ENVIRONMENTAL AND HEALTH IMPACTS OF THE BASIC ELECTRICITY SUPPORT TARIFF

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ABSTRACT

The main findings of this paper confirm that indoor air pollution, such as that resulting from combustion fuels, is an important contributor to respiratory disease, in particular lower respiratory infections. It is found that the provision of a basic electricity support tariff could assist with reducing indoor air pollution, but its success will be partially dependent on an associated reduced use of other fuels in households. Annual costs of lower respiratory infection treatment could be reduced by approximately R70-million under such a scenario. Impacts on greenhouse gas emissions are not noteworthy. Local vegetation impacts are dependent on the source of the current fuel wood, be it indigenous or alien vegetation.

1. INTRODUCTION

The South African government has committed itself to a basic electricity support tariff for poor households, with the aim of alleviating poverty. This paper focuses on the air pollution and health impacts, which are potentially attributable to a changed fuel use structure implied by such a tariff. It also considers briefly carbon emissions issues and the environmental impacts on local vegetation.

2. BROAD-SCALE EFFECTS OF ATMOSPHERIC AIR POLLUTION AND ITS EFFECTS ON ENVIRONMENTAL HEALTH

Primary energy use in South Africa is dominated by coal (~80%), half of which is used by Eskom in electricity production. Most electricity production is centred in the Eastern Highveld region, and coal combustion is a contributor to deteriorating air quality[1]. Domestic coal use and burning waste dumps are also important contributors to air pollution. The region is not suitable for low level dispersion, hence atmospheric conditions tend to aggravate the pollution problem. Higher grade coals are generally exported, and therefore coal in South African power stations tends to be of a poor quality [2].

Consideration needs to be given to the impact of the poverty tariff on broad-scale pollution. Encouragement to use electricity would imply an increase in electricity demand from coal-fired power stations. This in turn could lead to increased broad-scale air pollution. However, there may also be local-scale indoor air pollution benefits, such as health, which could outweigh the negative broad-scale pollution effects.

3. LOCAL/HOUSEHOLD SCALE AIR POLLUTION AND ENVIRONMENTAL HEALTH AND SAFETY IMPACTS

3.1 ENERGY SOURCES FOR LIGHTING, COOKING AND HEATING

A large proportion of those with access to electricity are using it predominantly to meet their lighting needs, rather than heating or cooking. In terms of health and safety, there needs to be a movement towards using electricity for cooking and heating as well. Movement away from using paraffin as a fuel source to meet heating and cooking needs will reduce accidental poisoning of children through ingestion and reduce costs associated with paraffin ingestion by up to R330-million (see www.pasasa.org) [3]. Burn and fire risks of candles and paraffin will also be minimised with greater electricity usage. Wood as a fuel bears high social costs, which could be reduced.

3.2 MODELLING THE HEALTH BENEFITS OF ELECTRIFICATION AND THE POVERTY TARIFF

A cost-benefit analysis is done to estimate the expected health and monetary benefits of a poverty tariff. It enables the health and monetary benefits of different policy decisions affecting health to be estimated, and the relative costs and benefits of different interventions to be compared.

Indoor air pollution increases the risk of acute respiratory infections in children, and chronic obstructive pulmonary disease in adults, most notably women. It is also associated with low birth weight, infant mortality, pulmonary tuberculosis, certain cancers (coal use is associated particularly with lung cancer) and cataracts.

Acute respiratory infections (ARI) in children are among the major diseases thought to be associated with indoor air pollution and acute lower respiratory infections (LRI) pose the highest risk of death. Since information regarding ARI in children is better than sources of information on other conditions related to health, the cost-benefit analysis focuses on ARI and on children rather than adults. In the analysis, the census year 1996 is used as the baseline, and 1999 (most recent data) is used in the second stage. The 1999 situation is analysed in two scenarios. In the first, electrification has increased the number of houses described as partially electrified. In the second scenario a basic electricity subsidy has resulted in many households becoming fully electrified i.e. electricity is not used simply for lighting.

