Rural Electrification in Mozambique
Is it worth the Investment?

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Abstracto (Português)
A electrificação rural é onerosa, enquanto a demanda de electricidade nos países em desenvolvimento é inerentemente baixa devido à pobreza. Além disso, evidências de literatura de que o consumo de electricidade conduz a um crescimento económico têm várias vertentes. Portanto, valerá a pena o investimento? Abordamos esta questão através duma análise de custo-benefício dum projecto duma zona tipicamente rural no norte de Moçambique (Ribáuè), incluindo uma avaliação do impacto da electricidade nas famílias agregadas, educação, produção agrícola, negócios e finanças públicas. Desenvolvemos 2 (dois) estudos subsequentes de impacto socioeconómico do projecto para estimar os seus benefícios privados e sociais e confrontar estes com os seus custos. Finalmente, esboçamos algumas implicações para a estratégia da electrificação rural em Moçambique, incluindo o desempenho dos investimentos complementares em outras infra-estruturas e o potencial hidroeléctrico existente.

Palavras-chave: Electrificação rural, Análise de custo-benefício

Abstract
Rural electrification is expensive, while electricity demand in developing countries is inherently low due to poverty. Moreover, evidence from the literature that electricity consumption leads to economic growth is at best mixed. So, is it worth the investment? We address this question by providing a cost-benefit analysis of a typical rural electrification project in Northern Mozambique (Ribáuè), including an assessment of the impact of electricity on households, education, agricultural production, business and local public finance. We build upon 2 subsequent socio-economic impact studies of the project to estimate its private and social benefits and confront these with its costs. Finally, we draw some implications for the rural electrification strategy of Mozambique, including the role of complementary investments in other infrastructure and available hydroelectric potential.

Key words: Rural Electrification, Cost-Benefit Analysis

1. Introduction

About one-quarter of the world population - some 1.6 billion people - have no access to electricity. Four out of five people without electricity live in rural areas of the developing world, mainly in South Asia and sub-Saharan Africa (IEA 2004, World Energy Outlook). In Mozambique, only about 7% of the population had access to electricity in 2005 (Ministry of Energy, 2006). The majority of these people are concentrated in a few urban centers, while the overall access rate in rural areas is estimated to be around 2%. Increasing access to electricity in these areas has proven to be difficult and expensive. In general, investment costs are high while demand is low because people are poor. This is particularly true in rural areas with its combination of low population density, and severe and persistent poverty. In spite of the fact that electricity is universally recognized as a key factor for achieving socio-economic transformation of rural areas, evidence from the literature that electricity consumption leads to economic growth is at best mixed (see, for example, Wolde-Rufael 2005). So after all is rural electrification worth the investment?

In this paper we try to answer this question for a typical rural electrification project in Mozambique. We do so by providing a cost-benefit analysis assessing the impact of electricity on households, education, agriculture and agro-business, small scale industry, and the public sector. The project comprises the electrification of the Ribáuè District, situated in the Northern Province of Nampula. The Ribáuè-Iapala line construction started early 1999 and the first consumers were connected in 2000. Subsequently, two socio-economic impact studies have been conducted – in 2001 and 2005 – to analyze the impact of the project (Åkesson and Nhate, 2002, 2006). Together with a 1997 baseline study of the project (Åkesson et al. 1997), they form the basis for our calculations. Whereas the aforementioned socio-economic impact studies describe the development of the district and the role of electricity in much detail, we focus on quantifying the benefits over the period 2000-2005 due to the arrival of electricity. As such our study enables us to compare costs and benefits of the project from an economic point of view, based on micro level information. Next, using the historical data for the period 2000-2005 we develop scenarios to assess future costs and benefits, up to the year 2020. Finally, we draw some lessons to be learned from our case study.

The organization of this paper is as follows. In section 2 we briefly describe the district and project under analysis. Section 3 presents the cost-benefit calculations for the period 2000-2005. In Section 4 we present scenarios for the period 2005-2020. Section 5 concludes.

2. The rural Ribáuè district and the project

Located in Nampula Province in northern Mozambique, Ribáuè district covers an area of 6,281 Km² and a relatively low population density of 18 per/Km². Its estimated population is about 126,000 inhabitants. In our analysis we take into account the whole Ribáuè district, which included the zones of Rapale, Namina, Namiconha, Iapala and Ribáuè-sede. The family farming sector occupies 38,348 hectares, which corresponds to about 6% of the total area of the district. Nevertheless, agriculture is the main economic activity in the district and involves almost all households. In addition the district includes, among others, a cotton fabric, maize mills, a hospital and a secondary school. Ribáuè district is integrated into the provincial trade network. Most trade in the district is based on marketing agricultural surpluses. The main market for consumer goods is in the district capital.

The electrification project of the Ribáuè-Iapala district comprised the construction of 33 kV overhead lines, distribution transformers, low voltage distribution networks and meters for connection of consumers. In doing so the project promoted infrastructure development expanding the existing national grid fed by Mozambique's large hydropower dam, Cahora-Bassa. The investment costs amounted for USD 4 million and were financed through a grant by the Swedish Development Cooperation (SIDA). The national Mozambican Power Utility, *Electricidade de Moçambique* (EdM), played its role in land acquisition and connecting consumers. The Ribáuè-Iapala line construction started early 1999 and the first consumers were connected in the year 2000.

The objective of the electrification project in Ribáuè-Iapala was to promote overall socio-economic development in the region. With electrification, there were expectations that it could boost local industry, trade and employment creation and improve life of the local residents by providing them with access to (improved) education, health facilities and social welfare, contributing to poverty reduction in line with the current Poverty Reduction Strategy for Mozambique.

