Managing the impacts of higher costs of renewable energy

Tilak Siyambalapitiya[1], WDAS Wijayapala[2]

[1]*Managing Director, RMA (Pvt) Ltd, 3, Charles Terrace, Colombo 3, Sri Lanka.*
[2]*Chairman, National Engineering Research and Development Center, Ekala, Ja-ela, Sri Lanka and Senior Lecturer, Department of Electrical Engineering, University of Moratuwa, Sri Lanka.*

[1]tilak@rmaenergy.lk, [2]anurawijayapala@yahoo.com

Abstract— *Certain emerging technologies to covert renewable energy to electricity come at a premium price. The reasons for these high prices are not only their higher capital costs in terms of cost per unit of capacity installed, but include the relatively low levels of maturity of such technologies, uncertainties of the resource availability owing to limited availability of historic information about resources and their variations, relatively smaller sizes of such conversion facilities, and the fact that the private investors are expected to develop such resources, whose cost of capital as well as expectation on return on investment are higher than those of state institutions.*

To encourage production of electricity from renewable energy, Sri Lanka has two key initiatives in operation: (i) the standardized feed-in tariffs available to electricity produced from any form of renewable energy and waste heat, on the basis of a standardized, non-negotiable power purchase agreement, (ii) a net metering facility afforded to any customer, to install a renewable energy-based generating facility, and to bank any surplus energy with the grid at a zero banking charge. On feed-in tariffs, Sri Lanka commenced with an offer of the avoided cost of thermal energy since year 1996, followed by a policy revision in year 2007, which established a cost-reflective, technology-specific feed-in tariff. In certain years, for certain technologies, Sri Lanka's feed-in tariffs have been the highest in the world.

Key questions raised on the feed-in tariff from the point of view of prospective investors, are: (i) Why is the tariff limited to a number of technologies? (ii) Why are tariffs too low for certain technologies? Key questions on the net metering procedure are: (i) Why is the surplus energy not paid for? (ii) Why surplus energy cannot be sold by one customer to another customer?

Key questions that should be raised by the policy makers and customers are: (i) Should renewable energy be purchased at higher prices and those costs passed-on to customers, in a developing country such as Sri Lanka? (ii) If more and more customers establish net metered generating systems, and if their bills approach zero, who will pay for the network investments and operational cost differentials for banked energy? In other words, the network charges for net-metered customers are paid by other customers who do not have net metered facilities.

The paper proposes (i) a transparent, balancing mechanism to ensure that the portfolio average prices are transparently calculated and limits established, (ii) a banking charge for net metered energy to ensure fairness in the procedure, as net metered facilities grow in number and variety.

I. INTRODUCTION TO RENEWABLE ENERGY USE AND PRICING IN SRI LANKA

More the 50% of primary energy supplied to the Sri Lankan economy is from renewable sources, dominated by biomass widely used for households and commercial applications. Although some reduction in terms of the share of renewable energy input to the economy has been reported since 1990, Sri Lanka still remains largely an economy powered by renewable energy (Figure 1). The status of power generation is similar: the planned contribution from renewable energy sources in year 2013, both conventional and non –conventional, is about 40%, but the decline has been rapid over the years, where up to about mid 1990s, almost 90% of electricity was produced using hydropower.

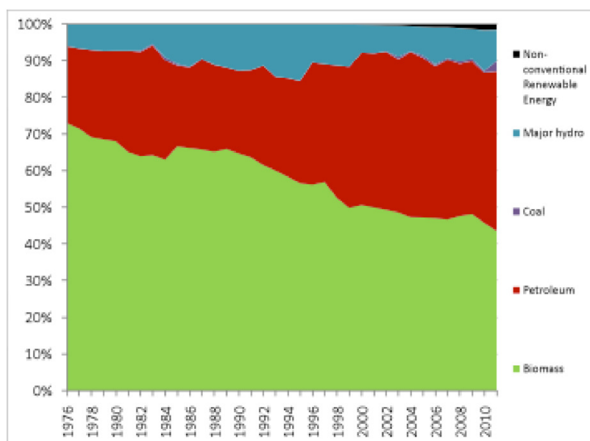

Fig 1. Renewable Energy Contribution to Sri Lanka's Economy
Source: Sri Lanka Energy Balance 2011

