A world
without oil or coal

A solution to Sri Lanka's electricity crisis in the post fossil fuel era

Asoka Abeygunawardane

Siyathra Media Publication

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This book is dedicated to my
father the Late Mr. Harry
Abeygunawardana,
the first MP for Matara
who gave me my first insights into
the post fossil era
when I was still a child.

Asoka Abeygunawardane

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About the Author

I met and befriended Asoka Abeygunawardana in the early part of the 1990s. One of the foremost activists in the areas of consumer issues and the environment, he was an individual who rendered invaluable service to the country by provided strong, firm and progressive solutions to the energy crisis arising at the time. An electrical engineer by profession, he harnessed his deep and spectral knowledge of social politics and economic vision to provide lasting solutions to the energy crisis through the publication of a booklet titled "Energy Crisis and Solutions" in 1996.

Moving in a diametrically opposite direction to existing thinking on the subject, Asoka went beyond simply identifying the issue as an "electricity crisis". In this book he states the following clear and correct idea: "We recognize that there is a crisis in the generation of electricity. The reason is that growing electricity demand far exceeds the supply. However, this problem is only a part of the larger crisis in the availability of all forms of energy. Thus, solutions should be found not just for the electricity crisis but rather for the entire energy crisis" I know firsthand that through his ideas he provided vision not only on the energy problem but also on environment and development to many social and political activists at the time. Ten years on, he has reiterated and expanded his original concepts through the booklet " A world without Oil or Coal" in which he has provided an excellent in-depth analysis and implementation plan for the global energy crisis generally and the Sri Lankan problem specifically.

The ideas expressed in this booklet are not merely concepts and ideologies. The critical importance of the work is in the fact that Asoka has used current scientific data and information as well as deep knowledge of the Sri Lankan situation to formulate his

conclusions and provide recommendations to a deep and complex problem affecting the entire planet.

There are many definitions and ideas floated at various forums and gatherings with regard to the energy crisis. To put it simply, all of these are a roundabout way of saying that the global oil prices are increasing exponentially not due to the limited availability of this resource but due to the war in Middle Eastern countries, uncontrollable intervention of middlemen and the rapid economic development of India and China. Against this context, Asoka's statement that the real reason for the problem is the lack and limitation of this resource and its excessive consumption is a fearless one. His ideas on the depletion of resources and how climate change resulted from environment pollution arising from its use and the definition of the energy crisis in the global context should be of invaluable assistance in paving the way for the reader to understand clearly and completely the problems and issues involved as well as sustainable solutions to the same.

Without limiting himself to the global crisis, his firm position with respect to the generation, supply and conservation of electricity in Sri Lanka has been excellently outlined in this booklet and it will, without doubt serve as an eye-opener for local policy planners and plan implementers. Instead of merely analyzing and criticizing, he has provided the reader with deep insight into practical solutions based on his long engagement and relentless wrestling with this most crucial of global problems.

We should all, sincerely thank Asoka for the effort and time he has put into compiling this simple and logical work through which he has provided the much needed vision and illumination that is so needed and which is the direct result of his work as the Executive Director of the Energy Forum, through his responsibilities in various

official forums and through the leadership he has provided for research and practical action as a specialist in energy sector.

Finally, I firmly believe that perusing this book and understanding its concepts would give any reader – of any capacity and at any level of ability to influence the collective action of human beings - the insight required to deeply understand the subject and use that knowledge towards ensuring not only sustainability of the nation but also the betterment of all of human civilization. I conclude by stating that the penetration of these ideas into the minds of the general public will go a long way in helping to establish a just and wholesome future for all of us.

Bandula Chandrasekera,
Program Coordinator ,
Energy Forum,
June 2008.

Preface

A dialogue on the energy crisis commenced in Sri Lanka in the eighties when the goal of utilizing the electricity generated from the newly constructed reservoir system of the Mahaweli scheme to feed the power needs of the entire nation and even sell excess power to India turned into a pipe dream. Despite the completion of the Kotmale, Victoria, Rantambe-Randenigala and the Samanala wewa reservoirs, due to various environmental and technological problems the anticipated outputs were never achieved and "Electricity" became a permanent crisis point in Sri Lanka. Further, since "giving lights" became such a powerful political promise that using any means to do so became a top priority of the politicians. The fairytale desire at the start of the eighties when a full half of Sri Lanka's homes did not have power; of reducing unemployment, even spread and growth of industry and becoming a Newly Industrialized Country such as Singapore, Malaysia, Hong Kong, Thailand and Korea being dashed, increasingly frustrated politicians succeeded in pushing the "electricity crisis" to the forefront in order to sideline all other problems that ailed the country.

At every stage, the strategies of the Planning Unit of the Ceylon Electricity Board were touted as the best and only solution to the crisis. These plans, based on the principles of supply and demand and assumptions on the future were far removed from reality and further compounded the problem. The officials of the CEB were unable to think beyond the premise that if it were not possible to provide electricity through hydro-power then the only other alternative was oil and coal.

Having chanted the "coal manthra" from 1987 onwards, they had reward for their efforts only with the laying of the foundation stone at Norachcholai for a coal power plant in 2006. The forecast of the officials that the annual increase in demand would be 10% has been proved to be a lie despite the fact that the current demand is met through a few oil power plants and medium scale hydro-power plants. With 75% of the homes in Sri Lanka having electricity and industrial sector performing at the levels that were anticipated, the government is not even aware that there is a crisis in power.

Given the thinking and the actions of the politicians and those reigning officials in the energy sector, the country is left wondering whether these individuals have any idea about the global political, economic and environmental fall out of their constant harping on oil, coal and nuclear power. This is against the backdrop of the fact that there is contradiction between the existing energy policies and the various international environment conservation, sustainable development and trade agreements that Sri Lanka is a signatory to.

We must recognize the fact that the reason why the government is stating on the one side that we should move towards renewable energy sources such as solar, wind, wave, biomass, micro and pico hydro power stations while on the other side it is trying to construct more and more coal power plants is the trade and regional commitments and ties that are forcing this duality and dubious approach to solving the problem.

Over the last two decades, through the use of "technical assistance", the powerful industrialized governments and International Financial Institutes have engaged in a massive brain washing process to ensure that the country's "thinking" is to move towards oil, coal and nuclear power. As a result of this effort, all those electrical engineers and researchers on the opposite side to the oil mafia have been branded as madmen or destructive elements with nothing better to do in life. However, in the face of the environmental crisis, most of these governments are now turning to these very same methods that they derided for so long. It is time to think what a heinous national crime it is to believe that energy sources such as coal and oil purchased from foreign countries should take precedence over our abundantly available renewable resources such as the sun, the sea, the wind and our rivers and streams.

If the spirit is willing then why is the body hesitant? Can't we see our way to this raw truth? If the government, government officials, intellectuals, journalists, civil society organizations, research organization and the general public is willing and ready to accept this challenge then this booklet will light their way for them as the morning star lights up the darkness before dawn.

Suranjan Kodituwakku,
Chairman,
The Green Movement of Sri Lanka.

1 Background

Over the last 150 years, the population of the world has increased fivefold (See fig. 1).

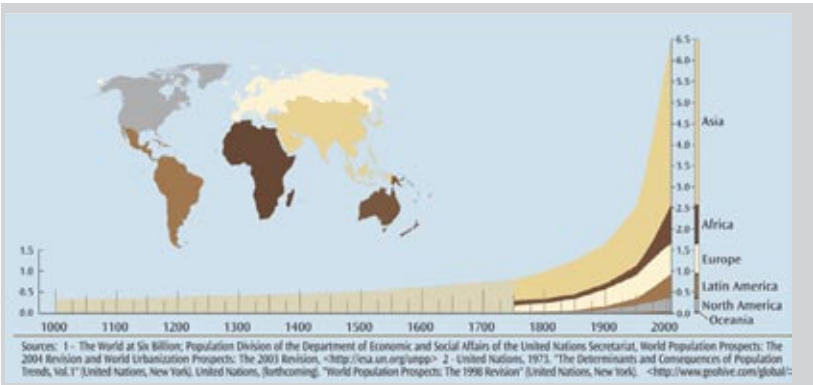


Figure 1 - Global population increase

Today, we are using fossil fuels to grow and manufacture the food that we consume. In the process of obtaining food, fossil fuels are used at every stage of the process from seed provision to soil preparation to manufacture of agro-chemicals and fertilizers to harvesting to post-harvest action to yield preservation to transportation of harvests to food preparation to food preservation.

The industrial sector, to a great extent, is also based upon and completely dependent on the use of fossil fuels. Efficient machines use less manpower and more fuel to manufacture items and provide services. Every single item of clothing we wear or appliances we use is manufactured through the burning of fossil fuels. A great deal of energy is also required by the construction sector. Additionally, a large amount of fuel is required for the maintenance and upkeep of modern houses and buildings.

Transportation requirements of mankind have grown beyond any rhyme or reason. Goods are manufactured at a great distance away from the individuals who will finally consume them. Thus, the amount of energy consumed by a single individual to ensure survival is a full eight fold higher than the requirement before the industrial revolution.