It has proven to be difficult to obtain consistent figures on the exact evolution of the number of consumers and their electricity consumption per category during the period 2000-2005, not least because the categorization as used by EdM has changed as of 2003. Nevertheless, by combining information from the impact studies on 2001 and 2005 (Åkesson and Nhate, 2002, 2006) with data from the EdM office in Nampula, we were able to reconstruct the categorized evolution of electricity consumption and number of clients from 2000-2005. The results are summarized in the Figures 2.1 and 2.2 (we refer to Table A.1 and A.2 in the Annex for more detail)

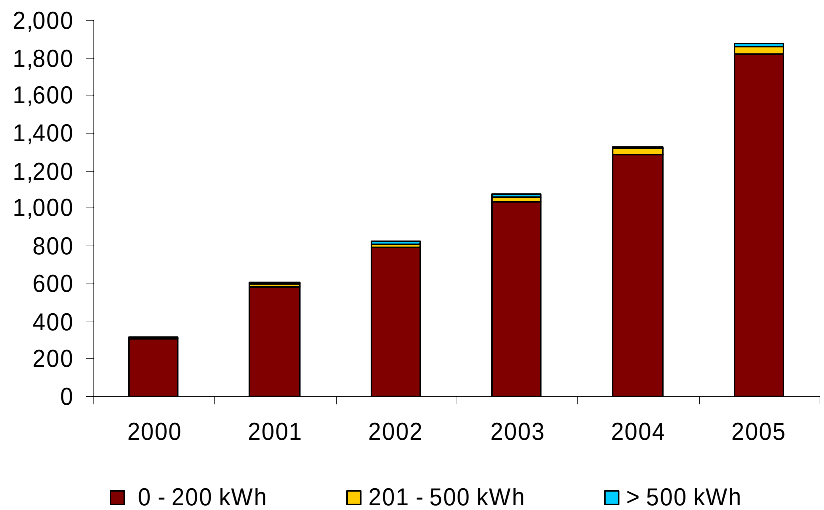

Figure 2.1 Number of customers 2000-2005

The Figure shows that the number of customers has been steadily increasing since the beginning of the project, from about 300 in 2000 to 1900 in 2005. The vast majority of these are small consumers in the category 0-200 kWh/month. This group predominantly consists of families that, in addition to their income from agriculture, have a supplementary income from wage work or permanent self-employment activities. Within this group, 90% consumes less than 85 kWh/month. It is to be noted that the number of consumers in 2001 was only about 50% of total clients foreseen (1100) by EdM and SIDA. In the initial period of the project (January - September 2001) 274 clients were cut off for non-payment, of which 148 were reconnected. During the same period in 2005 these figures were 459 and 288, respectively. Consumers in the private sector, undertaking commercial or semi-industrial activities, the public sector and civil society (churches, NGOs) together account for 6-10% of total consumers. Finally, Ribáuè district has a couple of large consumers, including a cotton fabric (CANAM), a secondary school and a couple of (flour) mills. The relatively low number of customers of course implies a high ratio investment costs per client. Given the initial investment costs of USD 4 million and a total of 1900 clients by 2005, the investment costs per client are about USD 2105 so far.

Accordingly to the growth in number of clients, electricity consumption has been steadily growing since 2000 to about 2300 MWh in 2005, as shown in Figure 2.2. By 2005, 97% of all consumers were responsible for about 60% of total electricity consumption. These are mainly households in the category 0-200 kWh/month. In addition, the few large consumers account for about 26% of total electricity consumption, of which the cotton fabric in the district is by far the largest electricity consumer.

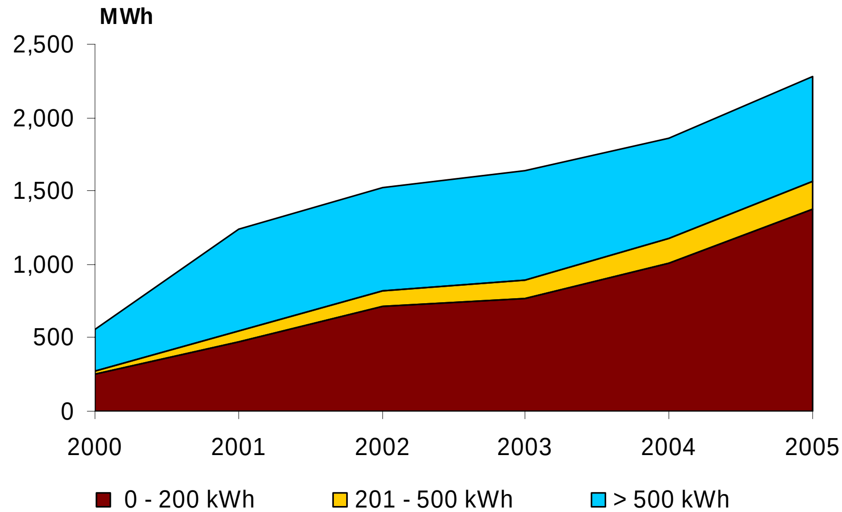

Figure 2.2 Electricity consumption 2000-2005

In sum, the (initially) low number of consumers, the extremely low electricity consumption of most clients and the relatively high number of disconnections indicate the very limited economic capacity of families living in rural areas. Nevertheless, after a slow start of the project the number of consumers is growing at an increasing pace since 2003, including not only households but also private sector clients.

3. Cost-benefit analysis 2000-2005

Cost-Benefit Analysis (CBA) estimates and aggregates the monetary value of the benefits and costs of projects to establish whether they are worthwhile. It is basically an accounting framework that prescribes classes of benefits and costs to consider, means to measure them, and approaches for aggregating them. Of course, no tool is perfect, and cost-benefit analysis suffers from many criticisms. These result from the techniques used to measure diverse benefits and costs in monetary terms, ethical objections to place some values – particularly of human life – under the realm of economics, and the fact that the present value calculation underlying a CBA leaves equity concerns unrecognized. Nevertheless, cost-benefit analysis is an indispensable tool to strengthen the economic foundations of decision making and thus can make a valuable contribution to the policy debate by emphasizing trade-offs, alternatives, and opportunities given up. That is exactly what we aim for with this study, while fully recognizing the aforementioned limitations of a CBA analysis.

In conducting a CBA usually a distinction is made between direct and indirect costs and benefits. Direct costs and benefits can be assigned to a particular party involved and are therefore also labeled as private costs and benefits. Indirect costs and benefits cannot easily be defined, principally because they are not accounted for in the transactions between buyer and seller, and hence are not reflected in the price of goods or service. Therefore, they are often referred to as externalities or social costs and benefits. Typical examples are environmental costs or the benefits from improved health care. In our costs-benefit analysis we try to quantify both direct and indirect costs and benefits. Furthermore, we apply a baseline discount rate of 5%. To check the robustness of our results we provide a sensitivity analysis of the cumulative net-benefits against a range of different discount rates. Finally, the original investment costs are given in Swedish Crones (SEK) while virtually all benefits are expressed in Mozambican Meticais (MT). Throughout the calculations we use a constant 2000 PPP exchange rate to convert values in different currencies to US dollars (US$).

The principal costs and benefits of a rural electrification project are summarized in Table 3.1. Below we elaborate upon these various costs and benefits.

