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Challenges for energy efficiency under programmatic CDM: case study of a CFL project in Chile

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Abstract

Energy Efficiency (ENEF) is one of the most promising sectors for reducing emissions of sustained growth and increasing energy security in developing countries. ENEF is, however, severely underrepresented in the Clean Development Mechanism (CDM), due in large part to its dispersed nature, which cannot be easily accommodated into traditional CDM modalities. Furthermore, in the present context, uncertainty prevails to whether the CDM is actually procuring its aims in terms of achieving Sustainable Development (SD) as well as to what extent. On the other hand, programmatic CDM (pCDM) could become an important tool to both bundle small-scale projects and organise similar (not necessarily small-scale) projects carried out at different locations and scales. In this respect, pCDM could offer a promising framework to maximize SD benefits through the inclusion of ENEF activities in developing countries. Compact Fluorescent Lamps (CFLs) technology has a significant technical potential within Chile, but 'somehow' do not receive sufficient attention from relevant stakeholders and key market players. This paper presents an analysis that explores for Chile, the potential of CFLs to deliver key energy services for the country. In the above framework, a simulation will be presented on the potential of large-scale CFL deployment in Chile in CDM emissions trading, energy and environmental terms.

Keywords: Energy efficiency, Sustainable development, Compact fluorescent lamps, Programmatic CDM, Chile.

1. Introduction

Climate change is one of the biggest challenges facing the humanity today. The Intergovernmental Panel on Climate Change (IPCC) highlights energy efficiency in energy supply, buildings, transport, industry and agriculture as key climate change mitigation opportunities. The Clean Development Mechanism (CDM), one of the flexibility mechanisms under the Kyoto Protocol provides a good opportunity to develop the markets for Energy Efficiency (ENEF) [1, 2] and address climate change. However, the share of ENEF in the CDM has been quite limited thus far.

From developing countries perspective the purpose of the CDM is to contribute to national Sustainable Development (SD) and to the global stabilization of the Greenhouse Gases (GHG) concentrations in the atmosphere. These goals can only be achieved through a transformative decarbonisation of economic growth in developing countries; the traditional - project-by-project - CDM approach supports the goals but is not sufficient. Although these individual projects have GHG reduction opportunities, they have little or no impact on the carbon intensity of growth. On the contrary, the CDM must provide the incentive for the transformation of key sectors that have a major potential for GHG reduction.

End-use Energy Efficiency is one of the most promising sectors for reducing emissions of sustained growth [3] and increasing energy security in developing countries. ENEF is, however, severely underrepresented in the CDM [4], due in large part to its dispersed nature, which cannot be easily accommodated into traditional CDM modalities. The first Conference of the Parties Serving as Meeting of the Parties to the Kyoto Protocol (COP/MOP 1) decision to render “project activities under a program of activities” (PoA) eligible for CDM - programmatic CDM (pCDM) - provides an interesting alternative for registering CDM activities that are distributed over space and time [5].

Article 12 of the Kyoto Protocol defines the CDM as a mechanism based on “project activities” [6]. A “project activity” can be an individual investment or action implemented in one clearly delineated geographical location, such as the construction of a wind farm or an efficiency retrofit in a specific industrial plant. This project-by-project approach is a means by which individual projects can be run in the most effective manner. It ensures that they have a clear remit, involve the right people, follow a clearly defined methodology and use appropriate tools and techniques.

However, CDM project activities can also be programmatic, where emission reductions are achieved not by one single investment, but rather by multiple actions executed over time as the result of a government measure or a voluntary program. Thus, a programmatic CDM project activity could for example involve energy efficiency standards for residential construction or an electric utility enacting a Demand Side Management (DSM) program. “Programme” is a widely-used word to describe activities that can vary substantially in terms of who is involved in a programme, what is targeted by the programme, where the programme is implemented, and when it occurs. A programmatic approach is a cross-cutting strategy that can catalyze, support, and sustain a process of regional development. The aim of this approach is to build the capacity of individuals, communities, and institutions to put regional development projects into action.