Global energy sources can be broadly categorized in to two in to two These are renewable and non-renewable sources. Renewable sources are those that continue to regenerate themselves. The primary source of such energy is the sun. Basic forms of solar energy are sunlight and heat. As the sun rises daily there are changes in the temperature of oceans. Due to changes in the temperature of the atmosphere wind power occurs. Due to wind action waves form in oceans. Due to changes in the sea temperature at different depths, ocean thermal energy and sea currents occur. Additionally, the internal heat of the earth can also be used as geothermal energy at some locations.

Due to the sun, plants grow and these give firewood and biogas. Due to solar power the water cycle occurs and this can be used to obtain hydropower. Due to the action of the moon high and low tides occur and this action can be converted into tidal energy. Since these sources regenerate themselves constantly they are known as renewable energy sources. While the sun exists, renewable energy sources will exist.

However, renewable energy exists as scattered energy sources and they require to be gathered together for use. Thus, with the finding of fossil fuels as a more efficient energy source, the industrial and technological ages arrived. Fossil fuels are those that were naturally formed from the sun's energy trapped in plants and trees millions of years ago. Petroleum and gas was formed from sea algae. Coal was formed from plants and trees growing close to water bodies. There exists only a limited amount of these energy sources. Thus fossil fuels are known as non-renewable energy sources.

Age	Per capita Daily Energy Consumption ('000 KCal)				
	Food preparation	Agriculture	Industry	Transport	Total
Ancient Man (1 million years ago)	2				2
Hunter - Gatherer (100,000 years ago)	3	2			5
Primitive agricultural man (5000)	4	4	4		12
Developed agricultural man (1400)	6	12	7	1	26
Industrial man (from 1875)	7	32	24	14	77
Technological man (from 1970)	10	66	91	63	230

Figure 2 - Per capita energy consumption

The only energy source that is neither a fossil fuel nor a renewable energy is nuclear energy. Even this energy sources is limited and to date safe use of this energy is still an unsolved riddle.

Considering modern energy usage it is clear that modern civilization is completely dependent on fossil fuels for its continuance. Thus modern human civilization cannot do without fossil fuels.

This fossil fuel based civilization is facing a massive threat. This is due to two reasons. The first is that the stocks of oil and natural gas on which modern civilization is based are ending. The second is the massive loss of life and property due to natural disasters caused by climate change which in turn was caused mainly by the burning of coal.

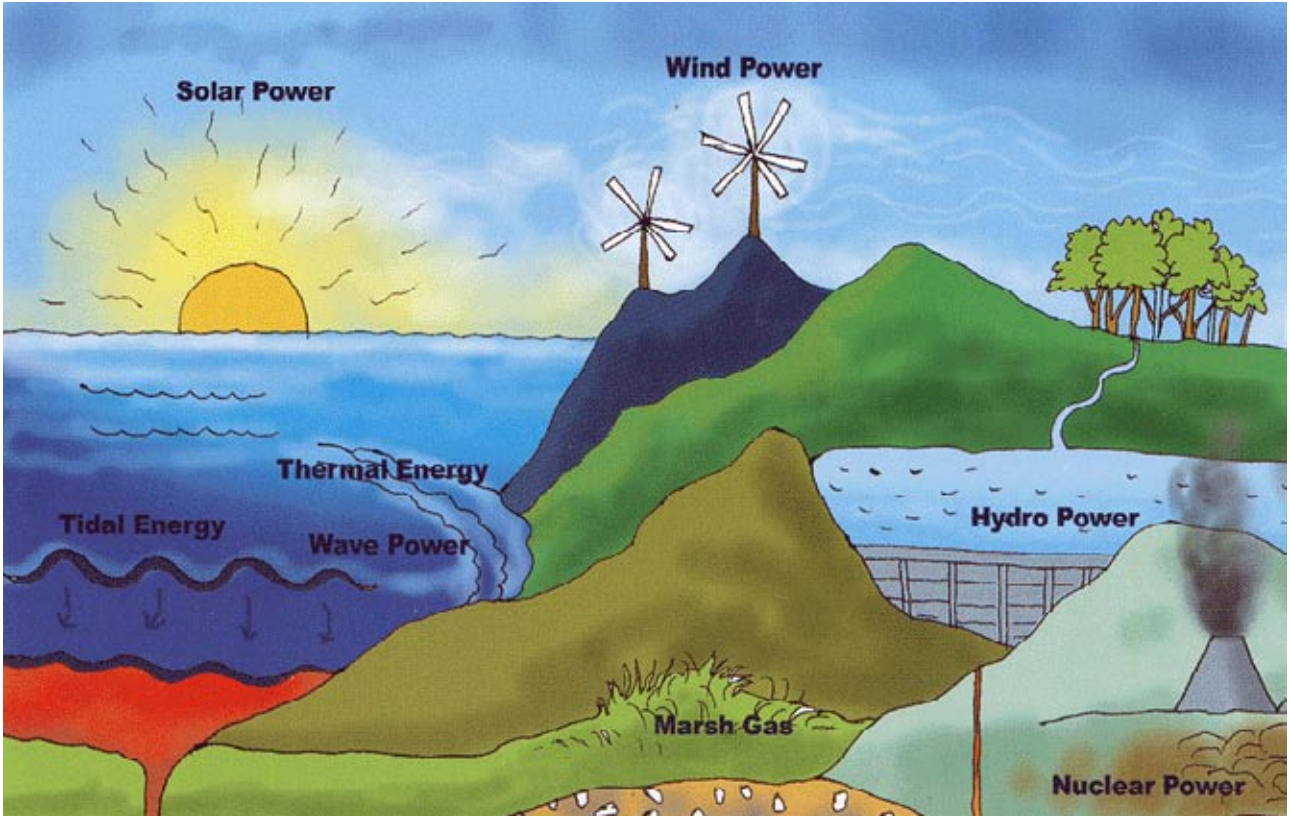


Figure 3 - Energy sources currently identified globally

Asoka Abeygunawardana

2 The challenge of depletion of fossil fuel reserves

The foundation of modern civilization is fossil fuel resources. These resources are rapidly nearing the end. From 1980 onwards, in every year, use of fossil fuels exceeded the amount of new deposits found within that year. Oil producing countries and oil companies which knew more than anyone else that their

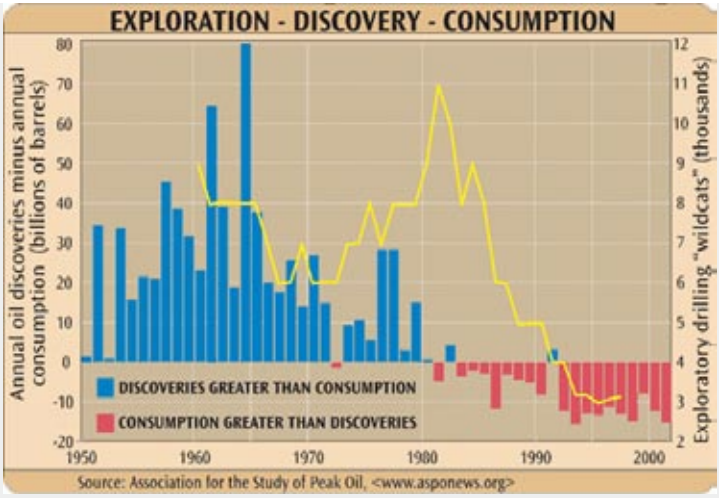


Figure 4 : y (left) axis: Difference between consumption and annual new identification of oil and gas (Bar chart); y (right) axis: exploratory drilling (yellow line)

oil sources were ending put all their energy into trying to find new sites with deposits of fossil fuels. However, these efforts did not yield the anticipated results. (See figure 4)

Thus, according to scientists, the oil and gas consumption/ production peak of the modern civilization will occur by the years 2010-2012. (See figure 5)

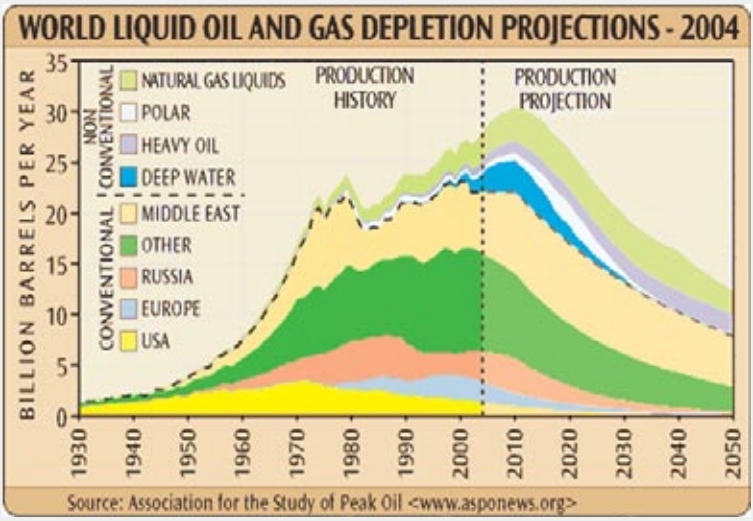


Figure 5 : Scientists prediction on the global oil and gas peak

Market forces will determine the optimal consumption point. Figure 6 shows the increase in the price of petroleum over the last few decades. The first significant increase in the price of petroleum occurred at the beginning of the '70s. The reason for this was the academic reports and forecasts of scientists that the deposits of oil would end. The second significant increase was in the early '80s.