Table 3.1 Principal Costs and Benefits of Rural Electrification

Costs	Benefits
Direct (private) Costs	Direct (private) Benefits
Initial Investment Costs	Saving Energy Costs
Depreciation Costs	Increased Economic Activity
Operating & Maintaining Costs	Indirect (social) Benefits
	Education
	Tax income
	Health
	Other (e.g., Public Lighting)

Costs

The costs of the project are threefold: initial investment costs, capital depreciation costs and operating costs. The initial investment costs are USD 4 million, spent between 1999 and 2000. In the analysis these costs are assumed to fall in the base year 2000. Concerning depreciation costs, we assume an annual depreciation rate of 5%, equivalent to a 20 year life span of the investment done. Finally, we assume that normal operating costs (collecting, service, maintenance, etc) depend on the amount of electricity sold and comprise 20% of the electricity price. Indirect costs, such as negative impacts on the environment, are very small – if any at all – and are therefore not taken into consideration.

Benefits

The benefits of the project can be divided into direct or private benefits and indirect or social benefits. The **direct benefits** include savings in energy costs and increased productivity from economic activities. The savings in energy costs rise primarily from the fact that the local cotton fabric as well as maize mills substituted electricity for diesel consumption. The monetary value of this is calculated by multiplying the price differential between diesel and electricity with the respective quantities consumed, given the realized production level. We refer to this as commercial saving of energy costs. In addition there are household savings, referring to the reduced energy costs of households since they substituted electricity for kerosene to meet their need for lighting services. Domestic energy savings are again calculated as the price differential between kerosene and electricity multiplied by their respective quantities consumed. The latter is based on the realized consumption levels of household with electricity consumption below 85 kWh/month, because it is mainly these households that use electricity predominantly for lighting.

Increased value from economic activity originates in our case mainly from the local cotton fabric that increased both its efficiency as well as the level of production. The use of electricity has allowed the cotton fabric to increase its efficiency with 30%. This led to a more rapid transport chain from producer to the mill and an increased demand for raw cotton benefiting the producer families. We calculate the monetary value from this straightforwardly from the combination of increased production levels and cotton prices per kg. In addition, the increased number of flour mills working with electric engines provided more regular and efficient service than those relying on diesel engines. As a result, milling charges went down and incomes for its owners went up. We calculate the total value of the consumer surplus on the basis of reported quantities and milling charges, while we assume the producer surplus to be 20% of total value. Finally, since electricity arrived, new shops, bars and restaurants have been created, most of them in the informal sector. Of course, here we touch upon the difficult issue of causality: has this been solely due to electrification? We estimate the value of this increased economic activity by combining the reported number of establishments of various types with assumptions on the number of workers per establishment and their salaries, and then assigning an arbitrary 20% of the total value to the electrification project. We assumed the number of workers per establishment to range from 2 (informal mechanical repair shop) to 30 (restaurant), with formal employees earning the official minimum wage while informal workers are supposed to earn 75% of that.

The **indirect benefits** include improved educational and health services, increased tax revenues for the local government and various other benefits like more and better channels of communication (radio, TV) and improved security due to public lighting. The impact of electrification on education is threefold. The introduction of electricity made the schools to offer night classes, which led to an increased number of students. Secondly, the promotion rates at day classes improved because of better study conditions (at night). Finally, the participation of female students increased, due to night classes and increased facilities such as a boarding school. Because of methodological difficulties we did not estimate the impact of the latter effect. To quantify the first effect we estimate the aggregate returns to education by multiplying the increased number of students finishing school with the so-called wage premium. The wage premium indicates the degree of higher wages earned when having a certain schooling level, and is obtained by applying a Mincer-type of wage regression (see, for example, Pritchett 2004 and Schultz 1999 for a detailed discussion). We took wage premium factors from Jones (2006) and Fox et al. (2005), which are derived from the 2003 national household survey in Mozambique. These values correct for various relevant factors, including the rural/urban dichotomy. We used the same methodology to quantify the effect of increased promotion rates, since they result in increased numbers of students obtaining their degree.

The tax income for the local government in the Ribaue district increased with 90% between 2001 and 2005. The majority of revenues originate from fees on trading. Since trading has increased significantly due to the availability of electricity we arbitrarily assume that 50% of the revenue increase is due to the electrification project.

Electricity also led to improved health services: the hospital now offers 24 hours emergency attendance and improved equipment allows for increased and better treatment of patients. Measuring welfare from health improvement requires finding appropriate "prices" to value health status. There is a voluminous literature on the value of fatalities prevented, with best estimates ranging from $0.6 million to $13.5 million per fatality prevented (see, for example, Viscusi, 1993). Unfortunately, we do not have appropriate data on fatalities prevented in the Ribaue district. We do know that in 2005 the hospital had to transfer 3 emergency cases to the hospital of Nampula city per month against 30 cases in 2001 and that maternal mortality had reduced from 16 in 2004 to 6 in 2005. However, according to hospital itself this is mainly due to improved skills of personnel, better informed population and the availability of an ambulance (Akesson and Nhate 2006: 64). As a result we feel it is difficult to assign the improved healthcare to electrification, and hence we decided not to include the health effects in our cost-benefit analysis. Admittedly this is a serious drawback because the monetary benefits of improved health care are substantial, given the aforementioned estimates of the value of fatalities prevented.

In addition, with electricity the district also got access to public lighting which improved the sense of security of inhabitants, in particular women. Finally, electricity led to improved access to modern communication means like radio and TV. Unfortunately, lack of data as well as methodological problems prevented us from quantifying these effects.

Below we present the main results of our calculations. Figure 3.1 shows the realized cost and benefits of the project so far (2000-2005). It can be seen that annual benefits are positive and increasing, while the cumulative net benefits have just become positive by 2005. As indicated before, the costs comprise initial investment costs of USD 4 million, depreciation costs and operating & maintenance costs.