The concept of programmatic CDM involves the aggregation of a number of relatively small emission reduction activities in developing countries into a larger bundle (or programme), which is then prepared and submitted to the CDM Executive Board (CDM EB) as a single CDM activity with one set of methodologies for baseline determination and monitoring of the project performance. Programmatic CDM offers a promising framework to maximize sustainable development benefits through the inclusion of ENEF activities in developing countries.

Energy efficiency has an important role to play in meeting the energy needs of Chile and the country must strengthen the efficient use of energy as a strategic goal of SD. Chile has several ENEF options with significant GHG emissions abatement potential that are ‘waiting’ to become financially and economically competitive [7]. Within the open market economy of Chile, it should be noted that private investments are the driving force behind projects in the field of power generation and other sectors. The CDM could also strongly contribute to the country’s energy efficiency, especially for heavy industries, such as cement production and copper mining [8].

In particular, the concept of energy efficiency and efficient light bulbs as well as the fact that Compact Fluorescent Lamps (CFLs) are a direct substitute for incandescent light bulbs is widely known in Chile and probably more compared to other sustainable energy technologies [9,10]. However, although the technology and its potential have been widely acknowledged up to date, there has been no large-scale and/or programmatic deployment of CFLs in Chile thus far, despite of its almost obvious benefits [11].

Within the CDM framework, only 6 CFL projects have already been developed in India, Ecuador and Rwanda. Currently, August 2009, 3 CLF projects in India have been registered by the CDM EB [11]. Rigid behavioural consumer patterns and a lack of clear incentives to reduce energy consumption are often key issues that need to be addressed when one wants to deploy CFLs on a large scale as well as other small-scale ENEF options in general [12, 13].

Despite the awareness, institutional preparedness and increased market activity, the CDM is far from delivering its full potential. Observers and analysts have pointed out that thus far, the CDM is having virtually no effect on the decarbonization of national economies, a key factor in developing countries’ sustainable development. While many factors are at play with respect to the impact of the CDM on GHG emissions in developing countries, the current project-by-project approach is unlikely to catalyze the profound and lasting changes that are necessary in the overall GHG intensities of developing countries’ economies. As policies and measures can have a significant impact on infrastructures and investments, this paper deals with the CDM’s ability to scale up to meet global GHG challenges. Particular emphasis is laid on the fact that the traditional project-by-project does not allow more coherent and scalable interventions and is also leaving important mitigation opportunities left out.

In the above framework, the paper presents an analysis that explores for Chile, the potential of CFLs to deliver key energy services for the country. The analysis below is only a first preliminary attempt to establish a well-informed discussion on the feasibility and potential of this particular sustainable energy technology within a given country context, namely Chile. It provides an overview of the fundamental (macro-economic) forces within Chile's economy and will identify some of the blockages and barriers that can be expected when introducing this new technology.

Apart from the introduction, the paper is structured along four sections. A concise analysis of Chile's energy picture, in terms of the current status of the country's energy sector, some key supporting actions for ENEF as well as the country's CDM profile is presented in the second section. The third section assesses and discusses the CFL technology within the country context of Chile. The CFL potential in the country emerges through a simulation in the fourth section. Finally, the last section is the conclusions, which summarizes the main points that have arisen in this paper.

2. Chile's energy profile

2.1 The energy sector

Chile consists of thirteen administrative regions (from north to south: I: Tarapaca, II: Antofagasta, III: Atacama, IV: Coquimbo, V: Valparaiso, RM: Region Metropolitana, VI: Libertador General Bernardo O'Higgins, VII: Maule, VIII: Biobio, IX: Araucania, X: Los Lagos, XI: Aisen del General Carlos Ibanez del Campo, XII: Magellanes y Antartica Chilena). The country's main inland border is with Argentina in the East and Peru and Bolivia in the North to Northeast. The population is highly urbanised and primarily lives in the central area/regions in and around the Region Metropolitana. Chile has four interconnected electric systems and several stand-alone power generation units with a total installed capacity of 57.555 GWh in 2006 [14]. The four grids are: The Northern Interconnected System (Sistema Interconectado del Norte Grande - SING, Figure 1), the Central Interconnected System (Sistema Interconectado Central - SIC, Figure 2), the Aysén System (Sistema de Aysén) and the Magallanes System (Sistema de Magallanes).