The petroleum resource is limited. The fear that it would soon end caused an exponential rise in the price of oil but due to three reasons the oil prices fell down to original levels within a short

period of time. The first was energy conservation through the invention of efficient machines and careful use of energy. The second was the finding of new petroleum deposits. The third was the American interventions in the Middle East to artificially lower the oil prices.

In the modern context, the price of oil has been steadily increasing from 1998 onwards. However, there is little chance that the annual average price of oil will drop globally. This is due to the fact that the world has arrived at the challenge of drying up of petroleum reserves. Thus, by the end of 2008, there are certain forecasts which say that the price of a barrel of oil may rise to US$ 200

When the price of oil increases, the poor will be forced to stop using petroleum. Thus, mankind will have to find a future that does not depend on oil or gas. As was previously thought, this is not a problem for future generations. This is a problem for the current generation. However painful this is to digest, it is the truth.

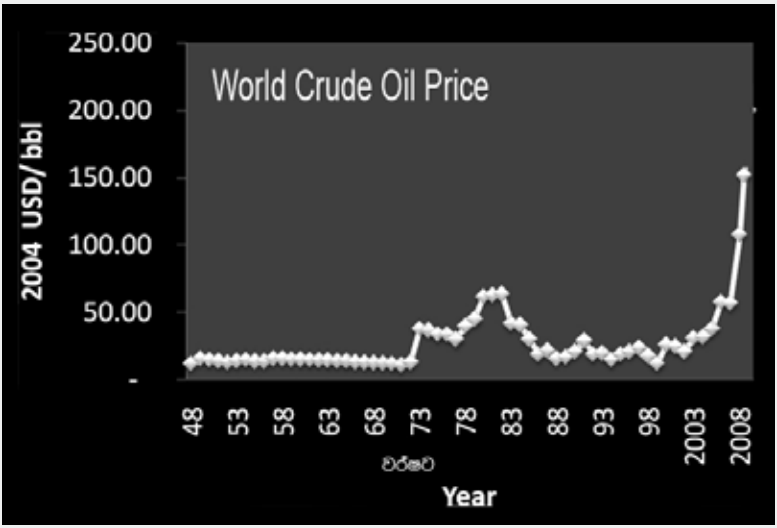


Figure 6 : Increase in global average oil prices

3 The challenge of climate change

One major reason why an environment suitable for the existence of man was created on earth was that fossil fuels trapped carbon in the atmosphere and deposited it deep under the earth. Yet now, through the combustion of these very fuels all that carbon is back in the atmosphere and the surface of the earth has heated up. Thus, the last decade was the hottest in recorded history. Our mother earth has been in the throes of a ten year old fever.

During the last decade mankind, through the burning of fossil fuels has spewed an amount of Carbon into the air that the earth is unable to bear. The chief polluter amongst these fuels is coal. (See figure *7*)

The earth's surface heats up mainly due to the percentage increase of carbon dioxide in the atmosphere. The climate conditions that arise out of this heating are many and occur through mechanisms of such complexity that it is impossible to predict or forecast their incidence or frequency. Disasters that were hitherto thought of as natural, such as the melting of the polar ice caps, the rise in sea levels, increase is rainfall and precipitation, drought, destruction of crops, hunger, unavailability of clean water, epidemics, forest fires, storms and cyclones, floods and landslides have all been

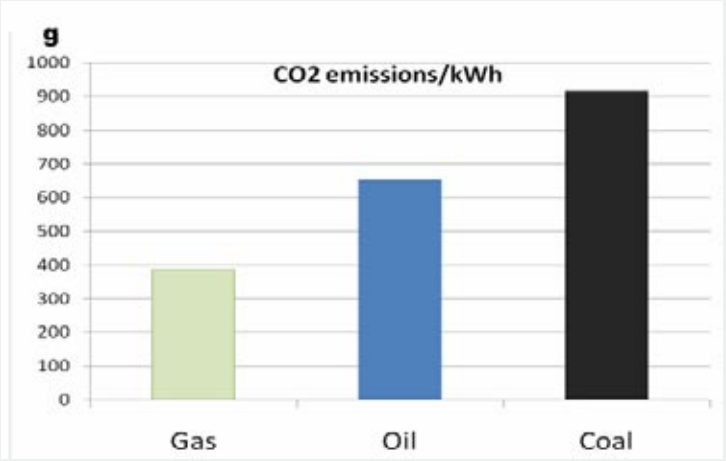


Figure 7 : Reason why coal is the chief reason for current climate instability
The amount of carbon dioxide emitted by each energy source in the production of one kilowatt of electricity

firmly laid at the door of climate change caused by the actions of mankind itself. To put it succinctly, these are disaster caused by the people, with the people, for the people! Due to these, a huge percentage of human beings living on this planet are victimized and face grave threats to their lives. A greater number are due to fall victim to these in the very near future.

By the year 2005, the amount of carbon in the atmosphere had risen to 375 ppm and the average temperature of the earth has risen accordingly by 0.75 degrees centigrade and the sea level has risen by 10 cm.

It is now impossible to prevent the average temperature of the earth from rising by another 2 centigrade degrees. Scientists forecast that the Arctic sea-ice could melt entirely during summers by 2013. We are already late. The best we can hope for mankind is to put all our efforts into ensuring that the temperature rise is

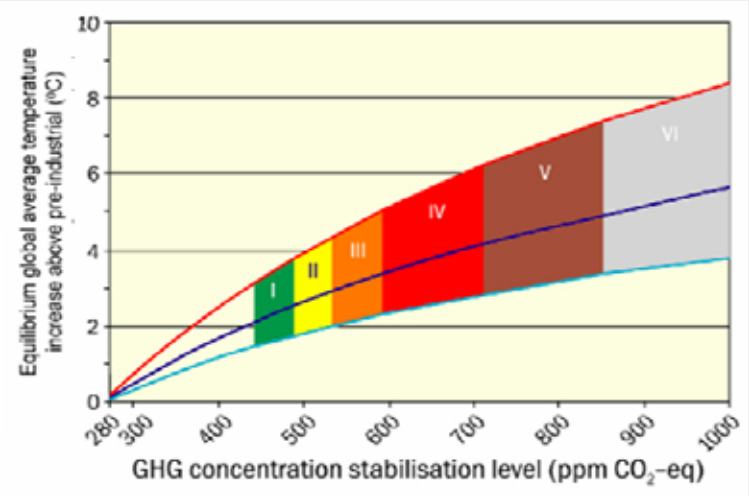


Figure 8 : Trends in global warming relative to alternatives to reduce global carbon emissions (from the 4th report of the IPCC)

no more than 2 centigrade degrees. (See figures 8 and 9). Our effort should be to maintain atmospheric carbon dioxide within the green belt shown in figure 9.

In order to achieve this, by the year 2050, mankind should have reduced carbon emissions to 50% of the levels in 1990. To do this, mankind should reach the carbon emissions peak by the year 2015 at least. The implication of this is that optimal use of the chief polluter - coal, should also be 2015.

This reality was first known to mankind with the publication of the report of the Intergovernmental Panel on Climate Change in 1988. However, the world's leaders were reluctant to act upon the recommendations of the scientists. Simply content to debate on the issue, the UN finally established the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The next five years was spent by the world leaders in procrastination and then finally, in 1997, established the Kyoto protocol and specifically

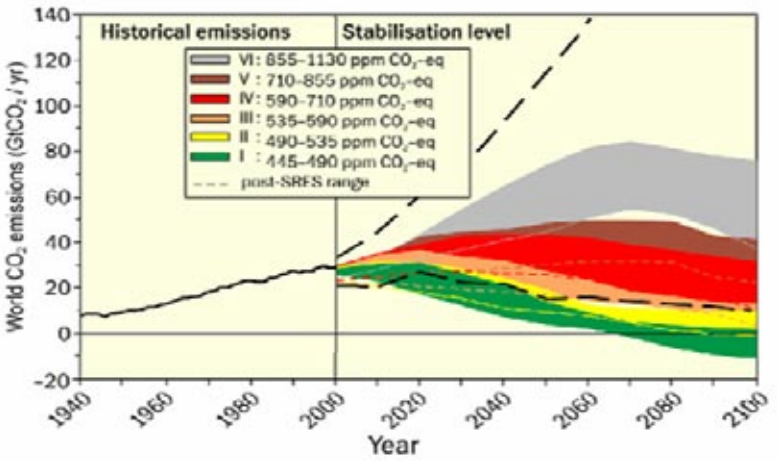


Figure 9 : Scenarios for reducing atmospheric carbon concentrations (from the 4th report of the IPCC)

identified developed countries to take action in this regard. Accordingly, the developed countries were bound to reduce their carbon emissions by 5% of 1990 levels. However, these countries requested 10 more years to implement this action which meant that this responsibility would be executed in 2008. The implication of this is that for a full 20 years, the so-called leaders of nations, fully aware of the problem and the dangers faced by mankind chose to ignore them. The result? Mankind is now unable to prevent the rise of global temperature by 2 centigrade degrees.

