global climate deal that ensures global emissions to peak by 2015 at the UN climate summit in Copenhagen in December 2009, which should include:

- Binding commitments from industrialised countries to reduce their emissions by at least 40% by 2020 (compared to 1990 levels). At least three quarters of these reductions must be achieved domestically.
- Binding commitments from industrialised countries to provide at least $140 billion a year by 2020, to help developing countries to adapt to unavoidable climate change impacts and enable these countries to reduce their greenhouse gas emissions by limiting their projected energy demand, switching to clean energy, and halting deforestation. This should help developing countries to take ambitious actions to reduce their projected emissions growth by 15-30% by 2020.
- A funding mechanism to stop deforestation and associated emissions in all developing countries by 2020, with key areas (Amazon, Congo Basin, Paradise Forests) achieving zero deforestation by 2015. Priority must be given to protecting forests with a high conservation value and those that are important for the livelihoods of indigenous peoples and forest communities. These emission reductions must be in addition to developed country emission reductions.

2. Develop policies that will enable the greening of their economies by:

- Committing at least 1% of their GDP to greening their economies as proposed by UNEP's Green New Deal Report.
- Phasing out all subsidies and other economic incentives that encourage inefficient use of energy and other natural resources and supports fossil fuel use or other activities that further contribute to climate change.

3. Kick start the energy revolution by:

- Setting stringent and ever-improving efficiency and emissions standards for appliances, buildings, power plants and vehicles.
- Establishing legally defined targets for renewable energy and combined heat and power generation.
- Reforming of the electricity market to allow better integration of renewable energy technologies on the market.
- Implementing fixed price mechanisms for renewable energy such as feed-in tariffs, which provide a stable return and long-term certainty for investors.
- Supporting innovation in energy efficiency, low-carbon transport systems, and renewable energy production.

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image WORKERS BUILD A WIND TURBINE IN A FACTORY IN PATHUM THANI, THAILAND.

appendix

GLOBAL

7

“investment in renewable energy helps the economy by increasing employment in the power sector.”

GREENPEACE INTERNATIONAL
CLIMATE CAMPAIGN

WORKER OUTSIDE A WIND TURBINE IN KUTCH, GUJARAT, INDIA. © GWEC/WIND POWER WORKS

image WORKER OUTSIDE A WINDTURBINE IN KUTCH, GUJARAT, INDIA.

appendix: regional and country factors for coal production and employment

	PRODUCTION MILLION TONS	PRODUCTION %	ELECTRICITY TONS/GWH	% OF LIGNITE IN ELECTRICITY PRODUCTION	EMPLOYMENT (THOUSANDS)	PRODUCTIVITY TONS / PERSON /YEAR	EMPLOYMENT FACTOR (EXISTING) JOBS PER GWH	EMPLOYMENT FACTOR (NEW) JOBS PER GWH
	2006	2006	2006	2006	2006	2006	2010	2010
World	6,669 m	99%	520	19%	n/a			
OECD North America	1,238 m	104%	403	9%	88	14,116	0.03	0.02
OECD Europe[a]	550 m	84%	678	66%	298	1,843	0.34	0.18
OECD Pacific (data for Australia only)	371 m	257%	659	51%	27	13,800	0.04	0.02
India	466 m	92%	745	6%	464	1,004	0.59	0.25
China	2,525 m	97%	516	-	3,600	701	0.55	0.02
Africa (data for South Africa only)	247 m	138%	492	-	60	4,110	0.11	0.08
Transition economies[b]	347 m		772	56%	237		0.43	0.20
Developing Asia (data for Asia exc China)	801 m	108%	648	9%	n/a			
Latin America	90 m	198%	425	20%	n/a			
Middle East	3 m	20%	365	3%	n/a			

a) OECD Europe results are the weighted average of data from the Czech Republic, France, Finland, Germany, Greece, Poland, the Slovak Republic and the UK.

b) Transition economies results are the weighted average of data from Russia, Bulgaria, and Slovenia.