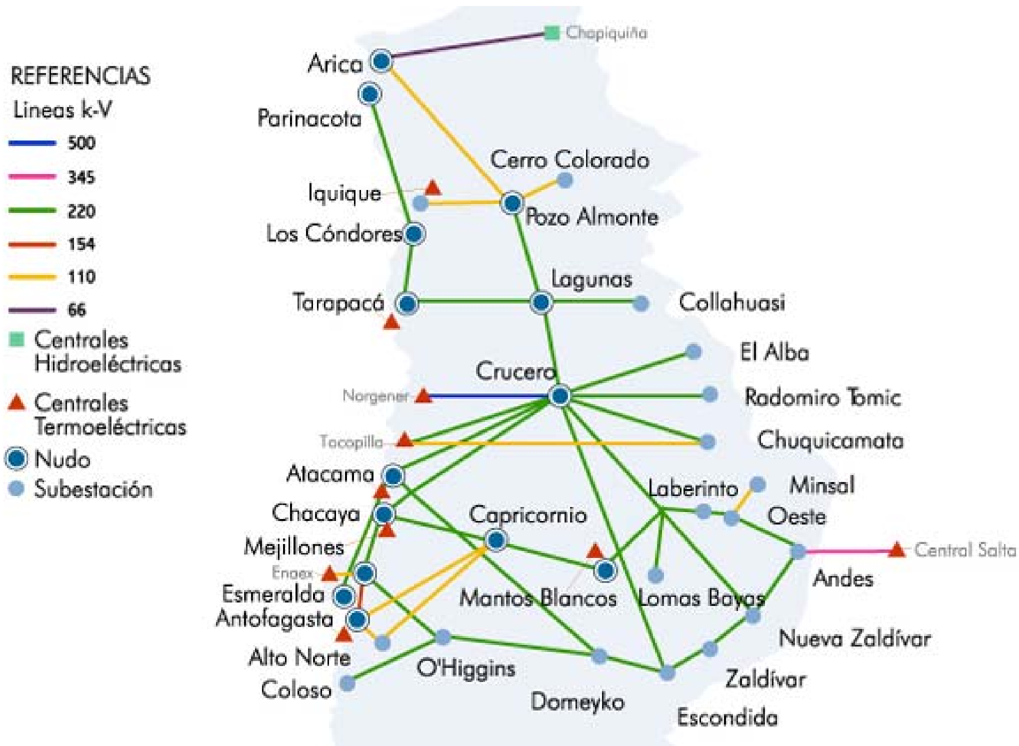

Figure 1. The northern interconnected system, SING. (Source: CNE 2009 [15])

Part 1 Part 2 Part 3

Figure 2. The Central Interconnected System, SIC. (Source: CNE 2009 [15])

The National Energy Commission (Comision Nacional de Energia - CNE) undertakes most of the regulatory functions for the energy sector, including proposing policies and strategies, tariff regulation, setting service standards, supervision of electricity dispatch and setting operational criteria for sector enterprises. It also undertakes indicative planning and may recommend state financing of generation or major transmission projects that are not being pursued by the private sector.

In 2006, about 70% of Chile’s electricity was supplied to and consumed within the central area of the country to the SIC power system. This amounted to 40.340 GWh generation in 2006, with a 70/30 division between hydroelectricity and thermal generation [14]. The country’s second largest power grid system is SING with 13.236 GWh produced in 2006, which has mainly thermal power generation units installed [14]. Generally, the SING power grid supplies electricity to the mining companies and urban demand and consists of few power generating units with large capacities.

In Figure 3 is illustrated the presentence of CO_2 emissions per sector in Chile. The transport sector is responsible for most of Chile’s CO_2 emissions (40%), followed by the energy sector (32%) and industrial sector (20%). The residential sector is responsible for 5% of the country’s emissions, while the commercial, institutional and agriculture activities are responsible for about 3% [16].

