TRENDS IN ENERGY USE

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1. A bit of history

A reliable, affordable and secure supply of energy is important for economic development. This has been true for the past and present and will remain valid for the future. However, over time changes have taken and will take place with regard to energy use, both with regard to the amount as well as with regard to the type of energy used. Many factors have played a role in bringing these changes. Availability, security of supplies, price, ease of handling, ease of use, external factors like technological development, introduction of subsidies, environmental constraints and legislation are some of these factors.

An example of the influence of such factors is the fact that as early as the sixteenth century, shortages of wood as a raw material for the making of charcoal resulted in that the iron-melting industry moved. Initially iron-making was common in England but due to shortages of charcoal, the industry moved by exporting ore first to Ireland and later to Scotland as abundant supplies of wood from forest were still available in these areas.

During this period, legislation was already enacted to protect forests in England and later in Ireland[1]. Much later (late 19th century), charcoal was replaced by coal as technologies became available like steam engines, to drive the forges which supplied the air-blasts necessary for the operation of coke furnaces.

While early on wood and charcoal were the most important sources of energy, they were replaced to a greater or lesser extent by coal, partly due to technological developments but also due to a transformation in society (improvements in living standards, wood to brick housing, open fire to enclosed fire places with grates, etc.).

Later on, once oil was becoming available, coal was slowly being replaced by oil as this was more easy to handle and use, became cheaper, etc. These changes from one type of energy to other types can clearly be observed in figure 1 which shows primary energy use in the United States during the period 1870-1970.

Predicting such changes however is wrought with uncertainties. When in 1893 the American Press Association asked the country's "best minds" to predict the future, the main mean of transport was still the horse-drawn carriage and street lighting was provided by gas lights which at that time were considered a high-tech novelty. Coal, which accounted for about 60% of commercial energy use, was expected to remain dominant for a long time to come. Major changes were predicted like "Electrical power will be universal…. Steam and all other sorts of power will be displaced" but other changes were not foreseen.

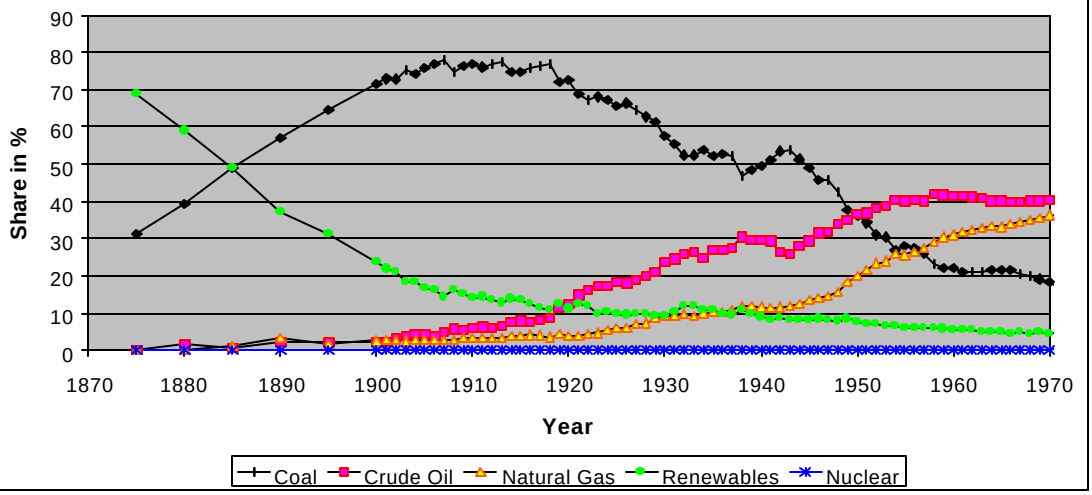
Table 1 World Energy Use - Million Ton Oil Equivalent (MTOE) and % in 1900 and 1997

Type of energy	Total in 1900	Share in 1990	Total in 1997	Share in 1997
Coal	501	55	2,122	22
Oil	18	2	2,940	30
Natural Gas	9	1	2,173	23
Nuclear	0	0	579	6
Renewables[1]	383	42	1,833	19
Total	911	100	9,647	100