c)All data for coal production and electricity from International Energy Agency statistics, downloaded 18th June 2009. www.iea.org

d)Employment data sources:
USA: Energy Information Administration (2008) Report No. DOE/EIA 0584 (2007) Table 18. Average Number of Employees by State and Mine Type, 2007, 2006
Canada: Natural Resources Canada. 2007. Table 22. Canada, employment in the mineral industry, stage 1 – mineral extraction and concentrating (total activity), (1) 1961-2006
Australia: Australian Bureau of Statistics. Cat. No. 2068.0 - 2006 Census Tables 2006
India: Data for coal mining employment from Government of India Ministry of Coal. 2008. Annual report 2007 - 08. Table 8.2.3. Employment has been scaled up from the reported figure of 429,500 employees because the reported production is 431 million tons rather than the IEA figure of 466 million tons.
China: China Yearbook 2008, cited in personal communication, Sven Teske, 21/6/09.
South Africa: personal communication, Sven Teske, 21st June 2009
Europe Glückauf: (German Coal statistics), cited in personal communication, Sven Teske, 21/6/09.
Russia: personal communication, Sven Teske, 21st June 2009

e) The calculated employment factors shown have been modified using the annual percentage growth in labour productivity for each region to arrive at the 2010 factor. 2006 factors are shown in the ISF Report: Rutovitz J. and Atherton A. 2009, *Energy sector jobs to 2030: a global analysis*. Prepared for Greenpeace International by the Institute for Sustainable Futures, University of Technology, Sydney.

appendix: technology decline rates

	ANNUAL DECLINE IN JOB FACTORS REFERENCE SCENARIO		ANNUAL DECLINE IN JOB FACTORS [R]EVOLUTION SCENARIO		SOURCE
	2010-20	2020-30	2010-20	2020-30	
Coal	0.9%	0.3%	1.0%	0.3%	GPI & EREC 2008 (cost data)
Gas	0.4%	0.5%	0.4%	0.6%	GPI & EREC 2008 (cost data)
Oil	0.4%	0.4%	0.4%	0.4%	GPI & EREC 2008 (cost data)
Diesel	0.0%	0.0%	0.0%	0.0%	GPI & EREC 2008 (cost data)
Nuclear	0.0%	0.0%	0.0%	n/a	GPI & EREC 2008 (cost data)
Biomass power plant	1.0%	0.5%	1.0%	0.5%	GPI & EREC 2008 (cost data)
Hydro	-0.6%	-0.5%	-0.6%	-0.5%	GPI & EREC 2008 (cost data)
Wind – on shore	1.40%	1.40%	1.40%	1.40%	Derived from EWEA 200, footnotes 5 & 6 page 22.
Wind – off shore	3.90%	1.50%	3.90%	1.50%	Derived from EWEA 200, footnotes 5 & 6 page 22.
Wind turbine *	1.1%	0.8%	1.2%	0.7%	GPI & EREC 2008 (cost data)
PV	6.88%	1.41%	7.72%	2.42%	EPIA 2008b
PV *	6.5%	5.7%	6.9%	5.2%	GPI & EREC 2008 (cost data)
Geothermal	2.3%	2.0%	2.5%	1.7%	GPI & EREC 2008 (cost data)
Solar thermal (electricity)	0%	2.2%	1.6%	0.5%	GPI/ ESTELA 2009, page 62
Solar thermal (electricity) *	2.0%	1.7%	2.0%	1.7%	GPI & EREC 2008 (cost data)
Ocean	7.80%	7.80%	7.80%	7.80%	SERG 2007
Ocean energy *	8.4%	3.8%	8.4%	3.8%	GPI & EREC 2008 (cost data)

*Factors not used in analysis, provided for comparison only.