In the electricity industry, owing to many reasons, including the need to retain the higher level of energy security offered by renewable energy (as they are indigenous) and the longer term sustainability of such resources (in the face of perceived environmental impacts of fossil fuels and owing to the diminishing nature of fossil fuels), Sri Lanka too has embraced a policy of positive encouragement

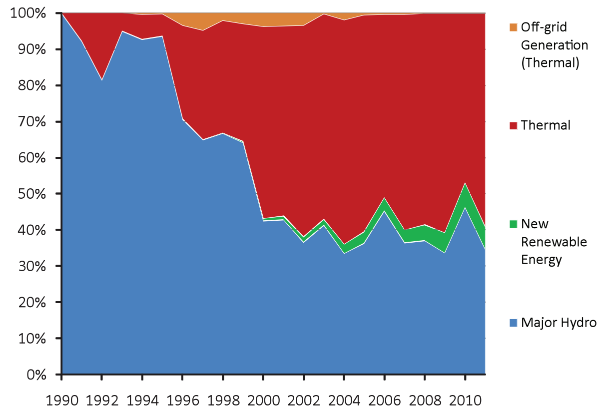

Fig 2. Renewable Energy in Power Generation in Sri Lanka
Source: Sri Lanka Energy Balance 2011

of using renewable energy for power generation. While efforts were underway throughout the past decades to develop renewable energy sources for power generation, several specific initiatives were taken from 1996 onwards.

The first initiative was to allow private sector to develop renewable energy sources for power generation, and supply the grid at a standardized a feed-in tariff. The agreement for such supplies was lenient, offering a 100% purchase guarantee for all the electricity produced for a period of 15 years, the power plant to be non-dispatchable (meaning that it will operate at all times with no restrictions, irrespective of the economic dispatch principles on which a power generating system normally operates) and with no liquidated damages in case of non-supply of energy. The price was based on the "avoided cost" of electricity generation on the grid. The "avoided cost" calculation involves the estimation of the value of fuel saved in the main power plants, as a result of injection of energy from these power plants. Within 10 years from the implementation of the policy, about 50 such power plants were operational on this feed-in tariff. As a consequence of increases in oil prices and the share of oil-fired electricity generation on the grid, the avoided cost that was Rs 2.90 per kWh in 1996, has now increased to Rs 15.63 per kWh. Owing to backward averaging for smoothening the rapid variations of avoided costs, the feed-in-tariff is presently at Rs 11.79 per kWh. In rupees terms, the feed-in-tariff has increased four-fold over the period 1996-2013, while in USD terms, the increase was about 1.75 times (Table 1).

The tariffs offered were technology neutral, meaning that whatever the operating technology of the power plant, the price paid for power fed into the grid was the same.

The second major policy initiative was in 2007, when the pricing policy was reviewed. After a long consultation process, the pricing policy was changed from one based on avoided costs to one based on actual costs of developing power plants from renewable energy sources. Thus, the tariffs for new contracts signed from 2008 onwards are paid on cost-reflective, technology-specific tariffs, announced for each year.

However, the price paid is the tariff applicable at the time of signing an agreement, inclusive of escalations as stated in the tariff. Thus unlike in the pre-2007 agreements, the tariff payable is reasonably predictable, which has provided comfort to the developers and their lenders. Fifteen-year agreements signed between 1996 and 2007 continue to be paid at tariffs based on avoided costs, as most of them

