ELSEVIER

Energy Policy 34 (2006) 2185–2190

ENERGY POLICY

www.elsevier.com/locate/enpol

The promise of clean energy

José Goldemberg*

São Paulo State Secretariat for the Environment (SMA-SP), Av. Prof. Frederico Hermann Jr. 345, São Paulo 05489090, Brazil

Available online 13 May 2005

Abstract

The world's energy system is at least a 1.5 trillion dollars market dominated by fossil fuels, where small changes can have a large influence on efforts to reach sustainability. Renewable energy sources are key to achieving this goal. Excluding traditional biomass, in 2001 renewables represented 4.4% of primary energy consumption, unevenly distributed between developed and developing countries. Environmental problems at local, regional and global levels, as well as external dependency and security of supply will persist if we rely on an energy future based on fossil fuels. Solutions encompass extending the life of fossil fuel reserves and expanding the share of renewable in the world energy system through top down and bottom up policies, described in this paper.

Keywords: Renewable energy policies; Sustainable development

1. Introduction

The human body—this marvellous machine produced by the evolutionary process—is driven by water, oxygen and by food which supplies the modest energy needed for human to go around and produce such wonders as Schiller's poems or Kurosawa films. In contrast, the machines that drive our modern society consume huge amounts of energy originating mostly in fossil fuels. Average energy "per capita" consumption in the world today is 20 times larger than the energy needed by human beings, approximately the same required by a 100 W light bulb. Fig. 1 shows the world primary energy sources in use in 2001.

Approximately, 1.5 trillion dollars are spent every year on primary energy without considering the cost of secondary conversion, such as electricity production or fuel refining. The world's energy system is thus a very large one and relatively small changes can have a large influence on efforts to reach sustainability.

Non-renewable sources are dominant today. Fossil fuels (coal, oil and natural gas) account for approximately 80% of primary energy consumption. Nuclear energy represent 6.9% and 9.3% comes from traditional biomass.

In 2001, renewables represented 4.4% of primary energy consumption, excluding traditional biomass, only a fraction of which is renewable. Of this percentage, 2.3% corresponds to large hydro and the remaining 2.1% are "new renewables", which include modern biomass (such as biofuels, electricity and heat from urban and agricultural solid wastes and reforested wood), wind, solar (PV and solar heat), small-scale hydropower, marine and geothermal energy.

Energy consumption is unevenly distributed between developed and developing countries (Fig. 2). Developing countries rely more on renewable energy sources, than developed countries. According to the International Energy Agency (2003) classification of renewables (combustible renewables & waste) they represent 3.3% in OECD countries and 19.6% in non-OECD countries, not all of which is strictly renewable.

Why then should we concerns ourselves with changing the present energy system—dominated by fossil fuels—which was the basis for the extraordinary progress of many nations in the 20th century? Shouldn't we insist and work harder in keeping the system as it is instead of looking for "new renewable" energy sources

*Tel.: +5511 3030 6179; fax: +5511 3030 6177.
E-mail address: oswaldol@cetesb.sp.gov.br.