There is no more time left to waste. It is already too late. Mankind must immediately stop using fossil fuels including coal. We have reached a point where we must reconstruct civilization. We have reached a point where we must reformulate our very ideas of how civilized people behave. We must engineer a world bereft of oil or coal! The key question here is this: Is mankind ready to take up this challenge?

"The crab swims happily in the pot – only as long as it takes for it to heat up"

-Lowedasangarawa

4 Is the great hope of us Sri Lankans the oil deposits in the Manner basin?

The current oil imports to Sri Lanka are about 4 million metric tons per annum and the demand for oil increases by 0.1 million metric tons each year. Analyzing the income of the State Petroleum Corporation, it is clear that about 60% of petroleum is used for transportation, 25% is used for electricity generation and the rest is equally distributed between domestic and industrial use. Additionally, since petroleum is used for the production of goods and delivery of services, an increase in its price will immediately result in an increase in the cost of electricity and transport as well as every other good and service.

Initial studies have determined that there is oil in the Mannar sea basin. The initial steps of oil exploration are being currently conducted. However, since it is difficult for Sri Lanka to extract the oil from its deposits, cost of production of petroleum will be higher. With the rapid depletion of global oil resources there is an opportunity for Sri Lanka to exploit its own resources but the question is whether this will provide a solution to the energy crisis.

The first point that needs to be clearly understood is that it will take ten year to complete the exploration and extract oil. Even if the

process is speeded up and optimized it will still take at least seven years. Thus, the deposits will not result in an instant solution to the problem in Sri Lanka.

Secondly, according to experts in charge of the exploration, the estimated deposit is roughly one billion barrels. This will be sufficient for Sri Lanka's needs for about 30 years. However, if demand keeps rising at present levels, then the deposit will only be sufficient for 13 years.

Thirdly, massive investment is required for oil exploration. Thus, the government will be left with no choice but to have international oil companies invest in this venture. This will result in the ownership of the oil being divided between the government and the companies even though the oil is rightfully ours. This will obviously mean that it will be difficult to achieve the anticipated goal of exploring for oil. Given the current global consumption of oil, our deposits will only be sufficient to meet the global oil demand for a mere ten days.

All of this yields a very simple conclusion. It is not possible for Sri Lanka to meet its energy challenges by exploiting its own oil resources.

5 The demand for electricity in Sri Lanka and currently proposed Solutions

Focusing our attention on the entire energy crisis it becomes obvious that solutions need to be found for many different facets. One of these is electricity. The primary goal of this booklet is to discuss the challenges and solutions to the problem of electrical energy. It should be understood that a solution need not be searched for in exclusivity. The problem is part based in the existing definition of development and in part based on the existing lifestyles of people. This booklet will focus on the crisis in electrical energy and use that as a basis to discuss cohesive and holistic solutions.

As the core source of energy to light up a home for a few hours at night and operate a television, electrical energy is a primary need of modern man. However, since electricity is also used to operate luxury equipment it is also a luxury requirement. In attempting to find solutions to the electricity crisis, this dual nature of its requirement needs to be kept in mind.

Twelve years ago, almost all of the electricity requirements of Sri Lanka were met by hydro power plants. By 2008, the required capacity had increased to 2000 MW while the total number of required electrical units had increased to 10,000 GWh. Despite

the fact that the petroleum crisis was looming, the Sri Lankan government still opted to generate electricity by burning fossil fuels. As a result, a full 60% of the electricity requirements are obtained currently by petroleum and only 40% through hydro-power. It is clear that this terrible situation is the direct result of the lack of foresight on the part of then governments.

According to the assessment of the CEB, the demand for electricity will increase by 7-10% per annum over the next twenty years. Accordingly, demand shall double every ten years. It is interpreted as the responsibility of the government to be able to meet this demand at affordable prices.

In order to address this issue, the CEB prepared a plan but this only focused attention on the generation of electricity through coal, petroleum and hydro power. The CEB, strangely, naively and dangerously decided that there were no other energy sources anywhere in Sri Lanka or, for that matter, the entire world. According to the plan, by the year 2020, Sri Lanka would have to

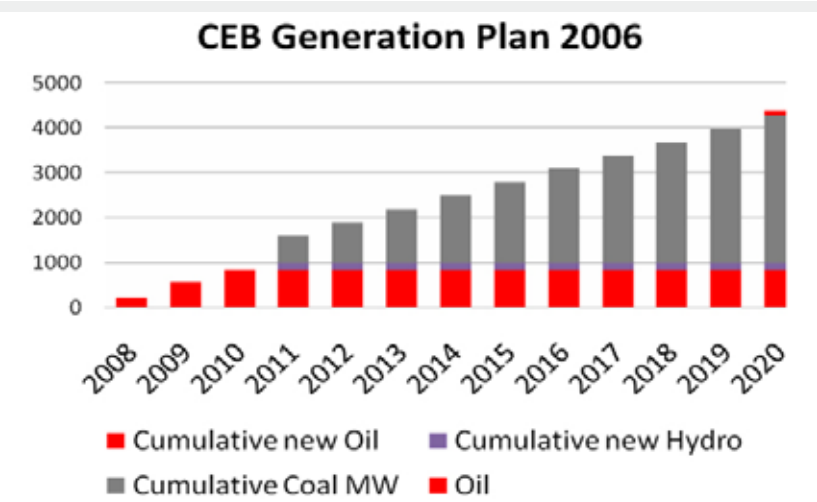


Figure 10 : CEB Generation Expansion Plan 2006

newly construct the Upper Kotmale hydro-power plant (150 MW), oil power plants (935MW) and coal power plants (3300MW). Additionally, since the first coal power plant will be commissions only in 2012, the government is taking steps to build oil power plants to meet the interim demand.

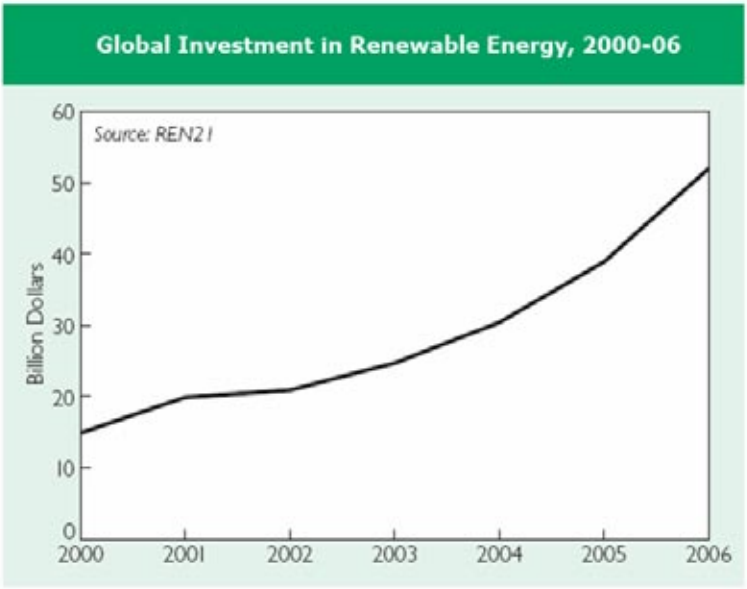


Figure 11 - How investment in renewable energy sources has increased globally

It is clear that this is a plan that has been formulated without considering the crisis that the planet is currently facing. It is clear from the diagram below that Sri Lanka is moving in the reverse direction to that of the rest of the planet.

This plan of the CEB was originally proposed about twenty years ago at the end of the Mahaweli project. Despite the massive and telling changes that have occurred globally, the CEB has obviously not changed its plans to reflect these realities.

The CEB formulated its plan stating that it was the most profitable for the country. According to them, the most economical and profitable means of satisfying the base load demand over the next 20 years is through coal power. Additionally, in their estimate, oil fired power is the cheapest for providing electricity at peak hours. The reason for this statement is that it is costly to start up and shut down a coal power plant for short periods of time.

The CEB and some experts in the energy sector have over the last 20 years constantly stated that the cheapest base load electricity is through coal power and the cheapest peak hours electricity is through oil power. As a result of this barrage, the people of Sri Lanka and the governments have accepted this view without question. This trend is still continuing with the present government also espousing these plans as being both viable and practicable and accordingly, the coal power plants proposed by the CEB are currently being built by the government.

Despite this myopia, given the current issues and problems that this planet is facing, it is critical that far more appropriate techniques are explored to provide solutions to the energy crisis.

The Upper Kotmale and Uma-Oya hydro-electrical projects are being implemented due to special decisions of the current government and not because they are cheaper alternatives as per the plans of the CEB. Further, the government in addition to implementing the CEB long-term generation expansion plan has made provision for the private sector to supply electricity to the CEB through alternative energy sources. Accordingly the government has announced a tariff system for small scale hydro, wind, dendro, solid waste and sea wave power plants which are less than 10 MW. This opens the door for the private sector to engage in generating electricity through renewable sources outside of the plans of the CEB. Thus, on paying royalty to the

government through the Sustainable Energy Authority, these parties may sell their electricity according to the established tariffs of the government.