1 Renewables includes biomass, hydro, wind, geothermal, solar, etc.
Source: *State of the World 1999 – World Watch Institute*

[1] In 1588 during the first year of the reign of Queen Elizabeth an act called "An Act that Timber shall not be felled to make Coals for Burning Iron" was promugated to protect woodlands. As early as 1543 the Parliament of England introduced statutory coppice management and also specified the enclosure of felled woodlands to allow for regeneration to ensure future supplies. Pollution was at that time common in these areas although some commented that the smoke issuing from forges and charcoal making sites "beautifully breaks their lines and unites them with the sky".

Fig. 1 Primary Energy Use in the United States 1860-1970 (source: World Watch Institute)



No one predicted that oil would become a major source of energy (oil accounted in 1900 for only 2% of energy use on a worldwide basis – see table 1). Some predicted trains travelling 100 miles per hour and moving sidewalks but none predicted that cars or planes would become an important means of transport.

2. Present day energy use

Energy use from the seventies onwards has been influenced by various factors of which the oil shocks in the seventies and eighties probably have had a marked influence, not only on energy use but probably more important on developments in the energy sector. The sudden and sharp increase in the oil price coupled with the threat of disruptions in the supply of fossil fuel (mainly oil) resulted in diversification of energy use. Many countries, in particular in the western world, switched from oil to other sources of energy like coal and natural gas and promoted nuclear energy (since discredited due to accidents like the 1979 meltdown of the Three Miles reactor and concerns about disposal of nuclear waste), etc. Besides, activities were undertaken to develop and promote alternative sources of energy like solar and wind.

Another effect was the start of energy conservation activities in many countries. Stove programmes became fashionable as a result of kerosene and other fossil fuel based energy sources becoming more expensive but also due to concerns of deforestation (the fuelwood gap theory) while health issues associated with the use of biomass energy also played a role. Renewed interest in energy conversion systems like biogas and gasification was also one of the outcomes of it. The latter technology had been used in European countries during Worldwar II in particular as a transportation fuel but, as soon as fossil fuels were again easily available, was abandoned in favour of liquid fuels. Besides the direct health issues related to energy use such as exposure to smoke, particulates, etc., a much broader concern with regard to the health of the environment emerged in the form of warnings about global warming.

All factors combined resulted in a move towards the development of environmental friendly sources of energy. This move was relatively successful, as is evident from energy statistics which show that the use of modern renewable sources of energy increased seven-fold from about 5,100 KTOE (less than 0.1% of all primary energy use in 1971) to about 36,000 KTOE (about 0.4% in 1995) over the period 1971-1995. The modern renewables include solar, wind, tide, geothermal, etc. with geothermal accounting for over 90% of those amounts.

Biomass (all types) remained at the same time a very important source of energy in particular in the developing countries but also in developed countries. While in 1973 biomass accounted

for about 11% or about 681 MTOE of all primary energy used the share in 1995 remained more or less stable at about 10.8% but the actual amount had increased about 50% to about 1,034 MTOE (see also table 2). This amount does include biomass used for traditional and modern applications. However, the share of traditional use of biomass (cooking, heating, etc.) is still far larger than the amount used for modern applications like power generation, etc. According to statistics some 20-25% of biomass energy is used for modern applications with the remainder being used for traditional applications. However, as data on biomass energy use in general appears to be on the low side, in particular where it concerns traditional use (cooking, etc.) it may be assumed that the 20-25% is on the high side. Other estimates indicate that roughly some 2 billion people depend on biomass as their main source of energy. These figures clearly show that traditional biomass energy use is important and it may be assumed that this will remain so for the next few decades.