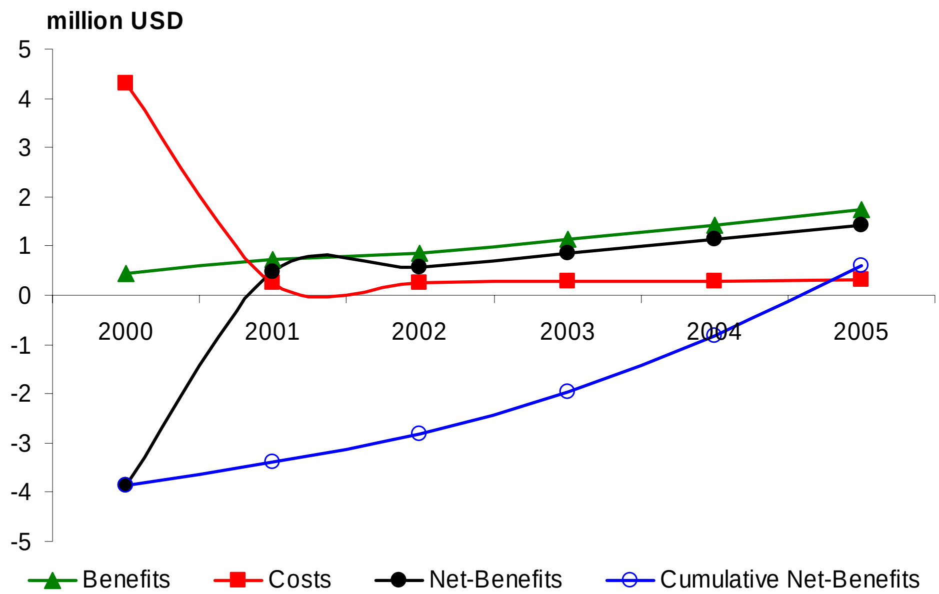

Figure 3.1 Costs & Benefits 2000-2005

Figure 3.2 provides a break down of total benefits of the project per year. The Figure shows that the majority of the benefits results from commercial energy savings and improved processing of cotton. Since the bulk of commercial energy savings also originates from the cotton fabric, Figure 3.2 leads to the conclusion that the cotton fabric is the principal source of benefits in the Ribáuè-Iapala electrification project. The absolute value of energy-costs saving component grew substantially as of 2003, which was due to increased production as well as increased diesel prices. Increased production was on its turn partly due to increased cotton prices. In addition, the estimated benefits from increases private sector activities (‘other business’) are considerable, while the value of improved education is gradually emerging. Finally, average domestic energy savings have been increasing considerably as of 2003 due to a relatively strong increase of the price of kerosene for lighting, following international oil price increases. As a result households have increasingly been able to save on energy costs by substituting electricity for kerosene.

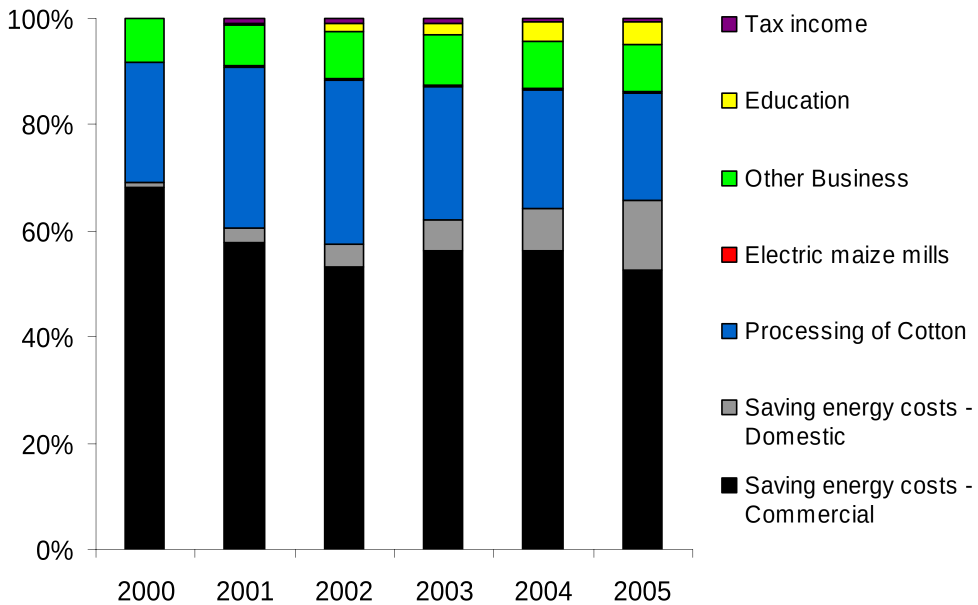

Figure 3.2: Decomposition of Benefits 2000-2005

As discussed above, these results are driven by a number of assumptions, most of which are straightforward. Three assumptions, however, are highly arbitrary. The first one is to assume that the producer surplus from increased performance of flour mills is 20% of total value. The second one is the assumption that 20% of the total value of increased economic activity of small businesses can be assigned to the electrification project. The third one is the assumption that 50% of increased public revenues are due to the electrification project. Therefore we performed a sensitivity analysis, reproducing the benefits of the project under different values regarding these assumptions. We adopted a high and low scenario, changing the aforementioned percentages (20%, 20% and 50%) in {40%, 40%, 80%} and {5%, 5%, 20%} respectively. The results indicate that the overall picture does not change: while the exact numbers change somewhat, the cotton fabric remains to dominate the results accordingly to the breakdown shown in figure 3.2. The reason is to be found obviously in the relatively small percentage contribution of these 3 components to total benefits. This is particularly true for the benefits from improved milling and tax income with a percentage contributing varying between 0.2% and 1.3%, while the percentage contribution of the tax income varies from 2% in the low scenario to 14% in the high scenario. We refer to Table A.4 in the Annex for details.

In conclusion, the electrification project has led to positive net-benefits as of its second year, while cumulative net-benefits have reached a positive level by 2005, i.e. within 5 years. This result is to be explained mainly from the improved performance of existing productive capacity of the local cotton fabric, helped by an exogenous increase in diesel and cotton prices. Increased other (informal) economic activities also have had a considerable impact. The monetized benefits for households have been relatively small, although rapidly increasing since 2003 due to sharp increases in kerosene prices. Thus the pattern of benefits is exactly opposite to the pattern of consumers: the large majority of consumers (households) are responsible for a minor part of total benefits while a few large consumers (principally the cotton fabric) account for almost all benefits.

4. Scenarios 2005-2020

Based on the cost-benefit analysis presented above, we develop three scenarios for the period 2005-2020. These scenarios reflect optimistic, average and pessimistic assumptions about the future costs and benefits. Table 2 summarizes the main assumptions underlying the three scenarios – labeled as High, Medium and Low – in relation to the values for the period 2000-2005. These assumptions are based on modeling the historical developments as well as additional calculations and assumptions on the development of key indicators. It is to be noted that the assumptions on commercial energy-costs saving, processing of cotton are deliberately conservative since they already constitute the major part of the benefits (see figure 3.2). The same applies to the emerging benefits from other business activities and education. On the other hand, assumptions on electric maize mills and tax income are deliberately positive. Furthermore it is to be noted that the annual increase in diesel en kerosene prices is assumed to be limited or even slightly negative, because their prices at the end of 2005 were already very high – based on a price of about 60 USD/barrel.