The Energy Ministry and the CEB claim that they have arrived at these tariffs by determining the cost of production and allowing for a reasonable profit for the operators but the fact remains that the private sector has failed to generate power to overcome the crisis situation. Thus, in order to optimize the exploitation of national energy resources, the government has to formulate a far more efficient and farsighted plan than those that exist today and the obvious first step would be to re-assess the plans of the CEB.

The statements of the CEB on the cheapest base and peak electricity generation sources were based on computer simulations and models. Using that very same framework, a study was commissioned with European Commission grants and this study revealed that the generation plan of the CEB was incorrect.

6 The cost of generating electricity

A whole 74% of the costs of the Ceylon Electricity Board (CEB) goes towards purchasing fuel. 50% of this is for private sector purchases and 24% is for fuel to fire CEB thermal power plants. 14% goes for maintenance and the remaining 12% is for depreciation and paying off of capital loans.

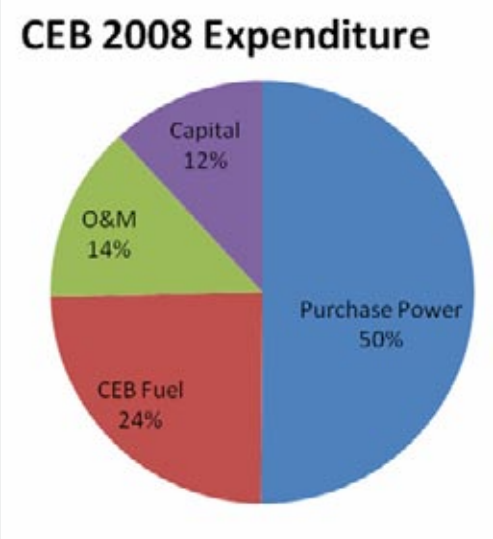


Figure 12 : Expenditure spread of the CEB

For their generation planning computer models, CEB has considered only coal, and hydro power sources. No other energy sources were even considered as candidate options for optimization computer model. However, both the people of Sri Lanka and the government believe that the CEB has considered every possible energy source in determining the best sources to be coal and oil and it is clear that the CEB has misled both the government and the citizens of Sri Lanka.

In order to determine appropriate alternative energy sources for producing electricity, the cost of producing electricity should be known for each such source. This is no easy task. The reason for this is that the capital investment and the changing cost of fuel for the lifetime of the plant should both be assessed. Since the average lifetime of a plant is greater than 30 years, the flux of the price of fuel over a long period of time needs to be assessed and in doing so, many factors need to be taken into consideration. A further point is that there is a general idea that the cost of

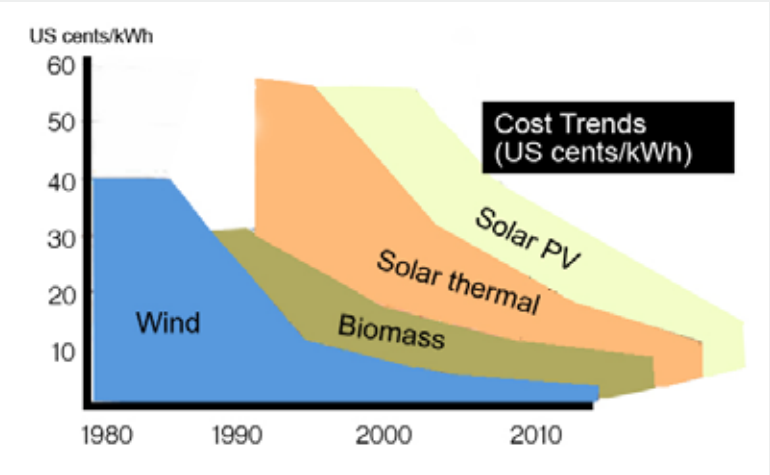


Figure 13 : The way in which the cost of renewable energy has decreased over the last 3 decades

generating electricity from each and every source is continuously increasing. This may be true of fossil fuel based technologies but with renewable energy sources, it is false since the capital investment for such energy sources has dropped steeply over the last 30 years.

This is in direct contravention to the popular myth that renewable energy is expensive. In figure 13, it is clearly seen that the cost of electricity generated through coal and oil increases steeply while that of renewable sources decreases equally steeply.

Given the new conditions, comparison of technologies for difference energy sources should be done with great care. Experts with vested interests in promoting fossil fuel based technologies cite only the high prices quoted by some of the private sector firms for establishing renewable energy power plants. Further they are attempting to curb the voices of those who propose alternatives. We have to consider number of factors while comparing the unit costs of different technologies. The Energy Forum study outcome summary in shown in note 14.

The government constructs coal power stations on obtaining concessionary loans. The private sector constructs renewable energy power plants on obtaining commercial loans. As two different interest rates apply this costing is not based on a level playing field. It will have a negative impact on zero fuel cost renewable energy sources as the capital investment of renewable energy is relatively higher. The first row of the table above indicates the cost of production if the government builds plants for both renewable and fossil fuel sources.

The second row figures are based on the government published tariff for the private sector. Thus, the result if all power plants are constructed by the private sector is clear from this row. Comparing

	Expenditure details	Oil	Large Hydro
1.	Capital investment Concessionary loans (ROE 04%, IR 02%)	0.51	5.69
2.	Capital investment Commercial Loans (ROE 22%,IR 17%)	1.56	17.50
3.	Maintenance costs	0.27	2.26
4.	Increase in maintenance costs (6.52%)	0.11	0.90
5.	Current fuel costs	27.72	-
6.	Increase in Fuel Costs	62.34	-
7.	Increase in Forex rates (2 Rs/USD)	18.61	-
8.	Fuel tax (28.5%)	30.97	-
9.	Fuel costs - subtotal	139.64	
10.	Additional transmission costs	1.07	2.67
11.	Carbon income at (15 USD/T) rate	-	1.23
12.	Additional Carbon income (60 USD/T)	-	3.69
13.	Carbon income - subtotal		6.59
14.	Net cost	142.64	18.41

Figure 14 - Cost for various energy sources in rupees/KW Hour

Coal	Mini Hydro	Dendro	Wind	Wave	Solar PV
1.74	3.41	1.96	5.06	1.93	23.64
5.34	10.48	6.04	15.57	5.94	72.74
0.92	1.35	1.04	2.01	0.77	9.39
0.37	0.54	0.42	0.80	0.31	3.75
5.25	-	5.74	-	-	-
8.45	-	6.74	-	-	-
2.79	-	-	-	-	-
4.70	-	-	-	-	-
21.19		12.48			
2.67	2.67	1.07	2.67	2.67	1.07
-	1.23	1.23	1.23	1.23	1.23
-	3.69	3.69	3.69	3.69	3.69
	6.59	6.59	6.59	6.59	6.59
30.47	10.13	16.12	16.14	4.76	82.03

these two rows it is clear that the method of comparing the costs of energy sources by mixing two different loan mechanisms is incorrect. In order to get a correct picture one must assume that all power stations are built either by the government or the private sector.

The 3rd and 4th rows indicate the maintenance costs. Since the CEB assumes that the cost of coal will remain unchanged, the 5th row shows the fuel costs with respect to current prices. However this is incorrect. The price of coal has increased threefold globally over the last three years. The 6th row indicates the costs taking into consideration the rise in fuel costs. It has been assumed here that the cost of coal will increase by 0.0225 USD/kg/y and wood will increase by 0.50 SLRs/kg/y. Further it was assumed that the cost of diesel will increase by Rs. 20 /l/year and this was factored into formulating the figures in row 6.

The CEB has decided that the foreign exchange rate will also remain constant. Again, this is incorrect. The assumed change (2 Rs/USD) is indicated in row 7. Further, the CEB does not see a difference between using resources within the country and using resources purchased overseas. However, Sri Lanka looses foreign exchange when it purchases fuels from abroad. The 8th row reflects this. Thus, by analyzing the figures in rows 5 through 8, one can determine the cost of using each of the energy sources. Accordingly, the final fuel cost is set out in row 9.

Coal power plants are usually built as large stations capable of generating 600-900 MW. However, the consumer of this generated electricity resides far away from the point of generation. With centralized generation schemes, new transmission and distribution networks need to be established to deliver the power to the consumer. Additionally, since there is a loss in transmission, stations with a greater capacity will need to be built to compensate

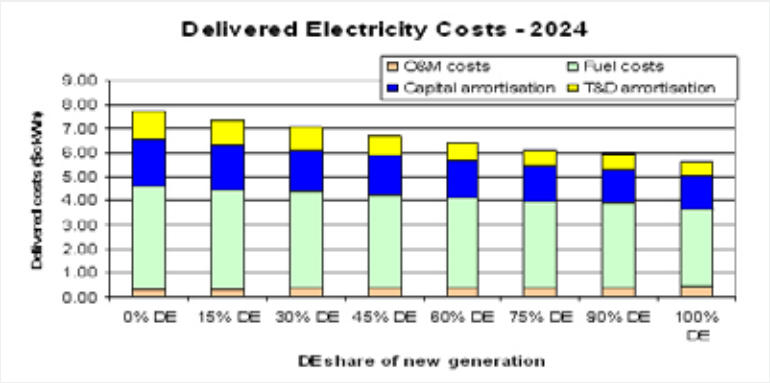


Figure 15 : How Decentralized electricity is cheaper than centralized electricity.
(According to a research report of the Energy Forum)

for this loss. Capital investment is required for all of these as well. Accordingly, the additional transmission costs are shown in row 10.