Table 2 Energy Use in the World

YEAR	1971	1975	1980	1985	1990	1995
Coal	1,521,194	1,680,836	1,927,998	2,227,941	2,426,677	2,463,501
Crude oil	2,502,963	2,747,911	3,119,751	2,827,718	3,178,333	3,305,385
Natural Gas	909,998	1,023,343	1,245,604	1,433,041	1,707,204	1,808,536
Nuclear	28,950	100,163	186,402	389,429	524,952	608,260
Hydro	103,981	124,649	149,669	171,222	185,784	214,867
Geothermal	3,808	6,841	11,780	19,855	31,939	34,541
Solar	0	3	21	284	607	916
Tide	43	44	43	54	51	52
Wind	0	0	1	5	270	632
Comb. Renewables	651,000	707,032	790,968	878,783	950,652	1,034,124
Others	129	0	0	0	0	56
Total	5,722,065	6,390,824	7,432,236	7,948,332	9,006,469	9,470,870

Source: Energy Statistics and Balances of Non-OECD countries 1995-1996
Combustible renewables include small amounts of municpal solid waste, etc.

As indicated earlier, biomass is also an important source of energy in industrialized countries. Although on a worldwide basis biomass accounts for about 10.8% of all primary energy, individual countries show large variations. While in developing countries the share of biomass may in average be about 30% the share of biomass in individual countries may go as high as 90-95%. In the developed world the share of biomass normally is quite low. In Europe the average is about 2% but here also there are large variations: Biomass energy in Finland, Sweden and Ireland account respectively for 14, 13 and 13% of all primary energy used while in the UK its share is only 0.3%. In the USA biomass accounts for about 4% of all primary energy used. However, on a per capita basis, a different picture emerges as is evident from the following table 3 which shows that on a per capita basis biomass energy use in developed countries can be as high or even surpass that of developing countries.

Table 3 Comparison of total and per capita energy use (1996)

	Population	TPES		Biomass	
	Million	Total Mtoe	TOE/Cap.	Total Mtoe	TOE/Cap.
World	5624.44	9447.86	1.680	1036.59	0.184
Asia excl. China	1698.74	960.80	0.566	349.15	0.206
OECD	1092.29	5019.76	4.596	157.05	0.144
China	1215.41	1096.80	0.902	206.08	0.170
India	945.12	450.29	0.476	188.65	0.200
Thailand	60.00	79.99	1.333	21.38	0.356
USA	265.56	2134.96	8.039	70.77	0.266
Finland	5.12	31.48	6.148	5.26	1.027
Sweden	8.90	52.57	5.907	7.63	0.857

However, even though the share of renewable sources of energy like solar, wind, etc. increased, it is also clear that it has not been plain sailing as the technologies did not live up to expectations. This is in particular valid with regard to market penetration. A recent study carried out in the USA[2] showed that of the 5 renewable energy technologies studied (biomass, geothermal, solar P.V., solar thermal and wind[3]) that in the USA:

- Market penetration of renewable energy technologies generally failed to meet expectations with the exception of a) wind which met projections from the 1980's although earlier predictions were overly optimistic and b) biomass which exceeded previous projections.

- Costs of renewable energy technologies generally succeeded in meeting expectations and successive projections of costs either conformed to expectations or declined relatively to these projections.

The following will briefly cover these technologies, their pro's and con's, and where available, their costs, etc. However, considering that these technologies are used mainly for electric power generation (solar thermal also for heat) a very brief overview of electricity generation costs of conventional power will be given[4] for reasons of comparison.

Conventional Power Generation

During the period 1980-1990 expectations were that electricity prices would rise by some 8%. In fact, prices declined by 10%. Subsequently, taking into account softening oil prices, forecasts for the period 1983-1995 indicated a decrease in electricity price of 5% but the actual decrease over this period was about 25%. The decrease can be contributed mainly to the lower cost of fuel used for power generation and to a lesser extent to lower capital costs as is evident from table 4.