Table 2: Assumptions for the 3 scenarios, annual % change or growth rate

	2000-2005	High	Medium	Low
Operating costs	**10%**	**6%**	**8%**	**10%**
Annual Depreciation costs	5%	4%	5%	6%
Operating costs (% of price per kWh)	20%	15%	20%	25%
Commercial Energy Saving	**27%**	**7%**	**4%**	**1%**
Production	3.5%	5%	3%	1%
Diesel price	23.6%	3%	1%	-1%
Electricity price	1.2%	1.5%	0.95%	0.05%
Domestic Energy Saving	**50%**	**12%**	**8%**	**4%**
Kerosine price	22.2%	3%	1%	-1%
Electricity price	0.3%	1.5%	0.95%	0.05%
Number of electricity consumers	34.6%	15%	10%	5%
Improved Processing of Cotton	**18%**	**8%**	**5%**	**2%**
Production	3.5%	5%	3%	1%
Cotton price	13.8%	5%	3%	1%
Electric maize mills	**37%**	**30%**	**20%**	**15%**
Production	36.8%	30%	20%	15%
Other Business	**35%**	**15%**	**10%**	**5%**
Income	6.8%	10%	5%	1%
People involved formal sector	38.7%	15%	10%	5%
People involved informal sector	22.7%	15%	10%	5%
Education	**86%**	**25%**	**20%**	**15%**
Inflation rate	13.0%	10%	8%	6%
Average number of new students	16.8%	12%	8%	4%
Tax income	**24%**	**25%**	**15%**	**5%**

Based on these assumptions, our model enabled us to make projection of total costs and benefits up to 2020. The resulting cumulative net-benefits of the 3 scenarios are summarized in Figure 4.1.

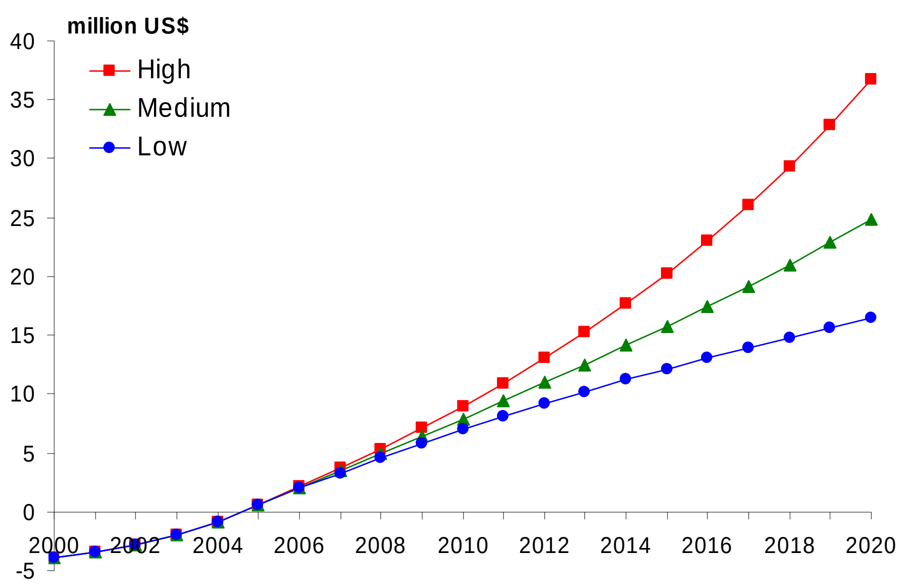

Figure 4.1 Cumulative Net-Benefits 2000-2020

The Figure shows that in all 3 scenarios the cumulative net-benefits will continue to increase considerably. In the most optimistic scenarios total net benefits are estimated to reach about 36 million by 2020, while this is about 16 million in the most pessimistic scenario. Hence it can be concluded that, overall the project realizes a high pay off over time. In Figure 4.2 we demonstrate again a breakdown of the benefits over time.

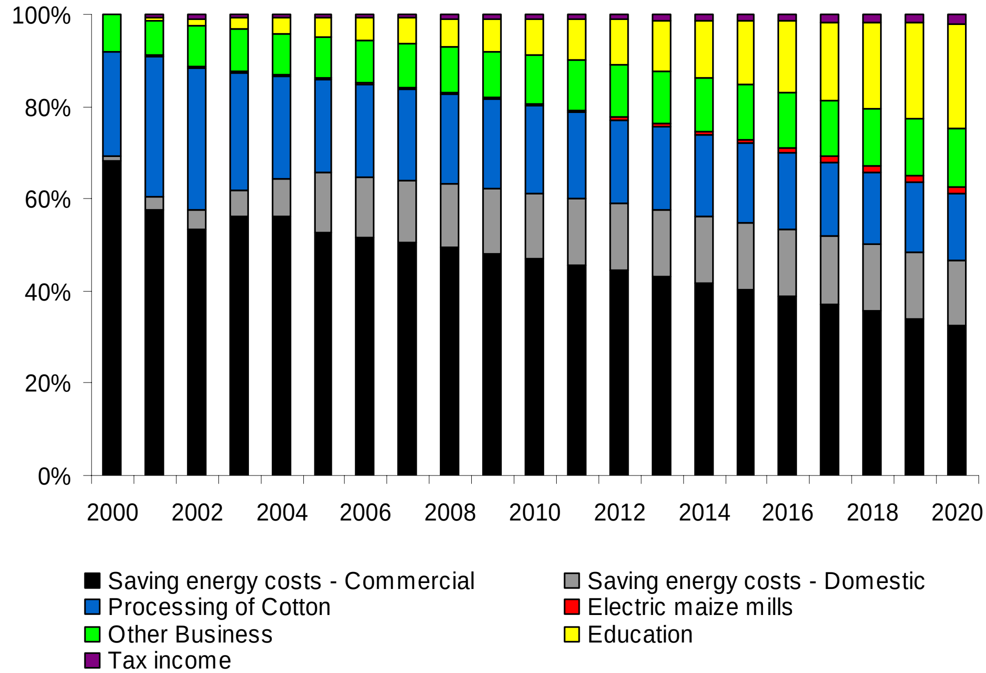

Figure 4.2 Decomposition of Benefits 2000-2020

The Figure shows that the cotton fabric remains to be the main driver of the results, both in terms of energy costs saving and improved performance of its production process. At the same time, the benefits from education are potentially big over a longer time span. The latter can be explained by the benefits from an ever increasing cumulative number of students over time. Obviously, since we measure the benefits from education by means of the wage-premium to higher education levels, there is an inherent time lag when it comes to materialize these benefits.