appendix: regional adjustment to be applied to employment factors

JOB MULTIPLIERS	CONSTRUCTION, MANUFACTURING, O&M	BIOMASS FUEL SUPPLY	CONSTRUCTION, MANUFACTURING, O&M	BIOMASS FUEL SUPPLY	CONSTRUCTION, MANUFACTURING, O&M	BIOMASS FUEL SUPPLY
	2010	2010	2020	2020	2030	2030
OECD	1.0	1.0	1.0	1.0	1.0	1.0
Africa	6.3	13.7	6.2	13.4	6.3	13.7
China	2.0	13.5	1.2	8.3	1.0	6.9
Developing Asia	2.5	12.0	1.7	8.4	1.5	7.2
India	2.7	18.2	1.9	12.7	1.5	9.7
Latin America	2.5	3.2	2.4	3.0	2.4	3.0
Middle East	2.4	3.0	2.2	2.7	2.3	2.8
Transition economies	2.6	4.5	2.0	3.4	1.9	3.2

a) For derviation of regional adjustment multipliers see the ISF report: Rutovitz J. and Atherton A. 2009, *Energy sector jobs to 2030: a global analysis*. Prepared for Greenpeace International by the Institute for Sustainable Futures, University of Technology, Sydney.

appendix: G8 employment and electricity generation at 2010, 2020, and 2030

CANADA		2010 REF	2020 REF	2030 REF	2010 E[R]	2020 E[R]	2030 E[R]
Electricity generation							
Coal	TWh	105	72	32	75	34	13
Gas	TWh	63	47	43	41	48	34
Nuclear, oil & diesel	TWh	114	108	104	83	12	0
Renewable	TWh	381	406	416	383	427	478
Total	TWh	662	650	604	581	556	552
CO_2 Emission - Power sector	**million t CO_2**	**148**	**92**	**48**	**100**	**43**	**17**
Jobs (thousands)							
Coal	jobs	4.8	3.6	2.3	3.5	1.5	0.5
Gas	jobs	13.5	4.5	4.0	5.7	6.5	3.8
Nuclear, oil & diesel	jobs	6.8	5.8	5.3	4.1	0.5	0.0
Renewable	jobs	37.4	54.4	48.3	40.4	62.1	74.7
Energy supply jobs	**jobs**	**62.5**	**68.3**	**60.0**	**53.6**	**70.5**	**79.1**
Efficiency	**jobs**	**-**	**-**	**-**	**18.3**	**18.7**	**9.7**
Total Jobs	**jobs**	**62.5**	**68.3**	**60.0**	**72.0**	**89.2**	**88.8**

FRANCE		2010 REF	2020 REF	2030 REF	2010 E[R]	2020 E[R]	2030 E[R]
Electricity generation							
Coal	TWh	30	38	61	25	23	18
Gas	TWh	53	72	120	107	234	309
Nuclear, oil & diesel	TWh	454	453	409	350	153	0
Renewable	TWh	90	125	135	98	145	189
Total	TWh	628	688	724	578	555	517
CO_2 Emission - Power sector	**million t CO_2**	**39**	**49**	**81**	**52**	**89**	**108**
Jobs (thousands)							
Coal	jobs	4.3	3.9	8.3	1.7	1.6	1.1
Gas	jobs	2.1	1.5	3.1	4.8	7.3	5.4
Nuclear, oil & diesel	jobs	19.5	19.0	15.5	15.0	6.4	0.0
Renewable	jobs	22.4	38.1	29.9	29.2	57.9	61.4
Energy supply jobs	jobs	**48.3**	**62.4**	**56.8**	**50.8**	**73.3**	**68.0**
Efficiency	**jobs**	**-**	**-**	**-**	**11.1**	**18.8**	**24.5**
Total Jobs	**jobs**	**48.3**	**62.4**	**56.8**	**61.9**	**92.1**	**92.5**

GERMANY		2010 REF	2020 REF	2030 REF	2010 E[R]	2020 E[R]	2030 E[R]
Electricity generation							
Coal	TWh	250	195	122	250	120	0
Gas	TWh	155	133	140	155	174	190
Nuclear, oil & diesel	TWh	110	30	0	110	0	0
Renewable	TWh	120	199	283	120	204	299
Total	TWh	635	557	546	635	497	488
CO_2 Emission - Power sector	**million t CO_2**	**320**	**249**	**172**	**320**	**195**	**82**
Jobs (thousands)							
Coal	jobs	31	23	18	31	16	-
Gas	jobs	10	2	5	10	7	8
Nuclear, oil & diesel	jobs	8	0	-	8	-	-
Renewable	jobs	226	219	277	230	243	313
Energy supply jobs	jobs	**275**	**244**	**299**	**278**	**266**	**321**
Efficiency	**jobs**	**-**	**-**	**-**	**-**	**11**	**9**
Total Jobs	**jobs**	**275**	**244**	**299**	**278**	**277**	**330**

