Seventh inventory

Edition 2005

Worldwide electricity production from renewable energy sources

STATS AND FIGURES SERIES

1. Electricity production in the world: general forecasts

Observ'ER
Observatoire des énergies renouvelables

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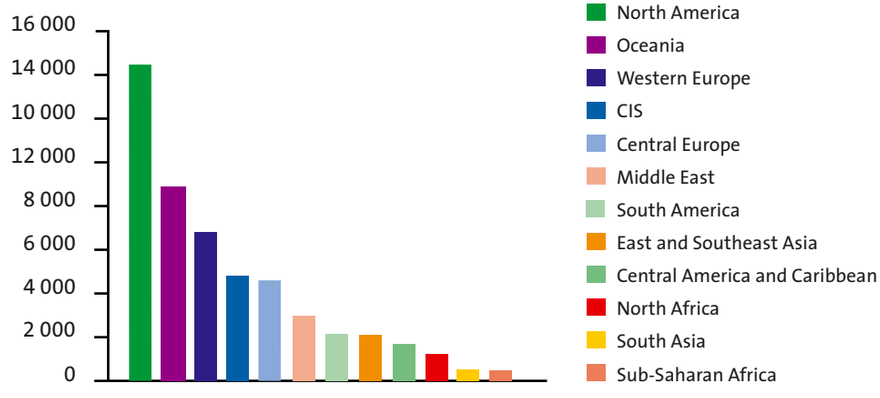
1.1. Economic development and electricity production

•Electrical production, an indicator of development to be used with caution

Electricity is a motor of economic and social development for a world population that will reach 10 billion inhabitants in 2050 (vs. 6.33 billion today). When considered on a per capita basis, electrical production can be used as an indicator of development. The difference between the few hundred kilowatt-hours per inhabitant in the poor regions of the world (485 kWh in Sub-Saharan Africa and 552 kWh in South Asia in 2004) and the 14 430 kWh per inhabitant in North America shows the different levels of development found between the various regions of the world.

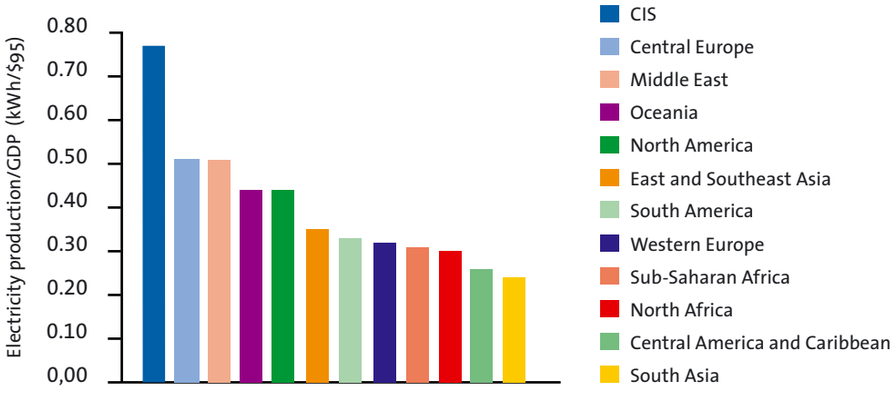
Per capita electricity production in 2004 in regions of the world in 2004 (kWh/inhabitant)



Nonetheless, certain precautions must be taken when using this indicator. A higher per capita production in one region does not necessarily signify a higher level of development. Electrical production per inhabitant in the Commonwealth of Independent States is, for example, 2.9 times greater than that of Central America (including Mexico) while per capita income is 1.4% lower in the CIS.

It should be kept in mind that these deviations do not only reflect disparities in terms of income. They are also due to differences in the energy content of economic growth (the amount of electricity needed to produce one unit of GDP). Because of a richer resource in primary energy, a particular geography and particular history, or an economy based on sectors or technologies requiring smaller or larger amounts of electricity, electrical production can follow distinctly different trajectories for comparable economic levels. The case of the CIS is a clear example in this respect. This region is characterised by the highest "electricity production per unit of GDP" ratio on the planet (0.77 kWh for 1 USD95) due to its past model of economic growth (based on intensive, high energy consumption).