0301-4215/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2005.03.009

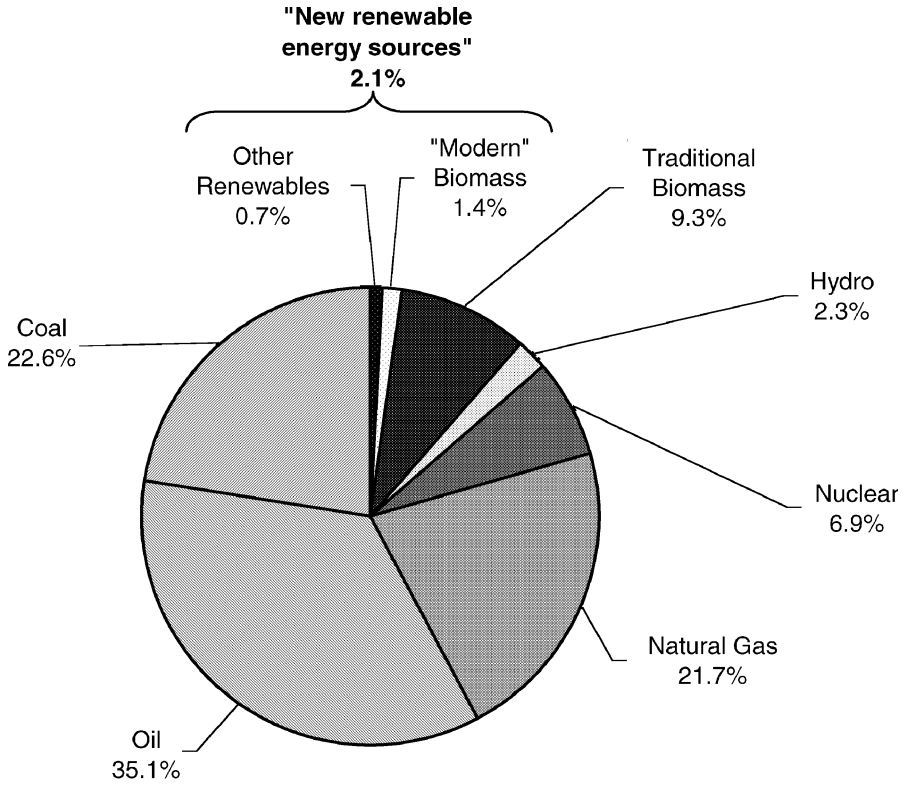


Fig. 1. World primary energy production by source in 2001, as shares of 10 Gtoe, for a population of 6.102 billion and a per capita energy consumption of 1.67 toe/year (UNDP, 2004).

which are frequently more expensive than fossil fuel sources, or plagued by problems such as intermittence, particularly some of them such as wind, PV and solar heat?

2. Problems

The answer to that question is that, despite their attractiveness, fossil fuels are the source of many problems difficult to resolve: (a) environmental degradation at the local, regional and global level and; (b) external dependency and security of supply.

2.1. Environmental degradation at the local, regional and global level

At the *local level*, energy-related emissions from fossil fuel combustion, including the transportation sector, particulate matter, sulphur oxides, nitrogen oxides, volatile organic compounds, carbon monoxide and other pollutants are major contributors to urban air pollution, which is thought to be responsible for about hundreds of thousands deaths annually around the world.[1] Half of the world's population live in urban areas and megacities (of 10 million people or more) are rapidly expanding. In the beginning of last century there were only three "1 million" cities; now there are 281 (UNFPA, 1999).

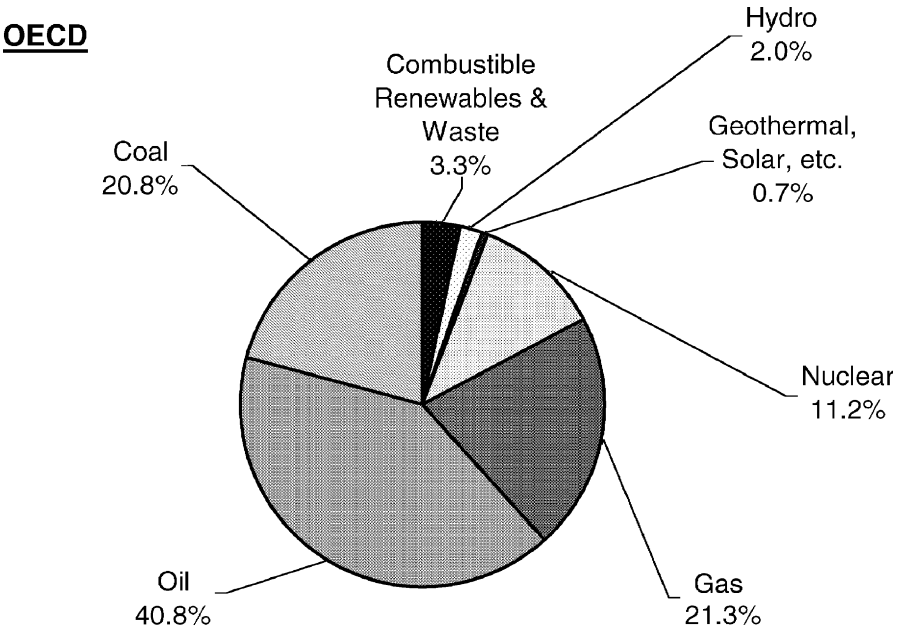
At the *regional level*, precursors of acid deposition originating from emissions from fuel combustion can be precipitated thousands of kilometres from their point of origin—often crossing national boundaries. The resulting acidification is causing significant damage to natural systems, crops, and human-made structures, and can, over time, alter the composition and function of entire ecosystems.