Coal usage will have to be reduced in order to counter the effects of global warming. The situation that would arise due to this cannot be clearly determined right now. However, from March 2008 onwards with the establishment of carbon trade, additional income may be generated by opting for renewable energy sources and rejecting coal power plants. The income from carbon trade at existing prices is shown in row 11. It should be noted that the value of carbon increases yearly. Accordingly, the increase in income in future years is shown in row 12.

According to the narrow minded thinking of the CEB, analysis of the figures in table 14 show that the cost of coal power plants is cheaper. However, their assumptions have not factored in national requirements. When other factors such as the increase

in FOREX rates, increase in fuel costs, differences in interest for concessionary and commercial loans, loss of foreign exchange for purchasing coal, capital investment for transmission systems for centralized generation plants and income from carbon trade are taken into account, it is clearly seen that the most costly sources are coal and oil. The implication is simple: There is an urgent requirement for an alternative generation plan.

A power station is built for use over 40-50 years. Thus, future outcomes during that period need to be assessed before a plan is made. There is no future for coal power stations due to the environmental costs incurred. Additionally, since Sri Lanka has no coal deposits, coal power generation is financially a loss making exercise. Thus, it is important that outdated technologies are rejected and new thinking is engaged to find solutions to the problems where high priority is given to energy conservation and renewable energy sources and the authorities stop giving these options step-motherly treatment.

Although not in the CEB plans, the Sustainable Energy Authority has been established to focus on energy conservation and the popularization of renewable energy sources. Through this institution some steps have already been taken to strategize energy conservation and utilize wind, solar, wave, bio-mass, industrial and agricultural waste based energy.

7 The demand for electricity

Managing the rising demand for electricity takes precedence amongst all proposed solutions to the existing problem. That demand should be allowed to increase infinitely is an outdated concept. A country cannot think along the lines of the CEB in its neutrality to demand. Thus, instead of constant and increasing growth, stability should be established when the demand curve reaches a certain level.

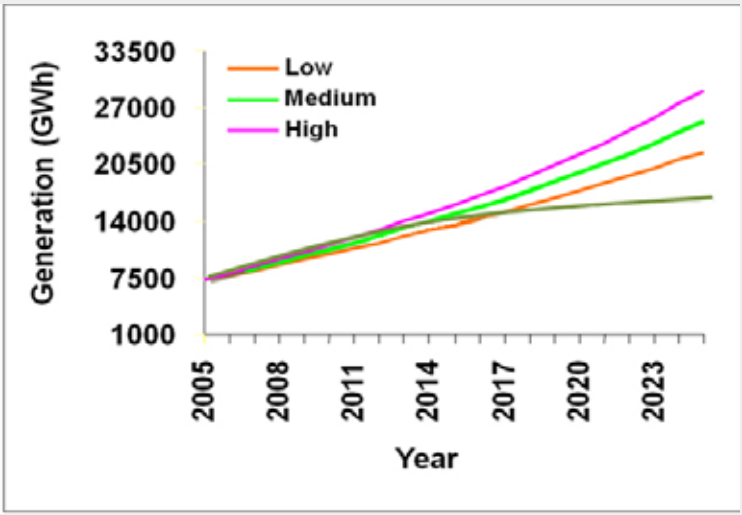


Figure 16 : Electricity demand forecast of the CEB

The CEB's generation plan is based to cater to the increasing demand forecasted in the figure 16. It has been submitted based on the hypothesis of low seed growth, medium speed growth and high speed growth. In the past, this type of rapid growth of demand was an indicator of prosperity. However, scientists believe that this unchecked growth will ultimately end in a massive disaster. Thus, the world is focusing on cyclic growth and not infinite growth. I have highlighted this scenario in dark green in figure 16. The question that springs to mind immediately is "How can the rising demand be controlled?" In order to answer that question it is imperative that we know what the current demand increase is.

Currently, the national grid provides electricity to 75% of Sri Lankans. According to forecasts, this figure will rise to 80%. Situation of homesteads in isolation as well as geographical difficulties of extending the grid are the reasons why the remaining 20% will not have electricity. Civil Society Organizations (CSOs) and the private sector have played a leading role in attempts to make electricity available to this group of citizens. Currently, over 100,000 homes have obtained Solar Home Systems and the total capacity is about 3MW. Additionally, small village micro-hydropower schemes managed through electricity consumer societies have provided electricity to a further 11,000 homes and their capacity is about 3.5MW.

Despite many obstacles, members of these small schemes have established the Federation of Electricity Consumer Societies in order to ensure the continuance and sustainability of power generation systems that were build through their own strength.

8 Energy Conservation

The rural communities who have recently obtained electricity from the national grid consume only marginal amounts of energy. Thus, the current increase in demand is not due to the greater number of rural people who have been provided with electricity but rather the increase in the usage of electricity by existing consumers.

If electricity from the national grid is to be managed, then the citizens should understand the economic advantage of not wasting it. On the other hand, awareness and technical facilities should also be made available. Both these tasks were the part of the responsibilities of the CEB. While there used to be a demand management unit within the CEB, at this most crucial time it was unfortunately discontinued. Thus, in order to effectively address the issue of energy conservation, the Ministry of Power and Energy recently established the Sustainable Energy Authority. Be that as it may, there is still much work to be done in this regard.

This is clear from figure 17 above. While the science of energy conservation is growing rapidly, the Sri Lankan consumer is still in the dark with regard to these matters. The Sri Lankan consumer has no knowledge of energy auditing.

Methods of how to reduce energy consumption should be taken into consideration when designing a home or selecting raw materials to built a house but unfortunately, the average Sri Lankan citizen is not aware of this. Thus, in attempting to copy the architectural designs of western countries, a great deal of energy is wasted. The public have no knowledge of how to design their homes and their gardens in an environment friendly manner. Further, they have no idea how to select electrical items based on need, how to use them efficiently and how to maintain them well and this leads to great waste. While great efficiencies can be engineered without any trouble, most citizens are of the view the conserving energy will lead to inconvenience. Thus, thinking that calls for energy conservation are equivalent to telling them to go back to the Stone Age, they actively resist such action. These are statements that the public make without understanding the context or the current realities that the world is working with. In order to educate the people quickly, it is also crucial that a vigorous school education program is established as soon as possible.

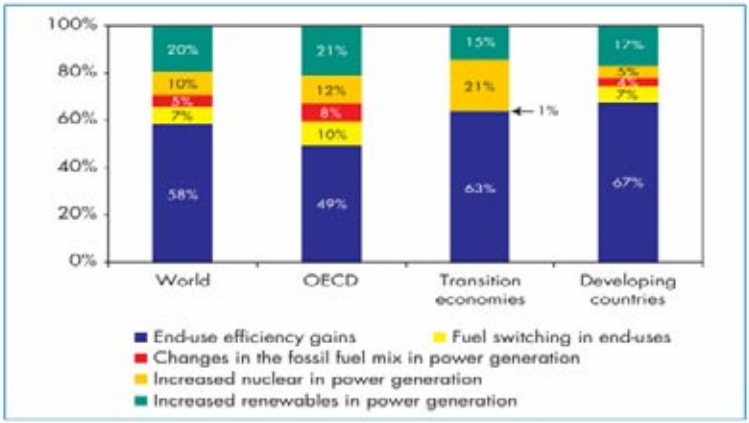


Figure 17 : Potential profor energy conservation
Source – International Energy Authority

9 The tariff system for electricity consumers

While there used to be a unit at the CEB to study tariff systems, this too has now been closed down and this has caused significant problems for reorganizing the system. The current system is shocking. It has been established to make low usage consumers pay premiums while large scale users are subsidized. This was done as a diabolic strategy to charge and obtain the average cost of a unit.

40% of electricity in Sri Lanka is for domestic use, 40% for industry and the other 20% for commercial and service sectors. Of these, a very small percentage of each sector use 60% of the electricity. Thus, 15% of the domestic users, 20% of religious institutes, 20% of industries and 15% of hotels utilize 60% of the electricity of each of these sectors. It is therefore clear that a handful of consumers use a very large percentage of the electricity generated in Sri Lanka. (See figure 18).

The reality is that the current hydro power generation in the country is sufficient to provide the electricity needs of 80% of the population. Oil is utilized to provide the requirements of a small group. Due to these excessive users, hydro-power is not sufficient and oil

is also used. The delivered cost of a hydro power unit is about Rs. 4 whereas the delivered cost of an oil fired power unit is currently around Rs. 35. Further the cost of oil fired power is increasing daily. Obviously, it is grossly unfair that a low consumer (80% of total consumers) is forced to may over Rs. 4.00 per unit for electricity.