Electricity production per unit of GDP in different regions of the world in 2004



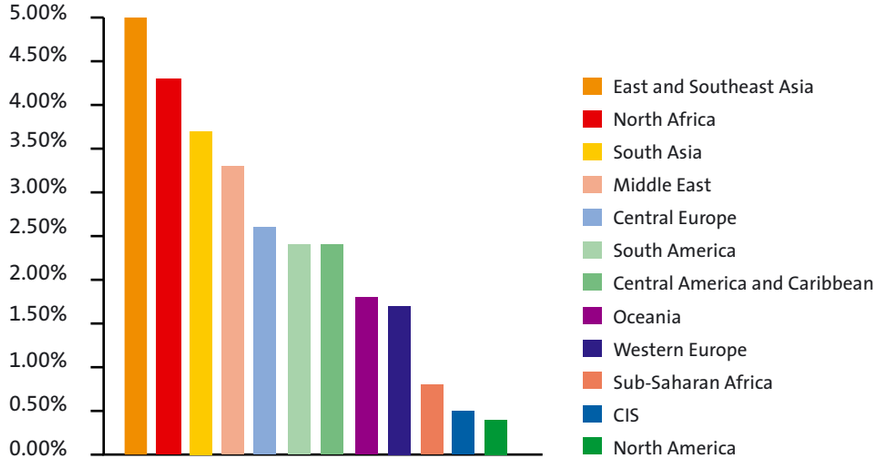
Growth in per capita electrical production between 1994 and 2004 that has only slowed down in post-industrial countries.

Dynamic analysis of per capita electrical production can be used to establish a first distinction between different regions of the world. For the period 1994-2004, the region of East and Southeast Asia had the most spectacular growth, with an average annual increase of 5.0% since 1993. This spectacular increase can be easily explained by the economic growth that this region of the world is currently experiencing. Three other regions of the world show strong growth in their per capita electricity production: North Africa (an average of 4.3% per year), South Asia (an average of 3.7% per year) and Middle East (an average of 3.3% per year).

Central Europe, South America, Central America, Oceania and Western Europe form another group where per capita electricity production grew more slowly (an average of from 1.7% to 2.6% per year). Paradoxically, Sub-Saharan Africa, CIS and North America are part of the same group of regions where the increase in per capita electricity production was weak (respectively an average of 0.8%, 0.5% and 0.4% per year).

The African situation can be explained by very sizeable demographic growth (the highest of the regions of the world) and by relatively low growth in electricity production. The low per capita growth in electrical production in the CIS can be explained by restructuring of the electrical production system since the break-up of the Soviet Union in 1991. This restructuring, which is still underway, is making it possible to rationalise electrical production and so limit new needs in electricity caused by the economic recovery. The low growth in per capita electricity production in North America

Growth in per capita electricity production in regions of the world (average annual growth rate, AAGR 1994–2004)



can be explained by both a “production per inhabitant” ratio is already very high and therefore grows more slowly and by greater and greater development of the service sector of the economy.

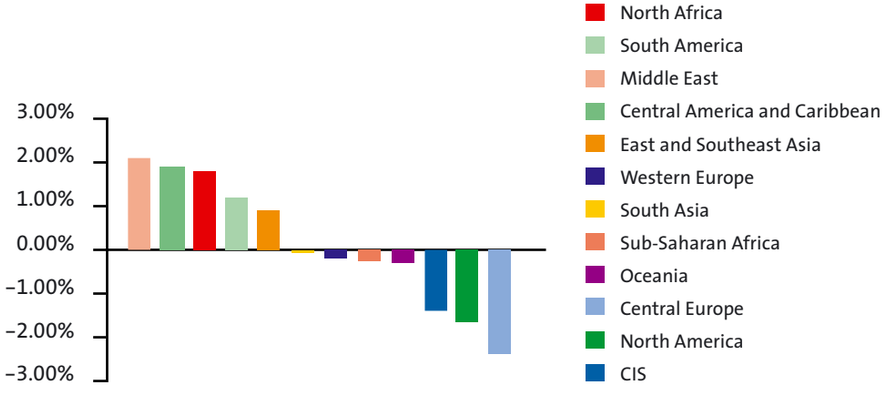
On the whole, constantly less and less electricity is needed to produce riches. Electricity production per unit of GDP has decreased by an average of 0.5% per year in the world between 1994 and 2004. However, this figure hides differences between “post-industrial” regions whose economic activity is turning toward the treatment of data requiring less electricity and those regions in extensive industrialisation phase that need more and more electricity to produce an additional unit of GDP.

Disassociation between economic growth and electrical production is especially marked in North America (an average of – 1.7% per year). Disassociation in Oceania (an average of – 0.3% per year) and Sub-Saharan Africa (an average of – 0.26% per year) can be explained by the importance of Australia and South Africa in these two regions of the world which have characteristics of post-industrial societies. The situation of Central Europe and that of the CIS are particular. The effect of restructuring underway in the industrial and electric sectors, which are becoming less and less high energy consuming, is a decrease in electricity needed to produce an additional unit of GDP (respectively an average of – 2.4% and – 1.4% per year).