To further illustrate the crucial role of the cotton fabric, we present in Figure 4.3 the estimated cumulative net-benefits of the electrification project after elimination of the cotton fabric. From the Figure it can be seen that without the cotton fabric, the cumulative net-benefits would have become positive only after 2011 in the most optimistic scenario, while in the most pessimistic scenario this would happen as late as 2018.

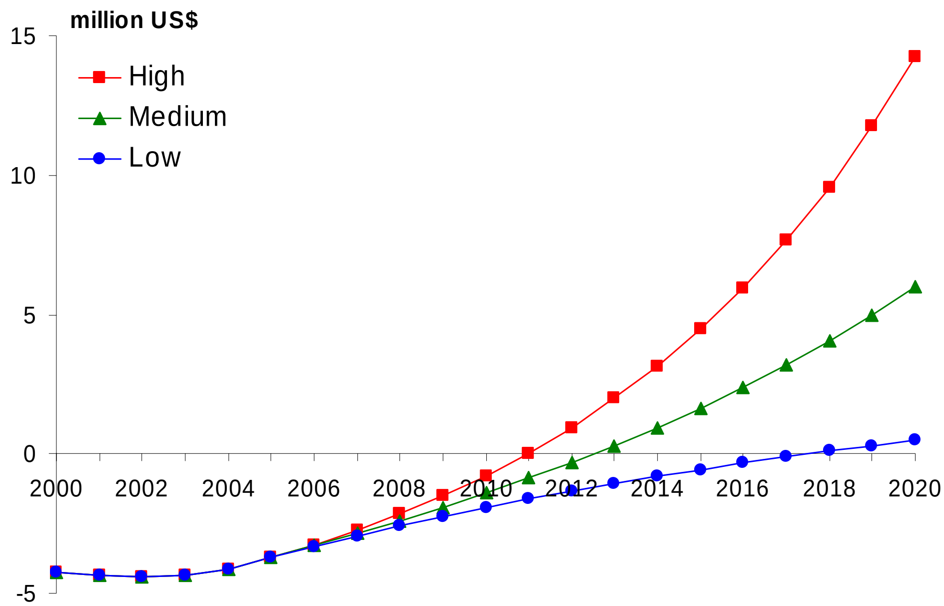

Figure 4.3 Cumulative Net-Benefits 2000-2020 without the Cotton Fabric

Moreover, it can be seen that without the existence of the cotton-fabric total cumulative net-benefits by 2020 would range between USD 0.5-14 million instead of the aforementioned USD 16-36 million (see Figure 4.1). In other words, if there were no such thing as a cotton fabric, the rural electrification project would have generated a very low pay off after a very long time: it would have taken at least 11 years to have generated positive cumulated net-benefits, and probably longer.

So far, our calculations are based on applying a discount rate of 5%. While this is a reference value used in most Cost-Benefit Analyses, it is worthwhile to check the robustness of our results for different discount rates given the potential large impact of the discount rate on Net Present Value calculations in the longer run. Figure 4.3 provides the results of a sensitivity analysis of the cumulative net-benefits against a range of different discount rates.

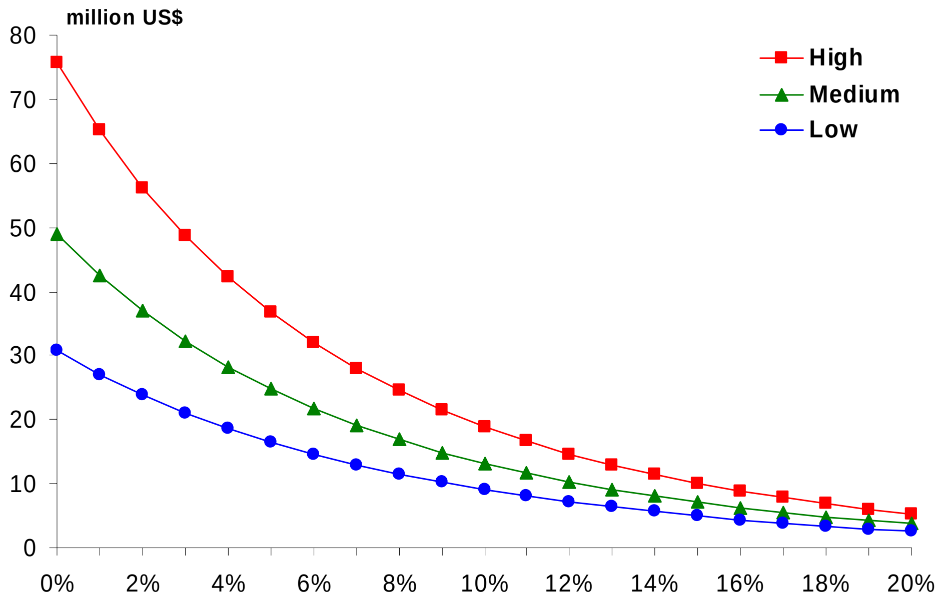

Figure 4.3 Cumulative Net-Benefits 2000-2020 at different discount rates

From the Figure it can be seen that even at a high discount rate of 20% the cumulative benefits of the project over the period 2000-2020 would be positive, albeit relatively small (around USD 3-5 million). For the evolution of net benefits over time at different discount rates, we refer to Figure A.1 in the Annex.

In conclusion, our scenarios for the period 2000-2020 show that the Ribaue electrification project is likely to result substantial positive benefits over the coming years, making it a successful project from an economic point of view. However, it has been shown that this success is highly dependent on the continued positive economic performance of the local cotton fabric. Without the cotton fabric, the project would have generated a very low pay off after a very long period only.

5. Conclusions

This paper dealt with the question whether rural electrification in developing countries is worth its investments. After all, investment costs in rural electrification projects are high while electricity demand is in general low because people are poor and evidence from the literature that electricity consumption leads to economic growth is at best mixed. We have approached this issue by conducting a cost-benefit analysis of a typical rural electrification project in a developing country, namely the electrification of the Ribáuè district, situated in the North of Mozambique. The construction started early 1999 and the first consumers were connected in 2000. Based on a baseline study (1997) and two subsequent socio-economic impact studies of the project (2001 and 2005) we have assessed the effect of electricity on households, education, agriculture and agro-business, small scale industry, and the public sector.