Year	Weighted average Avoided cost (LKRkWh)	Weighted average Tariff (LKRkWh)	Increase in LKRkWh wrt. 1996	LKRUSD (average)	Weighted average Tariff (US cets KWh)	Increase in US cets KWh wrt. 1996
1996	2.90	2.90	1.00	55.27	5.25	1.00
1997	3.01	3.01	1.04	57.99	5.11	0.97
1998	3.28	3.23	1.11	64.59	5.00	0.95
1999	2.34	2.86	0.99	70.39	4.06	0.77
2000	2.97	2.85	0.98	75.78	3.76	0.72
2001	6.84	4.05	1.40	89.36	4.53	0.86
2002	7.33	5.71	1.97	95.66	5.97	1.14
2003	3.54	5.90	2.04	96.52	6.16	1.17
2004	4.55	5.14	1.77	101.19	6.08	0.97
2005	8.38	5.49	1.89	100.50	5.46	1.04
2006	5.22	6.05	2.09	103.96	5.82	1.11
2007	7.75	7.12	2.45	110.62	5.43	1.23
2008	14.30	9.12	3.14	108.33	8.42	1.60
2009	10.07	10.74	3.70	114.94	9.34	1.78
2010	9.45	11.30	3.90	113.06	10.00	1.91
2011	11.80	10.47	3.61	110.57	9.47	1.80
2012	7.84	9.73	3.35	127.60	7.62	1.45
2013	15.53	11.79	4.06	127.60	9.24	1.76

Table 1. Feed-in-Tariffs in Sri Lanka for Renewable Energy-based Power Plants less than 10 MW (for agreements signed up to 2007)
Source: Compiled from information available in tariff announcements

For agreements in 2008

Technology	Escalable Base O&M Rate	Escalable Base Fuel rate	Non-escalable fixed rate		Escalable Year 16+ Base rate
			Year 1-8	Year 9-15	
Mini-hydro	1.35	none	11.80	4.45	1.30
Wind	2.14	none	18.66	7.03	1.30
Biomass	1.04	5.74	6.79	2.56	1.30
Agricultural & Industrial Waste	1.04	2.87	6.79	2.56	1.30
Municipal Waste	2.70	None	10.07	3.80	1.30
Waste Heat Recovery	0.41	None	8.11	3.06	1.30
Wave Energy	1.01	None	6.58	2.48	1.30
Escalation rate for year 2007	6.52%	4.35%	None	None	4.35%

Table 2. Feed-in-Tariff in Sri Lanka for Renewable Energy-based Power Plants less than 10 MW (for post 2008 agreements)

For agreements in 2010 and 2011

Technology / Source	Escalable Base O&M (year 1-20)	Escalable Base Fuel (year 1-20)	Non-escalable		Escalable Year 16+ Base Rate
			Year 1-8	Year 9-15	
Mini-hydro	1.61	None	12.64	5.16	1.68
Mini-hydro-local	1.65	None	12.92	5.28	1.68
Wind	3.03	None	17.78	7.26	1.68
Wind-local	3.11	None	18.28	7.47	1.68
Biomass	1.29	9.10	7.58	3.10	1.68
Biomass 16yr onwards	1.61	9.10			
Agro & Indus	1.29	4.55	7.58	3.10	1.68
Agro & Indus 16yr onwards	1.61	4.55			
Municipal Waste	4.51	1.75	15.16	6.19	1.68
Waste Heat	0.43	-	7.13	2.65	1.68
Escalation per year from 1st January after the commercial operation date	7.64%	5.09%			5.09%

Note: Additional details of tariffs have been removed from the above tables, to retain clarity. There was a tariff announcement for agreements signed in 2009 as well. More specific details are available on www.energy.gov.lk or www.ceb.lk

rejected an offer by the Government to transfer to the new cost-reflective, technology-specific tariffs, with the contract term extended from 15 to 20 years.

Table 2 shows the first tariff announcement in 2008 on the basis of cost-reflective, technology-specific policy, and the last announcement for the period 2010-2011[1].

Sometimes, especially in year 2009, the feed-in-tariff offered in Sri Lanka for wind power was the highest in the world, as documented in many studies[2]. A more recent study[3] shows a comprehensive assessment of feed-in-tariff in both developing and developed countries (Figure 3).