The situation is an intermediate one in Western Europe (an average of – 0.04% per year) where creation of one additional unit of GDP has required a practically constant amount of electricity over the studied period.
North Africa, South America, Middle East, Central America, South America, and East and Southeast Asia are the regions where creating an additional unit of GDP requires ever more and more electricity. The region of East and Southeast Asia is more complex to analyse because it includes China, which is in intensive industrialisation phase, and Japan, which is developing the service sector of its economy. China's weight results in all of the zone being considered as one of the regions needing an increasing amount of electricity to produce an additional unit of GDP.

These observations show that efforts must be made in these countries to promote a method of economic and energetic development different from that experienced in their time by the countries now entering a post-industrial era.

Growth in electricity production per unit of GDP in regions of the world (average annual growth rate, AAGR 1994–2004)



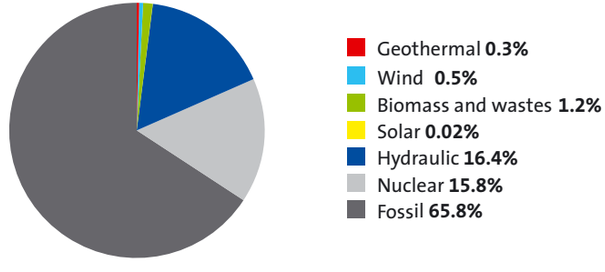
1.2. Electricity production from renewable energy sources

• A significant share of world production
Renewable energy origin electrical production is an integral part of the world electricity production system. During 2004, it represented production of 3 157.5 TWh, i.e. 18.2% of world production. This share remains greater than that of the electro-nuclear sector (15.8% in 2004) but considerably lower than the classical thermal sector using fossil fuels (65.8%). Excluding hydraulic power, this proportion reaches 1.75% of the worldwide total (303.7 TWh).
Renewable origin electricity comes from 5 distinct sources. Hydraulic power is the most sizeable, representing 90.4% of the renewable origin total. Biomass is in second place with 5.2%. Wind power (2.6%) is the third largest renewable sector in front of geothermal energy (1.7%). Solar energy origin electrical production, concentrated principally in three countries (USA, Japan and Germany), represents 0.1% of the renewable origin total.

World electricity production by source

TWh	1994	2001	2002	2003	2004	AAGR 94/03	GR 03/04
Geothermal	38.1	51.0	51.8	53.8	54.7	3.7%	1.8%
Wind	6.5	38.4	53.0	64.0	81.5	28.8%	27.4%
Biomass and wastes	121.1	169.3	185.0	198.8	203.1	5.3%	2.2%
(biomass share)	*98.8*	*133.3*	*149.3*	*159.1*	*164.2*	*5.2%*	*3.2%*
Solar	0.7	1.6	2.0	2.8	3.2	16.8%	16.0%
Hydraulic	2 426.2	2 643.6	2 714.4	2 729.7	2 853.8	1.6%	4.5%
(pump storage share)	*59.8*	*77.9*	*79.4*	*81.9*	*81.8*	*3.2%*	*0.0%*
Nuclear	2 241.8	2 637.7	2 660.8	2 636.9	2 752.2	2.1%	4.4%
Fossil	7 998.4	10 003.4	10 488.7	11 061.0	11 438.1	3.6%	3.4%
Total renewable	**2 570.3**	**2 867.9**	**2 970.4**	**3 009.4**	**3 157.5**	**2.1%**	**4.9%**
Total conventionnal	**10 262.5**	**12 677.0**	**13 185.2**	**13 737.5**	**14 229.2**	**3.3%**	**3.6%**
Total production	**12 832.8**	**15 544.9**	**16 155.6**	**16 746.9**	**17 386.7**	**3.1%**	**3.8%**
Renewable share	***20.0%***	***18.4%***	***18.4%***	***18.0%***	***18.2%***		

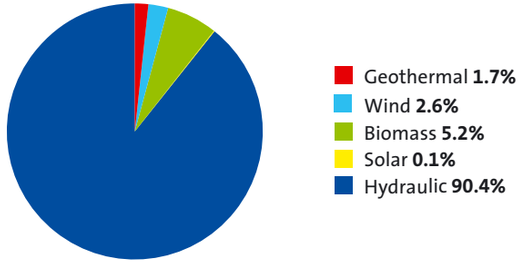
Structure of electricity production – 2004