At the *global level*, a critical environmental issue is the "greenhouse effect" due to releases of carbon dioxide and other gases into the atmosphere. Fossil fuel burning and deforestation are the main causes of such effect.

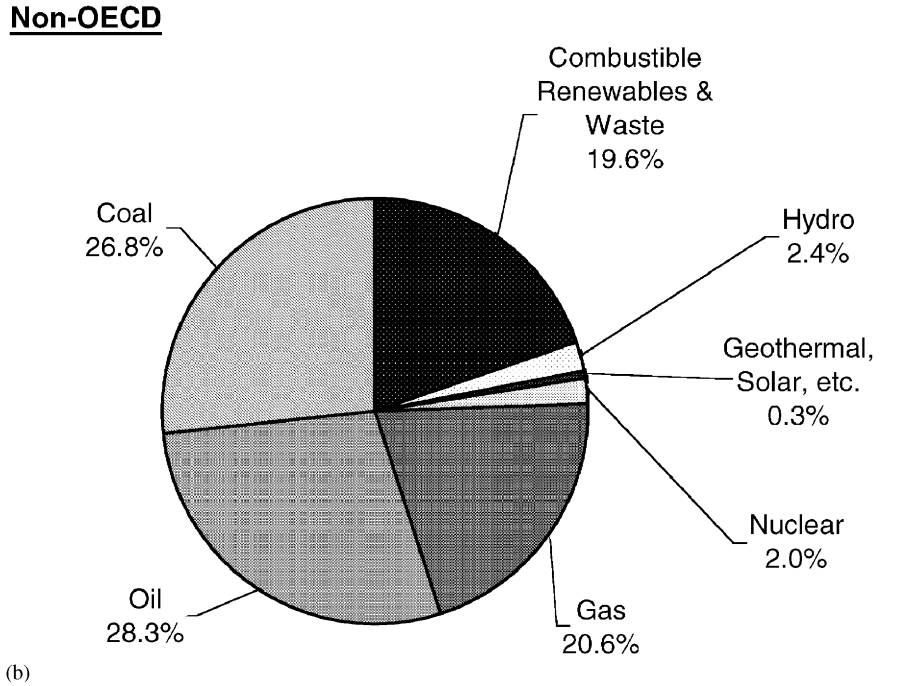
2.2. External dependency and security of supply

Being commodities which are concentrated in some parts of the world—such as oil on the Middle East—fossil fuels are an important item in trade (in hard currency) which hits very severely many non-oil producers in the developing world. In addition to that there is the heavy dependence on oil imports in countries like the United States, creating security problem of

[1]Detailed information on pollution in megacities is available through Molina and Molina (2004).



(a)



(b)

Fig. 2. (a, b) Primary energy use in various regions by energy source in 2001. In the OECD (Fig. 2a), population was 1138.5 million and per capita energy consuption was 4.68 toe. Non-OECD countries (Fig. 2b) had a population of 4964.0 million and energy consumption per capita of 0.95 toe (UNDP, 2004).

supply. An energy future based on fossil fuels is not sustainable.

3. Solutions

There are possible solutions to these problems, such as extending the life of fossil fuel reserves or expanding the share of renewable in the world energy system.