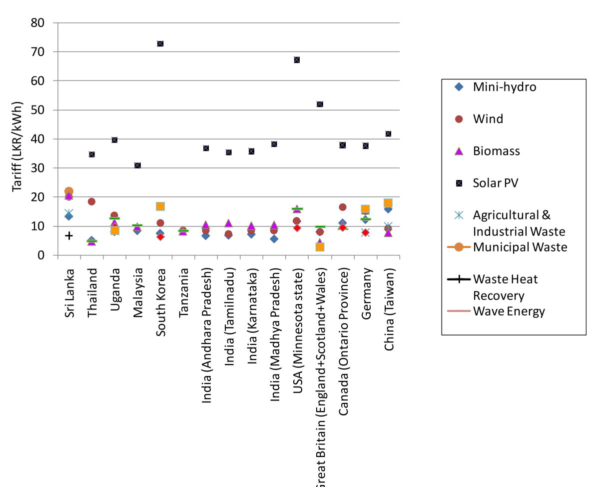

Fig 3. Feed-In-Tariffs Worldwide
Note: Prices based on published information on respective utility/regulatory websites, June 2011

The third policy initiative was in 2008, to introduce the net-metering facility to all customers. Since launching in 2008,

[1] Since 2010, feed-in tariffs under the technology-specific, cost-reflective regime have not been announced, owing to administrative delays and a difference of opinion between Ceylon Electricity Board and the Public Utilities Commission.

[2] Design and Performance of Policy Instruments to Promote the Development of Renewable Energy: Emerging Experience in Selected Developing Countries, Gabriela Elizondo Azuela and Luiz Augusto Barroso, Energy and Mining Sector Board Discussion Paper No 2, The World Bank, April 2011

[3] Renewable Energy Development: Power Purchase Agreements and Pricing Policies, Aug 2011 (Unpublished)

and a re-launch in 2010, about 500 customers by now (Aug 2013) have net-metered renewable energy-based power generating facilities, most of which are roof-top solar PV systems. What Sri Lanka provides is a net metering facility that enables a customer to bank any surplus energy with the grid. The facility is open for any form of renewable energy, and connected to the grid through the exiting connection through a 2-way meter. The grid operates as a free bank; absorbing any surplus energy at all times, and returning that energy back as and when required by the customer. Such "banked" energy can be carried forward for a period of 10 years, which is the tenure of the net-metering agreement. The capacity of the facility can be up to the contract demand of the customer, but limited to 10 MW.

II LIMITATIONS AND IMPACTS OF THE PRESENT POLICIES

With the introduction of the cost-reflective, technology-specific tariff in 2008, certain technologies have not been offered a tariff. A clear example is for electricity produced from solar energy. While in principle, such technologies were allowed in the pre-2008 tariff policy (although none were built owing to the fact that the avoided-cost based tariffs were inadequate to make such projects viable), the post-2008 pricing policy purposely excludes such technologies. The reason for the exclusion is that the comparatively high cost of producing electricity from solar technologies, solar thermal or solar PV. The estimated tariffs for such technologies, if calculated on the same basis of the presently-applicable cost-reflective tariffs, vary in the range of 25-35 UScts/kWh (30 to 40 LKR/kWh). While there is information that capital costs of solar PV systems are on the decline, there is still no mechanism to "discover" what the costs of such systems are from the point of view of a feed-in-tariff. Therefore, such technologies effectively do not have a published feed-in tariff in Sri Lanka.

The impacts of the feed-in tariffs on the customer, are yet to be realized. In 2011, the impacts on customer prices was about LKR 0.12 per kWh (about 0.1 UCts/kWh) at the feed-in tariffs applicable for projects signed up in 2009 (Table 3). With increasing feed-in tariffs, especially for technologies other than wind power, and with the declining variable costs of thermal generation in the grid with the introduction of coal-fired power plants, the impacts on customer prices in the coming years is likely to be higher. Accordingly, the issue of "who meets the additional cost" has not been resolved as yet, although the policy change in 2008 defined a clear policy of establishing an energy fund to bridge the difference between the feed-in tariffs and the avoided costs.

With regard to net metered facilities, the question is whether the surplus energy banked on the systems cannot be paid for. Many facilities that have been connected on the basis of net metering, have additional space that can be used to upgrade the capacity, and feed surplus energy to the grid, provided it is paid for.