Structure of electricity production from renewable energy sources – 2004

Source	TWh in 2004	% 2004
Hydraulic	2 853.8	90.4%
Biomass	164.2	5.2%
Wind	81.5	2.6%
Geothermal	54.7	1.7%
Solar	3.2	0.1%
Total	**3.157.5**	**100.0%**

Structure of electricity production from renewable energy sources – 2004



Decreasing relative share, but increasing production

A first observation on the worldwide level is that the renewable share of world electrical production is in constant diminution. From 20% in 1994, it decreased to 18.2% in 2004, i.e. a 1.8 point loss for all of the period. While this drop may seem worrying, it does not signify a lack of interest for renewable energies. It simply shows that conventional electricity growth is, on a worldwide scale, more rapid than that of renewable origin electricity (respectively averages of + 3.3% and + 2.1% per year). In terms of production, renewable origin electricity has continually progressed with an increase of 587.2 TWh between 1994 and 2004. Hydraulic power represents the largest share, with an additional 427.6 TWh, followed by biomass (+ 65.4 TWh), wind power (+ 75 TWh), geothermal energy (+ 16.6 TWh) and solar energy (+ 2.6 TWh).

Greater dynamism for renewable energy sectors other than hydraulic power

The importance of the hydraulic sector, which grew slowly over the period (an average of + 1.6% per year), hides the dynamism of the other renewable sectors. Without hydraulic power, renewable origin electricity growth would amount to an average of 7.7% per year since 1994, i.e. twice that of conventional origin electricity. The result is that the share of the renewable sectors other than hydraulic power has increased in world electrical production, going from 1.1% of the total in 1994 up to 1.7% of the total in 2004.

Detailed analysis by sector (including nuclear energy and fossil fuels) shows that wind power origin electricity had the most sizeable growth for the period, with an average increase of 28.8% per year from 1994 to 2004. Solar origin production grew by an average rate of 16.8% per year since 1994, positioning it in second place behind wind power. The biomass and geothermal sectors have also expanded with respective average growth rates of 5.2% and 3.7% per year.

Two main factors contributed to this growth. Firstly, significant progress made in the technologies used as well as in the organisation and follow-up of projects. This gain in reliability has attracted new actors and new investors who are interested by perspectives of development, which in turn leads to even more intensive technological emulation.

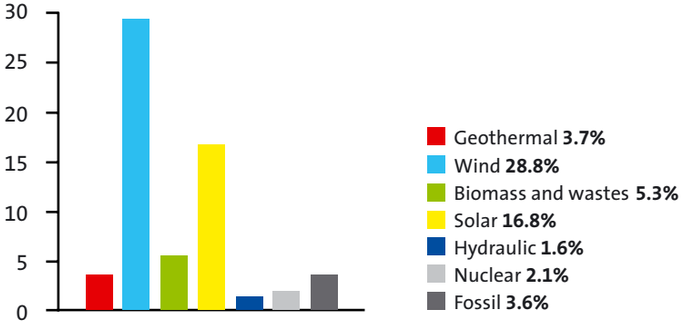
Secondly, global environmental questions, in particular the risk of climatic change, have reinforced the political will of numerous industrialised countries to support development of non polluting energies. This will has resulted in ambitious objectives in terms of renewable energies and establishment of specific regulatory instruments to reach them (guaranteed price, green certificates, quotas, favourable taxation, etc.). The goal, in the end, is to make the different renewable sectors autonomous.

In this context, the end of the 1990s was characterised for these different renewable energies by mature technologies. From research & development and pilot projects, we have now truly moved on to extended commercialisation and industrialisation, with the objective of adapting to a strongly competitive market. In the 1980s, 300 MW of wind turbines were installed during good years vs. more than 8 200 MW in 2004 (i.e. a cumulated total of 47 574 MW). In the same way, 50 MWp of photovoltaic modules left the factories in 1990, while 1 194 MWp were produced in 2004. This capacity represents a surface area of nearly 12 million square meters of collectors.

Certainly, the share of renewable origin electricity production, other than hydraulic power, remains low when conventional electrical production is considered. The differential in competitiveness, the growth of emerging countries founded on fossil fuels, the constraints of financing and the very low price of fossil fuels over the period, doubtless explain this situation. However, if most of these renewable sectors are not profitable at the current price of electricity, some of them are

approaching the profitability threshold more and more. Their progressive increase in the share of world production shows a more and more marked interest for these new sectors. They have proven that they have their place in the world energy mix. Their potential has been only barely exploited and their competitiveness is continuing to improve.

Average annual growth rate 1994-204



Electricity production from renewable energy sources – excluding hydropower (TWh)