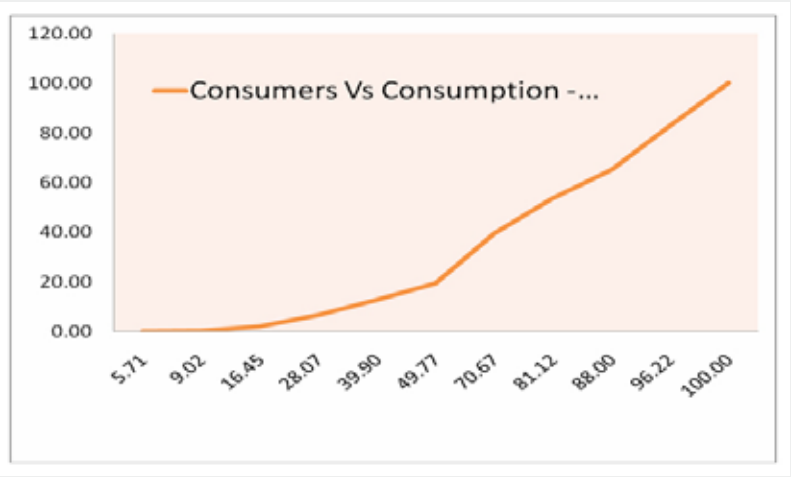


Figure 18 : Distribution of domestic electricity usage
x axis – Percentage of consumers
y axis –percentage of total units consumed

If a low consumption user is forced to pay over Rs. 4 for a unit, it only means that the low consumption user is currently subsidizing the high consumer. This will obviously decrease the will of the rich to conserve energy. The government of Sri Lanka, having understood the problem clearly, directed the CEB to take measures to rectify the matter but there has been no effort on the part of the CEB to do so to date.

Although the production cost of a unit through thermal power is Rs. 35, it is currently being sold to high consumers at Rs. 25 and the loss is incurred by the CEB as a government institution. When

the government has to absorb this loss, it ultimately means placing a greater burden on the general public. The worst damage is done to the 25% of people in the country who do not have any electricity. They have to use a kerosene lamp but due to the excessive electricity usage of others, they too have to subsidize them indirectly.

Rural poor in areas where there is no grid power and have purchased solar panels have to pay Rs. 100 per unit. Additionally, due to the bad tariff system of the CEB they have to additionally bear some of the cost of grid connected high electricity users. This is like stealing from a beggar's bowl. If the rural farming communities are to be saved, then the CEB needs to revise its tariff systems and make the high end users pay what they should while providing rural communities with subsidies to invest in alternative energy sources.

10 Hydro power

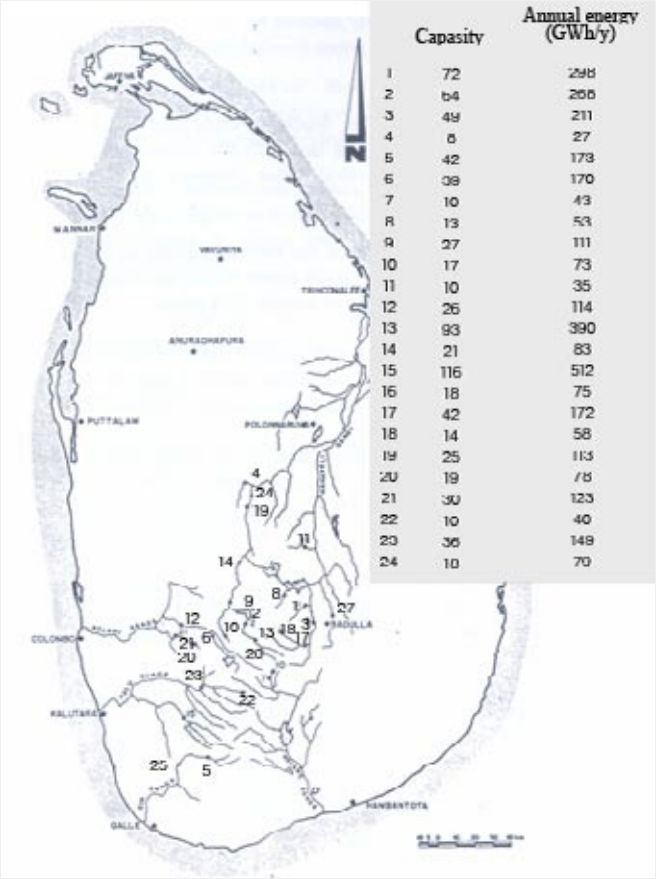
Of all renewable energy sources, this is the one in which Sri Lanka has the most experience. According to the CEB plan, the currently established capacity for hydro-power is 1314MW while there are resources for an additional 800 MW of power that has been identified. However, tapping this additional potential has been curbed due to two reasons.

The first is that the CEB has determined that the construction of medium scale generation plants at Broadlands, Gin-Ganga, Uma-Oya and Moragolla are not cost effective. However, in the preceding pages of this booklet, this calculation of the CEB has been proved wrong. The second reason for not tapping these sources is that they are located in environmentally and socially sensitive areas.

Thus, if the remaining sources are to be tapped, then the country needs a clear and careful plan as soon as possible. Although small scale hydro-electric plants are being established by the private sector, they have been delayed due to various environmental, social and administrative problems. Thus, developing these potencies should be part of the government's responsibility. If developed, it is estimated that there will be an additional 300 MW of capacity available and 1000 GWh can be fed into the grid.

With an efficient plan, these can be constructed within a period of 3 years while the capital investment is estimated to be Rs. 50 billion.

In addition to this, there are a large number of potential micro-hydro projects that can be established within the grid connected areas but they have not been given attention by anyone so far. The net metering initiative of the sustainable energy authority should address this matter as well.



	Capasity	Annual energy (GWh/y)
1	72	298
2	64	266
3	49	211
4	6	27
5	42	173
6	39	170
7	10	43
8	13	53
9	27	111
10	17	73
11	10	35
12	26	114
13	93	390
14	21	83
15	116	512
16	18	75
17	42	172
18	14	58
19	25	113
20	19	78
21	30	123
22	10	40
23	36	148
24	18	70

Figure 19 : Untapped Hydro potential in Sri Lanka (Source: CEB master plan)

11 Dendro Power

Of all the alternative energy sources that are available, the easiest dispatchable renewable energy source is dendro power. This is because wood can be stored and there would be a need to establish a planting culture to provide this material as fuel. Wood used for this purpose is grown in the preceding year and there is a fuel cost for purchasing the wood. However, since it can be stored, electricity can be generated throughout the year. Thus, like coal, electricity can be produced by dendro power plants over at least 80% of the year.

Dendro power is the most competitive renewable energy solution on the land. According to research conducted, Gliricidia can be grown for this purpose which can be integrated with the existing agricultural practices and the it will need a 1 acre plantation to be able to feed a 1 KW plant. Thus, scrub and barren lands which have so far provided no economic gain for the country can be enriched while providing the raw material for an alternative energy source. If efficiently planned, there is potential for 3000 MW capacity. Even if the estimated cost of wood rises, the profit would go to the dry zone farmer who is currently living under harsh economic conditions. Since leaves from the plant can be used for fertilizer it will also reduce fertilizer costs to the farmers

and increase the standard of living of these communities. As a start, it is recommended that the government initiates a project to produce a 300 MW capacity plant through dendro power. The capital investment for this would be about Rs. 50 billion and the generated annual power would be 2100 GWh.

Figure 20 : Areas designated for growing Glirecedia as the raw material for Dendro-power

12 Wave Energy

Of the area owned by Sri Lanka, the greater proportion is seas. Of all resources available from the sea, the most important is energy. There are oil resources not only in the Manner sea basin but there are indications in the Kovari basin as well. However, the most sustainable energy source available from the sea comes from waves, ocean thermal and thermal currents. However the only alternate energy source for which a tariff system has been formulated by the Ministry of Power and Energy is wave energy. According to the government calculations, this is the cheapest form of alternative energy.

Waves are stable in the South of Sri Lanka since there is no land mass all the way to Antarctica. Strong storms are rare. The wave energy potential of 1 meter off the southern coast of Sri Lanka is about 13 KW in January. It rises to 100 KW by May. The Ministry of Power and Energy estimates that stable electricity can be obtained at a plant factor of 67%..

However, amazingly, the government has so for not invested a single rupee to develop this resource. Since only one investor has so far come forward it is important to do a more reliable analysis of the power potential of waves Conducting a research and launching a plan to tap this source is an immediate responsibility of the government.

Figure 21 : Areas belonging to Sri Lanka

Figure 23 indicates that there is high potential for ocean thermal power – an area that the Sri Lanka government has so far failed to investigate.