However, the issue that remains to be resolved, if the decision is to pay for such energy, what is the price to be paid? This is because, although there is a perception that Sri Lanka's electricity prices to customers is high compared with other countries in the region (see Table 4), the actual costs of electricity consisting of capacity, energy and supply, are significantly different to the customer tariffs (see Table 5).

Accordingly, if a net metered customer "saves" a kWh, then the average benefits to the grid is the avoided cost of energy, about LKR 15 per kWh, and not the higher rates in the range of 22-58 LKR/kWh in published tariffs. As such, the determination of a price to be paid for surplus energy from such net metered facilities is a contentious issue, and with the energy component of the cost of supply declining (with more coal-fired power plants entering the service), and the capacity component increasing (with increasing investments on all system assets, especially generation), the amount payable. for surplus energy from net metered systems would be significantly lower than the apparent cost of supply or the customer tariffs.

		Economic dispatch	Short-term debt recovery	Renewable energy above avoided costs	Total BST (E)
BST day (E1) 6-Month weighted average	LKR/kWh	7.16	0.52	0.11	7.78
BST peak (E2) 6-Month weighted average	LKR/kWh	9.37	0.52	0.11	10.00
BST off-peak (E3) 6-Month weighted average	LKR/kWh	4.97	0.52	0.11	5.60

Table 3. Impact of Feed-in Tariff on Generation Costs 2011

Source: Tariff Decision 2011, Public Utilities Commission Sri Lanka (PUCSL)

Note: BST: Bulk supply tariff from Transmission to Distribution, E1, E2 and E3 signify the variable costs of energy at day, peak and off-peak periods .As renewable energy is non-dispatchable, its cost has been equally distributed among all the three time intervals, when the losses in distribution network are added, the impact on the customer prices is about 0.12 LKR/kWh sold to end-use customers.

Customer	Class	Electricity Usage (kWh/mth)	Maximum Demand (kW)	Average Unit Price in LKR (unity power factor)														
				Bangladesh	China	Hong Kong	Kerala, India	Maharashtra, India	Tamilnadu, India	Malaysia	Nepal	Pakistan	Philippines	Singapore	South Korea	Sri Lanka	Thailand	Vietnam
Household	Small	30	-	5.52	10.07	14.45	4.36	2.82	2.98	8.91	7.13	12.67	14.81	26.72	8.10	4.75	8.36	6.00
	Medium	90	-	6.01	10.07	14.45	4.47	10.16	3.60	8.91	11.02	17.54	22.39	26.72	7.10	12.73	10.05	8.16
	Large	180	-	6.90	10.07	15.58	5.30	12.93	7.95	8.91	12.24	18.87	27.58	26.72	10.32	29.63	11.09	9.09
	Very Large	600	-	9.37	12.41	18.68	9.54	18.66	10.93	12.98	15.85	22.74	29.10	26.72	34.69	50.23	13.07	12.15
Commercial	Small	1,000	-	14.82	15.62	21.78	20.74	22.08	16.19	17.57	14.73	18.98	27.15	26.72	11.49	27.12	13.58	13.56
	Medium	58,000	180	11.35	15.62	20.75	15.17	31.71	18.34	16.98	14.53	23.56	25.12	26.72	12.92	28.83	12.85	13.20
	Large	600,000	1500	10.79	15.72	20.69	12.23	30.44	18.34	16.98	14.18	23.56	22.92	19.83	13.46	27.13	12.31	12.36
	Small	5,000	-	11.56	13.87	20.58	8.29	13.21	12.57	15.41	11.75	23.61	25.09	26.72	9.79	14.50	14.20	8.53

[redacted]