appendix: overview G8 results per country

UK		2010 REF	2020 REF	2030 REF	2010 E[R]	2020 E[R]	2030 E[R]
Electricity generation							
Coal	TWh	119	94	74	106	23	3
Gas	TWh	122	219	220	137	185	134
Nuclear, oil & diesel	TWh	76	28	11	75	21	4
Renewable	TWh	32	54	128	34	168	255
Total	TWh	349	395	433	352	397	397
CO_2 Emission - Power sector	**million t CO_2**	**176**	**192**	**163**	**171**	**165**	**156**
Jobs (thousands)							
Coal	jobs	21.9	16.7	13.6	21.6	11.3	1.7
Gas	jobs	6.1	10.8	4.5	6.3	7.4	5.7
Nuclear, oil & diesel	jobs	4.3	1.6	0.6	4.3	1.2	0.3
Renewable	jobs	38	22	56	41	105	131
Energy supply jobs	jobs	**70**	**51**	**74**	**73**	**125**	**138**
Efficiency	**jobs**	**-**	**-**	**-**		**5.7**	**14.3**
Total Jobs	**jobs**	**70**	**51**	**74**	**73**	**130**	**152**

USA		2010 REF	2020 REF	2030 REF	2010 E[R]	2020 E[R]	2030 E[R]
Electricity generation							
Coal	TWh	2,361	2,797	3,324	2,286	1,598	1,000
Gas	TWh	824	887	944	1,105	1,353	1,432
Nuclear, oil & diesel	TWh	969	1,021	1,037	702	451	78
Renewable	TWh	455	708	870	513	1,462	2,650
Total	TWh	4,610	5,413	6,176	4,605	4,863	5,160
CO_2 Emission - Power sector	**million t CO_2**	**2,691**	**2,875**	**3,168**	**2,711**	**1,874**	**1,213**
Jobs (thousands)							
Coal	jobs	153	160	214	127	49	30
Gas	jobs	40	43	49	110	63	56
Nuclear, oil & diesel	jobs	45	47	45	28	17	4
Renewable	jobs	145	210	239	183	574	736
Energy supply jobs	jobs	**382**	**460**	**547**	**448**	**703**	**827**
Efficiency	**jobs**	**-**	**-**	**-**	**1**	**70**	**111**
Total Jobs	**jobs**	**382**	**460**	**547**	**449**	**772**	**938**

ITALY		2010 REF	2020 REF	2030 REF	2010 E[R]	2020 E[R]	2030 E[R]
Electricity generation							
Coal	TWh	47	27	46	44	25	15
Gas	TWh	185	262	290	179	186	131
Nuclear, oil & diesel	TWh	46	41	39	46	30	14
Renewable	TWh	61	105	121	62	121	175
Total	TWh	339	435	496	331	363	336
CO_2 Emission - Power sector	**million t CO_2**	**136**	**133**	**154**	**132**	**92**	**63**
Jobs (thousands)							
Coal	jobs	3.9	3.0	6.4	3.8	2.7	1.8
Gas	jobs	9.8	10.8	6.1	8.5	4.3	2.2
Nuclear, oil & diesel	jobs	5.7	4.0	3.6	5.8	2.7	1.3
Renewable	jobs	37.7	53.8	39.5	41.1	66.4	74.0
Energy supply jobs	jobs	**57**	**72**	**56**	**59**	**76**	**79**
Efficiency	**jobs**	**-**	**-**	**-**	**1.7**	**12.1**	**22.4**
Total Jobs	**jobs**	**57**	**72**	**56**	**61**	**88**	**102**