Table 4 Actual and Projected Electricity Prices in 1983 and 1995 (US$ cents/kWh)

	Actual 1983			Forecast 1995			Actual 1995		
	Generation	T/D	Total	Generation	T/D	Total	Generation	T/D	Total
Total	6.1	3.2	9.3	6.4	2.4	8.8	3.6	3.5	7.1
Capital	2.2	1.6	3.8	1.7	1.0	2.7	1.7	1.1	2.8
Fuel	3.3	-	3.3	4.0	-	4.0	1.1	-	1.1
O/M	0.6	1.6	2.2	0.7	1.4	2.1	0.8	2.4	3.2

Source: Resources for the Future

It should be noted that the cost data given are associated with large scale power generation units (generally over 250 MW) and are operating in a market which has become progressively de-regulated in the USA and therefore highly competitive. Fuels used are coal, oil or natural gas. In the western world the units are operating under stringent environmental rules and regulations with regard to emissions, etc. However, at the same time it may be assumed that not all of the external environmental costs associated with these fuels are internalized in the cost of electricity.

Biomass power generation

Biomass is widely used for power generation such as for example in the sugar industry and the pulp and paper industry. Those industries generate large quantities of residues on site which need to be disposed of. Generating power and heat (steam) for own use is therefor a logical options to pursue.

[2] Winner, Loser, or Innocent Victim? Has Renewable Energy Performed as Expected. Discussion Paper 99-28, Resources for the Future March/June 1999
[3] Hydro power was not considered as it often involves large mainstream units
[4] Information and data given are mainly based on conditions in the USA where deregulation of the power/energy sector has influenced the power sector to a large extent. The same may therefor not be directly applicable to other countries/regions.

Relatively new is power generation using biomass from other sources like logging residues, saw mill residues, wood from plantations, etc. For such cases biomass often needs to be transported to the power plant which increases the price of the fuel to a considerable extent. Unlike for powerplants using coal, oil or gas where the price of the fuel will remain constant whether the power plant is small or large this is not the case for biomass. Calculations show that the cost of transporting woody biomass for a 5-10 MW powerplant would be about 13-16 US cents per GJ while for a 30-35 MW plant transport costs would be about 35 US cents per GJ as the collection area and transport distances would increase (Renewable Energy World July 1999 – see footnote 5). Biomass fuelled power plants therefore are often relatively small (generally under 100 MW while the typical size is 20 MW or less) due to the increased cost of the fuel.

Most of the systems are based on the steam-based Rankine cycle but recent efforts have focussed on gasification/combined cycle technologies that offer substantial cost reductions and efficiency improvements over the traditional steam technology. Also co-firing wood/biomass with fossil fuels (mainly coal) offer opportunities where biomass supplies are climate/season dependent and/or for environmental reasons.

The costs of biomass based electrical power resemble to a certain extent those of fossil fuel based power generation as this is the only renewable energy with fuel costs. Capital costs are generally higher than for conventional power systems due to the small(er) size as well as the need for fuel handling/preparation and storage. The total installed capacity worldwide has been estimated to be about 108 GWe in 1994 (equal to about 4.1% of all electricity generating capacity)[5]. Biomass power generation systems, unlike wind and solar, are suitable for base-load generation, as the supply of biomass generally does not cause problems. Deregulation taking place in the USA has resulted in that several biomass power plants are expected to close down once their power purchase contracts come up for renewal. Many of these contracts were negotiated in the eighties when fuel was still relatively expensive but fuel costs have since dropped considerable – see table 4.

Wind

Wind powered electricity generation is a relatively new technology eventhough its mechanical power variant has been around for a long time. Large-scale wind based power generations has its roots dating back to 1941 in Vermont. Extensive research, which got a boost after the oilshocks, has resulted in a remarkable growth in wind power. Generating capacity increased from some 10 MW in 1980 to 7.6 GW in 1997 (0.3% of total worldwide generation capacity). In 1998 an additional 2 GW was installed. The growth since 1995 has ranged from 25-35% per year with the USA, Germany, Denmark and India being the leaders in using wind turbines for power generation.

Costs of generation have come down considerable with the advent of large sized wind turbines. While from 1990 – 1996 average wind turbine size increased from 250 kW to about 500 kW, in 1998 units between 660 kW and 1.65 MW were common. The average "availability" [6] of larger wind turbines is around 21-22%. In 1995 the estimated cost of wind based electricity was about 5.2 cents (US) per kWh and are still expected to come down. Current cost estimates are close to the average cost of fossil fuel based power.