Table 4. Comparative Customers Tariffs in Selected Countries in the Region

Source: Author's calculations

Household Customer category	Cost of supply (LKR/kWh)				Income from sales (LKR/kWh)	Subsidy
	Capacity	Energy	Retail Serv.	Total		
0-30	12.07	15.41	2.62	30.10	5.53	82%
31-60	10.94	15.42	0.94	27.30	5.97	78%
61-90	9.91	15.41	0.58	25.91	8.08	69%
91-120	8.18	15.28	0.44	23.91	15.28	36%
121-180	8.18	15.27	0.32	23.77	22.38	6%
181-600	7.78	15.08	0.19	23.04	35.50	-54%
>600	5.85	15.03	0.04	20.92	53.49	-156%
All households	9.32	15.32	0.65	25.29	15.47	39%
Religious	8.48	15.28	0.28	24.05	5.39	78%

Table 5. Structure of the Cost of Supply to Households 2013

A further issue is the provision of free banking for net metered customers. For such customers, who have a contract with their distribution service provider, system capacity is standing by at all times, to provide the requirements. Therefore, the free banking presently provided has to be considered as an incentive, rather than a longer term policy. For example, a peak-time customer using 30 kWh per month imposes capacity cost of LKR 12.07 per kWh on the system. Most likely, the net metered customers would be purchasing from the grid (or taking back the banked energy) in the peak period, during which time the capacity costs are the highest, because the network assets are designed and augmented to meet the peak time demand. Therefore, in principle, such net metered customers should pay a sum in the range of LKR 12 per kWh for each banked kWh, or on the average, about LKR 9.30 per kWh, if the time of use is disregarded.

III RESOLVING THE PRICE ISSUE

The issue of perceived higher costs of renewable energy-based electricity generation has to be resolved as a combination of two policy initiatives: (i) a clear declaration of how much extra price an electricity customer is required to pay above the avoided costs, to facilitate renewable energy deployment (this value can be zero, or up to a specific threshold, for example LKR 1 per kWh), (ii) establishing a portfolio approach in using the additional payment (eg: 1 LKR/kWh would yield a sum of LKR 11,000 million in 2013), which may be used to purchase renewable energy on a competitive basis, and (iii) establishing a fund (the renewable energy fund) to manage the process, with clear boundaries established, and (iv) liberalization of the generation business, so that customers may directly purchase renewable energy from suppliers.

Initiatives (i), (ii) and (iii) all converge on the concept of a centralized assessment and settlement of costs of renewable energy. Sources of income to the renewable energy fund:

(a) A share of avoided costs from the savings of thermal energy. In a previous Government decision, this amount has been fixed at 90% of avoided costs. This means, if CEB Transmission operator saves purchases of a thermal energy to a level of LKR 2 billion owing to renewable energy purchases, the fund is credited with 90% of LKR 2 billion.

(b) Customer contributions by way of incremental charges on each kWh, transparently shown on bills, collected by the Distribution Licensees and credited to the renewable energy fund

(c) Contributions from the Treasury

(d) Contributions from other national and international corporate agencies, donors and NGOs

Initiative (iv) requires further liberalization of the electricity industry, which may require amendments to the Electricity Act 2009 as well, to enable a generator to directly sell to a customer, or even a to Distribution Licensee. This, in effect, is wheeling, but limited to the trade of renewable energy-based electricity. A pre-requisite for such an arrangement is to eliminate cross subsidies between customer categories, such that customers or Distribution Licensees opting to purchase renewable energy would see the benefits of such purchases from the correct financial and economic perspective, and not from a perspective of artificially inflated prices for one group of customers, to facilitate cross subsidies.

Figure 4 shows a possible structure of such a "renewable energy fund" and Figure 5 shows a liberalized market for renewable energy, both of which are likely to further enhance Sri Lanka's on-going initiatives to further develop renewable energy for power generation.