3.2.1 Assumptions made in model calculations

- This analysis focuses on ARI, since information concerning other health conditions related to indoor air quality is limited.
- Census data for 1996 indicate that 57.6% of domestic households had access to electricity, of which 18.3% used electricity for lights, but not cooking. Electrification has increased.
- An average household size of 4.47 (based on 1999 statistics) is used. This could result in an underestimate of LRI burden as non-electrified rural households are larger and have higher LRI rates.
- According to Statistics South Africa (see www.statssa.gov.za) [4] a crude death rate of 66.3/ 100 000 in the <5 year age group is caused by LRI in urban, fully electrified households. A rate of 1.4/100 000 is used for the 5-14 year age group (extrapolated from ratios derived from 1980s coloured population data).
- It is assumed that children <5 years have one ARI episode per year, and that children in the 5-14 age category have one episode every four years.
- Primary health care costs of ARI are unknown and difficult to determine. It is assumed that ARI health care costs for paediatric primary consultations are R50 inclusive of medication.
- Hospitalisation costs, in keeping with the National Health Accounts Project 2000 Report for the Public Sector, are estimated at R450/day. It is assumed that LRI hospitalisations = 10 times LRI deaths.
- Odds ratios as a measure of risk for LRI were estimated by Terblanche *et al.* 1993 [5] as follows:
  Electrified vs non-electrified 2.9
  Electrified vs partially electrified 2.3

3.2.2 Burden of Lower Respiratory Infections and Associated Costs in South Africa - 1996

Assumptions:

- 10.9% of the population is aged 0-4 years
- 23% of the population is aged 5-14 years
- 265 305 fully electrified households @ 4.47 people/household = 19 065 913
- 955 521 partially electrified households @ 4.47 people/household = 4 271 179
- 3 838 745 non-electrified households @ 4.47 people/household = 17 159 190
- Total population = 40 496 282

Based on tables 1-4, there is an estimated excess of 2 915 LRI deaths attributable to domestic air pollution at a health care cost of R354 842 220.

Table 1: LRI burden and health care costs in children < 15 years in urban, fully electrified households (1996)

	Age 0-4	*Age 5-14*	*Total*
Population at risk	2 078 184	4 385 160	6 463 344
LRI deaths	1 315 (63.3/100 000)	61 (1.4/100 000)	1 376
LRI hospital-isations	13 150	610	13 760
LRI hospital-isation costs	R11 835 000	R549 000	R12 384 000
LRI consult costs	R103 909 200 (1/year @ R50)	R54 814 500 (1/four years @ R50)	R158 723 700
			R171 107 700

Table 2: LRI burden and health care costs in children < 15 years in partially electrified households (1996)

	Age 0-4	*Age 5-14*	*Total*
Pop. at risk	465 558	982 371	1 447 929
LRI deaths	678 (145.6/100 000)	31 (3.2/100 000)	709
LRI hospital-isations	6 780	310	7 090
LRI hospital-isation costs	R6 102 000	R279 000	R6 399 000
LRI consult costs	R53 539 170 (2.3/year @ R50)	R28 243 166 (2.3/four years @ R50)	R81 782 336
			R88 181 336

Lower confidence limits of estimate (LCE): Total cost: R38 339 711 LRI deaths: 308
Upper confidence limits of estimate (UCE): Total cost: R181 864 580 LRI deaths: 1 510

Table 3: LRI burden and health care costs in children < 15 years in non-electrified households (1996)

	Age 0-4	*Age 5-14*	*Total*
Pop. at risk	1 870 351	3 946 614	5 816 965
LRI deaths	3 453 (184.6/100 000)	162 (4.1/100 000)	3 615
LRI hospital-isations	34 530	1 620	36 150
LRI hospital-isation costs	R31 077 000	R1 458 000	R32 535 000
LRI consult costs	R271 150 000 (2.9/year @ R50)	R143 064 750 (2.9/four years @R50)	R414 214 750
			R446 749 750

LCE: Total cost: R215 672 280 LRI deaths: 1 745
UCE: Total cost: R616 206 520 LRI deaths: 4 986

Table 4: LRI burden and health care costs in children < 15 years in all households (1996)

	Age 0-4	*Age 5-14*	*Total*
Pop. at risk	4 144 095	9 314 145	13 458 240
LRI deaths	2 655 (63.3/100 000)	130 (1.4/100 000)	2 785
LRI hospital-isations	26 550	1 300	27 850
LRI hospital-isation costs	R23 895 000	R1 170 000	R25 065 000
LRI consult costs	R209 704 750 (1/year @ R50)	R116 426 810 (1/four years @ R50)	R326 131 560
			R351 196 560

3.2.3 Burden of Lower Respiratory Infections and Associated Costs in South Africa - 1999

It is important to consider the expected benefits of interventions made to reduce air pollution. In order to do this, two scenarios (scenarios 1 and 2) are considered for 1999 statistics. Over the 3 years between 1996 and 1999, 1 157 704 new domestic connections were made and housing stock increased by close on 600 000 units. Population growth was nearly 2.5 million. Note: Inflation costs are not included in the model calculations presented.