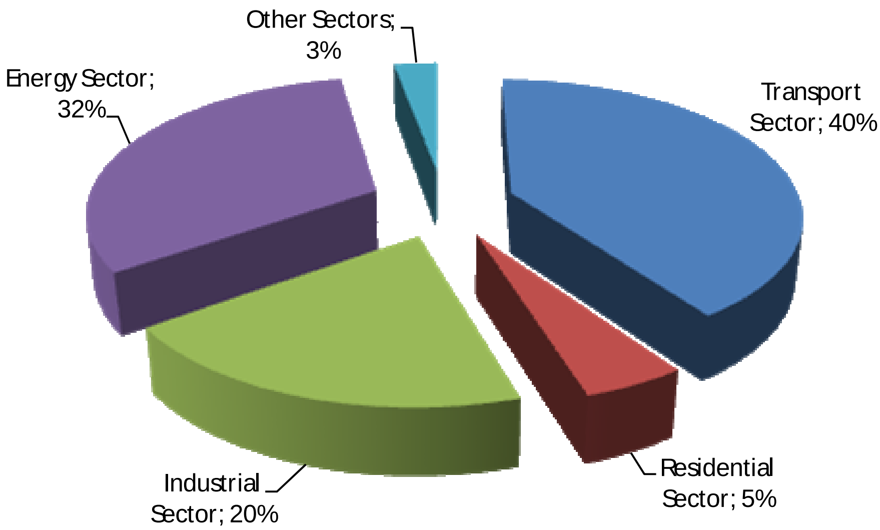

Figure 3. Chile’s CO_2 emissions by sector (2006). (Source: OLADE 2007 [16])

One specific feature of the Chilean energy situation is the substantial share of domestically produced hydroelectricity in the country's primary energy mix. In 2006, hydropower had a share of 19% in the energy mix [17]. The share of oil, which is almost fully imported, was 35,3% and natural gas had a share of 24,3%, of which 75% is imported [16]. Firewood (domestic) and coal (mainly imported) made up the remaining shares of 14 and 9,3%, respectively [18]. The overall energy import dependency in Chile is close to 70% [18]. Natural gas is mainly imported from Argentina via several pipeline connections, and oil is sourced from Argentina, Brazil, Angola and Nigeria. Concerns on security of natural gas supplies have recently arisen, due to recent and frequent natural gas supply reductions via pipelines from Argentina, where "between 20% and 50% below contracted daily volumes" [19 - 21] have been supplied.

2.2 Main supporting initiatives for energy efficiency

In Chile, energy efficiency programmes are coordinated by a small department of the National Energy Commission with a staff of three people. They are mainly focused on evaluations of mining sector activities, standards for the construction sector, and standards for electric appliances.

Several studies have indicated a significant potential for energy efficiency in Chile – between 1,700 MW and 4,100 MW by 2025 [22].

The country has set four lines of action to increase the efficient use of energy:

- To establish the institutional base for energy efficiency;
- To develop adequate knowledge for decision making;
- To promote energy efficiency in all sectors, and
- To regulate the markets, in particular the electric market, to incentivize efficiency.

The Energy Efficiency Country Program - Programa País de Eficiencia Energética, PPEE 2005 - [23] was established to implement these actions in 2005, initially under the Ministry of Economy but since 2008 incorporated within the CNE.

During 2009 an ENEF action plan for the years 2010 to 2020 will be developed [24], detailing the objectives, lines of action, programs, financing options and evaluation tools. To support the plan a series of end use surveys are scheduled with assessors from institutions such as the Lawrence Berkeley National Laboratory. A review of energy efficiency measures also will be undertaken by a group of experts from the Asia Pacific Economic Cooperation (APEC) forum.

At government level a program to improve ENEF in public buildings has been introduced. So far 16 energy audits have been undertaken, and during 2009 another four public buildings will be added to the program.

Among the most important measures that have been introduced is the lighting change-out program [25], which has the target of supplying energy efficient lighting to the most vulnerable 40% of the population. More than one million lights were supplied during 2008 and during 2009 it is planned to supply approximately 2,8 million lights. It is also planned to introduce an incentive scheme for thermal reconditioning of homes, with a target of 10.000 homes in 2009 to 2010.

In the industrial sector the ENEF potential has been estimated between 0,5 % and 2,9 % annually. At the end of 2006 a financial fund for ENEF support was launched [24]. At the regulatory level, the aim has been to introduce incentives for ENEF in the relevant sectors. In the electricity sector a review is prepared involving experts from California and Italy on the regulatory changes that would be required and on the possible decoupling of utility earnings from the supply of energy.