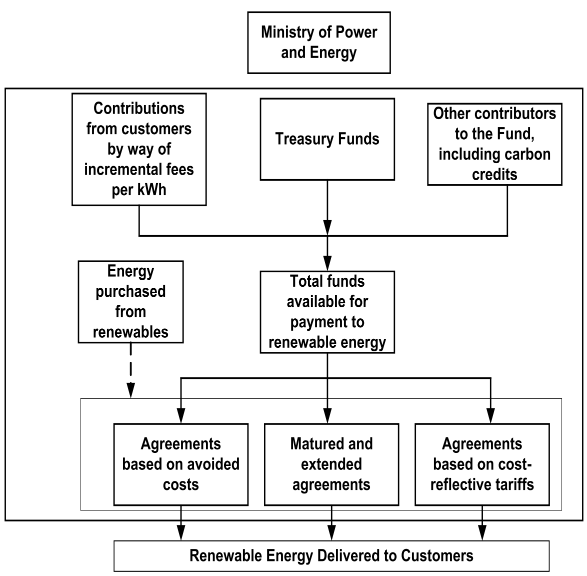

Fig 4. An Energy Fund to Make Renewable Energy Costs Transparent

Table 6 shows a scenario, developed on the basis of year 2005 costs, for the period 2006-2015 (unpublished). The plan extends from year 2006 to 2015, seven years of which have now elapsed. The financing plan and the renewable

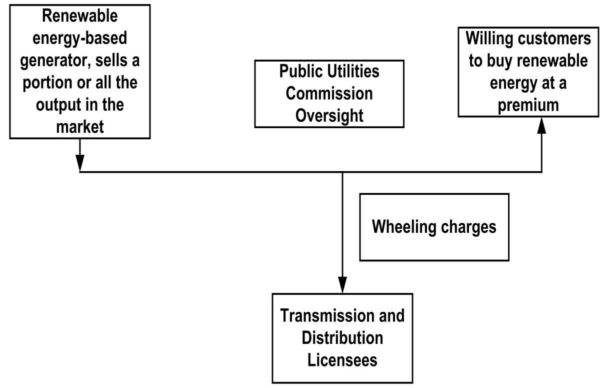

Fig 5. Wheeling of Renewable Energy to Facilitate Further Development

energy fund transactions prepared in 2005, have in-fact become almost a reality.

Year	Grid Electricity Generation (GWh)		Renewable Energy Share
	Other sources	From Renewable Energy	
2006	8,771	337	3.7%
2007	9,333	430	4.4%
2008	9,949	535	5.1%
2009	10,644	655	5.8%
2010	11,386	792	6.5%
2011	12,176	945	7.2%
2012	13,017	1,117	7.9%
2013	13,907	1,309	8.6%
2014	14,866	1,524	9.3%
2015	15,915	1,768	10.0%

Table 6. Results of a Case Study in 2007

Source: A renewable energy development plan, as seen in year 2005 (unpublished)

The study of 2007 demonstrates that the budget for renewable energy development can in-fact be planned accurately. As forecast in year 2005, the capacities of mini-hydro and wind power are about the same as that was actually developed by 2012. However, the 53 MW of biomass-based generating capacity did not materialize. Similarly, as forecast, the customer impacts commence from 2011, but not as high as 0.33 LKR/kWh as predicted but at 0.12 LKR/kWh. The impact over 2011-2013 is lower owing to higher oil and coal prices in 2013, when compared with the prices that prevailed in 2007. On the other hand, the burden on CEB has increased significantly more than that expected in 2007, because the feed-in tariffs have sharply increased between 2008 and 2012. For year 2013, PUCSL reported that the average cost of purchase of renewable energy on the basis of feed-in tariffs was 18 LKR/kWh, whereas the forecast in 2007estimated the year 2013 pool average price to be 11.30 LKR/kWh.