Scenario 1 Assumptions:

- 10.9% of the population is aged 0-4 years
- 23% of the population is aged 5-14 years
- 554 726 fully electrified households @ 4.47 people/household = 20 359 625
- 1 823 799 partially electrified households @ 4.47 people/household = 8 152 382
- 3 247 991 non-electrified households @ 4.47 people/household = 14 518 519
- 850 223 fully electrified households @ 4.47 people/household = 26 150 496

Table 5: LRI burden and health care costs in children < 15 years in electrified households in 1999 – Scenario 1

	Age 0-4	*Age 5-14*	*Total*
Pop. at risk	2 219 199	4 682 714	6 901 913
LRI deaths	1 404 (63.3/100 000)	63 (1.4/100 000)	1 467
LRI hospital-isations	14 040	630	14 670
LRI hospital-isation costs	R12 636 000	R567 000	R13 203 000
LRI consult costs	R110 959 950 (1/year @ R50)	R58 533 925 (1/four years @ R50)	R169 493 387
			R182 696 870

Table 6: LRI burden and health care costs in children < 15 years in partially electrified households in 1999 – Scenario 1

	Age 0-4	*Age 5-14*	*Total*
Pop. at risk	888 610	1 875 047	2 763 658
LRI deaths	1 294 (145.6/100 000)	60 (3.2/100 000)	1 354
LRI hospital-isations	12 940	600	13 540
LRI hospital-isation costs	R11 646 000	R540 000	R12 186 000
LRI consult costs	R102 190 150 (2.3/year @ R50)	R53 907 600 (2.3/four years @ R50)	R156 097 750
			R168 283 750

LCE: Total cost: R73 166 847 LRI deaths: 587
UCE: Total cost: R358 517 550 LRI deaths: 2 885

Table 7: LRI burden and health care costs in children < 15 years in non-electrified households in 1999 – Scenario 1

	Age 0-4	*Age 5-14*	*Total*
Pop. at risk	1 582 519	3 339 259	4 922 178
LRI deaths	2 921 (184.6/100 000)	137 (4.1/100 000)	3 058
LRI hospital-isations	29 210	1 370	30 580
LRI hospital-isation costs	R26 289 000	R1 233 000	R27 522 000
LRI consult costs	R229 465 250 (2.9/year @ R50)	R121 048 130 (2.9/four years @ R50)	R350 513 380
			R378 035 380

LCE: Total cost: R182 499 820 LRI deaths: 1 476
UCE: Total cost: R521 428 080 LRI deaths: 4 218

Scenario 2 Assumptions:

- 10.9% of the population is aged 0-4 years
- 23% of the population is aged 5-14 years
- 850 223 fully electrified households @ 4.47 people/household = 26 150 496
- 528 306 partially electrified households @ 4.47 people/household = 2 361 528
- 3 247 991 non-electrified households @ 4.47 people/household = 14 518 519

Table 8: LRI burden and health care costs in children < 15 years in electrified households in 1999 – Scenario 2

	Age 0-4	*Age 5-14*	*Total*
Pop. at risk	2 850 404	6 014 614	8 865 018
LRI deaths	1 804 (63.3/100 000)	84 (1.4/100 000)	1 888
LRI hospital-isations	18 040	840	18 880
LRI hospital-isation costs	R16 236 000	R756 000	R17 092 000
LRI consult costs	R142 520 200 (1/year @ R50)	R75 182 675 (1/four years @ R50)	R217 702 870
			R234 794 870

Table 9: LRI burden and health care costs in children < 15 years in partially electrified households in 1999 – Scenario 2

	Age 0-4	Age 5-14	Total
Pop. at risk	257 406	543 151	800 757
LRI deaths	374 (145.6/100 000)	17 (3.2/100 000)	391
LRI hospital-isations	3 740	170	3 910
LRI hospital-isation costs	R3 366 000	R153 000	R3 529 000
LRI consult costs	R29 601 690 (2.3/year @ R50)	R15 615 591 (2.3/four years @ R50)	R45 217 281
			R48 746 281

LCE: Total cost: R21 194 035 LRI deaths: 170
UCE: Total cost: R103 850 770 LRI deaths: 833

Table 10: LRI burden and health care costs in children < 15 years in non-electrified households in 1999 – Scenario 2