Energy efficiency in Chile is still in an early stage. To date, governmental efforts have concentrated mostly on assessing efficiency potentials, information campaigns and promoting voluntary standards. However, most of the industrial sector and the electricity utilities have yet to incorporate ENEF in their practices.

2.3 CDM status

Chile has three main governmental institutions that support the development of CDM projects: Comisión Nacional del Medio Ambiente (CONAMA), the National Environmental Commission; Prochile, the agency that promotes external commerce; and Production Promotion Corporation (Corporación de Fomento de la Producción - CORFO), the Economic Development Agency. CONAMA acts as the Designated National Authority (DNA), Prochile as a promoter of CDM projects and CORFO as facilitator by promoting regulations and feasibility studies that create incentives for CDM projects in the renewable energy sector.

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The DNA was established in May 2003 at the highest level of CONAMA, the Board of Ministers. As the Board includes 13 ministers and the Executive Director of CONAMA, activities are delegated to a steering committee formed of the Executive Director of CONAMA and representatives of the Ministries of Foreign Affairs and Agriculture, National Energy Commission, National Council for Clean Production and, if needed, a representative of the line Ministry under which a particular project falls. The DNA is only concerned with the sustainability and voluntary character of projects. It does not create additional political institutions or attributions.

Clear sustainable development criteria for CDM projects do not exist in Chile. The main consideration when judging a project is that if it does not have a negative impact on the environment, or can compensate for that impact, it contributes to the country's sustainable development.

CDM projects carried out in Chile need to comply with the country's existing environmental and socio-economic standards laid down in national legislation. The environmental impact of a CDM project in Chile is assessed by the regional authority in the region where the project will be implemented (regional Commission for the Environment). In case a project involves more than one region, an environmental impact assessment report must be submitted for review and approval to the CONAMA. CONAMA reviews the environmental impact assessment process and declares whether or not a project complies with the applicable national rules and regulations.

CONAMA intends to let CDM projects contribute to the domestic needs and priorities and in particular, security of energy supply [26].

Up to October 2009, 68 CDM projects in Chile have entered the pipeline of projects that are either under validation, or have been registered, (Table 1). In total, should these projects perform as planned in their design documents, it is expected that they will generate 38,9 million Certified Emission Reductions (CERs) by the year 2012 and 99 million CERs by 2020, which can then be transferred to industrialised countries with quantified commitments [11]. Moreover, most of the projects have a lifetime that goes beyond the year 2012 (the end of the Kyoto Protocol commitment period) and will continue generating emission reductions and thus CERs.

Table 1. CDM projects pipeline for Chile, as per October 2009. (Source: Fenhann 2009 [11])

Category	Registered	At Validation	Correction Requested	Total
Afforestation	0	1	0	1
Biomass Energy	7	6	0	13
CO_2 Capture	0	1	0	1
ENEF Supply Side	1	0	0	1
Fossil Fuel Switch	1	0	0	1
Hydro	8	12	0	20
Landfill Gas	10	7	1	18
Methane Avoidance	6	1	0	7
N_2O	1	0	0	1
Reforestation	0	1	0	1
Wind	1	3	0	4
Total	**35**	**32**	**1**	**68**

3. CFL status in Chile

An Integrated Environmental Strategies (IES) study published by the Catholic University of Chile in December [9], explores the GHG emission reduction and other effects (ambient air pollutants and health benefits) from an assumed climate change policy for Chile in relation to a business-as-usual scenario. In addition, it also simulated these effects for a number of technology options, including CFL in Chile. Based on data on the Santiago area, and an assumed baseline based on the dispatch regime of two local power plants, the application of CFL, for which a certain penetration rate was chosen, appeared to have significant benefits in terms of CO_2, CO, SO_2, NOx, NMHC, PM and PM2.5 in the order of magnitude of 80% given the assumed baseline, mainly due to electricity savings. Indirect public health (i.e. predominantly due to air quality improvement) benefits were derived from these results. The study also showed that an IES policy approach enables policy makers (from different ministries) to identify the trade-offs of certain policies more easily, and one of the main conclusions was that there is much to be gained in this area in terms of policy integration.