We found that in spite of the high costs (about USD 2100 per realized customer in 2005) the electrification project has led to positive cumulative net-benefits within 5 years. This result is to be explained mainly from the improved performance of existing productive capacity of the local cotton fabric, helped by an exogenous increase in diesel and cotton prices. Increased other (informal) economic activities also have had a considerable impact. The monetized benefits for households have been relatively small. In addition, we developed scenarios to estimate the potential costs and benefits for the period 2005-2020. The results of this exercise show that the Ribáuè electrification project is likely to raise substantial positive benefits over the coming years, making it a successful project from an economic point of view. However, this success is again highly dependant on the continued positive economic performance of the cotton fabric. At the same time, education emerges as a potentially important source of benefits over a longer time span, resulting from the wage-premium to higher education levels. The direct benefits for households and (informal) economic activity remain limited, and only pay off the initial investment costs after a very long period of time.

These results lead to the conclusion that from an economic point of view a rural electrification strategy should look for existing productive capacity, which potentially can be increased through access to electricity. Without a key customer (such as the cotton fabric in our case) that is able to generate substantial income for the electricity company, rural electrification projects are likely to generate at best very limited economic benefits. In effect, such a strategy is very similar to the idea underlying the macroeconomic strategy of the Government of Mozambique to attract so-called Mega-Projects. These 'anchor projects' are supposed to create economic dynamics by establishing linkages with other sectors, thus initiating 'trickle down effects'. While the Mega-Projects attract a great deal of attention, their sustainable impact on the Mozambican economy is rather limited (Anderson 2001, Carlos-Branco and Goldin 2003). On the contrary, through their impact on increasing agricultural productivity and other grass-root economic development in rural areas, the positive long-term macroeconomic effects of small anchor projects like the cotton fabric in Ribaue district might be considerable.

One could argue that if successful rural electrification project require the existence of a key customer or anchor project, it might not be appropriate to spend lots of public money (be it from donors or the government) on rural electrification: either they generate no or very small benefits or the benefits accrue to a private company – and why should one want to subsidize a private company rather than spend the money on helping the poor directly? A few things need to be said here. First, there are substantial positive externalities involved. The improved performance of the cotton fabric in Ribaue has evidently led to increased economic dynamics at the micro level, thereby particularly improving the economic conditions of the local farmers. We have not quantified these 'multiplier' effects in our study, and hence our results might well underestimate the positive economic effect of rural electrification in this respect. In this sense, subsidizing electrification is not different from subsidizing other types of infrastructure development such as roads – a very common practice everywhere in the world, including Mozambique. Second, our analysis indicates that over time social benefits from electrification emerge, with education probably very often as a key one. This then also in principle justifies the use of public funds, even it takes a long time for them to materialize, and in the mean time supporting private firms. In addition it is to be recalled that our CBA does not include the benefits from improved health service, public lighting and improved communication. Our results might thus well underestimate the social benefits of rural electrification in this respect. Third, even if a complete cost-benefit analysis indicates a negative NPV from electrification in a particular rural area, the government may still opt for investment because of social or political reasons.[1] Such a decision would require an assessment of the trade-off between social investments in electrification against investments in other sectors such as education or health. However, this would be a topic for another paper.

Finally, the Ribáuè district electrification project made clear that electricity alone cannot generate substantial benefits from increased economic activity in the informal

[1] With respect to the latter, from a strict economic point of view this might even be a rational decision in the case where social investments might help to prevent political unrest – the economic cost of political uncertainty are in general considerable.

sector and small (agricultural) business. The socio-economic impact studies (Åkesson and Nhate, 2002, 2006) also argue that for this to happen, complementary investments are needed. For example, the area studied currently faces lack of credit facilities (even a bank) and very poor road and telecommunications infrastructure. In such a situation, electricity alone will not trigger development Therefore, rural electrification programs should never be carried out isolated but should be integrated with complementary investments in infrastructure. Rural electrification can in principle help stimulating development of other activities, such as investments in roads network, transport system, telecommunications, the banking and financial system etc., and thereby creating mutual reinforcing dynamics of development. Obviously, this requires integrated planning and thus strong institutional players that can manage and enforce collaboration. We think it is here where the main challenge lies for the electrification strategy in Mozambique.

References

Åkesson, Gunilla, Mário Simoque and João Missão (1997), *Electrificação Rural Ribáuè/Iapala, Nampula. Estudos sobre aspectos sócio-económicos e de gênero.*

Åkesson, Gunilla, and Virgulino Nhate (2001), *Study on the impact of rural electrification in the Ribáuè, Namiginha and Iapala áreas*, Report to Swedish Embassy in Mozambique.

Åkesson, Gunilla, and Virgulino Nhate (2006), *Estudo Sócio-Económico e do Impacto na Pobreza do Projecto de Electrificação Rural Ribáuè/Iapala, Nampula Moçambique*, Report to Swedish Embassy in Mozambique.

Anderson, P.A., (2001), *The impact of the mega projects on the Moçambican economy*, Discussion Paper 18, Ministry of Planning and Finance, Mozambique: Maputo.

Carlos-Branco, C., and N. Goldin (2003), *Impacts of the Mozal Aluminium Smelter on the Mozambican Economy*, Final Report, Mozambique: Maputo.

International Energy Agency (2004), World Energy Outlook, Paris: IEA.

Jones, Sam (2006). *Growth accounting for Mozambique (1980-2004)*, DNEAP Discussion Paper XXX, Ministry of Planning and Development, Maputo, Mozambique.

.

Ministry of Energy (2006), Energy Statistics 2000-2005, Ministry of Energy, Maputo, Mozambique.

Fox, Louise, Elena Bardasi and Katleen Van den Broeck (2005), Poverty in Mozambique: Unraveling Changes and Determinants, Africa Region Working Paper Series No.87, Wahsington DC: World Bank.

Pritchett, Lant (2004), Does learning to add up add up? The returns to schooling in aggregate data, BREAD Working Paper No. 053

Schultz, T. Paul (1999), Health and Schooling Investments in Africa, *Journal of Economic Perspectives* 13(3), pp.67-88.

Viscusi, W. Kip (1993), "The Value of Risks to Health and Life," *Journal of Economic Literature*, vol. 31, pp. 1912-46.

Wolde-Rufael, Yemane (2005), Energy demand and economic growth: The African experience, *Journal of Policy Modeling* 27, pp 891-903.