Solar thermal and photo-voltaic

Solar thermal finds wide applications ranging from power generation to water and space heating, crop drying, etc. Although the latter are an important application, in particular in colder countries, these technologies are not covered here.

[5] Based on "Renewables prospects in todays conventional power generation market" in Renewable Energy World Vol. 2-4. July 1999. This would result in an overall efficiency – from biomass to electricity – of about 13% which appears to be low. Powerplants exclusively run for that purpose and using biomass can have overall effciciencies of about 30-35% depending on availability, load, etc.

[6] Availability here indicates basically the amount of power which may be expected from a given turbine.

Solar thermal power generation received much interest in the eighties and systems with a combined capacity of about 370-400 MW were installed (equal to about 0.015% of all generating capacity), mainly in the USA. Most of the capacity was in the form of parabolic through systems with the remainder made up by central receiver technology and other systems. Most of the systems in the USA are hybrid technologies with natural gas co-firing providing backup and/or additional capacity. Generation costs vary but in 1995 were about 20 cents (US) per kWh according to Resources for the Future. However, other sources indicate a price of about 13-16 cents (US) in 1990.

Solar PV technology is well established and used for a wide variety of applications (lighting, communication/signals, battery charging, consumer products, etc. as well as for off-grid and grid connected power supply). Annual shipments of P.V. modules generally increased by some 12-15% per year in the nineties but have increased sharply during the last 2 years (growth of 72% from 1996-1998 and 33% from 1997-1998) mainly due to heavily subsidized grid-connected residential programme in Japan and programmes in the Netherlands and Germany. Total shipments of P.V. modules since 1971 till the end of 1998 were about 960 MW which include PV modules for consumer products (calculators, etc.). In 1990 and presumably also earlier, PV modules for consumer products accounted for 1/3rd or more of all shipments, over time this dropped to 1/4th and in 1997 and 1998 dropped to about 1/5th of all shipments. Using these figures it has been assumed that PV modules shipments till now have been about 75% which implies that out of the total shipments of 960 MW some 720 MW would be for stand-alone and grid connected power systems. This would be equal to about 0.025% of all generation capacity.

Costs of electricity generated has dropped sharply but have been estimated to be in 1995 about 30 cents (US) per kWh for relatively small grid connected systems. The costs for stand-alone systems vary widely depending upon configuration. Although grid-connected systems seem at present to find more applications (generally heavily subsidized such as the 70,00 roof programme in Japan, etc.) most of the P.V. applications are stand-alone systems for lighting, communications, etc. in particular for those areas where grid connections are not available (it has been estimated that some 2 billion people have no access to the electricity grid and could be potential users of solar home systems) or where the supply of other sources of energy is giving problems (remote sites for telecommunication repeaters and so on. Such solar home systems are basically for “services” like lighting during the evening, street lighting, for T.V and radio reception, etc. rather than for continuous power generation.

Geothermal

Geothermal power generation is normally only possible in certain areas (boundary areas of lithospheric plates) such as the west-coast of North and South America, New Zealand, Indonesia, the Philippines, Japan, Iceland, etc. Total installed capacity in 1998 was about 7,900 MW with modest growth registered for geothermal based electricity generation as well as for direct heat applications. In 1989 installed capacity was about 6 GW while in 1998 the capacity was 7.9 GW indicating an average growth rate of about 3-4%. Costs of geothermal electricity can compete with those from conventional power generation systems and were about 5.5 cents (US) in 1995 and are expected to drop to about 4 cents/kWh in the future.

A brief review of renwables over the last few years

Looking at the individual renewable sources of energy it is clear that there are large differences between importance as well as growth in the different sources of renewable energy. Biomass energy in general as well as modern applications of biomass energy are by far the most important. However, wind and solar have shown very impressive growth rates but their overall contribution to the energy scene is still very small. Table 5 provides a brief overview of these changes over time.