Within Chile's Programa Pais de Eficiencia Energetica [27] two efficient lighting projects have been proposed, the first is on the replacement of inefficient incandescent light bulbs in households (Proyecto de Recambio de Ampolletas) [25] and the second project involves the replacement of inefficient public lighting (Proyecto de Recambio Luminaries Publicas). In 2007, it became clear that the Government of Chile was considering the implementation of these projects as a programme of activities under the CDM based on the distribution of CFL within the country [23]. The basic idea of the project is to distribute two CFLs each to 40% of the lower-income households free of charge. The programme is developed together with the Inter-American Development Bank (IADB).

The programme's contribution to energy savings is estimated to be around 97 GWh per annum and 388 GWh in total during the four-year project duration. The climatic benefits of this programme have not been calculated yet and depend on the specific project design. Assuming a countrywide applicable power grid emission factor of 596 tonnes of CO_2-eq per GWh/y (assumed country-wide grid emission factor equal to SIC-grid factor) the estimated GHG emission reduction mounts up to 57,8 ktonnes CO_2-eq/y (231,25 ktonnes CO_2-eq. in assumed four year period).

In order to get a clearer view of what the project design could look like and what kind of impact such a programmatic initiative would generate, a simulation will be presented below on the potential of large-scale CFL deployment in Chile in CDM emissions trading, energy and environmental (only GHG emissions) terms. It is important to mention that within the CDM framework, a number of CFL projects have already been developed.

4. CFL potential in Chile: a simulation

The proposed CDM-CFL projects, which promote ENEF, involve a large amount of CFLs to be distributed to domestic end-users. For instance, the Visakhapatnam CFL project [28] in India involves the distribution of about 870.000 CFLs to approximately 580.000 households, while claiming a GHG emission reduction of 49 ktonnes of CO_2-eq annual average during a ten-year crediting period. The project participants aim to distribute 45.000 CFLs in Ghana (Ghana efficient lighting retrofit project 2006) [26] with an annual average estimated GHG emission reduction of 1,1 ktonnes of CO_2-eq during a ten-year crediting period. Both projects mentioned calculate their estimated GHG emission reduction based on the applicable grid emission factor. One positive feature of the specific CFLs used in the Ghana project is that they are able to withstand substantial voltage fluctuations, so that they have a significant longer life span than the average conventional incandescent light bulb.

A CFL project at such a scale has never been considered in Latin America, although government programmes and several papers indicate the desirable characteristics of widespread use of CFLs in countries like Chile. In order to make an adequate technology simulation for the impact of the above-mentioned CDM-CFL project in Chile it is essential to acquire data and information on the power grid and its emission factor(s).

As Chile has four largely independent power grids (with specific emission factors), it is relatively straightforward to identify where a CFL project will generate the most emission reductions. In the Northern part of the country the grid emission factor is favourable for CFL application, since still a significant share of coal fired power in that area. Together with natural gas the Northern grid, SING is predominantly fossil fuel-based. The central and largest power grid SIC has a large share of hydropower generation supplemented with natural gas and some diesel and coal. Given the seasonal and annual variability of hydropower generation the grid's emission factor can vary significantly, which is a factor that should be taken into account when establishing the baseline emission factor.

The other two Chilean independent power grids are much smaller and are located in significantly less densely populated areas. When considering a countrywide distribution of CFLs this could decrease project economics somewhat in terms of distribution costs and monitoring. However, there are a number of possible additional sustainable development benefits of CFL application, such as ambient air quality improvement (and indoor air quality, especially in cases where liquid or gaseous fuel for lighting in domestic use is replaced by CFLs). Another benefit, mainly for smaller and/or unstable grids that frequently experience significant voltage fluctuations CFL application could also be favourable as CFLs are better able to cope with this issue and thus have a relatively long lifetime.

For the purpose of this analysis, the focus lays on the SING and SIC power grids as they represent about 93% of the total power produced in Chile. Both grids are by far the largest of the country and are located in the most densely populated area of Chile, particularly in the Santiago area. The relevant grid emission factor can be derived from various CDM projects in Chile that take the SIC as the relevant grid. From the documentation of the Hornitos hydropower plant, the combined margin (weighted composite of the build margin and operating margin emission factors) emission factor is taken, which amounts up to 596 tonnes of CO_2-eq per GWh/y. As currently no CFL project via the CDM is proposed within Chile, it could be assumed a specific number of CFLs being deployed for instance in the Santiago area.