	Age 0-4	Age 5-14	Total
Pop. at risk	1 582 519	3 339 259	4 922 178
LRI deaths	2 921 (184.6/100 000)	137 (4.1/100 000)	3 058
LRI hospital-isations	29 210	1 370	30 580
LRI hospital-isation costs	R26 289 000	R1 233 000	R27 522 000
LRI consult costs	R229 465 250 (2.9/year @ R50)	R121 048 130 (2.9/four years @ R50)	R350 513 380
			R378 035 380

LCE: Total cost: R182 499 820 LRI deaths: 1 476
UCE: Total cost: R521 482 080 LRI deaths: 4 218

Total population scenario:
Total population = 40 496 282

Table 11: LRI burden and health care costs in children < 15 years in all households (1999)

	Age 0-4	Age 5-14	Total
Pop. at risk	4 690 305	9 206 974	13 897 279
LRI deaths	2 969 (63.3/100 000)	129 (1.4/100 000)	3 098
LRI hospital-isations	29 690	1 290	30 980
LRI hospital-isation costs	R26 721 000	R1 161 000	R27 882 000
LRI consult costs	R234 515 250 (1/year @ R50)	R115 075 000 (1/four years @ R50)	R349 590 250
			R377 482 250

3.2.4 Summary of scenarios 1 and 2

In Scenario 1, LRI deaths in children were 5 879, with total health care costs of R729 016 000. In Scenario 2, LRI deaths in children were 5 337, with total health care costs of R661 576 530. There is a reduction of 9.2% in LRI deaths between Scenarios 1 and 2, and a decrease in health related costs of R67 439 470.

3.2.4.1 Comparison between 1996 and 1999 analyses

Between 1996 and 1999 there is an increase in the overall number of deaths, attributed to the population increase. The overall health costs in the 1999 scenarios were lower than 1996, although not statistically significantly so. In scenario 1, there would be no real costs savings (in fact an increase of R22 977 220 per year), but in scenario 2 there would be a notable savings from assisting partially electrified households to become fully electrified (R44 811 270 per year).

3.2.5 Model strengths and weaknesses

- Demographic data on the blurred question of urban or rural residence were not all available and prevented a more complex analysis, and not taking the urban/rural difference into account has in all likelihood resulted in low estimated LRI deaths and health-care costs.
- Validated data on the national burden of LRI on children is sparse. This is somewhat surprising, considering it is the third most common cause of death in children < 5 years.
- The rand costs estimates of health care cannot be improved upon, since there is no statistic such as an average cost of a paediatric LRI consultation across public and private sectors in all provinces. The costs of R50 per outpatient, and two days at R450/day for LRI health-care, are considered realistic.
- The model has only considered direct costs. Indirect costs such as wages lost by parents taking time off work to look after a sick child have not been included, but could be substantial.
- Variables external to the model can play an important role. For example, in LRI in children it is expected that there will be increases in LRI attack and death rates due to the HIV epidemic. In fact, LRI are one of the most common complications of HIV infection in the age group considered in the model.

4. SCENARIO ANALYSIS OF INDOOR AIR POLLUTION LEVELS THROUGH CHANGED FUEL USE

4.1 ELECTRICITY CONSUMPTION REQUIREMENTS OF DIFFERENT HOUSEHOLD APPLIANCES

Before a good understanding of the effect of a basic electricity support tariff for the poor can be achieved, it is important to examine the electricity consumption of different electrical appliances. This will provide an idea of the level of appliance which could be used with a portion of free or subsidised electricity. Table 12 shows some common household appliances and their relative electricity costs. The table also provides an estimate of a possible purchase price for a new item.

If a household used all appliances in Table 12 (a winter scenario, with indoor heating), the average monthly electricity bill would be R160.36 (400.9 KWh). Those appliances requiring the most electricity are the geyser, fridge, stove and heater.

Coal, wood and paraffin, the primary contributors to indoor air pollution, are used mainly in cooking and heating. Therefore, electrical appliances performing these functions (geyser, stove and heater), would most benefit households in terms of indoor air quality. However, these appliances are not only the most expensive to purchase, but are also the appliances using the most electricity. These 3 appliances alone would result in the use of 288 units of electricity at the given hours of use. This is 238 units in excess of the suggested poverty tariff of 50 units. In summer, without the need for a heater, the number of units required would be fewer. An additional appliance with health benefits would be a fridge, since contamination risks (particularly in summer) would be reduced and food could also be stored for longer. The total units required would then be increased to 342. The reduction of a geyser, which could perhaps be viewed as a luxury, would reduce the units required to approximately 168.