3.1. Extending the life of fossil fuel reserves

Improvement in the end-use efficiency in fossil fuels can be a very powerful instrument to extend the life of reserves which means facing the problem from the demand and not from the supply side that is being used since the 1970s but still considerable potential.

Its application as a general recipe in developing countries requires however some qualifications. The

"per capita" consumption in many developing countries is very small and frequently does not involve electricity since approximately 2 billion of people around the world does not access to it. Clearly, the consumption "per capita" of commercial energy will have to grow—at least initially—at it is happening in China and other countries. This does not mean they will have to adapt the technologies in production and end-use have the industrialized countries when they developed 50 or 150 years ago. Industrialized countries should adapt modern energy—saving technologies *as they grow* "leapfrogging" in may cases the path followed by developed other countries in the part.

Another approach in the "cleaning" of fossil fuels extending thus the life of presently known reserves of oil because there are large untapped deposits of lower quality which will require new technological developments.

Removing particulates sulphur oxides and others can help reducing local and regional environmental problems but the global problem will require recapturing CO_2, which is a major task particularly in the transportation sectors.

The carbon capture processes available are costly energy intensive. The amount of carbon sequestrated must be stored and leakage can be a disaster. Besides, it tends to be an action of mitigation since the consumption of fossil fuel will continue and the areas available for storage are limited.

3.2. Expanding the share of renewable in the world energy system

Many of the technologies involved (wind, PV, biomass, etc.) are developed and passed the stage of research and development being fully commercial at least in some, which markets.

Renewables avoid the previously mentioned problems, since they have very little net emissions of carbon in their cycle. Surely, unsustainable biomass burning increases global warming, but emissions can be reduced by efficient technologies. Renewables also cause much less pollution in terms of sulphur, lead and other toxic substances and net emissions of CO_2.

In addition to that, one of the most impressive advantages of renewable energies is job creation, which can help in solving the present equity problems in this access to energy. One will notice in Fig. 2 that energy consumption "per capita" is 0.9 toe in non-OECD countries and approximately 5 times higher (4.68 toe). There is thus a serious problem of inequity in the use of energy/capita. The same problem of equity exists also in income. It is not obvious that changes in the way energy is produced and used will help solving this problem. While production of electricity from fossil fuels create 250 jobs-year per Terawatt-hour, wind creates approximately 10 times more and wood 4 times more (Goldemberg, 2004).

Although representing a small contribution to the present world's energy system, the use of "new" renewables is growing more rapidly—3.5% per year—than total primary energy supply (TPES)—2% per year in the period 1990–2001. Wind and photovoltaics are growing at a spectacular rate of approximately 30%, "albeit" from a low patamar.

Table 1 indicates the role "new renewable" will play in the year 2020 it the growth rate observed in the period 1997–2001 continues. This is a rather conservative assumption. Modern biomass energy (particularly biofuels, i.e. ethanol and biodiesel) will very likely grow faster since it is being an aggressively introduced in several countries includes the US, Brazil and the European Union. Assuming a growth rate of 10%/year seems reasonable.

As a consequence, "new renewables" will contribute between 6.7% and 12.9% of total energy consumption by the year 2020.

Some of them, as all "infant technologies", might require government support in its initial phases, to lower costs through the well- known process of "learning curves" (Fig. 3).

The point has repeatedly been made that new renewable require a lot of government subsides in their initial phase of development and introduction in the market. The subsidies usually are not favoured in present international scenario if economic globalization but we have to contrast that with the fact that fossil fuels (coal, oil and gas as well as nuclear energy are being presently being subsidized by approximately 167 billion dollars per year in the period 1995–1998 (Table 2). In total, energy subsidies currently amount to over $US 240 billion per year. In fact, since power generation usually involves burning fossil fuels, adding subsidies for electricity further raises the share to over 80% (UNDP, 2004). Subsidies comprise all measures that keep prices for consumers below market level or keep prices for producers above market level or that reduce costs for consumers and producers by giving direct or indirect support, in a wide variety of public interventions not directly visible but is hidden in public and economic structures.

The projections of the role of renewables in the next one or two decades discussed above might seem modest, since they will probably not represent more than 10–20% of the world's energy consumption.