Annex

Table A.1

Number of Clients	2000	2001	2002	2003	2004	2005
Household Tariff	**288**	**537**	**749**	**978**	**1217**	**1761**
0-200 kWh	285	526	734	959	1192	1726
201-500 kWh	3	11	14	19	22	33
> 500 kWh	0	0	1	1	2	2
General Tariff	**28**	**70**	**72**	**95**	**105**	**115**
0-200 kWh	22	56	58	76	94	93
201-500 kWh	3	7	7	9	10	12
> 500 kWh	3	7	7	9	1	10
Large Consumers	**2**	**4**	**4**	**5**	**6**	**6**
TOTAL	**317**	**611**	**825**	**1078**	**1328**	**1882**

Table A.2

Electricity Consumption (MWh)	2000	2001	2002	2003	2004	2005
Household Tariff	**240**	**469**	**736**	**808**	**1,079**	**1,444**
0-200 kWh	227	424	653	700	939	1,289
201-500 kWh	13	45	70	94	126	139
> 500 kWh	0	0	13	13	14	17
General Tariff	**61**	**155**	**179**	**190**	**208**	**246**
0-200 kWh	20	50	62	62	69	86
201-500 kWh	12	29	36	40	44	48
> 500 kWh	29	76	82	88	95	112
Large Consumers	**251**	**613**	**606**	**645**	**571**	**589**
TOTAL	**552**	**1,237**	**1,521**	**1,642**	**1,859**	**2,279**

Table A.3 Economic activities of consumers of domestic tariff

Source of income	Ribáuè-headquarters 2001		Ribáuè-headquarters 2005		Namiconha 2001		Namiconha 2005	
	Nr.	%	Nr.	%	Nr.	%	Nr.	%
Market seller	20	20%	65	14%	23	51%	57	30%
Factory worker	23	23%	23	5%	-	-	-	-
Private sector worker	7	7%	25	5%	4	9%	8	4%
Own business	11	11%	36	8%	6	13%	16	9%
Farmer	1	1%	15	3%	-	-	11	6%
Trader	2	2%	3	1%	-	-	5	3%
Public servant	15	15%	60	13%	1	2%	8	4%
Teacher	12	12%	119	26%	6	13%	51	28%
Health service technician	1	1%	35	8%	3	7%	14	8%
Police	3	3%	15	3%	-	-	3	2%
NGO	1	1%	16	4%	2	4%	2	1%
Other	2	2%	44	10%	-	-	10	5%
Total	**98**	**100%**	**456**	**100%**	**45**	**100%**	**185**	**100%**

Source: Akesson and Nhate.

Table A.4 Sensitivity Analysis Benefits 2000-2005

	Baseline				High				Low			
	2001 USD NPV	2001 %	2005 USD NPV	2005 %	2001 USD NPV	2001 %	2005 USD NPV	2005 %	2001 USD NPV	2001 %	2005 USD NPV	2005 %
Direct Benefits	**722,240**	**99%**	**1,650,238**	**95%**	**778,554**	**98%**	**1,804,556**	**95%**	**679,901**	**99%**	**1,534,201**	**95%**
Saving Energy Costs	**442,139**	**60%**	**1,139,759**	**66%**	**442,139**	**56%**	**1,139,759**	**60%**	**442,139**	**64%**	**1,139,759**	**71%**
Commercial	422,462	58%	912,421	53%	422,462	53%	912,421	48%	422,462	62%	912,421	57%
Domestic	19,677	3%	227,338	13%	19,677	2%	227,338	12%	19,677	3%	227,338	14%
Economic Activities	**280,101**	**38%**	**510,479**	**29%**	**336,415**	**42%**	**664,797**	**35%**	**237,762**	**35%**	**394,441**	**24%**
Processing of Cotton	222,460	30%	352,337	20%	222,460	28%	352,337	19%	222,460	32%	352,337	22%
Electric maize mills	1,743	0%	5,019	0%	2,158	0%	6,214	0%	1,328	0%	3,824	0%
Other Business	55,899	8%	153,123	9%	111,798	14%	306,246	16%	13,975	2%	38,281	2%
Indirect Benefits	**9,375**	**1%**	**86,974**	**5%**	**13,110**	**2%**	**94,309**	**5%**	**5,640**	**1%**	**79,639**	**5%**
Education	3,150	0%	74,749	4%	3,150	0%	74,749	4%	3,150	0%	74,749	5%
Tax income	6,225	1%	12,225	1%	9,960	1%	19,560	1%	2,490	0%	4,890	0%
Total Benefits	**731,615**	**100%**	**1,737,212**	**100%**	**791,664**	**100%**	**1,898,865**	**100%**	**685,541**	**100%**	**1,613,840**	**100%**
Net-Benefits	**470,909**		**1,425,984**		**530,958**		**1,587,637**		**424,835**		**1,302,612**	
Cumulative Net-Benefits	**-3,389,293**		**609,493**		**-3,291,989**		**1,196,079**		**-3,463,309**		**161,719**	

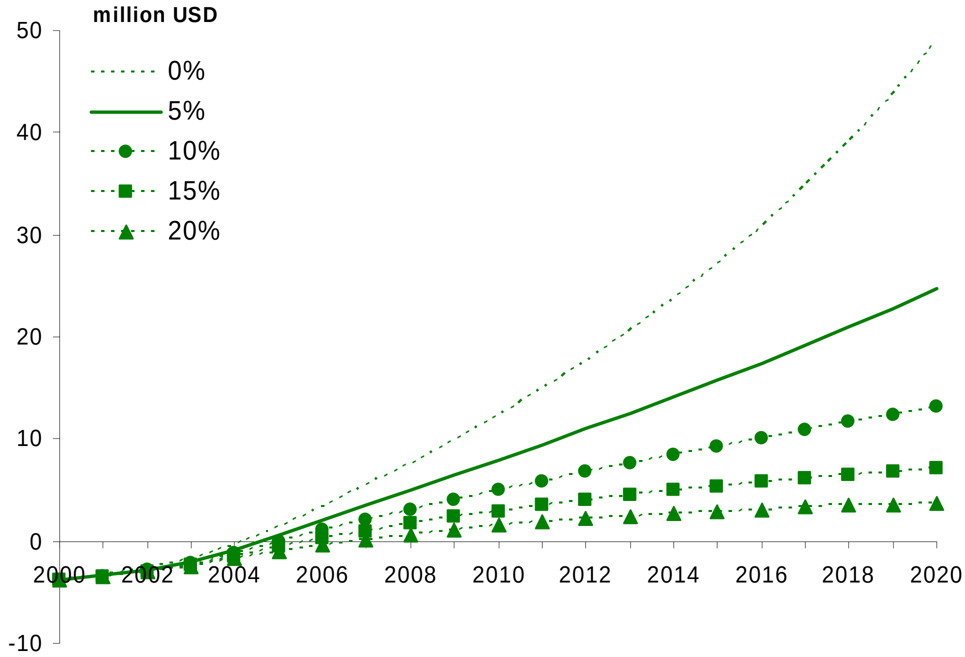

Figure A.1 Net-Benefits 2000-2020 at different discount rates, Medium Scenario