Figure 22 : Potential for sea wave energy in Sri Lanka

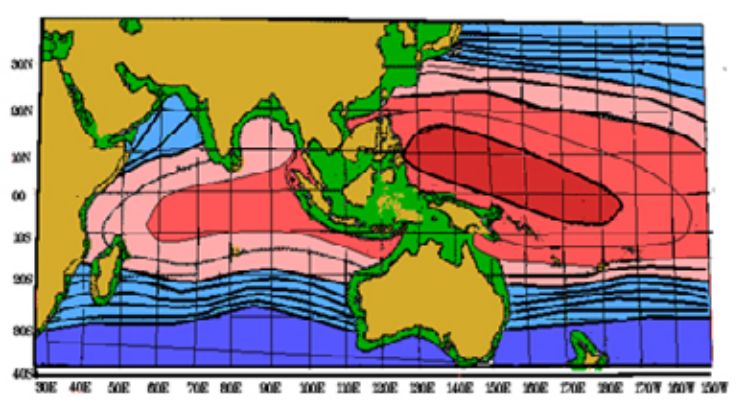


Figure 23 : Global potential for sea heat energy

13 Wind Power

The alternative energy source that is being most tapped globally is wind power and this fact is reflected in figure 24.

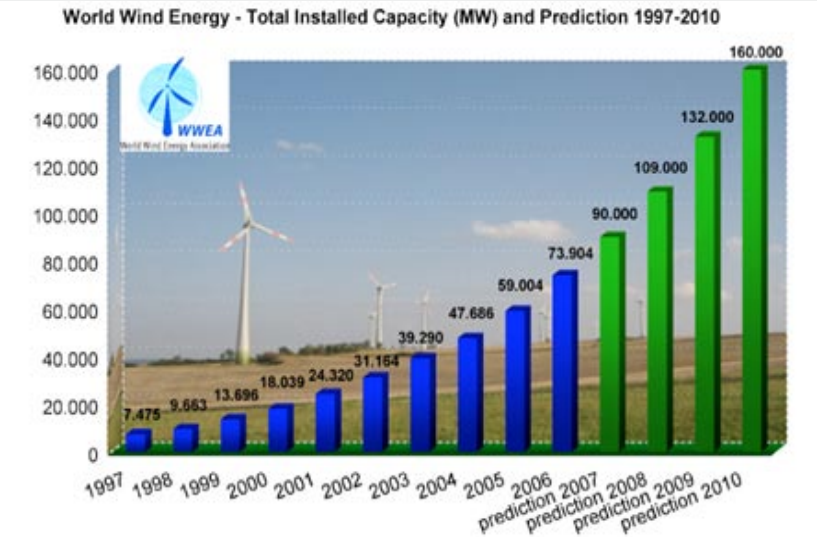


Figure 24 : Global rate of propagation of the use of wind power

According to research conducted by the National Renewable Energy Laboratory (NREL) of America, there is high wind potential over 6% of land in Sri Lanka. They have estimated a potential capacity of 20,000 MW. Additionally, they have identified an estimated potential capacity of 24,000 MW in lagoon areas.

The greatest drawback of wind power is that electricity can only be obtained through this method when there is wind. Thus, the plant factor of wind power is only 30%. To be able to use this energy at any time, there has to be a mechanism to store the energy. Since this is costly, it is better to consume wind power when it is available without investing on establishing a storage facility. So this has to be considered as a non dispatchable energy source.

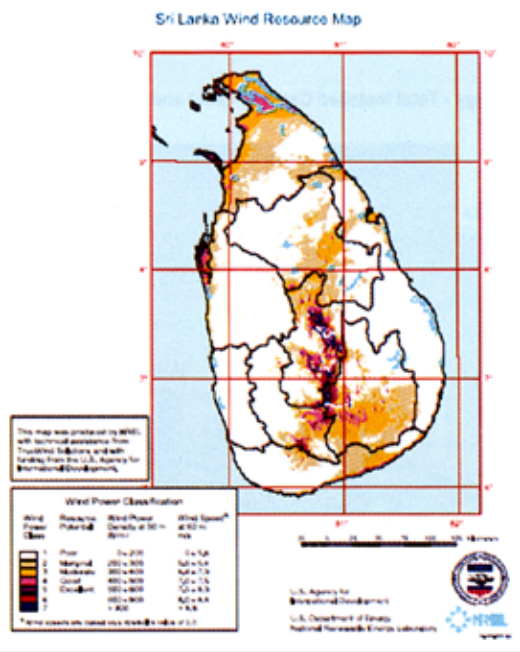


Figure 25 : Wind energy potential in Sri Lanka

14 Solution

Planning of energy supply without taking into consideration the global energy crisis should be stopped even at this late stage. Sri Lanka, having built oil power plants while staring the oil crisis in the face is now fighting to construct coal power plants with the coal crisis and climate change staring them in the face. Exchanging one rapidly depleting source for another is possibly the most foolish policy decision that the government can make. Instead it should strategize and implement a plan for tapping renewable energy sources over the next six years.

Leaving aside all argument and contention, tapping the remaining 800MW of hydro-power over the next six years should be a national priority.

As a solution to the energy crisis, the agro-chemical crisis and the financial crisis, soil enriching Gliricidia should be planted for the year around operation of about 600 MW dendro power plants as a second priority noting that this would have the additional benefit of enhancing the quality of life amongst the rural farming communities while piping funds that are being currently pumped overseas to the poor.

While establishing a network of dendro plants across the country a parallel exercise to establish industrial parks to use waste heat of the power plants for industries that need heat can be initiated to double the overall efficiency of machines. This will also have the added benefit of reducing the amount of oil that is used by industries leading to saving about 200,000 Metric Tons of oil annually.

To provide electricity for rural poor who don't have electricity, community based bio-gas and dendro units can be introduced by the government. The total capacity would be about 10 MW.

Wind power is an unlimited resource. However, since the return on investment takes a relatively longer time, a gradual increase of wind power plants over the next six years for a capacity of 300 MW would be realistic and appropriate.

If wave energy is as cheap as the government says, the reason why it hasn't done anything to tap this resource is a problem. However, it should at least target tapping about 200 MW of wave energy over the next six years.

By implementing these proposals there is a potential to increase annual electricity generation by 10,000 GWh. Of all of these sources, due to technical reasons, hydro-power has to be used for peaking purposes.

Domestic energy conservation should be initiated through reworking the building codes. Instead of aping designs suited for cold climates, designs should be appropriate to Sri Lanka while the home garden should also be designed to creating a microclimate that reduces consumption of electricity. Additionally, the standards for electrical appliances should also be established.

Proper use and maintenance is essential to improve the overall efficiency of electrical appliances. In order to provide lighting and air conditioning for buildings during the day time appropriate solar thermal and lighting technologies should be introduced as Sri Lanka is an for equatorial country. The tariff system is the key factor that will drive the will of the consumer to achieve all of these conservation goals. For formulating appropriate tariff structures, a separate research unit should be established.

Reorganizing the transport sector should begin with town planning. Workplaces and home should be adjacent to each other. The differences in the quality of schools should be reduced and an optimal efficiency should be obtained from the school network that is spread across the country. Through this, congestion in transport can be avoided. The public transport system should be significantly improved with reasonable tariffs so that both low and high income earners will use it as a matter of preference.

Goods transport can be reduced by establishing self sustaining units in different geographic areas. It is also required to take the technical steps to consolidate and interconnect the road and rail networks since this will increase the efficiency of both goods and people transportation.

Attention should be given to electric automobiles and trains for transportation but this should come with a mechanism to increase the generation of electricity. Using bio-fuels for the transport sector is also an excellent alternative for equatorial countries but care should be taken to prevent a mono cropping culture from taking root which will lead the country into an even greater disaster.

The bottom line is that a sustainable development paradigm should be established for society.

From the time he was a student of engineering at the University of Moratuwa, Asoka Nalanda Abeygunawardana has worked with commitment and zeal on the energy crisis facing Sri Lanka. He was a key member of the complex dialogues on the problems of modern development and the environment and was a leading activist in social movements that arose out of the scenario. He executed his social responsibilities as both an electrical engineer and a street fighter for environment conservation and social equity. He is a leading Sri Lankan intellectual who has, over the last two decades, worked tirelessly to promote the use of renewable energy as a lecturer, researcher, writer and policy planner. As the Executive Director of the Energy Forum and Senior Consultant to the Strategic Enterprise Management Agency established by the President's Office and as a Director of the Sustainable Energy Authority, he has continued his unrelenting efforts to promote holistic and sustainable solutions to the currently existing crises in food and energy.

Due to the challenges faced by the modern world, there is no future for fossil fuels. Thus, the effort to construct 3300MW coal power plants and 935 oil power plants is simply an investment for outdated technologies. Attempting to do this is a national crime.

Yet, the CEB states that the cheapest electricity is through coal power. Accordingly they state that the price of a unit of electricity will be Rs. 6.00 However, if one discards the wrong assumptions of the CEB and do a proper assessment of costs, then the price of a unit of coal powered electricity will exceed Rs. 30 while the cost of renewable energy in Sri Lanka is substantially lower and lies between Rs.4.75 and Rs. 16.15.

There is a future only for energy conservation and renewable energy sources. Thus, it is absolutely essential that funds earmarked for fossil fuel based techniques should be channeled towards energy conservation and tapping renewable energy sources. As is commonly know, procrastination always leads to regret.

Rs: 200/=