Table 5 Comparative review of renewable electricity generation capacity

	1970	1975	1980	1985	1990	1995	1996	1997	1998
Biomass						10800			
						0			
Wind			10	1020	1930	4820	6115	7630	10220
Solar PV[7]		2	19	98	273	595	683	810	963
Solar Therm.		Neg.	5	50	1000	900			
Geothermal	817	1287	2471	3912	5832	6798	7173		

The data show that solar and wind, the two renewable sources receiving a lot of attention and almost synonym with renewable sources of energy unlike biomass, which is often not mentioned at all, do show impressive growth-rates over time. Average growth rates from 1990-1997 have been respectively 23.27% for wind, 16% for solar, 3.5% for geothermal (1990-1996). Data for modern applications of biomass energy are not available but estimates from the USA for the period 1990-1995 show growth-rates of 7.5%. On a worldwide basis the average is probably considerable lower as in particular in the USA a lot of new biomass based generating capacity was added. In fact other sources seem to indicate an average growth-rate of about 3% on a worldwide basis. Unfortunately, this figure could not be verified.

3. A peek in the future

For today's "energy forecasters" the present system may seem to be even more solid than 100 years ago even though during the last 2-3 decades changes have taken place. Internal combustion engines and cars fuelled by oil have been around for over eighty years and electricity is taken for granted. Due to various reasons a.o. over-supply and competition, deregulation, etc. the price of energy is low and in fact, in the developed world in terms of consumer purchasing power, the price is nearly as low as it has ever been. This for sure has an influence on developments in the energy sector be it in choice of type of energy to be used, developing "new" types of energy, energy conversion systems, etc.

What is also sure is that oil, coal and natural gas are finite resources. However, no one knows when the world will run out of them. There have been many pessimistic forecasts, all proven to be wrong. In 1950 proven reserves of oil and gas stood at 30 billion tons of oil equivalent (btoe); in 1990 they exceeded 250 btoe not withstanding the fact that during the 40 year period over 100 btoe have been consumed. Proven reserves of coal rose from 450 to 570 btoe over the same period. The increase in proven reserves can partly be contributed by the oil shocks of the 70's and 80's. Sharp increases in the oil price put market forces to work and led to increased exploration, more efficient production as well as increases in end-use efficiency. Estimates of "ultimately recoverable" fossil fuel reserves worldwide stand now at more than 600 times the 1990 annual rate of extraction. At the same time it should be noted that there is a large imbalance in energy use not only in between the developed and the developing world (see table 5 - see also table 3).

Table 5 Regional Energy Indicators in 1996

Region	TPES[1]	GDP[2]	Population	TPES/GDP	TPES/Cap.
World	9448	24194	5624	0.39	1.68
OECD-North America	2513	7236	392	0.35	6.41
OECD Europe	1717	8030	507	0.21	3.39
OECD Pacific	790	4107	193	0.19	4.09
Non-OECD	4297	4821	4532	0.89	0.95
Asia	2058	2106	2914	0.98	0.71

[1] *Energy Supply in Million Tons of Oil Equivalent*
[2] *GDP expressed in billion US$ (1990) using exchange rates*
Source: Energy Statistics & Balances of Non-OECD Countries 1995-1996, IEA

[7] The amounts shown include those for consumer products

The same is true for differences between the regions. Energy consumption over the period 1988 –1998 grew roughly 13% in North America while over the same period the growth in Europe was less than 2% (BP Amoco, 1999). In the Asia-Pacific the growth was some 46%, in Africa some 28%, in South and Central America about 37% and in the Middle East the growth was almost 56%. In contrast, the former Soviet Union saw a decrease of almost 35%. Other estimates[8] show that oil consumption would triple from 67 million barrels a day to some 200 million if China, India and the rest of the developing world would start using oil in the same way as the developed world is doing at present.

However, long before the world runs out of fossil fuels, health and environmental impacts of their use will force the world in the direction of clean(er) energy systems and/or sources. This reality has a pronounced influence on predictions what will happen in the future with regard to energy use. Various organizations have put efforts into predicting what the future holds with regard to energy use (table 6 gives some examples of these predictions). These predictions show large variations in the importance of the various sources of energy depending on what view is taken with regard to:

- the use of fossil fuels;
- the acceptability of nuclear energy and;
- renewable energy technology development.