However, if such level is achieved, it will place renewables as a major player in the world's energy industry on the road to a greater role and therefore to a sustainable energy future.

Table 1
Modern ("new") renewables contribution and growth, by source, 2001 (UNDP, 2004)

	2001	2020		2020	
		Low		High	
	Contribution (EJ)	Growth rate per year in the period (1997–2001) (%)	Contribution (EJ)	Assumed growth rate per year (%)	Contribution (EJ)
Modern biomass energy	6.000	2.5	9.592	10.0	36.695
Geothermal energy	2.100	3.0	3.682	10.0	12.843
Small hydropower	0.360	3.0	0.631	3.0	0.631
Low-temperature solar heat	0.200	10.0	1.223	10.0	1.223
Wind electricity	0.160	30.0	23.391	30.0	23.391
Solar photovoltaic electricity	0.004	30.0	0.585	30.0	0.585
Solar thermal electricity	0.003	2.0	0.004	2.0	0.004
Marine energy	0.002	0.0	0.002	0.0	0.002
Total of new renewables	8.900		39.111		75.375
World energy consumption	402.00	2.0	585.64		585.64
Fraction of new renewables	2.2%		6.7%		12.9%

Growth numbers are approximate. Assumed average conversion efficiency: for biomass heat, 85%; biomass electricity, 22%; biomass combined heat and power (CHP), 80%; geothermal electricity, 10%; all others 100%.

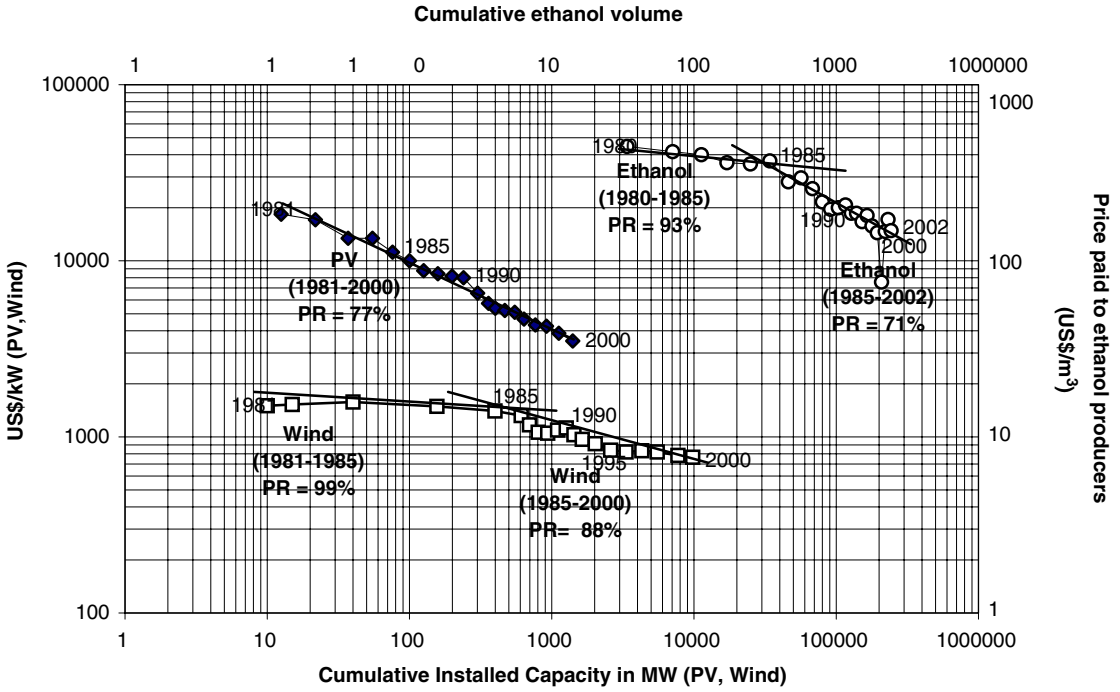


Fig. 3. Experience curves for photovoltaics, windmills, Gas turbines, and ethanol production (UNDP, 2004).