There will be a setup cost associated with moving away from traditional energy sources to electricity. Electrical appliances required for lighting, cooking and heating purposes are displayed on Table 12. It is evident from this table, that the basic setup costs are a hindrance to a large percentage of the poor population. The purchase of a new geyser, two-plate stove and a few lightbulbs could amount to R1326. A refrigerator, with its additional health benefits, could add another R1000 to the costs. Given the large setup costs, it is likely that appliances would be bought second hand. Given the monthly and setup costs, it is questionable whether a poverty tariff would shift fuel use in favour of heating and cooking, or whether it would be used primarily for lighting.

Table 12: Electrical ratings of common household appliances, estimated monthly costs and appliance purchase costs

Appliance	*Watts*	*Hours of daily use*	*Days / month used*	*KWh (units) / month used*	*Monthly cost at 40c/kWh (R)*	*Cost new (R)*
Lighting (2 x 60W bulbs)	2*60	2*4	30	14.4	5.76	6
Heater (2 bars)	1300	4	15	78	31.20	120
TV (37cm colour)	50	6	30	9	3.60	1000
Radio (portable)	6	4	30	0.7	0.28	100
2 plate stove (hot plate)	2000	1.5	30	90	36.00	120
Iron (1000W)	1000	4	6	24	9.60	80
Kettle	2400	0.15	30	10.8	4.32	80
Geyser	2000	2	30	120	48.00	1200
Bar fridge	75	24	30	54	21.60	1000

Income is not always the only determinant of household fuel use. Multiple fuel use is often viewed simplistically as being a period of transition (paraffin, gas, batteries) from traditional (wood) to modern (electricity) fuels [6]. In reality the issue is far more complex. Fuel use is not determined by cost alone, but also by gender of the purchaser, socialisation and cultural ideology, for example [6].

4.2 INDOOR AIR POLLUTION UNDER DIFFERENT FUEL USE SCENARIOS

Although there are monetary benefits associated with using paraffin (costs usually amount to about R30/household), wood (often collected therefore free) or coal (inexpensive low grade coal is used in urban households), these fuels do not provide the same indoor health benefits provided by electricity. Coal and wood are notable contributors to indoor air pollution and paraffin has safety considerations that need to be addressed. Thus, in order to address the potential impacts of a poverty tariff on indoor air pollution, the fuel mix structure needs to be examined. In order to have a real impact, full electrification (i.e. for lighting, cooking and heating) is desirable.

5. CARBON EMISSIONS CONSIDERATIONS

South Africa contributes 1.5% to the world's total CO_2 emissions, and is the largest emissions source in Africa. The most significant source of greenhouse gas emissions, especially CO_2, is coal-based electricity generation. Impact on CO_2 emissions under a poverty tariff can be examined from two perspectives, viz., household emissions reduction due to substitution of fossil fuels by electricity, and increase in emissions from increased electricity production due to an increase in electricity consumption as a result of the poverty tariff. Calculations show that even with an assumption of no household emissions reductions, there will be little increase in CO_2 emissions as a result of the poverty tariff – a maximum increment of 0.076% of the year 2000 electricity production CO_2 emissions.

6. IMPACTS ON LOCAL VEGETATION

Wood in South Africa is increasingly becoming scarcer, resulting in woodland denudation. A popular view is that deforestation in rural areas is caused by collection for fuelwood purposes. Local and international experience suggests another significant factor - clearing of land for agricultural purposes may, in fact, be the primary reason [1]. The situation in South Africa remains unclear, and suggestions are that fuelwood collection, land clearing for human settlement, overgrazing and wood used for construction and medicinal purposes may be more significant [1]. The poverty tariff, however, may have both negative and positive impacts. Electrification could be expected to have a very minimal impact on rural communities who use wood as a fuel source, since it is freely available [7]. However, this ignores health impact costs associated with wood as a fuel source. With even partial use of electricity encouraged, vegetation impacts may be reduced. In the Cape Flats, much fuelwood is derived from alien vegetation (e.g. Port Jackson). Hence, fuelwood collection may be indirectly assisting with the clearing of invasive aliens. In other areas, indigenous vegetation is being cleared and hence a shift away from wood to electricity would be beneficial.

7. CONCLUSION

Indoor air pollution, from combustion fuels, is an important contributor to lower respiratory infections. The main findings suggest that a basic electricity support tariff could be a beneficial means of reducing indoor air pollution, and could have important health impacts. Annual costs of lower respiratory infection treatment could be reduced by about R70-million. Such a tariff could also have local vegetation impacts. Carbon emissions impacts are negligible.

8. REFERENCES

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