Besides these factors, population growth, economic development, improvements in energy conversion efficiency rates, environmental considerations are some of the other factors that have influenced the outcome of these predictions.

Table 6 Some Prediction of Global Energy Use in 2050 (EJ per year)

Primary Energy	Actual 1990	IS 92 a Ref.	WEC / IAASA			Shell Sustained Growth
			B	A1	C1	
Coal	96.9	356	179	160	66	184
Oil	142.9	153	179	333	121	148
Natural gas	76.0	143	210	198	182	140
Nuclear	22.8	87	121	123	22	94
Renewables	73.5	252	197	229	250	680
Total	412.1	991	886	1,048	641	1,246

Source: Reddy e.a. 1997
IS 92a – The Intergovernmental Panel on Climate Change (IPCC) Reference Scenario
WEC / IAASA – World Energy Council and International Institute for Advanced Systems Analysis: Scenario B = Reference, Scenario A1 = High Growth with ample Oil and Gas, Scenario C1 = Ecological Driven with New Renewables and with Nuclear phase-out

It is clear that the different forecasts show large variations depending on which scenario is taken and this shows that making forecasts for such a long period is wrought with difficulties. In order to provide some indications on where things are going in particular for renewables, a forecast was made up to the year 2020 realizing however, that the underlying assumptions remain the same. Table 7 gives forecasts for renewable energy in terms of expected generation capacity, taking into account average growth-rates mentioned earlier.

Table 7 Forecast of renewable energy electricity generation capacity (MWe)

	1995	2000	2010	2020
Solar P.V	595	1295	5720	25,218
Wind	4,820	15,512	124,962	1,006,668
Geothermal	7,173	8,231	11,610	16,378
Modern Biomass 7.5%	108,000	155,050	319,600	658,620
Modern Biomass 3.0%	108,000	125,200	145,143	168,300

[8] See “State of the World: 1999” Worldwatch Institute 1999

The table shows that biomass remains the leader in renewable energy generation capacity with the exception of wind which growth at an incredible annual rate of over 23%. Sustaining such a growth over the next 20-25 years seems highly unlikely. Conventional power generation capacity stood in 1995 at about 2,615 Gwe and is expected to rise to about 4,872 Gwe in 2020. If wind indeed would continue to rise at the present growth-rate, wind would account for about 20% of all generating capacity. In fact, models mentioned earlier show much smaller increases with Other energy sources including wind increasing at an annual rate of about 12% in scenario B (middle ground) of WEC/IIASA.

4. Concluding Remarks

It is clear from the above that biomass energy for modern applications will play an important role, not only in the sphere of renewable energy but also in the overall energy picture. This view is strengtened by the fact that besides its use for power and heat generation, the traditional use of biomass energy (cooking, heating, etc.) is probably even more important.

Total biomass energy use, according to IIASA/World Energy Council predictions[9], accounted in 1990 for about 849 MTOE or about 9.5% of all energy consumed on a world-wide basis and 1,095 MTOE or 12.2% if modern biomass energy is included. These figures would change to 842 MTOE (8.3%) or 1,170 MTOE (11.5%) in 2000 and respectively 857 MTOE (6.3%) of 1,330 MTOE (9.8%) in 2020 for traditional biomass and all biomass. In contrast, the other renewable sources of energy (solar, wind, geothermal, tide, etc. but with the exception of nuclear energy) would account respectively for about 0.2%, 0.54% and 2.23% in 1990, 2000 and 2020.

This does show that biomass energy is at present an important source of energy with biomass energy being after oil, coal and natural gas the most important fuel on a worldwide basis. At the same time it is also clear that traditional use of biomass energy is still far higher than that used for modern applications. Although the share of modern biomass energy viz-a-viz traditional biomass energy use will rise in the future, there is at the same time also no doubt that the latter will continue for the near future.

[9] See http://www.iiasa.ac.at/cgi-bin/ecs/book_dyn/bookcnt.py – IIASA / WEC Global Energy Perspectives – The data given by IIASA/WEC for 1990 are higher than those reported by IEA (950 MTOE in 1990) which recently has put efforts into providing information on the importance of biomass energy