RUSSIA		2010 REF	2020 REF	2030 REF	2010 E[R]	2020 E[R]	2030 E[R]
Electricity generation							
Coal	TWh	239	275	307	237	170	95
Gas	TWh	460	527	543	461	450	420
Nuclear, oil & diesel	TWh	187	241	263	187	153	52
Renewable	TWh	193	225	264	194	352	550
Total	TWh	1,078	1,268	1,377	1,078	1,125	1,117
CO_2 Emission - Power sector	**million t CO_2**	**794**	**885**	**950**	**791**	**673**	**557**
Jobs (thousands)							
Coal	jobs	169	134	128	161	56	25
Gas	jobs	134	103	76	147	92	68
Nuclear, oil & diesel	jobs	30	44	31	30	15	4
Renewable	jobs	69	64	71	67	252	337
Energy supply jobs	jobs	**401**	**345**	**307**	**406**	**415**	**434**
Efficiency	**jobs**	**-**	**-**	**-**	**0**	**50**	**63**
Total Jobs	**jobs**	**401**	**345**	**307**	**406**	**465**	**497**

JAPAN		2010 REF	2020 REF	2030 REF	2010 E[R]	2020 E[R]	2030 E[R]
Electricity generation							
Coal	TWh	288	312	349	187	167	151
Gas	TWh	308	323	375	321	398	413
Nuclear, oil & diesel	TWh	475	521	552	475	341	181
Renewable	TWh	113	132	155	131	233	347
Total	TWh	1,185	1,288	1,430	1,114	1,138	1,092
CO_2 Emission - Power sector	**million t CO_2**	**468**	**410**	**414**	**381**	**319**	**277**
Jobs (thousands)							
Coal	jobs	36	31	31	23	20	20
Gas	jobs	12	6	9	15	13	9
Nuclear, oil & diesel	jobs	55	56	49	52	22	13
Renewable	jobs	37	43	55	65	132	155
Energy supply jobs	jobs	**140**	**136**	**145**	**155**	**188**	**197**
Efficiency	**jobs**	**-**	**-**	**-**	**16**	**26**	**50**
Total Jobs	**jobs**	**140**	**136**	**145**	**171**	**214**	**247**

GREENPEACE

Greenpeace is a global organisation that uses non-violent direct action to tackle the most crucial threats to our planet's biodiversity and environment. Greenpeace is a non-profit organisation, present in 40 countries across Europe, the Americas, Asia and the Pacific. It speaks for 2.8 million supporters worldwide, and inspires many millions more to take action every day. To maintain its independence, Greenpeace does not accept donations from governments or corporations but relies on contributions from individual supporters and foundation grants.

Greenpeace has been campaigning against environmental degradation since 1971 when a small boat of volunteers and journalists sailed into Amchitka, an area west of Alaska, where the US Government was conducting underground nuclear tests. This tradition of 'bearing witness' in a non-violent manner continues today, and ships are an important part of all its campaign work.

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EREC

european renewable energy council - [EREC]
Created on 13 April 2000, the European Renewable Energy Council (EREC) is the umbrella organisation of the European renewable energy industry, trade and research associations active in the sectors of bioenergy, geothermal, ocean, small hydro power, solar electricity, solar thermal and wind energy. EREC represents thus 40 billion € turnover and provides jobs to around 350,000 people!

EREC is composed of the following non-profit associations and federations: AEBIOM (European Biomass Association); eBIO (European Bioethanol Fuel Association); EGEC (European Geothermal Energy Council); EPIA (European Photovoltaic Industry Association); ESHA (European Small Hydro power Association); ESTIF (European Solar Thermal Industry Federation); EUBIA (European Biomass Industry Association); EWEA (European Wind Energy Association); EUREC Agency (European Association of Renewable Energy Research Centers); EREF (European Renewable Energies Federation); EU-OEA (European Ocean Energy Association); ESTELA (European Solar Thermal Electricity Association) and Associate Member: EBB (European Biodiesel Board)

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image GROUP OF YOUNG PEOPLE TOUCH SOLAR PANELS DURING THE POSITIVE ENERGY TOUR, BRAZIL. GREENPEACE TOUR THROUGH BRAZIL IN LARGE TRUCK LOADED WITH A CONTAINER FULL OF FACTUAL INFORMATION ON THE POSITIVE ASPECTS OF RENEWABLE ENERGY.