Assuming a programme of activities in CFL distribution in the Santiago area amongst all income groups, it could be derived a crude absolute number of CFLs. As Santiago has about 5 million inhabitants, and assuming an average of 2 people per household and while assuming an average of 3 CFLs per household the theoretical maximum potential for CFL deployment in this geographical area is about 7,5 million CFLs.

Additionally, if 20% of this population acquires access to the CFL programme (according to project criteria) an estimated number of 1,5 million CFLs will be distributed. The baseline assumption here is that solely conventional incandescent light bulbs are replaced. With an estimated average number of operating hours of four hours per day and a subsequent project lifetime of ten years the estimated reduction in power consumption in the area is estimated to be about 97,5 GWh per annum (about 65 Watt reduced consumption per CFL per annum (65 W per CFL per annum is taken from relevant PDDs as a default factor for energy savings (CDM-EB 2006 [28])) resulting in an annual GHG emission reduction of approximately (97,5 GWh x 596 tones CO_2-eq/GWh) 58 ktones CO_2-eq. per annum (using the approved methodology AMS II.J) (It should be noted that the CDM EB has approved a methodology especially for efficient lighting (AMS.II.J - Demand-side activities for efficient lighting technologies), which specifies default parameters, e.g. 3.5 hours per day (UNFCCC 2009 [4])). During an assumed 10-year crediting period this would yield a total power saving of 975 GWh and 0,58 Mt CO_2 (Table 2).

The size (i.e. number of CFLs, energy savings) and scope (lower-income households) of this project simulation – in terms of estimated GHG-emission reductions – is comparable to the CDM-CFL project that is currently being developed by the IADB. This would imply that the future CDM-CFL project should involve the distribution of about 1,5 million CFLs in Chile.

These savings are significant and could be rolled out across the country and not just in Santiago so that the potential in avoidance of coal-fired power generation and the environmental implications including GHG reductions would be significant. The development of a market for CFLs could be stimulated by the proposed CDM project.

5. Conclusion

To sum up, Compact Fluorescent Lamps constitute very promising alternative in order to deliver key energy services for the country of Chile. Despite, however, their significant technical potential within Chile, CFL technology lack the expected development, mainly due gaps in stakeholders’ awareness of the specific technologies as well as in domestic Research and Development (R&D) and/or public, private investment.

On the whole, stakeholders and key market players in Chile consider CFLs to be generally a high priority technology and that it could play a very important role in contributing to the country’s SD. Though, there has been no large-scale and/or programmatic deployment of CFLs in Chile so far.

The analysis presented made it obvious that the deployment of CFLs can result in significant energy savings across the country and consequently in the avoidance of coal-fired power generation. In addition, the environmental implications including GHG reductions would be significant. Most often, the key issues that lead to no large scale deployment of CFLs and have to be addressed consist of rigid behavioural consumer patterns and lack of clear incentives to reduce energy consumption.

Finally, it should also be mentioned that in Chile coal has recently been discovered and the large utilities are planning to move to coal technology and not necessarily clean-coal technology, as costs will be a major factor in their investment decisions. There is therefore little time left before lock-in to a high carbon future for Chile. In addition, the lack of confidence in the practicality and affordability of low carbon technologies in the country context and in the necessary timescales presents a major barrier for a low carbon future.

Table 2. CFL pCDM project simulation

CFL ***pCDM Project***	
Sector: Energy Efficiency	
Type of Project: Demand-side Energy Efficiency Programmes	
Implementation Area: Chile, Santiago **Population:** 5 million	
Assumptions	
✓ 2 people per household; ✓ 3 CFLs per household; ✓ 20% of population ⇒ access to the CFL distribution programme; ✓ Average Operation: 4 hour per day; ✓ Project's lifetime: 10 years; ✓ Crediting Period: 10 years.	
Results	
Energy Consumption Reduction Achieved per year	*7,5 GWh*
Emission Reduction Achieved per year	*58 kt* CO_2*-eq*
Total Energy Consumption Reduction Achieved	*975 GWh*
Total Emission Reductions Achieved	*0,58 Mt* CO_2*-eq*

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