4. Policies needed

What is in order is the need of policies to accelerate the adoption of renewables are of two types: *top down* and *bottom up*. The best example of a *top down* approach is the Kyoto Protocol, which established mandatory targets for countries for the reduction of greenhouse gas emissions and thus the consumption of fossil fuels of industrialised countries (Annex I).

The European Union (EU) has adopted, prior to Johannesburg, a target of 21% of electricity production from renewables and a Directive for achieving a target of 5.75% of biofuels in the transportation sector, both by 2010. The EU targets are indicative only and require national legislation to make them effective.

The Latin American and Caribbean (LAC) countries have already exceeded their target of 10% of renewables

Table 2
Cost of energy subsidies, by source, 1995–98, in US$ billion/year (UNDP, 2004)

	OECD countries	Non-OECD countries	Total
Coal	30	23	53
Oil	19	33	52
Gas	8	38	46
All fossil fuels	*57*	*94*	*151*
Electricity	[a]	48	48
Nuclear	16	nil	16
Renewable and end-use	9	nil	9
Non-payments and bailout[b]	0	20	20
Total	82	162	244
Per capita ($US)	*88*	*35*	*44*

[a]Subsidies for electricity in OECD countries are included in fossil fuel subsidies, by energy source.
[b]Subsidies from non-payments and bail out operations are not included in data by energy source.

in 2001 but they represent only approximately 5% of the world's primary energy consumption (UNEP, 2002).

On the other hand, several countries and even states of the United States and some regional governments which are non-Annex I countries (and thus not bound by the targets set by the Kyoto Protocol) have already adopted the so-called Renewable Portfolio Standards (RPS). A RPS represent a *bottom-up* approach at regional or country level, a policy that States may use to remove market barriers to renewable power and ensure that it continues to play a role in the competitive environment that follows restructuring of the electricity generating industry. In their simplest form, RPS specify that a percentage of all electricity generated must come from specified renewable energy sources such as wind, hydroelectric, solar energy, landfill gas, geothermal, and biomass (EPA, 2002).

The proactive involvement of industrialized countries—where most of the markets are today—in promoting the use of renewable energies in their countries and encouraging the renewable "infant" industries leads to reduction in costs, making them accessible to developing markets where huge potential markets exist.

For example wind has been widely adapted in three countries (Denmark, Germany and Spain) and biomass in the US and Brazil. Therefore, there is a lot of space for these activities to grow as they spread out among other countries particularly the developing countries.

Initially, this will take place through exports from industrialized countries followed by the establishment of local subsidiaries by multinationals or "join-ventures" with local industries. In some cases, indigenous industrial development will take the lead this is the strategy proposed by the G8 Task Force on Renewables in the year 2001 (WEC, 2001), which could make the "promise of renewables" a reality.

References

EPA, 2002. Renewable Portfolio Standards. US Environmental Protection Agency. Available at http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BVPC6/$File/renewablesportfoliostandards.pdf

Goldemberg, J., 2004. The case for renewable energies. Thematic background paper for the International Conference for Renewable Energies, Bonn.

International Energy Agency, Energy Balances of non-OECD Countries 2000–2001. OECD/IEA, Paris, 2003.

Molina, M., Molina, L.T., 2004. Megacities and atmospheric pollution. Journal of Air & Waste Management Association 54, 644–680.

UNEP, 2002. Final Report of the Seventh Meeting of the Inter-Sessional Committe of the Forum of Ministers of the Environment of Latin America and the Caribbean (Sao Paulo, Brazil, 15–17 May 2002). Report UNEP/LAC-IC.7/6.

UNDP, 2004. World Energy Assessment—Energy and the Challenge of Sustainability. Overview: 2004 Update. United Nations Development Programme, New York, ISBN:92-1-126126-0.

WEC, 2001. G8 Renewable Energy Taskforce Report 17/7/2001. Available at http://www.worldenergy.org/wec-geis/focus/renew/g8.asp