Year	Operational NRE Capacity (MW)			Financial Commitments (LKR million)				
	Total Hydro	New Biomass, new tariff	New Wind, new tariff	Total Payments to SPPs by CEB	Total Royalty Payments to Govt by CEB	Total Payments by CEB	Limit of CEB Commitment (90% of avoided cost)	Gross Impact on Customer Price (LKR/ kWh)
2007	109	-	-	3,664.9	-	3,664.9	4,871.6	(0.15)
2008	119	5	10	5,814.0	-	5,814.0	6,983.8	(0.13)
2009	134	15	30	9,469.6	-	9,469.6	8,535.8	0.10
2010	151	31	54	12,629.4	-	12,629.4	12,732.5	(0.01)
2011	168	42	78	14,138.0	1.9	14,139.9	10,444.6	0.33
2012	186	53	102	15,740.0	2.0	15,742.0	10,941.7	0.40
2013	203	64	125	17,023.4	3.2	17,026.6	12,230.4	0.37
2014	220	75	149	18,381.3	7.5	18,388.8	10,170.1	0.58
2015	250	80	170	19,486.3	16.6	19,502.9	12,115.1	0.49
2016	250	102	200	20,696.7	31.8	20,728.6	13,546.5	0.44
2017	250	151	200	23,394.4	46.3	23,440.6	15,748.0	0.44
2018	250	195	230	26,769.9	53.2	26,823.1	18,127.4	0.46
2019	250	255	230	29,990.9	99.4	30,090.3	20,837.0	0.45
2020	250	311	260	34,251.9	115.6	34,367.5	23,768.3	0.48
2021	250	385	260	38,777.1	133.0	38,910.1	27,078.8	0.50
2022	250	452	300	44,262.0	146.5	44,408.5	30,653.5	0.54
2023	250	543	300	50,092.9	159.9	50,252.8	34,692.6	0.57

Table 7. Results of a Case Study in 2007 (Ctd..)

SPP: Small Power Producer
Gross impacts on customer price: If positive, customer pays more than his due, to accommodate NRE
Basis: August 2006 fuel prices, coal USD 100 per MT
CEB: Ceylon Electricity Board, the single-buyer in Sri Lanka.

Source: A renewable energy development plan conducted in year 2007.

CONCLUSIONS

There is significant enthusiasm among developers for further investment on renewable energy projects for electricity generation. Their impacts on customer prices have certainly exceeded the break-even customer price, meaning that from year 2011, electricity customers are already paying more than they should, to accommodate renewable energy in the system, including wind power. The case study presented in the paper shows that the impacts on customer prices can be estimated reasonably accurately, and solutions found in advance to address the issue of higher costs. The paper proposes the establishment of a renewable energy fund, to attract contributions to bridge the revenue gap. However, the feed-in tariff regime does not allow higher cost forms of renewable energy to be awarded a tariff, whereas the actual price can only be discovered through a market-based mechanism. This requires, in the minimum, allowing wheeling of renewable energy between willing parties.

All the above analyses are subject to the renewable energy integration meeting the technical requirements of steady state and transient stability of the electricity network.

REFERENCES

Gabriela Elizondo Azuela and Luiz Augusto Barroso, Design and Performance of Policy Instruments to Promote the Development of Renewable Energy: Emerging Experience in Selected Developing Countries, , Energy and Mining Sector Board Discussion Paper No 2, The World Bank, April 2011

Indatissa AS, Perera HYR and Siyambalapitiya T, Economics of Reaching year 2015 Non-Conventional Renewable Electricity Generation Objective of Sri Lanka, 2010

BIOGRAPHY OF AUTHORS

[1]Author, Dr Tilak Siyambalapitiya is Managing Director, RMA (Pvt) Ltd., Sri Lanka. He currently works as an international consultant in energy development in Asia and Africa. He graduated in Electrical Engineering from University of Moratuwa, Sri Lanka, in 1982, and earned his PhD in Power Engineering from University of Cambridge, UK, in 1988. He works in the areas of power engineering, renewable energy development, energy management and energy economics. He is a member of the Institution of Engineers Sri Lanka, and he is a life member of Sri Lanka Energy Managers Association (SLEMA). He was President SLEMA in 2004-6.

[2]Author is the Chairman of the National Engineering and Research Center of Sri Lanka. He is also a Senior Lecturer attached to the Department of Electrical Engineering of University of Moratuwa. He served in the private electricity sector of Sri Lanka from 1992 to 2005 before joining the University of Moratuwa as a Senior Lecturer in 2005. He obtained his BSc Eng (Hon) degree in 1991 and his MSc in Electrical Engineering degree in 2001 from University of Moratuwa. And he is a Fellow of the Institution of Engineers Sri Lanka, a Chartered Engineer and an International Professional Engineer.